PHYSICS

BOOKS - RESNICK AND HALLIDAY PHYSICS (HINGLISH)

ELECTROMAGNETIC INDUCTION

Sample Problems

1. A current I = 1.5 A is flowing through a long solenoid of diameter 3.2 cm, having 220 turns per cm. At its centre, a 130 turn closely packed coil of diameter 2.1 cm is placed such that the coil is coaxial with the long solenoid. The current in the solenoid is reduced to zero at a steady rate in 25 ms. What is the magnitude of emf induced in the coil while the current in the solenoid is changing?

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2. A small coil of N turns has its plane perpendicular to a uniform magnetic field as shown in Fig. 30-5. The coil is connected to a Ballistic galvanometer, a device designed to measure the total charge passing through it. Find the charge passing through the coil if the coil is rotated through 180° about its diameter.

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3. Induced emf and current due to a changing uniform B field

Figure 30-8 shows a conducting loop

consisting of a half-circle of radius r = 0.20 m and three straight sections. The halfcircle lies in a uniform magnetic field $\vec{B}$ that is directed out of the page, the field magnitude is given by $B = 4.0t^2 + 2.0t + 3.0$, with B in teslas and tin seconds. An ideal battery with emf E_{bat} = 2.0 V is connected to the loop. The resistance of the loop is 2.0 Ω.

(a) What are the magnitude and direction of the emf E_{ind} induced around the loop by field $\vec{B}$ at t = 10 s?

(b) What is the current in the loop at t = 10 s?

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4. Induced emf due to a changing nonuniform B field

Figure 30-9 shows a rectangular loop of wire immersed in a nonuniform and varying magnetic field $\overrightarrow{B}$ that is perpendicular to and directed into the page. The field's magnitude is given by $B = 4t^2x^2$, with B in teslas, tin seconds, and x in meters. (Note that the function depends on both time and position.) The loop has width W = 3.0 m and height H =

2.0 m. What are the magnitude and direction of the induced emf E around the loop at t = 0.10 s?

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5. When a rod of length l is rotated with angular velocity of ω in a perpendicular field of induction B , about one end , the emf across its ends is

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

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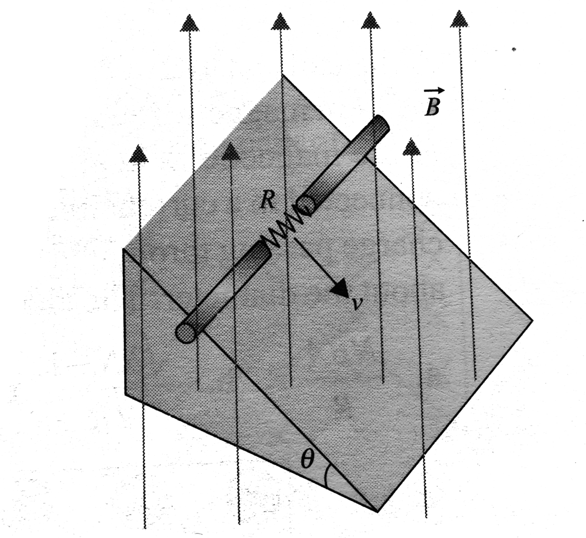
7. A wire of length l, mass m and resistance R slides without any friction down the parallel conducting rails of negligible resistance . The rails are connected to each other at the bottom by a resistanceless rail parallel to the wire so that the wire and the rails form a closed rectangualr conducting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



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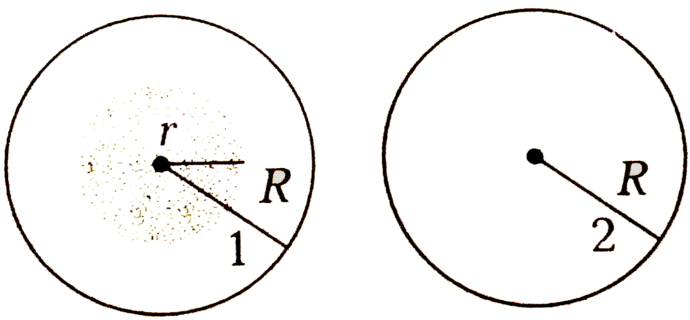
8. A uniform magnetic field is restricted within a region of radius r. The magnetic field changes with time at a rate $\frac{dB}{dt}$. Loop 1 of radius R $>$ r encloses the region r and loop 2 of radius R is outside the region of magnetic field as shown in figure. Then, the emf generated is



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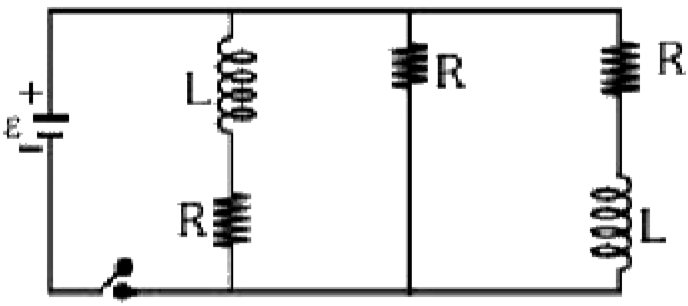
9. A circuit that contains three identical resistors with resistance $R = 9.0\Omega$ each, two identical inductors with inductance L = 2.0 mH each, and an ideal battery with emf $\varepsilon = 18V$. The current 'i' through the battery just after the switch closed



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10. RL circuit, current during the transition

A solenoid has an inductance of 53 mH and a resistance of 0.37 Ω . If the solenoid is connected to a battery, how long will the current take to reach half its final equilibrium value? (This is a real solenoid because we are considering its small, but nonzero, internal resistance.)

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11. Energy stored in a magnetic field

A coil has an inductance of 53 mH and a resistance of 0.35 Ω.

(a) If a 12 V emf is applied across the coil, how much energy is stored in the magnetic field after the current has built up to its equilibrium value?

(b) After how many time constants will half this equilibrium energy be stored in the magnetic field?

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12. Finding total energy stored in a magnetic field for a length of coaxial cable from the energy density

Finding total energy stored in a magnetic field for a length of coaxial cable from the energy density

(b) What is the stored energy per unit length of the cable if a= 1.2 mm, b = 3.5 mm, and i = 2.7 A?

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13. Two circular coils, one of smaller radius r_1 and the other of very large radius r_2 are placed co-axially with centres coinciding. Obtain the mutual inductance of the arrangement.

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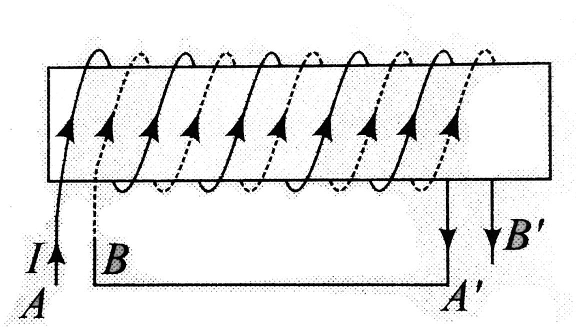
14. In Fig. coil 1 and coil 2 are wound on a long cylindrical insulator. The ends A' and B are joined together and current I is passed. Self-inductance of the two coils are L_1 and L_2, and their mutual inductance is M.

a. Show that this combination can be replaced by a single coil of equivalent inductanCe given by

$$L_{eq} = L_1 + L_2 + 2M.$$

b. How could the coils be reconnected by yieldings an equivalent inductance of

$$L_{eq} = L_1 + L_2 - 2M.$$



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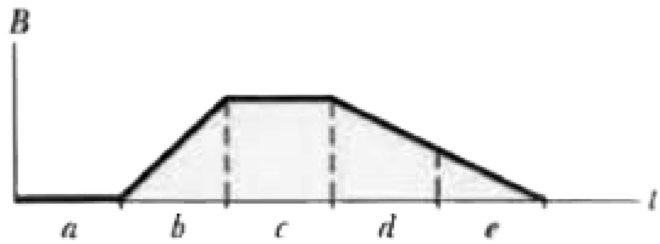
Checkpoints

1. The graph gives the magnitude B(t) of a uniform magnetic field that exists throughout a conducting loop, with the direction of the field perpendicular to the plane of the loop. Rank the five regions of the graph according to the magnitude of the emf induced in the loop, greatest first.



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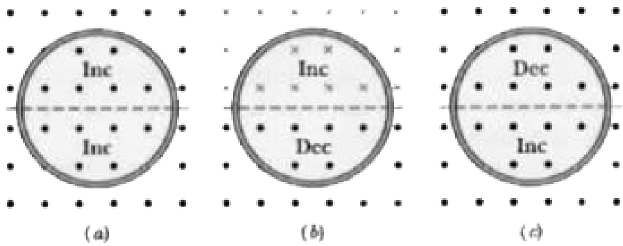
2. The figure shows three situations in which identical circular conducting loops are in uniform magnetic fields that are either increasing (Inc) or decreasing (Dec) in magnitude at identical rates. In each, the dashed line coincides with a diameter. Rank the situations according to the magnitude of the current induced in the loops, greatest first.



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3. If the rod were translating as well as rotating, what will be its emf? Assume that the centre of mass has a velocity v and the rod is rotating with an angular velocity ω atout its centre of mass.

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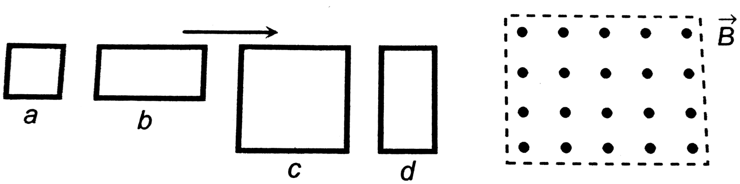
4. The figure shows four wire loops, with edge length of either L or $2L$. All four loops will move through a region of uniform magnetic field $\vec{B}$ (directed out of the page) at the same constant velocity . Rank the four loops according to the maximum magnitude of the e.m.f. induced as they move through the field, greatest first



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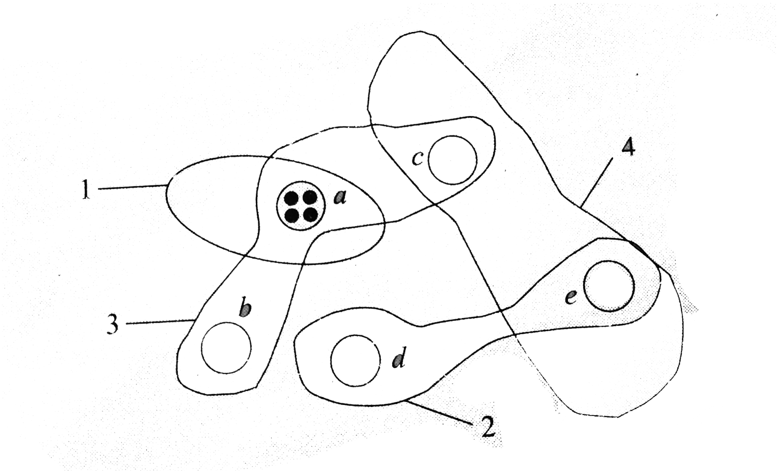
5. Figure shows five lettered regions in which a uniform magnetic field extends directly either out of the page (as in region a) or into the page. The field is increasing in magnitude at the same steady rate in all five regions, the regions are identical in area. Also shows four numbered paths along which $\oint \vec{E}\,.\,\vec{dl}$ has the magnitudes given below in terms of a quantity mag. Determine whether the magnetic fields in regions b to e are directed into or out of the page.

Path	1	2	3	4
$\oint \vec{E} . \vec{dl}$	mag	$2(mag)$	$3(mag)$	0



?

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6. A uniform copper ring is threaded by a steadily increasing magnetic field so that the magnetic flux through the ring is changing by

a constant rate. Use a voltmeter to measure the voltage across the metal ring. What do you predict?

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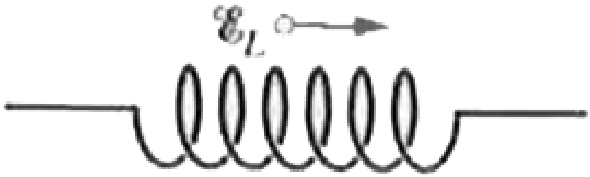
7. The figure shows an emf E_L induced in a coil. Which of the following can describe the current through the coil: (a) constant and rightward, (b) constant and leftward, (c) increasing and rightward, (d) decreasing and rightward, (e) increasing and leftward, (f) decreasing and leftward?



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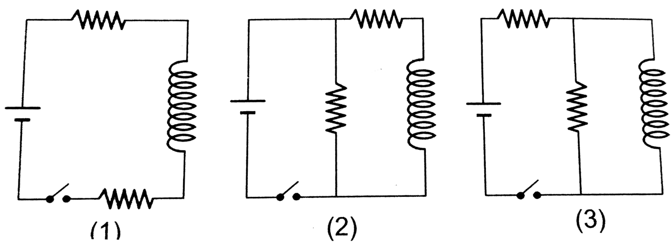
8. The figure shows theree cirrcuit with idential batteries, inductors, and resistors. Rank the circuit according to the current through the battery (i) just after the switch is closed and (ii) a long time later, greatest first



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9. The table lists the number of turns per unit length, current, and cross-sectional area for three solenoids. Rank the solenoids according to the magnetic energy density within them,

greatest first.

Solenoid	Turns per Unit Length	Current	Area
a	$2n_1$	i_1	$2A_1$
b	n_1	$2i_1$	A_1
c	n_1	i_1	$6A_1$

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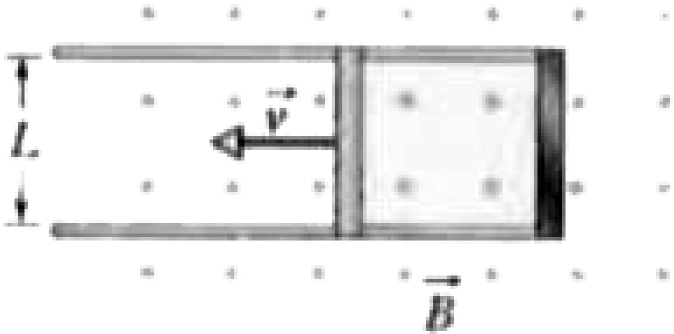
Problems

1. In Fig. 30-37, a metal rod is forced to move with constant velocity $\vec{v}$ along two parallel metal rails, connected with a strip of metal at one end. A magnetic field of magnitude B = 0.125 T points out of the page. (a) If the rails are separated by L = 25.0 cm and the speed of the rod is 38.0 emfs, what emf is generated? (b) If the rod has a resistance of 18.0 Ω and the rails and connector have negligible resistance, what is the current in the rod? (c) At what rate is energy being transferred to thermal energy? (d) What is the magnitude of the leftward force that causes the rod to move?



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2. Coil 1 has L_1 = 25 mH and N_1 = 100 turns. Coil 2, has L_2= 40 mH and N_2 = 200 turns. The coils are fixed in place, their mutual inductance M is 9.0 mH. A 6.0 mA current in coil 1 is changing at the rate of 4.0 A/s. (a)

What magnetic flux ϕ_{12} 12 links coil 1, and (b) what self-induced emf appears in that coil? (c) What magnetic flux ϕ_{21} links coil 2, and (d) what mutually induced emf appears in that coil?

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3. The conducting rod shown in Fig. 30-37 has length Land is being pulled along horizontal, frictionless conducting rails at a constant velocity $\overrightarrow{v}$. The rails are connected at one end with a metal strip. A uniform magnetic field $\vec{B}$, directed out of the page, fills the region in which the rod moves. Assume that L = 10 cm, v = 5.0 m/s, and B = 1.2 T. What are the (a) magnitude and (b) direction (up or down the page) of the emf induced in the rod? What are the (c) size and (d) direction of the current in the conducting loop? Assume that the resistance of the rod is 0.40 Ω and that the resistance of the rails and metal strip is negligibly small. (e) At what rate is thermal energy being generated in the rod? (f) What external force on the rod is needed to maintain $\vec{v}$? (g) At what rate does this force do work on the rod?

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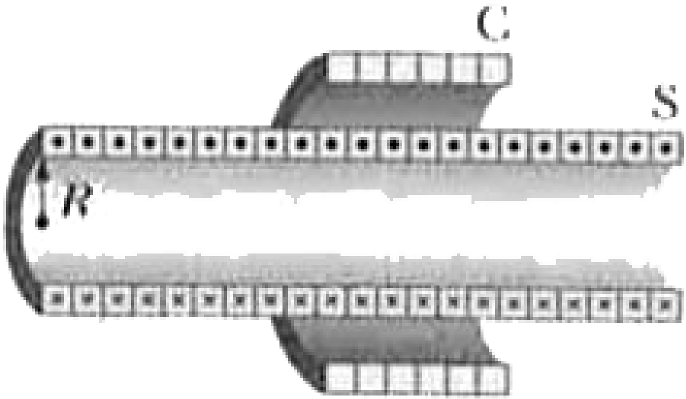
4. A coil C of N turns is placed around a long solenoid S of radius R and n turns per unit length, as in Fig. 30-38.

(a) Show that the mutual inductance for the coil-solenoid combination is given by $M = \mu_0 \pi R^2 n N$.

(b) Explain why M does not depend on the shape, size, or possible lack of close packing of the coil.



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5. If 50.0 cm of copper wire (diameter= 3.00 mm) is formed into a circular loop and placed perpendicular to a uniform magnetic field that is increasing at the constant rate of 30.0 mT/s, at what rate is thermal energy generated in the loop?

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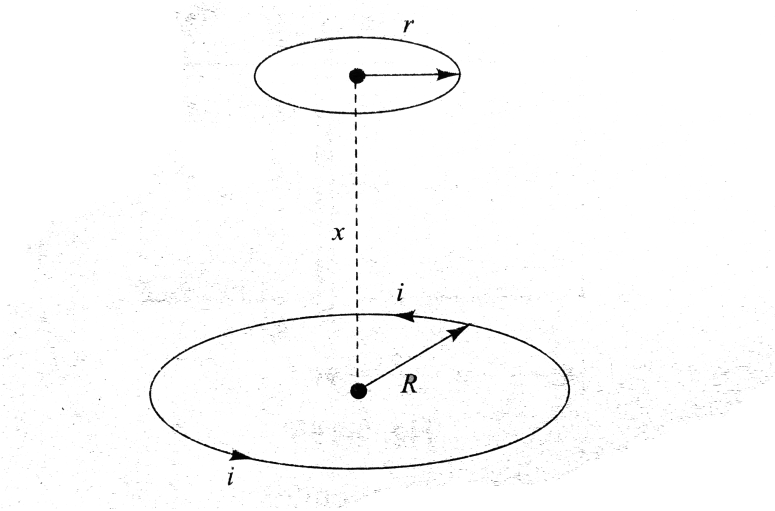
6. Figure 3.188 shows two parallel and coaxial loops. The smaller loop (radius r) is above the larger loop (radius R), by distance $x > > R$. The magnetic field due to current i in the larger loop is nearly constant throughout the smaller loop. Suppose that x is increasing at a constant rate of $dx / dt = v$.



The induced emf in the smaller loop is

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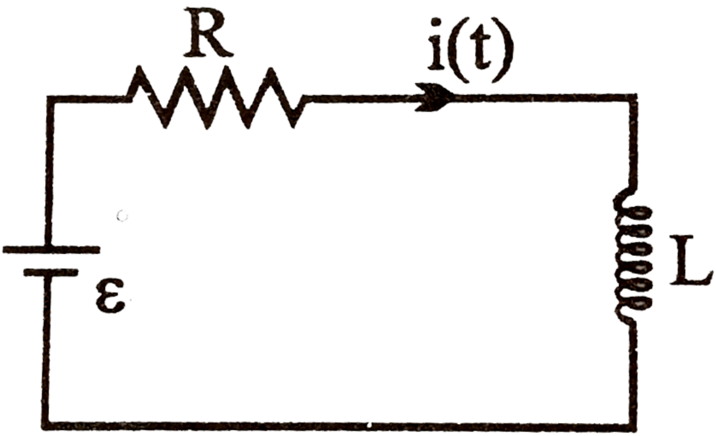
7. Suppose the emf of the battery, the circuit shown varies with time t so the current is given by $i(t) = 3 + 5t$, where i is in amperes

& t is in seconds. Take $R = 4\Omega, L = 6H$ & find an expression for the battery emf as function of time.



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8. The magnetic field of a cylindrical magnet that has a poleface diameter of 3.3 cm can be varied sinusoidally between 29.6 T and 31.2 T at a frequency of 15 Hz. (The current in a wire wrapped around a permanent magnet is varied to give this variation in the net field.) At a radial distance of 1.6 cm, what is the amplitude of the electric field induced by the variation?

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9. At t = 0, a battery is connected to a series arrangement of a resistor and an inductor. At what multiple of the inductive time constant will the energy stored in the inductor's magnetic field be 0.500 of its steady-state value?

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10. A 12 H inductor carries a current of 2.0 A. At what rate must the current be changed to produce a 60 V emf in the inductor?

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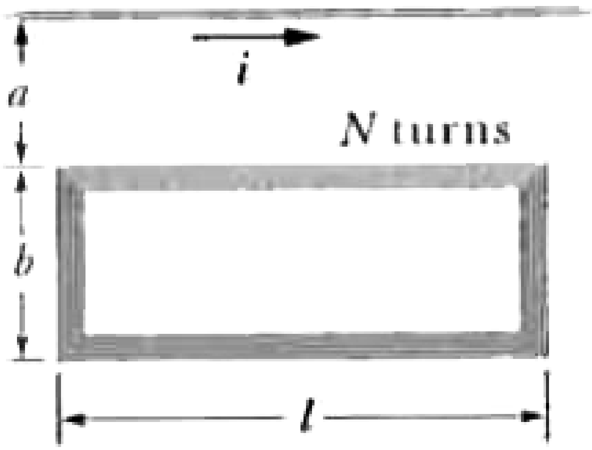
11. A rectangular loop of N closely packed turns is positioned near a long straight wire as shown in Fig. 30-40. What is the mutual inductance M for the loop-wire combination if N = 150, a = 1.0 cm, b = 9.5 cm, and l = 30 cm?



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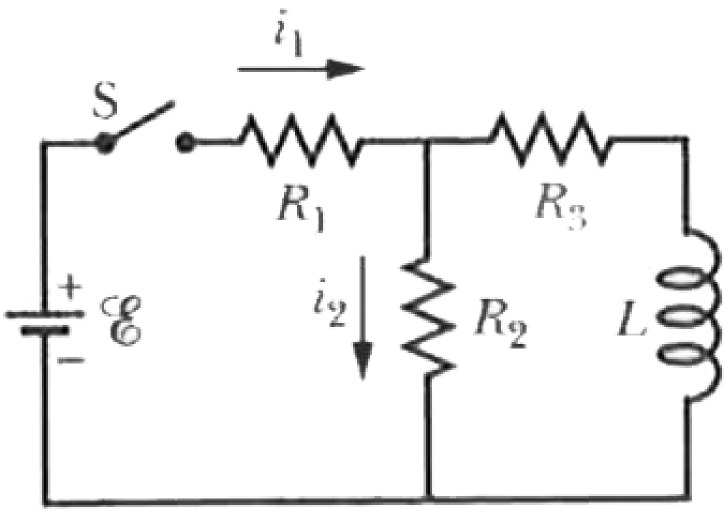
12. In Fig. 30-41, E = 100 V, $R_1 = 10.0\Omega$, $R_2 = 20.0\Omega$, $R_3 = 31.0\Omega$, and L = 2.00 H. Immediately after switch S is closed, what are (a) i_1 and (b) i_2? (Let currents in the indicated directions have positive values and currents in the opposite directions have negative values.) A long time later, what are (c) i_1 and (d) i_2? The switch is then reopened. Just then, what are (e) i_1 and (f) i_2? A long time later, what are (g) i_1 and (h) i_2?



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13. A coil is connected in series with a 10.0 $k\Omega$ resistor. An ideal 50.0 V battery is applied across the two devices and the current reaches a value of 2.00 mA after 5.00 ms. (a) Find the inductance of the coil. (b) How much energy is stored in the coil at this same moment?

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14. Two coils are at fixed locations. When coil 1 has no current and the current in coil 2 increases at the rate 21.0 A/s, the emf in coil 1 is 25.0 mV. (a) What is their mutual inductance? (b) When coil 2 has no current and coil 1 has a current of 1.35 A, what is the flux linkage in coil 2?

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15. The switch in Fig. 30-28 is closed on a at time t = 0. What is the ratio E_L / E of the inductor's self-induced emf to the battery's emf (a) just after t = 0 and (b) at t = 2.00 τ_L? (b) At what multiple of τ_L, will $E_L / E = 0.500$?

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16. Two identical long wires of radius a = 0.530 mm are parallel and carry identical currents in opposite directions. Their center-to-center separation is d = 20.0 cm. Neglect the flux within the wires but consider the flux in the region between the wires. What is the inductance per unit length of the wires?

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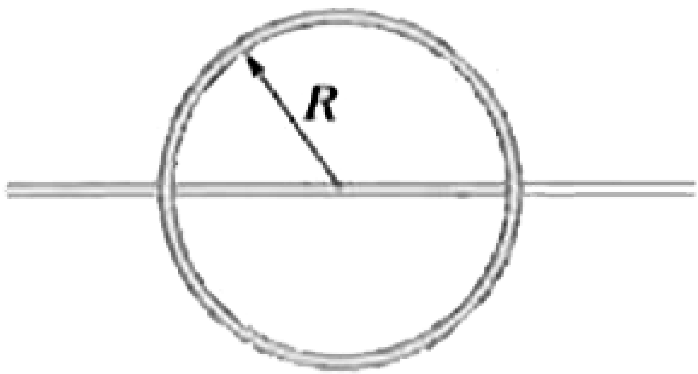
17. In Fig. 30-42, a wire forms a closed circular loop, of radius R = 0.32 m and resistance 0.056

Ω. The circle is centered on a long straight wire, at time t = 0, the current in the long straight wire is 5.0 A rightward. Thereafter, the current changes according to i = $5.0A - (2.0A/s^2)t^2$. (The straight wire is insulated, so there is no electrical contact between it and the wire of the loop.) What is the magnitude of the current induced in the loop at times $t > 0$?



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18. The current in an RL circuit drops from 2.30 A to 3.40 mA in 0.025 s following removal of the battery from the circuit. If L is 10 H, find the resistance R in the circuit.

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19. A coil with an inductance of 2.0 Hand a resistance of 10 Ω is suddenly connected to an

ideal battery with E = 100 V. At 0.10 s after the connection is made, what is the rate at which (a) energy is being stored in the magnetic field, (b) thermal energy is appearing in the resistance, and (c) energy is being delivered by the battery?

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20. A length of copper wire carries a current of 3.5 A uniformly distributed through its cross section. Calculate the energy density of (a) the magnetic field and (b) the electric field at the surface of the wire. The wire diameter is 2.5 mm, and its resistance per unit length is 3.3 Ω /km.

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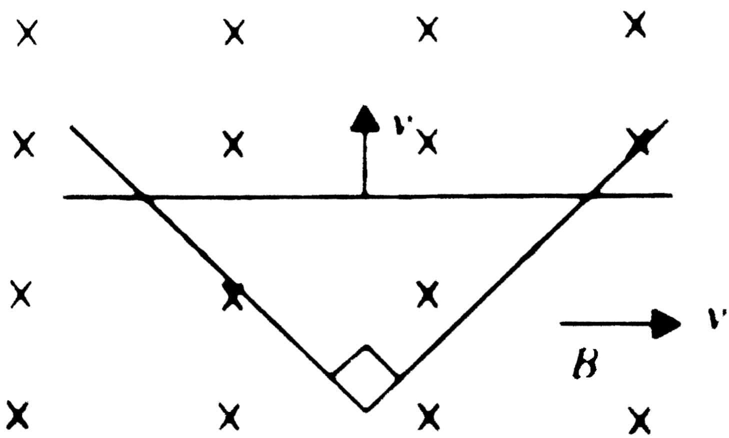
21. Two straight conducting rails form a right angle where their ends are joined. A conducting bar in contact with the rails starts at the vertex at time t = 0 and moves with constant velocity v along them as shown in

Fig. A magnetic field $\vec{B}$ is directed into the page. the induced emf in the circuit at any time t is proportional to



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22. A solenoid having an inductance of 9.70 μH is connected in series with a 1.20 $k\Omega$ resistor.

(a) If a 14.0 V battery is connected across the pair, how long will it take for the current through the resistor to reach 40.0% of its final value? (b) What is the current through the resistor at time $t = 0.50\tau_L$?

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23. A solenoid that is 85.0 cm long has a cross-sectional area of 17.0 cm^2. There are 1210 turns of wire carrying a current of 6.60 A. (a) Calculate the energy density of the magnetic field inside the solenoid. (b) Find the total energy stored in the magnetic field there (neglect end effects).

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24. A rectangular loop (area = 0.15 m^2) turns in a uniform magnetic field, B = 0.20 T. When the angle between the field and the normal to the plane of the loop is $\pi/2$ rad and increasing at 0.60 rad/s, what emf is induced in the loop?

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25. For the circuit of Fig. 30-29, assume that ~ = 10.0 V, R = 112Ω, and L = 5.50 H. The ideal battery is connected at time t = 0. (a) How much energy is delivered by the battery during the first 2.00 s? (b) How much of this energy is stored in the magnetic field of the inductor? (c) How much of this energy is dissipated in the resistor?

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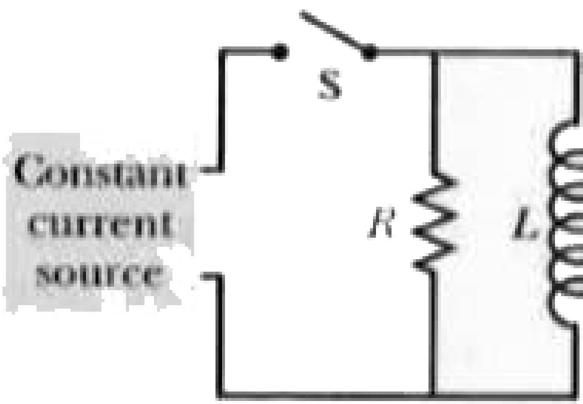
26. In Fig. 30-44, after switch S is closed at time t = 0, the emf of the source is automatically adjusted to maintain a constant current i through S. (a) Find the current through the inductor as a function of time. (b) At what time is the current through the resistor equal to the current through the inductor?



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27. A toroidal inductor with an inductance of 90 mH encloses a volume of 0.0200 m^3. If the average energy density in the toroid is 70.0 J/ m^3, what is the current through the inductor?

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28. Two solenoids are part of the spark coil of an automobile. When the current in one solenoid fails from 6.0 A to zero in 2.5 ms, an emf of 31 kV is induced in the other solenoid. What is the mutual inductance M of the solenoids?

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29. A small circular loop of area 2.00 cm^2 is placed in the plane of, and concentric with, a large circular loop of radius 1.00 m. The current in the large loop is changed at a constant rate from 50.0 A to -50.0 A (a change in direction) in a time of 1.00 s, starting at t= 0. What is the magnitude of the magnetic field B at the center of the small loop due to the current in the large loop at (a) t = 0, (b) t = 0.500 s, and (c) t = 1.00 s? (d) From t= 0 to t= 1.00 s, is $\vec{B}$ reversed? Because the inner loop is small, assume $\vec{B}$ is uniform over its area. (e) What emf is induced in the small loop at t = 0.500 s?

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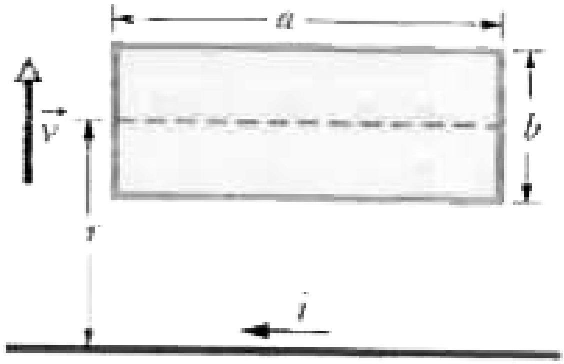
30. In Fig. 30-45 , a rectangular loop of wire with length a= 2.2 cm, width b = 0.80 cm, and resistance R = 0.40 mn is placed near an infinitely long wire carrying current i = 4.7 A. The loop is then moved away from the wire at constant speed v = 3.2 mm/s. When the center of the loop is at distance r = 1.5b, what are (a) the magnitude of the magnetic flux through the loop and (b) the current induced in the loop?



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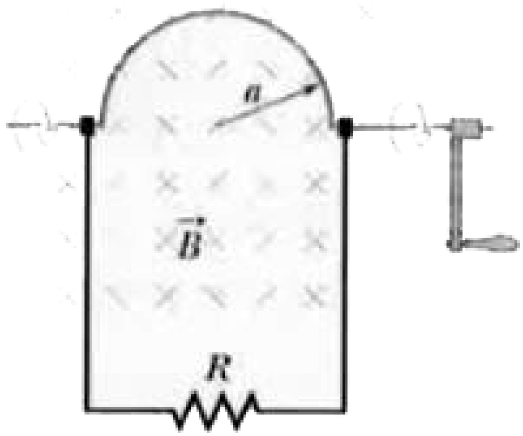
31. In Fig. 30-46, a stiff wire bent into a semicircle of radius a = 1.4 cm is rotated at constant angular speed 30 rev/s in a uniform 20 mT magnetic field. What are the (a) frequency and (b) amplitude of the emf induced in the loop?



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32. The current in an RL circuit builds up to one-third of its steady-state value in 5.00 s. Find the inductive time constant.

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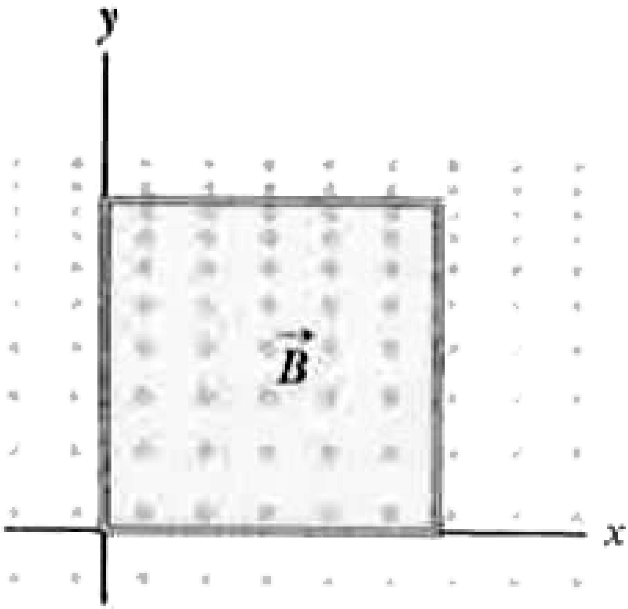
33. As seen in Fig. 30-47, a square loop of wire has sides of length 3.0 cm. A magnetic field is directed out of the page, its magnitude is given by $B = 5.0t^2y$, where B is in teslas, t is in seconds, and y is in meters. At t = 2.5 s, what are the (a) magnitude and (b) direction of the emf induced in the loop?



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34. What must be the magnitude of a uniform electric field if it is to have the same energy density as that possessed by a 20 mT magnetic field?

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35. A long solenoid has a diameter of 12.0 cm. When a current i exists in its windings, a uniform magnetic field of magnitude B = 30.0 mT is produced in its interior. By decreasing i, the field is caused to decrease at the rate of 6.50 mT/s. Calculate the magnitude of the induced electric field (a) 4.20 cm and (b) 10.3 cm from the axis of the solenoid.

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36. Two inductances L_1 & L_2 are connected in series & are seperated by a large distance.

(a) Show that their equivalent inductance is $L_1 + L_2$.

(b) Why must their seperation be larger ?

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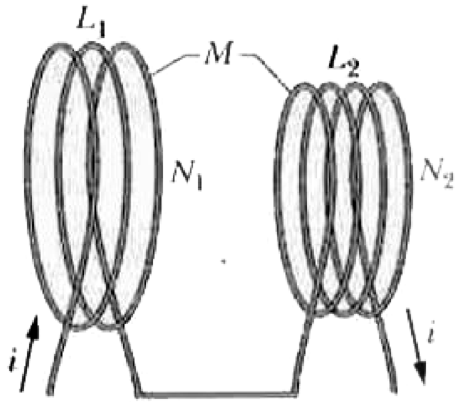
37. Two coils connected as shown in Fig. 30-48 separately have inductances L_1 and L_2. Their mutual inductance is M. (a) Show that this combination can be replaced by a single coil of equivalent inductance given by

$$L_{eq} = L_1 + L_2 + 2M$$

(b) How could the coils in Fig. 30-48 be reconnected to yield an equivalent inductance of

$$L_{eq} = L_1 + L_2 - 2M?$$



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38. Inductors in parallel. Two inductors L_1 and L_2 are connected in parallel and separated by a large distance so that the magnetic field of one cannot affect the other. (a) Show that the equivalent inductance is given by

$$\frac{1}{L_{eq}} = \frac{1}{L_1} = \frac{1}{L_2}$$

(Hint: Review the derivations for resistors in parallel and capacitors in parallel. Which is similar here?) (b) What is the generalization of (a) for N inductors in parallel?

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39. A small loop of area 3.1 mm^2 is placed inside a long solenoid that has 672 turns/cm and carries a sinusoidally varying current i of amplitude 1.28 A and angular frequency 212 rad/s. The central axes of the loop and solenoid coincide. What is the amplitude of the emf induced in the loop?

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40. At a certain place, Earth's magnetic field has magnitude B = 0.590 gauss and is inclined downward at an angle of 70.0^{o} to the horizontal. A flat horizontal circular coil of wire with a radius of 10.0 cm has 1000 turns and a total resistance of 85.0 Ω. It is connected in series to a meter with 140 Ω resistance. The coil is flipped through a half revolution about a diameter, so that it is again horizontal. How much chHrge flows through the meter during the flip?

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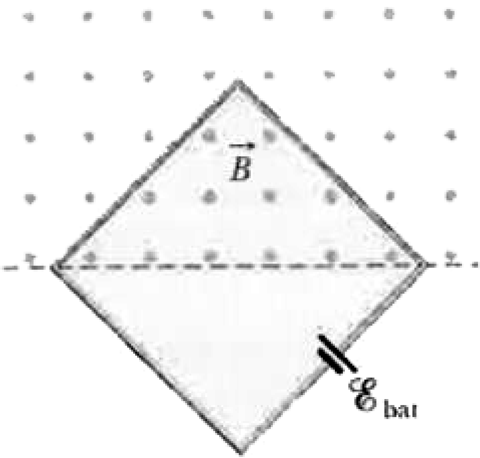
41. A square wire loop with 2.00 m sides is perpendicular to a uniform magnetic field, with half the area of the loop in the field as shown in Fig. 30-49. The loop contains an ideal battery with emf E = 12.0 V. If the magnitude of the field varies with time according to B = 0.603 - 1.25t, with B in teslas and I in seconds, what are (a) the net emf in the circuit and (b) the direction of the (net) current around the loop?



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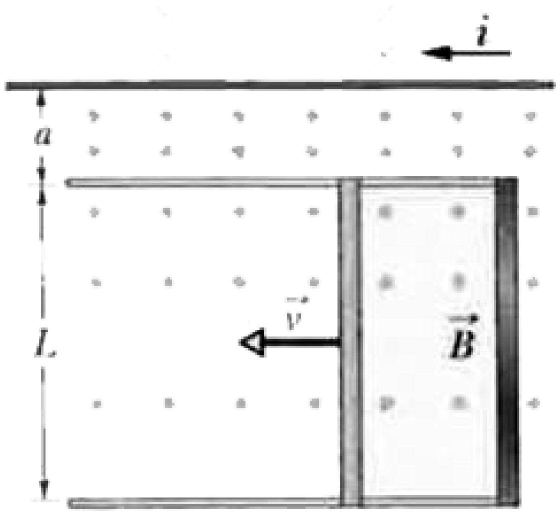
42. Figure 30-50 shows a rod of length L = 12.0 cm that is forced to move at constant speed v = 5.00 m/s along horizontal rails. The rod, rails, and connecting strip at the right form a conducting loop. The rod has resistance 0.400 Ω the rest of the loop has negligible resistance. A current i = 100 A through the long straight wire at distance a= 5.00 mm from the loop sets up a (nonuniform) magnetic field through the loop. Find the (a) emf and (b) current induced in the loop. (c) At what rate is thermal energy generated in the rod? (d) What is the magnitude of the force that must be applied to the rod to make it move at constant speed? (e) At what rate does this force do work on the rod?



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43. A wooden toroidal core with a square cross section has an inner radius of 10 cm and an outer radius of 12 cm. It is wound with one layer of wire (of diameter 1.0 mm and resistance per meter 0.020 Ω /m). What are (a) the inductance and (b) the inductive time constant of the resulting toroid? Ignore the thickness of the insulation on the wire.

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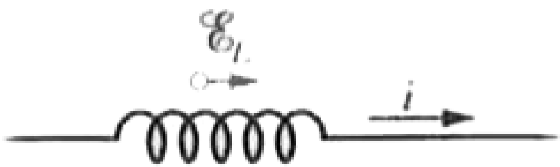
44. At a given instant the current and self-induced emf in an inductor are directed as indicated in Fig. 30-51. (a) Is the current increasing or decreasing? (b) The induced emf is 23 V, and the rate of change of the current is 18 kA/s, find the inductance.



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45. A battery is connected to a series RL circuit at time t = 0. At what multiple of τ_L will the current be 1.00% less than its equilibrium value?

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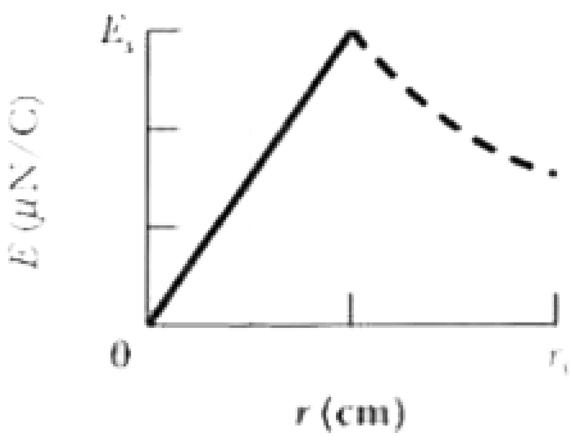
46. A circular region in an xy plane is penetrated by a uniform magnetic field in the positive direction of the z axis. The field's magnitude B (in teslas) increases with time t (in seconds) according to B = at, where a is a constant. The magnitude E of the electric field set up by that increase in the magnetic field is given by Fig. 30-52 versus radial distance r, the vertical axis scale is set by $E_s = 310 \mu N/C$, and the horizontal axis scale is set by r_s = 4.00 cm. Find a.



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47. A circular coil has a 15.0 cm radius and consists of 30.0 closely wound turns of wire. An externally produced magnetic field of magnitude 2.60 mT is perpendicular to the coil. (a) If no current is in the coil, what magnetic flux links its turns? (b)When the current in the coil is 2.80 A in a certain direction, the net flux through the coil is found to vanish. What is the inductance of the coil?

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48. A certain elastic conducting material is stretched into a circular loop of 12.0 cm radius. It is placed with its plane perpendicular to a uniform 0.800 T magnetic field. When released, the radius of the loop starts to shrink at an instantaneous rate of 75.0 emfs. What emf is induced in the loop at that instant?

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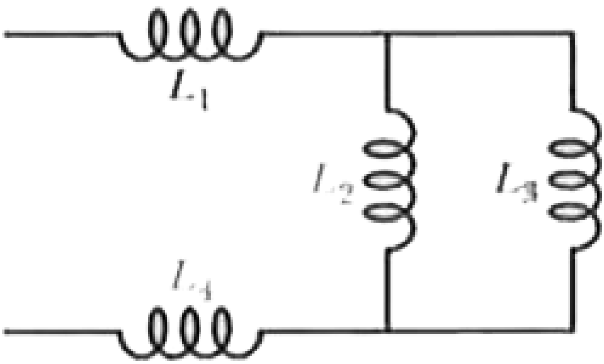
49. The inductor arrangement of Fig. 30-53, with L_1 = 50.0 mH, L_2 = 80.0 mH, L_3 = 20.0 mH, and L_4 = 15.0 mH, is to be connected to a varying current source. What is the equivalent inductance of the arrangement?



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50. Two long, parallel copper wires of diameter 4.0 mm carry currents of 7.0 A in opposite directions. (a) Assuming that their central axes are 20 mm apart, calculate the magnetic flux per meter of wire that exists in the space between those axes. (b) What percentage of this flux lies inside the wires? (c) Repeat part (a) for parallel currents.

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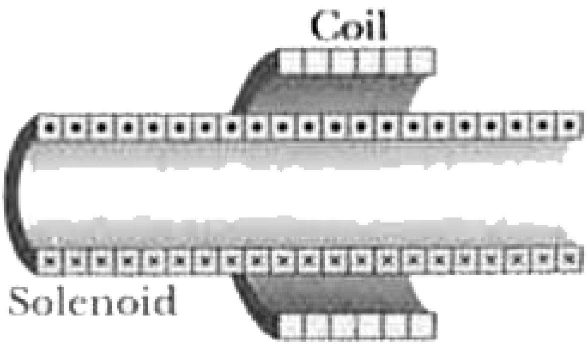
51. In Fig. 30-54, a 120-turn coil of radius 1.8 cm and resistance 5.3 Ω is coaxial with a solenoid of 220 turns/cm and diameter 3.2 cm. The solenoid current drops from 0.42 A to zero in time interval $\Delta t = 0.67$ s. What current is induced in the coil during Δt?



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52. A loop antenna of area 2.00 cm^2 and resistance 5.21 $\mu\Omega$. is perpendicular to a uniform magnetic field of magnitude 17.0 μT. The field magnitude drops to zero in 2.96 ms. How much thermal energy is produced in the loop by the change in field?

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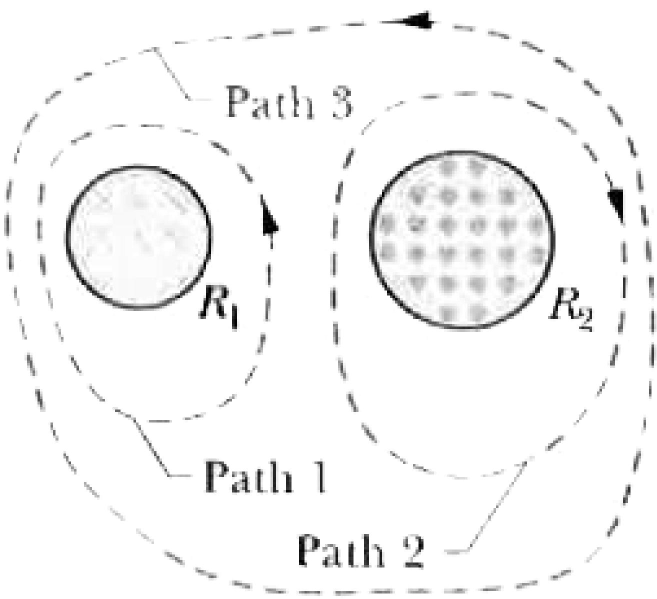
53. Figure 30-55 shows two circular regions R_1 and R_2 with radii r_1 = 20.0 cm and r_2 = 31.0 cm. In R_1 there is a uniform magnetic field of magnitude B_1= 50.0 mT directed into the page, and in R_2 there is a uniform magnetic field of magnitude B_2 = 75.0 mT directed out of the page (ignore fringing) . Both fields are decreasing at the rate of 8.50 mT/s. Calculate $\int o\vec{E}\,.\,d\,\vec{s}$ for (a) path 1, (b) path 2, and (c) path 3.



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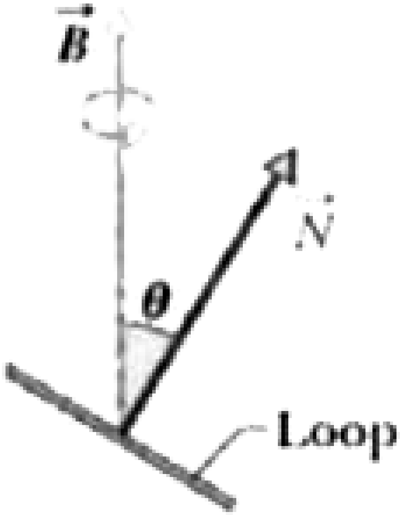
54. In Fig. 30-56, a circular loop of wire 10 cm in diameter (seen edge-on) is placed with its normal $\vec{N}$ at an angle θ = 20° with the direction of a uniform magnetic field $\vec{B}$ of magnitude 1.5 T. The loop is then rotated such that $\vec{N}$ rotates in a cone about the field direction at the rate 100 rev/min, angle θ remains unchanged during the process. What is the emf induced in the loop?



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55. The inductance of a closely packed coil of 400 turns is 8.0 mH. Calculate the magnetic flux through the coil when the current is 5.0 mA.

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56. One hundred turns of (insulated) copper wire are wrapped around a wooden cylindrical core of cross-sectional area $1.90 \times 10^{-3} m^2$. The two ends of the wire are connected to a resistor. The total resistance in the circuit is 9.50 Ω. If an externally applied uniform longitudinal magnetic field in the core changes from 1.60 T in one direction to 1.60 T in the opposite direction, how much charge flows through a point in the circuit during the change?

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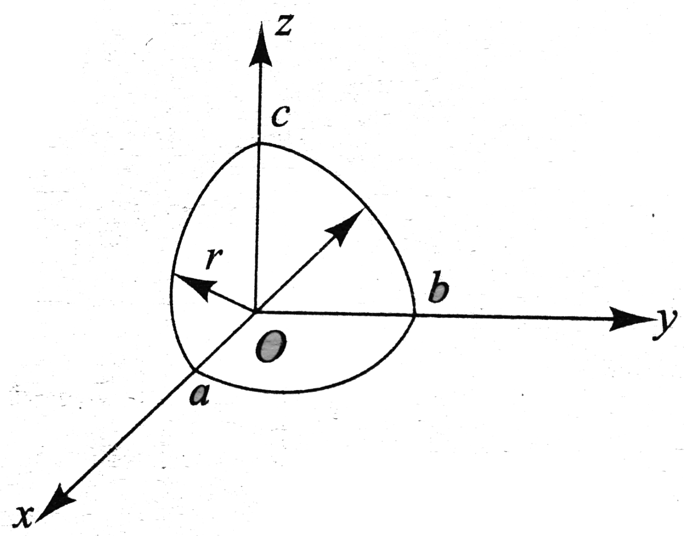
57. A wire is bent into three circular segment of radius $r = 10cm$ as shown in. Each segment is a quadrant of a circle ab lying in the $x - y$ plane, bc lying in the $y - z$ plane and ca lying in the $z - x$ plane.

(a) if a magnetic field B points in the positive x direction, what is the magnitude of the emf developed in the wire when B increases at the rate of $3mTs^{-1}$?

(b) What is the direction of the current in the segment bc.



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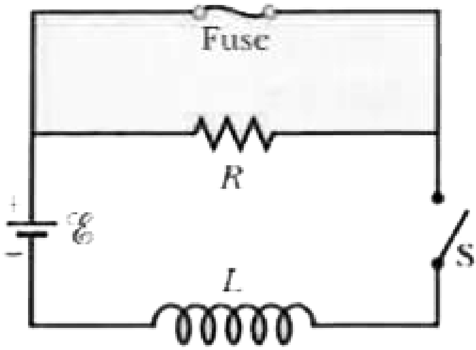
58. In Fig. 30-58, R = 15 Ω, L = 15 H , the ideal battery has E = 10 V, and the fuse in the upper branch is an ideal 3.0 A fuse. It has zero resistance as long as the current through it remains less than 3.0 A. If the current reaches 3.0 A, the fuse "blows" and thereafter has infinite resistance. Switch S is closed at time t = 0. (a) When does the fuse blow? (b) Sketch a graph of the current i through the inductor as a function of time. Mark the time at which the fuse blows.



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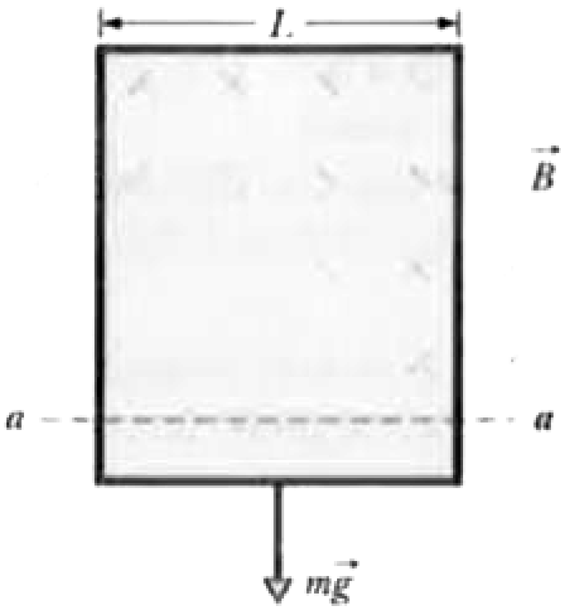
59. In Fig. 30-59, a long rectangular conducting loop, of width L , resistance R, and mass m, is hung in a horizontal, uniform magnetic field $\vec{B}$ that is directed into the page and that exists only above line aa. The loop is then dropped, during its fall , it accelerates until it reaches a certain terminal speed v_t. Ignoring air drag, find an expression for v_t.



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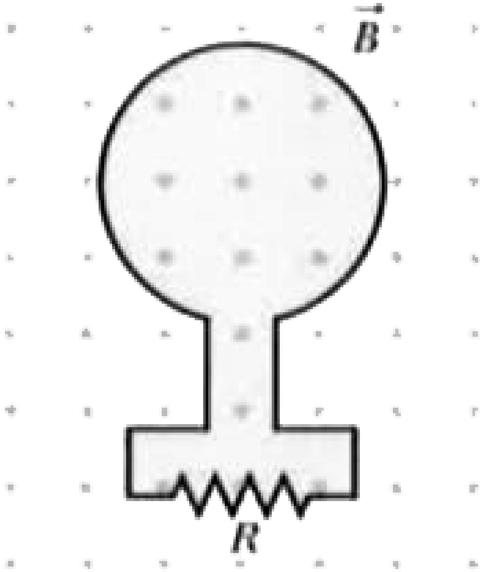
60. In Fig. 30-60, the magnetic flux through the loop increases according to the relation $\phi_B = 3.0t^2 = 7.0t$, where ϕ_B is in milliwebers and tis in seconds. (a) What is the magnitude of the emf induced in the loop when t = 1.5 s? (b) Is the direction of the current through R to the right or left?



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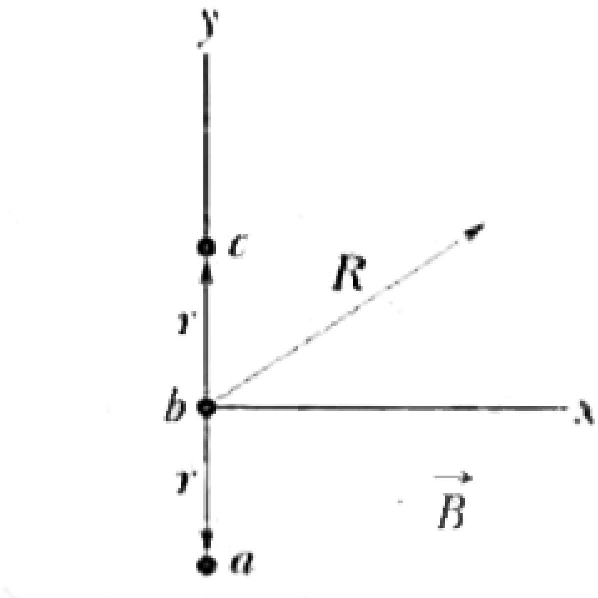
61. Figure 30-61 shows a uniform magnetic field $\vec{B}$ confined to a cylindrical volume of radius R. The magnitude of $\vec{B}$ is decreasing at a constant rate of 10 mT/s. In unit-vector notation, what is the initial acceleration of an electron released at (a) point a (radial distance r = 5.0 cm), (b) point b (r = 0), and (c) point c (r = 5.0 cm)?



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62. A square loop 10 cm to a side is placed on a wooden table in a uniform magnetic field of magnitude 0.25 T. It is found that the biggest magnetic flux through the loop is measured when the loop is flat on the table. What is the flux through the loop when it is tilted such that the plane of the loop makes a 60° angle with the table?

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63. The magnetic flux through each of give faces of a neutral playing dice is given $\phi_B = \pm NWb, whereN(= 1to5)$ is the number of spots on the face. The flux is positive (out -ward) for N even and negative (inward) for N odd What is the flux through sixth face of the die ?

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64. Initially there is no magnetic flux through a certain conducting loop. A magnetic field near the loop is then suddenly turned on, and 5 s later, the magnetic flux through the loop is 1.0 Tm^2. What is the average magnitude of the induced emf in the loop during those 5 s?

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65. At the Earth's equator, B is horizontal and to the north, with a magnitude of approximately $7 \times 10^{-5} T$. (a) What is the magnetic flux through a loop of radius 0.1 m, lying flat on the ground? (b) If the same loop is balanced on its edge such that its axis points northwest, what is the magnetic flux through the loop? (c) If the loop is now rotated such that its axis points north, what is the magnetic flux through the loop? (d) If the loop is now rotated such that its axis points west, what is the magnetic flux through the loop?

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66. An airliner with a wingspan of 33.5 m travels toward the east at a speed of 280 m/s in a region where the Earth's magnetic field is 4.2×10^{-5} T directed toward the north and 53° below horizontal. (a) What is the induced emf between the plane's wingtips? (b) Will a bulb glow if we connect the tip of wings by a conducting wire with a bulb in between?

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67. A cubical region of space with side lengths 0.05 m contains a uniform magnetic field. If the total magnetic energy stored in this region is π J, what is the magnitude of the magnetic field?

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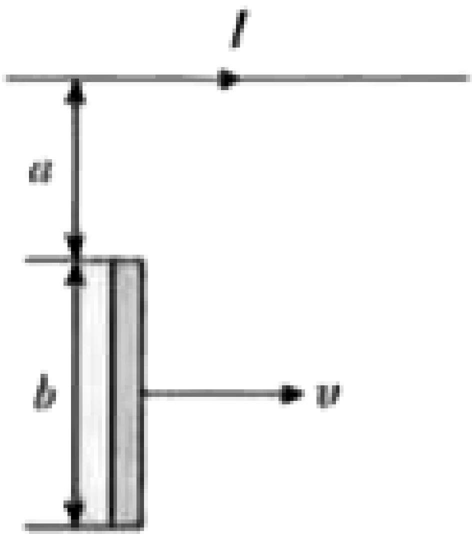
Practice Questions Single Correct Choice Type

1. A rod of length b moves with a constant velocity v in the magnetic field of a straight long conductor that carries a current I as shown in the below figure. The emf induced in the rod is



A. $\frac{\mu_0 I v}{2\pi}\tan^{-1}\left(\frac{a}{b}\right)$

B. $\frac{\mu_0 I v}{2\pi} \ln\left(1 + \frac{a}{b}\right)$

C. $\frac{\mu_0 I v \sqrt{ab}}{2\pi(a+b)}$

D. $\frac{\mu_0 I v (a+b)}{4\pi ab}$

Answer: B

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2. A car moves on a plane road, induced emf produced across the axis is maximum when it

A. Moves at the pole

B. Moves at equator

C. Remain stationary

D. No emf induced at all

Answer: A

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3. The current flowing in two coaxial coils in the same direction. On increasing the distance the two, the electric current will

A. Increase

B. Decrease

C. Remain unchanged

D. The information is incomplete

Answer: A

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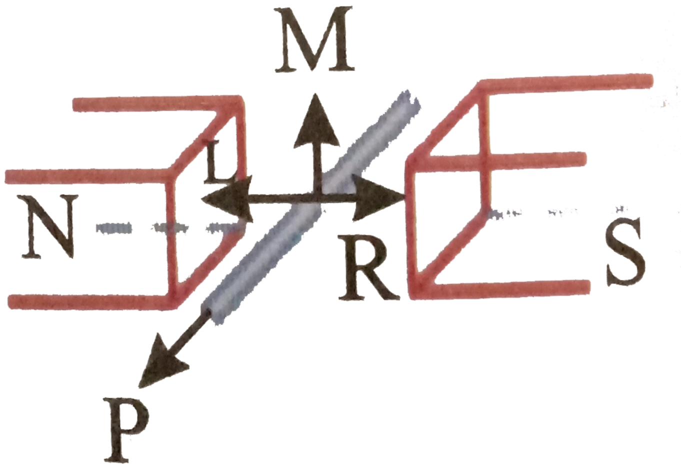
4. An electric potential difference will be induced between the ends of the conductor shown in the figure, if the conductor moves in the direction shown by



A. P

B. Q

C. L

D. M

Answer: D

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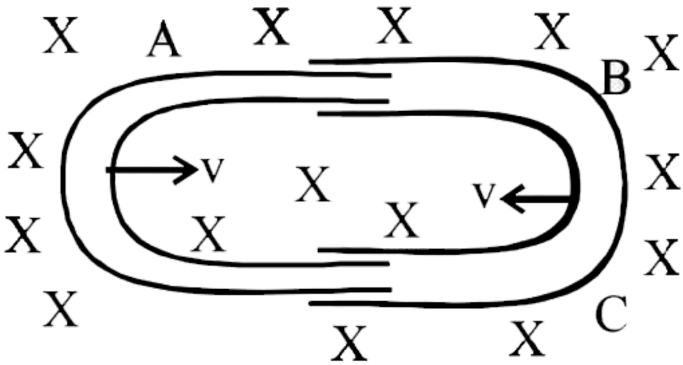
5. One conducting U tube can slide inside another as shown in figure, maintaining electrical contacts between the tubes. The magnetic field B is perpendicular to the plane of the figure. If each tube maoves towards the other at a constant speed v. Then the emf induced in the circuit in terms of B, l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



A. Zero

B. 2B/v

C. B/v

D. $-B/v$

Answer: B

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

A. $\frac{\mu_0}{4\pi l} \times \frac{Rm}{pD}$

B. $\frac{\mu_0}{4\pi R} \times \frac{lm}{pD}$

C. $\frac{\mu_0}{4\pi l} \times \frac{R^2 m}{pD}$

D. $\frac{\mu_0}{2\pi R} \times \frac{lm}{pD}$

Answer: A

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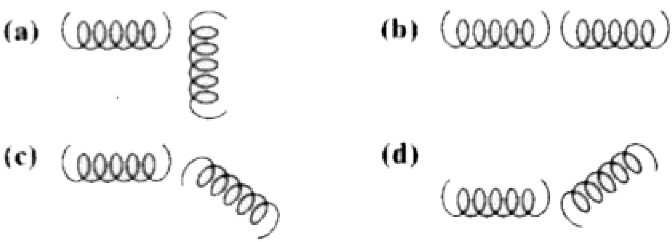
7. For which arrangement of two coils, shown in the below figure, coefficient of mutual inductance is maximum and for which it is minimum?



A. For (a) and (d), respectively

B. For (b) and (a), respectively

C. For (c) and (a), respectively

D. For (a) and (d), respectively

Answer: B

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8. Find the inductance of a solenoid of length l whose winding is made of copper wire of mass m. The winding resistance is equal to R. The solenoid diameter is considerably less than its length.

A. $\frac{\mu_0 R}{4\pi m l p p_0}$

B. $\frac{\mu_0 l p p_0}{4\pi m R}$

C. $\frac{\mu_0}{4\pi} \times \frac{mR}{l p p_0}$

D. None of these

Answer: C

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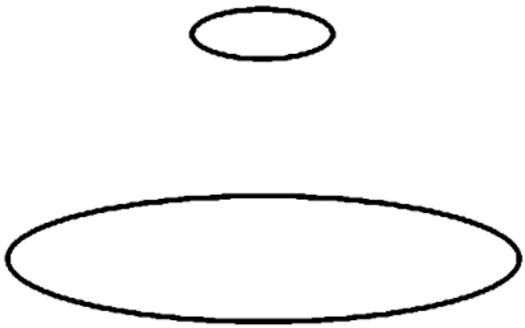
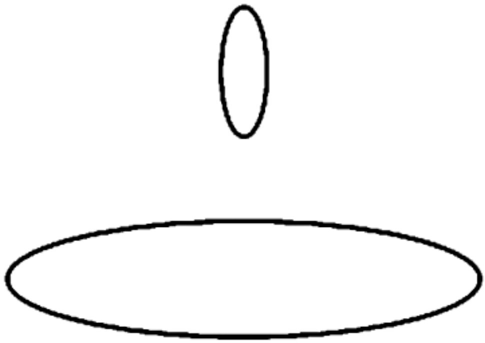
9. Two circular coils can be arranged in any of the three situation shown in the figure. Their mutual inductance will be



(a)

,



(b)

,

(c)

A. Maximum in situation depicted in figure

(i)

B. Maximum in situation depicted in figure

(ii)

C. Maximum in situation depicted in figure

(iii)

D. The same in all situations

Answer: A

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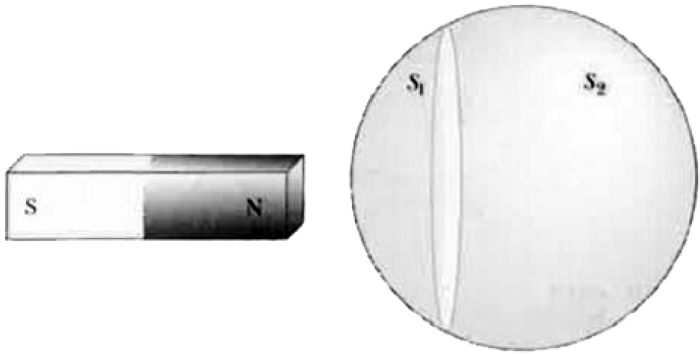
10. A spherical surface is split into two parts, S_1 and S_2, by a circular loop. The sphere is placed near a bar magnet, as shown in the following figure.



Through which of the two parts is the magnitude of the magnetic flux larger?

A. S_1

B. S_2

C. The magnitude of the flux is the same for both

D. Cannot tell without more information about the magnetic field

Answer: C

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11. A sphere of radius R is placed near a long straight wire that carries a steady current I. The magnetic field generated by the current is B. The total magnetic flux passing through the sphere is

A. $\mu_0 I$

B. $\mu_0 I / \left(4\pi R^2\right)$

C. Zero

D. Need more information

Answer: C

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12. A coil wire rotates about a horizontal north-south axis with its plane kept along axis. Assume that at the point, the earth's magnetic field is along north direction. How does the magnetic field contribute to the emf induced in this coil?

A. Both the horizontal and vertical components contribute to the induced emf

B. Only the horizontal component induces an emf

C. Only the vertical component induces an emf

D. There is no emf induced in the coil

Answer: D

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13. A magnet moves inside a coil. Which of the following factors can affect the emf induced in the coil?

I. The speed at which the magnet moves

II. The magnetic field of the magnet

III. The number of turns in the coil

A. I only

B. I and II only

C. II and III only

D. I, II and III

Answer: D

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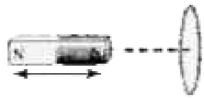
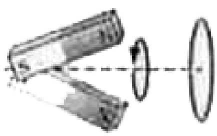
14. A magnet is in form of a bar as shown in the figure. The line joining the center of the bar and the center of the coil (central axis) is perpendicular to the plane of the oil. Which of the following motions of the bar will not induce electric current in the coil?

A. Translation motion back and forth

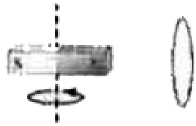


B. Translation motion up and down

C. The bar axis is at angle to the central axis and spins around it.



D. The bar spins around an axis in the paper plane.



Answer: C

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15. A rectangular loop of wire is placed perpendicualr to a uniform magnetic field and then spun around one of its sides at frequency f. The induced emf is a maximum when the

A. The flux is zero

B. The flux is a maximum

C. The flux is half its maximum value

D. The derivative of the flux with respect to time is zero

Answer: A

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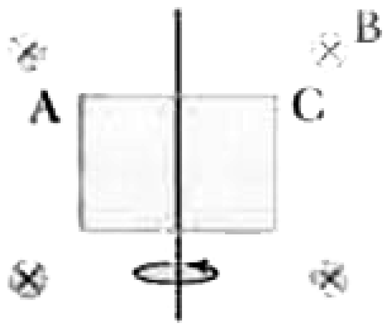
16. A loop of wire is turned round the vertical axis by 180° in a uniform magnetic field so that at the beginning of motion the point A moves toward the observer while the point C moves away from the observer. The direction of current, induced in the loop, is



A. Permanently from A to C

B. Permanently from C to A

C. From A to C during the first half of the turn and then has the opposite direction

D. From C to A during the first half of the turn and then has the opposite direction

Answer: C

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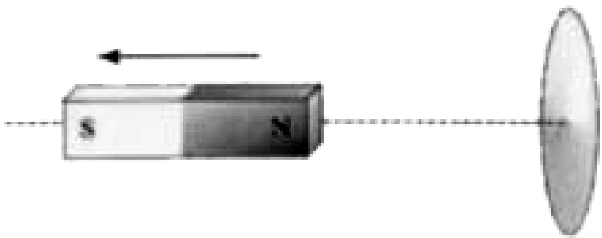
17. A bar magnet with its north (N) and south (S) poles as shown in the following figure is initially moving to the left, along the axis of, and away from a circular conducting loop. A current I is induced in the loop, with a being the acceleration of the magnet due to this current. As seen from the magnet looking in the direction of the loop,



A. I runs clockwise and a points to the left

B. I runs counterclockwise and a points to the right

C. I runs clockwise and a points to the right

D. I runs counterclockwise and a points to the left

Answer: C

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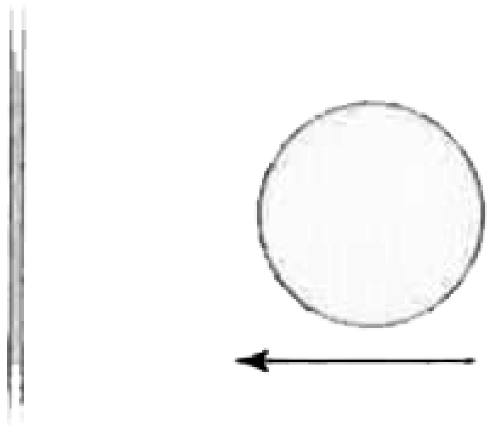
18. A coil is moving toward a straight long wire carrying a steady electric current. The wire and the motion are within the plane of the coil as shown in the following figure. The force exerted by the wire on the coil is in the direction



A. Away from the wire

B. Toward the wire

C. Into the paper plane

D. Out of the paper plane

Answer: A

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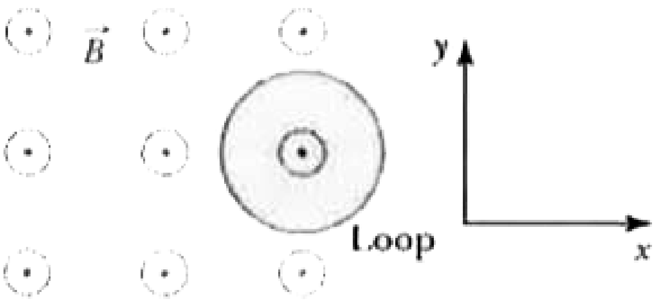
19. A circular loop of wire is positioned half in and half out of a square region of uniform magnetic field directed in the +z direction, out of the paper, as shown in the following figure. To induce a counterclockwise current in this loop



A. Move it in the +y direction

B. Move it in the -x direction

C. Move it in the +x direction

D. Move it in the -y direction

Answer: C

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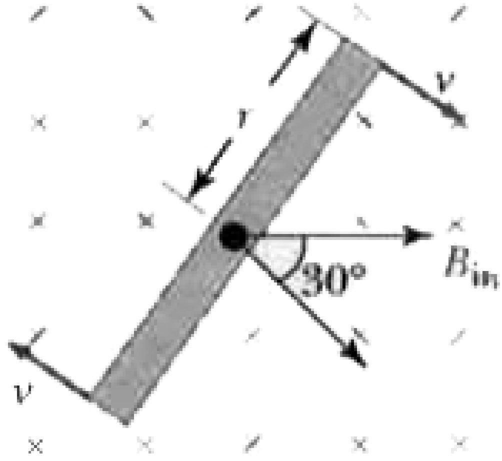
20. A rectangular loop, in edge view, as shown in the following figure, is rotating in a horizontal magnetic field. The axis of rotation is perpendicular to the page and is shown by a black dot in the middle of the figure. The parts of the loop perpendicular to the page are moving at a velocity v as shown in the figure. At the instant depicted, the normal to the loop makes an angle of 30° with the east direction. Which of the following statements, about the magnetic flux ϕ through the loop and the induced emf in the loop, are true, at the instant depicted?



A. ϕ is increasing and emf is increasing

B. ϕ is increasing and emf is decreasing

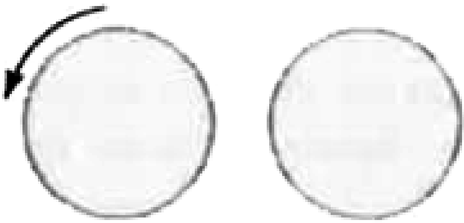
C. ϕ is decreasing and emf is increasing

D. ϕ and emf are both zero

Answer: D

View Text Solution

21. A constant current of 3.0 A flows counterclockwise in the circular coil in the following figure. What is the direction of the induced current in the coil on the right?



A. Counterclockwise

B. Clockwise

C. Out of the page

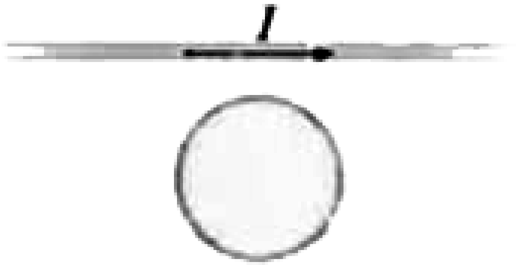
D. There is no induced current

Answer: D

Watch Video Solution

22. A long straight wire carries a current of 10.05 A to the right. A circular loop of wire lies below the long straight wire, as shown in the following figure. The current in the long straight wire decreases to zero in a time of

4.652 s. What direction does the induced current flow around the circular loop of wire?



A. Counterclockwise

B. Clockwise

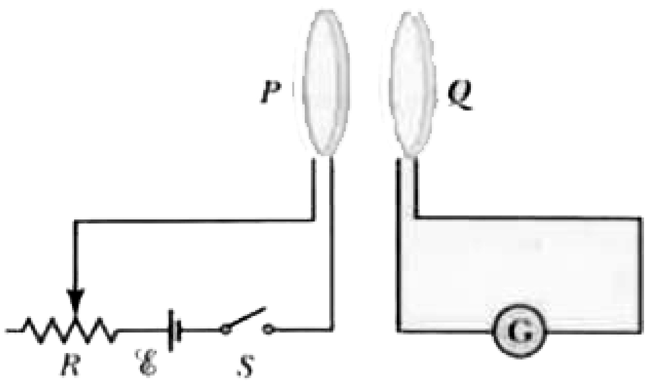
C. No induced current flows around the loop

D. The information given is insufficient for determining the direction of the induced current

Answer: B

Watch Video Solution

23. Coils P and Q each have a large number of turns of insulated wire. When switch S is closed, the pointer of galvanometer G is deflected toward the left (as shown in the following figure). With Snow closed, to make the pointer of G deflect toward the right one could



A. Move the slide of the rheostat R quickly

to the right

B. Move coil P toward coil Q

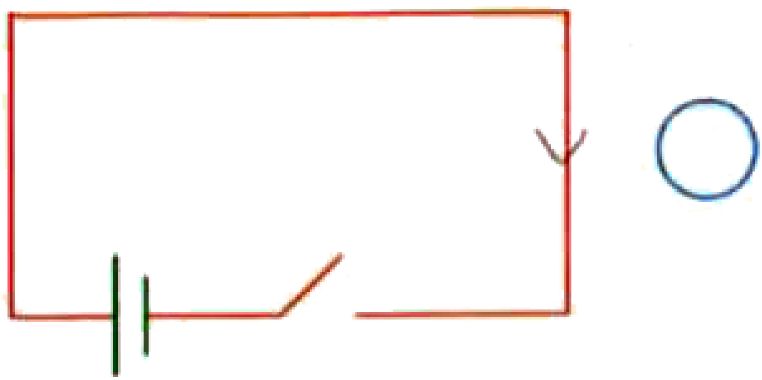
C. Move coil Q toward coil P

D. Open S

Answer: D

View Text Solution

24. Consider the situation shown in figure. 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

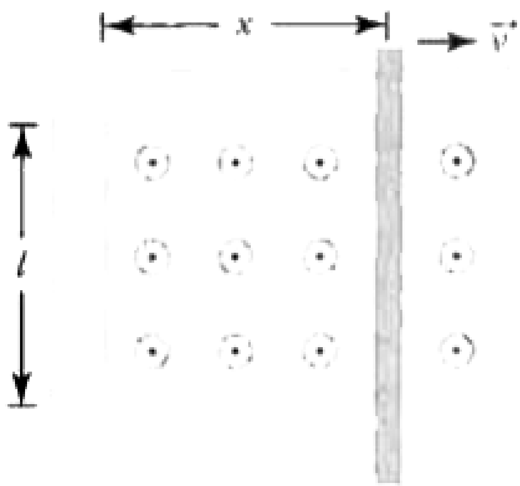
C. An anticlockwise current-pulse and then a clockwise current-pulse

D. A clockwise current-pulse and then an anticlockwise current-pulse

Answer: D

Watch Video Solution

25. A rod with resistance R lies across frictionless conducting rails in a constant uniform magnetic field $\vec{B}$, as shown in the following figure. Assume the rails have negligible resistance. The magnitude of the force that must be applied by a person to pull the rod to the right at constant speed v is



A. 0

B. Blv

C. Blv//R

D. B^2l^2v/R

Answer: D

Watch Video Solution

26. A glass rod of length l with resistance R lies in a constant uniform magnetic field rB perpendicular to the rod. The surface is frictionless. The magnitude of the force that must be applied by a person to pull the rod at constant speed v is

A. 0

B. Blv

C. Blv//R

D. B^2l^2v / R

Answer: A

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27. A metal rod is falling toward the surface of the Earth near the equator. As it falls, one end of the rod become positively charged due to the motional emf of the rod through the Earth's magnetic field. The rod is oriented so that

A. The rod is horizontal with the positive end toward the west

B. The rod is vertical with the positive end toward the north

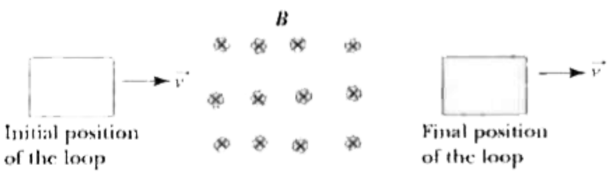
C. The rod is vertical with the positive end higher

D. The rod is horizontal with the positive end toward the east

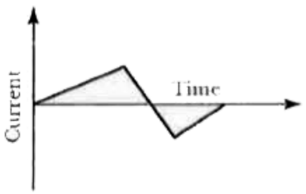
Answer: D

Watch Video Solution

28. A rectangular loop of wire in the plane of the paper starts outside a perpendicular uniform magnetic field directed into the paper as shown in the following figure. The loop is pulled with a constant velocity through the magnetic field and out the other side. Which of the following graphs would best represent the variation of the electric current in the wire with time?

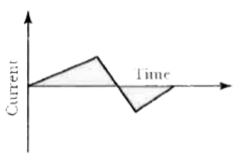


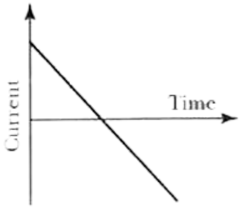
(a)

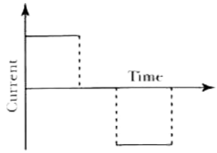


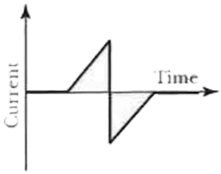
3

A.



B. 

C. 

D. 

Answer: C

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29. Which of the following is impossible in electromagnetism?

A. Breaking a magnet in half, with one piece having only northpole and the other having only south pole

B. Breaking a charged conductor in half with one piece carrying positive charge and the other carrying negative charge

C. Detecting static electric charges with a compass

D. Detecting steady electric currents with a compass

Answer: A

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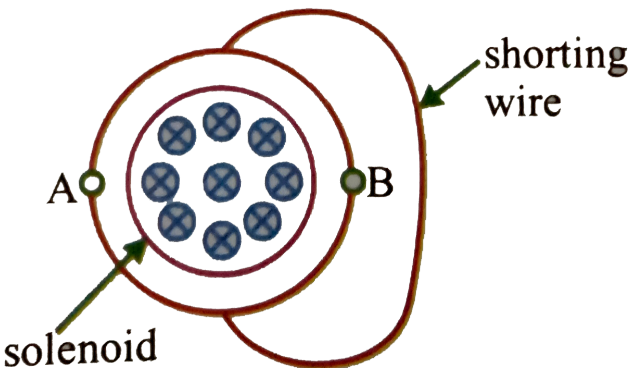
30. A very long solenoid with its axis perpendicular to the page generates an inward magnetic field whose magnitude increases with time. This induces an emf in a conducting wire loop around the solenoid which lights two identical bulbs A and B connected in series along the wire. Now two points dimetrically opposite on the wire loop are shorted with another conducting wire (having zero resistance) lying to the right og bulb B in the plane of the page. After the shorting wire is inserted:



A. Bulb A goes out, and bulb B dims

B. Bulb A goes out, and bulb B gets brighter

C. Bulb B goes out, and bulb A dims

D. bulb B goes out, and bulb A gets brighter

Answer: D

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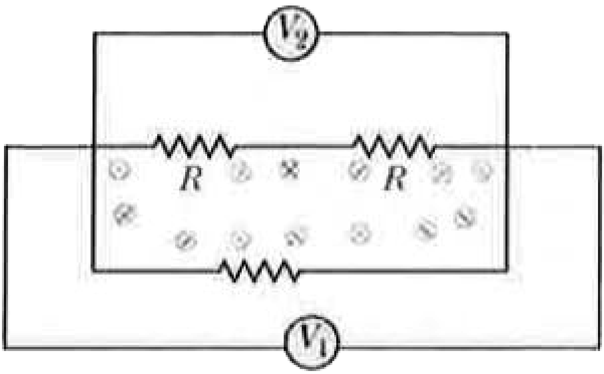
31. A changing magnetic field pierces the interior of a circuit containing three identical resistors. Two ideal voltmeters are connected to the same points, as shown in the following figure. If V_1 reads 1 mV, then V_2 reads



A. 0

B. 13 mV

C. 12 mV

D. 1 mV

Answer: D

View Text Solution

32. What will happen to the inductance of a solenoid if it is stretched to twice its length while maintaining the same number of turns and cross-sectional area?

A. Its inductance will double

B. Its inductance will be reduced to half

C. Its inductance will remain unchanged

D. Its inductance will be reduced to one fourth

Answer: B

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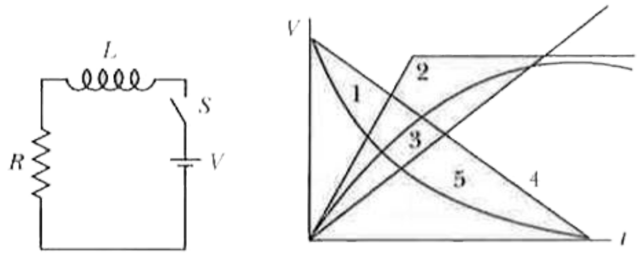
33. An open switch in an RL circuit is closed at time t = 0, as shown in the following figure. The curve that best illustrates the variation of potential difference across the resistor as a function of time is



A. 1

B. 2

C. 3

D. 4

Answer: C

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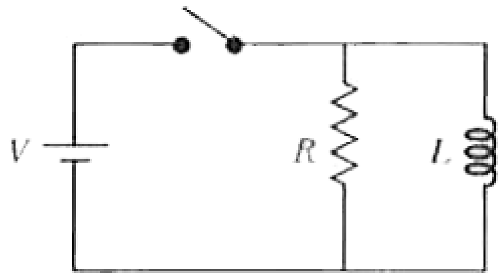
34. A 2 H coil, a 10 μF resistor, and a 5 V battery are all connected in parallel. After a current is well established through the resistor and inductor, the battery is disconnected from the circuit by opening a switch as shown in the following figure.

Immediately after the battery is disconnected, Lenz's law would predict



A. The voltage across R is zero

B. The current through R reverses direction

C. The current through the inductor reverses direction, but its magnitude tends to remain the same

D. The magnitude and direction of the voltage across the inductor tend to remain the same

Answer: B

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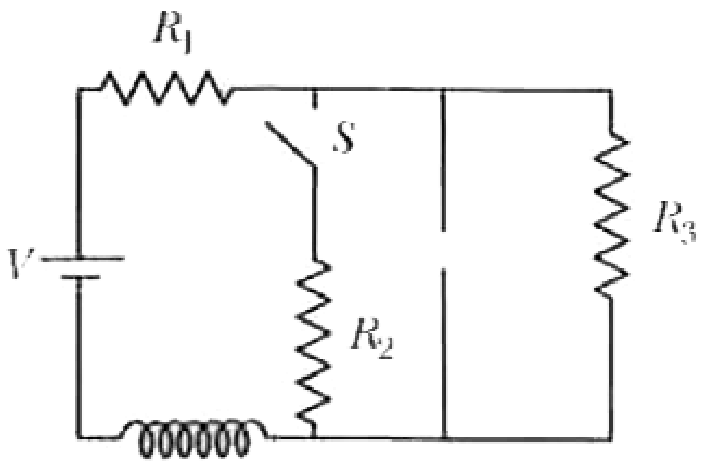
35. The circuit shown in the following figure is in a steady state with the switch open. When the switch is closed, which of the following will change immediately? (All of them eventually change, but three of them stay the same for an instant.)



A. The potential difference around the capacitor C

B. The current through the inductor L

C. The potential difference around the resistor R_1

D. The current through the resistor R_3

Answer: D

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36. In a circuit made up of inductor, resistance, ammeter, battery, and switch in series, at which of the following times after the switch is

closed is the rate of increase of current greatest?

A. The rate of current increase does not change in time

B. One time constant

C. Reciprocal of one time constant

D. Zero

Answer: D

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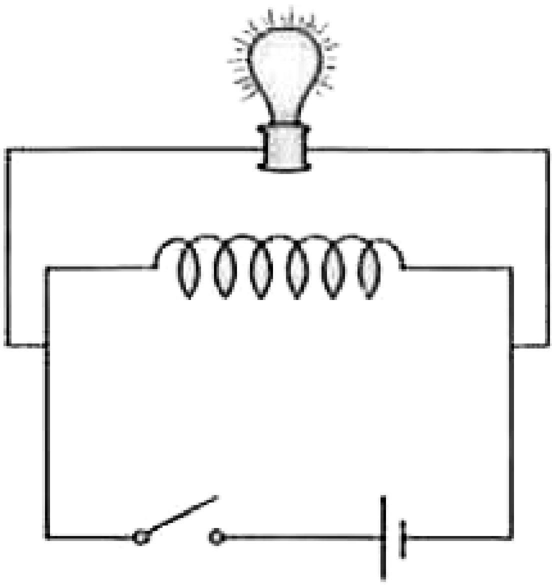
37. A battery is connected to an ideal solenoid and a light bulb in parallel (As shown in the following figure). When the switch is opened, the light bulb



A. Remains off

B. Instantly goes off

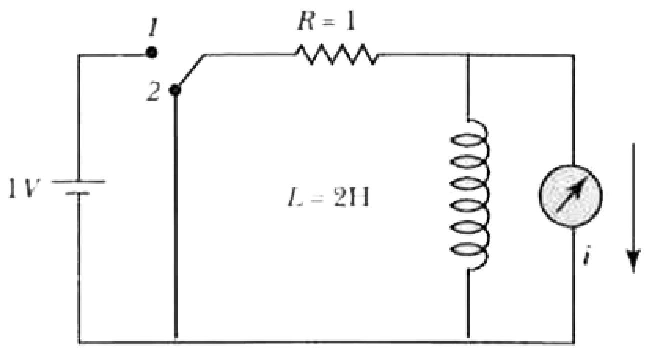
C. Slowly dims out

D. Flares up brightly, then dims and goes off

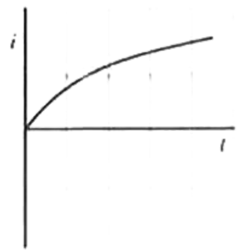
Answer: D

View Text Solution

38. In the circuit shown in the following figure, the switch is moved to position 1 at t = 0. Which of the following most closely represents the current I as a function of time?

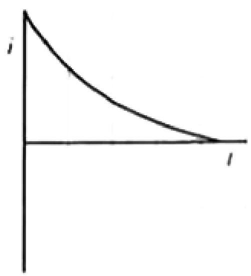


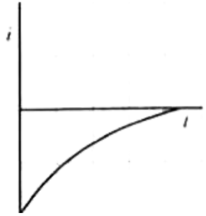
A.



B.

C.



D. 

Answer: C

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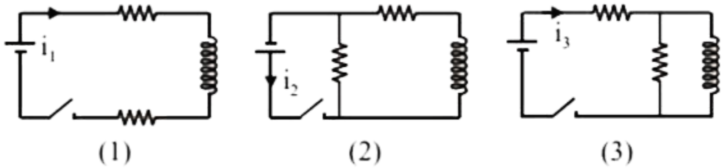
39. The figure shows three circuit with identical batteries, inductors and resistance. Rank the circuit according to the currents through the battery just after the switch is closed greatest first :



A. 3,2,1

B. 1,3,2

C. 1,2,3

D. 3,1,2

Answer: B

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40. The Earth's magnetic field passes through a square tabletop with a magnitude of $4.95 \times 10^{-5}T$ and is directed at an angle of 165° relative to the normal of the tabletop. If the tabletop has 1.50 m sides, what is the magnitude of the magnetic flux through it?

A. $1.08 \times 10^{-4}Wb$

B. $2.88 \times 10^{-5}Wb$

C. $7.11 \times 10^{-5}Wb$

D. $1.92 \times 10^{-5}Wb$

Answer: A

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41. A circular copper loop is placed perpendicular to a uniform magnetic field of 0.50 T. Due to external forces, the area of the loop decreases at a rate of $1.26 \times 10^{-3} m^2$/s. Determine the induced emf in the loop.

A. $3.1 \times 10^{-4} V$

B. $1.2 \times 10^{-3} V$

C. $6.3 \times 10^{-4} V$

D. $7.9 \times 10^{-3} V$

Answer: C

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42. A uniform magnetic field passes through two areas, A_1 and A_2. The angles between the magnetic field and the normals of areas A_1 and A_2 are 30.0° and 60.0°, respectively. If the magnetic flux through the two areas is the same, what is the ratio A_1 / A_2?

A. 0.577

B. 1

C. 0.816

D. 1.23

Answer: A

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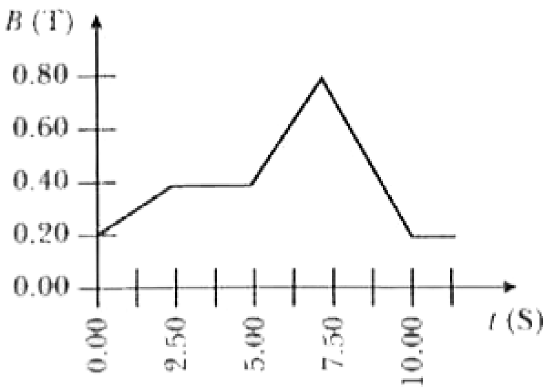
43. A circular coil of wire has 25 turns and has a radius of 0.075 m. The coil is located in a variable magnetic field whose behavior is shown on the graph. At all times, the magnetic field is directed at an angle of 75° relative to the normal to the plane of a loop. What is the average emf induced in the coil in the time interval from t = 5.00 s to 7.50 s?



A. $-18mV$

B. $-140mV$

C. $-49mV$

D. $-180mV$

Answer: A

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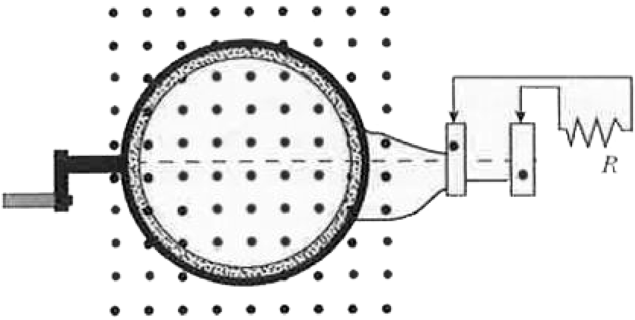
44. A circular coil has 275 turns and a radius of 0.045 m. The coil is used as an ac generator by rotating it in a 0.500 T magnetic field, as shown in the figure. At what angular speed should the coil be rotated so that the maximum emf is 175 V?



A. 28 rad/s

B. 200 rad/s

C. 50 rad/s

D. 490 rad/s

Answer: B

View Text Solution

45. A transformer has 450 turns in its primary coil and 30 turns in its secondary coil. Which one of the following statements concerning this transformer is true?

A. The turns ratio is 15 for this transformer.

B. The ratio of the voltages V_s / V_p is 15 for this transformer.

C. The ratio of the currents I_s / I_P is 0.067 for this transformer.

D. The power delivered to the secondary must be the same as that delivered to the primary.

Answer: A,C

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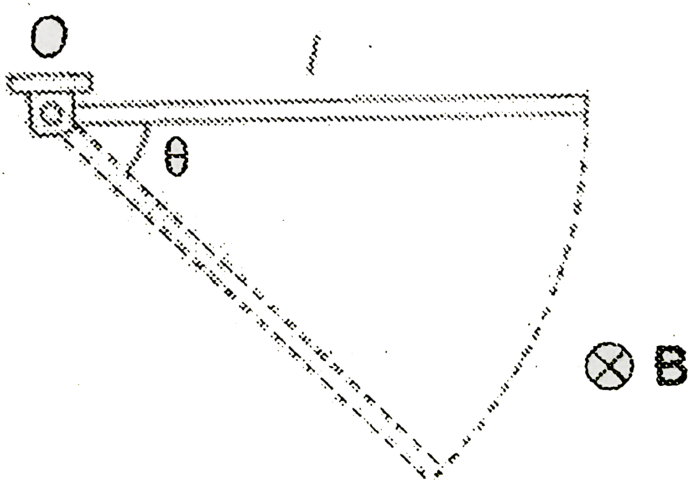
Practice Questions More Than One Correct Choice Type

1. A conducting rod of length l is hinged at point O. It is a free to rotate in a verical plane. There exists a uniform magnetic field B in horizontal direction. The rod is released from the position shown. The potential difference between the two ends of the rod is proportional to



A. $l^{3/2}$

B. l^2

C. $\sin\theta$

D. $(\sin\theta)^{1/2}$

Answer: A::D

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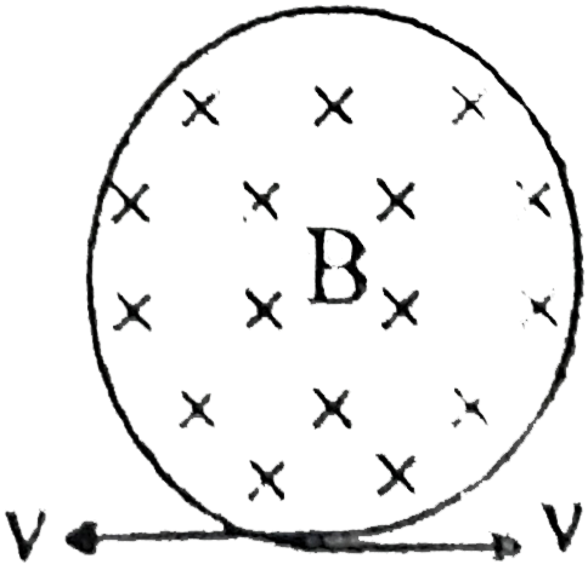
2. A circular conducting loop of radius r_0 and having resistance per unit length lamba as shown in the figure is placed in a magnetic field B which is constant in space and time. The ends of the loop are crossed and pulled in opposite directions with a velocity v such that the loop always remains circular and the radius of the loop goes on decreasing then



A. Radius of the loop changes with

$$r = r_0 - v\frac{t}{\pi}$$

B. The emf induced in the loop as a function of time is $e = 2Bv(r_0 - vt/\pi)$

C. The current induced in the loop is $I = Bv/2\pi\lambda$.

D. The current induced in the loop is $I = Bv/\pi\lambda$.

Answer: A::B::D

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3. A constant current I is maintained in a solenoid. Which of lthe following quantities will increase if an iron rod is inserted in the solenoid along its asix?

A. Magnetic field at the center

B. Magnetic flux linked with the solenoid

C. Self-inductance of the solenoid

D. Rate of Joule heating

Answer: A::B::C

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4. Two different coils have self-inductances $L_1 = 8mH$ and $L_2 = 2mH$. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power given to the two coil 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. $I_1 / I_2 = 1/4$

B. $I_1 / I_2 = 4$

C. $W_2 / W_1 = 4$

D. $V_2 / V_t = 1/4$

Answer: A::C::D

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

A. $<$ g when it is above R and moving toward R

B. $>$ g when it is above Rand moving toward R

C. =g when it is below Rand moving away from R

D. = g when it is below Rand moving away from R

Answer: A::C

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6. The magnetic flux (ϕ) linked with the coil depends on time t as $\phi = at^n$, where a and n are constants. The emf induced in the coil is e

A. If $0 < n$ then ε=0

B. If $0 < n < 1$, then $\varepsilon \neq 0$ and $|\varepsilon|$ decreases with time

C. If n = 1, then ε is constant

D. If $n > 1$, then $|\varepsilon|$ increases with time

Answer: B::C::D

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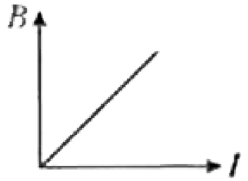
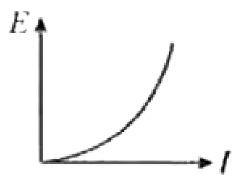
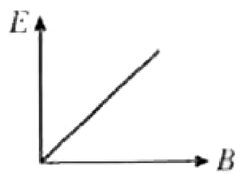
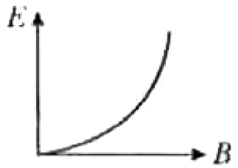
7. If B and E denote induction of magnetic field and energy density at the midpoint of a long solenoid carrying a current I, then which of the graph/graphs, shown in the following figure, is/are correct?

A. 

B. 

C. 

D. 

Answer: A::B::C

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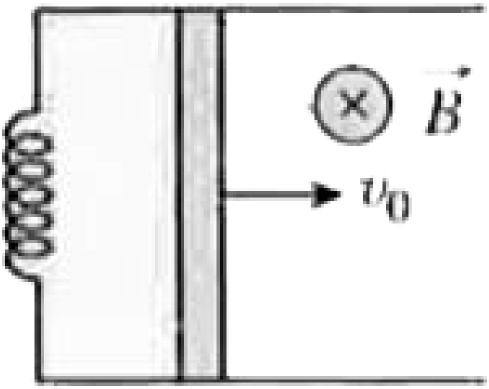
8. A loop is formed by two parallel conductors connected by a solenoid with inductance L and a conducting rod of mass M which can freely slide over the conductors. The conductors are located in a uniform magnetic field with induction B perpendicular to the plane of loop. The distance between conductors is l. At t = 0, the rod is given a velocity v_0 directed toward right and the current through the inductor is initially zero (below figure) .



A. The maximum current in circuit during the motion of rod is $v_0\sqrt{M/L}$

B. The rod moves for some distance and comes to permanently rest

C. The velocity of rod when current in the circuit is half of maximum is $\left(\sqrt{3}/2\right)v_0$

D. The rod oscillates in SHM

Answer: A::C::D

View Text Solution

9. A metal sheet is placed in front of a strong magnetic pole. A force is needed to

A. Hold the sheet there if the metal is magnetic

B. Hold the sheet there if the metal is non-magnetic

C. Move the sheet away from the pole with uniform velocity if the metal is magnetic

D. Move the sheet away from the pole with uniform velocity if the metal is nonmagnetic (Neglect any effect of paramagnetism, diamagnetism, and gravity.)

Answer: A::C

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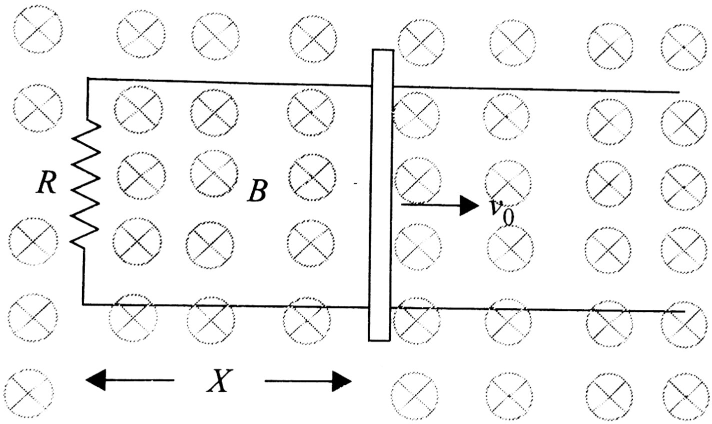
10. A conducting rod of length is moved at constant velocity v_0 on two parallel, conducting, smooth, fixed rails, that are placed in a uniform constant magnetic field B perpendicular to the plane for the rails as shown in Fig. A resistance R is connected between the two ends of the rails.

Then which of the following is/are correct:



A. The thermal power dissipated in the resistor is equal to rate of work done by external.

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 the constant velocity v_0 becomes half

Answer: A::B::D

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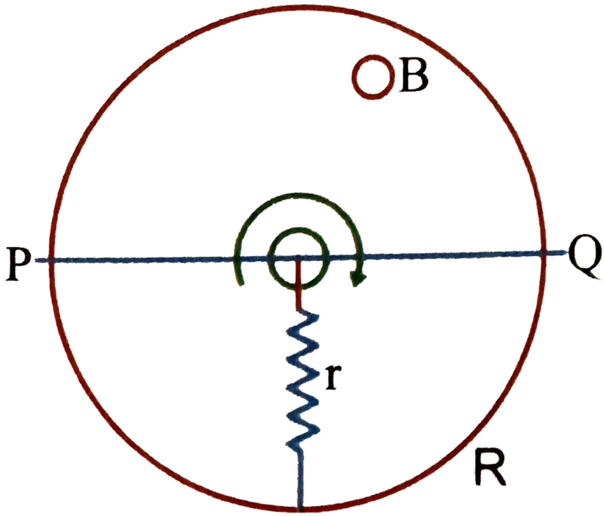
11. In the figure shown $'R'$ is a fixed conducting fixed ring of negligible resistance and radius $'a'$ PQ is a uniform rod of resistance r. It is hinged at the centre of the ring and rotated about this point in clockwise direction with a uniform angular velocity w. These is a uniform magnetic filled of strength $'B'$ ponting inwards. $'r'$ is a stationary resistance



A. Current through r is zero

B. Current through r is $2B\omega a^2 / 5r$

C. Direction of current in external r is from center to circumference

D. Direction of current in external r is from circumference to center

Answer: B::D

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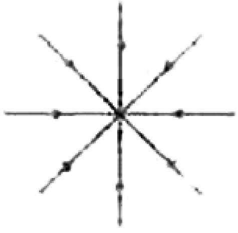
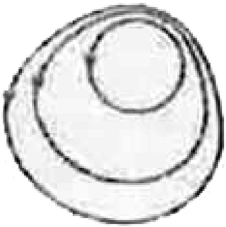
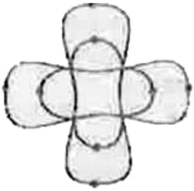
12. Which of the following field line patterns could represent a magnetic field?

A. 

B. 

C. 

D. 

Answer: B::D

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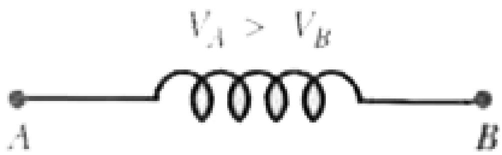
13. The potential at point A is higher than the potential at point B (shown in the following figure). Which of the following statements about the inductor current i could be true?



A. i is from A to B and increasing

B. i is from B to A and decreasing

C. i is from B to A and increasing

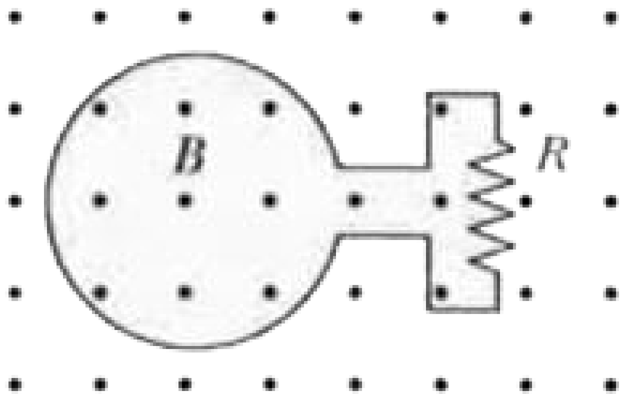
D. i is from A to B and decreasing

Answer: A::B

Watch Video Solution

Practice Questions Linked Comprehension

1. The figure shows a uniform, 3.0 T magnetic field that is normal to the plane of a conducting, circular loop with a resistance of 1.5 Ω and a radius of 0.024 m. The magnetic field is directed out of the paper as shown . Note: The area of the non-circular portion of the wire is considered negligible compared to that of the circular loop.



What is the magnitude of the average induced emf in the loop if the magnitude of the magnetic field is doubled in 0.4 s?

A. 0.43 V

B. 0.014 V

C. 0.65 V

D. 0.027 V

Answer: B

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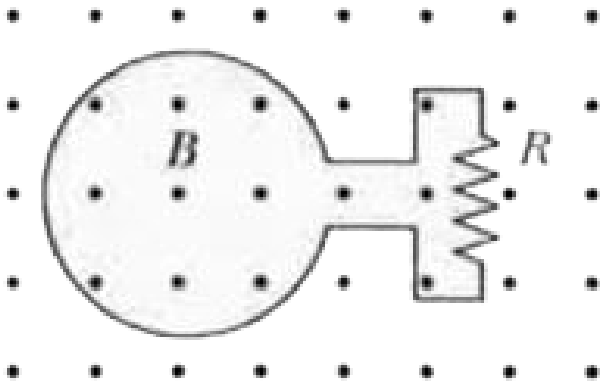
2. The figure shows a uniform, 3.0 T magnetic field that is normal to the plane of a conducting, circular loop with a resistance of 1.5 Ω and a radius of 0.024 m. The magnetic field is directed out of the paper as shown .

Note: The area of the non-circular portion of the wire is considered negligible compared to that of the circular loop.



What is the average current around the loop if the magnitude of the magnetic field is doubled in 0.4 s?

A. $2.8 \times 10^{-3} A$,clockwise

B. $9.0 \times 10^{-3}, A$, clockwise

C. 4.5×10^{-3}, A, clockwise

D. 9.0×10^{-3}, A, counterclockwise

Answer: B

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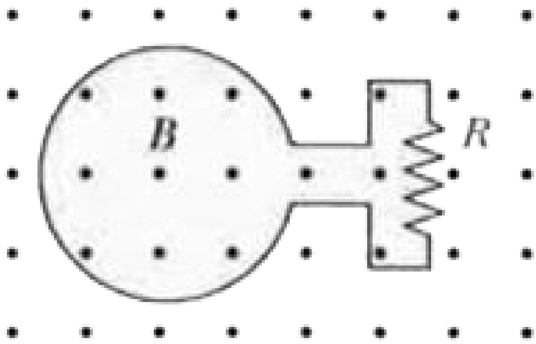
3. The figure shows a uniform, 3.0 T magnetic field that is normal to the plane of a conducting, circular loop with a resistance of 1.5 Ω and a radius of 0.024 m. The magnetic field is directed out of the paper as shown .

Note: The area of the non-circular portion of the wire is considered negligible compared to that of the circular loop.



If the magnetic field is held constant at 3.0 T and the loop is pulled out of the region that contains the field in 0.2 s, what is the magnitude of the average induced emf in the loop?

A. $2.7 \times 10^{-2} V$

B. $6.4 \times 10^{-2} V$

C. $9.8 \times 10^{-2} V$

D. $5.4 \times 10^{-2} V$

Answer: A

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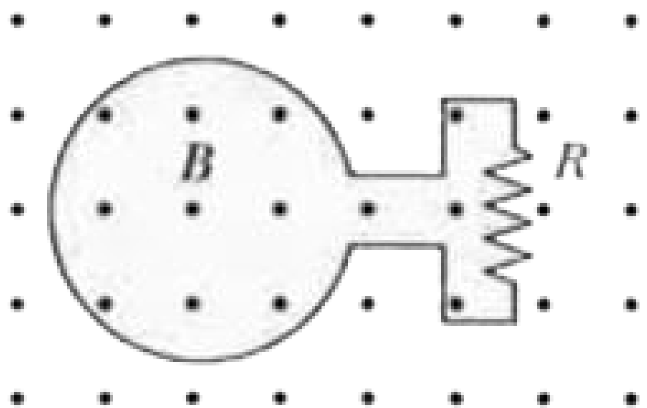
4. The figure shows a uniform, 3.0 T magnetic field that is normal to the plane of a conducting, circular loop with a resistance of 1.5 Ω and a radius of 0.024 m. The magnetic field is directed out of the paper as shown .

Note: The area of the non-circular portion of the wire is considered negligible compared to that of the circular loop.



If the magnetic field is held constant at 3.0 T and the loop is pulled out of the region that contains the field in 0.2 s, at what rate is energy dissipated in R?

A. $1.8 \times 10^{-2} W$

B. $3.8 \times 10^{-3} W$

C. $4.9 \times 10^{-4} W$

D. $2.7 \times 10^{-4} W$

Answer: C

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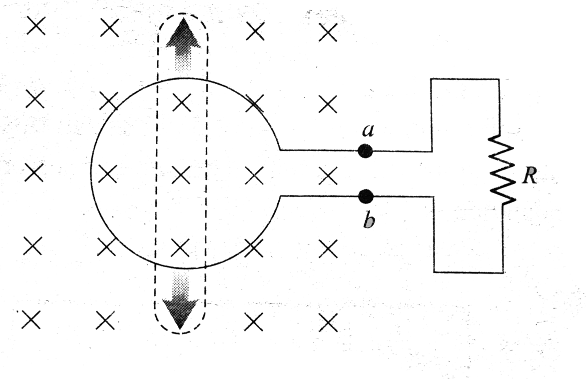
5. A flexible circular loop $20cm$ in diameter lies in a magneic field with magnitude $1.0T$, direction lies into the plane of the page as shown in Fig. 3.187. The loop is pulled at the points indicated by the arrws, forming a loop of zero area in $0.314s$.



The average induced emf in the circuit is

A. 0.2 V

B. 0.1 V

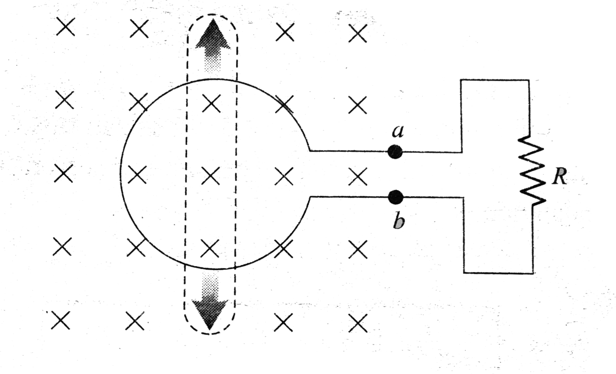
C. 1 V

D. 10 V

Answer: B

Watch Video Solution

6. A flexible circular loop $20cm$ in diameter lies in a magneic field with magnitude $1.0T$, direction lies into the plane of the page as shown in Fig. 3.187. The loop is pulled at the points indicated by the arrws, forming a loop of zero area in $0.314s$.



if $R = 0,01\Omega$, the magnitude and direction of current flowing in the loop are

A. 1 A, clockwise

B. 1 A, anticlockwise

C. 10 A, clockwise

D. 10 A, anticlockwise

Answer: C

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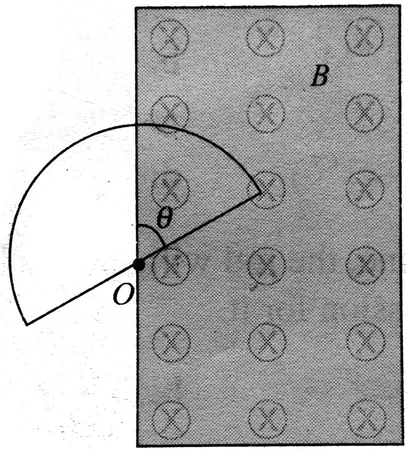
7. A wire loop enclosing a semicircle of radius R is located on the boundary of a uniform magnetic field B. At the moment $t = 0$, the loop is set into rotation with constant angular acceleration α about an axis O. The clockwise emf direction is taken to be positive.



The variation of emf as function of time is

A. $\frac{1}{2}BR^2\alpha t$

B. $\frac{3}{2}BR^2\alpha t$

C. $\sqrt{3}BR^2\alpha t$

D. $\frac{BR^2\alpha t}{\sqrt{2}}$

Answer: A

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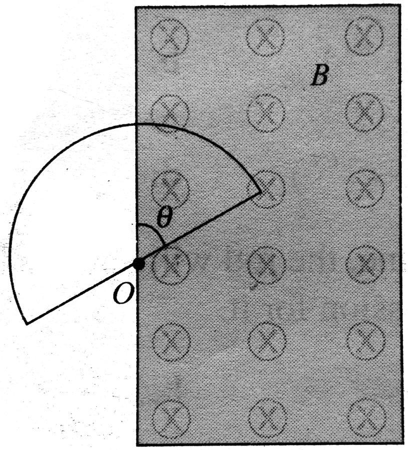
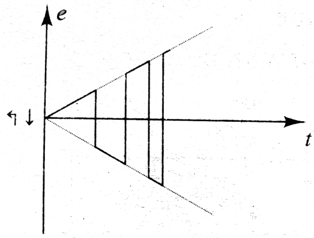
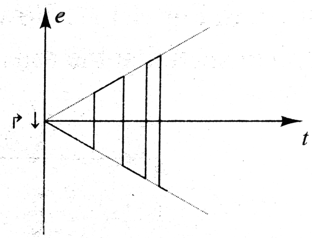
8. A wire loop enclosing a semicircle of radius R is located on the boundary of a uniform magnetic field B. At the moment $t = 0$, the loop is set into rotation with constant angular acceleration α about an axis O. The clockwise emf direction is taken to be positive.



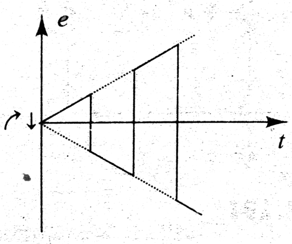
a.



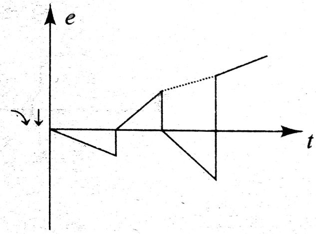
b.



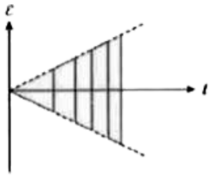
c.

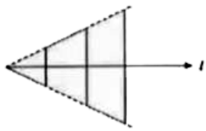


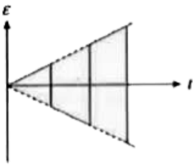
d.

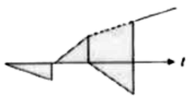


The variation of emf as a function of time is

A. 

B. 

C. 

D. 

Answer: A

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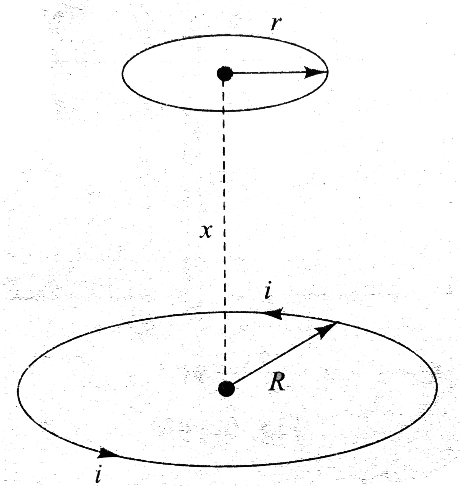
9. Figure. shows two parallel and coaxial loops. The smaller loop (radius r) is above the larger loop (radius R), by distance $x > > R$. The magnetic field due to current i in the larger loop is nearly constant throughout the smaller loop. Suppose that x is increasing at a constant rate of $dx / dt =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



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

A. $\frac{\mu_0 I R^2 \times \pi r^2}{(R^2 + x^2)^{3/2}}$

B. $\frac{\mu_0 I R^2 \times \pi r^2}{2(R^2 + x^2)^{3/2}}$

C. $\frac{2\mu_0 I R^2 \times \pi r^2}{(R^2 + x^2)^{3/2}}$

D. $\frac{\sqrt{2}\mu_0 I R^2 \times \pi r^2}{(R^2 + x^2)^{3/2}}$

Answer: B

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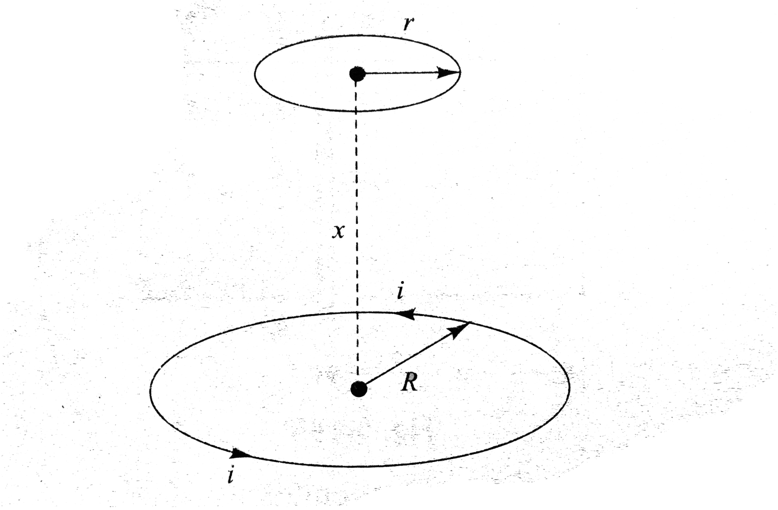
10. Figure 3.188 shows two parallel and coaxial loops. The smaller loop (radius r) is above the larger loop (radius R), by distance $x > > R$. The magnetic field due to current i in the larger loop is nearly constant throughout the smaller loop. Suppose that x is increasing at a constant rate of $dx / dt = v$.



The induced emf in the smaller loop is

A. $\frac{\mu_0 I R^2 r^2}{x^4} v$

B. $\frac{\mu_0 I R^2 r^2}{2x^4} v$

C. $\frac{3}{2} \frac{\mu_0 I R^2 r^2}{x^4} v$

D. $\frac{\mu_0 I R^2 r^2}{3x^4} v$

Answer: C

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11. In a conventional vehicle, power is dissipated due to friction . To reduce the loss of power due to friction MAGLEV train using an LEDS (electrodynamic suspension) technology was developed. It works on the principle of Lenz's law. In this system, a train moves without contact with the track due to which there is no loss of power due to friction. The advantage of EDS is that

A. No power is required to propel the train

B. No energy is lost due to conservative forces

C. No power is dissipated against frictional force

D. No force is required to overcome gravity

Answer: C

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12. In a conventional vehicle, power is dissipated due to friction . To reduce the loss of power due to friction MAGLEY train using an EDS (electrodynamic suspension) technology was developed. It works on the principle of Lenz's law. In this system, a train moves without contact with the track due to which there is no loss of power due to friction. Which of the following statements about MAGLEV train is correct?

A. It moves due to electrostatic attraction

B. It is lifted due to magnetic repulsion

C. It moves due to magnetic attraction

D. It is lifted due to electrostatic repulsion

Answer: B

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13. In a conventional vehicle, power is dissipated due to friction . To reduce the loss of power due to friction MAGLEV train using an LEDS (electrodynamic suspension) technology was developed. It works on the principle of Lenz's law. In this system, a train moves without contact with the track due to which there is no loss of power due to friction. The disadvantage of LEDS is that

A. It cannot overcome the force of gravity

B. Repulsive force is conservative so it lifts the vehicle and brings down

C. Magnetic force tends to bring down the train

D. Lot of energy is lost to start the motion as there is more opposition to the motion at lower speeds

Answer: D

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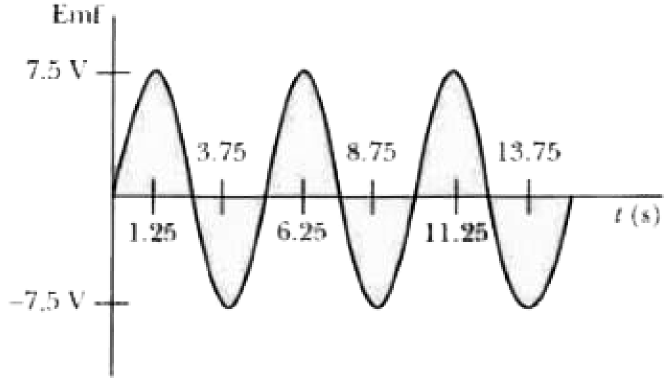
14. A single conducting loop with an area of 2.0 m^2 rotates in a uniform magnetic field so that the induced emf has a sinusoidal time dependence as shown.



With what angular frequency does the loop rotate?

A. 0.16 rad/s

B. 0.52 rad/s

C. 1.26 rad/s

D. 0.30 rad/s

Answer: C

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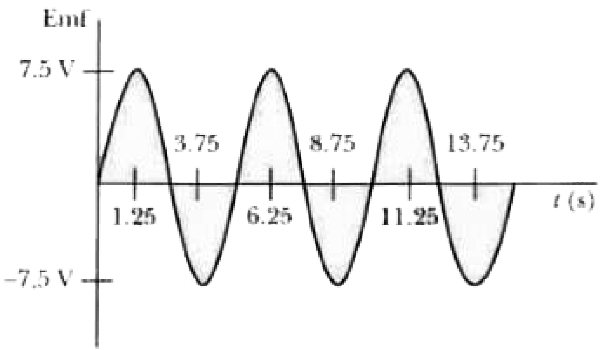
15. A single conducting loop with an area of 2.0 m^2 rotates in a uniform magnetic field so that the induced emf has a sinusoidal time dependence as shown.



What is the period of the induced current?

A. 1.25 s

B. 3.75 s

C. 2.50 s

D. 5.00 s

Answer: D

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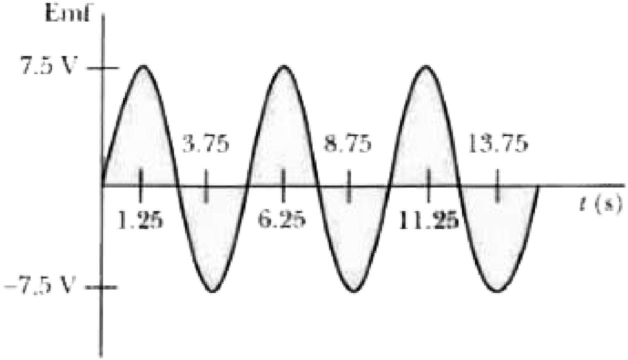
16. A single conducting loop with an area of 2.0 m^2 rotates in a uniform magnetic field so that the induced emf has a sinusoidal time dependence as shown.



Determine the strength of the magnetic field in which the loop rotates.

A. 0.5 T

B. 3.0 T

C. 2.4 T

D. 7.5 T

Answer: B

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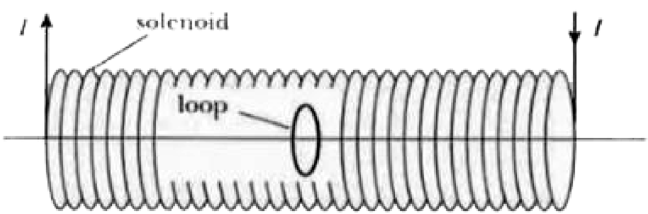
17. A 0.100 m long solenoid has a radius of 0.050 m and 1.50×10^4 turns. The current in the solenoid changes at a rate of 6.0 A/s. A conducting loop of radius 0.0200 m is placed at the center of the solenoid with its axis the same as that of the solenoid as shown.



What is the magnetic flux through the small loop when the current through the solenoid is 2.50 A?

A. 2.95×10^{-2} Wb

B. 5.92×10^{-4} Wb

C. 7.28×10^{-2} Wb

D. 4.38×10^{-4} Wb

Answer: B

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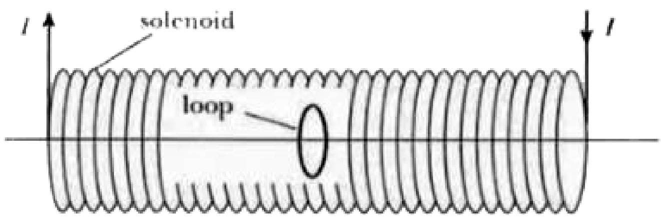
18. A 0.100 m long solenoid has a radius of 0.050 m and 1.50×10^4 turns. The current in the solenoid changes at a rate of 6.0 A/s. A conducting loop of radius 0.0200 m is placed at the center of the solenoid with its axis the same as that of the solenoid as shown.



Determine the mutual inductance of this combination.

A. $1.8 \times 10^{-4} H$

B. $3.6 \times 10^{-4} H$

C. $2.4 \times 10^{-4} H$

D. $4.4 \times 10^{-4} H$

Answer: C

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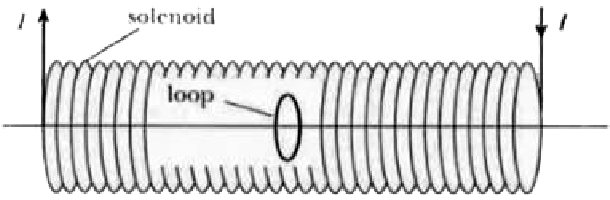
19. A 0.100 m long solenoid has a radius of 0.050 m and 1.50×10^{4} turns. The current in the solenoid changes at a rate of 6.0 A/s. A conducting loop of radius 0.0200 m is placed at the center of the solenoid with its axis the same as that of the solenoid as shown.



Determine the induced emf in the loop.

A. 0.7×10^{-3} V

B. 2.8×10^{-3} V

C. 1.4×10^{-3} V

D. 5.6×10^{-3} V

Answer: C

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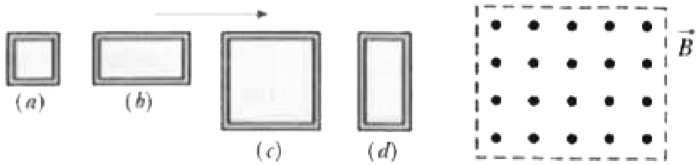
Practice Questions Matrix Match

1. The following figure shows four wire loops, with edge lengths of either Lor 2L. All four loops will move through a region of uniform magnetic field B (directed out of the page) at the same constant velocity. (Corresponding to loop mentioned in Column II, information on induced emf is provided in Column I, match them correctly).



Column I	Column II
(a) Maximum emf	**(p)** a
(b) Minimum emf	**(q)** b
(c) Greater equal emf	**(r)** c
(d) Lower equal emf	**(s)** d

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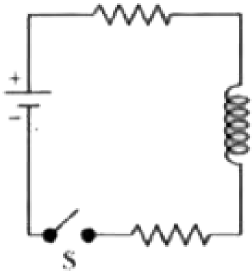
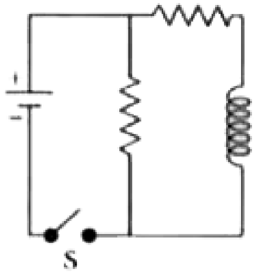
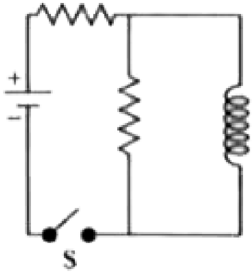
2. The following figure shows three circuits with identical batteries, inductors, and resistors.







Column I	Column II
(a) Greatest current circuit when just switch is closed	**(p)** (1)
(b) Minimum current circuit when just switch is closed	**(q)** (2)
(c) Greater current circuit after long time switch is closed	**(r)** (3)
(d) Minimum current circuit after long time switch is closed	**(s)** Impossible to determin

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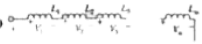
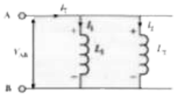
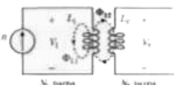
3. In each question, there is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Each question has 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

In the given table Column I lists the elements in the circuit, Column II shows their combination and Column III shows the circuit diagram.

Column I	Column II	Column III
(I) If two inductors	(i) L_1 and L_2 are over each other	(J) 
(II) If two conductors	(ii) connected in series and they have mutual inductance M	(K) 
(III) If two coils of self-inductances	(iii) kept far apart and joined in series	(L) 
(IV) If semi-conductor	(iv) connected in parallel and are kept far apart	(M) 

What are the conditions for $L = L_1 + L_2$?

A. (I) (ii) (J)

B. (IV) (ii) (M)

C. (II) (i) (M)

D. (I) (iii) (J)

Answer: (1) $\rightarrow$ (d)

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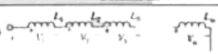
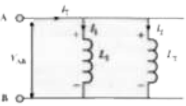
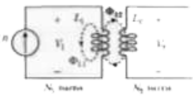
4. In each question, there is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Each question has 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

In the given table Column I lists the elements in the circuit, Column II shows their combination and Column III shows the circuit diagram.

Column I	Column II	Column III
(I) If two inductors	(i) L_1 and L_2 are over each other	(J) 
(II) If two conductors	(ii) connected in series and they have mutual inductance M	(K) 
(III) If two coils of self-inductances	(iii) kept far apart and joined in series	(L) 
(IV) If semi-conductor	(iv) connected in parallel and are kept far apart	(M) 

What are the conditions for

$$1/L = 1/L_1 + 1/L_2?$$

A. (I) (iv) (L)

B. (IV) (iii) (L)

C. (II) (iii) (L)

D. (I) (i) (M)

Answer: (2) $\rightarrow$ (a)

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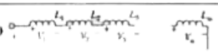
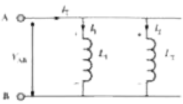
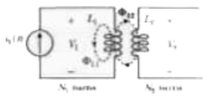
5. In each question, there is a table having 3 columns and 4 rows. Based on the table, there are 3 questions. Each question has 4 options (a), (b), (c) and (d), ONLY ONE of these four options is correct.

In the given table Column I lists the elements in the circuit, Column II shows their combination and Column III shows the circuit diagram.

Column I	Column II	Column III
(I) If two inductors	(i) L_1 and L_2 are over each other	(J) 
(II) If two conductors	(ii) connected in series and they have mutual inductance M	(K) 
(III) If two coils of self-inductances	(iii) kept far apart and joined in series	(L) 
(IV) If semi-conductor	(iv) connected in parallel and are kept far apart	(M) 

What are the conditions for M $=K\sqrt{L_1 L_2}$?

A. (III) (i) (K)

B. (I) (i) (L)

C. (III (i) (M)

D. (II) (iii) (M)

Answer: (3) $\rightarrow$ (c)

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6. Let magnetic flux be ϕ_B , induced emf be ξ and power P. All the three quantities related with each other, that is, if we vary the magnetic flux, induced emf and power change according the variation of magnetic flux. In the given table, Column I shows the variation of magnetic flux, Column II shows the effect on induced emf and Column III shows the effect on power.

Column I	Column II	Column III
(I) ϕ_B is equal to 0	(i) E is equal to L	(J) P is equal to E
(II) ϕ_B decreases gradually	(ii) E is equal to 0	(K) P is a positive constant
(III) ϕ_B remains constant	(iii) E is a positive constant	(L) P is equal to 0
(IV) ϕ_B increases gradually	(iv) E is a negative constant	(M) P is a negative constant

What are the conditions for a coil entering the magnetic field?

A. (I) (iii) (L)

B. (IV) (iv) (M)

C. (IV) (iv) (K)

D. (I) (iii) (J)

Answer: (1) $\rightarrow$ (c)

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7. Let magnetic flux be ϕ_B , induced emf be ξ and power P. All the three quantities related with each other, that is, if we vary the magnetic flux, induced emf and power change according the variation of magnetic flux. In the given table, Column I shows the variation of magnetic flux, Column II shows the effect on induced emf and Column III shows the effect on power.

Column I		Column II		Column III	
(I)	ϕ_B is equal to 0	(i)	E is equal to L	(J)	P is equal to E
(II)	ϕ_B decreases gradually	(ii)	E is equal to 0	(K)	P is a positive constant
(III)	ϕ_B remains constant	(iii)	E is a positive constant	(L)	P is equal to 0
(IV)	ϕ_B increases gradually	(iv)	E is a negative constant	(M)	P is a negative constant

What are the conditions for a coil moving in the magnetic field?

A. (III) (ii) (L)

B. (IV) (iii) (L)

C. (II) (iii) (K)

D. (I) (i) (M)

Answer: (2) $\rightarrow$ (a)

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8. Let magnetic flux be ϕ_B , induced emf be ξ and power P. All the three quantities related with each other, that is, if we vary the magnetic flux, induced emf and power change according the variation of magnetic flux. In the given table, Column I shows the variation of magnetic flux, Column II shows the effect on induced emf and Column III shows the effect on power.

Column I	Column II	Column III
(I) ϕ_B is equal to 0	(i) E is equal to L	(J) P is equal to E
(II) ϕ_B decreases gradually	(ii) E is equal to 0	(K) P is a positive constant
(III) ϕ_B remains constant	(iii) E is a positive constant	(L) P is equal to 0
(IV) ϕ_B increases gradually	(iv) E is a negative constant	(M) P is a negative constant

What are the conditions for a coil out of the field?

A. (III) (i) (L)

B. (I) (i) (J)

C. (III) (iii) (J)

D. (I) (ii) (L)

Answer: (3) $\rightarrow$ (d)

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Practice Questions Integer Type

1. A straight conductor 1 m long moves at right angle to both its length and a uniform magnetic field. If the speed of conductor is 2.0 m/s and strength of magnetic field is 104 G, find the value of induced emf in volts.

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2. A closely wound rectangular coil of 200 turns and size 0.30×0.05 m is placed perpedicular to a megnetic field of induction $0.20 Wbm^{-2}$ Calculate the induced e.m.f. in the coil, when megnetic induction drop to 0.15 Wbm^{-2} in 0.02 s.

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3. A coil of 100 turns is pulled from the magnetic field where its area includes 21×10^{-4} Wb to a place where its area includes 1×10^{-4} Wb. If the time for pulling is 0.05 s, find the emf induced in the coil.

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4. A metal disk of radius 200 cm is rotated at a constant angular speed of 60 rad/s in a plane at right angles to an external field of magnetic induction 0.05 Wb/m. Find the emf induced between the center and a point on the rim.

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5. A uniform magnetic flux density of 0.1 Wb/m extends over a plane circuit of area 2 m2 and is normal to it. How quickly must the field be reduced to zero, if an emf of 100 V is to be induced in the circuit?

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6. The two rails of a railway track insulated from each other and the ground are connected to a millivoltmeter. What will be the reading of the millivoltmeter, when a train travels at a speed of 180 km/h along the track? Given that the vertical component of Earth's field is $2 \times 10^{-5} Wb/m^2$ and the rails are separated by 1 m.

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7. A circular disc of radius 20 cm is rotating with a constant angular speed of $2.0 rad/s$ in a uniform magnetic field of 0.2 T. Find the e.m.f. induced between the centre and rim of the disc. Given magnetic field is along the axis of rotation of disc.

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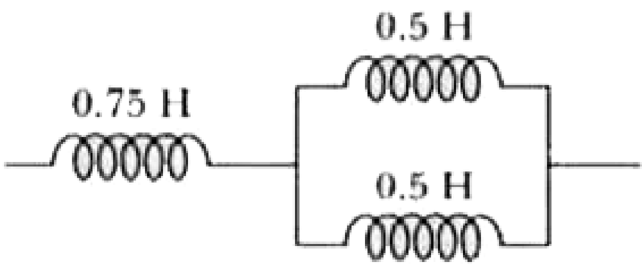
8. Calculate the resultant inductance of the three inductances that are connected as shown in the following figure.



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9. Magnetic flux of 20 μWb is linked with a coil when current of 5 mA is flown through it. What is the self-inductance of the coil (in $\times 10^{-3}$ H) ?

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10. A bicycle generator creates a 3 . 0 V , when the bicycle is travelling a speed of $9.0 kmh^{-1}$.

How much emf is generated when the bieycls is travelling a $15 km h^{-1}$.

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11. Magnetic flux of 5 microweber is linked with a coil when a current of 1 mA flows through it. What is self inductance of the coil ?

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12. A magnetic field of flux density 1.0 Wb/m^2 acts normal to an 80 tum coil of 0.01 m2 area. Find the emf induced in it, if this coil is removed from the field in 0.1 s.

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13. A coil has an inductance of $1.5 \times 10^{-2} H$. Calculate the emf induced, when current in the coil changes at the rate 200 A/s.

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14. An a.c. generator consists of a coil of 50 turns and area $2.5m^2$ rotating att an angular speed of $60rads^{-1}$ in a uniform magnetic field B = 0.3 T between two fixed pole pieces. The resistance of the circuit including that of coil is 500Ω. Find (i) the max. current drawn from the generator.

(ii) What will be the orientaiton of the coil w.r.t. the magnetic field to have (a) maximum (b) zero magnetic flux ?

(iii) Would the generator work if the coil were stationary and instead, the pole pieces rotated together with the same speed as above ?

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