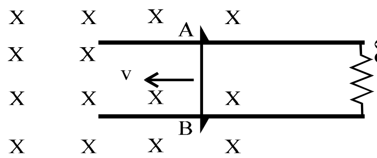
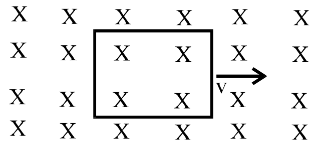
EXERCISE-1

SECTION (A) : FLUX AND FARADAY'S LAWS OF ELECTROMAGNETIC INDUCTION

A 1. Consider the situation shown in fig. The resistanceless wire AB is slid on the fixed rails with a constant velocity. If the wire AB is replaced by a resistanceless semicircular wire, the magnitude of the induced current will
(A) increase (B) remain the same
(C) decrease
(D) increase or decrease depending on whether the semicircle bulges towards the resistance or away from it.

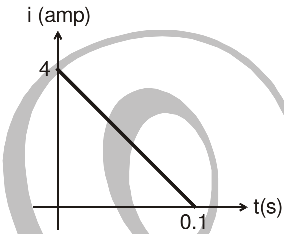


A 2. A conducting square loop of side l and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A uniform and constant magnetic field B exists along the perpendicular to the plane of the loop in fig. The current induced in the loop is
(A) $Bl\upsilon/R$ clockwise (B) $Bl\upsilon/R$ anticlockwise (C) $2Bl\upsilon/R$ anticlockwise
(D) zero

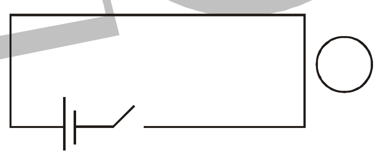


A 3*. A conducting loop is placed in a uniform magnetic filed with its plane perpendicular to the field. An emf is induced in the loop if
(A) it is translated (B) it is rotated about its axis
(C) it is rotated about a diameter (D) it is deformed

A 4. Some magnetic flux is changed from a coil of resistance 10 ohm. As a result an induced current is developed in it, which varies with time as shown in figure. The magnitude of change in flux through the coil in Webers is
(A) 2 (B) 4
(C) 6 (D) 8



A 5. Consider the situation shown in fig. If the switch is closed and after some time it is opened again, the closed loop will show
(A) an anticlockwise current-pulse
(B) a clockwise current-pulse
(C) an anticlockwise current-pulse and then a clockwise current-pulse
(D) a clockwise current-pulse and then an anticlockwise current-pulse

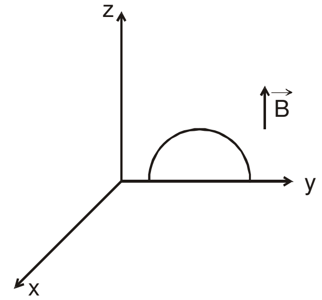


A 6. Solve the previous question if the closed loop is completely enclosed in the circuit containing the switch.
(A) an anticlockwise current-pulse
(B) a clockwise current-pulse
(C) an anticlockwise current-pulse and then a clockwise current-pulse
(D) a clockwise current-pulse and then an anticlockwise current-pulse

A 7. Consider the following statements:
(A) An emf can be induced by moving a conductor in a magnetic field
(B) An emf can be induced by changing the magnetic field.
(A) Both A and B are true (B) A is true but B is false
(C) B is true but A is false (D) Both A and B are false

A 8. A small, conducting circular loop is placed inside a long solenoid carrying a current. The plane of the loop contains the axis of the solenoid. If the current in the solenoid is varied, the current induced in the loop is
(A) clockwise (B) anticlockwise (C) zero
(D) clockwise or anticlockwise depending on whether the resistance in increased or decreased.

A 9. A semicircular conducting wire is placed in yz plane in a uniform magnetic field directed along positive z-direction. An induced emf will be developed between the ends of the wire if it is moved along:
(A) positive x direction
(B) positive y direction
(C) positive z direction
(D) none of these



A 10. If flux in a coil changes by $\Delta\phi$, and the resistance of the coil is R , prove that the charge flown in the coil during the flux change is $\frac{\Delta\phi}{R}$. (Note : It is independent of the time taken for the change.)

A 11. The flux of magnetic field through a closed conducting loop of resistance 0.4 Ω changes with time according to the equation $\Phi = 0.20t^2 + 0.40t + 0.60$ where t is time in seconds. Find (i) the induced emf at t = 2s. (ii) the average induced emf in t = 0 to t = 5 s. (iii) charge passed through the loop in t = 0 to t = 5s (iv) average current in time interval t = 0 to t = 5 s (v) heat produced in t = 0 to t = 5s.

A 12. A wire - loop confined in a plane is rotated in its own plane with some angular velocity. A uniform magnetic field exist in the region. Find the emf induced in the loop

A 13. A closed circular loop of 200 turns of mean diameter 50 cm & having a total resistance of 10 Ω is placed with its plane at right angles to a magnetic field strength 10^{-2} Tesla. Calculate the quantity of electric charge passing through it when the coil is turned through 180º about an axis in its plane.

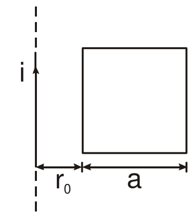
A 14. A solenoid has a cross sectional area of 6.0×10^{-4} m^2, consists of 400 turns per meter, and carries a current of 0.40 A. A 10 turn coil is wrapped tightly around the circumference of the solenoid. The ends of the coil are connected to a 1.5 Ω resistor. Suddenly, a switch is opened, and the current in the solenoid dies to zero in a time 0.050 s. Find the average current in the coil.

A 15. A heart pacing device consists of a coil of 50 turns & radius 1 mm just inside the body with a coil of 1000 turns & radius 2 cm placed concentrically just outside the body. Calculate the induced EMF in the internal coil, if a current of 1A in the external coil collapses in 10 milliseconds.

A 16. Figure illustrates plane figures made of thin conductors which are located in a uniform magnetic field directed away from a reader beyond the plane of the drawing. The magnetic induction starts diminishing. Find how the currents induced in these loops are directed.

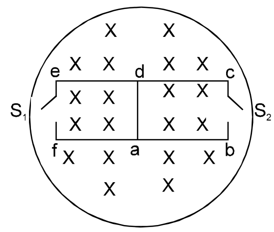
(a) (b) (c) (d)

A 17. An infinitely long straight conductor lies in the plane of a square loop with an ohmic resistance R & a side length *a* at a distance r_0 parallel to one of the loop's sides. The current flowing in the conductor varies according to the law $i = \alpha t^3$ where α is constant. Find the current in the loop at time t.



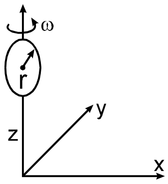
A 18. Prove that the emf induced in a wire of any shape in a uniform magnetic field $\vec{B}$ has magnitude $\left|\vec{V}.(\vec{B}\times\vec{L})\right|$ where $\vec{V}$ is the velocity of the wire and $\vec{L}$ is the position vector of one end of the wire relative to the other end.

A 19. The magnetic field in the cylindrical region shown in figure increases at a constant rate of 20.0 m T/s. Each side of the square loop acid and defa has a length of 1.00 cm and resistance of 4.00 Ω Find the current (magnitude and sense) in the wire ad if (a) the switch S is closed but S_2 is open (b) S_1 is open but S_2 is closed (c) both S_1 and S_2 are open and (d) both S_1 and S_2 are closed.

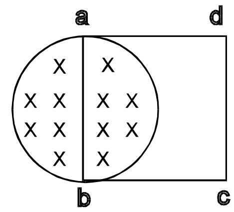


A 20. A circular loop of radius *r* is fixed to a rotation axis along the z direction, so that the plane of the loop always perpendicular to the xy plane. The loop is rotating in anticlockwise sense with angular velocity ω, at t = 0 loop lies in yz plane. Given a uniform & constant externally applied magnetic field B. $\vec{B}$

$= B\left(\cos\alpha\hat{i} + \sin\alpha\hat{k}\right)$. Evaluate the magnetic flux $\phi(t)$ through the loop & EMF $\varepsilon(t)$ induced in the loop.



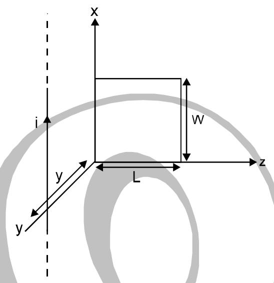
A 21. A uniform magnetic field B exist in a cylindrical region or radius 10cm as shown in figure. A uniform wire of length 80 cm and resistance 4.0 Ω is bent into a square frame and is placed with one side along a diameters of the cylindrical region. If the magnetic field increases at a constant rate of 0.010 T/s find the current induced in the frame.



A 23. A constant current I is flowing in a circular ring 1 of radius R. A second ring 2 whose radius r is much smaller than that of the first, is moving with a constant velocity V along the axis in such a manner that the plane of the ring 2 remains parallel to the plane of the ring 1 during the course of the motion. Find the maximum EMF induced in the ring 2.

A 24. A plane spiral with a great number N of turns wound tightly to one another is located in a uniform magnetic field perpendicular to the spiral's plane. The outside radius of the spiral's turns is equal to a. The magnetic induction varies with time as $B = B_0 \sin \omega t$, where B_0 and ω are constants. Find the amplitude of emf induced in the spiral.

A 25. In the figure, a long thin wire carrying a varying current $i = i_0 \sin \omega t$ lies at a distance y above one edge of a rectangular wire loop of length L and width W lying in the x-z plane. What emf is induced in the loop.



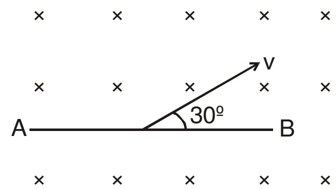
SECTION (B) : EMF IN A MOVING ROD

B 1. A conducting rod is moved with a constant velocity $\vec{\upsilon}$ in a magnetic field. A potential difference appears across the two ends

(A) if $\vec{\upsilon} \parallel \vec{I}$ (B) if $\vec{\upsilon} \parallel \vec{B}$ (C) if $\vec{I} \parallel \vec{B}$ (D) none of these

B 2. A conducting rod AB of length ℓ = 1 m is moving at a velocity v = 4 m/s making an angle 30º with its length. A uniform magnetic field B = 2T exists in a direction perpendicular to the plane of motion. Then

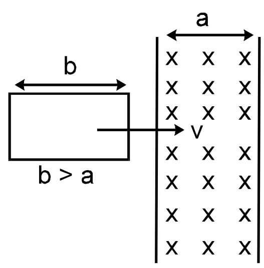
(A) $V_A - V_B = 8V$ (B) $V_A - V_B = 4V$
(C) $V_B - V_A = 8V$ (D) $V_B - V_A = 4V$



B 3. In the given arrangement, the loop is moved with constant velocity v in a uniform magnetic field B in a restricted region of width a. The time for which the emf is induced in the circuit is:

(A) $\frac{2b}{v}$ (B) $\frac{2a}{v}$

(C) $\frac{(a+b)}{v}$ (D) $\frac{2(a-b)}{v}$



B 4 A solid conducting sphere of radius R is moved with a velocity V in a uniform magnetic field of strength B such that $\vec{B}$ is perpendicular to $\vec{V}$. The maximum e.m.f. induced between two points of the sphere is :

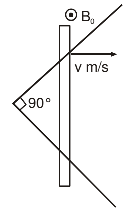
(A) 2 R B V (B) RBV (C) $\sqrt{2}$ RBV (D) $\frac{RBV}{2}$

B 5 A vertical rod of length ℓ is moved with constant velocity v towards East. The vertical component of the earth's magnetic field is B and the angle of dip is θ. The induced e.m.f. in the rod is:

(A) B lv cot θ (B) B lv sin θ (C) B lv tan θ (D) B lv cos θ

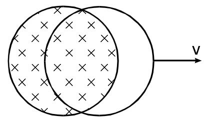
B 6 A uniform magnetic field exists in region given by $\vec{B} = 3\hat{i} + 4\hat{j} + 5\hat{k}$. A rod of length 5 m is placed along y−axis is moved along x−axis with constant speed 1 m/sec. Then induced e.m.f. in the rod will be:
(A) zero (B) 25 v (C) 20 v (D) 15 v

B 7. Two straight conducting rails form a right angle where their ends are joined. A conducting bar in contact with the rails starts from vertex at the time t = 0 & moves with a constant velocity of v m/s to the right as shown in figure. A magnetic field B = B_0 (Tesla) points out of the page. Calculate:

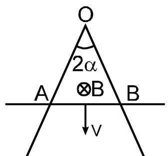


(a) The flux through the triangle formed by the rails & bar at t = 3.0 s.
(b) The EMF around the triangle at that time.
(c) In what manner does the EMF around the triangle vary with time.

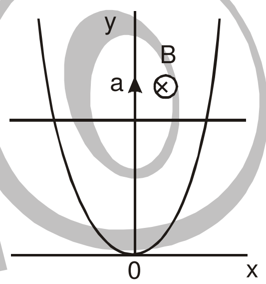
B 8. A uniform magnetic field of induction B exists in a circular region of radius R. A loop of radius R encloses the magnetic field at t = 0 and then pulled at a uniform speed v in the plane of the paper. Find the direction of induced current and induced EMF in the loop as a function of time.



B 9. A straight wire with a resistance of r per unit length is bent to form an angle 2α. A rod of the same wire perpendicular to the angle bisector (of 2α) forms a closed triangular loop. This loop is placed in a uniform magnetic field of induction B. Calculate the current in the loop when the rod moves at a constant speed V.



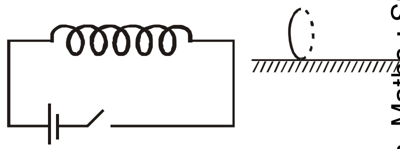
B 10. A wire bent as a parabola y = kx² is located in a uniform magnetic field of induction B, the vector B being perpendicular to the plane x, y. At the moment t = 0 a connector starts sliding translation wise from the parabola apex with a constant acceleration a (figure). Find the emf of electromagnetic induction in the loop thus formed as a function of y.



B 11. A Π-shaped conductor is located in a uniform magnetic field perpendicular to the plane of the conductor and varying with time at the rate $\frac{dB}{dt}$ = 0.10 T/s. A conducting connector starts moving with an acceleration w = 10 cm/s² along the parallel bars of the conductor. The length of the connector is equal to ℓ = 20 cm. Find the emf induced in the loop t = 2.0 s after the beginning of the motion, if at the moment t = 0 the loop area and the magnetic induction are equal to zero. The self inductance of the loop is to be neglected.

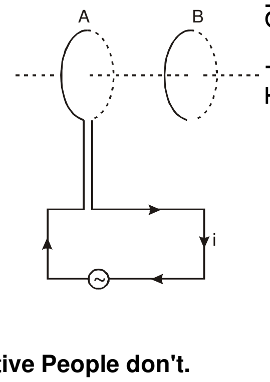
SECTION (C) : LENZ'S LAW

C 1. Fig. shown a horizontal solenoid connected to a battery and a switch. A copper ring is place on a frictionless track, the axis of the ring being along the axis of the solenoid. As the switch is closed, the ring will



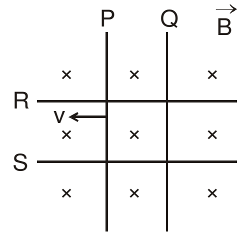
(A) remain stationer
(B) move towards the solenoid
(C) move away from the solenoid
(D) move towards the solenoid or away from it depending on

C 2. 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.

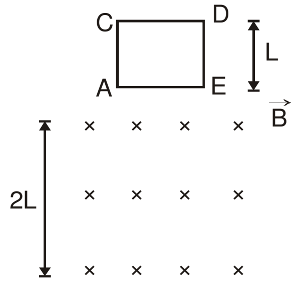
C 3. Two identical conductors P and Q are placed on two frictionless fixed conducting rails R and S in a uniform magnetic field directed into the plane. If P is moved in the direction shown in figure with a constant speed, then rod Q



(A) will be attracted towards P (B) will be repelled away from P
(C) will remain stationary (D) may be repelled or attracted towards P

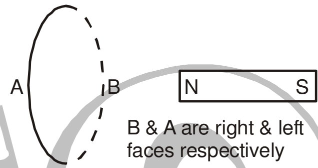
C 4. Two identical coaxial circular loops carry a current i each circulating in the same direction. If the loops approach each other
(A) the current in each loop will decrease (B) the current in each loop will increase
(C) the current in each loop will remain the same
(D) the current in one loop will increase and in the other loop will decrease

C 5. A square coil ACDE with its plane vertical is released from rest in a horizontal uniform magnetic field $\vec{B}$ of length 2L. The acceleration of the coil is



(A) less than g for all the time till the loop crosses the magnetic field completely
(B) less than g when it enters the field and greater than g when it comes out of the field
(C) g all the time
(D) less than g when it enters and comes out of the field but equal to g when it is within the field

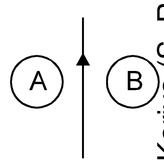
C 6. In the figure shown, the magnet is pushed towards the fixed ring along the axis of the ring and it passes through the ring.



(A) when magnet goes towards the ring the face B becomes south pole and the face A becomes north pole
(B) when magnet goes away from the ring the face B becomes north pole and the face A becomes south pole
(C) when magnet goes away from the ring the face A becomes north pole and the face B becomes south pole
(D) the face A will always be a north pole.

C 7. A metallic ring (non magnetic) with a small cut is held horizontally and a magnet is allowed to fall vertically through the ring, then the acceleration of the magnet is :
(A) always equal to g
(B) initially less than g but greater than g once it passes through the ring
(C) initially greater than g but less than g once it passes through the ring
(D) always less than g

C 8. A and B are two metallic rings placed at opposite sides of an infinitely long straight conducting wire as shown. If current in the wire is slowly decreased, the direction of induced current will be :

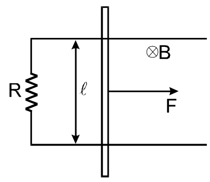


(A) clockwise in A and anticlockwise in B (B) anticlockwise in A and clockwise in B
(C) clockwise in both A and B (D) anticlockwise in both A & B

C 9. A bar magnet is released from rest along the axis of a very long, vertical copper tube. After some time the magnet
(A) will stop in the tube (B) will move with almost constant speed
(C) will move with an acceleration g (D) will oscillate

SECTION (D) : CIRCUIT PROBLEMS & MECHANICS

D 1 A constant force F is being applied on a rod of length 'l' kept at rest on two parallel conducting rails connected at ends by resistance R in uniform magnetic field B as shown.

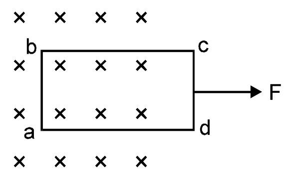


(A) the power delivered by force will be constant with time
(B) the power delivered by force will be increasing first and then will decrease
(C) the rate of power delivered by the external force will be increasing continuously
(D) the rate of power delivered by external force will be decreasing continuously.

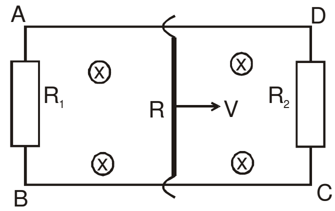
D 2 BACD is a fixed conducting smooth rail placed in a vertical plane . PQ is a conducting rod which is free to slide on the rails. A horizontal uniform magnetic field exists in space as shown. If the rod PQ in released from rest then,

(A) The rod PQ will move downward with constant acceleration
(B) The rod PQ will move upward with constant acceleration
(C) The rod will move downward with decreasing acceleration and finally acqcure a constant velocity
(D) either A or B.

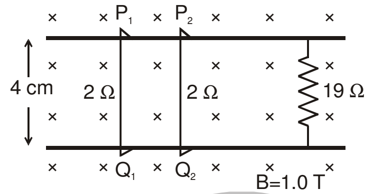
D-3. A rectangular frame of wire abcd has dimensions 32 cm × 8.0 cm and a total resistance of 2.0 Ω. It is pulled out of a magnetic field B = 0.02 T by applying a force of 3.2×10^{-5} N (figure). It is found that the frame moves with constant speed. Find (a) this constant speed, (b) the emf induced in the loop, (c) the potential difference between the points a and b and (d) the potential difference between the points c and d.



D-4. A rectangular loop with a sliding connector of length ℓ is located in a uniform magnetic field perpendicular to the loop plane (figure). The magnetic induction is equal to B. The connector has an electric resistance R, the sides AB and CD have resistances R_1 and R_2 respectively. Neglecting the self-inductance of the loop, find the current flowing in the connector during its motion with a constant velocity v.

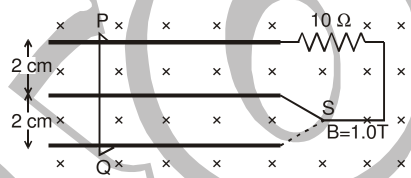


D 5. Consider the situation shown in figure. The wires P_1Q_1 and P_2Q_2 are made to slide on the rails with the same speed 5 cm/s. Find the electric current in the 19 Ω resistor if (a) both the wires move towards right and (b) if P_1Q_1 moves towards left but P_2Q_2 moves towards right.

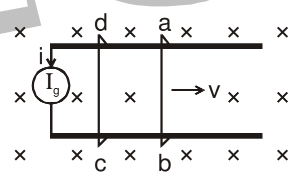


D 6. Suppose the 19Ω resistor of the previous problem is disconnected. Find the current through P_2Q_2 in the two situations (a) and (b) of that problem.

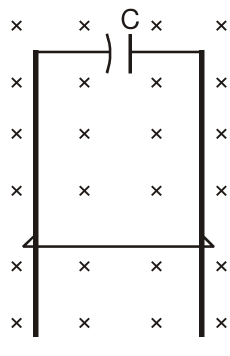
D 7. Consider the situation shown in figure. The wire PQ has a negligible resistance and is made to slide on the three rails with a constant speed of 5 cm/s. Find the current in the 10 Ω resistor when the switch S is thrown to (a) the middle rail (b) bottom rail.



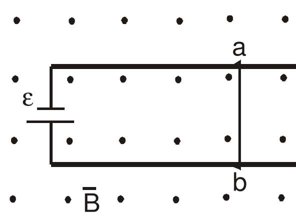
D 8. The current generator I_g, shown in figure, sends a constant current i through the circuit. The wire cd is fixed and ab is made to slide on the smooth, thick rails with a constant velocity v towards right. Each of these wires has resistance r. Find the current through the wire cd.



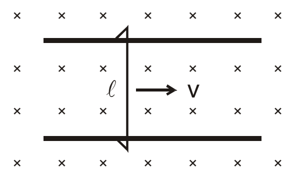
D 9. A wire of mass m and length ℓ can slide freely on a pair of smooth, vertical rails (figure). A magnetic field B exists in the region in the direction perpendicular to the plane of the rails. The rails are connected at the top end by an initially uncharged capacitor of capacitance C. Find the acceleration of the wire neglecting any electric resistance.



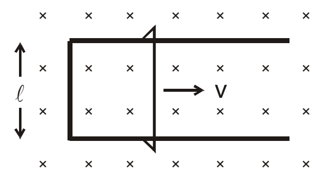
D 10. Figure shows a smooth pair of thick metallic rails connected across a battery of emf ε having a negligible internal resistance. A wire ab of length ℓ and resistance r can slide smoothly on the rails. The entire system lies in a horizontal plane and is immersed in a uniform vertical magnetic field B. At an instant t, the wire is given a small velocity v towards right. (a) Find the current in the wire at this instant. (b) What is the force acting on the wire at this instant. Show that after some time the wire ab will slide with a constant velocity. Find this velocity.



D 11. Figure shows a wire sliding on two parallel, conducting rails placed at a separation ℓ. A magnetic field B exists in a direction perpendicular to the plane of the rails. What force is necessary to keep the wire moving at a constant velocity v?

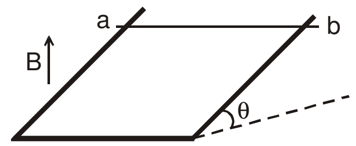


D 12. Figure shows a long U-shaped wire of width ℓ placed in a perpendicular magnetic field B. A wire of length ℓ is slid on the U-shaped wire with a constant velocity v towards right. The resistance of all the wires is r per unit length. At t = 0, the sliding wire is close to the left edge of the U-shaped wire. Draw an equivalent circuit diagram at time t , showing the induced emf as a battery. Calculate the current in the circuit.



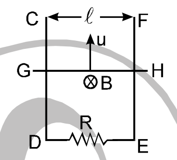
D 13. Consider the situation of the previous problem. (a) Calculate the force needed to keep the sliding wire moving with a constant velocity v. (b) If the force needed just after t = 0 is F_0, find the time at which the force needed will be $F_0/2$.

D 14. A wire ab of length ℓ, mass m and resistance R slides on a smooth, thick pair of metallic rails joined at the bottom as shown in figure. The plane of the rails makes an angle θ with the horizontal. A vertical magnetic field B exists in the region. If the wire slides on the rails at a constant speed v,

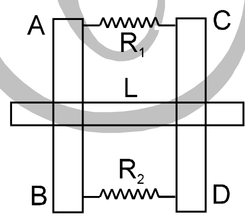


show that $B = \sqrt{\dfrac{mg\,R\,\sin\theta}{v\ell^2\cos^2\theta}}$

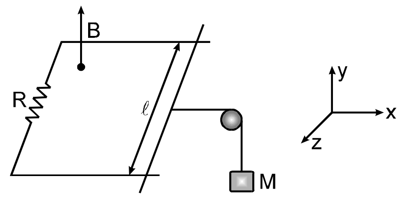
D 15. In the figure, CDEF is a fixed conducting smooth frame in vertical plane. A conducting uniform rod GH of mass 'm' can move vertically and smoothly without losing contact with the frame. GH always remains horizontal. It is given velocity 'u' upwards and released. Taking the acceleration due to gravity as 'g' and assuming that no resistance is present other than 'R'. Find out time taken by rod to reach the highest point.



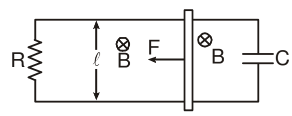
D 16. Two parallel vertical metallic rails AB and CD are separated by 1 m. They are connected at the two ends by resistance R_1 and R_2 as shown in the figure. A horizontal metallic bar L of mass 0.2 kg slides without friction, vertically down the rails under the action of gravity. There is a uniform horizontal magnetic field of 0.6T perpendicular to the plane of the rails. It is observed that when the terminal velocity is attained, the power dissipated in R_1 and R_2 are 0.76 W and 1.2 W respectively. Find the terminal velocity of bar L and value R_1 and R_2.



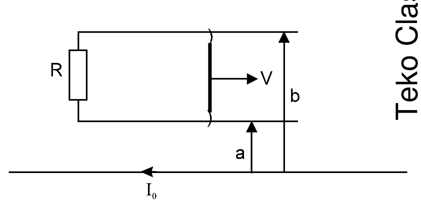
D 17. A bar of mass m is pulled horizontally (in xz plane) across a set of parallel rails by a massless string that passes over an ideal pulley and is attached to a freely suspended mass M. At t = 0 bar is at rest. Find the horizontal speed of the bar as a function of time t. B is constant and is along +y axis.



D 18. Two parallel long smooth conducting rails separated by a distance ℓ are connected by a movable conducting connector of mass 'm'. Terminals of the rails are connected by the resistor R & the capacitor C as shown. A uniform magnetic field B perpendicular to the plane of the rails is switched on. The connector is dragged by a constant force F. Find the speed of the connector as function of time if the force F is applied at t = 0. Also find the terminal velocity of the connector.



D 19. A long straight wire carries a current I_0. at distance a and b from it there are two other wires, parallel to the former one, which are interconnected by a resistance R (figure). A connector slides without friction along the wires with a constant velocity v. Assuming the resistances of the wires, the connector, the sliding contacts, and the self-inductance of the frame to be negligible, find;



(a) The magnitude and the direction of the current induced in the connector;
(b) The force required to maintain the connector's velocity constant.
(c) Point of application of magnetic force on sliding wire due to the long wire.

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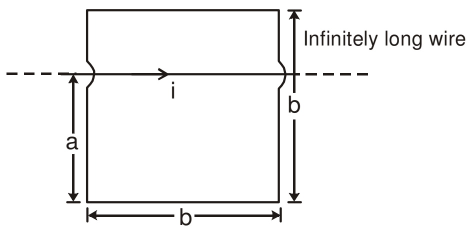
SECTION (E) : EMF INDUCED IN A ROD OR LOOP IN NONUNIFORM MAGNETIC FIELD

E 1 For the situation shown in the figure, flux through the square loop is :

(A) $\left(\frac{\mu_0 ia}{2\pi}\right)\ell n\left(\frac{a}{2a-b}\right)$ (B) $\left(\frac{\mu_0 ib}{2\pi}\right)\ell n\left(\frac{a}{a-2b}\right)$

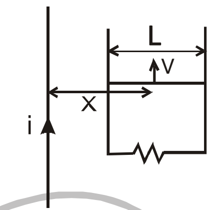
(C) $\left(\frac{\mu_0 ib}{2\pi}\right)\ell n\left(\frac{a}{b-a}\right)$ (D) $\left(\frac{\mu_0 ia}{2\pi}\right)\ell n\left(\frac{2a}{a-b}\right)$



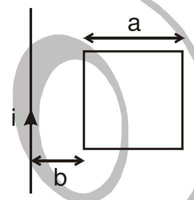
E-2. A circular copper-ring of radius r translates in its plane with a constant velocity v. A uniform magnetic field B exists in the space in a direction perpendicular to the plane of the ring. Consider different pairs of diametrically opposite points on the ring. (a) Between which pair of points is the emf maximum? (b) Between which pair of points is the emf minimum? What is the value of this minimum emf?

E 3. The magnetic field in a region is given by $\vec{B} = \hat{k}\frac{B_0}{L}$ y where L is a fixed length. A conducting rod of length L lies along the Y-axis between the origin and the point (0, L, 0). If the rod moves with a velocity $v = v_0\vec{i}$, find the emf induced between the ends of the rod.

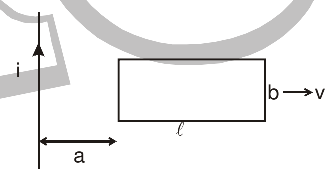
E 4. A conducting rod slides on a pair of thick metallic rails laid parallel to an infinitely long fixed wire carrying a constant current i. The center of the rod is at a distance x from the wire. The ends of the rails are connected by resistor of resistance R. (a) What force is needed to keep the rod sliding at a constant speed v, as shown in figure ? (b) In this situation what is the current in the resistance R ? (c) Find the rate of heat developed in the resistor. (d) Find the power delivered by the external agent exerting the force on the rod.



E 5. Figure shows a square frame of wire having a total resistance r placed complanarly with a long, straight wire. The wire carries a current i given by $i = i_0 \sin \omega t$. Find (a) the flux of the magnetic field through the square frame, (b) the emf induced in the frame and (c) the heat developed in the frame in the time interval 0 to $\frac{20\pi}{\omega}$.

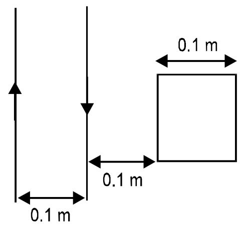


E 6. A rectangular metallic loop of length l and width b is placed complanary with a long wire carrying a current i (figure). The loop is moved perpendicular to the wire with a speed v in the plane containing the wire and the loop. Calculate the emf induced in the loop when the rear end of the loop is at a distance a from the wire. Solve by using Faraday's law for the flux through the loop and also by replacing different segments with equivalent batteries.



E 7. A current of 10 A is flowing in a long straight wire situated near a rectangular circuit whose two side of length 0.2 m are parallel to the wire. One of them is at a distance of 0.05 m and the other at a distance of 0.1 m from the wire. The wire is in plane of the rectangle. Find the magnetic flux through the rectangular circuit. If the current decays uniformly to zero in 0.02 sec, find the EMF induced in the circuit and indicate the direction in which the induced current flow.

E 8. Two infinite long straight parallel wires A and B are separated by 0.1 m distance and carry equal current in opposite directions. A square loop of wire C of side 0.1 m lies in the plane A and B. The loop of wire C is kept parallel to both A and B at a distance of 0.1 m from the nearest wire. Calculate the EMF induced in loop C while the current in A and B is increasing at the same rate of 10^3 As^{-1}. Also indicate the direction of current in loop C



SECTION (F) : INDUCED EMF IN A ROD, RING, DISC ROTATING IN A UNIFORM MAGNETIC FIELD

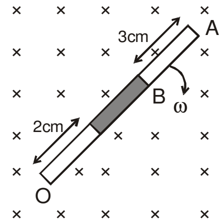
F 1. A rod a length l rotates with a small but uniform angular velocity ω about its perpendicular bisector. A uniform magnetic field B exists parallel to the axis of rotation. The potential difference between the centre of the rod and an end is

(A) zero (B) $\frac{1}{8}\omega Bl^2$ (C) $\frac{1}{2}\omega Bl^2$ (D) $B\omega l^2$

F 2. A rod of length l rotates with a uniform angular velocity ω about its perpendicular bisector. A uniform magnetic field B exists parallel to the axis of rotation. The potential difference between the two ends of the rod is

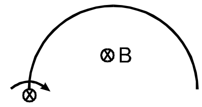
(A) zero (B) $\frac{1}{2}\omega Bl^2$ (C) $B\omega l^2$ (D) $2B\omega l^2$

F 3. A rod of length 10 cm made up of conducting and non-conducting material (shaded part is non-conducting). The rod is rotated with constant angular velocity 10 rad/sec about point O, in constant magnetic field of 2 tesla as shown in the figure. The induced emf between the point A and B of rod will be



(A) 0.029 v (B) 0.1 v (C) 0.051 v (D) 0.064 v

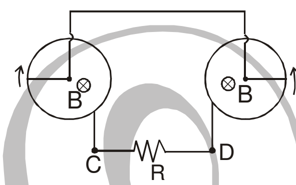
F 4. A semicircular wire of radius R is rotated with constant angular velocity ω about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength B. The induced e.m.f. between the ends is:



(A) B $\omega R^2/2$ (B) 2 B ωR^2 (C) is variable (D) none of these

F 5. Two identical cycle wheels (geometrically) have different number of spokes connected from centre to rim. One is having 20 spokes and other having only 10 (the rim and the spokes are resistanceless). One resistance of value R is connected between centre and rim. The current in R will be:
(A) double in first wheel than in the second wheel
(B) four times in first wheel than in the second wheel
(C) will be double in second wheel than that of the first wheel
(D) will be equal in both these wheels.

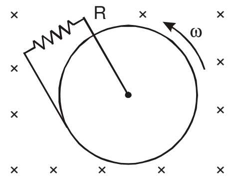
F 6. In the figure there are two identical conducting rods each of length 'a' rotating with angular speed ω in the directions shown. One end of each rod touches a conducting ring. Magnetic field B exists perpendicular to the plane of the rings. The rods, the conducting rings and the lead wires are resistanceless. Find the magnitude and direction of current in the resistance R.



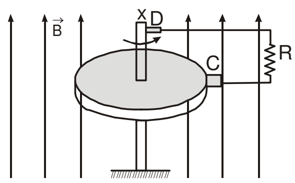
F 7. A circular coil of one turns of radius 5.0 cm is rotated about a diameter with a constant angular speed of 80 revolutions per minute. A uniform magnetic field B = 0.010 T exists in a direction perpendicular to the axis of rotation. Find (a) the maximum emf induced. (b) the average emf induced in the coil over a long period and (c) the average of the squares of emf induced over a long period.

F 8. A bicycle is resting on its stand in the east-west direction and the rear wheel is rotated at an angular speed of 100 revolutions per minute. If the length of each spoke is 30.0 cm and the horizontal component of the earth's magnetic field is 2.0×10^{-5} T, find the emf induced between the axis and the outer end of a spoke. Neglect centrepetal force acting on the free electrons of the spoke.

F 9. Figure shows a conducting disc rotating about its axis in a perpendicular magnetic field B. A resistor of resistance R is connected between the centre and the rim. Calculate the current in the resistor. Does it enter the disc or leave it at the centre ? The radius of the disc is 5.0 cm, angular speed ω = 10 rad/s, B = 0.40 T and R = 10 Ω.

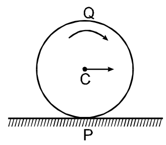


F 10. A metal disc of radius r = 0.1m is placed perpendicular to a uniform magnetic field of induction B = 0.50 T. It is capable of rotation about an axis XY parallel to the induction B, the axis is passing through its centre. Using sliding contacts C & D the disc is connected to a resistance R = 2.5 Ω. Determine the mechanical power required in rotating the disc if a current of 0.10 A flows through R. Also find the angular velocity of rotation of the disc. Friction can be neglected.



F 11. A thin wire & a small spherical bob constitute a simple pendulum of effective length ℓ. If this pendulum is made to swing through a semi-vertical angle θ, under gravity in a plane normal to a uniform magnetic field of induction B, find the maximum potential difference between the ends of the wire.

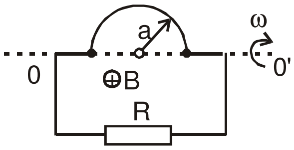
F 12. A conducting disc of radius R is rolling without sliding on a horizontal surface with a constant velocity 'v'. A uniform magnetic field of strength B is applied normal to the plane of the disc. Find the EMF induced between
(a) P & Q (b) P & C.
(C is centre, P&Q are opposite points on vertical diameter of the disc)



F 13. A circular coil of one turns of radius 5.0 cm is rotated about a diameter with a constant angular speed of 80 revolutions per minute A uniform magnetic field B = 0.010 T exists in a direction perpendicular to the axis of rotation. Find (a) the maximum emf induced. (b) the average emf induced in the coil over a long period and (c) the average of the squares of emf induced over a long period.

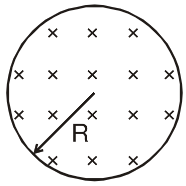
F 14. Suppose the ends of the coil in the previous problem are connected to a resistance of 100 Ω. Neglecting the resistance of the coil find the heat produced in the circuit in one minute.

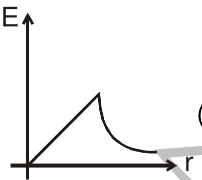
F 15. A wire shaped as a semi-circle of radius a rotates about an axis OO' with an angular velocity ω in a uniform magnetic field of induction B (figure). The rotation axis is perpendicular to the field direction. The total resistance of the circuit is equal to R. Neglecting the magnetic field of the induced current, find the mean amount of thermal power being generated in the loop during a rotation period.

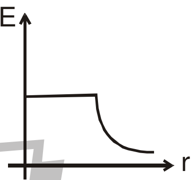


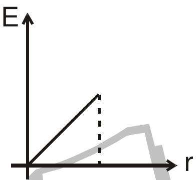
SECTION (G) : FIXED LOOP IN A TIME VARYING MAGNETIC FIELD & INDUCED ELECTRIC FIELD

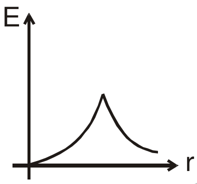
G 1. A cylindrical space of radius R is filled with a uniform magnetic induction B parallel to the axis of the cylinder. If B changes at a constant rate, the graph showing the variation of induced electric field with distance r from the axis of cylinder is



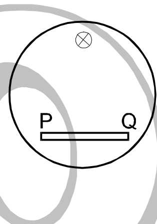
(A) 

(B) 

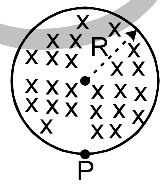
(C) 

(D) 

G. 2 In a cylindrical region uniform magnetic field which is perpendicular to the plane of the figure is increasing with time and a conducting rod PQ is placed in the region. Then
(A) P will be at higher potential than Q.
(B) Q will be at higher potential than P.
(C) Both P and Q will be equipotential.
(D) no emf will be developed across rod as it is not crossing / cutting any line of force.

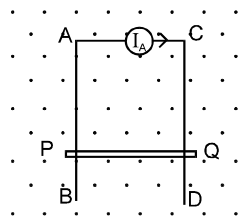


G 3 A uniform magnetic field of induction B is confined to a cylindrical region of radius R. The magnetic field is increasing at a constant rate of $\frac{dB}{dt}$ (tesla/second). An electron of charge q, placed at the point P on the periphery of the field experiences an acceleration :



(A) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward left
(B) $\frac{1}{2}\frac{eR}{m}\frac{dB}{dt}$ toward right
(C) $\frac{eR}{m}\frac{dB}{dt}$ toward left
(D) zero

G 4 AB and CD are fixed conducting smooth rails placed in a vertical plane and joined by a constant current source at its upper end. PQ is a conducting rod which is free to slide on the rails. A horizontal uniform magnetic field exists in space as shown. If the rod PQ in released from rest then,
(A) The rod PQ will move downward with constant acceleration
(B) The rod PQ will move upward with constant acceleration
(C) The rod will move downward with decreasing acceleration and finally acqcure a constant velocity
(D) either A or B.



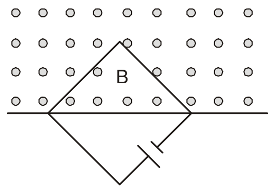
G 5. A circular loop of radius 1m is placed in a varying magnetic field given as B = 6t Tesla. Find the emf induced in the coil if the plane of the coil is perpendicular to the magnetic field.

G 6. In the above question find the average electric field in the tangential direction, induced due to the changing magnetic field.

G 7. In the above question find the current in the loop if its resistance is1Ω/m.

G 8. The current in an ideal, long solenoid is varied at a uniform rate of 0.01 A/s. The solenoid has 2000 turns/m and its radius is 6.0 cm. (a) Consider a circle of radius 1.0 cm inside the solenoid with its axis coinciding with the axis of the solenoid. Write the change in the magnetic flux through this circle in 2.0 seconds. (b) Find the electric field induced at a point on the circumference of the circle. (c) Find the electric field induced at a point outside the solenoid at a distance 8.0 cm from its axis.

G 9. A square wire loop with 2 m sides in perpendicular to a uniform magnetic field, with half the area of the loop in the field. The loop contains a 20 V battery with negligible internal resistance. If the magnitude of the field varies with time according to B = 2 – 4 t, with B in Tesla & t in sec.
(a) What is the total EMF in the circuit ?
(b) What is the direction of the current ?

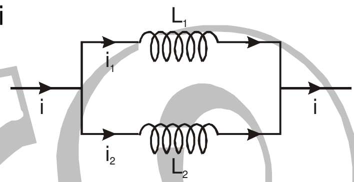


SECTION (H) : SELF INDUCTION, SELF INDUCTANCE SELF INDUCED EMF & MAGNETIC ENERGY DENSITY

H 1.* Two different coils have self-inductance L_1 = 8 mH, L_2 = 2 mH. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same 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) $\frac{V_2}{V_1} = \frac{1}{4}$

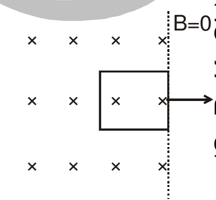
H 2. Two inductors L_1 and L_2 are connected in parallel and a time varying current i flows as shown. The ratio of currents i_1/i_2 at any time t is



(A) L_1/L_2 (B) L_2/L_1 (C) $\frac{L_1^2}{(L_1+L_2)^2}$ (D) $\frac{L_2^2}{(L_1+L_2)^2}$

H 3*. A constant current i is maintained in a solenoid. Which of the following quantities will increase if an iron rod is inserted in the solenoid along axis ?
(A) magnetic field at the centre (B) magnetic flux linked with the solenoid
(C) self-inductance of the solenoid (D) rate of Joule heating

H 4. Figure shows a square loop of side 0.5 m and resistance 10 Ω. The magnetic field has a magnitude B = 1.0T. The work done in pulling the loop out of the field uniformly in 2.0 s is
(A) 3.125×10^{-3} J (B) 6.25×10^{-4} J
(C) 1.25×10^{-2} J (D) 5.0×10^{-4} J

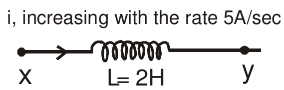


H 5. A coil of inductance 1 H and negligible resistance is connected to a source of supply whose voltage is given by V = 4t volt. If the voltage is applied when t = 0, then find the energy stored in the coil in 4 second.
(A) 512 J (B) 256 J (C) 1024 J (D) 144 J

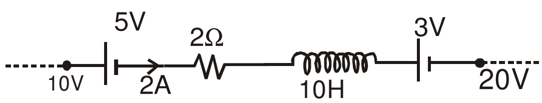
H 6. The dimensions of the quantity L/(RCV) is.................

H 7. Find the self inductance of a solenoid which has 10 turns per cm. Its length is 1m and radius 1 cm.

H 8. The figure shows an inductor of 2 H through which a current which is increasing at the rate of 5A/sec, is flowing. Find the potential difference V_X-V_Y.



H 9. Figure shows a part of a circuit. Find the rate of change of the current, shown.



H 10. An average emf of 20 V is induced in an inductor when the current in it is changed from 2.5 A in one direction to the same value in the opposite direction in 0.1 s. Find the self-inductance of the inductor.

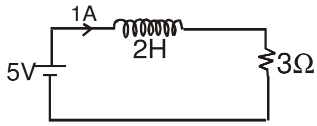
H 11. A magnetic flux of 8 x 10^{-4} weber is linked with each turn of a 200 turn coil when there is an electric current of 4A in it. Calculate the self-inductance of the coil.

H 12. The current in a solenoid of 240 turns, having a length of 12 cm and a radius of 2 cm, changes at a rate of 0.8 A/s. Find the self emf induced in it.

H 13. Current in an inductor of self inductance 6H changes from 1A to 2A in 1 sec. Find the increase in the stored energy in the inductor.

H 14. Find the rate of increase in the stored energy at t= 1sec in an inductor 5H if the current passing through it is given as $i = 2t^3 + 5t$.

H 15. In the circuit shown find (a) the power drawn from the cell, (b) the power consumed by the resistor which is converted into heat and (c) the power given to the inductor.



H 16. A current of 1.0 A is established in a tightly wound solenoid of radius 2 cm having 1000 turns/metre. Find the magnetic energy stored in each metre of the solenoid.

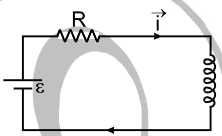
H 17. Consider a small cube of volume 1 mm^3 at the centre of a circular loop of radius 10 cm carrying a current of 4A. Find the magnetic energy stored inside the cube.

H 18. A long wire carries a current of 4.00 A. Find the energy stored in the magnetic field inside a volume of 1.00 mm^3 at a distance of 10.0 cm from the wire.

H 19. A long wire carries a current of uniform density. Let i be the total current carried by the wire. Show that the magnetic energy per unit length stored within the wire equals $\frac{\mu_0 i^2}{16\pi}$. (Note that it does not depend on the wire diameter).

H 20. What is the magnetic energy density (in terms of standard constant & r) at the centre of a circulating electron in the hydrogen atom in first orbit. (Radius of the orbit is r)

H 21. 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 Ω, L = 6 H & find an expression for the battery EMF as a function of time.



SECTION (I) : CIRCUIT CONTAINING INDUCTANCE, RESISTANCE & BATTERY, GROWTH AND DECAY OF CURRENT IN A CIRCUIT CONTAINING INDUCTOR

I 1. L, C and R represent the physical quantities inductance, capacitance and resistance combinations have dimensions of frequency ?

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

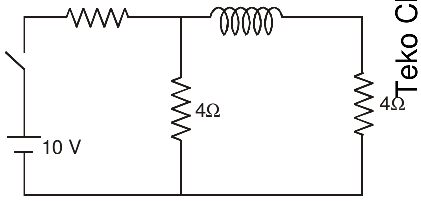
I 2. An LR circuit with a battery is connected at t =0. Which of the following quantities is not zero just after the connection ?

(A) current in the circuit
(B) magnetic field energy in the inductor
(C) power delivered by the battery
(D) emf induced in the inductor

I 3. In an LR circuit current at t = 0 is 20 A. After 2s it reduces to 18 A. The time constant of the circuit is (in second):

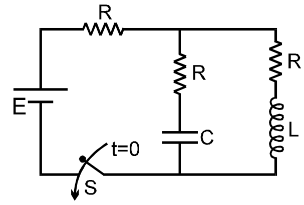
(A) $\ln\left(\frac{10}{9}\right)$ (B) 2 (C) $\frac{2}{\ln\left(\frac{10}{9}\right)}$ (D) $2\ln\left(\frac{10}{9}\right)$

I 4. 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 = ∞) current through the battery :



(A) 1.0
(B) 0.8
(C) 1.2
(D) 1.5

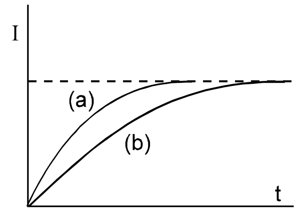
I 5. In the circuit shown in figure, switch S is closed at t = 0. Then:



(A) after a long time interval potential difference across capacitor and inductor will be equal.
(B) after a long time interval charge on capacitor will be E C.
(C) after a long time interval current in the inductor will be E /R.
(D) after a long time interval current through battery will be same as the current through it initially.

I 6. In a series L–R growth circuit, if maximum current and maximum induced emf in an inductor of inductance 3mH are 2A and 6V respectively, then the time constant of the circuit is :
(A) 1 ms. (B) 1/3 ms. (C) 1/6 ms (D) 1/2 ms

I 7*. A circuit consisting of a constant e.m.f. 'E', a self induction 'L' and a resistance 'R' is closed at t = 0. The relation between the current I in the circuit and time t is as shown by curve 'a' in the figure. When one or more of parameters E, R & L are changed, the curve 'b' is obtained.The steady state current is same in both the cases. Then it is possible that:



(A) E & R are kept constant and L is increased.
(B) E & R are kept constant and L is decreased
(C) E & R are both halved and L is kept constant
(D) E & L are kept constant and R is decreased

I 8. A solenoid of resistance 50 Ω and inductance 80 Henry is connected to a 200 V battery. How long will the current take to reach 50 % of its final equilibrium value? Calculate the maximum energy stored.

I 9. Find the value of t/τ for which the current in an LR circuit builds up to (a) 90%, (b) 99% and (c) 99.9% of the steady-state value (given ℓn 10 = 2.3)
(a) 90%, (b) 99% (c) 99.9% ℓn 10 = 2.3)

I 10. An inductor-coil carries a steady-state current of 2.0 A when connected across an ideal battery of emf 4.0 V. If its inductance is 1.0 H, find the time constant of the circuit.

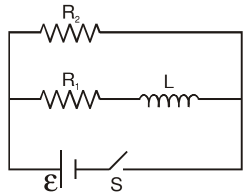
I 11. A coil of resistance 40 Ω is connected across a 4.0 V battery, 0.10 s after the battery is connected, the current in the coil is 63 mA. Find the inductance of the coil. [$e^{-1} \approx 0.37$]

I 12. (i) An LR circuit has L = 1.0 H and R = 20 Ω. It is connected across an emf of 2.0 V at t = 0. Find di/dt at (a) t = 0, (b) t = 50 ms and (c) $t \to \infty$.

(ii) What are the values of the self-induced emf in the circuit of the previous problem at the times indicated therein?

I 13. The current in a discharging LR circuit without the battery drops from 2.0 A to 1.0 A in 0.10 s. (a) Find the time constant of the circuit. (b) If the inductance of the circuit is 4.0 H, what is its resistance?

I 14. Consider the circuit shown in figure. (a) Find the current through the battery a long time after the switch S is closed. (b) Suppose the switch is opened at t = 0. What is the time constant of the decay circuit? (c) Find the current through the inductor after one time constant.

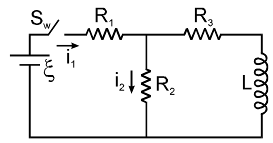


I 15. A superconducting loop of radius R has self inductance L. A uniform & constant magnetic field B is applied perpendicular to the plane of the loop. Initially current in this loop is zero. The loop is rotated about its diameter by 180º. Find the current in the loop after rotation.

I 16. Show that if two inductors with equal inductance L are connected in parallel then the equivalent inductance of the combination is L/2. The inductors are separated by a large distance.

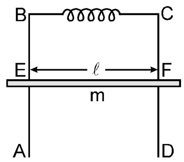
I 17. A closed circuit consists of a source of constant emf E and a choke coil of inductance L connected in series. The active resistance of the whole circuit is equal to R. It is in steady state at the moment t = 0 the choke coil inductance was decreased abruptly η times. Find the current in the circuit as a function of time t.

I 18. In figure, $\xi = 100$ V, $R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 30\ \Omega$ and $L = 2$ H. Find the value of i_1 & i_2.



(a) immediately after switch S_w is closed
(b) a long time after
(c) immediately after S_w is opened again
(d) a long time later.

I 19. A conducting frame ABCD is kept in a vertical plane. A conducting rod EF of mass m can slide smoothly on it remaining horizontal always. The resistance of the loop is negligible and inductance is constant having value L. The rod is left from rest and allowed to fall under gravity and inductor has no initial current. A uniform magnetic field of magnitude B is present throughout the loop pointing inwards. Determine.



(a) position of the rod as a function of time assuming initial position of the rod to be x = 0 and vertically downward as the positive X-axis.
(b) maximum current in the circuit
(c) maximum velocity of the rod.

SECTION (J) : MUTUAL INDUCTION & MUTUAL INDUCTANCE

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

J 2. 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) 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 2 A
(C) the change in current in B in this time interval is 8 A
(D) a change in current of 1 A in coil A will produce a change in flux passing through B by 4 Weber

J.3 A rectangular loop of sides 'a' and 'b' is placed in xy plane. A very long wire is also placed in xy plane such that side of length 'a' of the loop is parallel to the wire. The distance between the wire and the nearest edge of the loop is 'd'. The mutual inductance of this system is proportional to:
(A) a (B) b (C) 1/d (D) current in wire

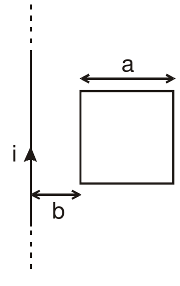
J.4 Two coils of self inductance 100 mH and 400 mH are placed very close to each other. Find the maximum mutual inductance between the two when 4 A current passes through them
(A) 200 mH (B) 300 mH (C) $100\sqrt{2}$ mH (D) none of these

J.5 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

J 6. The average emf induced in the secondary coil is 0.1 V when the current in the primary coil changes from 1 to 2 A in 0.1 s . What is the mutual inductance of the coils.

J 7. The mutual inductance between two coils is 2.5 H. It the current in one coil is changed at the rate of 1 A/s, what will be the emf induced in the other coil?

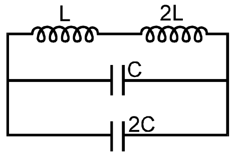
J 8. Find the mutual inductances between the straight wire and the square loop of figure.



J 9. A solenoid of length 10 cm, area of cross-section 4.0 cm^2 and having 4000 turns is placed inside another solenoid of 2000 turns having a cross-sectional area 8.0 cm^2 and length 20 cm. Find the mutual inductance between the solenoids.

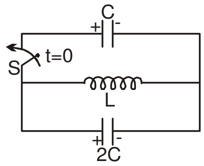
SECTION (K) : L C OSCILLATIONS

K 1. The frequency of oscillation of current in the inductor is:



(A) $\frac{1}{3\sqrt{LC}}$ (B) $\frac{1}{6\pi\sqrt{LC}}$ (C) $\frac{1}{\sqrt{LC}}$ (D) $\frac{1}{2\pi\sqrt{LC}}$

K 2. In the given LC circuit if initially capacitor C has charge Q on it and 2C has charge 2Q .The polarities are as shown in the figure. Then after closing switch S at t = 0



(A) energy will get equally distributed in both the capacitor just after closing the switch.
(B) initial rate of growth of current in inductor will be $2Q/3CL$
(C) maximum energy in the inductor will be $3Q^2/2C$
(D) none of these

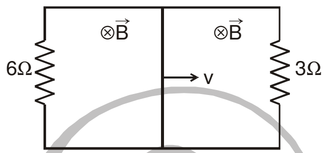
MISCLLENOUS

* **ONE OR MORE THEN ONE MAY BE CORRECT :**

1. An inductor coil stores energy U when a current i 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) $\frac{2U}{U}$

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

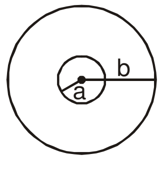


(A) 6N (B) 4N (C) 2N (D) 1N

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

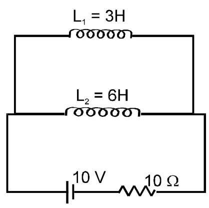
(A) $\frac{1}{4}$ A (B) $\frac{1}{2}$ A (C) $\frac{1}{3}$ A (D) zero

4. Two concentric and coplanar circular coils have radii a and b (>> a) as shown in figure. Resistance of the inner coil is R. Current in the outer coil is increased from 0 to i, then the total charge circulating the inner coil is :



(A) $\frac{\mu_0 i\pi a^2}{2Rb}$ (B) $\frac{\mu_0 iab}{2R}$ (C) $\frac{\mu_0 ia}{2a}\frac{\pi R^2}{R}$ (D) $\frac{\mu_0 ib}{2\pi R}$

5. Two inductor coils of self inductance 3H and 6H respectively are connected with a resistance 10Ω and a battery 10 V as shown in figure. The ratio of total energy stored at steady state in the inductors to that of heat developed in resistance in 10 seconds at the steady state is(neglect mutual inductance between L_1 and L_2):

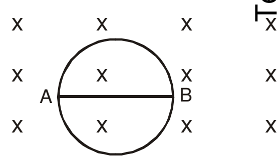


(A) $\frac{1}{10}$ (B) $\frac{1}{100}$ (C) $\frac{1}{1000}$ (D) 1

6*. A metal disc of radius a rotates with a constant angular velocity ω about its axis. The potential difference between the centre and the rim of the disc in steady state is (m = mass of electron, e = charge on electron):

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

7. The radius of the circular conducting loop shown in figure is R. Magnetic field is decreasing at a constant rate α. Resistance per unit length of the loop is ρ. Then current in wire AB is (AB is one of the diameters)

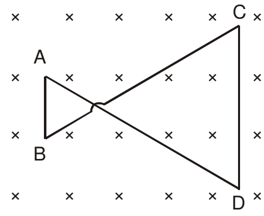


(A) $\frac{R\alpha}{2\rho}$ from A to B (B) $\frac{R\alpha}{2\rho}$ from B to A (C) $\frac{2R\alpha}{\rho}$ from A to B (D) Zero

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

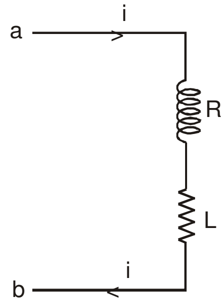
(A) $\frac{4qmR}{g}$ (B) $\frac{2qmR}{g}$ (C) $\frac{8qR}{mg}$ (D) $\frac{qR}{2mg}$

9. 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 :



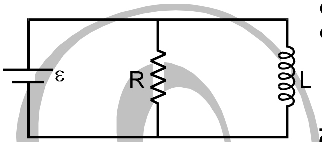
(A) B to A and D to C (B) A to B and C to D
(C) A to B and D to C (D) B to A and C to D

10. When the current in the portion of the circuit shown in the figure is 2A and increasing at the rate of 1A/s, the measured potential difference V_{ab} = 8V. However when the current is 2A and decreasing at the rate of 1A/s, the measured potential difference V_{ab} = 4V. The values of R and L are :



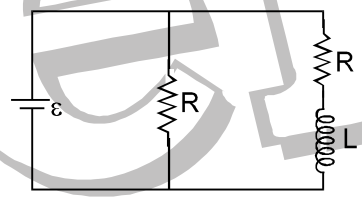
(A) 3 ohm and 2 henry respectively
(B) 2 ohm and 3 henry respectively
(C) 10 ohm and 6 henry respectively
(D) 6 ohm and 1 henry respectively

11. The battery shown in the figure is ideal. The values are ε = 10 V, R = 5Ω, L = 2H . Initially the current in the inductor is zero. The current through the battery at t = 2s is



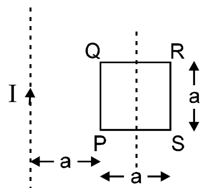
(A) 12 A (B) 7 A (C) 3 A (D) none of these

12*. In the circuit diagram shown



(A) time constant is L/R (B) time constant is 2L/R
(C) steady state current in inductor is $2\varepsilon/R$ (D) steady state current in inductor is ε/R

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



(A) $\frac{\mu_0 Ia}{2\pi r}\ \ell n2$ (B) $\frac{\mu_0 Ia}{\pi r}\ \ell n2$ (C) $\frac{\mu_0 Ia^2}{2\pi r}$

(D) cannot be found because time of rotation not give.

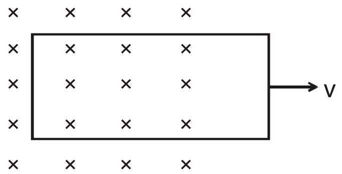
14*. A conducting loop rotates with constant angular velocity about its fixed diameter in a uniform magnetic field in a direction perpendicular to that fixed diameter.

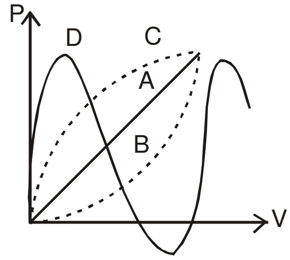
(A) The emf will be maximum at the moment when flux is zero.
(B) The emf will be '0' at the moment when flux is maximum.
(C) The emf will be maximum at the moment when plane of the loop is parallel to the magnetic field
(D) The phase difference between the flux and the emf is $\pi/2$

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

(A) zero (B) E/R (C) $4\frac{E}{R}$ (D) $\frac{E}{4R}$

16. Fig. shows a conducting loop being pulled out of a magnetic field with a constant speed v. Which of the four plots shown in fig. may represent the power delivered by the pulling agent as a function of the constant speed v.





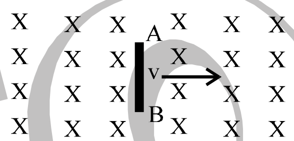
17. Two circular loops of equal radii are placed coaxially at some separation. The first is cut and a battery is insetted in between to drive a current in it. The current changes slightly because of the variation in resistance with temperature. During the period, the two loops

(A) attract each other (B) repel each other

(C) do not exert any force on each other

(D) attract or repel each other depending on the sense of the current

18. A rod AB moves with a uniform velocity v in a uniform magnetic field as shown in fig.



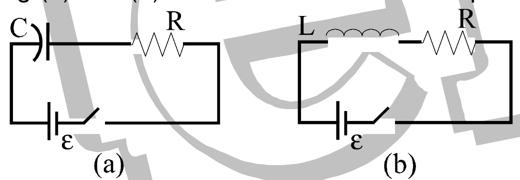
(A) The rod becomes electrically charged

(B) The end A becomes positively charged

(C) The end B become positively charged

(D) The rod becomes hot because of Joule heating

19. The switches in fig.(a) and (b) are closed at t = 0 and reopened after a long time at t = t_0.



(A) The charge on C just after t = 0 is εC. (B) The charge on C long after t = t_0 is εC.

(C) The current in L just before t = t_0 is ε/R (D) The current in L long after t = t_0 is ε/R

20. A conducting ring lies on a horizontal plane. If a charged metallic particle is released from a point (on the axis) at some height from the plane, then :

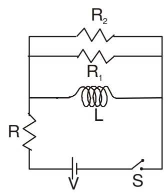
(A) an induced current will flow in clockwise or anticlockwise direction in the loop depending upon the nature of the charge

(B) the acceleration of the particle will decrease as it comes down

(C) the rate of production of heat in the ring will increase as the particle comes down

(D) no heat will be produced in the ring.

21. Switch S is closed at t = 0 as shown in the circuit. After a long time it is opened, then which of the following is correct option :



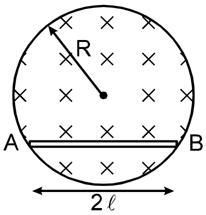
(A) total heat produced in resistor R after opening the switch is $\frac{1}{2}\frac{LV^2}{R^2}$

(B) total heat produced in resistor R_1 after opening the switch is $\frac{1}{2}\frac{LV^2}{R^2}\left(\frac{R_1}{R_1+R_2}\right)$

(C) heat produced in resistor R_1 after opening the switch is $\frac{1}{2}\frac{R_2 L V^2}{(R_1+R_2)R^2}$

(D) no heat will be produced in R_1.

22. A uniform magnetic field, $B = B_0 t$ (where B_0 is a positive constant), fills a cylindrical volume of radius R, then the emf induced in the conducting rod AB is :



(A) $B_0\ell\sqrt{R^2+\ell^2}$ (B) $B_0\ell\sqrt{R^2-\frac{\ell^2}{4}}$

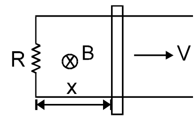
(C) $B_0\ell\sqrt{R^2-\ell^2}$ (D) $B_0R\sqrt{R^2-\ell^2}$

23. In the above question the potential difference between the points A and B of the rod is :

(A) $B_0\ell\sqrt{R^2+\ell^2}$ (B) $B_0\ell\sqrt{R^2-\frac{\ell^2}{4}}$ (C) $B_0\ell\sqrt{R^2-\ell^2}$ (D) zero

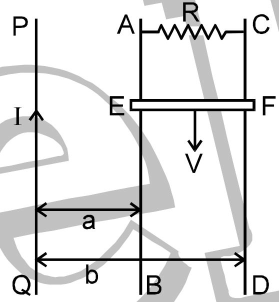
24*. A super conducting loop having an inductance 'L' is kept in a magnetic field which is varying with respect to time. If ϕ is the total flux, ε = total induced emf, then:
(A) ϕ = constant (B) I = 0 (C) $\varepsilon = 0$ (D) $\varepsilon \neq 0$

25*. A conducting rod of length ℓ slides at constant velocity 'v' on two parallel conducting rails, placed in a uniform constant magnetic field B perpendicular to the plane of the rails as shown in figure. A resistance R is connected between the two ends of the rail. Then which of the following is/are correct :



(A) The thermal power dissipated in the resistor is equal to rate of work done by external force against magnetic force on the rod.
(B) If applied external force is doubled than a part of external power increases the velocity of rod.
(C) Lenz's Law is not satisfied if the rod is accelerated by external force
(D) If resistance R is doubled then power required to maintain velocity becomes half.

26. PQ is an infinite current carrying conductor. AB and CD are smooth conducting rods on which a conductor EF moves with constant velocity V as shown. The force needed to maintain constant speed of EF is.



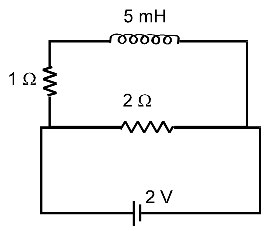
(A) $\frac{1}{VR}\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2$ (B) $\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]\frac{1}{VR}$

(C) $\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2\frac{V}{R}$ (D) $\frac{V}{R}\left[\frac{\mu_0 IV}{2\pi}\ell n\left(\frac{b}{a}\right)\right]^2$

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

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

28. When induced emf in inductor coil is 50% of its maximum value then stored energy in inductor coil in the given circuit will be : -

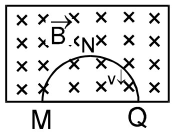


(A) 2.5 mJ (B) 5mJ (C) 15 mJ (D) 20 mJ

EXERCISE-2

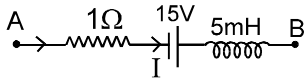
1. A solenoid has an inductance of 10 Henry and a resistance of 2 Ω. It is connected to a 10 volt battery. How long will it take for the magnetic energy to reach 1/4th of its maximum value? **[JEE - 96, 3 marks]**

2. A thin semicircular conducting ring of radius R is falling with its plane vertical in a horizontal magnetic induction $\vec{B}$. At the position MNQ the speed of the ring is v and the potential difference developed across the ring is: **[JEE - 96, 2 marks]**



(A) zero
(B) $\frac{Bv\pi R^2}{2}$ and M is at higher potential
(C) π RBV and Q is at higher potential
(D) 2 RBV and Q is at higher potential.

3. The network shown in Fig. is a part of a complete circuit. What is the potential difference $V_B - V_A$, when the current I is 5A and is decreasing at a rate of 10^3 (A/s)? **[JEE - 97,1 marks]**



4. State whether the following statement is true or false giving reason in brief.
The dimension of (h/e) is the same as that of magnetic flux ϕ. **[REE - 97]**

5. The magnetic flux through each turn of a 100 turn coil is $(t^3 - 2t) \times 10^{-3}$ weber, where t is in seconds. The induced EMF. at t = 2s is **[REE - 97]**
(A) – 4 V (B) + 4 V (C) – 1 V (D) + 1 V

6*. The SI unit of inductance, the Henry, can be written as: **[JEE - 98, 2 marks]**
(A) Weber/ampere (B) Volt – second/ampere
(C) Joule/(ampere)^2 (D) Ohm – second

7. A small square loop of wire of side ℓ is placed inside a large square loop of wire of side L(L >> ℓ). The loops are co – planar and their centres coincide. The mutual inductance of the system is proportional to: **[JEE - 98, 2 marks]**
(A) $\frac{\ell}{L}$ (B) $\frac{\ell^2}{L}$ (C) $\frac{L}{\ell}$ (D) $\frac{L^2}{\ell}$

8. A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant, uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement(s) from the following **[JEE - 98,2 marks]**
(A) The entire rod is at the same electric potential
(B) There is an electric field in the rod
(C) The electric potential is highest at centre of the rod and decreases towards its ends
(D) The electric potential is lowest at centre of the rod and increases towards its ends.

9. An inductor of inductance 2.0mH, is connected across a charged capacitor of capacitance 5.0μF, 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 μC. **[JEE - 98,8 marks]**
(A) When Q = 100 μ C, what is the value of $|dI/dt|$?
(B) When Q=200 μ C, what is the value of I?
(C) Find the maximum value of I.
(D) When I is equal to one half its maximum value, what is the value of $|Q|$

10. A current $i = 3.36\,(1 + 2t) \times 10^{-2}$ A increases at a steady rate in a long straight wire. A small circular loop of radius 10^{-3} m is in the plane of the wire and is placed at a distance of 1 m from the wire. The resistance of the loop is 8.4×10^{-2} Ω. Find the magnitude and the direction of the induced current in the loop. **[REE - 98]**

11. The earth's magnetic field (say B) at equator is horizontal, uniform and points north-south. A conducting square loop of side ℓ and resistance R is kept in the vertical plane with two of its sides pointing east-west direction. This loop is moved in east direction with a velocity v. The current induced in the loop is- **[REE - 98]**

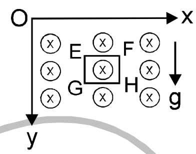
(A) $\frac{Bv\ell}{R}$ (B) $\frac{2Bv\ell}{R}$ (C) $\frac{4Bv\ell}{R}$ (D) 0

12. Two identical circular loops of metal wire are lying on a table without touching each other. Loop-A carries a current which increases with time. In response, the loop-B **[JEE - 99,2 marks]**
(A) remains stationary (B) is attracted by the loop-A
(C) is repelled by the loop-A (D) rotates about its CM, with CM fixed

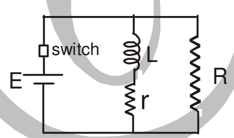
13. A coil of inductance 8.4 mH and resistance 6Ω is connected to a 12V battery. The current in the coil is 1.0 A at approximately the time **[JEE - 99,2 marks]**
(A) 500 s (B) 20 s (C) 35 ms (D) 1 ms

14. A circular loop of radius R, carrying current I, lies in x-y plane with its centre at origin. The total magnetic flux through x-y plane is **[JEE - 99, 2 marks]**
(A) directly proportional to I (B) directly proportional to R
(C) directly proportional to R^2 (D) zero

15. A magnetic field $B = (B_0 y / a)\ \hat{k}$ is into the 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, and
(c) an expression for the speed of the loop, $v(t)$ and its terminal value. **[JEE - 99,10 marks]**

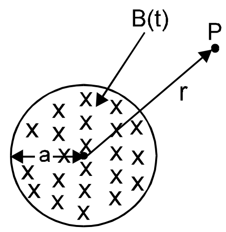


16. A coil has inductance $L = 50 \times 10^{-6}$ Henry and resistance r = 0.5Ω. A resistance of R = 10 Ω is connected in parallel to the coil. A battery of E = 5.0V is connected in parallel to the coil(see figure). Now at some instant the connection of the battery is switched off. Find the amount of total heat generated in the coil after switching off the battery. **[REE - 99]**



17. A metal rod of length 15×10^{-2} m rotates about an axis passing through one end with a uniform angular velocity of 60 rad s^{-1}. A uniform magnetic field of 0.1 Tesla exists in the direction of the axis of rotation. Calculate the EMF induced between the ends of the rod. **[REE - 99]**

18. A uniform but time-varying magnetic field B (t) exists in a circular region of radius a and is directed into the plane of the paper, as shown fig. The magnitude of the induced electric field at point P at a distance r from the centre of the circular region. **[JEE - 2000,3 marks]**
(A) is zero (B) decreases as 1/r
(C) increases as r (D) decreases as $1/r^2$



19. A coil of wire having finite inductance and resistance has a conducting ring placed coaxially within it. The coil is connected to a battery at time t = 0, so that a time-dependent current I_1 (t) starts flowing through the coil. If I_2(t) is the current induced in the ring, and B(t) is the magnetic field at the axis of the coil due to I_1(t), then as a function of time (t > 0), the product I_2 (t) B(t). **[JEE - 2000, 3 marks]**
(A) increases with time (B) decreases with time
(C) does not vary with time (D) passes through a maximum

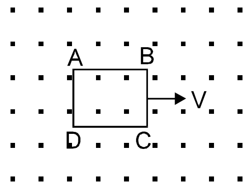
20. A coil of inductance 1 Henry and resistance 10Ω is connected to a resistanceless battery of EMF 50 V at time t = 0. Calculate the ratio of the rate at which magnetic energy is stored in the coil to the rate at which energy is supplied by the battery at t = 0.1 s. **[REE - 2000]**

21. The current in a LR circuit builds up to $\frac{3}{4}$ the of its steady state value in 4s. The time constant of this circuit is - **[REE-2000]**

(A) $\frac{1}{\ell n2}$ sec. (B) $\frac{2}{\ell n2}$ sec. (C) $\frac{3}{\ell n2}$ sec. (D) $\frac{4}{\ell n2}$ sec.

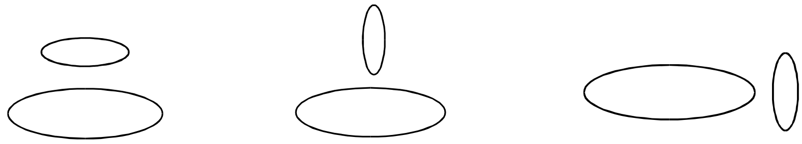
22*. A bar magnet is placed along the axis of a circular ring at a certain distance from its centre. The magnetic flux through the ring will change, when the ring. **[REE - 2000]**
(A) is rotated about its own axis.
(B) is rotated about one of its diameters.
(C) moves towards the magnet
(D) moves away from the magnet

23. A metallic square loop ABCD is moving in its own plane with velocity v in a uniform magnetic field perpendicular to its plane as shown in the figure
An electric field is induced **[JEE-2001, 3 marks]**



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

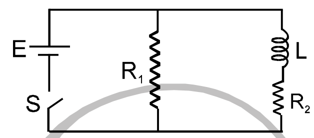
24. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be: **[JEE-2001, 3 marks]**



(a) (b) (c)

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

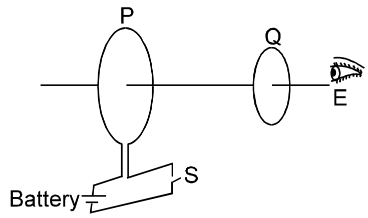
25. An inductor of inductance L = 400 mH and resistors of resistances R_1 and R_2 of 2 Ω each are connected to a battery of EMF. E = 12 V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at time t = 0. What is the potential drop across L as a function of time? After the steady state is reached, the switch is opened. What is the direction and the magnitude of current through R_i as a function of time? **[JEE-2001,5 marks]**



26. A wire in the form of a circular loop of radius 10 cm lies in a plane normal to a magnetic field of 100 T. If this wire is pulled to take a square shape in the same plane in 0.1 s, find the average induced EMF in the loop. **[REE-2001]**

27. The current (in ampere) in an inductor is given by I = 5 + 16 t, where t is in second. The self-induced EMF in it is 10 mV. Find
(a) the self-inductance, and
(b) the energy stored in the inductor and the power supplied to it at t = 1 second. **[REE-2001]**

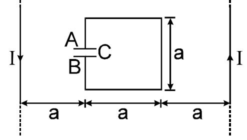
28. As shown in the fig. P and Q are two coaxial conducting loops separated by some distance. When the switch S is closed a clockwise current I_P flows in P (as seen by E) and an induced current I_{Q1} flows in Q. The switch remains closed for a long time. When S is opened, a current I_{Q2} flows in Q. Then the directions of I_{Q1} and I_{Q2} (as seen by E) are **[JEE 2002 (Screening)]**



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

29. A short circuited coil is placed in a time-varying magnetic field. Electrical power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled and the wire radius halved keeping the radius of the loop unchanged, the electrical power dissipated would be: **[JEE 2002 (Screening)]**
(A) halved (B) the same (C) doubled (D) quadrupled

30. In the figure shown $I = I_0 \sin \omega t$. Assuming anticlock current to be positive, plot the graph of charge on plate A with respect to time. Also find the maximum current in the circuit. **[JEE - 2003]**



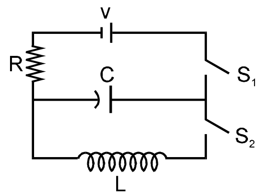
31. An infinitely long cylindrical conducting rod is kept along + Z direction. A constant magnetic field is also present in + Z direction. Then current induced will be **[JEE (Scr. 2005) 3/84]**

(A) 0
(B) along +z direction
(C) along clockwise as seen from + Z
(D) along anticlockwise as seen from + Z

32. Current passing through a long solenoid having n turns per unit length is $I = I_0 \sin \omega t$. Find induced current through copper shell having resistivity ρ as shown in figure. **[JEE (Mains 2005) 4/60]**

COMPREHENSIVE QUESTIONS **[IIT-JEE – 2006, 5 or – 2 for each question]**

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.



33. 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 $CV(1 - e^{-1})$

34. 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 be $V\sqrt{\frac{C}{L}}$

35. If at t=0, the maximum charge on the capacitor of an 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 $Q = -\frac{1}{\sqrt{LC}}\,\frac{d^2Q}{dt^2}$

ANSWER

EXERCISE 1

SECTION (A) :

A 1.	B	**A 2.**	D	**A 3.***	CD
A 4.	A	**A 5.**	D	**A 6.**	C
A 7.	A	**A 8.**	C	**A 9.**	A

A 11. (i) 1.2 Volt (ii) 1.4 volt (iii) 17.5 C (iv) 3.5 A (v) 86/3 joule.

A 12. zero **A 13.** 0.078 C

A 14. 1.6×10^{-5}A **A 15.** 493 μV

A 16. (a) In the round conductor the current flows clockwise, there is no current in the connector; (b) in the outside conductor clockwise;
(c) in both round conductors, clockwise; no current in the connector,
(d) in the left-hand side of the figure eight, clockwise.

A 17. $\dfrac{3\mu_0 a\alpha\,\ell n\left(1+\frac{a}{r_0}\right)}{2\pi R}\, t^2$

A 19. (a) 1.25×10^{-7} A, a to d (b) 1.25×10^{-7} A, d to a.
(c) zero (d) zero

A 20. $\phi(t) = \pi r^2 B\cos\alpha\cos\omega t$, $\varepsilon(t) = \pi r^2\omega B\cos\alpha\,\sin\omega t$

A 21. 3.9×10^{-5} A **A 23.** $\dfrac{\frac{\mu_0}{4}(2I)\left(\pi r^2\right)\left(\frac{3}{2}v\right)}{\left(\frac{5}{4}\right)^{5/2}R^2}$

A 24. $e_{im} = (1/3)pa^2\,NwB_0$.

A 25. $\dfrac{\mu_0 i_0 W\omega\cos\omega t}{4\pi}\,\ell n\left(\dfrac{L^2}{Y^2}+1\right)$]

SECTION (B) :

B 1.	D	**B 2.**	B	**B 3.**	B
B 4	A	**B 5**	A	**B 6**	B

B 7. (i) $\dfrac{Vt^2B_0}{\sqrt{2}}$ T m^2 (ii) $\sqrt{2}VtB_0$ V
(iii) linearly

B 8. clockwise, $BV\sqrt{4R^2-v^2t^2}$

B 9. (BV sin a) / P(1 + sin a)

B 10. B y $\sqrt{8a/k}$ **B 11.** $\varepsilon_i = 3/2\,\omega\ell\dfrac{dB}{dt}t^2 = 12$ mV.

SECTION (C) :

C 1.	C	**C 2.**	A	**C 3.**	A
C 4.	A	**C 5.**	D	**C 6.**	C
C 7.	A	**C 8.**	B	**C 9.**	B

SECTION (D) :

D 1 D **D 2** C

D-3. (a) 25 m/s (b)4.0×10^{-2}V (c)3.6×10^{-2}V(d)4.0×10^{-3} V.

D-4. $I = Bv\ell/(R + R_{eq})$, where $R_{eq} = R_1R_2/(R_1 + R_2)$.

D 5. (a) 0.1 mA (b) zero

D 6. (a) zero (b) 1 mA **D 7.** (a) 0.1 mA (b) 0.2 mA

D 8. $\dfrac{ir - B\ell v}{2r}$ upwards. **D 9.** $\dfrac{mg}{m + CB^2\ell^2}$

D 10. (a) $\dfrac{1}{r}(E - vB\ell)$, from b to a

(b) $\dfrac{\ell B}{r}(E - vB\ell)$ towards right (c) $\dfrac{E}{B\ell}$.

D 11. zero **D 12.** $\dfrac{B\ell v}{2r(\ell + vt)}$

D 13. (a) $\dfrac{B^2\ell^2 v}{2r(\ell+vt)}$ (b) ℓ/v.

D 15. $t = \dfrac{mR}{B^2\ell^2}\,\ell n\dfrac{mg + \dfrac{B^2\ell^2u}{R}}{mg}$

D 16. V = 1 ms$^{-1,}$ $R_1 = 0.47\ \Omega$, $R_2 = 0.30\ \Omega$

D 17. $(MgR/B^2L^2)\{1 - e^{-[B^2L^2t/(M+m)R]}\}$

D 18. $V = \dfrac{FR}{B^2\ell^2}\left(1 - e^{\left[\frac{-B^2\ell^2t}{R(m+B^2\ell^2C)}\right]}\right)$, $V_{terminal} = \dfrac{FR}{B^2\ell^2}$

D 19. (a) $I = \dfrac{\mu_0 I_0 v}{2\pi R}\,\ell n\dfrac{b}{a}$ (b) $F = \dfrac{v}{R}\left(\dfrac{\mu_0 I_0}{2\pi}\,\ell n\dfrac{b}{a}\right)^2$

(c) (b – a) / log (b /a) from the long wire.

SECTION (E) :

E 1 C

E-2. (a) at the ends of the diameter perpendicular to the velocity, 2rvB (b) at the ends of the diameter parallel to the velocity, zero.

E 3. $\dfrac{B_0 v_0 \ell}{2}$

E 4. (a) $\dfrac{v}{R}\left(\dfrac{\mu_0 i}{2\pi}\ln\dfrac{2x+\ell}{2x-\ell}\right)^2$ (b) $\dfrac{\mu_0 iv}{2\pi R}\ln\dfrac{2x+\ell}{2x-\ell}$

(c) $\dfrac{1}{R}\left(\dfrac{\mu_0 iv}{2\pi}\ln\dfrac{2x+\ell}{2x-\ell}\right)^2$ (d) same as (c)

E 5. $\phi = \frac{\mu_0 ia}{2\pi}\ell n\left(\frac{a+b}{a}\right)$, $E = \frac{d\phi}{dt} = \frac{M_0 I_0 \omega a \cos\omega t}{2\pi}$

$\ell n\left(\frac{a+b}{b}\right)$;heat $= \frac{20\pi}{\omega}\left(\frac{\mu_0^2 I_0^2 \omega^2 a^2}{8\pi^2 r}\right)\left[\ell n\left(\frac{a+b}{b}\right)\right]^2$

E 6. $\frac{\mu i \ell vb}{2\pi a(a+\ell)}$

E 7. $\phi = 2.772 \times 10^{-7}$ Wb, $\varepsilon = 1.386 \times 10^{-5}$ V, clockwise direction

E 8. $2 \times 10^{-5} \times \log_e \frac{4}{3}$ volts, clockwise

SECTION (F) :

F 1. B **F 2.** A **F 3.** C

F 4. B **F 5.** D

F 6. $\frac{B\omega a^2}{R}$ from C to D

F 7. (a) 6.6×10^{-4} V (b) zero (c) 2.2×10^{-7} V²

F 8. 9.4×10^{-6} V **F 9.** 0.5 mA, leaves

F 10. 2.5×10^{-2} W, 100 rad/s **F 11.** $B\ell\sqrt{g\ell}\ \sin\frac{\theta}{2}$

F 12. (a) 2BR v (b) $\frac{BRv}{2}$

F 13. (a) 6.6×10^{-4} V (b) zero (c) 2.2×10^{-7} V²

F 14. 1.3×10^{-7} J **F 15.** $<P> = (\pi\omega a^2 B)^2/8R$.

SECTION (G) :

G 1. A **G. 2** B **G 3** A

G 4 D **G 5.** 6π Volt **G 6.** 3 N/C

G 7. 3 A

G 8. (a) 1.6×10^{-8} weber (b) $4\pi \times 10^{-8}$ V/m (c) 5.6×10^{-7} V/m

G 9. (a) 12 V, (b) clockwise

SECTION (H) :

H 1.* A,C,D **H 2.** B **H 3.*** ABC

H 4. A **H 5.** A **H 6.** [A⁻¹]

H 7. 4×10^{-4} H **H 8.** 10V

H 9. 2.2 A/s, decreasing **H 10.** 0.4 H

H 11. 4×10^{-2} H **H 12.** 6×10^{-4} V

H 13. 9 J **H 14.** 385 W

H 15. (a) 5 W (b) 3W (c) 2 W

H 16. 7.9×10^{-4} J **H 17.** $8\pi \times 10^{-14}$ J

H 18. 2.55×10^{-14} J **H 20.** $\frac{\mu_0 e^4}{128\pi^3 \varepsilon_0 m R^5}$

H 21. 42 + 20 t volt

SECTION (I) :

I 1. ABC **I 2.** D **I 3.** C

I 4. B **I 5.** D **I 6.** A

I 7*. AC **I 8.** (L/R) ln 2 = 1.104 s, 640 J

I 9. (a) ln 10 ≃ 2.3, (b) ln 100 ≃ 4.6, (c) ln 1000 ≃ 6.9

I 10. 0.50 s **I 11.** 4.0 H

I 12. **(i)** (a) 2 A/s (b) 0.74 A/s (c) ≈ 0
(ii) (a) 2V (b) 0.74 V (c) ≈ 0

I 13. (a) $\frac{0.1}{\ln 2}$ s = 0.14 s (b) 40 ln2 Ω = 27.72 Ω

I 14. (a) $\frac{\varepsilon(R_1+R_2)}{R_1R_2}$ (b) $\frac{L}{R_1+R_2}$ (c) $\frac{\varepsilon}{R_1 e}$

I 15. $\frac{2B\pi R^2}{L}$ **I 17.** $I = \frac{\ell}{R}[1 + (\eta - 1)\, e^{-t\eta R/L}]$

I 18. (a) $i_1 = i_2 = 3.33$ A
(b) $i_1 = 4.55$ A; $i_2 = 2.73$ A
(c) $i_1 = 0$, $i_2 = 1.82$ A
(d) $i_1 = i_2 = 0$

I 19. (a) $x = \frac{g}{W^2}[1-\cos\omega t]$, (b) $I_{max} = \frac{2mg}{B\ell}$,
(c) $V_{max} = \frac{g}{\omega}$

SECTION (J) :

J 1. D **J 2.** B **J.3** A

J.4 A **J.5** D **J 6.** 0.01 H

J 7. 2.5 V **J 8.** $\frac{\mu_0 a}{2\pi}\ln\left(1+\frac{a}{b}\right)$

J 9. $6.4\, p \times 10^{-3}$ H

SECTION (K) :

K 1. B **K 2.** C

MISCLLENOUS

*** ONE OR MORE THEN ONE MAY BE CORRECT :**

1.	C	**2.**	C	**3.**	C
4.	A	**5.**	B	**6*.**	BC
7.	D	**8.**	C	**9.**	A
10.	A	**11.**	A	**12*.**	AD
13.	B	**14*.**	ABCD	**15.**	C
16.	B	**17.**	A	**18.**	B
19.	BC	**20.**	D	**21.**	C
22.	C	**23.**	C	**24*.**	AC
25*.	ABD	**26.**	A	**27.**	A
28.	A				

EXERCISE 2

1. $t = (L/R)\ \ell n\, 2 = 3.47$ s **2.** D

3. 15V **4.** True **5.** C

6*. A, B, C, D **7.** B **8.** B

9. (A) 10^4 A/s (B) 0 (C) 2 A (D) 173.2 μC

10. $1.6\pi \times 10^{-13}$ A **11.** D **12.** C

13. D **14.** D

15. (a) $i == \frac{B_0 a v}{R}$ in anticlocwise direction. v = velocity at time t
(b) $F_{nett} = B_0{}^2 a^2 V/R$, upward

(c) $V = \frac{mgR}{B_0^2 a^2}\left(1 - e^{-\frac{B_0^2 a^2 t}{mR}}\right)$, $V_t = \frac{mgR}{B_0^2 a^2}$

16. $\frac{1}{2} L \left(\frac{E}{r}\right)^2 \frac{r}{R + r}$ = 25/21 x 10^{-4} J

17. 67.5 mV **18.** B

19. D **20.** 0.37

21. B **22*.** B, C, D

23. D **24.** A

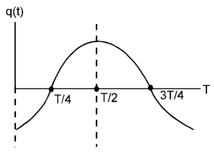
25. $V = 12\, e^{-5t}$ Volt ; I_{st} = 6 A, clockwise , $i = 6e^{-10t}$

26. 6.75 volt

27. (a) 6.25×10^{-4} H (b) 137.8 mJ, 0.21 watt.

28. D

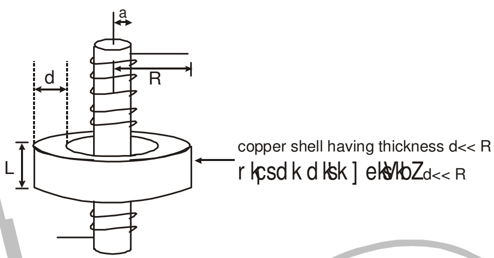
29. B

30. 

$I_{max} = \frac{a^2 \mu_0 I_0 \omega^2 c\, \ell n\, 2}{\pi}$

31. A

32. $\frac{(\mu_0\, n a^2 I_0 \omega \cos \omega t)\, Ld}{2\rho R}$



33. B **34.** D

35. C

