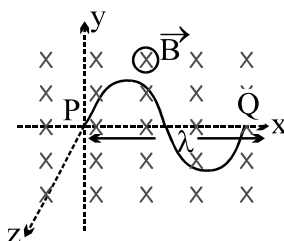


EXERCISE

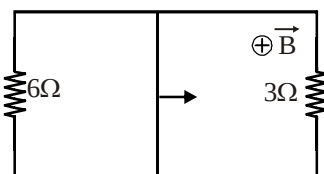
EXERCISE (S-1)

HCV Worked out Examples(Chapter No. 38 - 2,3,4,5,6,7,8,9,10-18,20)

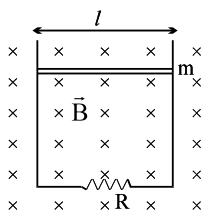
1. A rectangular wire loop of sides 8 cm and 2 cm with a small cut is moving out of a region of uniform magnetic field of magnitude 0.3 T directed normal to the loop. What is the emf developed across the cut if the velocity of the loop is 1 cm s^{-1} in a direction normal to the (a) longer side, (b) shorter side of the loop? For how long does the induced voltage last in each case ? (NCERT)
2. A horizontal straight wire 10 m long extending from east to west is falling with a speed of 5.0 m s^{-1} , at right angles to the horizontal component of the earth's magnetic field, $0.30 \times 10^{-4} \text{ Wb m}^{-2}$.
(a) What is the instantaneous value of the emf induced in the wire ? (NCERT)
(b) What is the direction of the emf ?
(c) Which end of the wire is at the higher electrical potential ?
3. A wire forming one cycle of sine curve is moved in x-y plane with velocity $\vec{V} = V_x \hat{i} + V_y \hat{j}$. There exist a magnetic field $\vec{B} = -B_0 \hat{k}$. Find the motional emf develop across the ends PQ of wire.



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

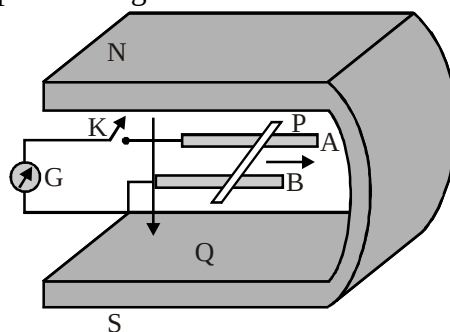


5. A horizontal wire is free to slide on the vertical rails of a conducting frame as shown in figure. The wire has a mass m and length l and the resistance of the circuit is R . If a uniform magnetic field B is directed perpendicular to the frame, then find the terminal speed of the wire as it falls under the force of gravity.



6. A jet plane is travelling towards west at a speed of 1800 km/h. What is the voltage difference developed between the ends of the wing having a span of 25 m, if the Earth's magnetic field at the location has a magnitude of $5 \times 10^{-4} \text{ T}$ and the dip angle is 30° . (NCERT)

7. Figure shows a metal rod PQ resting on the smooth rails AB and positioned between the poles of a permanent magnet. The rails, the rod and the magnetic field are in three mutual perpendicular directions. A galvanometer G connects the rails through a switch K. Length of the rod = 15 cm, $B = 0.50$ T, resistance of the closed loop containing the rod = $9.0\text{ m}\Omega$. Assume the field to be uniform. (NCERT)



- Suppose K is open and the rod is moved with a speed of 12 cm s^{-1} in the direction shown. Give the polarity and magnitude of the induced emf.
 - Is there an excess charge built up at the ends of the rods when K is open? What if K is closed?
 - With K open and the rod moving uniformly, there is no net force on the electrons in the rod PQ even though they do experience magnetic force due to the motion of the rod. Explain.
 - What is the retarding force on the rod when K is closed?
 - How much power is required (by an external agent) to keep the rod moving at the same speed ($= 12\text{ cm/s}$) when K is closed? How much power is required when K is open?
 - How much power is dissipated as heat in the closed circuit? What is the source of this power?
 - What is the Induced emf in the moving rod if the magnetic field is parallel to the rails instead of being perpendicular?
8. A 1.0 m long metallic rod is rotated with an angular frequency of 400 rad s^{-1} about an axis normal to the rod passing through its one end. The other end of the rod is in contact with a circular metallic ring. A constant and uniform magnetic field of 0.5 T parallel to the axis exists everywhere. Calculate the emf developed between the centre and the ring. (NCERT)

HCV Exercises (Chapter No.38 - 1,3,5,6,7,9,11,13-16,21,23,26,27,31,32,34,36,38,40,41,44,46,48,50,53-55,57,59,62,63)

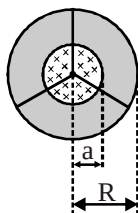
HCV Worked out Examples(Chapter No. 38 - 19)

- A rectangular wire loop of sides 8 cm and 2 cm with a small cut is stationary but the current feeding the electromagnet that produces the magnetic field is gradually reduced so that the field decreases from its initial value of 0.3 T at the rate of 0.02 T s^{-1} . If the cut is joined and the loop has a resistance of 1.6Ω , how much power is dissipated by the loop as heat? What is the source of this power? (NCERT)
- There exists a uniform cylindrically symmetric magnetic field directed along the axis of a cylinder but varying with time as $B = kt$. If an electron is released from rest in this field at a distance of ' r ' from the axis of cylinder, its acceleration, just after it is released would be (e and m are the electronic charge and mass respectively)
- A square loop of side 12 cm with its sides parallel to X and Y axes is moved with a velocity of 8 cm s^{-1} in the positive x-direction in an environment containing a magnetic field in the positive z-direction. The field is neither uniform in space nor constant in time. It has a gradient of 10^{-3} T cm^{-1} along the negative x-direction (that is it increases by 10^{-3} T cm^{-1} as one moves in the negative x-direction), and it is decreasing in time at the rate of 10^{-3} T s^{-1} . Determine the direction and magnitude of the Induced current in the loop if its resistance is $4.50\text{ m}\Omega$ (NCERT)

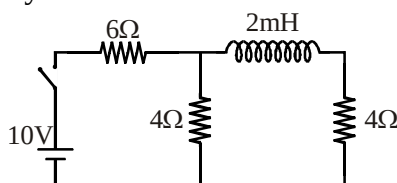
HCV Exercises (Chapter No.38 - 8,18,19,20,64)

HCV Worked out Examples(Chapter No. 38 - 21,22,23,25,27,28,29)

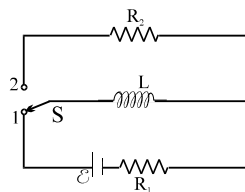
12. A long solenoid with 15 turns per cm has a small loop of area 2.0 cm^2 placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0.1 s , what is the induced emf in the loop while the current is changing ? **(NCERT)**
13. A circular coil of radius 8.0 cm and 20 turns is rotated about its vertical diameter with an angular speed of 50 rad s^{-1} in a uniform horizontal magnetic field of magnitude $3.0 \times 10^{-2} \text{ T}$. Obtain the maximum and average emf induced in the coil. If the coil forms a closed loop of resistance 10Ω , calculate the maximum value of current in the coil. Calculate the average power loss due to Joule heating. Where does this power come from **(NCERT)**
14. It is desired to measure the magnitude of field between the poles of a powerful loud speaker magnet. A small flat search coil of area 2 cm^2 with 25 closely wound turns, is positioned normal to the field direction, and then quickly snatched out of the field region. Equivalently, one can give it a quick 90° turn to bring its plane parallel to the field direction. The total charge flown in the coil (measured by a ballistic galvanometer connected to coil) is 7.5 mC . The combined resistance of the coil and the galvanometer is 0.50Ω . Estimate the field strength of magnet. **(NCERT)**
15. A line charge λ per unit length is lodged uniformly onto the rim of a wheel of mass M and radius R . The wheel has light nonconducting spokes and is free to rotate without friction about its axis see figure. A uniform magnetic field extends over a circular region within the rim. It is given by,
 $\mathbf{B} = -B_0 \mathbf{k} \quad (r \leq a ; a < R)$
 $= 0 \text{ (otherwise)}$
 What is the angular velocity of the wheel after the field is suddenly switched off ? **(NCERT)**



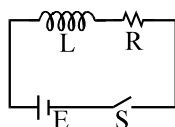
16. Current in a circuit falls from 5.0 A to 0.0 A in 0.1 s . If an average emf of 200 V induced, give an estimate of the self-inductance of the circuit. **(NCERT)**
17. An air-cored solenoid of length 30 cm , area of cross-section 25 cm^2 and number of turns 500, carries a current of 2.5 A . The current is suddenly switched off in a brief time of 10^{-3} s . How much is the average back emf induced across the ends of the open switch in the circuit? Ignore the variation in magnetic field near the ends of the solenoid. **(NCERT)**
18. In the given circuit, find the ratio of i_1 to i_2 where i_1 is the initial (at $t = 0$) current and i_2 is steady state (at $t = \infty$) current through the battery.



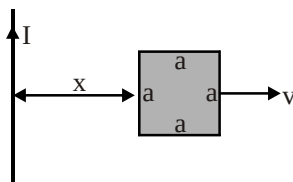
19. Find the dimension of the quantity $\frac{L}{RCV}$, where symbols have usual meaning.
20. In the circuit shown, initially the switch is in position 1 for a long time. Then the switch is shifted to position 2 for a long time. Find the total heat produced in R_2 .



21. An emf of 15 volt is applied in a circuit containing 5 H inductance and 10Ω resistance. Find the ratio of the currents at time $t = \infty$ and $t = 1$ second.
22. In the circuit shown in figure switch S is closed at time $t = 0$. Find the charge which passes through the battery in one time constant.



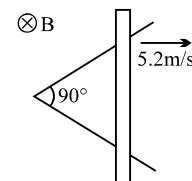
23. An inductor of inductance 2.0mH, is connected across a charged capacitor of capacitance $5.0\mu\text{F}$ and the resulting LC circuit is set oscillating at its natural frequency. Let Q denote the instantaneous charge on the capacitor, and I the current in the circuit. It is found that the maximum value of Q is $200\mu\text{C}$.
- when $Q=100\mu\text{C}$, what is the value of $|dI/dt|$?
 - when $Q=200\mu\text{C}$, what is the value of I ?
 - Find the maximum value of I .
24. A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil? (NCERT)
25. (a) Obtain an expression for the mutual inductance between a long straight wire and a square loop of side a as shown in figure.
- (b) Now assume that the straight wire carries a current of 50 A and the loop is moved to the right with a constant velocity, $v = 10 \text{ m/s}$. Calculate the induced emf in the loop at the instant when $x=0.2 \text{ m}$. Take $a = 0.1 \text{ m}$ and assume that the loop has a large resistance. (NCERT)



HCV Exercises (Chapter No.38 - 12,65,66,69,74,77,81,85,88,90,91,94,95,98)

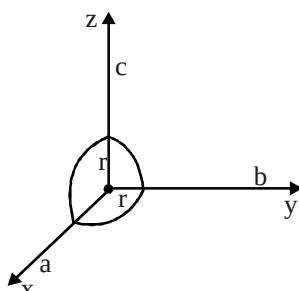
EXERCISE (S-2)

1. Two straight conducting rails form a right angle where their ends are joined. A conducting bar contact with the rails starts at vertex at the time $t = 0$ & moves symmetrically with a constant velocity of 5.2 m/s to the right as shown in figure. A 0.35 T magnetic field points out of the page. Calculate:

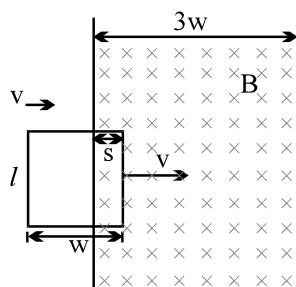


- The flux through the triangle by the rails & bar at $t = 3.0 \text{ s}$.
- The emf around the triangle at that time.
- In what manner does the emf around the triangle vary with time.

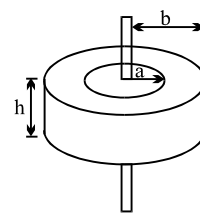
2. A wire is bent into 3 circular segments of radius $r = 10 \text{ cm}$ as shown in figure. Each segment is a quadrant of a circle, ab lying in the xy plane, bc lying in the yz plane & ca lying in the zx plane.



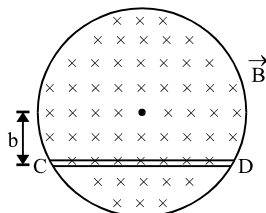
- If a magnetic field B points in the positive x direction, what is the magnitude of the emf developed in the wire, when B increases at the rate of 3 mT/s ?
 - What is the direction of the current in the segment bc .
3. Consider the possibility of a new design for an electric train. The engine is driven by the force due to the vertical component of the earth's magnetic field on a conducting axle. Current is passed down one coil, into a conducting wheel through the axle, through another conducting wheel & then back to the source via the other rail.
- What current is needed to provide a modest 10 - KN force? Take the vertical component of the earth's field be $10 \mu\text{T}$ & the length of axle to be 3.0 m .
 - How much power would be lost for each Ω of resistivity in the rails?
 - Is such a train unrealistic?
4. A rectangular loop of dimensions l & w and resistance R moves with constant velocity V to the right as shown in the figure. It continues to move with same speed through a region containing a uniform magnetic field B directed into the plane of the paper & extending a distance $3w$. Sketch the flux, induced emf & external force acting on the loop as a function of the distance.



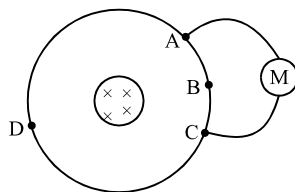
5. A long straight wire is arranged along the symmetry axis of a toroidal coil of rectangular cross-section, whose dimensions are given in the figure. The number of turns on the coil is N , and relative permeability of the surrounding medium is unity. Find the amplitude of the emf induced in this coil, if the current $i = i_m \cos \omega t$ flows along the straight wire.



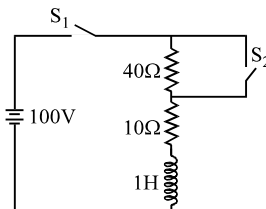
6. A uniform magnetic field $\vec{B}$ fills a cylindrical volume of radius R . A metal rod CD of length l is placed inside the cylinder along a chord of the circular cross-section as shown in the figure. If the magnitude of magnetic field increases in the direction of field at a constant rate dB/dt , find the magnitude and direction of the EMF induced in the rod.



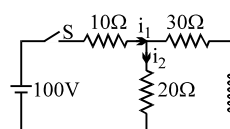
7. A variable magnetic field creates a constant emf E in a conductor $ABCD$. The resistances of portion ABC , CDA and AMC are R_1 , R_2 and R_3 respectively. What current will be shown by meter M ? The magnetic field is concentrated near the axis of the circular conductor.



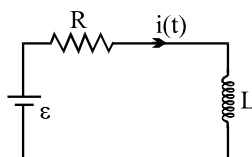
8. In the circuit shown in the figure the switches S_1 and S_2 are closed at time $t = 0$. After time $t = (0.1) \ln 2$ sec, switch S_2 is opened. Find the current in the circuit at time $t = (0.2) \ln 2$ sec.



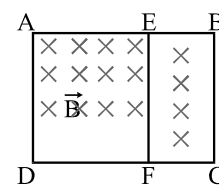
9. Find the values of i_1 and i_2
(i) immediately after the switch S is closed.
(ii) long time later, with S closed.
(iii) immediately after S is open.
(iv) long time after S is opened.



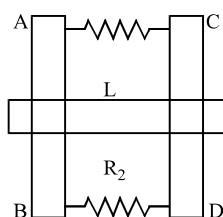
10. Suppose the emf of the battery, the circuit shown varies with time t so the current is given by $i(t) = 3 + 5t$, where i is in amperes & t is in seconds. Take $R = 4\Omega$, $L = 6H$ & find an expression for the battery emf as function of time.



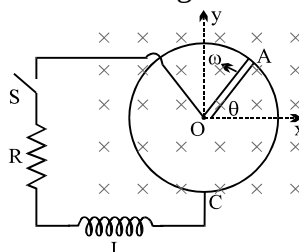
11. A rectangular frame ABCD made of a uniform metal wire has a straight connection between E & F made of the same wire as shown in the figure. AEFD is a square of side 1 m & EB = FC = 0.5 m. The entire circuit is placed in a steadily increasing uniform magnetic field directed into the plane of the paper & normal to it. The rate of change of the magnetic field is 1 T/s, the resistance per unit length of the wire is 1 Ω /m. Find the current in segments AE, BE & EF.



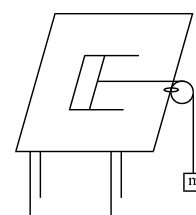
12. Two parallel vertical metallic rails AB & CD are separated by 1 m. They are connected at the two ends by resistance R_1 & R_2 as shown in the figure. A horizontally metallic bar L of mass 0.2 kg slides without friction, vertically down the rails under the action of gravity. There is a uniform horizontal magnetic field of 0.6 T perpendicular to the plane of the rails, it is observed that when the terminal velocity is attained, the power dissipated in R_1 & R_2 are 0.76 W & 1.2 W respectively. Find the terminal velocity of bar L & value R_1 & R_2 .



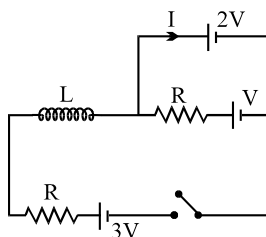
13. A metal rod OA of mass m & length r is kept rotating with a constant angular speed ω in a vertical plane about a horizontal axis at the end O. The free end A is arranged to slide without friction along a fixed conducting circular ring in the same plane as that of rotation. A uniform & constant magnetic induction $\vec{B}$ is applied perpendicular & into the plane of rotation as shown in figure. An inductor L and an external resistance R are connected through a switch S between the point O & a point C on the ring to form an electrical circuit. Neglect the resistance of the ring and the rod. Initially, the switch is open.



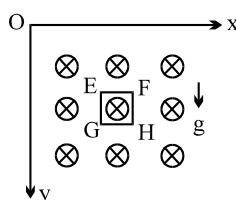
- (a) What is the induced emf across the terminals of the switch ?
(b) (i) Obtain an expression for the current as a function of time after switch S is closed.
(ii) Obtain the time dependence of the torque required to maintain the constant angular speed, given that the rod OA was along the positive X-axis at $t = 0$.
14. A pair of parallel horizontal conducting rails of negligible resistance shorted at one end is fixed on a table. The distance between the rails is L. A conducting massless rod of resistance R can slide on the rails frictionlessly. The rod is tied to a massless string which passes over a pulley fixed to the edge of the table. A mass m, tied to the other end of the string hangs vertically. A constant magnetic field B exists perpendicular to the table. If the system is released from rest, calculate:
(i) the terminal velocity achieved by the rod.
(ii) the acceleration of the mass at the instant when the velocity of the rod is half the terminal velocity.



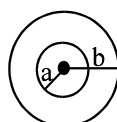
15. In the LR circuit shown, what is the variation of the current I as a function of time? The switch is closed at time $t = 0$ sec.



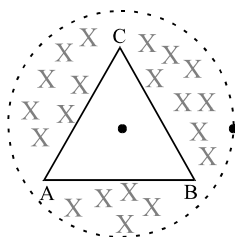
16. A magnetic field $\vec{B} = (B_0 y / a) \hat{k}$ is into the plane of paper in the $+z$ direction. B_0 and a are positive constants. A square loop EFGH of side a , mass m and resistance R , in x - y plane, starts falling under the influence of gravity. Note the directions of x and y axes in the figure. Find



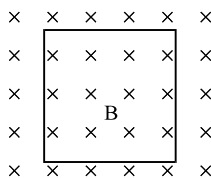
- (a) the induced current in the loop and indicate its direction,
(b) the total Lorentz force acting on the loop and indicate its direction,
(c) an expression for the speed of the loop, $v(t)$ and its terminal value.
17. The horizontal component of the earth's magnetic field at a place is 3×10^{-4} T and the dip is $\tan^{-1}(4/3)$. A metal rod of length 0.25 m placed in the north-south position is moved at a constant speed of 10 cm/s towards the east. Find the e.m.f. induced in the rod.
18. Two concentric and coplanar circular coils have radii a and b ($b \gg a$) as shown in figure. Resistance of the inner coil is R . Current in the outer coil is increased from 0 to i , then find the total charge circulating the inner coil.



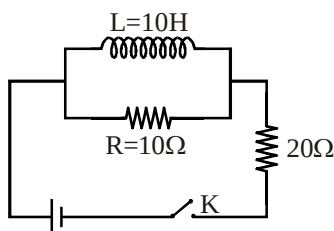
19. A metal rod of resistance 20Ω is fixed along a diameter of a conducting ring of radius 0.1 m and lies on x - y plane. There is a magnetic field $\vec{B} = (50 \text{ T}) \hat{k}$. The ring rotates with an angular velocity $\omega = 20$ rad/sec about its axis. An external resistance of 10Ω is connected across the centre of the ring and rim. Find the current through external resistance.
20. A triangular wire frame (each side = 2m) is placed in a region of time variant magnetic field having $dB/dt = \sqrt{3}$ T/s. The magnetic field is perpendicular to the plane of the triangle. The base of the triangle AB has a resistance 1Ω while the other two sides have resistance 2Ω each. The magnitude of potential difference between the points A and B will be



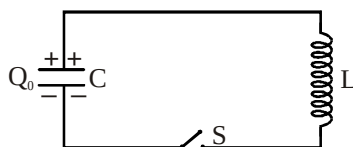
21. A uniform magnetic field of 0.08 T is directed into the plane of the page and perpendicular to it as shown in the figure. A wire loop in the plane of the page has constant area 0.010 m^2 . The magnitude of magnetic field decrease at a constant rate of $3.0 \times 10^{-4} \text{ Ts}^{-1}$. Find the magnitude and direction of the induced emf in the loop.



22. A uniform but time varying magnetic field $B = Kt - C$; ($0 \leq t \leq C/K$), where K and C are constants and t is time, is applied perpendicular to the plane of the circular loop of radius 'a' and resistance R. Find the total charge that will pass around the loop.
23. A charged ring of mass $m = 50 \text{ gm}$, charge 2 coulomb and radius $R = 2\text{m}$ is placed on a smooth horizontal surface. A magnetic field varying with time at a rate of (0.2 t) Tesla/sec is applied onto the ring in a direction normal to the surface of ring. Find the angular speed attained in a time $t_1 = 10 \text{ sec}$. Assume that the magnetic field is cylindrically symmetric and covering the entire ring.
24. Two resistors of 10Ω and 20Ω and an ideal inductor of 10H are connected to a 2V battery as shown. The key K is shorted at time $t = 0$. Find the initial ($t = 0$) and final ($t \rightarrow \infty$) currents through battery.



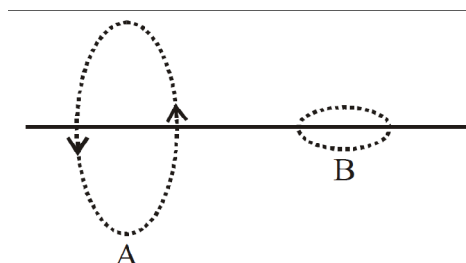
25. Two coils, 1 & 2, have a mutual inductance $= M$ and resistances R each. A current flows in coil 1, which varies with time as; $I_1 = kt^2$, where k is a constant and 't' is time. Find the total charge that has flown through coil 2, between $t = 0$ and $t = T$.
26. A capacitor C with a charge Q_0 is connected across an inductor through a switch S. If at $t = 0$, the switch is closed, then find the instantaneous charge q on the upper plate of capacitor.



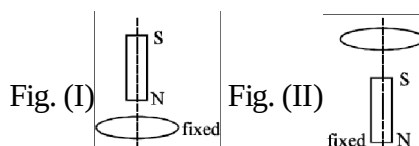
EXERCISE (O-1)

(Single Correct Type Questions)

- A square of side 2 meters lies in the x-y plane in a region, where the magnetic field is given by $\vec{B} = B_0 (2\hat{i} + 3\hat{j} + 4\hat{k}) T$, where B_0 is constant. The magnitude of flux passing through the square is:-
 (A) $8 B_0 \text{ Wb}$. (B) $12 B_0 \text{ Wb}$. (C) $16 B_0 \text{ Wb}$. (D) $\sqrt{4 \times 29} B_0 \text{ Wb}$
- Statement-1 :** When a magnet is made to fall freely through a closed coil, its acceleration is always less than acceleration due to gravity.
and
Statement-2 : Current induced in the coil opposes the motion of the magnet, as per Lenz's law.
 (A) Statement-1 is true, Statement-2 is true ; Statement-2 is a correct explanation for Statement-1
 (B) Statement-1 is true, Statement-2 is true, Statement-2 is NOT a correct explanation for Statement-1
 (C) Statement-1 is True, Statement-2 is False
 (D) Statement-1 is False, Statement-2 is True
- In the given figure the centre of a small conducting circular loop B lies on the axis of bigger circular loop A and their axis are mutually perpendicular. An anticlockwise (when viewed from the side of B) current in the loop A start increasing then :-
 (A) current induced in the loop B is in clockwise direction (when viewed from above the B)
 (B) current induced in the loop B is in anti-clockwise direction (when viewed from above the B)
 (C) current must induced in the loop B but its direction can not be predicted
 (D) no current is induced in the loop B

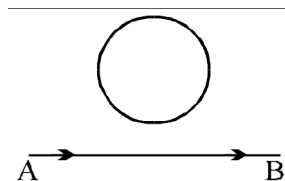


- A vertical bar magnet is dropped from position on the axis of a fixed metallic coil as shown in fig - I. In fig. II the magnet is fixed and horizontal coil is dropped. The acceleration of the magnet and coil are a_1 and a_2 respectively then :-

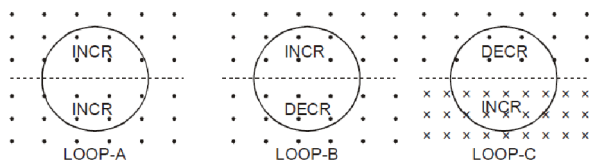


- (A) $a_1 > g, a_2 > g$ (B) $a_1 > g, a_2 < g$ (C) $a_1 < g, a_2 < g$ (D) $a_1 < g, a_2 > g$
- Two identical coaxial circular loops carry a current i each circulating in the same direction. If the loops approach each other
 (A) the current in each will decrease
 (B) the current in each will increase
 (C) the current in each will remain the same
 (D) the current in one will increase and in other will decrease

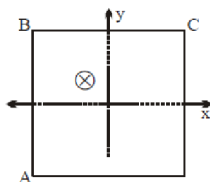
6. In the arrangement shown in given figure current from A to B is increasing in magnitude. Induced current in the loop will



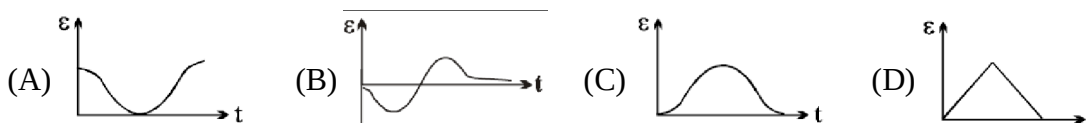
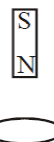
- (A) have clockwise direction
(B) have anticlockwise direction
(C) be zero
(D) oscillate between clockwise and anticlockwise
7. Three identical conducting circular loops are placed in uniform magnetic fields. Inside each loop, there are two magnetic field regions, separated by dashed line that coincides with a diameter, as shown. Magnetic fields may either be increasing (marked as INCR) or decreasing (marked as DECR) in magnitude at the same rates. If I_A , I_B and I_C are the magnitudes of the induced currents in the loops A, B and C respectively then choose the CORRECT relation :-



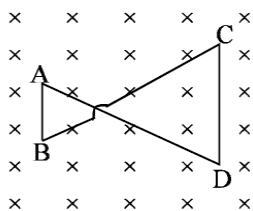
- (A) $I_A > I_B = I_C$
(B) $I_A = I_C > I_B$
(C) $I_A = I_B = I_C$
(D) $I_C > I_A > I_B$
8. A square coil ABCD is placed in x-y plane with its centre at origin. A long straight wire, passing through origin, carries a current in negative z-direction. Current in this wire increases with time. The induced current in the coil is :



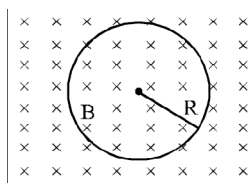
- (A) clockwise
(B) anticlockwise
(C) zero
(D) alternating
9. A short circuited coil is kept on the ground and a magnet is dropped on it as shown. The coil shows (when viewed from top)
- (A) anticlockwise current that increases in magnitude
(B) anticlockwise current that remains constant
(C) clockwise current that remains constant
(D) clockwise current that increases in magnitude
10. 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 [JEE 2004(Scr)]



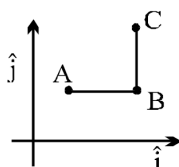
11. A conducting wire frame is placed in a magnetic field which is directed into the paper. The magnetic field is increasing at a constant rate. The directions of induced currents in wires AB and CD are



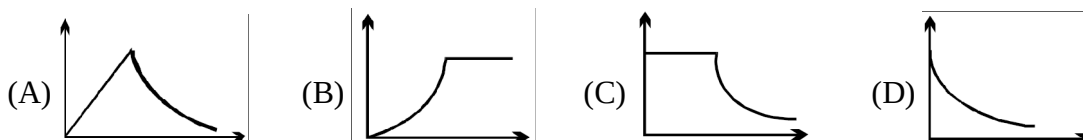
- (A) B to A and D to C
(B) A to B and C to D
(C) A to B and D to C
(D) B to A and C to D
12. A conducting loop of radius R is present in a uniform magnetic field B perpendicular to the plane of the ring. If radius R varies as a function of time ' t ', as $R = R_0 + t$. The e.m.f induced in the loop is



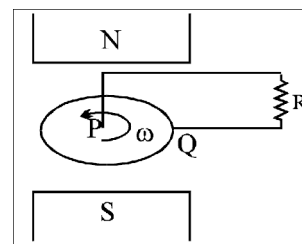
- (A) $2\pi(R_0 + t)B$ clockwise
(B) $\pi(R_0 + t)B$ clockwise
(C) $2\pi(R_0 + t)B$ anticlockwise
(D) zero
13. A thin wire of length $2m$ is perpendicular to the xy plane. It is moved with velocity $\vec{v} = (2\hat{i} + 3\hat{j} + \hat{k}) \text{ m/s}$ through a region of magnetic induction $\vec{B} = (\hat{i} + 2\hat{j}) \text{ Wb/m}^2$. Then potential difference induced between the ends of the wire :
- (A) 2 volts
(B) 4 volts
(C) 0 volts
(D) none of these
14. A square loop of side a and resistance R is moved in the region of uniform magnetic field B (loop remaining completely inside field), with a velocity v through a distance x . The work done is :
- (A) $\frac{B\ell^2 vx}{R}$
(B) $\frac{2B^2 \ell^2 vx}{R}$
(C) $\frac{4B^2 \ell^2 vx}{R}$
(D) 0
15. There is a uniform magnetic field B normal to the xy plane. A conductor ABC has length $AB = l_1$, parallel to the x -axis, and length $BC = l_2$, parallel to the y -axis. ABC moves in the xy plane with velocity $v_x \hat{i} + v_y \hat{j}$. The potential difference between A and C is proportional to :-



- (A) $v_x l_1 + v_y l_2$
(B) $v_x l_2 + v_y l_1$
(C) $v_x l_2 - v_y l_1$
(D) $v_x l_1 - v_y l_2$
16. A uniform but time variant magnetic field exists in a cylindrical region directed along the axis of cylinder of radius R . The graph of induced electric field at a given time v/s . r is (r = distance from axis)



17. A metal disc rotates freely, between the poles of a magnet in the direction indicated. Brushes P and Q make contact with the edge of the disc and the metal axle. What current, if any, flows through R?
- (A) a current from P to Q
(B) a current from Q to P
(C) no current, because the emf in the disc is opposed by the back emf
(D) no current, because the emf induced in one side of the disc is opposed by the emf induced in the other side.
(E) no current, because no radial emf is induced in the disc



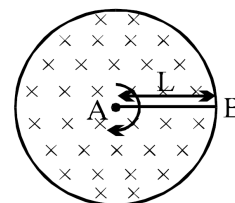
18. A copper rod AB of length L, pivoted at one end A, rotates at constant angular velocity ω , at right angles to a uniform magnetic field of induction B. The e.m.f developed between the mid point C of the rod and end B is

(A) $\frac{B\omega L^2}{4}$

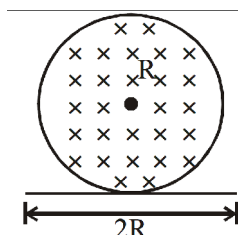
(B) $\frac{B\omega L^2}{2}$

(C) $\frac{3B\omega L^2}{4}$

(D) $\frac{3B\omega L^2}{8}$



19. The e.m.f. induced in a coil of wire, which is rotating in a magnetic field, does not depend on
- (A) the angular speed of rotation
(B) the area of the coil
(C) the number of turns on the coil
(D) the resistance of the coil
20. A ring of resistance 10Ω , radius 10cm and 100 turns is rotated at a rate 100 revolutions per second about its diameter is perpendicular to a uniform magnetic field of induction 10mT. The amplitude of the current in the loop will be nearly (Take : $\pi^2 = 10$)
- (A) 200A
(B) 2A
(C) 0.002A
(D) none of these
21. A uniform but time varying magnetic field is present in a circular region of radius R. The magnetic field is perpendicular and into the plane of the loop and the magnitude of field is increasing at a constant rate α . There is a straight conducting rod of length $2R$ placed as shown in figure. The magnitude of induced emf across the rod is



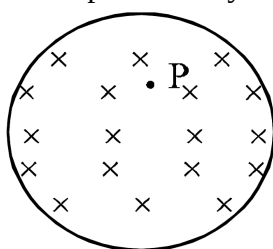
(A) $\pi R^2 \alpha$

(B) $\frac{\pi R^2 \alpha}{2}$

(C) $\frac{R^2 \alpha}{\sqrt{2}}$

(D) $\frac{\pi R^2 \alpha}{4}$

22. Figure shows a uniform magnetic field B confined to a cylindrical volume and is increasing at a constant rate. The instantaneous acceleration experienced by an electron placed at P is



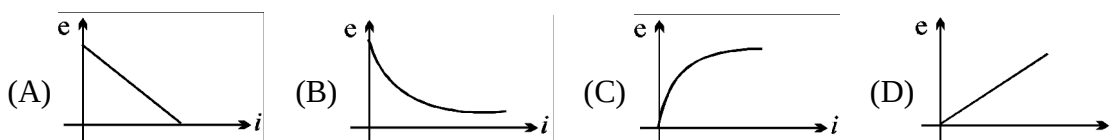
(A) zero

(B) towards right

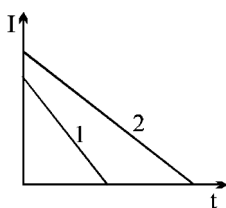
(C) towards left

(D) upwards

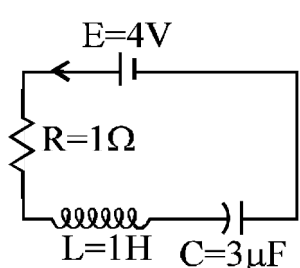
23. Statement-1 : For a charged particle moving from point P to point Q the net work done by an induced electric field on the particle is independent of the path connecting point P to point Q.
Statement-2 : The net work done by a conservative force on an object moving along closed loop is zero.
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.
24. In an L-R circuit connected to a battery of constant e.m.f. E switch S is closed at time $t = 0$. If e denotes the magnitude of induced e.m.f. across inductor and i the current in the circuit at any time t . Then which of the following graphs shows the variation of e with i ?



25. A current of $2A$ is increasing at a rate of $4 A/s$ through a coil of inductance $2H$. The energy stored in the inductor per unit time is :-
(A) $2 J/s$ (B) $1 J/s$ (C) $16 J/s$ (D) $4 J/s$
26. Two identical inductance carry currents that vary with time according to linear laws (as shown in figure). In which of two inductance is the self induction emf greater?

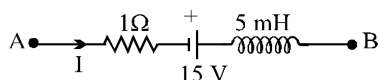


- (A) 1 (B) 2
(C) same (D) data are insufficient to decide
27. The current in the given circuit is increasing with a rate $a = 4 \text{ amp/s}$. The charge on the capacitor at an instant when the current in the circuit is 2 amp will be :

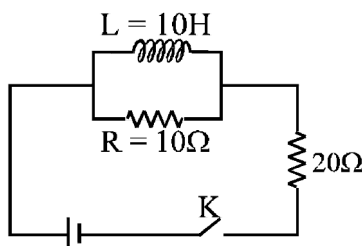


- (A) $4\mu C$ (B) $5\mu C$ (C) $6\mu C$ (D) none of these
28. A long solenoid of N turns has a self inductance L and area of cross section A . When a current i flows through the solenoid, the magnetic field inside it has magnitude B . The current i is equal to:
(A) BAN/L (B) $BANL$ (C) BN/AL (D) B/ANL

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



- (A) 20 V (B) 15 V (C) 10 V (D) 5 V
30. In Problem 29, if I is reversed in direction, then $V_B - V_A$ equals
(A) 5 V (B) 10 V (C) 15 V (D) 20 V
31. Two resistors of 10Ω and 20Ω and an ideal inductor of 10H are connected to a 2V battery as shown. The key K is shorted at time $t = 0$. Find the initial ($t = 0$) and final ($t \rightarrow \infty$) currents through battery.



- (A) $\frac{1}{15} \text{ A}, \frac{1}{10} \text{ A}$ (B) $\frac{1}{10} \text{ A}, \frac{1}{15} \text{ A}$ (C) $\frac{2}{10} \text{ A}, \frac{1}{15} \text{ A}$ (D) $\frac{1}{15} \text{ A}, \frac{2}{25} \text{ A}$
32. An inductor coil stores U energy when i current is passed through it and dissipates energy at the rate of P . The time constant of the circuit, when this coil is connected across a battery of zero internal resistance is :-
(A) $\frac{4U}{P}$ (B) $\frac{U}{P}$ (C) $\frac{2U}{P}$ (D) $\frac{2P}{U}$
33. A small coil of radius r is placed at the centre of a large coil of radius R , where $R \gg r$. The coils are coplanar. The coefficient of mutual inductance between the coils is :-
(A) $\frac{\mu_0 \pi r}{2R}$ (B) $\frac{\mu_0 \pi r^2}{2R}$ (C) $\frac{\mu_0 \pi r^2}{2R^2}$ (D) $\frac{\mu_0 \pi r}{2R^2}$
34. A long straight wire is placed along the axis of a circular ring of radius R . The mutual inductance of this system is :-
(A) $\frac{\mu_0 R}{2}$ (B) $\frac{\mu_0 \pi R}{2}$ (C) $\frac{\mu_0}{2}$ (D) 0
35. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon-
(A) the rates at which currents are changing in the two coils
(B) relative position and orientation of the two coils
(C) the materials of the wires of the coils
(D) the currents in the two coils
36. A small square loop of wire of side l is placed inside a large square loop of wire of side L ($L \gg l$). The loop are coplanar & their centres coincide. The mutual inductance of the system is proportional to :
(A) $\frac{l}{L}$ (B) $\frac{l^2}{L}$ (C) $\frac{L}{l}$ (D) $\frac{L^2}{l}$

37. L, C and R represent physical quantities inductance, capacitance and resistance. The combination which has the dimensions of frequency is

(A) $\frac{1}{RC}$ and $\frac{R}{L}$ (B) $\frac{1}{\sqrt{RC}}$ and $\sqrt{\frac{R}{L}}$ (C) $\sqrt{LC}$ (D) $\frac{C}{L}$

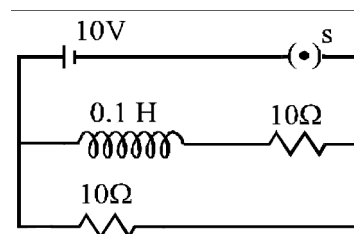
38. A coil of inductance 5H is joined to a cell of emf 6V through a resistance 10Ω at time $t = 0$. The emf across the coil at time $t = \ln \sqrt{2}$ s is:

(A) 3V (B) 1.5 V (C) 0.75 V (D) 4.5 V

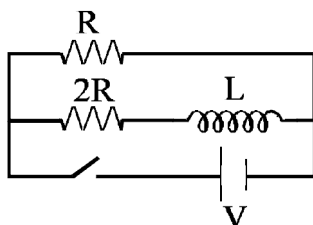
39. For L-R circuit, the time constant is equal to
(A) twice the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance
(B) ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance
(C) half the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance
(D) square of the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance

40. In the adjoining circuit, initially the switch S is open. The switch 'S' is closed at $t = 0$. The difference between the maximum and minimum current that can flow in the circuit is

(A) 2 Amp (B) 3 Amp
(C) 1 Amp (D) nothing can be concluded

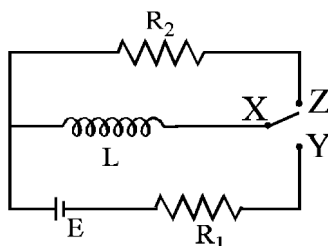


41. Find the ratio of time constant in build up and decay in the circuit as shown in figure :-



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

42. In the circuit shown, X is joined to Y for a long time, and then X is joined to Z. The total heat produced in R is :

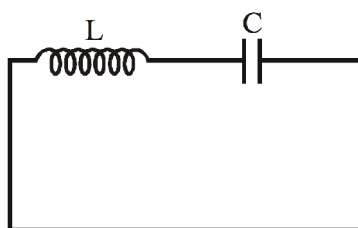


(A) $\frac{LE^2}{2R_1^2}$ (B) $\frac{LE^2}{2R_2^2}$ (C) $\frac{LE^2}{2R_1R_2}$ (D) $\frac{LE^2R_2}{2R_1^2}$

43. In a L-R decay circuit, the initial current at $t = 0$ is I. The total charge that has flown through the resistor till the energy in the inductor has reduced to one-fourth its initial value, is

(A) LI/R (B) $LI/2R$ (C) $LI\sqrt{2}/R$ (D) None

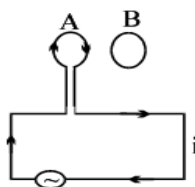
44. The inductor in a L–C oscillation has a maximum potential difference of 16 V and maximum energy of 640 μJ . Find the value of capacitor in μF in L–C circuit.
(A) 5 (B) 4 (C) 3 (D) 2
45. A condenser of capacity 6 μF is fully charged using a 6-volt battery. The battery is removed and a resistanceless 0.2 mH inductor is connected across the condenser. The current which is flowing through the inductor when one-third of the total energy is in the magnetic field of the inductor is :-
(A) 0.1 A (B) 0.2 A (C) 0.4 A (D) 0.6 A
46. In an LC circuit the capacitor has maximum charge q_0 . The value of $\left(\frac{dI}{dt}\right)_{\text{max}}$ is :



- (A) $\frac{q_0}{LC}$ (B) $\frac{q_0}{\sqrt{LC}}$ (C) $\frac{q_0}{2LC}$ (D) $\frac{2q_0}{LC}$

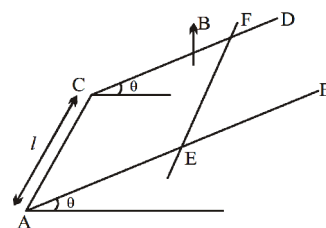
(Multiple Correct Type Questions)

47. The dimension of the ratio of magnetic flux and the resistance is equal to that of :
(A) induced emf (B) charge (C) inductance (D) current
48. Two circular coils A and B are facing each other as shown in figure. The current i through A can be altered

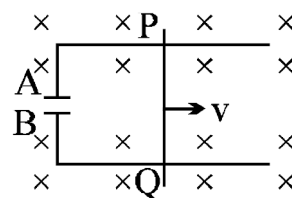


- (A) there will be repulsion between A and B if i is increased
(B) there will be attraction between A and B if i is increased
(C) there will be neither attraction nor repulsion when i is changed
(D) attraction or repulsion between A and B depends on the direction of current. It does not depend whether the current is increased or decreased.
49. A bar magnet is moved along the axis of copper ring placed far away from the magnet. Looking from the side of the magnet, an anticlockwise current is found to be induced in the ring. Which of the following may be true?
(A) The south pole faces the ring and the magnet moves towards it.
(B) The north pole faces the ring and the magnet moves towards it.
(C) The south pole faces the ring and the magnet moves away from it.
(D) The north pole faces the ring and the magnet moves away from it.

50. AB and CD are smooth parallel rails, separated by a distance l , and inclined to the horizontal at an angle θ . A uniform magnetic field of magnitude B , directed vertically upwards, exists in the region. EF is a conductor of mass m , carrying a current i . For EF to be in equilibrium,



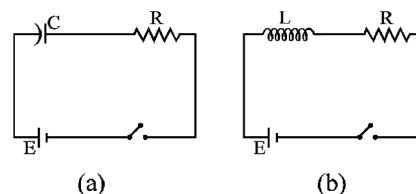
- (A) i must flow from E to F (B) $Bil = mg \tan \theta$
(C) $Bil = mg \sin \theta$ (D) $Bil = mg$
51. In the previous question, if B is normal to the plane of the rails
(A) $Bil = mg \tan \theta$ (B) $Bil = mg \sin \theta$
(C) $Bil = mg \cos \theta$ (D) equilibrium cannot be reached
52. A conducting rod PQ of length $L = 1.0$ m is moving with a uniform speed $v = 20$ m/s in a uniform magnetic field $B = 4.0$ T directed into the paper. A capacitor of capacity $C = 10 \mu\text{F}$ is connected as shown in figure. Then



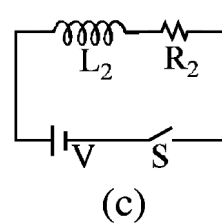
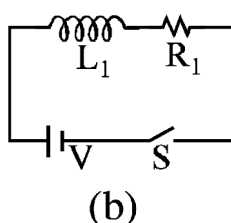
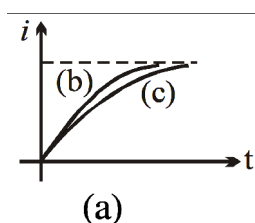
- (A) $q_A = +800 \mu\text{C}$ and $q_B = -800 \mu\text{C}$
(B) $q_A = -800 \mu\text{C}$ and $q_B = +800 \mu\text{C}$
(C) $q_A = 0 = q_B$
(D) charge stored in the capacitor increases exponentially with time
53. An LR circuit with a battery is connected at $t = 0$. Which of the following quantities is not zero just after the circuit is closed ?
(A) current in the circuit (B) magnetic field energy in the inductor
(C) power delivered by the battery (D) emf induced in the inductor

54. The switches in figures (a) and (b) are closed at $t = 0$

- (A) The charge on C just after $t = 0$ is EC .
(B) The charge on C long after $t = 0$ is EC .
(C) The current in L just after $t = 0$ is E/R .
(D) The current in L long after $t = 0$ is E/R .

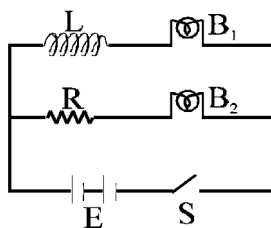


55. Current growth in two L-R circuits (b) and (c) as shown in figure (a). Let L_1 , L_2 , R_1 and R_2 be the corresponding values in two circuits. Then :-

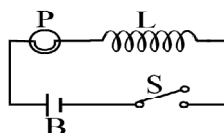


- (A) $R_1 > R_2$ (B) $R_1 = R_2$ (C) $L_1 > L_2$ (D) $L_1 < L_2$

56. An inductor L , a resistance R and two identical bulbs B_1 and B_2 are connected to a battery through a switch S as shown in the figure. The resistance of coil having inductance L is also R . Which of the following statement gives the correct description of the happenings when the switch S is closed?



- (A) The bulb B_2 lights up earlier than B_1 and finally both the bulbs shine equally bright.
 (B) B_1 lights up earlier and finally both the bulbs acquire equal brightness.
 (C) B_2 lights up earlier and finally B_1 shines brighter than B_2 .
 (D) B_1 and B_2 light up together with equal brightness all the time.
57. In figure, a lamp P is in series with an iron-core inductor L . When the switch S is closed, the brightness of the lamp rises relatively slowly to its full brightness than it would do without the inductor. This is due to

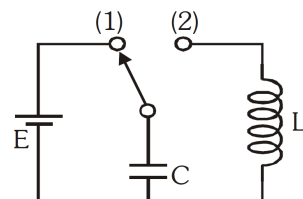


- (A) the low resistance of P
 (B) the induced-emf in L
 (C) the low resistance of L
 (D) the high voltage of the battery B
58. Two different coils have self inductance 8mH and 2mH . The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power given to the two coils is the same. At that time the current, the induced voltage and the energy stored in the first coil are I_1 , V_1 and W_1 respectively. Corresponding values for the second coil at the same instant are I_2 , V_2 and W_2 respectively. Then :

- (A) $\frac{I_1}{I_2} = \frac{1}{4}$ (B) $\frac{I_1}{I_2} = 4$ (C) $\frac{W_2}{W_1} = 4$ (D) $\frac{V_2}{V_1} = \frac{1}{4}$

59. Initially key was placed on (1) till the capacitor got fully charged. Key is placed on (2) at $t = 0$. The time when the energy in both capacitor and inductor will be same-

- (A) $\frac{\pi\sqrt{LC}}{4}$ (B) $\frac{\pi\sqrt{LC}}{2}$
 (C) $\frac{5\pi\sqrt{LC}}{4}$ (D) $\frac{5\pi\sqrt{LC}}{2}$



(Comprehension Type Questions)

Paragraph for Question Nos. 60 to 62

The fact that a changing magnetic flux produces an electric field is basic to the operation of many high energy particle accelerators. Since the principle was first successfully applied to the acceleration of electrons (or β particles) in a device called the betatron, this method of acceleration is often given that name. The general idea involved is shown in figure.

An electromagnet is used to produce a changing flux through a circular loop defined by the doughnut shaped vacuum chamber. We see that there will be an electric field E along the circular length of the doughnut, i.e. circling the magnet poles, given by

$$2\pi a E \frac{d\phi}{dt}$$

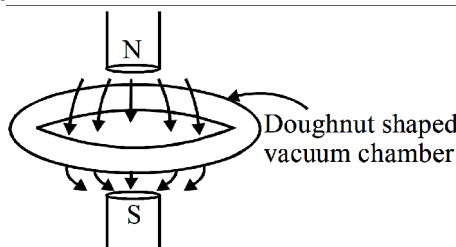
Where a is the radius of the doughnut. Any charged particle inside the vacuum chamber will experience a force qE and will accelerate. Ordinarily, the charged particle would shoot out of the vacuum chamber and becomes lost.

However, if the magnetic field at the position of the doughnut is just proper to satisfy the relation Centripetal force = magnetic force

$$\text{or } \frac{mv^2}{a} = qvB$$

then the charge will travel in a circle within the doughnut. By proper shaping of the magnet pole pieces, this relation can be satisfied. As a result, the charge will move at high speed along the loop within the doughnut. Each time it goes around the loop, it has, in effect, fallen through a potential difference equal to

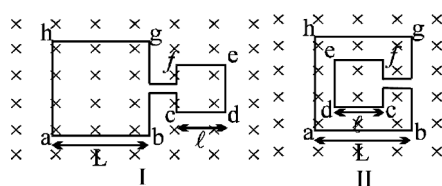
the induced, emf, namely $\varepsilon = \frac{d\phi}{dt}$. Its energy after n trips around the loop will be



60. Working of betatron is not based upon which of the following theories :-
 (A) Changing magnetic flux induces electric field
 (B) Charged particle at rest can be accelerated only by electric fields
 (C) magnetic fields can apply a force on moving charges which is perpendicular to both magnetic field and motion of the particle
 (D) Beta particles are emitted in radioactive decay process.
61. Variable magnetic flux :-
 (A) Can change sinusoidally
 (B) Should either increase or decrease all the time
 (C) Must becomes zero when induced field is maximum
 (D) None of these
62. Magnetic field which keeps the particles in circular path must :-
 (A) Remain a constant every where
 (B) Increase gradually which is proportional to K.E. of the particle
 (C) Increase gradually which is proportional to speed of the particle
 (D) None of these

Paragraph for Question No. 63 to 66

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

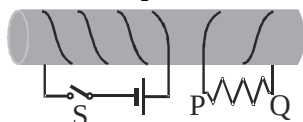


63. The value of magnetic flux in each case is given by
 (A) Case I: $\Phi = \pi(L^2 + \ell^2)B$; Case II: $\Phi = \pi(L^2 - \ell^2)B$
 (B) Case I: $\Phi = \pi(L^2 + \ell^2)B$; Case II: $\Phi = \pi(L^2 + \ell^2)B$
 (C) Case I: $\Phi = (L^2 + \ell^2)B$; Case II: $\Phi = (L^2 - \ell^2)B$
 (D) Case I: $\Phi = (L + \ell)^2B$; Case II: $\Phi = \pi(L - \ell)^2B$
64. The direction of induced current in the case I is
 (A) from a to b and from c to d
 (B) from a to b and from f to e
 (C) from b to a and from d to c
 (D) from b to a and from e to f
65. The direction of induced current in the case II is
 (A) from a to b and from c to d
 (B) from b to a and from f to e
 (C) from b to a and from c to d
 (D) from a to b and from d to c
66. If I_1 and I_2 are the magnitudes of induced current in the cases I and II, respectively, then
 (A) $I_1 = I_2$ (B) $I_1 > I_2$ (C) $I_1 < I_2$ (D) nothing can be said

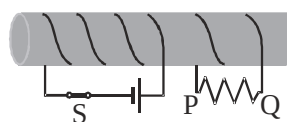
EXERCISE (O-2)

(Single Correct Type Questions)

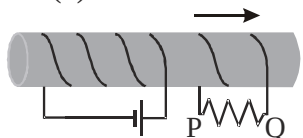
1. For each of the experiments (1, 2, 3, 4) shown in figure. Choose the **CORRECT** option(s) which shows the direction of current flow through the resistor PQ? Note that the wires are not always wrapped around the plastic tube in the same way.



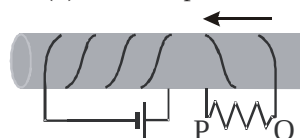
(1) S to be closed



(2) S to be opened



(3) Resistor coil PQ moves to right



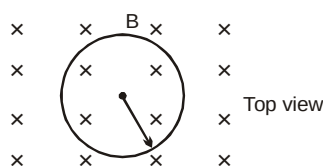
(4) Resistor coil PQ moves to left

- | (1) | (2) | (3) | (4) |
|------------|--------|--------|--------|
| (A) P to Q | P to Q | P to Q | P to Q |
| (B) P to Q | Q to P | P to Q | Q to P |
| (C) Q to P | Q to P | Q to P | Q to P |
| (D) Q to P | Q to P | P to Q | P to Q |

2. An electron is moving in a circular orbit of radius R with an angular acceleration α . At the centre of the orbit is kept a conducting loop of radius r , ($r \ll R$). The e.m.f induced in the smaller loop due to the motion of the electron is

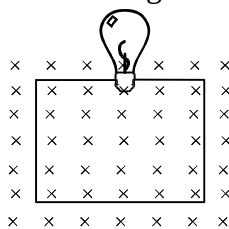
- (A) zero, since charge on electron is constant (B) $\frac{\mu_0 e r^2}{4R} \alpha$
 (C) $\frac{\mu_0 e r^2}{4\pi R} \alpha$ (D) none of these

3. A non conducting ring (of mass m , radius r , having charge Q) is placed on a rough horizontal surface (in a region with transverse magnetic field). The field is increasing with time at the rate R and coefficient of friction between the surface and the ring is μ . For ring to remain in equilibrium μ should be greater than



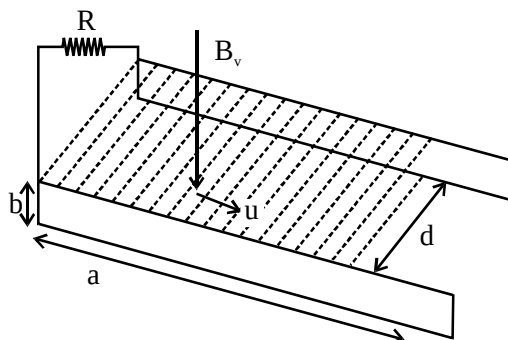
- (A) $\frac{QrR}{mg}$ (B) $\frac{QrR}{2mg}$ (C) $\frac{QrR}{3mg}$ (D) $\frac{2QrR}{mg}$

4. A square wire loop of 10.0 cm side lies at right angles to a uniform magnetic field of 20T. A 10 V light bulb is in a series with the loop as shown in the fig. The magnetic field is decreasing steadily to zero over a time interval Δt . The bulb will shine with full brightness if Δt is equal to

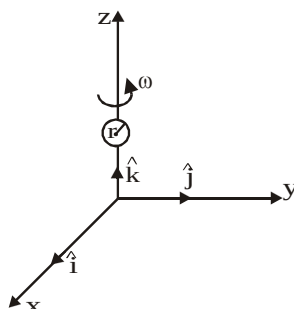


- (A) 20 ms (B) 0.02 ms (C) 2 ms (D) 0.2 ms

5. The figure shows an apparatus suggested by Faraday to generate electric current from a flowing river. Two identical conducting plates of length a and width b are placed parallel facing one another on opposite sides of the river following with velocity u at a distance d apart. Now both the plates are connected by a load resistance R . Then the current through the load R is :- (Consider vertical component of the magnetic field produced by earth is B_v and the resistivity of river water is ρ .)

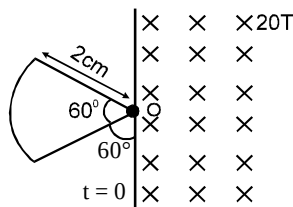


- (A) $\frac{B_v ub}{R}$ (B) $\frac{B_v ub}{R + \frac{\rho d}{ab}}$ (C) $\frac{B_v ud}{R + \frac{\rho d}{ab}}$ (D) None of the above
6. The radius of a coil decreases steadily at the rate of 10^{-2} m/s. A constant and uniform magnetic field of induction 10^{-3} Wb/m² acts perpendicular to the plane of the coil. The radius of the coil when the induced e.m.f. in the coil is 1mV, is
- (A) $\frac{20}{\pi}$ m (B) $\frac{30}{\pi}$ m (C) $\frac{40}{\pi}$ m (D) $\frac{50}{\pi}$ m
7. A composite rod of length ℓ is one fourth insulator and remaining conductor is made to rotate freely with angular velocity ω , in a space free of any gravitational, electric & magnetic field. Then potential difference across the conducting region will be (rotation is about insulating end).
- (A) $\frac{3m_e \omega^2 \ell^2}{4e}$ (B) $\frac{1}{4} \frac{m_e \omega^2 \ell^2}{e}$ (C) $\frac{1}{16} \frac{m_e \omega^2 \ell^2}{e}$ (D) $\frac{15}{32} \frac{m_e \omega^2 \ell^2}{e}$
8. A circular loop wire of radius r rotates about the z -axis with angular velocity ω . The normal to the loop is always perpendicular to the z -axis. At time $t=0$, the normal is parallel to the y -axis. An external magnetic field $\vec{B} = B_y \hat{j} + B_z \hat{k}$ is applied. The EMF $\varepsilon(t)$ induced in the loop is

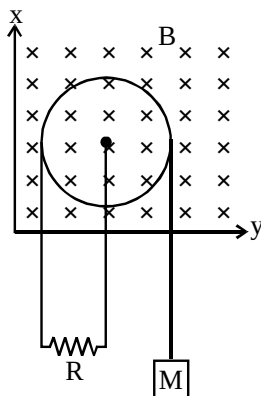


- (A) $\pi r^2 \omega B_y \sin \omega t$ (B) $\pi r^2 \omega B_z \cos \omega t$ (C) $\pi r^2 \omega B_z \sin \omega t$ (D) $\pi r^2 \omega B_y \cos \omega t$

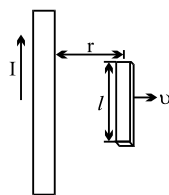
9. A uniform magnetic field 20 T exists on right side of the boundary in a gravity free space as shown in figure. The given circular arc of radius 2 cm made of conducting wire of total resistance 4Ω is rotated around point O at a constant angular speed 2 rad per second. Power required to maintain the constant angular velocity between time interval $t = \frac{\pi}{6}$ s to $t = \frac{\pi}{3}$ s is :



- (A) $64 \mu W$ (B) $32 \mu W$ (C) $128 \mu W$ (D) $16 \mu W$
10. The block of mass (M) is connected by thread which is wound on a pulley, free to rotate about fixed horizontal axis as shown. A uniform magnetic field B exists in a horizontal plane. The disc is connected with the resistance R as shown. Calculate the terminal velocity of the block if it was released from rest. Treat pulley as uniform metallic disc of radius L.



- (A) $\frac{4mgR}{B^2L^2}$ (B) $\frac{3mgR}{4B^2L^2}$ (C) $\frac{2mgR}{B^2L^2}$ (D) $\frac{3mgR}{2B^2L^2}$
11. A conducting rod moves with constant velocity v perpendicular to the long, straight wire carrying a current I as shown compute that the emf generated between the ends of the rod.

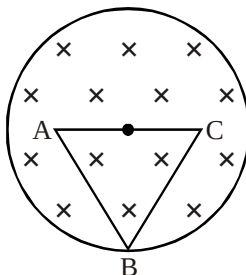


- (A) $\frac{\mu_0 v I l}{\pi r}$ (B) $\frac{\mu_0 v I l}{2\pi r}$ (C) $\frac{2\mu_0 v I l}{\pi r}$ (D) $\frac{\mu_0 v I l}{4\pi r}$
12. A metallic rod of length L and mass M is moving under the action of two unequal forces F_1 and F_2 (directed opposite to each other) acting at its ends along its length. Ignore gravity and any external magnetic field. If specific charge of electrons is (e/m), then the potential difference between the ends of the rod is steady state must be
- (A) $|F_1 - F_2| mL/eM$ (B) $(F_1 - F_2) mL/eM$
(C) $[mL/eM] \ln [F_1/F_2]$ (D) None of these

13. Two parallel long straight conductors lie on a smooth surface. Two other parallel conductors rest on them at right angles so as to form a square of side a initially. A uniform magnetic field B exists at right angles to the plane containing the conductors. They all start moving out with a constant velocity v . If r is the resistance per unit length of the wire the current in the circuit will be

(A) $\frac{Bv}{r}$ (B) $\frac{Br}{v}$ (C) Bvr (D) Bv

14. An equilateral triangle ABC of side a is placed in the magnetic field with side AC and its centre coinciding with the centre of the magnetic field. The magnetic field varies with time as $B = kt$. The emf induced across side AB is

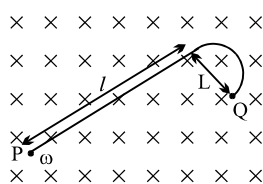


(A) $\frac{\sqrt{3}}{4}a^2k$ (B) Zero (C) $\frac{\sqrt{3}}{8}a^2k$ (D) $\frac{(\sqrt{2}-1)}{2}a^2k$

15. The magnetic field in a region is given by $\vec{B} = B_0 \left(1 + \frac{x}{a} \right) \hat{k}$. A square loop of edge-length d is placed with its edge along x & y axis. The loop is moved with constant velocity $\vec{V} = V_0 \hat{i}$. The emf induced in the loop is

(A) $\frac{V_0 B_0 d^2}{a}$ (B) $\frac{V_0 B_0 d^2}{2a}$ (C) $\frac{V_0 B_0 a^2}{d}$ (D) None

16. When a 'J' shaped conducting rod is rotating in its own plane with constant angular velocity ω , about one of its end P , in a uniform magnetic field $\vec{B}$ directed normally into the plane of paper) then magnitude of emf induced across it will be



(A) $B\omega\sqrt{L^2 + l^2}$ (B) $\frac{1}{2}B\omega L^2$ (C) $\frac{1}{2}B\omega(L^2 + l^2)$ (D) $\frac{1}{2}B\omega l^2$

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

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

18. In figure (a) a solenoid produce a magnetic field whose strength increases into the plane of the page . An induced emf is established in a conduction loop surrounding the solenoid, and this emf lights bulbs A and B. In figure (b) point P and Q are shorted. After the short is inserted

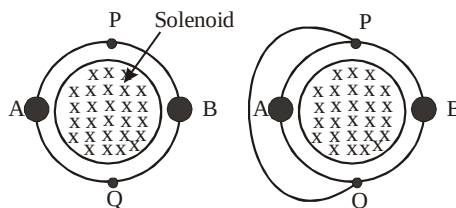
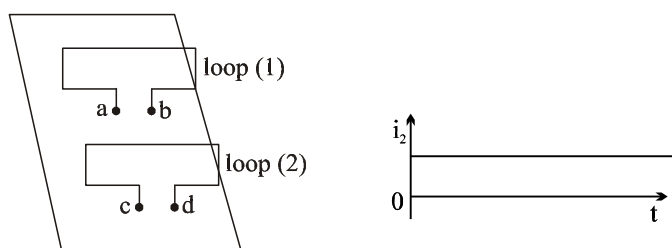


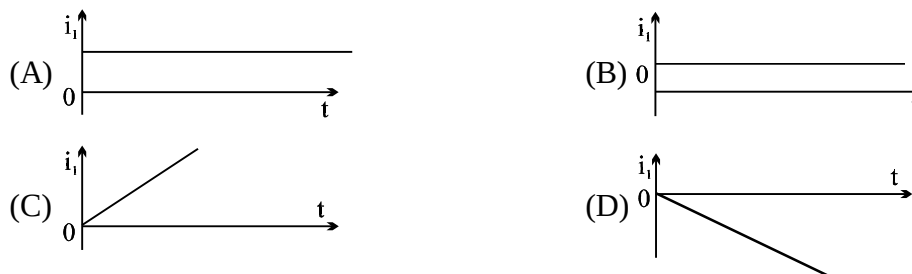
Figure (a)

Figure (b)

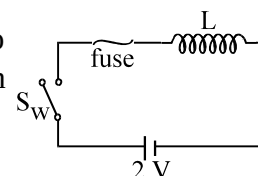
- (A) Bulb A goes out bulb B gets brighter
(B) Bulb B goes out bulb A gets brighter
(C) Bulb A goes out bulb B gets dimmer
(D) Bulb B goes out bulb A gets dimmer
19. An electric current i_1 can flow either direction through loop (1) and induced current i_2 in loop (2). Positive i_1 is when current is from 'a' to 'b' in loop (1) and positive i_2 is when the current is from 'c' to 'd' in loop (2). In an experiment, the graph of i_2 against time 't' is as shown below



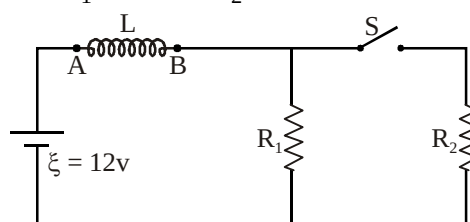
Which one(s) of the following graphs could have caused i_2 to behave as give above.



20. In the circuit shown, the cell is ideal. The coil has an inductance of 4H and zero resistance. F is a fuse of zero resistance and will blow when the current through it reaches 5A. The switch is closed at $t = 0$. The fuse will blow :
(A) just after $t=0$
(B) after 2s
(C) after 5s
(D) after 10s



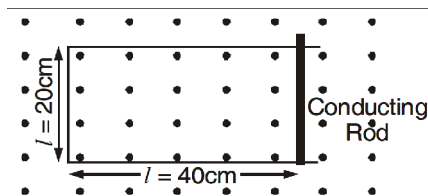
21. The circuit shown has been operating for a long time. The instant after the switch in the circuit labeled S is opened, what is the voltage across the inductor V_L and which labeled point (A or B) of the inductor is at a higher potential ? Take $R_1 = 4.0 \Omega$, $R_2 = 8.0 \Omega$, and $L = 2.5 \text{ H}$.



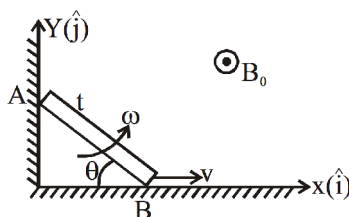
- (A) $V_L = 12 \text{ V}$; Point A is at the higher potential (B) $V_L = 12 \text{ V}$; Point B is at the higher potential
(C) $V_L = 6 \text{ V}$; Point A is at the higher potential (D) $V_L = 6 \text{ V}$; Point B is at the higher potential

(Multiple Correct Type Questions)

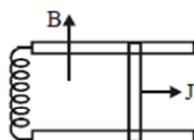
22. Figure shows a conducting rod of negligible resistance that can slide on smooth U-shaped rail made of wire of resistance $1 \Omega/\text{m}$. Position of the conducting rod at $t = 0$ is shown. A time dependent magnetic field $B = 2t$ Tesla is switched on at $t = 0$. After the magnetic field is switched on, the conducting rod is moved to the left perpendicular to the rails at constant speed 5 cm/s by some external agent.



- (A) The current in the loop at $t = 0$ due to induced emf is 0.16 A , clockwise
 (B) At $t = 2\text{s}$, induced emf has magnitude 0.08 V
 (C) The magnitude of the force required to move the conducting rod at constant speed 5 cm/s at $t = 2\text{s}$, is equal to 0.08 N
 (D) The magnitude of the force required to move the conducting rod at constant speed 5 cm/s at $t = 2\text{s}$, is equal to 0.16 N
23. A thin conducting rod of length ℓ is moved such that its end B moves along the X-axis while end A moves along the Y-axis. A uniform magnetic field $B = B_0 \hat{k}$ exists in the region. At some instant, velocity of end B is v and the rod makes an angle of $\theta = 60^\circ$ with the X-axis as shown in the figure. Then, at this instant



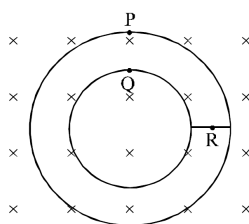
- (A) angular speed of rod AB is $\omega = \frac{2v}{\sqrt{3}\ell}$ (B) angular speed of rod AB is $\omega = \frac{\sqrt{3}v}{2\ell}$
 (C) e.m.f. induced in rod AB is $B\ell v \sqrt{3}$ (D) e.m.f. induced in rod AB is $B\ell v/2 \sqrt{3}$
24. Two parallel resistanceless rails are connected by an inductor of inductance L at one end as shown in the figure. 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 rails and given an impulse J towards the rightward direction. Then choose the CORRECT option (s).



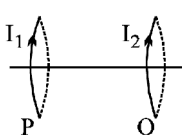
- (A) Velocity of the conductor is half of the initial velocity after a displacement of the conductor $d = \sqrt{\frac{3J^2 L}{4B^2 \ell^2 m}}$
 (B) Current flowing through the inductor at the instant when velocity of the conductor is half of the initial velocity is $i = \sqrt{\frac{3J^2}{4Lm}}$

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

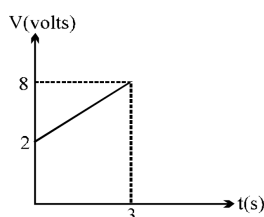
25. Figure shown plane figure made of a conductor located in a magnetic field along the inward normal to the plane of the figure. The magnetic field starts diminishing. Then the induced current



- (A) at point P is clockwise
(B) at point Q is anticlockwise
(C) at point Q is clockwise
(D) at point R is zero
26. Two circular coils P & Q are fixed coaxially & carry currents I_1 and I_2 respectively



- (A) if $I_2 = 0$ & P moves towards Q, a current in the same direction as I_1 is induced in Q
(B) if $I_1 = 0$ & Q moves towards P, a current in the opposite direction to that of I_2 is induced in P.
(C) when $I_1 \neq 0$ and $I_2 \neq 0$ are in the same direction then the two coils tend to move apart.
(D) when $I_1 \neq 0$ and $I_2 \neq 0$ are in opposite directions then the coils tends to move apart.
27. A circuit element is placed in a closed box. At time $t = 0$, constant current generator supplying a current of 1 amp, is connected across the box. Potential difference across the box varies according to graph shown in figure. The element in the box is :

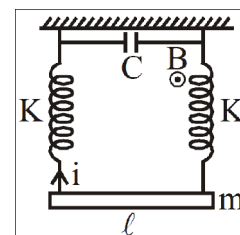


- (A) resistance of 2Ω
(B) battery of emf 6V
(C) inductance of 2H
(D) capacitance of 0.5F
28. Two coils A and B have coefficient of mutual inductance $M = 2H$. The magnetic flux passing through coil A changes by 4 Weber in 10 seconds due to the change in current in B. Then
- (A) the change in current in B in this time interval is 0.5 A
(B) the change in current in B in this time interval is 2A
(C) the change in current in B in this time interval is 8A
(D) a change in current of 1A in coil A will produce a change in flux passing through B by 4 Weber.

(Comprehension Type Questions)

Paragraph for Question Nos. 29 and 30

In the figure shown a uniform conducting rod of mass m and length l is suspended in vertical plane by two conducting springs of spring constant K . Upper end of spring are connected to each other by capacitor of capacitance C . A uniform horizontal magnetic field (B_0) perpendicular to plane of spring exists in space. Initially rod is in equilibrium but if centre of rod is pulled down and released, it performs SHM. Assume that the spring is small and neglect the magnetic force of interaction between circular section of springs & self inductance of rod.



29. Find time period of oscillation of rod :-

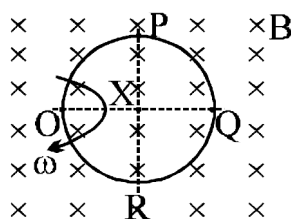
- (A) $2\pi\sqrt{\frac{m}{k}}$ (B) $2\pi\sqrt{\frac{B^2\ell^2C}{K}}$ (C) $\pi\sqrt{\frac{m + B^2\ell^2C}{k}}$ (D) $2\pi\sqrt{\frac{B^2\ell^2C + m}{2K}}$

30. Choose correct options from following :-

- (A) Electrical energy stored in capacitor is maximum when rod is at its lower extreme position
(B) Electrical energy stored in capacitor is maximum when rod is at its mean position
(C) Current in rod is maximum at mean position of rod
(D) If magnetic field is switched off then mean position of rod will change

Paragraph for Question No. 31 to 33

A conducting ring of radius a is rotated about a point O on its periphery as shown in the figure in a plane perpendicular to uniform magnetic field B which exists everywhere. The rotational velocity is ω .



31. Choose the correct statement(s) related to the potential of the points P, Q and R

- (A) $V_P - V_O > 0$ and $V_R - V_O < 0$ (B) $V_P = V_R > V_O$
(C) $V_O > V_P = V_Q$ (D) $V_Q - V_P = V_P - V_O$

32. Choose the correct statement(s) related to the magnitude of potential differences

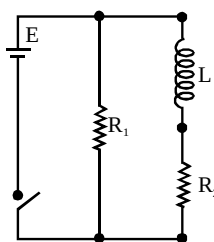
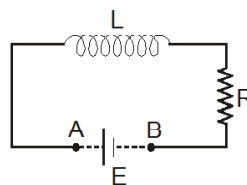
- (A) $V_P - V_O = \frac{1}{2} B\omega a^2$ (B) $V_P - V_Q = \frac{1}{2} B\omega a^2$
(C) $V_Q - V_O = 2B\omega a^2$ (D) $V_P - V_R = 2B\omega a^2$

33. Choose the correct statement(s) related to the induced current in the ring

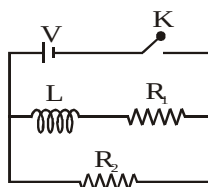
- (A) Current flows from $Q \rightarrow P \rightarrow O \rightarrow R \rightarrow Q$
(B) Current flows from $Q \rightarrow R \rightarrow O \rightarrow R \rightarrow Q$
(C) Current flows from $Q \rightarrow P \rightarrow O$ and from $Q \rightarrow R \rightarrow O$
(D) No current flows

EXERCISE (JM)

- The flux linked with a coil at any instant 't' is given by $\phi = 10t^2 - 50t + 250$. The induced emf at $t = 3s$ is- [AIEEE-2006]
 (1) -190 V (2) -10 V (3) 10 V (4) 190 V
- An inductor ($L = 100\text{ mH}$), a resistor ($R = 100\Omega$) and a battery ($E = 100\text{ V}$) are initially connected in series as shown in the figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit 1 ms after the short circuit is [AIEEE-2006]
 (1) $1/e\text{ A}$ (2) $e\text{ A}$ (3) 0.1 A (4) 1 A
- In an AC generator, a coil with N turns, all of the same area A and total resistance R , rotates with frequency ω in a magnetic field B . The maximum value of emf generated in the coil is - [AIEEE-2006]
 (1) $NABR\omega$ (2) NAB (3) $NABR$ (4) $NAB\omega$
- An ideal coil of 10 H is connected in series with a resistance of 5Ω and a battery of 5 V . 2s after the connection is made, the current flowing (in ampere) in the circuit is- [AIEEE-2007]
 (1) $(1 - e)$ (2) e (3) e^{-1} (4) $(1 - e^{-1})$
- Two coaxial solenoids are made by winding thin insulated wire over a pipe of cross-sectional area $A = 10\text{ cm}^2$ and length $= 20\text{ cm}$. If one of the solenoids has 300 turns and the other 400 turns, their mutual inductance is ($\mu_0 = 4\pi \times 10^{-7}\text{ TmA}^{-1}$) [AIEEE-2008]
 (1) $2.4\pi \times 10^{-5}\text{ H}$ (2) $4.8\pi \times 10^{-4}\text{ H}$ (3) $4.8\pi \times 10^{-5}\text{ H}$ (4) $2.4\pi \times 10^{-4}\text{ H}$
- An inductor of inductance $L = 400\text{ mH}$ and resistors of resistances $R_1 = 2\Omega$ and $R_2 = 2\Omega$ are connected to a battery of emf 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at $t = 0$. The potential drop across L as a function of time is:- [AIEEE-2009]

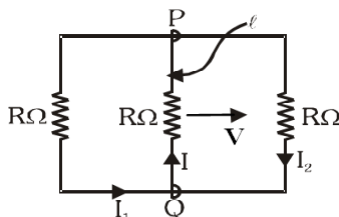


- $6(1 - e^{-t/0.2})\text{ V}$
 - $12e^{-5t}\text{ V}$
 - $6e^{-5t}\text{ V}$
 - $\frac{12}{t}e^{-3t}\text{ V}$
- In the circuit shown below, the key K is closed at $t = 0$. The current through the battery is : [AIEEE-2010]

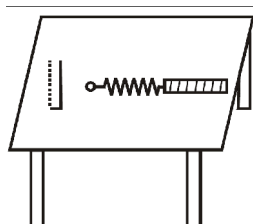


- $\frac{V(R_1 + R_2)}{R_1 R_2}$ at $t = 0$ and $\frac{V}{R_2}$ at $t = \infty$
- $\frac{V R_1 R_2}{\sqrt{R_1^2 + R_2^2}}$ at $t = 0$ and $\frac{V}{R_2}$ at $t = \infty$
- $\frac{V}{R_2}$ at $t = 0$ and $\frac{V(R_1 + R_2)}{R_1 R_2}$ at $t = \infty$
- $\frac{V}{R_2}$ at $t = 0$ and $\frac{V R_1 R_2}{\sqrt{R_1^2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

8. A rectangular loop has a sliding connector PQ of length ℓ and resistance $R\Omega$ and it is moving with a speed v as shown. The set-up is placed in a uniform magnetic field going into the plane of the paper. The three currents I_1 , I_2 and I are :- **[AIEEE-2010]**



- (1) $I_1 = I_2 = \frac{B\ell v}{6R}$, $I = \frac{B\ell v}{3R}$ (2) $I_1 = -I_2 = \frac{B\ell v}{R}$, $I = \frac{2B\ell v}{R}$
 (3) $I_1 = I_2 = \frac{B\ell v}{3R}$, $I = \frac{2B\ell v}{3R}$ (4) $I_1 = I_2 = I = \frac{B\ell v}{R}$
9. A boat is moving due east in a region where the earth's magnetic field is $5.0 \times 10^{-5} \text{ NA}^{-1} \text{ m}^{-1}$ due north and horizontal. The boat carries a vertical aerial 2m long. If the speed of the boat is 1.50 ms^{-1} , the magnitude of the induced emf in the wire of aerial is :- **[AIEEE-2011]**
 (1) 0.50 mV (2) 0.15 mV (3) 1 mV (4) 0.75 mV
10. A horizontal straight wire 20 m long extending from east to west is falling with a speed of 5.0 m/s, at right angles to the horizontal component of the earth's magnetic field $0.30 \times 10^{-4} \text{ Wb/m}^2$. The instantaneous value of the e.m.f. induced in the wire will be :- **[AIEEE-2011]**
 (1) 6.0 mV (2) 3 mV (3) 4.5 mV (4) 1.5 mV
11. A fully charged capacitor C with initial charge q_0 is connected to a coil of self inductance L at $t = 0$. The time at which the energy is stored equally between the electric and the magnetic fields is :- **[AIEEE-2011]**
 (1) $2\pi\sqrt{LC}$ (2) $\sqrt{LC}$ (3) $\pi\sqrt{LC}$ (4) $\frac{\pi}{4}\sqrt{LC}$
12. A coil is suspended in a uniform magnetic field, with the plane of the coil parallel to the magnetic lines of force. When a current is passed through the coil it starts oscillating; it is very difficult to stop. But if an aluminium plate is placed near to the coil, it stops. This is due to :- **[AIEEE-2012]**
 (1) Electromagnetic induction in the aluminium plate giving rise to electromagnetic damping
 (2) Development of air current when the plate is placed
 (3) Induction of electrical charge on the plate
 (4) Shielding of magnetic lines of force as aluminium is a paramagnetic material
13. A metallic rod of length 'l' is tied to a string of length 2l and made to rotate with angular speed ω on a horizontal table with one end of the string fixed. If there is a vertical magnetic field 'B' in the region, the e.m.f. induced across the ends of the rod is : **[JEE Main-2013]**



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

14. A circular loop of radius 0.3 cm lies parallel to a much bigger circular loop of radius 20 cm. The centre of the small loop is on the axis of the bigger loop. The distance between their centres is 15 cm. If a current of 2.0 A flows through the smaller loop, then the flux linked with bigger loop is :- [AIEEE - 2013]
(1) 9.1×10^{-11} weber (2) 6×10^{-11} weber (3) 3.3×10^{-11} weber (4) 6.6×10^{-9} weber

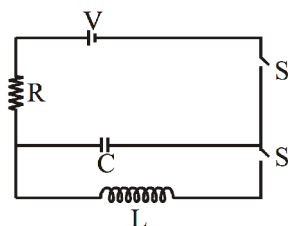
15. In an LCR circuit as shown below both switches are open initially. Now switch S_1 is closed, S_2 kept open, (q is charge on the capacitor and $\tau = RC$ is Capacitive time constant). Which of the following statement is correct? [JEE Main-2013]

(1) Work done by the battery is half of the energy dissipated in the resistor

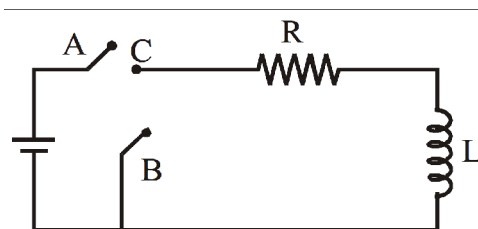
(2) At $t = \tau$, $q = CV/2$

(3) At $t = 2\tau$, $q = CV(1 - e^{-2})$

(4) At $t = \frac{\tau}{2}$, $q = CV(1 - e^{-1})$

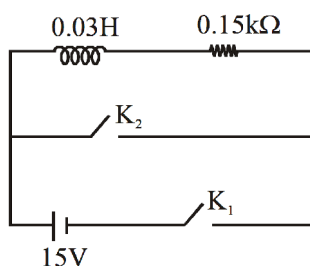


16. In the circuit shown here, the point 'C' is kept connected to point 'A' till the current flowing through the circuit becomes constant. Afterward, suddenly, point 'C' is disconnected from point 'A' and connected to point 'B' at time $t = 0$. Ratio of the voltage across resistance and the inductor at $t = L/R$ will be equal to : [JEE Main-2014]



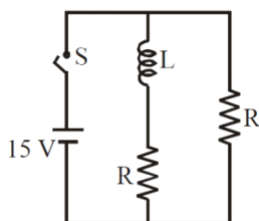
- (1) -1 (2) $\frac{1-e}{e}$ (3) $\frac{e}{1-e}$ (4) 1

17. An inductor ($L = 0.03$ H) and a resistor ($R = 0.15$ k Ω) are connected in series to a battery of 15V EMF in a circuit shown below. The key K_1 has been kept closed for a long time. Then at $t = 0$, K_1 is opened and key K_2 is closed simultaneously. At $t = 1$ ms, the current in the circuit will be ($e^5 \approx 150$):- [JEE Main-2015]



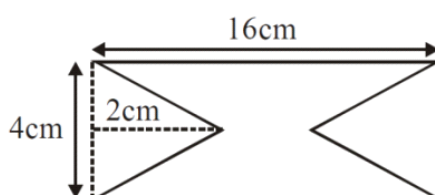
- (1) 6.7 mA (2) 0.67mA (3) 100mA (4) 67mA

18. A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. The output power is delivered at 230 V by the transformer. If the current in the primary of the transformer is 5 A and its efficiency is 90%, the output current would be:
[JEE Main-2019]
- (1) 45 A (2) 50 A (3) 35 A (4) 25 A
19. A solid metal cube of edge length 2 cm is moving in a positive y-direction at a constant speed of 6 m/s. There is a uniform magnetic field of 0.1 T in the positive z-direction. The potential difference between the two faces of the cube perpendicular to the x-axis, is :
[JEE Main-2019]
- (1) 2 mV (2) 6 mV (3) 12 mV (4) 1 mV
20. The self induced emf of a coil is 25 volts. When the current in it is changed at uniform rate from 10 A to 25 A in 1s, the change in the energy of the inductance is :
[JEE Main-2019]
- (1) 740 J (2) 437.5 J (3) 637.5 J (4) 540 J
21. There are two long co-axial solenoids of same length l . the inner and outer coils have radii r_1 and r_2 and number of turns per unit length n_1 and n_2 respectively. The ratio of mutual inductance to the self-inductance of the inner-coil is :
[JEE Main-2019]
- (1) $\frac{n_2}{n_1}$ (2) $\frac{n_2 \cdot r_2^2}{n_1 \cdot r_1^2}$ (3) $\frac{n_2 \cdot r_1}{n_1 \cdot r_2}$ (4) $\frac{n_1}{n_2}$
22. In the figure shown, a circuit contains two identical resistors with resistance $R = 5\Omega$ and an inductance with $L = 2\text{mH}$. An ideal battery of 15 V is connected in the circuit. What will be the current through the battery long after the switch is closed?
[JEE Main-2019]



- (1) 3 A (2) 7.5 A (3) 6 A (4) 5.5 A
23. Consider a circular coil of wire carrying constant current I , forming a magnetic dipole. The magnetic flux through an infinite plane that contains the circular coil and excluding the circular coil area is given by ϕ_i . The magnetic flux through the area of the circular coil area is given by ϕ_o . Which of the following option is correct?
[JEE Main-2020]
- (1) $\phi_i = -\phi_o$ (2) $\phi_i = \phi_o$ (3) $\phi_i < \phi_o$ (4) $\phi_i > \phi_o$
24. A long solenoid of radius R carries a time (t) - dependent current $I(t) = I_0 t(1 - t)$. A ring of radius $2R$ is placed coaxially near its middle. During the time interval $0 \leq t \leq 1$, the induced current (I_R) and the induced EMF (V_R) in the ring change as :
[JEE Main-2020]
- (1) At $t = 0.25$ direction of I_R reverses and V_R is maximum
(2) Direction of I_R remains unchanged and V_R is maximum at $t = 0.5$
(3) Direction of I_R remains unchanged and V_R is zero at $t = 0.25$
(4) At $t = 0.5$ direction of I_R reverses and V_R is zero

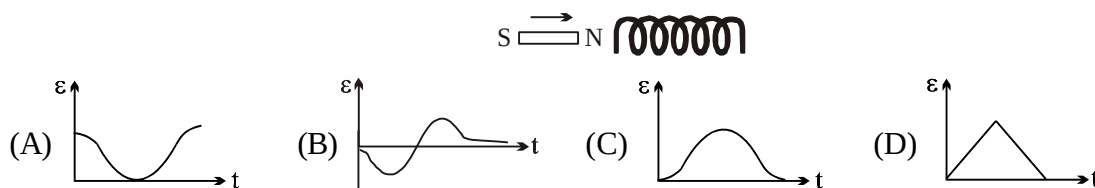
25. A loop ABCDEFA of straight edges has six corner points A(0,0,0), B(5,0,0), C(5, 5, 0), D(0, 5, 0), E(0, 5, 5) and F(0, 0, 5). The magnetic field in this region is $\vec{B} = (3\hat{i} + 4\hat{k})\text{ T}$. The quantity of flux through the loop ABCDEFA (in Wb) is **[JEE Main-2020]**
26. A planar loop of wire rotates in a uniform magnetic field. Initially, at $t = 0$, the plane of the loop is perpendicular to the magnetic field. If it rotates with a period of 10 s about an axis in its plane then the magnitude of induced emf will be maximum and minimum, respectively at: **[JEE Main-2020]**
(1) 5.0 s and 7.5 s (2) 2.5 s and 5.0 s (3) 5.0 s and 10.0 s (4) 2.5 s and 7.5 s
27. At time $t = 0$ magnetic field of 1000 Gauss is passing perpendicularly through the area defined by the closed loop shown in the figure. If the magnetic field reduces linearly to 500 Gauss, in the next 5 s, then induced EMF in the loop is : **[JEE Main-2020]**



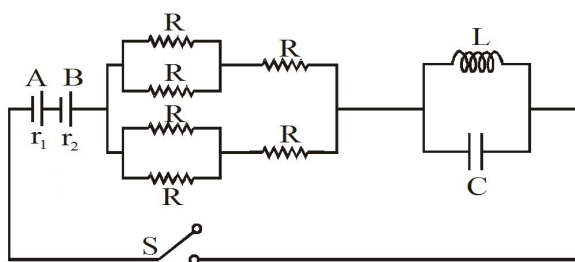
- (1) $56\ \mu\text{V}$ (2) $36\ \mu\text{V}$ (3) $28\ \mu\text{V}$ (4) $48\ \mu\text{V}$
28. In a fluorescent lamp choke (a small transformer) 100 V of reverse voltage is produced when the choke current changes uniformly from 0.25 to 0 in a duration of 0.025 ms. The self-inductance of the choke (in mH) is estimated to be _____. **[JEE Main-2020]**

EXERCISE (JA)

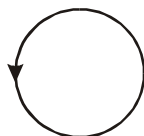
1. The variation of induced emf (ε) with time (t) in a coil if a short bar magnet is moved along its axis with a constant velocity is best represented as [IIT JEE- 2004(Scr.)]



2. In the circuit shown A and B are two cells of same emf E but different internal resistances r_1 and r_2 ($r_1 > r_2$) respectively. Find the value of R such that the potential difference across the terminals of cell A is zero a long time after the key K is closed. [IIT JEE- 2004]



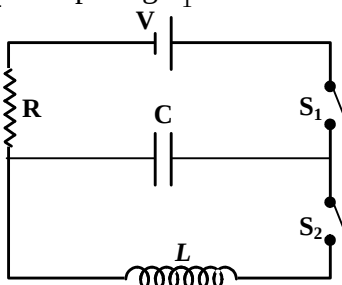
3. An infinitely long cylindrical conducting rod is kept along $+Z$ direction. A constant magnetic field is also present in $+Z$ direction. Then current induced will be [IIT JEE-2005 (Scr.)]
 (A) 0 (B) along $+z$ direction
 (C) along clockwise as seen from $+Z$ (D) along anticlockwise as seen from $+Z$
4. A field line shown in the figure. This field cannot represent. [IIT JEE-2006]



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

Paragraph for Q. No. 5 to 7

The capacitor of capacitance C can be charged (with the help of a resistance R) by a voltage source V , by closing switch S_1 while keeping switch S_2 open. The capacitor can be connected in series with an inductor ' L ' by closing switch S_2 and opening S_1 . [IIT JEE-2006]



5. Initially, the capacitor was uncharged. Now, switch S_1 is closed and S_2 is kept open. If time constant of this circuit is τ , then
 (A) after time interval τ , charge on the capacitor is $CV/2$
 (B) after time interval 2τ , charge on the capacitor is $CV(1-e^{-2})$
 (C) the work done by the voltage source will be half of the heat dissipated when the capacitor is fully charged.
 (D) after time interval 2τ , charge on the capacitor is $CV(1-e^{-1})$ [IIT JEE-2006]
6. After the capacitor gets fully charged, S_1 is opened and S_2 is closed so that the inductor is connected in series with the capacitor. Then,
 (A) at $t = 0$, energy stored in the circuit is purely in the form of magnetic energy
 (B) at any time $t > 0$, current in the circuit is in the same direction
 (C) at $t > 0$, there is no exchange of energy between the inductor and capacitor
 (D) at any time $t > 0$, instantaneous current in the circuit may $V\sqrt{\frac{C}{L}}$
7. If the total charge stored in the LC circuit is Q_0 , then for $t \geq 0$
 (A) the charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} + \frac{t}{\sqrt{LC}}\right)$
 (B) the charge on the capacitor is $Q = Q_0 \cos\left(\frac{\pi}{2} - \frac{t}{\sqrt{LC}}\right)$
 (C) the charge on the capacitor is $Q = -LC \frac{d^2Q}{dt^2}$
 (D) the charge on the capacitor is $Q = -\frac{1}{\sqrt{LC}} \frac{d^2Q}{dt^2}$

Paragraph for Q. No. 8 to 10

Modern trains are based on Maglev technology in which trains are magnetically levitated, which runs its EDS Maglev system. There are coils on both sides of wheels. Due to motion of train, current induces in the coil of track which levitate it. This is in accordance with Lenz's law. If trains lower down then due to Lenz's law a repulsive force increases due to which train gets uplifted and if it goes much high then there is a net downward force due to gravity. The advantage of Maglev train is that there is no friction between the train and the track, thereby reducing power consumption and enabling the train to attain very high speeds. Disadvantage of Maglev train is that as it slows down the electromagnetic forces decrease and it becomes difficult to keep it levitated and as it moves forward according to Lenz law there is an electromagnetic drag force. [IIT JEE-2006]

8. What is the advantage of this system ?
 (A) no friction hence reduced power consumption (B) no electric power is used
 (C) gravitation force is zero (D) electrostatic force draws the train
9. What is the disadvantage of this system :
 (A) By Lenz's law train experience a drag
 (B) Friction force create a drag on the train
 (C) Retardation
 (D) Train experiences upward force according to Lenz's law

10. Which force causes the train to elevate up ?
 (A) electrostatic force (B) time varying electric field
 (C) magnetic force (D) induced electric field
11. 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.

[IIT JEE- 2007]

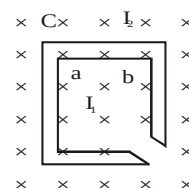
Column-I

- (A) A charged capacitor is connected to the ends of the wire
 (B) The wire is moved perpendicular to its length with constant velocity in a uniform magnetic field perpendicular to the plane of motion.
 (C) The wire is placed in a constant electric field that has a direction along the length of the wire
 (D) A battery of constant emf is connected to the ends of the wire

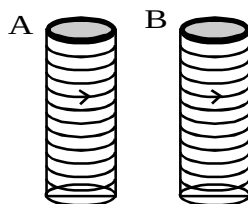
Column-II

- (P) A constant current flows through the wire
 (Q) Thermal energy is generated in the wire
 (R) A constant potential difference develops between the ends of the wire
 (S) Charges of constant magnitude appear at the ends of the wire

12. 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



13. 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): [IIT JEE-2009]



- (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 $m_A < m_B$

14. Column-II gives certain systems undergoing a process. Column I suggests changes in some of the parameters related to the system. Match the statements in Column I to the appropriate process(es) from Column-II. [IIT JEE- 2009]

Column-I

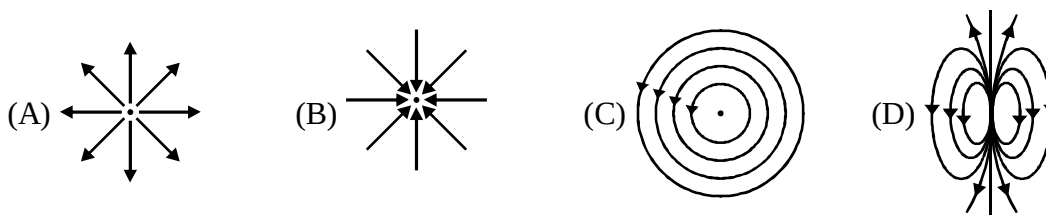
- (A) The energy of the system is increased
(B) Mechanical energy is provided to the system, which is converted into energy of random motion of its parts
(C) Internal energy of the system is converted into its mechanical energy
(D) Mass of the system is decreased

Column-II

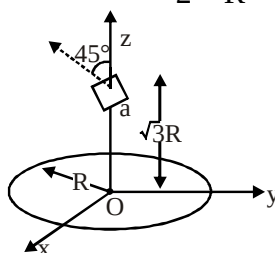
- (P) System : A capacitor, initially uncharged
Process : It is connected to a battery
(Q) System : A gas in an adiabatic container fitted with an adiabatic piston
Process: The gas is compressed by pushing the piston
(R) System : A gas in a rigid container
Process : The gas gets cooled due to colder atmosphere surrounding it
(S) System : A heavy nucleus, initially at rest
Process : The nucleus fissions into two fragments of nearly equal masses and some neutrons are emitted
(T) System : A resistive wire loop
Process : The loop is placed in a time varying magnetic field perpendicular to its plane.

15. Which of the field patterns given below is valid for electric field as well as for magnetic field?

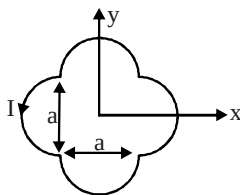
[IIT JEE-2011]



16. A circular wire loop of radius R is placed in the x - y plane centred at the origin O . A square loop of side a ($a \ll R$) having two turns is placed with its centre at $z = \sqrt{3}R$ along the axis of the circular wire loop, as shown in figure. The plane of the square loop makes an angle of 45° with respect to the z -axis. If the mutual inductance between the loops is given by $\frac{\mu_0 a^2}{2^{p/2} R}$, then the value of p is [IIT JEE- 2012]



17. A loop carrying current 'I' lies in the x-y plane as shown in the figure. The unit vector $\hat{k}$ is coming out of the plane of the paper. The magnetic moment of the current loop is [IIT JEE-2012]



- (A) $a^2 I \hat{k}$ (B) $\left(\frac{\pi}{2} + 1\right) a^2 I \hat{k}$ (C) $-\left(\frac{\pi}{2} + 1\right) a^2 I \hat{k}$ (D) $(2\pi + 1) a^2 I \hat{k}$
18. 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) [IIT JEE-2012]
- (A) The emf induced in the loop is zero if the current is constant.
 (B) The emf induced in the loop is infinite 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.

Paragraph for Q.No. 19 & 20

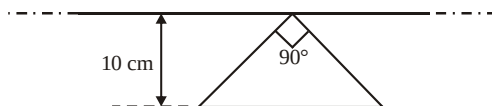
A point charge Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω . This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. A uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an emf in the orbit. The induced emf is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It is known that for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ . [IIT JEE-2013]

19. The change in the magnetic dipole moment associated with the orbit, at the end of the time interval of the magnetic field change is
- (A) $-\gamma BQR^2$ (B) $-\gamma \frac{BQR^2}{2}$ (C) $\gamma \frac{BQR^2}{2}$ (D) γBQR^2
20. The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change is
- (A) $\frac{BR}{4}$ (B) $\frac{BR}{2}$ (C) BR (D) $2BR$

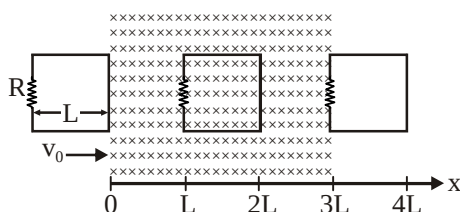
Paragraph for Q.No. 21 & 22

A thermal power plant produces electric power of 600 kW and 4000 V, which is to be transported to a place 20 km away from the power plant for consumers' usage. It can be transported either directly with a cable of large current carrying capacity or by using a combination of step-up and step-down transformers at the two ends. The drawback of the direct transmission is the large energy dissipation. In the method using transformers, the dissipation is much smaller. In this method, a step-up transformer is used at the plant side so that the current is reduced to a smaller value. At the consumers' end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resistive and the transformers are ideal with a power factor unity. All the currents and voltages mentioned are rms values. [IIT JEE -2013]

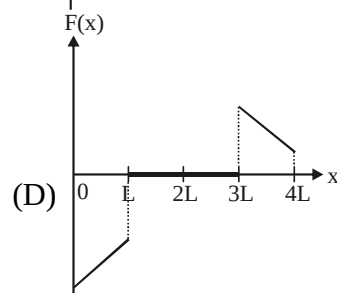
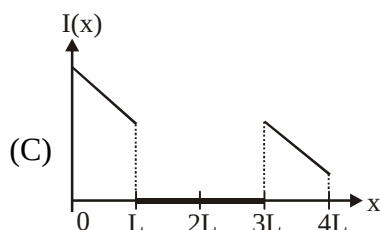
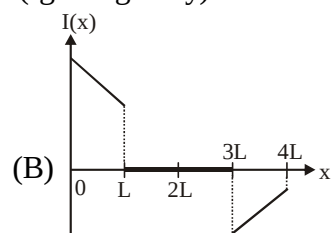
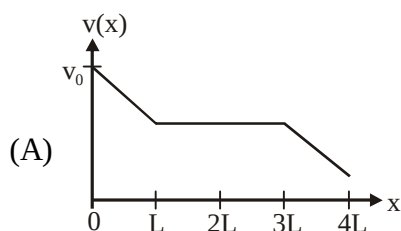
21. In the method using the transformers, assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is 1 : 10. If the power to the consumers has to be supplied at 200 V, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is
(A) 200 : 1 (B) 150 : 1 (C) 100 : 1 (D) 50 : 1
22. If the direct transmission method with a cable of resistance $0.4 \Omega \text{ km}^{-1}$ is used, the power dissipation (in %) during transmission is
(A) 20 (B) 30 (C) 40 (D) 50
23. A conducting loop in the shape of a right angled isosceles triangle of height 10 cm is kept such that the 90° vertex is very close to an infinitely long conducting wire (see the figure). The wire is electrically insulated from the loop. The hypotenuse of the triangle is parallel to the wire. The current in the triangular loop is in counterclockwise direction and increased at a constant rate of 10 A s^{-1} . Which of the following statement(s) is (are) true? **[IIT JEE 2016 (P-1)]**



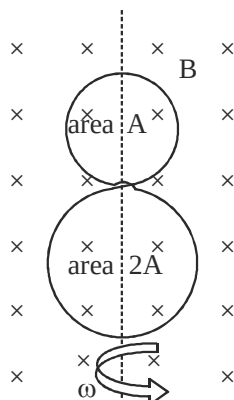
- (A) The magnitude of induced emf in the wire is $\left(\frac{\mu_0}{\pi}\right)$ volt
- (B) If the loop is rotated a constant angular speed about the wire, an additional emf of $\left(\frac{\mu_0}{\pi}\right)$ volt is induced in the wire.
- (C) The induced current in the wire is in opposite direction to the current along the hypotenuse.
- (D) There is a repulsive force between the wire and the loop
24. Two inductors L_1 (inductance 1 mH, internal resistance 3Ω) and L_2 (inductance 2 mH, internal resistance 4Ω), and a resistor R (resistance 12Ω) are all connected in parallel across a 5V battery. The circuit is switched on at time $t = 0$. The ratio of the maximum to the minimum current ($I_{\text{max}} / I_{\text{min}}$) drawn from the battery is **[IIT JEE 2016 (P-1)]**
25. A rigid wire loop of square shape having side of length L and resistance R is moving along the x -axis with a constant velocity v_0 in the plane of the paper. At $t = 0$, the right edge of the loop enters a region of length $3L$ where there is a uniform magnetic field B_0 into the plane of the paper, as shown in the figure. For sufficiently large v_0 , the loop eventually crosses the region. Let x be the location of the right edge of the loop. Let $v(x)$, $I(x)$ and $F(x)$ represent the velocity of the loop, current in the loop, and force on the loop, respectively, as a function of x . Counter-clockwise current is taken as positive. **[IIT JEE 2016 (P-2)]**



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



26. A circular insulated copper wire loop is twisted to form two loops of area A and $2A$ as shown in the figure. At the point of crossing the wires remain electrically insulated from each other. The entire loop lies in the plane (of the paper). A uniform magnetic field $\vec{B}$ points into the plane of the paper. At $t = 0$, the loop starts rotating about the common diameter as axis with a constant angular velocity ω in the magnetic field. Which of the following options is/are correct? [IIT JEE 2017 (P-1)]



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

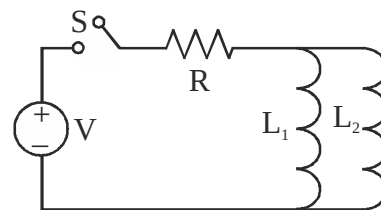
27. A source of constant voltage V is connected to a resistance R and two ideal inductors L_1 and L_2 through a switch S as shown. There is no mutual inductance between the two inductors. The switch S is initially open. At $t = 0$, the switch is closed and current begins to flow. Which of the following options is/are correct? [IIT JEE 2017 (P-2)]

(A) After a long time, the current through L_1 will be $\frac{V}{R} \frac{L_2}{L_1 + L_2}$

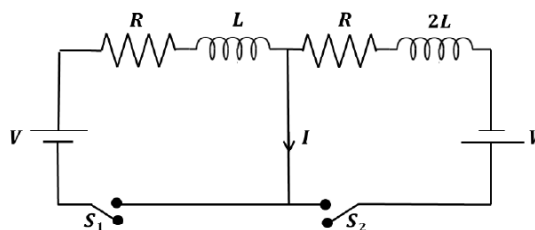
(B) After a long time, the current through L_2 will be $\frac{V}{R} \frac{L_1}{L_1 + L_2}$

(C) The ratio of the currents through L_1 and L_2 is fixed at all times ($t > 0$)

(D) At $t = 0$, the current through the resistance R is $\frac{V}{R}$



28. In the figure below, the switches S_1 and S_2 are closed simultaneously at $t = 0$ and a current starts to flow in the circuit. Both the batteries have the same magnitude of the electromotive force (emf) and the polarities are as indicated in the figure. Ignore mutual inductance between the inductors. The current I in the middle wire reaches its maximum magnitude I_{max} at time $t = \tau$. Which of the following statements is (are) true? [IIT JEE 2018 (P-1)]



(A) $I_{max} = \frac{V}{2R}$

(B) $I_{max} = \frac{V}{4R}$

(C) $\tau = \frac{L}{R} \ln 2$

(D) $\tau = \frac{2L}{R} \ln 2$

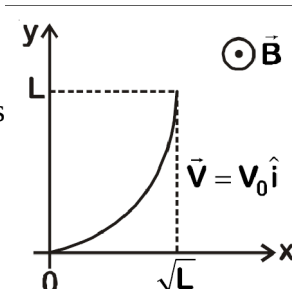
29. A conducting wire of parabolic shape, initially $y = x^2$, is moving with velocity $\vec{V} = V_0 \hat{i}$ in a non-uniform magnetic field $\vec{B} = B_0 \left(1 + \left(\frac{y}{L} \right)^\beta \right) \hat{k}$, as shown in figure. If V_0 , B_0 , L and β are positive constants and $\Delta\phi$ is the potential difference developed between the ends of the wire, then the correct statement(s) is/are: [JEE ADVANCED 2019]

(A) $|\Delta\phi| = \frac{1}{2} B_0 V_0 L$ for $\beta = 0$

(B) $|\Delta\phi|$ is proportional to the length of the wire projected on the y-axis

(C) $|\Delta\phi|$ remains the same if the parabolic wire is replaced by a straight wire, $y = x$ initially, of length $\sqrt{2}L$

(D) $|\Delta\phi| = \frac{4}{3} B_0 V_0 L$ for $\beta = 2$

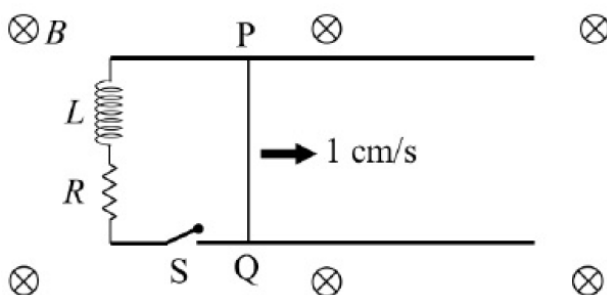


30. A 10 cm long perfectly conducting wire PQ is moving with a velocity 1 cm/s on a pair of horizontal rails of zero resistance. One side of the rails is connected to an inductor $L = 1 \text{ mH}$ and a resistance $R = 1 \Omega$ as shown in figure. The horizontal rails, L and R lie in the same plane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

[Assume the velocity of wire PQ remains constant (1 cm/s) after key S is closed.]

Given: $e^{-1} = 0.37$, where e is base of the natural logarithm]

[JEE ADVANCED 2019]



ANSWER KEY

EXERCISE (S-1)

1. (a) 2.4×10^{-4} V, lasting 2s; (b) 0.6×10^{-4} V, lasting 8s
2. (a) 1.5×10^{-3} V, (b) West to East, (c) Eastern end
3. $\lambda V_y B_0$ 4. 2N 5. $\frac{mgR}{B^2 l^2}$
6. Vertical component of $B = 5.0 \times 10^{-4} \sin 30^\circ = 2.5 \times 10^{-4}$ T
 $\varepsilon = B\ell v$
 $\varepsilon = 2.5 \times 10^{-4} \times 25 \times 500 = 3.125$ V
 The emf induced is 3.1 V (using significant figures). The direction of the wing is immaterial (as long as it is horizontal) for this answer
7. (a) $|\varepsilon| = vB\ell = 0.12 \times 0.50 \times 0.15 = 9.0$ mV ;
 P positive end and Q negative end.
 (b) Yes. When K is closed, the excess charge is maintained by the continuous flow of current.
 (c) Magnetic force is cancelled by the electric force setup due to the excess charge of opposite signs at the ends of the rod.
 (d) Retarding force = $IB\ell$

$$= \frac{9\text{mV}}{9\text{m}\Omega} \times 0.5\text{T} \times 0.15\text{m} = 75 \times 10^{-3} \text{ N}$$

 (e) Power expended by an external agent against the above retarding force to keep the rod moving uniformly at 12 cm s^{-1}

$$= 75 \times 10^{-3} \times 12 \times 10^{-2} = 9.0 \times 10^{-3} \text{ W}$$

 (f) $I^2 R = 1 \times 1 \times 9 \times 10^{-3} = 9.0 \times 10^{-3} \text{ W}$
 The source of this power is the power provided by the external agent as calculated above.
 (g) Zero: motion of the rod does not cut across the field lines. [Note: length of PQ has been considered above to be equal to the spacing between the rails.]
8. 100V 9. Induced emf = $8 \times 2 \times 10^{-4} \times 0.02 = 3.2 \times 10^{-5}$ V
10. $\frac{er_k}{2m}$ directed along tangent to the circle of radius r , whose centre lies on the axis of cylinder.
11. Induced emf = 12.96×10^{-5} V, induced current = 2.88×10^{-2} A 12. 7.5×10^{-6} V
13. Flux through each turn of the loop = $\pi r^2 B \cos(\omega t)$
 $\varepsilon = -N\omega\pi r^2 B \sin(\omega t)$
 $\varepsilon_{\max} = -N\omega\pi r^2 B$

$$= 20 \times 50 \times \pi \times 64 \times 10^{-4} \times 3.0 \times 10^{-2} = 0.603 \text{ V}$$

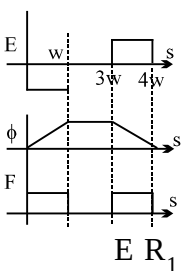
 ε_{avg} is zero over a cycle
 $I_{\text{m,ax}} = 0.0603 \text{ A}$

$$P_{\text{average}} = \frac{1}{2} \varepsilon_{\max} I_{\max} = 0.018 \text{ W}$$

 The induced current causes a torque opposing the rotation of the coil. An external agent (rotor) must supply torque (and do work) to counter this torque in order to keep the coil rotating uniformly. Thus, the source of the power dissipated as heat in the coil is the external rotor.
14. 0.75 Tesla 15. $-\frac{B\pi a^2 \lambda}{MR} \hat{k}$ 16. 4H 17. $E_{\text{av}} = 6.5 \text{ V}$ 18. 0.8

19. I^{-1} 20. $\frac{LE^2}{2R_1^2}$ 21. $\frac{e^2}{e^2 - 1}$ 22. $\frac{EL}{eR^2}$
23. (a) 10^4 A/s (b) 0 (c) 2A (d) $100\sqrt{3} \mu\text{C}$ 24. 30 Wb.
25. $M = \frac{\mu_0 a}{2\pi} n \left(1 + \frac{a}{x} \right); \epsilon = 1.7 \times 10^{-5} \text{ V}$

EXERCISE (S-2)

1. (i) 85.22 Tm^2 ; (ii) 56.8 V ; (iii) linearly from c to b 2. (i) $2.4 \times 10^{-5} \text{ V}$ (ii)
3. (i) $3.3 \times 10^8 \text{ A}$, (ii) $1.1 \times 10^{17} \text{ W}$, (iii) totally unrealistic
4.  5. $\frac{\mu_0 h \omega i_m N}{2\pi} \ln \frac{b}{a}$ 6. $\frac{l}{2} \frac{dB}{dt} \sqrt{R^2 - \frac{l^2}{4}}$
7. $\frac{E R_1}{R_1 R_2 + R_2 R_3 + R_3 R_1}$ 8. $67/32 \text{ A}$
9. (i) $i_1 = i_2 = 10/3 \text{ A}$, (ii) $i_1 = 50/11 \text{ A}$; $i_2 = 30/11 \text{ A}$, (iii) $i_1 = 0$, $i_2 = 20/11 \text{ A}$, (iv) $i_1 = i_2 = 0$
10. $42 + 20t \text{ volt}$ 11. $I_{EA} = \frac{7}{22} \text{ A}$; $I_{BE} = \frac{3}{11} \text{ A}$; $I_{FE} = \frac{1}{22} \text{ A}$
12. $V = 1 \text{ ms}^{-1}$, $R_1 = 0.47 \Omega$, $R_2 = 0.30 \Omega$
13. (a) $E = \frac{1}{2} B \omega r^2$ (b) (i) $I = \frac{B \omega r^2 [1 - e^{-Rt/L}]}{2R}$, (ii) $\tau = \frac{mgr}{2} \cos \omega t + \frac{\omega B^2 r^4}{4R} (1 - e^{-Rt/L})$
14. (i) $V_{\text{terminal}} = \frac{mgR}{B^2 Z^2}$; (ii) $\frac{g}{2}$ 15. $-\frac{V}{R} e^{-\frac{Rt}{L}}$
16. (a) $i = \frac{B_0 a v}{R}$ in anticlockwise direction, $v = \text{velocity at time } t$,
(b) $F_{\text{net}} = B_0^2 a^2 v / R$, (c) $V = \frac{mgR}{B_0^2 a^2} \left(1 - e^{-\frac{B_0^2 a^2 t}{mR}} \right)$
17. $10 \mu\text{V}$ 18. $\frac{\mu_0 i a^2 \pi}{2Rb}$ 19. $\frac{1}{3} \text{ A}$ 20. 0.4 V
21. $3 \mu\text{V}$, clockwise 22. $C \pi a^2 / R$ 23. 200 rad/sec 24. $\frac{1}{15} \text{ A}$, $\frac{1}{10} \text{ A}$
25. $kMT^2 / (R)$ 26. $q = Q_0 \sin \left(\sqrt{\frac{1}{LC}} t + \frac{\pi}{2} \right)$

EXERCISE (O-1)

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

EXERCISE (O-2)

- | | | | | | | |
|-----------|---------|----------|-----------|---------|-------|-------|
| 1. A | 2. B | 3. B | 4. A | 5. C | 6. D | 7. D |
| 8. A | 9. D | 10. A | 11. B | 12. A | 13. A | 14. C |
| 15. A | 16. C | 17. D | 18. A | 19. D | 20. D | 21. D |
| 22. A,B,C | 23. A,D | 24. A, B | 25. A,C,D | 26. B,D | 27. D | 28. B |
| 29. D | 30. B | 31. B, D | 32. C | 33. D | | |

EXERCISE (JM)

- | | | | | | | |
|-------|-------|-------|-----------|-------|-------|-------------|
| 1. 2 | 2. 1 | 3. 4 | 4. 4 | 5. 4 | 6. 2 | 7. 3 |
| 8. 3 | 9. 2 | 10. 2 | 11. 4 | 12. 1 | 13. 4 | 14. 1 |
| 15. 3 | 16. 1 | 17. 2 | 18. 1 | 19. 3 | 20. 2 | 21. 1 |
| 22. 3 | 23. 1 | 24. 4 | 25. (175) | 26. 2 | 27. 1 | 28. (10.00) |

EXERCISE (JA)

- | | | | | | | |
|----------|-----------------------------|---------------------------------------|---|---------|--------|---------|
| 1. B | 2. $\frac{4}{3}(r_1 - r_2)$ | 3. A | 4. BD | 5. B | 6. D | 7. C |
| 8. A | 9. A | 10. C | 11. (A)→ Q; (B)→ RS; (C)→ S ; (D)→ P Q R; | | | |
| 12. D | 13. BD | 14. (A)→ PQT; (B)→ Q; (C)→ S ; (D)→ S | | | | 15. C |
| 16. 7 | 17. B | 18. AC | 19. B | 20. B | 21. A | 22. B |
| 23. AD | 24. 8 | 25. AB | 26. AD | 27. ABC | 28. BD | 29. BCD |
| 30. 0.63 | | | | | | |