ADVANCE LEVEL – I

1. An inductor coil stores 32 J of magnetic energy and dissipates energy as heat at the rate of 320 W when a current of 4A is passed through it. Find the time constant of the circuit when this coil is joined across an ideal battery.

2. It is desired to set up an undriven L - C circuit in which the capacitor is originally charged to a difference of potential of 100.0 V. The maximum current is to be 1.0 A, and the oscillation frequency is to be 1000 Hz. What are the required values of L and C?

3. A circular ring of diameter 20 cm has a resistance of 0.01 Ω. How much charge will flow through the ring if it is turned from a position perpendicular to a uniform magnetic field of 2.0 T to a position parallel to the field?

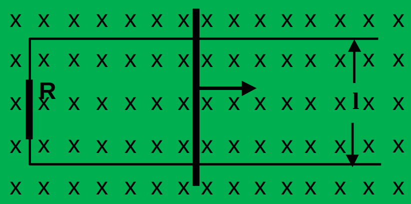
4. A solenoid of inductance 100 mH and resistance 20 Ω is connected to a cell of emf 10 V. Find the energy stored in the inductor at the time $t = 5 \ln 2$ milli sec.

5. An inductor-coil of inductance 20 mH having resistance 10 Ω is joined to an ideal battery of emf 5.0 V. Find the rate of change of the induced emf at t = 0.

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

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

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

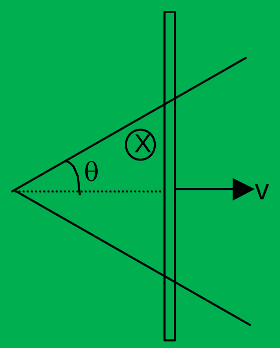


9. A semicircular copper rod of radius R rotates about an axis passing through one of its ends with an angular speed ω in a uniform magnetic field B. Find the emf developed between the two ends of the rod. The field is perpendicular to the motion of the rod.

10. A square-shaped copper coil has edges of length 50 cm and contains 50 turns. It is placed perpendicular to a 1.0 T magnetic field. It is rotated in the magnetic field about one of its diameter with time period 0.25 s. Find the magnitude of the r.m.s value of emf induced in the loop.

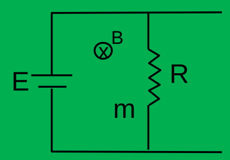
ADVANCE LEVEL – II

1. A conducting bar of sufficient length is pulled with a constant velocity on a conducting $\wedge$ shaped rail as shown in the figure. Inward magnetic field of induction B is present inside the area bounded by the bar & the rail. Find the external power delivered in moving the rail with constant velocity v (A = area of cross section of the bar, p = resistivity of the bar).

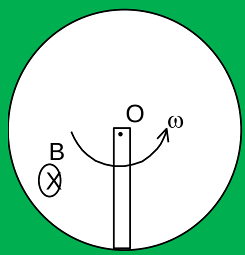


2. An LR circuit having a time constant of 50 ms is connected with an ideal battery of emf ε. Find the time elapsed before
(a) the current reaches half its maximum value
(b) the magnetic field energy stored in the circuit reaches half its maximum value.

3. A sliding bar of mass m, resistance R is released from rest. It starts sliding due to the current drawn from a battery of emf E, in a steady inward magnetic field. Find the variation of its speed with time. Find the terminal speed of the bar.



4. A metallic rod of length ℓ & resistance R is free to rotate about one of its ends over a smooth, rigid circular metallic frame of radius ℓ in an inward magnetic field of induction B. What torque should be applied by an external agent to rotate the rod with constant angular velocity ω ?

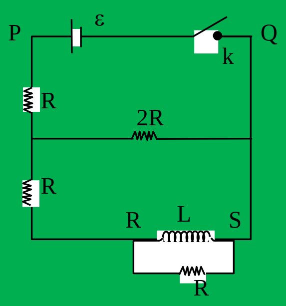


5. A small square loop of wire of side ℓ is placed inside a large square loop of wire of side L ($>>\ell$). the loops are coplanar and their centres coincide. What is the mutual inductance of the system?

6. An inductor of inductance 20 mH is connected across a charged capacitor of capacitance 5 μF & resulting L-C circuit is set oscillating at its natural frequency. The maximum charge q is 200 μC on the capacitor. Find the potential difference across the inductor, when the charge is 100 μC.

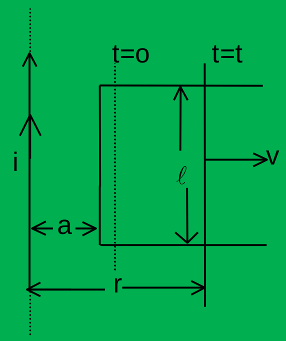
7. There are two concentric coplaner circular loops made of wire, with resistance per unit length 10^{-4} ohm/m, having diameters 0.2 m and 2m. A time varying potential difference (4+2.5t) volts is applied to the larger loop. Calculate the current in the smaller loop. Assume field direction normal to the loop.

8. In the figure shown is a R-L circuit connected with a cell of emf ε through a key k. If key k is closed find the current drawn by the battery
(a) just after the key k is closed,
(b) long after the key k is closed.



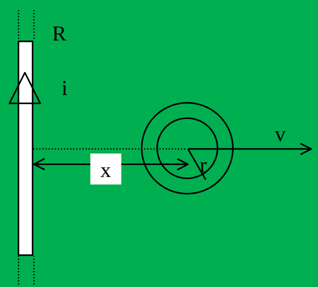
9. A very small circular loop of area 5×10^{-4} m^2, resistance 2 ohm and negligible self inductance is initially coplanar and concentric with a much larger fixed circular loop of radius 0.1 m. A constant current of 1.0 A is passed through the bigger loop. The smaller loop is rotated with constant angular velocity ω rad/sec about its diameter. Calculate the (a) induced emf and (b) the induced current through the smaller loop as a function of time.

10. A long straight wire carrying a current i and a ⊏ shaped conductor with sliding connector are located in the same plane as shown in figure. The connector of legngth ℓ and resistance R slides to the right with a constant velocity v. Find the current induced in the loop as a function of separation r between the connector and the straight wire. The resistance of the ⊏ shaped conductor and the self- inductance of the loop are assumed to be negligible.

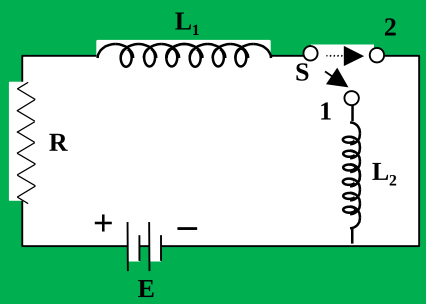


ADVANCE LEVEL – III

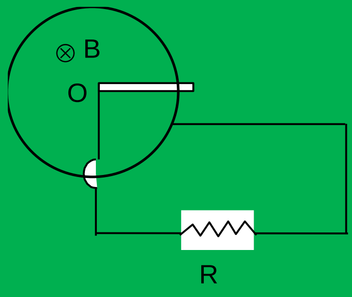
1. A small conducting loop of radius r & resistance R is pulled with velocity v perpendicular to a long straight current carrying conductor carrying a current i. If the power P dissipated in the loop is constant, find the variation of the velocity of the loop with the displacement x. (x >>r)



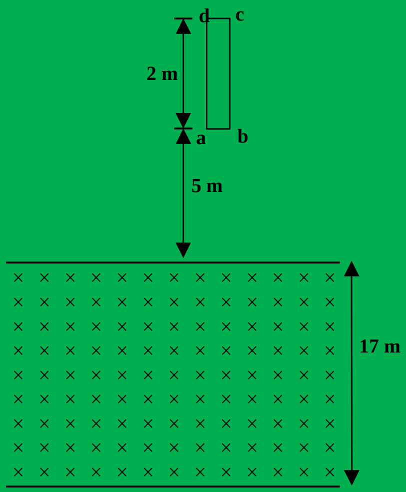
2. In the circuit shown, if the switch S is suddenly shifted to position 2 from 1 at t = 0. Find the current in the circuit as a function of time . Assume initially the circuit is in steady state condition.



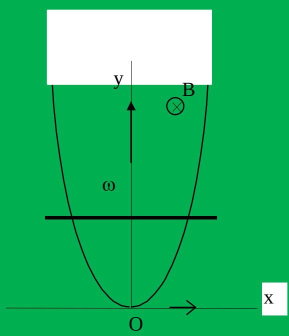
3. A conducting bar of mass M, length ℓ is set in rotation with an angular speed ω_0 so that it rotates in a rough horizontal plane of coefficient of friction μ. The magnetic induction B is directed into the plane of the paper (i.e. along the axis of rotation) The periphery of the bar is in contact with a circular conducting path of resistance R. Find the variation of ω w.r.t. time, if the bar is free to rotate about a vertical axis passing through O.



4. A rectangular wire frame of dimensions (0.25m $\times$ 2.0 m) and mass 0.5 kg falls from a height 5m above a region occupied by uniform magnetic field of magnetic induction 1 T. The resistance of the wire frame is $\frac{1}{8}\Omega$. Find the time taken by the wire frame when it just starts coming out of the magnetic field.



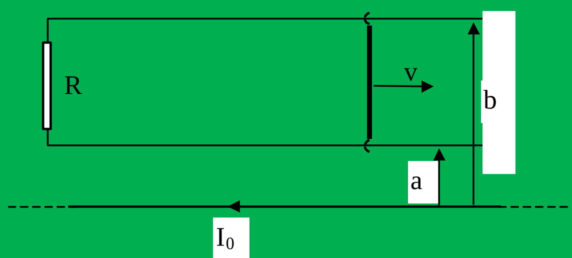
5. A wire bent as a parabola $y = ax^2$ is located in a uniform magnetic field of induction B, the vector $\vec{B}$ being perpendicular to the plane xy. At the moment t = 0 a connector starts sliding from the parabola apex with a constant acceleration 'ω'. Find the emf of electromagnetic induction in the loop thus formed as a function of y.



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

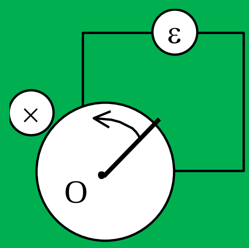
(a) the magnitude and the direction of the current induced in the connector;

(b) the force required to maintain the connector's velocity constant.

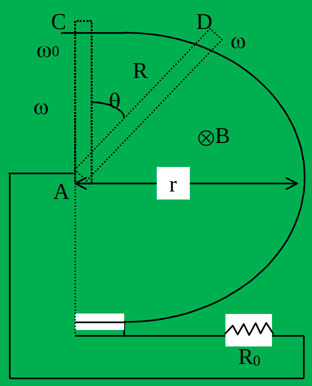


7. A metal rod of mass m can rotate about a horizontal axis O, sliding along a circular conductor of radius ℓ as shown in figure. The arrangement is located in a uniform magnetic field

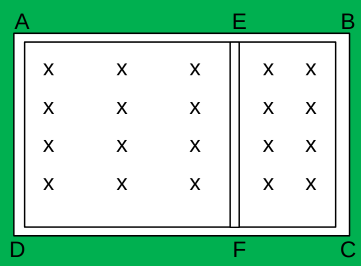
of induction B directed perpendicular to the ring plane. The axis and the ring are connected to an emf source to form a circuit of resistance R. Neglecting the friction, circuit inductance, and ring resistance, find the law according to which the source emf must vary to make the rod rotate with a constant angular velocity ω.



8. Find the current through R_0 when the rod rotates through an angle θ . The rod AD is pushed with initial angular velocity ω_0 at the position AC on a semicircular conductor about A in a uniform magnetic field perpendicular to the plane of semicircular loop. The length of the rod is r and resistance R & the rod rotates in a horizontal plane. [Ignore the resistance of semicircular conductor].



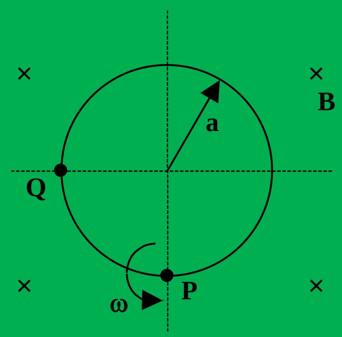
9. A rectangular frame ABCD made of a uniform metal wire has a straight connection between E and F made of the same wire as shown in figure. AEFD is a square of side 1 m and EB = FC = 0.5m. The entire circuit is placed in a steadily increasing uniform magnetic field directed into the plane of the paper and normal to it. The rate of change of the magnetic field is 1 Ts^{-1}. The resistance per unit length of the wire is $1\Omega m^{-1}$. Find the magnitude and direction of the currents in the segments AE, BE and EF.



10. A conducting ring of radius a is rotated in a uniform magnetic field B about P in the plane of the paper as shown in the figure.

(a) Find the induced emf between P and Q and indicate the polarity of the points P and Q.

(b) If a resistane R is connected between P and Q determine the current through the resistor.



MAINS LEVEL - I

1. Two different wire loops are concentric and lie in the some plane. The current in the outer loop is clockwise and increase with time. The induced current in the inner loop then is :

(A) clockwise

(B) zero

(C) counter-clockwise

(D) In a direction that depend on loop radii

2. An inductor coil of inductance L is divided into two equal parts and both parts are connected in parallel. The net inductance is :

(A) L (B) 2L

(C) L/2 (D) L/4

3. An e.m.f. of 5 millivolt is induced in a coil when in a nearby placed another coil, the current changes by 5 ampere in 0.1 second. The coefficient of mutual induction between the two coils will be :

(A) 1 Henry (B) 0.1 Henry

(C) 0.1 millihenry (D) 0.001 millihenry

4. The coefficient of mutual inductance of the two coils is 0.5 H. If the current is increased from 2A to 3 A in 0.01 sec. in one of them, then the induced e.m.f. in the second coil is :

(A) 25 V (B) 50 V

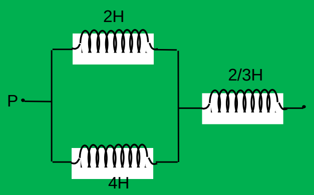
(C) 75 V (D) 100 V

5. If L, Q, R represent inductance, charge and resistance respectively, the units of:

(A) $\frac{QR}{L}$ will be those of current (B) $\frac{Q^2R^3}{L^2}$ will be those of energy

(C) $\frac{QL}{R}$ will be those of current (D) $\frac{Q^3R^2}{L}$ will be those of power

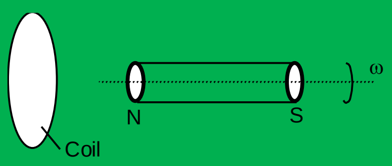
6. The equivalent inductance between points P and Q in figure is :



(A) 2 H (B) 6 H

(C) 8/3 H (D) 4/9 H

7. A cylindrical magnet is placed near a circular coil. The magnet is rotated about its own axis as shown in figure. The induced current in the coil is :



(A) zero
(B) in anticlockwise direction
(C) in clockwise direction

(D) directly proportional to the speed of rotation ω

8. A metal disc of radius R rotates with an angular velocity ω about an axis perpendicular to its plane passing through its centre in a magnetic field of induction B acting perpendicular to the plane of the disc. The induced e.m.f. between the rim and axis of the disc is:

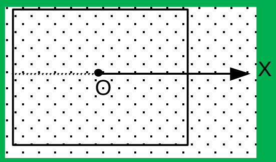
(A) $B\pi R^2$

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

(C) $B\pi R^2\omega$

(D) $\frac{BR^2\omega}{2}$

9. A rectangular coil is placed in a region having a uniform magnetic field B, perpendicular to the plane of the coil. No e.m.f. will be induced in the coil if the:



(A) magnetic field increases uniformly

(B) coil is rotated about an axis perpendicular to the plane of the coil and passing through its centre 0, the coil remaining in the same plane

(C) coil is rotated about the axis OX

(D) magnetic field is suddenly switched off

10. A coil of resistance R and inductance L is connected to a battery of E volts emf. The final current in the coil is

(A) E/R

(B) E/L

(C) $\sqrt{[E/(R^2+L^2)}$

(D) $\sqrt{[EL/(R^2+L^2)]}$

MAINS LEVEL – II

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

(A) 500 ms

(B) 20 s

(C) 35 ms

(D) 1 ms

2. A coil has 2000 turns and area of 70 cm^2. The magnetic field perpendicular to the plane of the coil is 0.3 wb/m^2 and takes 0.1 sec. to rotate through 180^o. The value of induced e.m.f. will be :

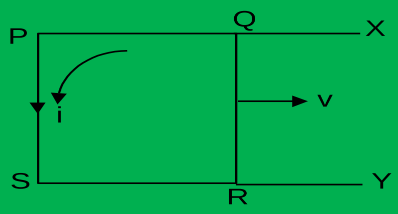
(A) 8.4 volt

(B) 84 volt

(C) 42 volt

(D) 4.2 volt

3. QR is a wire moving with a speed v as shown in figure. The conducting rails PX and SY are smooth. The induced current is in anticlockwise direction. The magnetic field in the region is:



(A) directed from left to right in the plane of page

(B) directed from right to left in the plane of page

(C) perpendicular to the plane of page and directed into the plane

(D) perpendicular to the plane of page and directed upward

4. The direction of the induced current is such that it opposes the cause to which it is due, this is :

(A) consistent with observed facts
(B) a statement of Lenz's law
(C) a consequence of law of conservation of energy
(D) all of the above

5. Two coils A and B have 200 and 400 turns respectively. A current of 1 A in coil A causes a flux per turn of 10^{-3} Wb to link with A and a flux per turn of 0.8×10^{-3} Wb through B. The ratio of self-inductance of A and the mutual inductance of A and B is :

(A) 5/4 (B) 1/1.6

(C) 1.6 (D) 1

6. A coil of insulated wire is connected in series with a bulb, a battery and a switch. When the circuit is completed bulb lights up immediately. The current is switched of and a rod of soft iron is placed inside the coil. On completing the circuit again it is observed that :

(A) the final intensity of bulb is less than before

(B) the final intensity of bulb is more than before

(C) initially bulb is brighter but finally it is less bright

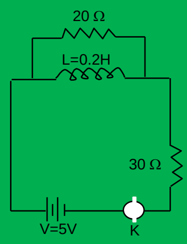
(D) the final intensity of bulb is same as before, but it takes a longer time to attain this steady state

7. A long straight wire lies along the axis of a straight solenoid as shown in figure. The wire carries a current $i = i_0 \sin \omega t$. The induced emf in solenoid is :

(A) $e_0 \sin \omega t$ (B) $e_0 \cos \omega t$

(C) zero (D) e_0

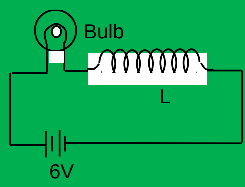
8. Consider the shown arrangement. When key k is pressed, the steady value of current in 20 Ω resistance is :



(A) 0.1 A (B) 0.25 A

(C) 0.017 A (D) zero

9. A bulb is connected in series with an inductance and a 6 V d.c. source as shown in figure. A soft iron core is inserted in the coil quickly. During this process, the intensity of bulb:



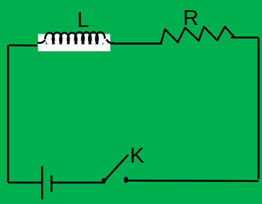
(A) remains unaltered

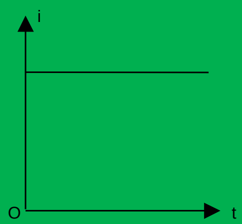
(B) increases

(C) decreases

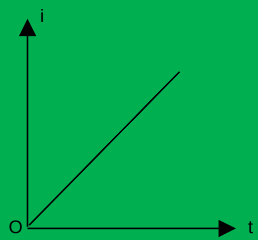
(D) may increase or decrease depending on size of core

10. Which one of the following graphs represent correctly the variations of current (i) and time (t) when key k is pressed in the circuit shown in figure?

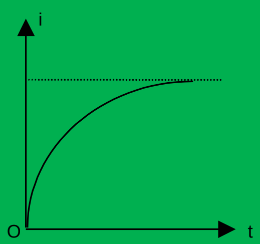




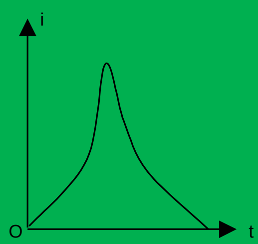
(A)



(B)



(C)



(D)

ANSWER KEY

ADVANCE LEVEL - I

1. 0.2 s
2. $C = \frac{10^{-5}}{\sqrt{39.2}}$ F , $L = \frac{1}{10\sqrt{39.2}}$ H
3. 2π C
4. (1/320) J
5. 2.5×10^4 units
6. 0.5 s
7. 40 H
8. $\frac{B^2\ell^2 v}{R}$
9. $2\,B\omega R^2$
10. $50\sqrt{2}\,\pi$ volts

ADVANCE LEVEL - II

1. $\frac{2B^2 A v^3 \tan\theta}{\rho} t$
2. (a) 3.46×10^{-2} s (b) 6.02×10^{-2} s
3. $\frac{E}{B\ell}$
4. $\frac{B^2\ell^4\omega^2}{4R}$
5. $2\sqrt{2}\,\frac{\mu_0 \ell^2}{4\pi L}$
6. 20 V
7. 0.8 A
8. (a) $\frac{\varepsilon}{2R}$ (b) $\frac{3\varepsilon}{5R}$
9. (a) $(\pi\, 10^{-19}\, \omega)\sin \omega t$

   (b) $\frac{\varepsilon_{induced}}{R}$
10. $\frac{\mu_0 i \ell v a}{2\pi R r^2}$

ADVANCE LEVEL - III

1. $\sqrt{\frac{4x^4 PR}{\mu_0^2 i^2 r^4}}$
2. $\frac{E}{R}\left[1 + \frac{L_2}{L_1} e^{-\frac{Rt}{L_1}}\right]$
3. $\frac{2R}{B^2\ell^2}\left[\left(\frac{B^2\ell^2\omega_0}{2R}\right)e^{-3\frac{B^2\ell^2}{4MR}t} - \frac{\mu Mg}{\ell}\left(1 - e^{-3\frac{B^2\ell^2}{4MR}t}\right)\right]$

4. 2.2 sec

5. $E = By\,(8\omega/a)^{1/2}$

6. (a) $I = \frac{\mu_0 v I_0}{2\pi R}\ln\frac{b}{a}$ (b) $F = \frac{v}{R}\left(\frac{\mu_0 I_0}{2\pi}.\ln\frac{b}{a}\right)^2$

7. $\varepsilon = \frac{B\ell^2\omega}{2} + \frac{mgR}{B\ell}\sin\omega t$

8. $$\frac{Br^2\left[\omega_0 - \frac{3}{4}\frac{B^2r^2\theta}{(R_0+R)}\right]}{2(R_0+R)}$$

9. $I_1 = \frac{7}{22}A$ (E to A)

$I_2 = \frac{6}{22}A$ (B to E)

$I_3 = \frac{1}{22}A$ (F to E)

10. (a) $B\omega a^2$ (b) $\frac{B\omega a^2}{R}$

MAINS LEVEL - I

1.	**C**	**2.**	**D**
3.	**C**	**4.**	**B**
5.	**A**	**6.**	**A**
7.	**A**	**8.**	**D**
9.	**B**	**10.**	**A**

MAINS LEVEL - II

1.	**D**	**2.**	**B**
3.	**C**	**4.**	**D**
5.	**B**	**6.**	**D**
7.	**C**	**8.**	**D**
9.	**C**	**10.**	**C**