SOLVED EXAMPLES

Example 1.	A small square loop of wire of side *l* is placed inside a large square loop of wire of side L(>>*l*). The loops are coplanar and their centres coincide. What is the mutual inductance of the system? (1) $\frac{\mu_0}{4\pi}\frac{2\sqrt{2}\,\ell^2}{L}$ (2) $\frac{\mu_0}{4\pi}\frac{2\sqrt{2}\,\ell}{L^2}$ (3) $\frac{\mu_0}{4\pi}\frac{8\sqrt{2}\,\ell^2}{L}$ (4) $\frac{\mu_0}{4\pi}\frac{8\sqrt{2}\,\ell}{L^2}$
Solution :	**(3)** Considering the larger loop to be made up of four rods each of length L, the field at the centre, i.e. at a distance (L/2) from each rod, will be $B = 4\times\frac{\mu_0}{4\pi}\frac{I}{d}[\sin\alpha + \sin\beta]$ i.e., $B = 4\times\frac{\mu_0}{4\pi}\frac{I}{(L/2)}\times 2\sin 45^0$ i.e., $B_1 = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}}{L}I$ So the flux linked with smaller loop $\phi_2 = B_1S_2 = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}}{L}\ell^2 I$ $M = \frac{\phi}{I} = \frac{\mu_0}{4\pi}\frac{8\sqrt{2}}{L}\ell^2$
Example 2.	When the current in a coil changes from 8A to 2A in 3×10^{-2} s. The emf induced in the coil is 2V. What is the self-inductance of the coil in mH? (1) 10 mH (2) 20 mH (3) 5 mH (4) 40 mH
Solution :	**(1)** An in case of electromagnetic induction $\lvert e\rvert = L\frac{dI}{dt}$ $\Rightarrow L = e\times\frac{dt}{dI}$ So substituting the given data, $L = 2\times\frac{3\times10^{-2}}{(8-2)} = 10^{-2}\,H = 10mH$
Example 3.	The current (in ampere) in an inductor is given by I = 5 + 16 t, where t is in second. The self-induced emf in it is 10 mV. Find the self inductance (1) 6.25×10^{-4} H (2) 2.5×10^{-4}H (3) 62.5×10^{-4} (4) 25×10^{-4} H
Solution :	**(1)** Induced emf in an inductor is given by $\varepsilon_{\text{induced}} = -L\frac{dI}{dt}$ Hence $L\frac{d}{dt}(5+16t) = 10mV$ or $L = 6.25\times10^{-4}\,H$
Example 4.	A circuit contains an inductance L, a resistance R and a battery of emf E. The circuit is switched on at t=0. The charge flown through the battery in one time constant (τ) is (1) $\frac{2E\tau}{Re}$ (2) $\frac{E\tau}{2Re}$ (3) $\frac{E\tau}{Re}$ (4) Zero

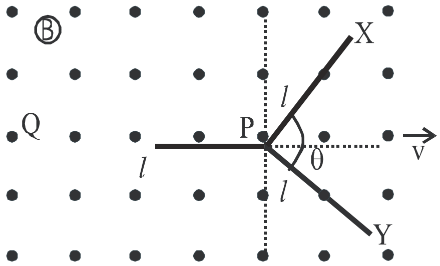
Solution :	**(3)** At any time t, the current in the circuit grows in accordance with formula $I = I_0(1-e^{-Rt/L}) = I_0(1-e^{-t/\tau})$ $\Rightarrow I = \frac{E}{R}(1-e^{-t/\tau})$ $\Rightarrow \frac{dq}{dt} = \frac{E}{R}(1-e^{-t/\tau})$ $\Rightarrow dq = \frac{E}{R}dt - \frac{E}{R}e^{-t/\tau}dt$ $\Rightarrow q = \frac{E}{R}\int_0^{\tau} dt - \frac{E}{R}\int_0^{\tau} e^{-t/\tau}dt$ $\Rightarrow q = \frac{E\tau}{R} - \left[-\frac{E\tau}{Re} + \frac{E\tau}{R}\right] = \frac{E\tau}{Re}$
Example 5. **Solution :**	In a plane E.M. wave the electric field oscillates sinusodially at a frequency 3×10^{10} Hz and amplitude 50 Vm^{-1}. What is the wavelength of the wave? (1) 1 cm (2) 2 cm (3) 05 cm (4) 1 mm **(1)** Here frequency $v = 3\times10^{10}$ Hz, E_0 = 50 Vm^{-1} Wavelength, $\lambda = \frac{c}{v} = \frac{3\times10^8}{3\times10^{10}} = 10^{-2}\,m = 1cm$
Example 6 **Solution :**	If the voltage in an a.c. circuit is represented by the equation $V = 220\sqrt{2}\sin(314t-\phi)$. Calculate frequency of a.c. (1) 100 Hz (2) 50 Hz (3) 200 Hz (4) 175 Hz (1) As in case of a.c., $V = V_0\sin(\omega t - \phi)$ The peak value, $V_0 = 220\sqrt{2} = 311$volt and as in case of a.c. $V_{rms} = \frac{V_0}{\sqrt{2}}$, $\therefore V_{rms} = 220$volt (2) In case of a.c., $V_{av} = \frac{2V_0}{\pi} = \frac{2\times311}{\pi} = 198.17$volt (3) As $\omega = 2\pi f$ hence $2\pi f = 314$ or, $f = \frac{314}{2\pi} = 50$Hz Hence the correct answer is (2)
Example 7 **Solution :**	If a direct current of value a ampere is superimposed on an alternating current I = b sin ωt flowing through a wire, what is the effective value of the resulting current in the circuit? (1) $\sqrt{a^2+b^2}$ (2) $\sqrt{a^2+\frac{b^2}{2}}$ (3) $\sqrt{\frac{a^2}{2}+b^2}$ (4) $\sqrt{\frac{1}{2}(a^2+b^2)}$ **(2)** As current at any instant in the circuit will be $I = I_{dc} + I_{ac} = a + b\sin\omega t$ So, $I_{eff} = \left[\frac{\int_0^T I^2 dt}{\int_0^T dt}\right]^{1/2} = \left[\frac{1}{T}\int_0^T (a+b\sin\omega t)^2\,dt\right]^{1/2}$

	i.e., $I_{eff} = \left[\frac{1}{T}\int_0^T \left(a^2 + 2ab\sin\omega t + b^2\sin^2\omega t\right)dt\right]^{1/2}$ but as $\frac{1}{T}\int_0^T \sin\omega t dt = 0$ and $\frac{1}{T}\int_0^T \sin^2\omega t\, dt = \frac{1}{2}$ So, $I_{eff} = \left[a^2 + \frac{1}{2}b^2\right]^{1/2}$
Example 8.	When 100 volt d.c. is applied across a coil, a current of 1 amp flows through it; when 100 V a.c. of 50 Hz is applied to the same coil, only 0.5 amp flows. Calculate inductance of the coil. (1) 0.55 H (2) 0.25 H (3) 0.75 H (4) 0.10 H
Solution :	**(1)** In case of coil, i.e., L–R circuit $I = (V/Z)$ with $Z = \sqrt{(R^2 + X^2)} = \sqrt{\left(R^2 + (\omega L)^2\right)}$ So when d.c. is applied, $\omega = 0$ and Z = R and hence $I = V/R$ i.e., $R = (V/I) = (100/1) = 100\Omega$ and when a.c. of 50 Hz is applied. $I = (V/Z)$ i.e., $Z = \frac{V}{I} = \frac{100}{0.5} = 200\Omega$ but $Z = \sqrt{(R^2 + \omega^2 L^2)}$ i.e., $\omega^2 L^2 = Z^2 - R^2$ i.e., $(2\pi f L)^2 = (200)^2 - (100)^2 = 3\times 10^4$ So, $L = \frac{\sqrt{3}\times 10^2}{2\pi\times 50} = \frac{\sqrt{3}}{\pi} = 0.55H$
Example 9.	An LCR series circuit with 100Ω resistance is connected to an a.c. source of 200 V and angular frequency 300 rad/sec. When only the capacitance is removed, the current lags behind the voltage by 60°. When only the inductance is removed, the current leads the voltage 60°. Calculate the current in the LCR circuit. (1) 2 A (2) 1 A (3) 4 A (4) zero
Solution :	**(1)** When capacitance is removed, the circuit becomes L–R with, $\tan\phi = \frac{X_L}{R}$ i.e., $X_L = R\tan\phi = 100\sqrt{3}\Omega$ and when inductance is removed, the circuit becomes C–R with, $\tan\phi = \frac{X_C}{R}$ i.e., $X_C = R\tan\phi = 100\sqrt{3}\Omega$ As here $X_L = X_C$ so the circuit is in series resonance and hence as $X = X_L - X_C = 0$ i.e., $Z = \sqrt{(R^2 + X^2)} = R$ So, $I_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{R} = \frac{200}{100} = 2A$

Example 10

A conducting wire in the shape of Y, with each side of length l is moving in a uniform magnetic field B, with a uniform speed v as shown in figure. The induced emf at the two ends X and Y of the wire will be

(1) Zero (2) $2Bl\text{v}$ (3) $2Bl\text{v}\sin(\theta/2)$ (4) $2Bl\text{v}\cos(\theta/2)$



Solution :

The induced emf $e = (\vec{v} \times \vec{B}).l$ for the part PX, $\vec{v} \perp \vec{B}$ and the angle between $(\vec{v} \perp \vec{B})$ direction (the dotted line in figure) and $\vec{l}$ is $(90 - \theta/2)$. Thus

$\varepsilon_p - \varepsilon_x = vBl\cos(90 - \theta/2) = vBl\sin(\theta/2)$

Similarly $\varepsilon_y - \varepsilon_p = vBl\sin(\theta/2)$

Therefore induced emf between X and Y be

$\varepsilon_{yx} = 2Bvl\sin(\theta/2)$. The correct answer is (3).

Example 11

10 ampere alternating current flows through the primary coil of transformer of 230 volt. If a voltage of 23000 volt is produced in the secondary coil and half of the power is lost in it, then the current in the secondary coil will be

(1) 0.05 A (2) 0.5 A (3) 0.1 A (4) 1 A

Solution :

(1) $\frac{1}{2}E_pI_p = E_sI_s \quad \therefore I_s = \frac{E_pI_p}{2E_s} = \frac{230 \times 10}{2 \times 23000} = \frac{1}{20} = 0.05\text{A}$

Example 12

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

(1) $\frac{\omega BA}{\pi}$ (2) $\frac{\omega BA}{2\pi}$ (3) $\frac{\omega BA}{4\pi}$ (4) $\frac{2\omega BA}{\pi}$

Solution :

(4) $\Delta\phi = 0 - BA$

$\Rightarrow \Delta\phi = -BA$ and $\Delta t = \frac{T}{4}$ for $\theta = \frac{\pi}{2}$

$\Rightarrow \varepsilon_{av} = \left|\frac{\Delta\phi}{\Delta t}\right| = \frac{BA}{\left(\frac{T}{4}\right)}$ $\Rightarrow \varepsilon_{av} = \frac{BA}{\frac{2\pi}{4\omega}} = \frac{2\omega BA}{\pi}$

Example 13

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

(1) 500 s (2) 20 ms (3) 35 ms (4) 1 ms

Solution :

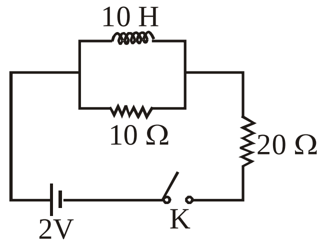
(4) $I = I_0\left(1 - e^{-\frac{Rt}{L}}\right)$, where $I_0 = \frac{12}{6}A = 2A$

$\Rightarrow \; 1 = 2\left(1 - e^{-\frac{6t}{8.4\times10^{-3}}}\right)$; $\Rightarrow e^{\frac{6t}{8.4\times10^{-3}}} = \frac{1}{2}$

$\Rightarrow \frac{6t}{8.4\times10^{-3}} = \text{In}\,2$ $\Rightarrow t = (1.4\times0.693)\,\text{ms}$ $\Rightarrow t = 0.97\,\text{ms}$

Example 14

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



(1) $\frac{1}{15}A, \frac{1}{10}A$ (2) $\frac{1}{10}A, \frac{1}{15}A$ (3) $\frac{2}{15}A, \frac{1}{10}A$ (4) $\frac{1}{15}A, \frac{1}{25}A$

Solution :

(1) At t =0, i.e when the key is just pressed, no current exists inside the inductor. So 10Ω and 20Ω resistors are in series and a net resistance of (10 + 20) = 30Ω exists across the circuit.

Hence $I_1 = \frac{2}{30} = \frac{1}{15}A$

As $t\to\infty$ the current in the inductor grows to attain a maximum value i.e. the entire current passes through the inductor and no current passes through 10Ω resistor.

Hence $I_2 = \frac{2}{20} = \frac{1}{10}A$

MULTIPLE CHOICE QUESTIONS

LEVEL - I

1. A coil of resistance R and inductance L is connected to a battery of emf E. The maximum current in the coil is :
(1) E/R (2) E/L
(3) $\sqrt{E/(R^2+L^2)}$ (4) $\sqrt{EL/(R^2+L^2)}$

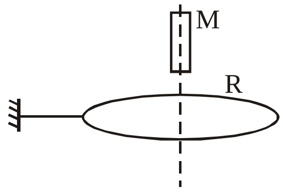
2. A metal disc of radius R rotates with an angular velocity ω about an axis perpendicular to its plane passing through its centre in a magnetic field of induction B acting perpendicular to the plane of the disc. The induced e.m.f. between the rim and the axis of the disc is
(1) $B\pi R^2$ (2) $\frac{2B\pi R^2}{\omega}$
(3) $B\pi R^2\omega$ (4) $\frac{BR^2\omega}{2}$

3. A coil of inductance L and resistance R is connected to a steady soruce of voltage. The current reaches half of its steady state vlaue in time
(1) $\frac{L}{R}\ln 2$ (2) L/R
(3) R/L (4) $\frac{R}{L}\ln 2$

4. In an LR circuit, the AC source has voltage 220 volt. The potential difference across the inductance is 176 volt. The potential difference across the ressitance will be :
(1) (220 – 176) volt
(2) (220 + 176) volt
(3) $\sqrt{220\times176}$ volt
(4) $\sqrt{(220)^2-(176)^2}$ volt

5. A resistor R, an inductor L and a capaictor C are connected in series to an oscillator of frequency n. If the resonant frequency is n_r, then the current lags behind voltage, when :
(1) n = 0 (2) $n < n_r$
(3) $n = n_r$ (4) $n > n_r$

6. 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 :



(1) < g when it is above R and moving towards R
(2) > g when it is above R and moving towards R
(3) = g when it is below R and moving away from R
(4) > g when it is below R and moving away form R

7. The primary winding of a transformer has 100 turns and its secondary windings has 200 turns. The primary is connected to an AC supply of 120 V and the current flowing in it is 10 A. The voltage and the current in the secondary are :
(1) 240 V, 5A (2) 240 V, 10 V
(3) 60 V, 20 A (4) 120 V, 20 A

8. In LCR series AC circuit, the voltage across each of the components L, C and R is 50 V. The voltage across the LC combination will be :
(1) 50 V (2) $50\sqrt{2}$ V
(3) 100 V (4) Zero volt

9. The self inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50 Hz it should be connected to a capacitance of :
(1) $1\mu F$ (2) $2\mu F$
(3) $4\mu F$ (4) $8\mu F$

10. Which of the following relation is correct regarding EM waves.
(1) $\sqrt{\epsilon_0}E_0 = \sqrt{\mu_0}B_0$ (2) $\sqrt{\mu_0\epsilon_0}E_0 = B_0$
(3) $E_0 = \sqrt{\mu_0\epsilon_0}B_0$ (4) $\sqrt{\mu_0}E_0 = \sqrt{\epsilon_0}B_0$

11 A transformer has 100 windings in the primary and 200 windings in the secondary. The primary is connected to a.c. supply of 120 volts at 10 amperes. Check the correct situation for this transformer out of the following: (Assume that transformer is ideal)

(1) The secondary voltage 240 volts and current 10 amperes

(2) The secondary voltage 240 volts and current 5 amperes

(3) The secondary voltage 60 volts and current 10 amperes

(4) The secondary voltage 240 volts and current 20 amperes

12. When two inductors L_1 and L_2 are connected in parallel, the equivalent inductance

(1) Is $L_1 + L_2$

(2) Lies between L_1 and L_2

(3) Is less than both L_1 and L_2

(4) None of the above is true

13. Consider the following statements:

A: An e.m.f. can be induced by moving a conductor in a magnetic field

B: An e.m.f. can be induced by changing the magnetic field

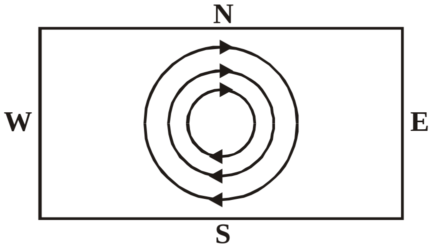
(1) Both A & B are true

(2) A is true but B is false

(3) B is true but A is false

(4) Both A and B are false

14. When a sheet of metal is placed in a magnetic field, which changes from zero to a maximum value, induced currents are setup in the direction as shown in the diagram. What is the direction of the magnetic field?



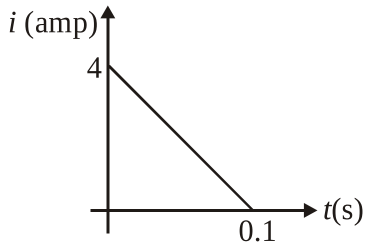
(1) Into the plane of paper

(2) East to West

(3) Out of the plane of paper

(4) North to South

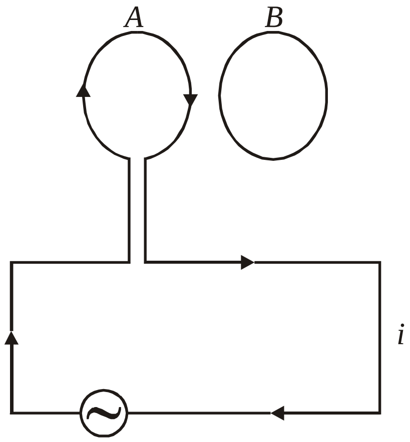
15. Some magnetic flux is changed from a coil of resistance 10 ohm. As a result an induced current is developed in it, which varies with time as shown in figure. The magnitude of change in flux through the coil in Webers is



(1) 2 (2) 4

(3) 6 (4) 8

16. Two circular coils *A* and *B* are facing each other as shown in figure. The current *i* through *A* can be altered,



(1) There will be repulsion between *A* and *B* if *i* is increased

(2) There will be attraction between *A* and *B* if *i* is increased

(3) There will be neither attraction nor repulsion when *i* is changed

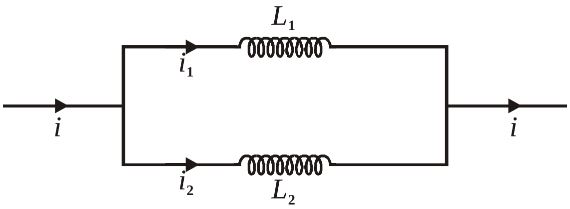
(4) Attraction or repulsion between *A* and B depends on the direction of current. It does not depend whether the current is increased or decreased

17. A current of 2A is increasing at a rate of 4 A/s through a coil of inductance 2 H. The energy stored in the inductor per unit time is (when current was 2A)

(1) 2 J/s (2) 1 J/s

(3) 16 J/s (4) 4 J/s

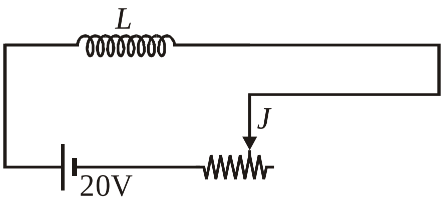
18. Two inductors L_1 and L_2 are connected in parallel and a time varying current flows as shown. The ratio of currents i_1/i_2 at any time t is



(1) L_1/L_2 (2) L_2/L_1

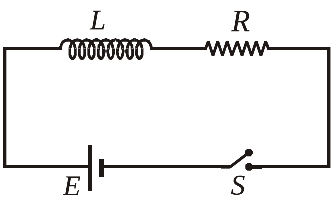
(3) $\frac{L_1}{(L_1+L_2)^2}$ (4) $\frac{L_2}{(L_1+L_2)^2}$

19. In the circuit shown in figure the jockey J is being pulled towards right so that the resistance in the circuit is increasing. Its value at some instant is $5\,\Omega$. The current in the circuit at this instant will be



(1) 4A
(2) Less than 4A
(3) More than 4A
(4) May be less than or more than 4A on the value of L

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



(1) $\frac{eR^2}{E}$ (2) $E\left(\frac{L}{R}\right)$

(3) $\frac{EL}{eR^2}$ (4) $\frac{eL}{ER}$

LEVEL - II

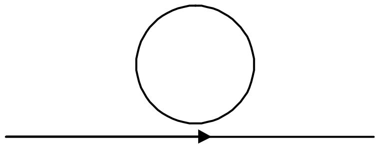
1. In an induction coil the coefficient of mutual induction is 4 H. If current of 5 A in the primary coil is cut off in 1/1500s, the e.m.f. induced in the secondary coil is

(1) 15 kV (2) 60 kV
(3) 10 kV (4)30 kV

2. The current passing through a choke coil of 5 Henry is decreasing at the rate of 2 As^{-1}. The e.m.f. developed across the coil is

(1) 10 V (2) –10 V
(3) 2.5 V (4)–2.5 V

3. The current flowing in wire AB is increasing, then the direction of the induced current in the loop will be :



(1) straight line (2) anticlockwise
(3) clockwise (4) none of these

4. A capacitor of capacitance $1\mu F$ is charged to a potential of 1V. It is connected in parallel to an inductor of inductance 10^{-3} H. The maximum current that will flow in the circuit has the value :

(1) $\sqrt{1000}$ mA (2) 1 mA

(3) $1\mu A$ (4) 1000 mA

5. An electric bulb in series with a large inductor when connected across a DC sources takes a little time before reaching a stable glow. If an iron core is inserted into the inductor, the delay will:

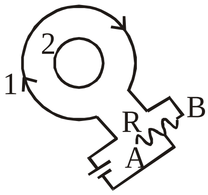
(1) increase
(2) decrease
(3) remain the same
(4) may increase or decrease depending upon the values of inductance and resistance.

6. A plane electromagnetic wave is incident on a material surface. If the wave delivers momentum of magnitude p and energy E, then

(1) p = 0, E = 0 (2) $p \neq 0, E \neq 0$

(3) $p \neq 0, E = 0$ (4) $p = 0, E \neq 0$

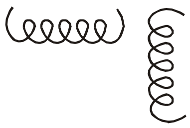
7. Shown in the figure is a small loop that is kept coaxially with the bigger loop. If the slider moves from A to B, then

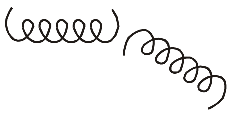


(1) current in loop 2 will flow randomly
(2) anticlockwise current in loop 2 will flow
(3) no current flows in loop 2
(4) clockwise current flows in loop 2

8. The core of a transformer is laminated so that:
(1) ratio of voltage in the primary and secondary may be increased
(2) energy losses due to eddy currents may be minimised
(3) weight of transformer may be reduced
(4) rusting may be prevented

9. For which arrangement of two coils coefficient of mutual inductance is maximum and for which it is minimum

(a)  (b) 

(c)  (d) 

(1) for (a) and (d) respectively
(2) for (b) and (a) respectively
(3) for (c) and (a) respectively
(4) for (a) and (d) respectively

10. A rod is falling vertically downwards with speed v_0 at a certain time. The horizontal magnetic field B is at an angle of 30^0 with length of rod and the rod while falling is horizontal. The induced emf across the end of the rod of length l is at that time is

(1) $vBl\sin 30^0$ (2) $vBl\cos 30^0$
(3) $vBl\tan 30^0$ (4) zero

11. A resistance of R is connected to two points at a distance $\frac{l}{4}$ and $3\frac{l}{4}$ from one end of a circulating metallic rod about which rotation takes place. The rotation plane is normal to magnetic field and the angular speed is ω. The current through the resistance is

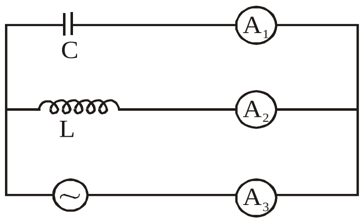
(1) $\frac{1}{4R}B\omega l^2$ (2) $\frac{1}{2R}B\omega l^2$
(3) zero (4) $\frac{1}{8R}B\omega l^2$

12. A coil of 40 henry inductance is connected in series with a resistance of 8 ohm and the combination is joined to the terminals of a 2 volt battery. The time constant of the circuit is:
(1) 5 seconds (2) (1/5) seconds
(3) 40 seconds (4) 20 seconds

13. A circular coil of radius 5 cm has 500 turns of a wire. The approximate value of the coefficient of self-induction of the coil will be
(1) 25 mH (2) 25×10^{-3} mH
(3) 50×10^{-3} mH (4) 50×10^{-4} mH

14. In an inductor of self-inductance L = 2 mH, current changes with time according to relation $I = t^2e^{-t}$ the induced emf is zero at time.
(1) 4 s (2) 3 s
(3) 2 s (4) 1 s

15. An inductor L, a capacitor C and ammeters A_1, A_2 and A_3 are connected to an oscillator in the circuit as shown in the adjoining figure. When the frequency of the oscillator is increased, then at resonant frequency, the ammeter reading is zero for:



(1) ammeter A_1 (2) ammeter A_2
(3) ammeter A_3
(4) all the three ammeters

16. A current $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ in an AC circuit exists if potential of $E = E_0 \sin \omega t$ has been applied, then the power consumption P in the circuit will be:

(1) $P = \frac{E_0 I_0}{\sqrt{2}}$ (2) $P = \frac{EI}{\sqrt{2}}$

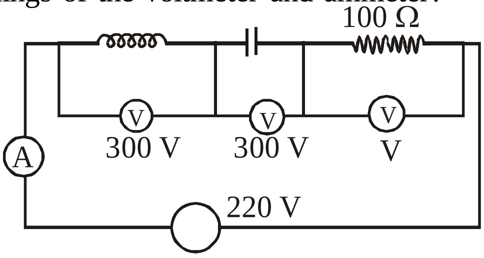
(3) $P = \frac{E_0 I_0}{2}$ (4) $P = zero$

17. The peak value of an alternating e.m.f. given by $E = E_0 \cos \omega t$ is 10 volt and its frequency is 50 Hz. At a time $t = \frac{1}{600} s$ the instantaneous value of the e.m.f. is

(1) 10 volt (2) $5\sqrt{3}$ volt

(3) 5 volt (4) 1 volt

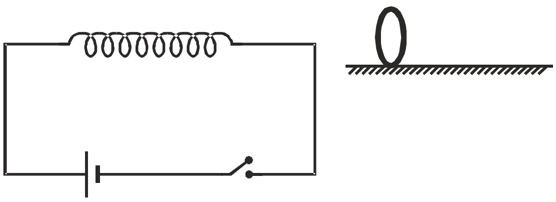
18. In the circuit shown below, what will be the readings of the voltmeter and ammeter?



(1) 800 V, 2A (2) 300 V, 2A

(3) 220 V, 2.2 A (4) 100 V, 2A

19. Figure shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a frictionless track, the axis of the ring being along the axis of the solenoid. As the switch is closed, the ring will



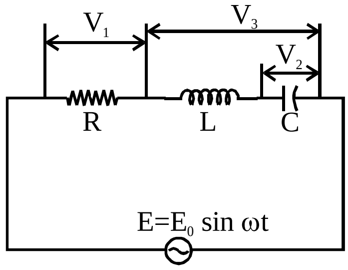
(1) Remain stationary

(2) Move towards the solenoid

(3) Move away from the solenoid

(4) Move towards the solenoid or away from it depending on which terminal (positive or negative) of the battery is connected to the left end of the solenoid

20. The value of potential difference maybe zero for



(1) V_1 (2) V_3

(3) V_2 (4) None of these

LEVEL - III

1. The magnetic field energy in an inductor changes from maximum value to minimum value in 5.0 ms when connected to an AC source. The frequency of the source is

(1) 20 Hz (2) 50 Hz

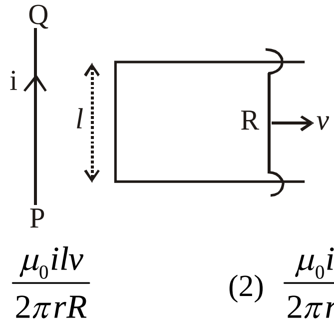
(3) 200 Hz (4) 500 Hz

2. Two circular coils of radii R_1 and R_2, turns N_1 and N_2 are placed concentrically in the same plane. If $R_2 << R_1$, then the mutual inductance between them is equal to

(1) $\frac{\mu_0 \pi R_2^2}{2R_1}$ (2) $\frac{\mu_0 \pi R_2^2 N_1 N_2}{2R_1}$

(3) $\frac{\mu_0 \pi R_2 N_1 N_2}{2R_1}$ (4) $\frac{\mu_0 \pi R_1 N_1 N_2}{2R_2}$

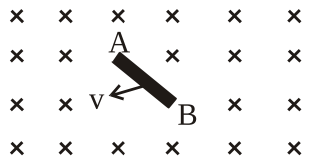
3. A very long straight conductor carrying current i and a loop closed by a sliding connector of ressitance R lie in the same plane as shown in fig. The connector slides towards right with a uniform velocity v. The induced current generated in the loop in terms of distance r of the connector from the straight conductor will be



(1) $\frac{\mu_0 i l v}{2\pi r R}$ (2) $\frac{\mu_0 i l}{2\pi r v}$

(3) $\frac{\mu_0 i l v}{2\pi r l R}$ (4) $\frac{\mu_0 i l}{2\pi r R v}$

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



(1) The rod becomes electrically charged

(2) The end A becomes positively charged

(3) The end B becomes positively charged

(4) The rod becomes hot because of Joule heating

5. A small conducting circular loop is placed inside a long solenoid carrying a current. The plane of the loop contains the axis of the solenoid. If the current in the solenoid is varied, the current induced in the loop is

(1) clockwise (2) anticlockwise

(3) zero

(4) clockwise or anticlockwise depending on whether the resistance is increased or decreased.

6. What is the self inductance of an air core solenoid 1m long, diameter 0.05 m, if it has 500 turns?

(1) 3.15×10^{-4} H (2) 4.8×10^{-4} H

(3) 5×10^{-4} H (4) 6.17×10^{-4} H

7. A rectangular coils placed in a region having a uniform magnetic field B, perpendicular to the plane of the coil. An e.m.f. will not be induced in the coil if the

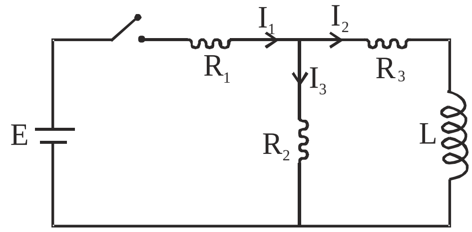
(1) Magnetic field increases uniformly

(2) Coil is rotated about an axis perpendicular to the plane of the coil and passing through its centre

(3) Coil is rotated about one of its diameters

(4) Magnetic field is suddenly switched off

8. In the circuit shown in the following figure E=10 V, R_1 = 2 ohm, R_2 = 3 ohm and R_3 = 6 ohm and L = 5 henry. The current I_1 just after pressing the switch S is:



(1) (10/4) amp (2) (10/5) amp

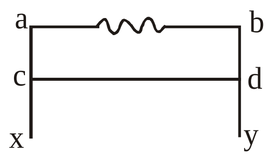
(3) (10/12) amp (4) (10/6) amp

9. The coefficient of mutual inductance, when magnetic flux changes by 2×10^{-2} wb and current changes by 0.01 A, is

(1) 2 H (2) 3 H

(3) 4 H (4) 8 H

10. A wire cd of length l and mass m is sliding without friction on conducting rails ax and yb as shown. The vertical rails are connected to each other with a resistance R between a and b. A uniform magnetic field B is applied perpendicular to the plane abcd such that cd moves with a constant velocity of:



(1) $\frac{mgR}{Bl}$ (2) $\frac{mgR}{B^2l^2}$

(3) $\frac{mgR}{B^3l^3}$ (4) $\frac{mgR}{B^2l}$

11. Let C be the capacitance of a capacitor discharging through a resistor R. Suppose t_1 is the time taken for the energy stored in the capacitor to reduce to half its initial value and t_2 is the time taken for the charge to reduce to one–fourth its initial value. Then the ratio t_1/t_2 will be

(1) 2 (2) 1

(3) 1/2 (4) 1/4.

ANSWERS (EMI, AC & EM WAVES)

LEVEL - I

1. (1)	5. (4)	9. (1)	13. (1)	17. (3)
2. (4)	6. (1)	10. (2)	14. (3)	18. (2)
3. (1)	7. (1)	11. (2)	15. (1)	19. (3)
4. (4)	8. (4)	12. (3)	16. (1)	20. (3)

LEVEL - II

1. (4)	5. (1)	9. (2)	13. (1)	17. (2)
2. (1)	6. (2)	10. (1)	14. (3)	18. (3)
3. (3)	7. (2)	11. (1)	15. (3)	19. (3)
4. (1)	8. (2)	12. (1)	16. (4)	20. (2)

LEVEL - III

1. (2)	3. (1)	5. (3)	7. (2)	9. (1)
2. (2)	4. (3)	6. (4)	8. (2)	10. (2)
				11. (4)

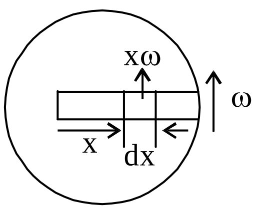
SOLUTIONS

(LEVEL - I)

1. $i = \frac{E}{\sqrt{R^2 + \omega^2 L^2}}$

For D.C. source $\omega = 0$

$$\boxed{i = \frac{E}{R}}$$

2. 

$\varepsilon = \int vBdx$

$= \int_0^R x\omega Bdx$ $\boxed{\varepsilon = \frac{1}{2}B\omega R^2}$

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

$\frac{i_0}{2} = i_0\left(1 - e^{-t/\tau}\right)$

$\frac{i_0}{2} = e^{-t/\tau}$

$\ell n 2 = t/\tau$

$t = \tau \ln 2$

$$\boxed{t = \frac{L}{R}\ln 2}$$

4. $V = \sqrt{V_L^2 + V_R^2}$

$(220)^2 = (176)^2 + V_R^2$

$V_R = \sqrt{(220)^2 - (176)^2}$

5. $n > n_r$

6. e.g. due to induce current it will repel the magnet.

7. $\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{\ell_2}{\ell_1}$

8. $V_{LC} = \left(V_L \square V_C\right) = 0$

9. $f = \frac{1}{2\pi\sqrt{LC}}$

$(50\times 2\pi)^2 = \frac{1}{10C}$

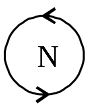
$C = \frac{1}{10\times 10^5}$ $\boxed{C = 1\mu F}$

10. $\frac{E_0}{B_0} = C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

11. $\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{\ell_2}{\ell_1}$

12. $Leq = \frac{L_1 L_2}{L_1 + L_2}$

13. Both A and B are true.

14. 

Direction of magnetic field south pole to North pole inside the magnet i.e. out of the plane of the paper.

15. $e = \left|\frac{d\phi}{dt}\right|$

$i = \left|\frac{e}{R}\right| \Rightarrow |e| = iR$

$d\phi = iRdt$

$\phi = R\int idt$

$\phi = 10\times\frac{4.01}{2}$ $\boxed{\phi = 2}$

16. Conceptual

17. $\varepsilon = \left|-L\frac{di}{dt}\right|$

$\varepsilon = 2\times 4 = 8$ volt

$p = \varepsilon.i = 8\times 2 = 16$ watt

18. $i = \frac{V}{X_L} = \frac{V}{\omega L}$

$\frac{i_1}{i_2} = \frac{L_2}{L_1}$

19. Using Lenz's law $i > 4A$

20. $t = \frac{\varepsilon}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$

$q = \int_0^{L/R} idt$

$q = \frac{\varepsilon}{R}\left[t - \frac{e^{-\frac{Rt}{L}}}{-\frac{R}{L}}\right]_0^{\frac{L}{R}}$

$q = \frac{\varepsilon}{R}\left[\frac{L}{R} + \frac{L^{(e^{-1}-1)}}{R}\right]$

$\boxed{q = \frac{\varepsilon L}{eR^2}}$

(LEVEL - II)

1. $\phi_2 = Mi_1$

$\varepsilon_2 = \left|\frac{d\phi_2}{dt}\right| = M\frac{di_1}{dt}$

$\varepsilon_2 = 4\times 5\times 1500 = 30KV$

2. $\varepsilon = L\dfrac{di}{dt} = 5\times 2 = 10V$

3.

5. Inductance will increase i.e. time constant will increase i.e. the delay will increase.

6. $p \neq 0 \quad E \neq 0$

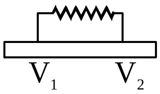
7. Anticlockwise current in loop 2.

8. Energy losses due to eddy currents may be minimized.

9. (b)

10. $\varepsilon = \left[\left(\vec{v}\times\vec{B}\right).\vec{\ell}\right]$

$\varepsilon = v\times B\ell\sin 30^\circ$.

11. 

$$V_1 = \frac{1}{2}B\omega\left(\frac{\ell}{4}\right)^2$$

$$V_2 = \frac{1}{2}B\omega\left(\frac{3\ell}{4}\right)^2$$

$$V_2 - V_1 = \frac{1}{2}B\omega\frac{8\ell^2}{16}$$

$$i = \frac{V_2 - V_1}{R} = \frac{1}{4R}B\omega\ell^2$$

12. $\tau = \dfrac{L}{R} = \dfrac{40}{8} = 5\sec$

13. $L = \dfrac{\mu_0}{2}\pi N^2 r$

$L = 25mH$

14. $\varepsilon = -L\dfrac{di}{dt} = -2\times 10^{-3}\left[-t^2e^{-t} + 2 + e^{-t}\right]$

$\varepsilon = 0$

$t = 0$ or $(2-t)e^{-t} = 0$

$\Rightarrow \quad t = 2\sec$

$t \to \infty \qquad \boxed{t = 2\sec}$

15. Ammeter A_3

16. $p.f. = \cos\phi = \cos\dfrac{\pi}{2} = 0$

$p = V_{rms}i_{rms}\cos\phi = 0$

17. $E = 10\cos\left(100\pi\times\dfrac{1}{650}\right)$

$E = 5\sqrt{3}$ volt

18. $V = \sqrt{V_R^2 + (V_L - V_C)^2}$

$V_R = 220$ volt

$i = \dfrac{V_R}{R} = 2.2$

19. Conceptual

20. $V_3 = (V_L \square V_C)$

i.e. V_3 may be zero.

(Level - III)

1. Frequency of variation of magnetic energy $= \left(\dfrac{1}{10\text{ms}}\right) = 100$ Hz

Now frequency of A.C.$=\left(\dfrac{100}{2}\right)$ Hz $= 50$ Hz

2. Magnetic field at centre, B = $\dfrac{\mu_0 N_1 i}{2R_1}$

Flux associated with smaller coil,

$\Rightarrow \phi = BN_2\pi R_2^2 \Rightarrow \phi = \dfrac{\mu_0\pi N_1 N_2 R_2^2}{2R_1}i$

$\Rightarrow$ comparing with ϕ = M i

$$\Rightarrow M = \frac{\mu_0 \pi N_1 N_2 R_2^2}{2R_1}$$

3. Magnetic field induction at the place of coil

$$B = \frac{\mu_0 i}{2\pi R}$$

flux associated with the coil

$$\phi = \frac{\mu_0 i}{2\pi r}(\ell.vt) \text{ (Assuming r >> vt)}$$

Now current induced in the coil $i = \frac{(d\phi / dt)}{R}$

$$i = \left[\frac{\mu_0 i \ell v}{2\pi r R}\right]$$

4. Conceptual

5. Flux associated with the will be always zero (constant) i.e., no will be induced

6. $L = \left[\frac{\mu_0 N^2 \pi R^2}{\ell}\right] = 6.17 \times 10^{-4} H$

7. When coil is rotated about an axis passing normal to its plance and from its centre, no flux will change and induced emf will be zero.

8. At t = 0 current will only pass through R_1 and R_2 $\therefore$ $i = \left(\frac{10}{5}\right) A$

9. $M = \frac{d\phi}{dv} = \frac{2 \times 10^{-2}}{10^{-2}} = 2H$

10. For constant velocity of wire

Fm = mg

i B l = mg

$$\frac{e}{R} B\ell = mg$$

$$\frac{(B\ell v)}{R} B \ell = mg$$

$$V = \left(\frac{mgR}{B^2 \ell^2}\right).$$

11. $\frac{q^2}{2C} = \frac{1}{2}\frac{q_0^2}{2C}$; $q^2 = \frac{q_0^2}{2}$ $\left[q_0 e^{-t_1/RC}\right]^2 = \frac{q_0^2}{2}$

$$e^{-2t_1/RC} = \frac{1}{2}$$

$$\frac{2t_1}{RC} = \ell n2$$

$$\Rightarrow t_1 = \frac{RC\ell n2}{2}; \; q = q_0 e^{-t_2/RC}$$

$$\frac{q_0}{4} = q_0 e^{-t_2/RC}$$

$$\Rightarrow t_2 = RC\,\ell n4$$

$$\frac{t_1}{t_2} = \frac{\frac{RC\ell n2}{2}}{RC\ell n4} = \frac{1}{4}.$$