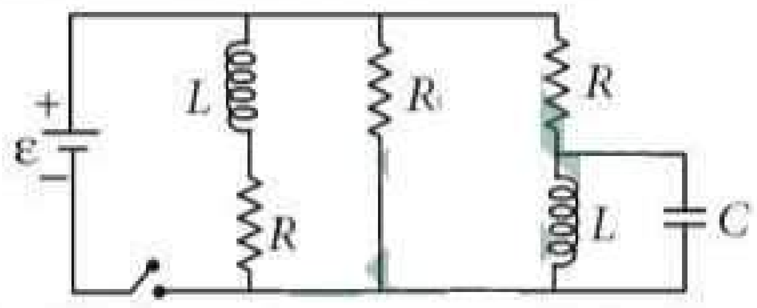
Chapter 16. Electromagnetic Induction and Alternating Current

1. A long solenoid of diameter 0.1 m has 2×10^4 turns per meter. At the centre of the solenoid, a coil of 100 turns and radius 0.01 m is placed with its axis coinciding with the solenoid axis. The current in the solenoid reduces at a constant rate to 0 A from 4 A in 0.05 s. If the resistance of the coil is $10\,\pi^2\,\Omega$, the total charge flowing through the coil during this time is
   (a) 16 μC (b) 32 μC
   (c) 16π μC (d) 32π μC
   (NEET 2017)

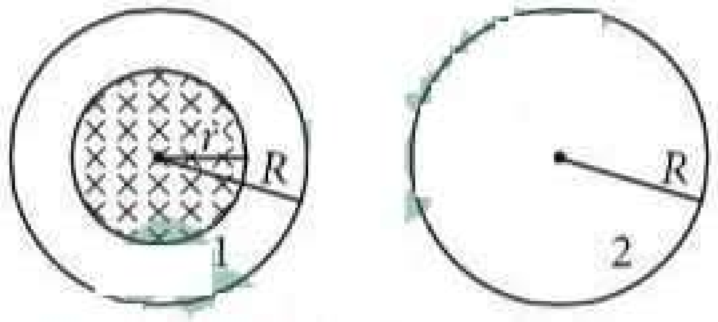
2. Figure shows a circuit that contains three identical resistors with resistanace $R = 9.0\,\Omega$ each, two identical inductors with inductance $L = 2.0$ mH each, and an ideal battery with emf $\varepsilon = 18$ V. The current i through the battery just after the switch closed is



   (a) 0.2 A (b) 2 A
   (c) 0 ampere (d) 2 mA
   (NEET 2017)

3. Which of the following combinations should be selected for better tuning of an L-C-R circuit used for communication ?
   (a) $R = 20\,\Omega, L = 1.5$ H, $C = 35\,\mu$F
   (b) $R = 25\,\Omega, L = 2.5$ H, $C = 45\,\mu$F
   (c) $R = 15\,\Omega, L = 3.5$ H, $C = 30\,\mu$F
   (d) $R = 25\,\Omega, L = 1.5$ H, $C = 45\,\mu$F
   (NEET-II 2016)

4. A uniform magnetic field is restricted within a region of radius r. The magnetic field changes with time at a rate $\frac{d\vec{B}}{dt}$. 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 the figure. Then the e.m.f. generated is



   (a) zero in loop 1 and zero in loop 2
   (b) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 2
   (c) $-\frac{d\vec{B}}{dt}\pi R^2$ in loop 1 and zero in loop 2
   (d) $-\frac{d\vec{B}}{dt}\pi r^2$ in loop 1 and zero in loop 2
   (NEET-II 2016)

5. The potential differences across the resistance, capacitance and inductance are 80 V, 40 V and 100 V respectively in an L-C-R circuit. The power factor of this circuit is
   (a) 0.4 (b) 0.5
   (c) 0.8 (d) 1.0
   (NEET-II 2016)

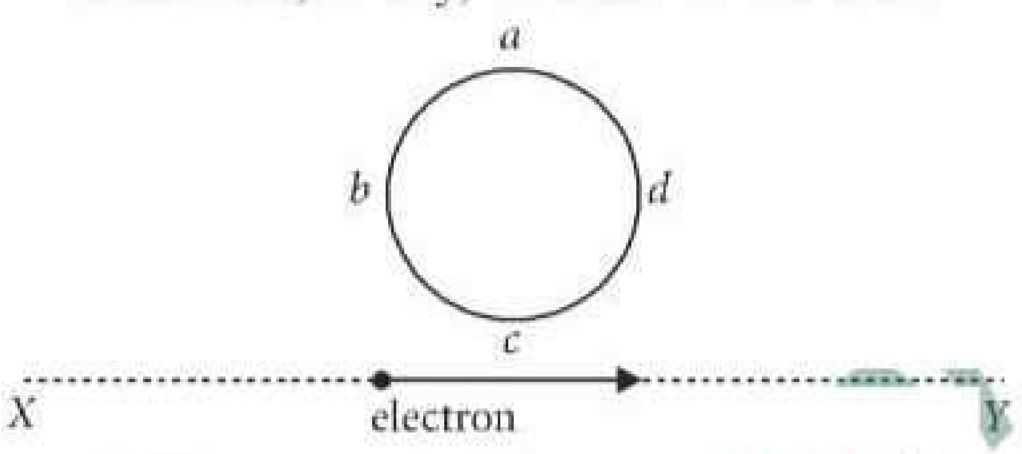
6. An inductor 20 mH, a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf $V = 10 \sin 340t$. The power loss in A.C. circuit is
   (a) 0.76 W (b) 0.89 W
   (c) 0.51 W (d) 0.67 W
   (NEET-I 2016)

7. A small signal voltage $V(t) = V_0 \sin\omega t$ is applied across an ideal capacitor C
   (a) Current $I(t)$ is in phase with voltage $V(t)$.
   (b) Current $I(t)$ leads voltage $V(t)$ by 180°.
   (c) Current $I(t)$, lags voltage $V(t)$ by 90°.
   (d) Over a full cycle the capacitor C does not consume any energy from the voltage source. *(NEET-I 2016)*

8. A long solenoid has 1000 turns. When a current of 4 A flows through it, the magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is
(a) 2 H (b) 1 H
(c) 4 H (d) 3 H
(NEET-I 2016)

9. A series R-C circuit is connected to an alternating voltage source. Consider two situations :
(a) When capacitor is air filled.
(b) When capacitor is mica filled.
Current through resistor is i and voltage across capacitor is V then
(a) $i_a > i_b$ (b) $V_a = V_b$
(c) $V_a < V_b$ (d) $V_a > V_b$ *(2015)*

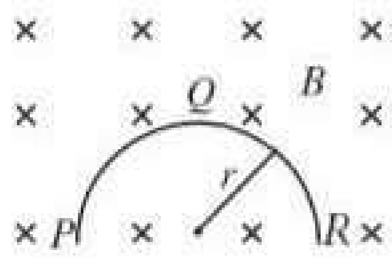
10. An electron moves on a straight line path XY as shown. The $abcd$ is a coil adjacent to the path of electron. What will be the direction of current, if any, induced in the coil?



(a) The current will reverse its direction as the electron goes past the coil
(b) No current induced
(c) $abcd$ (d) $adcb$ *(2015)*

11. A resistance 'R' draws power 'P' when connected to an AC source. If an inductance is now placed in series with the resistance, such that the impedance of the circuit becomes 'Z', the power drawn will be
(a) $P\left(\frac{R}{Z}\right)$ (b) P
(c) $P\left(\frac{R}{Z}\right)^2$ (d) $P\sqrt{\frac{R}{Z}}$
(2015 Cancelled)

12. A thin semicircular conducting ring (PQR) of radius r is falling with its plane vertical in a horizontal magnetic field B, as shown in the figure.



The potential difference developed across the ring when its speed is v, is
(a) zero
(b) $\frac{Bv\pi r^2}{2}$ and P is at higher potential
(c) πrBv and R is at higher potential
(d) $2rBv$ and R is at higher potential
(2014)

13. A transformer having efficiency of 90% is working on 200 V and 3 kW power supply. If the current in the secondary coil is 6 A, the voltage across the secondary coil and the current in the primary coil respectively are
(a) 300 V, 15 A (b) 450 V, 15 A
(c) 450 V, 13.5 A (d) 600 V, 15 A
(2014)

14. A wire loop is rotated in a magnetic field. The frequency of change of direction of the induced e.m.f. is
(a) four times per revolution
(b) six times per revolution
(c) once per revolution
(d) twice per revolution *(NEET 2013)*

15. A coil of self-inductance L is connected in series with a bulb B and an AC source. Brightness of the bulb decreases when
(a) a capacitance of reactance $X_C = X_L$ is included in the same circuit.
(b) an iron rod is inserted in the coil.
(c) frequency of the AC source is decreased.
(d) number of turns in the coil is reduced.
(NEET 2013)

16. The primary of a transformer when connected to a dc battery of 10 Volt draws a current of 1 mA. The number of turns of the primary and secondary windings are 50 and 100 respectively. The voltage in the secondary and the current drawn by the cricuit in the secondary are respectively
(a) 20 V and 2.0 mA
(b) 10 V and 0.5 mA
(c) Zero volt and therefore no current
(d) 20 V and 0.5 mA
(Karnataka NEET 2013)

17. A current of 2.5 A flows through a coil of inductance 5 H. The magnetic flux linked with the coil is
(a) 0.5 Wb (b) 12.5 Wb
(c) zero (d) 2 Wb
(Karnataka NEET 2013)

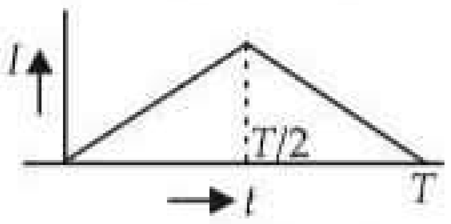
18. A coil of resistance 400 Ω is placed in a magnetic field. If the magnetic flux ϕ (Wb) linked with the coil varies with time t (sec) as $\phi = 50t^2 + 4$.
The current in the coil at $t = 2$ sec is
(a) 0.5 A (b) 0.1 A
(c) 2 A (d) 1 A *(2012)*

19. In an electrical circuit R, L, C and ac voltage source are all connected in series. When L is removed from the circuit, the phase difference between the voltage and the current in the circuit is If instead, C is removed from the circuit, the phase difference is again The power factor of the circuit is

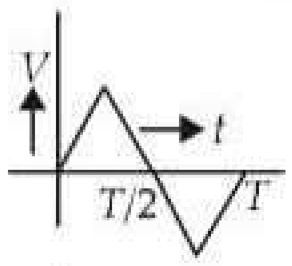
(a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{2}}$

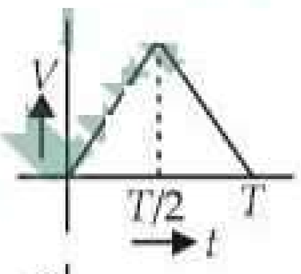
(c) 1 (d) $\frac{\sqrt{3}}{2}$ *(2012)*

20. The current (I) in the inductance is varying with time according to the plot shown in figure.

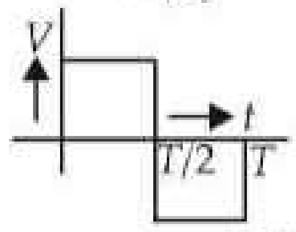


Which one of the following is the correct variation of voltage with time in the coil?

(a) 

(b) 

(c) 

(d) 

(2012)

21. The instantaneous values of alternating current and voltages in a circuit are given as

$i = \frac{1}{\sqrt{2}}\sin(100\pi t)$ ampere

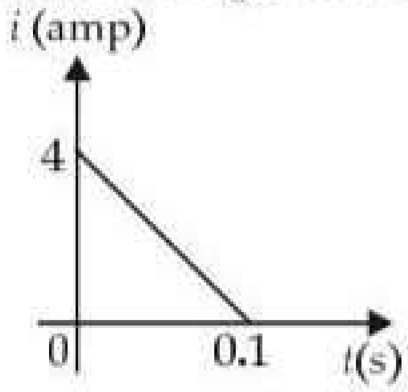
$e = \frac{1}{\sqrt{2}}\sin(100\pi t + \frac{\pi}{3})$ Volt

The average power in watts consumed in the circuit is

(a) $\frac{1}{4}$ (b) $\frac{\sqrt{3}}{4}$

(c) $\frac{1}{2}$ (d) $\frac{1}{8}$ *(Mains 2012)*

22. In a coil of resistance 10 Ω, the induced current developed by changing magnetic flux through it, is shown in figure as a function of time. The magnitude of change in flux through the coil in weber is



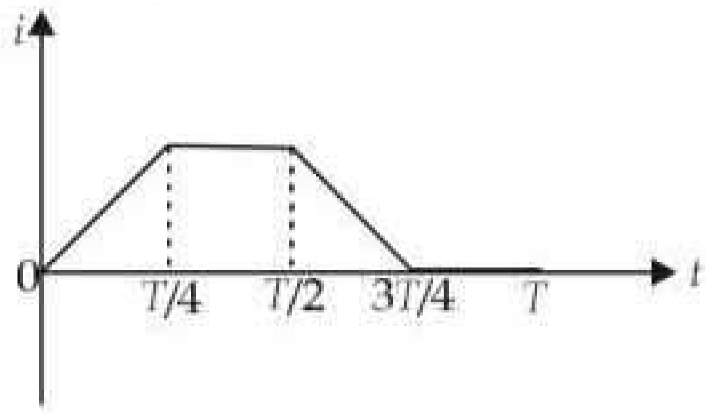
(a) 8
(b) 2
(c) 6
(d) 4

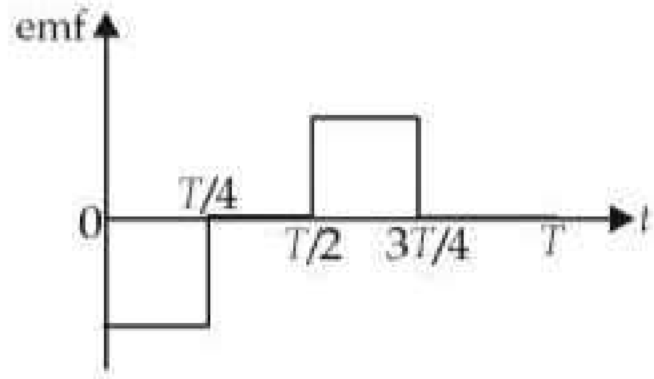
(Mains 2012)

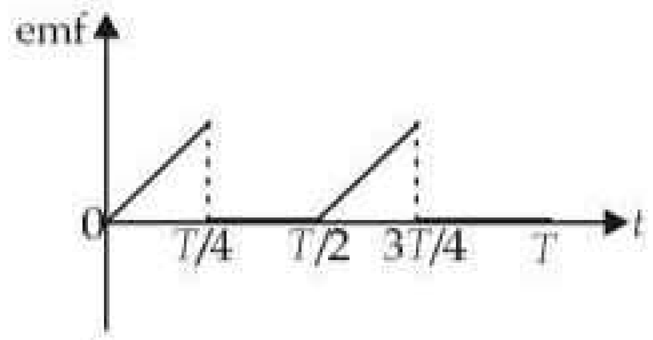
23. An ac voltage is applied to a resistance R and an inductor L in series. If R and the inductive reactance are both equal to 3 Ω, the phase difference between the applied voltage and the current in the circuit is
(a) π/6 (b) π/4
(c) π/2 (d) zero *(2011)*

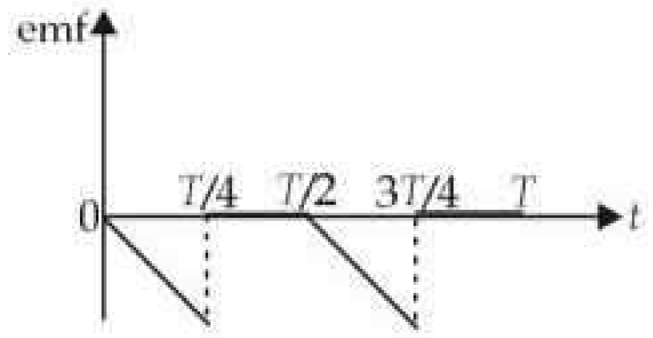
24. In an ac circuit an alternating voltage volts is connected to a capacitor of capacity 1 μF. The r.m.s. value of the current in the circuit is
(a) 10 mA (b) 100 mA
(c) 200 mA (d) 20 mA *(2011)*

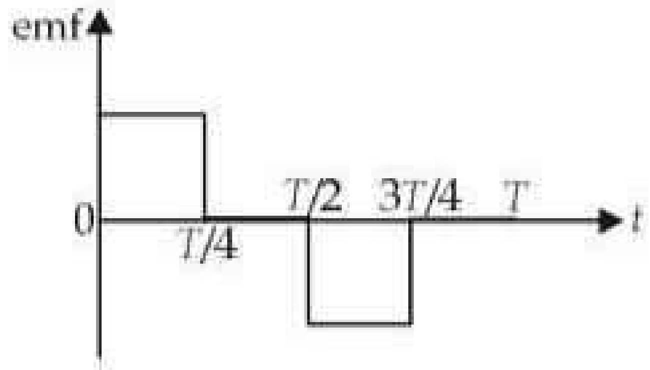
25. The current i in a coil varies with time as shown in the figure. The variation of induced emf with time would be



(a) 

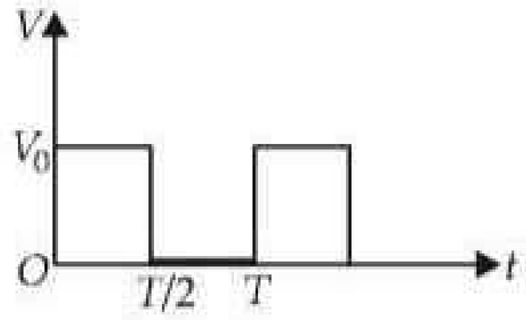
(b) 

(c) 

(d) 

(2011)

26. The r.m.s. value of potential difference V shown in the figure is



(a) $\frac{V_0}{\sqrt{3}}$
(b) V_0
(c) $\frac{V_0}{\sqrt{2}}$
(d) $\frac{V_0}{2}$ *(Mains 2011)*

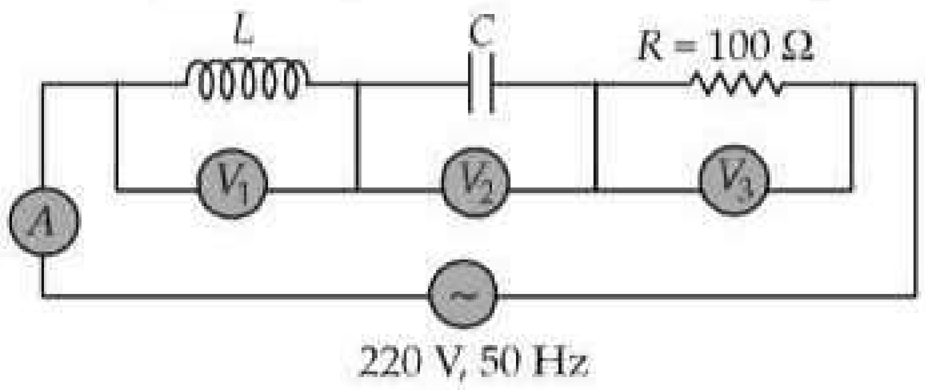
27. A coil has resistance 30 ohm and inductive reactance 20 ohm at 50 Hz frequency. If an ac source, of 200 volt, 100 Hz, is connected across the coil, the current in the coil will be

(a) 2.0 A (b) 4.0 A
(c) 8.0 A (d) $\frac{20}{\sqrt{13}}$ A *(Mains 2011)*

28. A conducting circular loop is placed in a uniform magnetic field, B = 0.025 T with its plane perpendicular to the loop. The radius of the loop is made to shrink at a constant rate of 1 mm s^{-1}. The induced emf when the radius is 2 cm, is

(a) $2\pi\,\mu V$ (b) $\pi\,\mu V$
(c) $\frac{\pi}{2}\,\mu V$ (d) $2\,\mu V$ *(2010)*

29. In the given circuit the reading of voltmeter V_1 and V_2 are 300 volts each. The reading of the voltmeter V_3 and ammeter A are respectively



(a) 150 V, 2.2 A (b) 220 V, 2.2 A
(c) 220 V, 2.0 A (d) 100 V, 2.0 A
(2010)

30. A 220 volt input is supplied to a transformer. The output circuit draws a current of 2.0 ampere at 440 volts. If the efficiency of the transformer is 80%, the current drawn by the primary windings of the transformer is

(a) 3.6 ampere (b) 2.8 ampere
(c) 2.5 ampere (d) 5.0 ampere
(2010)

31. A condenser of capacity C is charged to a potential difference of V_1. The plates of the condenser are then connected to an ideal inductor of inductance L. The current through the inductor when the potential difference across the condenser reduces to V_2 is

(a) $\left(\frac{C(V_1-V_2)^2}{L}\right)^{\frac{1}{2}}$ (b) $\frac{C(V_1^2-V_2^2)}{L}$

(c) $\frac{C(V_1^2+V_2^2)}{L}$ (d) $\left(\frac{C(V_1^2-V_2^2)}{L}\right)^{\frac{1}{2}}$

(Mains 2010)

32. A rectangular, a square, a circular and an elliptical loop, all in the (x-y) plane, are moving out of a uniform magnetic field with a constant velocity, $\vec{V} = v\hat{i}$. The magnetic field is directed along the negative z axis direction. The induced emf, during the passage of these loops, out of the field region, will not remain constant for

(a) the circular and the elliptical loops
(b) only the elliptical loop
(c) any of the four loops
(d) the rectangular, circular and elliptical loops
(2009)

33. Power dissipated in an LCR series circuit connected to an A.C. source of emf e is

(a) $\frac{\varepsilon^2\sqrt{R^2+\left(L\omega-\frac{1}{C\omega}\right)^2}}{R}$

(b) $\frac{\varepsilon^2\left[R^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]}{R}$

(c) $\frac{\varepsilon^2 R}{\sqrt{R^2+\left(L\omega-\frac{1}{C\omega}\right)^2}}$

(d) $\frac{\varepsilon^2 R}{\left[R^2+\left(L\omega-\frac{1}{C\omega}\right)^2\right]}$ *(2009)*

34. A conducting circular loop is placed in a uniform magnetic field 0.04 T with its plane perpendicular to the magnetic field. The radius of the loop starts shrinking at 2 mm/s. The induced emf in the loop when the radius is 2 cm is

(a) $4.8\pi\,\mu V$ (b) $0.8\pi\,\mu V$
(c) $1.6\pi\,\mu V$ (d) $3.2\pi\,\mu V$ *(2009)*

35. A long solenoid has 500 turns. When a current of 2 ampere is passed through it, the resulting magnetic flux linked with each turn of the solenoid is 4×10^{-3} Wb. The self-inductance of the solenoid is

(a) 1.0 henry (b) 4.0 henry
(c) 2.5 henry (d) 2.0 henry *(2008)*

36. In an a.c. circuit the e.m.f. (ε) and the current (i) at any instant are given respectively by

$\varepsilon = E_0 \sin\omega t$, $i = I_0 \sin(\omega t - \phi)$

The average power in the circuit over one cycle of a.c. is

(a) $\frac{E_0 I_0}{2}\cos\phi$ (b) $E_0 I_0$
(c) $\frac{E_0 I_0}{2}$ (d) $\frac{E_0 I_0}{2}\sin\phi$ *(2008)*

37. A circular disc of radius 0.2 meter is placed in a uniform magnetic field of induction $\frac{1}{\pi}\left(\frac{\text{Wb}}{\text{m}^2}\right)$ in such a way that its axis makes an angle of 60° with $\vec{B}$. The magnetic flux linked with the disc is

(a) 0.08 Wb (b) 0.01 Wb
(c) 0.02 Wb (d) 0.06 Wb *(2008)*

38. The primary and secondary coils of a transformer have 50 and 1500 turns respectively. If the magnetic flux ϕ linked with the primary coil is given by $\phi = \phi_0 + 4t$, where ϕ is in webers, t is time in seconds and ϕ_0 is a constant, the output voltage across the secondary coil is

(a) 120 volts (b) 220 volts
(c) 30 volts (d) 90 volts. *(2007)*

39. A transformer is used to light a 100 W and 110 V lamp from a 220 V mains. If the main current is 0.5 amp, the efficiency of the transformer is approximately

(a) 50% (b) 90%
(c) 10% (d) 30%. *(2007)*

40. What is the value of inductance L for which the current is maximum in a series LCR circuit with $C = 10\ \mu F$ and $\omega = 1000\ s^{-1}$?

(a) 1 mH
(b) cannot be calculated unless R is known
(c) 10 mH
(d) 100 mH. *(2007)*

41. A coil of inductive reactance 31 Ω has a resistance of 8 Ω. It is placed in series with a condenser of capacitative reactance 25 Ω. The combination is connected to an a.c. source of 110 V. The power factor of the circuit is

(a) 0.33 (b) 0.56
(c) 0.64 (d) 0.80 *(2006)*

42. Two coils of self inductance 2 mH and 8 mH are placed so close together that the effective flux in one coil is completely linked with the other. The mutual inductance between these coils is

(a) 16 mH (b) 10 mH
(c) 6 mH (d) 4 mH. *(2006)*

43. The core of a transformer is laminated because

(a) ratio of voltage in primary and secondary may be increased
(b) energy losses due to eddy currents may be minimised
(c) the weight of the transformer may be reduced
(d) rusting of the core may be prevented. *(2006)*

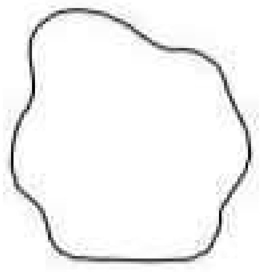
44. A transistor-oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produce oscillations of frequency f. If L is doubled and C is changed to $4C$, the frequency will be

(a) $f/2$ (b) $f/4$
(c) $8f$ (d) $f/2\sqrt{2}$ *(2006)*

45. In a circuit L, C and R are connected in series with an alternating voltage source of frequency f. The current leads the voltage by 45°. The value of C is

(a) $\frac{1}{\pi f(2\pi f L - R)}$ (b) $\frac{1}{2\pi f(2\pi f L - R)}$
(c) $\frac{1}{\pi f(2\pi f L + R)}$ (d) $\frac{1}{2\pi f(2\pi f L + R)}$ *(2005)*

46. As a result of change in the magnetic flux linked to the closed loop as shown in the figure, an e.m.f. V volt is induced in the loop. The work done (joule) in taking a charge Q coulomb once along the loop is



(a) QV (b) $2QV$
(c) $QV/2$ (d) zero. *(2005)*

47. 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
(a) 5 seconds (b) 1/5 seconds
(c) 40 seconds (d) 20 seconds *(2004)*

48. The magnetic flux through a circuit of resistance R changes by an amount $\Delta\phi$ in a time Δt. Then the total quantity of electric charge Q that passes any point in the circuit during the time Δt is represented by

(a) $Q = \frac{1}{R} \cdot \frac{\Delta\phi}{\Delta t}$ (b) $Q = \frac{\Delta\phi}{R}$

(c) $Q = \frac{\Delta\phi}{\Delta t}$ (d) $Q = R \cdot \frac{\Delta\phi}{\Delta t}$ *(2004)*

49. For a series LCR circuit the power loss at resonance is

(a) $\frac{V^2}{\left[\omega L - \frac{1}{\omega C}\right]}$ (b) $I^2 L\omega$

(c) I^2R (d) $\frac{V^2}{C\omega}$. *(2002)*

50. For a coil having $L = 2$ mH, current flow through it is $I = t^2 e^{-t}$ then, the time at which emf become zero
(a) 2 sec (b) 1 sec
(c) 4 sec (d) 3 sec. *(2001)*

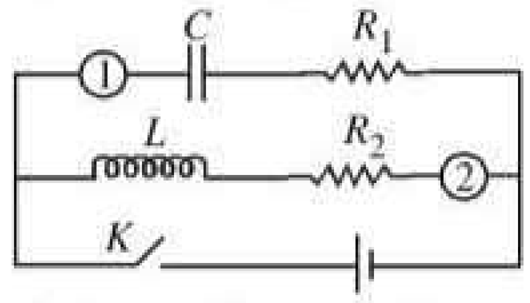
51. A capacitor of capacity C has reactance X. If capacitance and frequency become double then reactance will be
(a) $4X$ (b) $X/2$
(c) $X/4$ (d) $2X$. *(2001)*

52. The value of quality factor is

(a) $\frac{\omega L}{R}$ (b) $\frac{1}{\omega RC}$

(c) $\sqrt{LC}$ (d) L/R. *(2000)*

53. In the circuit given in figure, 1 and 2 are ammeters. Just after key K is pressed to complete the circuit, the reading will be



(a) zero in 1, maximum in 2
(b) maximum in both 1 and 2
(c) zero in both 1 and 2
(d) maximum in 1, zero in 2 *(1999)*

54. A step-up transformer operates on a 230 V line and supplies a load of 2 ampere. The ratio of the primary and secondary windings is 1 : 25. The current in the primary is
(a) 15 A (b) 50 A
(c) 25 A (d) 12.5 A *(1998)*

55. Two coils have a mutual inductance 0.005 H. The current changes in the first coil according to equation $I = I_0 \sin \omega t$, where $I_0 = 10$ A and $\omega = 100\,\pi$ rad/sec. The maximum value of e.m.f. in the second coil is
(a) π (b) 5π
(c) 2π (d) 4π *(1998)*

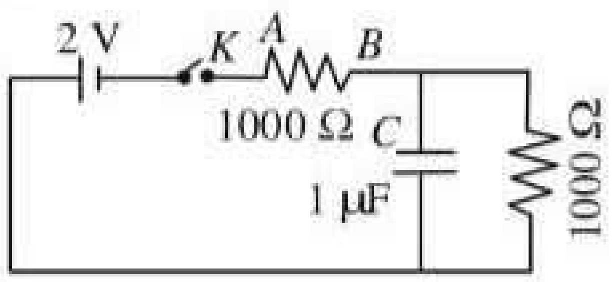
56. The primary winding of a transformer has 500 turns whereas its secondary has 5000 turns. The primary is connected to an A.C. supply 20 V, 50 Hz. The secondary will have an output of
(a) 2 V, 50 Hz (b) 2 V, 5 Hz
(c) 200 V, 50 Hz (d) 200 V, 500 Hz. *(1997)*

57. In an a.c. circuit with phase voltage V and current I, the power dissipated is
(a) $V.I$
(b) depends on phase angle between V and I
(c) $\frac{1}{2} \times V.I$
(d) $\frac{1}{\sqrt{2}} \times V.I$. *(1997)*

58. A metal ring is held horizontally and bar magnet is dropped through the ring with its length along the axis of the ring. The acceleration of the falling magnet is
(a) more than g (b) equal to g
(c) less than g (d) either (a) or (c). *(1996)*

59. In an A.C. circuit, the current flowing is $I = 5 \sin (100t - \pi/2)$ ampere and the potential difference is $V = 200 \sin (100t)$ volts. The power consumption is equal to
(a) 20 W (b) 0 W
(c) 1000 W (d) 40 W. *(1995)*

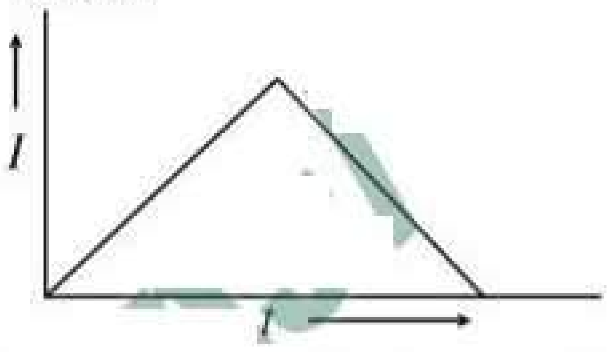
60. When the key K is pressed at time $t = 0$, then which of the following statement about the current I in the resistor AB of the given circuit is true?



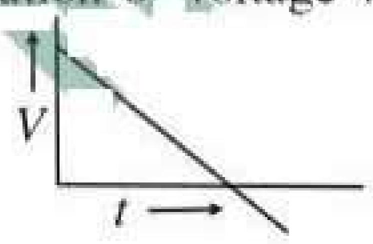
(a) I oscillates between 1 mA and 2 mA
(b) at $t = 0$, $I = 2$ mA and with time it goes to 1 mA
(c) $I = 1$ mA at all t
(d) $I = 2$ mA at all t. *(1995)*

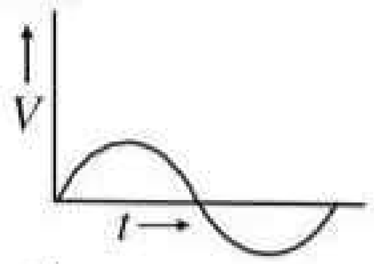
61. A straight line conductor of length 0.4 m is moved with a speed of 7 m/s perpendicular to a magnetic field of intensity 0.9 Wb/m^2. The induced e.m.f. across the conductor is
(a) 5.04 V (b) 25.2 V
(c) 1.26 V (d) 2.52 V. *(1995)*

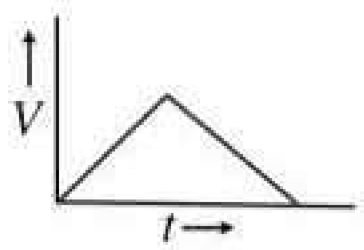
62. The current I in an A.C. circuit with inductance coil varies with time according to the graph given below.

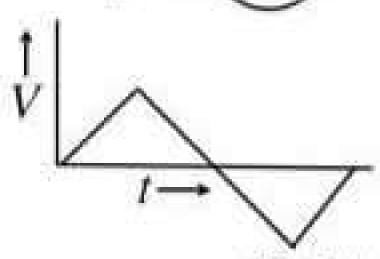


Which one of the following graphs gives the variation of voltage with time?

(a)


(b)


(c)


(d)


(1994)

63. In an A.C. circuit, I_{rms} and I_0 are related as
(a) $I_{rms} = \pi I_0$ (b) $I_{rms} = \sqrt{2}\, I_0$
(c) $I_{rms} = I_0/\pi$ (d) $I_{rms} = I_0/\sqrt{2}$. *(1994)*

64. An series L-C-R circuit is connected to a source of A.C. current. At resonance, the phase difference between the applied voltage and the current in the circuit, is
(a) π (b) zero
(c) $\pi/4$ (d) $\pi/2$. *(1994)*

65. Two cables of copper are of equal lengths. One of them has a single wire of area of cross-section A, while other has 10 wires of cross-sectional area $A/10$ each. Give their suitability for transporting A.C. and D.C.
(a) only multiple strands for A.C., either for D.C.
(b) only multiple strands for A.C., only single strand for D.C.
(c) only single strand for D.C., either for A.C.
(d) only single strand for A.C., either for D.C. *(1994)*

66. If N is the number of turns in a coil, the value of self inductance varies as
(a) N^0 (b) N
(c) N^2 (d) N^{-2} *(1993)*

67. What is the self-inductance of a coil which produces 5 mV when the current changes from 3 ampere to 2 ampere in one millisecond?
(a) 5000 henry (b) 5 mili-henry
(c) 50 henry (d) 5 henry *(1993)*

68. The time constant of C-R circuit is
(a) $1/CR$ (b) C/R
(c) CR (d) R/C *(1992)*

69. The total charge, induced in a conducting loop when it is moved in magnetic field depend on
(a) the rate of change of magnetic flux
(b) initial magnetic flux only
(c) the total change in magnetic flux
(d) final magnetic flux only *(1992)*

70. A rectangular coil of 20 turns and area of cross-section 25 sq. cm has a resistance of 100 Ω. If a magnetic field which is perpendicular to the plane of coil changes at a rate of 1000 tesla per second, the current in the coil is
(a) 1A (b) 50 A
(c) 0.5 A (d) 5 A *(1992)*

71. Faraday's laws are consequence of conservation of
(a) energy
(b) energy and magnetic field
(c) charge
(d) magnetic field *(1991)*

72. If the number of turns per unit length of a coil of solenoid is doubled, the self-inductance of the solenoid will
(a) remain unchanged
(b) be halved
(c) be doubled
(d) become four times *(1991)*

73. A 100 millihenry coil carries a current of 1A. Energy stored in its magnetic field is
(a) 0.5 J (b) 1 A
(c) 0.05 J (d) 0.1 J *(1991)*

74. A magnetic field of 2×10^{-2} T acts at right angles to a coil of area 100 cm^2, with 50 turns. The average e.m.f. induced in the coil is 0.1 V, when it is removed from the field in t sec. The value of t is
(a) 10 s (b) 0.1 s
(c) 0.01 s (d) 1 s *(1991)*

75. The current in self inductance L = 40 mH is to be increased uniformly from 1 amp to 11 amp in 4 milliseconds. The e.m.f. induced in inductor during process is
(a) 100 volt (b) 0.4 volt
(c) 4.0 volt (d) 440 volt *(1990)*

76. An inductor may store energy in
(a) its electric field
(b) its coils
(c) its magnetic field
(d) both in electric and magnetic fields *(1990)*

77. In a region of magnetic induction $B = 10^{-2}$ tesla, a circular coil of radius 30 cm and resistance π^2 ohm is rotated about an axis which is perpendicular to the direction of B and which forms a diameter of the coil. If the coil rotates at 200 rpm the amplitude of the alternating current induced in the coil is
(a) $4\pi^2$ mA (b) 30 mA
(c) 6 mA (d) 200 mA *(1988)*

78. Eddy currents are produced when
(a) a metal is kept in varying magnetic field
(b) a metal is kept in steady magnetic field
(c) a circular coil is placed in a magnetic field
(d) through a circular coil, current is passed *(1988)*

Answer Key

1.	(b)	**2.**	(*)	**3.**	(c)	**4.**	(d)	**5.**	(c)	**6.**	(c)	**7.**	(d)	**8.**	(b)	**9.**	(d)	**10.**	(a)
11.	(c)	**12.**	(d)	**13.**	(b)	**14.**	(d)	**15.**	(b)	**16.**	(c)	**17.**	(b)	**18.**	(a)	**19.**	(c)	**20.**	(d)
21.	(d)	**22.**	(b)	**23.**	(b)	**24.**	(d)	**25.**	(a)	**26.**	(c)	**27.**	(b)	**28.**	(b)	**29.**	(b)	**30.**	(d)
31.	(d)	**32.**	(a)	**33.**	(d)	**34.**	(d)	**35.**	(a)	**36.**	(a)	**37.**	(c)	**38.**	(a)	**39.**	(b)	**40.**	(d)
41.	(d)	**42.**	(d)	**43.**	(b)	**44.**	(d)	**45.**	(d)	**46.**	(a)	**47.**	(a)	**48.**	(b)	**49.**	(c)	**50.**	(a)
51.	(c)	**52.**	(a, b)	**53.**	(d)	**54.**	(b)	**55.**	(b)	**56.**	(c)	**57.**	(b)	**58**	(c)	**59.**	(b)	**60.**	(b)
61.	(d)	**62.**	(a)	**63.**	(d)	**64.**	(b)	**65.**	(a)	**66.**	(c)	**67.**	(b)	**68.**	(c)	**69.**	(c)	**70.**	(c)
71.	(d)	**72.**	(d)	**73.**	(c)	**74.**	(b)	**75.**	(a)	**76.**	(c)	**77.**	(c)	**78.**	(a)				

* None is correct.

EXPLANATIONS

1. **(b) :** Given $n = 2 \times 10^4$; $I = 4$ A

Initially $I = 0$ A

$\therefore \quad B_i = 0$ or $\phi_i = 0$

Finally, the magnetic field at the centre of the solenoid is given as

$B_f = \mu_o nI$

$B_f = 4\pi \times 10^{-7} \times 2 \times 10^4 \times 4$

$B_f = 32\pi \times 10^{-3}$ T

Final magnetic flux through the coil is given as

$\phi_f = NBA = 100 \times 32\,\pi \times 10^{-3} \times \pi \times (0.01)^2$

$\phi_f = 32\pi^2 \times 10^{-5}$ T m^2

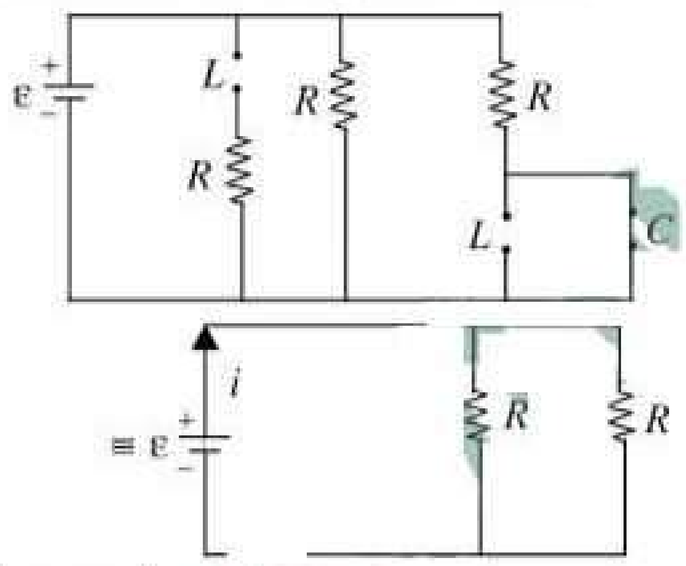
Induced charge,

$$q = \frac{|\Delta\phi|}{R} = \frac{|\phi_f - \phi_i|}{R} = \frac{32\pi^2 \times 10^{-5}}{10\pi^2}$$

$$= 32 \times 10^{-6}\ \text{C} = 32\ \mu\text{C}$$

2. **(*) :** At time, $t = 0$ *i.e.*, when switch is closed, inductor in the circuit provides very high resistance (open circuit) while capacitor starts charging with maximum current (low resistance).

Equivalent circuit of the given circuit



Current drawn from battery,

$$i = \frac{\varepsilon}{(R/2)} = \frac{2\varepsilon}{R} = \frac{2 \times 18}{9} = 4\ \text{A}$$

*None of the given options is correct.

3. **(c) :** Quality factor of an *L*-*C*-*R* circuit is given by,

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$Q_1 = \frac{1}{20}\sqrt{\frac{1.5}{35 \times 10^{-6}}} = 50 \times \sqrt{\frac{3}{70}} = 10.35$$

$$Q_2 = \frac{1}{25} \times \sqrt{\frac{2.5}{45 \times 10^{-6}}} = 40 \times \sqrt{\frac{5}{90}} = 9.43$$

$$Q_3 = \frac{1}{15}\sqrt{\frac{3.5}{30 \times 10^{-6}}} = \frac{100}{15}\sqrt{\frac{35}{3}} = 22.77$$

$$Q_4 = \frac{1}{25} \times \sqrt{\frac{1.5}{45 \times 10^{-6}}} = \frac{40}{\sqrt{30}} = 7.30$$

Clearly Q_3 is maximum of Q_1, Q_2, Q_3, and Q_4.

Hence, option (c) should be selected for better tuning of an *L*-*C*-*R* circuit.

4. **(d) :** Emf generated in loop 1,

$$\varepsilon_1 = -\frac{d\phi}{dt} = -\frac{d}{dt}(\vec{B} \cdot \vec{A}) = -\frac{d}{dt}(BA) = -A \times \frac{dB}{dt}$$

$$\varepsilon_1 = -\left(\pi r^2 \frac{dB}{dt}\right)$$

($\because A = \pi r^2$ because $\frac{dB}{dt}$ is restricted upto radius r.)

Emf generated in loop 2,

$$\varepsilon_2 = -\frac{d}{dt}(BA) = -\frac{d}{dt}(0 \times A) = 0$$

5. **(c) :** Here, $V_R = 80$ V, $V_C = 40$ V, $V_L = 100$ V

Power factor, $\cos\phi = \frac{R}{Z}$

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

$$= \frac{80}{\sqrt{(80)^2 + (100 - 40)^2}} = \frac{80}{100} = 0.8$$

6. **(c) :** Here, $L = 20$ mH $= 20 \times 10^{-3}$ H,

$C = 50\ \mu$F $= 50 \times 10^{-6}$ F

$R = 40\ \Omega$, $V = 10 \sin 340t = V_0 \sin\omega t$

$\omega = 340$ rad s^{-1}, $V_0 = 10$ V

$X_L = \omega L = 340 \times 20 \times 10^{-3} = 6.8\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{340 \times 50 \times 10^{-6}} = \frac{10^4}{34 \times 5} = 58.82\ \Omega$$

$$Z = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{(40)^2 + (58.82 - 6.8)^2}$$

$$= \sqrt{(40)^2 + (52.02)^2} = 65.62\ \Omega$$

The peak current in the circuit is

$$I_0 = \frac{V_0}{Z} = \frac{10}{65.62}\ \text{A}, \cos\phi = \frac{R}{Z} = \left(\frac{40}{65.62}\right)$$

Power loss in A.C. circuit,

$$= V_{rms}\, I_{rms} \cos\phi = \frac{1}{2} V_0 I_0 \cos\phi$$

$$= \frac{1}{2} \times 10 \times \frac{10}{65.62} \times \frac{40}{65.62} = 0.46\ \text{W}$$

7. **(d) :** When an ideal capacitor is connected with an ac voltage source, current leads voltage by 90°.

Since, energy stored in capacitor during charging is spent in maintaining charge on the capacitor during discharging. Hence over a full cycle the capacitor does not consume any energy from the voltage source.

8. **(b) :** Here, $N = 1000$, $I = 4$ A , $\phi_0 = 4 \times 10^{-3}$ Wb

Total flux linked with the solenoid, $\phi = N\phi_0$

$= 1000 \times 4 \times 10^{-3}$ Wb $= 4$ Wb

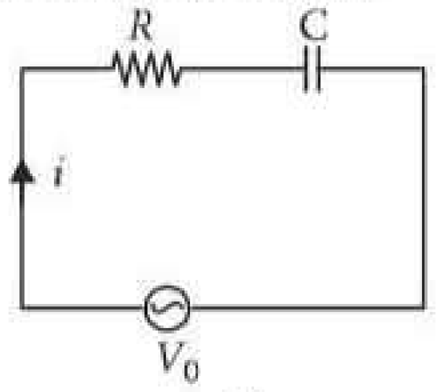
Since, $\phi = LI$

∴ Self-inductance of solenoid,

$$L = \frac{\phi}{I} = \frac{4\ \text{Wb}}{4\ \text{A}} = 1\ \text{H}$$

9. **(d) :** Current through resistor, i

= Current in the circuit



$$= \frac{V_0}{\sqrt{R^2 + X_C^2}} = \frac{V_0}{\sqrt{R^2 + (1/\omega C)^2}}$$

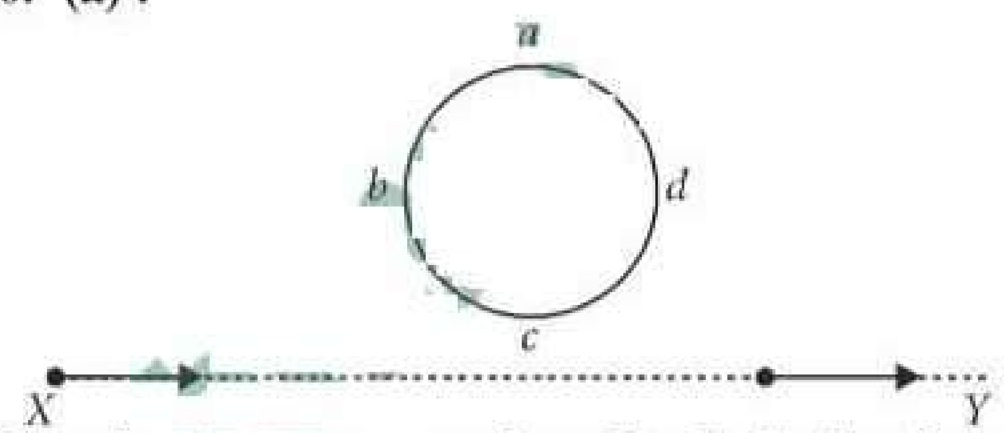
Voltage across capacitor, $V = iX_C$

$$= \frac{V_0}{\sqrt{R^2 + (1/\omega C)^2}} \times \frac{1}{\omega C} = \frac{V_0}{\sqrt{R^2\omega^2 C^2 + 1}}$$

As $C_a < C_b$

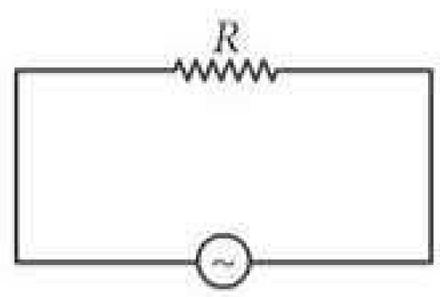
∴ $i_a < i_b$ and $V_a > V_b$

10. **(a) :**



When the electron moves from X to Y, the flux linked with the coil *abcd* (which is into the page) will first increase and then decrease as the electron passes by. So the induced current in the coil will be first anticlockwise and will reverse its direction (*i.e.* will become clockwise) as the electron goes past the coil.

11. **(c) : Case I :** $P = V_{\text{rms}} I_{\text{rms}}$

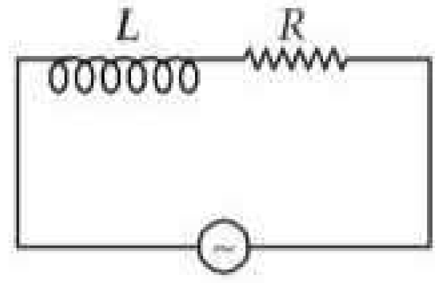


$$= V_{\text{rms}} \times \frac{V_{\text{rms}}}{R}$$

$$P = \frac{V_{\text{rms}}^2}{R} \Rightarrow V_{\text{rms}}^2 = PR \quad \ldots\text{(i)}$$

Case II : Power drawn in *LR* circuit

$$P' = V_{\text{rms}} I_{\text{rms}} \cos\phi = V_{\text{rms}} \times \frac{V_{\text{rms}}}{Z} \times \frac{R}{Z}$$



$$= V_{\text{rms}}^2 \frac{R}{Z^2} = PR \times \frac{R}{Z^2}$$

[Using eqn (i)]

$$P' = P\frac{R^2}{Z^2}$$

12. **(d) :** Motional emf induced in the semicircular ring *PQR* is equivalent to the motional emf induced in the imaginary conductor *PR*.

i.e., $\varepsilon_{PQR} = \varepsilon_{PR} = Bvl = Bv(2r)$ $\quad (l = PR = 2r)$

Therefore, potential difference developed across the ring is $2rBv$ with R is at higher potential.

13. **(b) :** Here,

Efficiency of the transformer, $\eta = 90\%$

Input power, $P_{\text{in}} = 3$ kW $= 3 \times 10^3$ W $= 3000$ W

Voltage across the primary coil, $V_p = 200$ V

Current in the secondary coil, $I_s = 6$ A

As $P_{\text{in}} = I_p V_p$

∴ Current in the primary coil,

$$I_p = \frac{P_{\text{in}}}{V_p} = \frac{3000\ \text{W}}{200\ \text{V}} = 15\ \text{A}$$

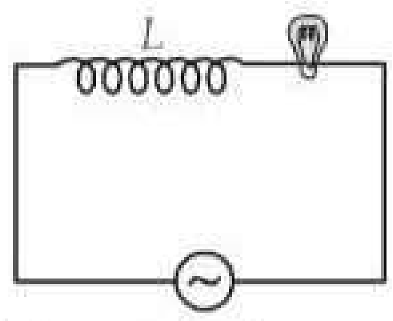
Efficiency of the transformer,

$$\eta = \frac{P_{\text{out}}}{P_{\text{in}}} = \frac{V_s I_s}{V_p I_p}$$

$$\therefore \quad \frac{90}{100} = \frac{6V_s}{3000} \text{ or } V_s = \frac{90 \times 3000}{100 \times 6} = 450\ \text{V}$$

14. **(d)**

15. **(b) :** The situation is as shown in the figure.



As the iron rod is inserted, the magnetic field inside the coil magnetizes the iron increasing the magnetic field inside it. Hence, the inductance of the coil increases. Consequently, the inductive reactance of the coil increases. As a result, a larger fraction of the applied AC voltage appears across the inductor, leaving less voltage across the bulb. Therefore, the brightness of the light bulb decreases.

16. (c) : Transformer cannot work on dc.

$\therefore \quad V_s = 0$ and $I_s = 0$

17. (b) : Here, $I = 2.5$ A, $L = 5$ H

Magnetic flux linked with the coil is

$$\phi_B = LI = (5 \text{ H})(2.5 \text{ A}) = 12.5 \text{ Wb}$$

18. (a) : Here, $\phi = 50t^2 + 4$ Wb, $R = 400\ \Omega$

Induced emf, $\varepsilon = -\frac{d\phi}{dt} = -\frac{d}{dt}(50t^2 + 4) = -100t$ V

At $t = 2$ s, $\varepsilon = -200$ V

$$|\varepsilon| = 200 \text{ V}$$

Induced current in the coil at $t = 2$ s is

$$I = \frac{|\varepsilon|}{R} = \frac{200 \text{ V}}{400\ \Omega} = \frac{1}{2} \text{ A} = 0.5 \text{ A}$$

19. (c) : When L is removed, the phase difference between the voltage and current is

$$\tan\phi_1 = \frac{X_C}{R}$$

$$\tan\frac{\pi}{3} = \frac{X_C}{R} \text{ or } X_C = R\tan 60° \text{ or } X_C = \sqrt{3}R$$

When C is removed, the phase difference between the voltage and current is

$$\tan\phi_2 = \frac{X_L}{R}$$

$$\tan\frac{\pi}{3} = \frac{X_L}{R} \text{ or } X_L = R\tan 60° = \sqrt{3}R$$

As $X_L = X_C$, the series LCR circuit is in resonance.

Impedance of the circuit,

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = R \qquad (\because X_L = X_C)$$

Power factor, $\cos\phi = \frac{R}{Z} = \frac{R}{R} = 1$

20. (d) : $V = -L\frac{dI}{dt}$

$V \propto$ slope of I-t graph

21. (d) : Given $I = \frac{1}{\sqrt{2}}\sin(100\pi t)$ ampere

Compare it with $i = i_0 \sin(\omega t)$, we get

$$i_0 = \frac{1}{\sqrt{2}} \text{ A}$$

Given : $e = \frac{1}{\sqrt{2}}\sin\left(100\pi t + \frac{\pi}{3}\right)$ volt

Compare it with , we get

$$e_0 = \frac{1}{\sqrt{2}} \text{V}, \phi = \frac{\pi}{3}$$

$$\therefore \quad i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} \text{ A} = \frac{1}{2} \text{ A}$$

$$e_{rms} = \frac{e_0}{\sqrt{2}} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} \text{ V} = \frac{1}{2} \text{ V}$$

Average power consumed in the circuit,

$$P = i_{rms} e_{rms} \cos\phi$$

$$= \left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\cos\frac{\pi}{3} = \left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right) = \frac{1}{8} \text{ W}$$

22. (b) : q = Area under i-t graph

$$= \frac{1}{2} \times 4 \times 0.1 = 0.2 \text{ C}$$

As $q = \frac{\Delta\phi}{R}$

$\therefore \quad \Delta\phi = qR = (0.2 \text{ C})(10\ \Omega) = 2$ weber

23. (b) : Here, $R = 3\ \Omega$

Inductive reactance, $X_L = 3\ \Omega$

The phase difference between the applied voltage and the current in the circuit is

$$\tan\phi = \frac{X_L}{R} = \frac{3\ \Omega}{3\ \Omega} = 1$$

$$\phi = \tan^{-1}(1) \text{ or } \phi = \frac{\pi}{4}$$

24. (d) : The given equation of alternating voltage is

$$e = 200\sqrt{2}\sin 100t \qquad \text{...(i)}$$

The standard equation of alternating voltage is

$$e = e_0 \sin\omega t \qquad \text{...(ii)}$$

Comparing (i) and (ii), we get

$$e_0 = 200\sqrt{2} \text{ V}, \omega = 100 \text{ rad s}^{-1}$$

The capacitive reactance is

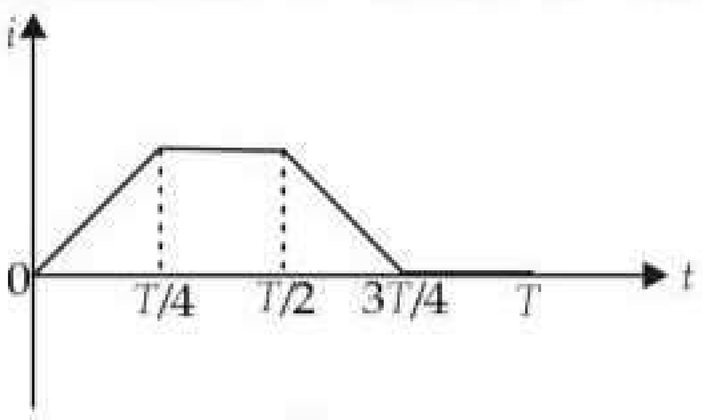
$$X_C = \frac{1}{\omega C} = \frac{1}{100 \times 1 \times 10^{-6}}\ \Omega$$

The r.m.s. value of the current in the circuit is

$$i_{r.m.s.} = \frac{v_{r.m.s.}}{X_C} = \frac{e_0/\sqrt{2}}{1/\omega C} = \frac{(200\sqrt{2}/\sqrt{2})}{(1/100 \times 10^{-6})}$$

$$= 200 \times 100 \times 10^{-6} \text{ A} = 2 \times 10^{-2} \text{ A} = 20 \text{ mA}$$

25. (a) :



Induced emf, $e = -L\frac{di}{dt}$

For $0 \le t \le \frac{T}{4}$,

i-t graph is a straight line with positive constant slope.

$\therefore \quad \frac{di}{dt} = \text{constant}$

$\Rightarrow \quad e = -\text{ve and constant} \qquad \text{For } 0 \le t \le \frac{T}{4}$

For $\frac{T}{4} \le t \le \frac{T}{2}$

i is constant $\therefore \frac{di}{dt} = 0$

$\Rightarrow \quad e = 0 \qquad \text{For } \frac{T}{4} \le t \le \frac{T}{2}$

For $\frac{T}{2} \le t \le \frac{3T}{4}$

i-t graph is a straight line with negative constant slope.

$\therefore \quad \frac{di}{dt} = \text{constant}$

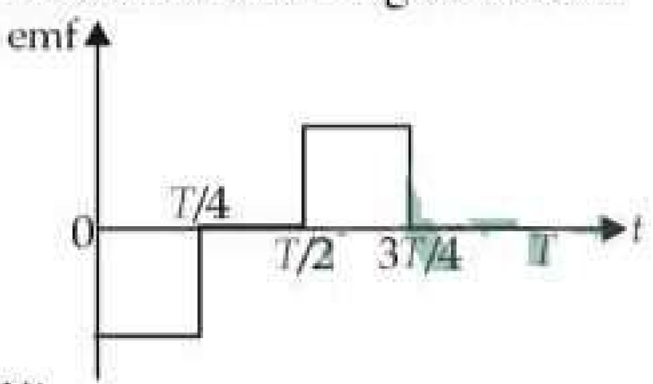
$\Rightarrow \quad e = +\text{ve and constant} \qquad \text{For } \frac{T}{2} \le t \le \frac{3T}{4}$

For $\frac{3T}{4} \le t \le T$,

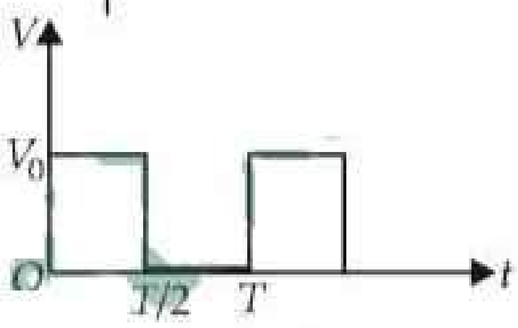
i is zero $\therefore \frac{di}{dt} = 0$

$\Rightarrow \quad e = 0 \qquad \text{For } \frac{3T}{4} \le t \le T$

From this analysis, the variation of induced emf with time as shown in the figure below.



26. (c) :



$V = V_0$ for $0 \le t \le \frac{T}{2}$

$V = 0$ for $\frac{T}{2} \le t \le T$

$$V_{rms} = \left[\frac{\int_0^T V^2 dt}{\int_0^T dt}\right]^{1/2} = \left[\frac{\int_0^{T/2} V_0^2 dt + \int_{T/2}^{T} (0) dt}{\int_0^T dt}\right]^{1/2}$$

$$= \left[\frac{V_0^2}{T}[t]_0^{T/2}\right]^{1/2} = \left[\frac{V_0^2}{T}\left(\frac{T}{2}\right)\right]^{1/2} = \left[\frac{V_0^2}{2}\right]^{1/2}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

27. (b) : Here, Resistance, $R = 30\ \Omega$

Inductive reactance, $X_L = 20\ \Omega$ at 50 Hz

$\because \quad X_L = 2\pi\upsilon L$

$\therefore \quad \frac{X_L}{X_L'} = \frac{\upsilon}{\upsilon'}$

$$X_L' = \frac{\upsilon'}{\upsilon} \times X_L = \left(\frac{100}{50}\right) \times 20\ \Omega = 40\ \Omega$$

Impedance, $Z = \sqrt{R^2 + (X_L')^2} = \sqrt{(30)^2 + (40)^2} = 50\ \Omega$

Current in the coil, $I = \frac{V}{Z} = \frac{200\ V}{50\ \Omega} = 4\ A$

28. (b) : Here,

Magnetic field, $B = 0.025$ T

Radius of the loop, $r = 2$ cm $= 2 \times 10^{-2}$ m

Constant rate at which radius of the loop shrinks,

$$\frac{dr}{dt} = 1 \times 10^{-3}\ \text{m s}^{-1}$$

Magnetic flux linked with the loop is

$$\phi = BA\cos\theta = B(\pi r^2)\cos 0° = B\pi r^2$$

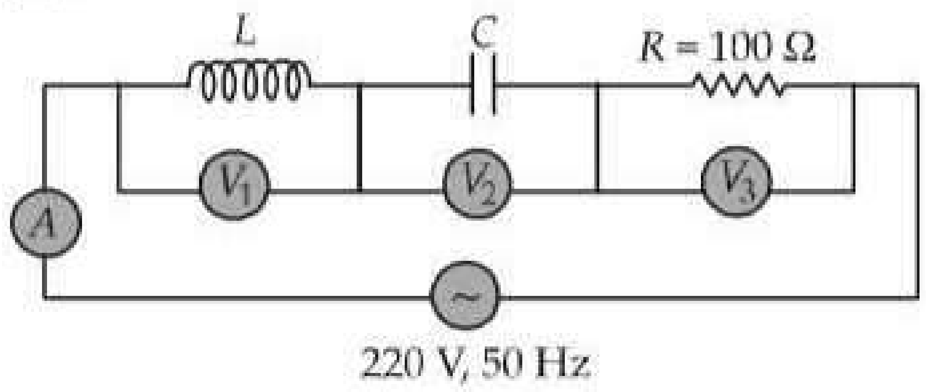
The magnitude of the induced emf is

$$|\varepsilon| = \frac{d\phi}{dt} = \frac{d}{dt}(B\pi r^2) = B\pi 2r\frac{dr}{dt}$$

$$= 0.025 \times \pi \times 2 \times 2 \times 10^{-2} \times 1 \times 10^{-3}$$

$$= \pi \times 10^{-6}\ V = \pi\ \mu V$$

29. (b) :



As $V_L = V_C = 300$ V, therefore the given series LCR circuit is in resonance.

$\therefore \quad V_R = V = 220$ V, $Z = R = 100\ \Omega$

Current, $I = \frac{V}{Z} = \frac{220\ V}{100\ \Omega} = 2.2$ A

Hence, the reading of the voltmeter V_3 is 220 V and the reading of ammeter A is 2.2 A.

30. (d) : Here, Input voltage, $V_p = 220$ V

Output voltage, $V_s = 440$ V

Input current, I_p = ?

Output current, $I_s = 2$ A

Efficiency of the transformer, $\eta = 80\%$

Efficiency of the transformer, $\eta = \frac{\text{Output power}}{\text{Input power}}$

$$\eta = \frac{V_s I_s}{V_p I_p} \quad \text{or} \quad I_p = \frac{V_s I_s}{\eta V_p} = \frac{(440\text{ V})(2\text{ A})}{\left(\frac{80}{100}\right)(220\text{ V})}$$

$$= \frac{(440\text{ V})(2\text{ A})(100)}{(80)(220\text{ V})} = 5\text{ A}$$

31. (d) : In case of oscillatory discharge of a capacitor through an inductor, charge at instant t is given by

$$q = q_0 \cos\omega t$$

where, $\omega = \frac{1}{\sqrt{LC}}$ ...(i)

$$\therefore \cos\omega t = \frac{q}{q_0} = \frac{CV_2}{CV_1} = \frac{V_2}{V_1} \quad (\because q = CV)$$

Current through the inductor

$$I = \frac{dq}{dt} = \frac{d}{dt}(q_0 \cos\omega t) = -q_0 \omega \sin\omega t$$

$$|I| = CV_1 \frac{1}{\sqrt{LC}}[1 - \cos^2\omega t]^{1/2}$$

$$= V_1\sqrt{\frac{C}{L}}\left[1 - \left(\frac{V_2}{V_1}\right)^2\right]^{1/2} = \left[\frac{C\left(V_1^2 - V_2^2\right)}{L}\right]^{1/2}$$

(using (i))

32. (a) : Once a rectangular loop or a square loop is being drawn out of the field, the rate of cutting the lines of field will be a constant for a square and rectangle, but not for circular or elliptical areas.

33. (d) : Average power, $P = E_{\text{r.m.s}} I_{\text{r.m.s}} \cos\phi$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}, \ \cos\phi = \frac{R}{Z}$$

But $I_{\text{r.m.s}} = \frac{E_{\text{r.m.s}}}{Z}$. $\therefore P = E_{\text{r.m.s}}^2 \cdot \frac{R}{Z^2}$

$$\therefore P = E_{\text{r.m.s}}^2 \frac{R}{\{R^2 + (X_L - X_C)^2\}}.$$

$$= \frac{\varepsilon^2 R}{\left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]}$$

34. (d) : Rate of decrease in the radius of the loop is 2 mm/s.

Final radius = 2 cm = 0.02 m

Initial radius = 2.2 cm = 0.022 m, $B = 0.04$ T

$$\varepsilon = -\frac{d\phi}{dt} = -B\frac{dA}{dt}$$

$\varepsilon = -\pi(0.022^2 - 0.02^2) \times 0.04 = -\pi \times 3.36 \times 10^{-6}$ V

$|\varepsilon| = \pi \times 3.36 \times 10^{-6}\text{ V} = 3.4\pi\ \mu\text{V}$

35. (a) : For a long solenoid, $B = \mu_0 ni = \mu_0 \frac{N}{l} \cdot i$

$$\text{Flux} = \mu_0 \frac{N}{l} \cdot i \cdot A$$

given flux per turn = 4×10^{-3}, $i = 2$ A

$\therefore$ Total flux = 4×10^{-3}

$$L = \left(\mu_0 \frac{N}{l} \cdot NA\right) = \frac{4 \times 10^{-3} \times 500}{2} = 1 \text{ henry}$$

36. (a) : Average power $= \frac{E_0 I_0}{2}\cos\phi$

37. (c) : $\vec{B} = \frac{1}{\pi}\left(\frac{\text{Wb}}{\text{m}^2}\right)$

Area of the disc normal to B is $\pi R^2 \cos 60°$.

Flux = B × Area normal

$$\therefore \text{Flux} = \frac{1}{2} \times 0.04 = 0.02 \text{ Wb}$$

38. (a) : Given : No. of turns across primary $N_p = 50$

Number of turns across secondary $N_s = 1500$

Magnetic flux linked with primary, $\phi = \phi_0 + 4t$

$\therefore$ Voltage across the primary,

$$V_p = \frac{d\phi}{dt} = \frac{d}{dt}(\phi_0 + 4t) = 4 \text{ volt.}$$

Also, $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$$\therefore V_s = \left(\frac{1500}{50}\right) \times 4 = 120 \text{ V}.$$

39. (b) : Given : Output power $P = 100$ W

Voltage across primary $V_p = 220$ V

Current in the primary $I_p = 0.5$ A

Efficiency of a transformer $\eta = \frac{\text{output power}}{\text{input power}} \times 100$

$$= \frac{P}{V_p I_p} \times 100 = \frac{100}{220 \times 0.5} \times 100 = 90\%.$$

40. (d) : In series LCR, current is maximum at resonance.

$\therefore$ Resonant frequency $\omega = \frac{1}{\sqrt{LC}}$

$$\therefore \omega^2 = \frac{1}{LC} \quad \text{or,} \quad L = \frac{1}{\omega^2 C}$$

Given $\omega = 1000\ \text{s}^{-1}$ and $C = 10\ \mu$F

$$\therefore L = \frac{1}{1000 \times 1000 \times 10 \times 10^{-6}} = 0.1 \text{ H} = 100 \text{ mH}.$$

41. (d) : $X_L = 31\ \Omega, X_C = 25\ \Omega, R = 8\ \Omega$

Impedence of series *LCR* is

$$Z = \sqrt{(R^2) + (X_L - X_C)^2}$$
$$= \sqrt{(8)^2 + (31-25)^2} = \sqrt{64+36} = 10\ \Omega.$$

Power factor, $\cos\phi = \frac{R}{Z} = \frac{8}{10} = 0.8$

42. (d) : Mutual inductance between coils is

$$M = K\sqrt{L_1 L_2}$$

or, $M = 1\sqrt{2\times10^{-3}\times8\times10^{-3}}$ $(\because K = 1)$

$= 4 \times 10^{-3} = 4$ mH.

43. (b) : The core of a transformer is laminated to minimise the energy losses due to eddy currents.

44. (d) : Frequency of *LC* oscillation $= \frac{1}{2\pi\sqrt{LC}}$

or, $\frac{f_1}{f_2} = \left(\frac{L_2C_2}{L_1C_1}\right)^{1/2} = \left(\frac{2L\times4C}{L\times C}\right)^{1/2} = (8)^{1/2}$

$\therefore \frac{f_1}{f_2} = 2\sqrt{2} \Rightarrow f_2 = \frac{f_1}{2\sqrt{2}}$ or, $f_2 = \frac{f}{2\sqrt{2}}$. $(\because f_1 = f)$

45. (d) : $\tan\phi = \frac{X_C - X_L}{R}$

$$\tan\left(\frac{\pi}{4}\right) = \frac{\frac{1}{\omega C} - \omega L}{R}$$

$$R = \frac{1}{\omega C} - \omega L$$

$$(R + 2\pi fL) = \frac{1}{2\pi fC} \text{ or } C = \frac{1}{2\pi f(R + 2\pi fL)}$$

46. (a) : Work done due to a charge $W = QV$

47. (a) : Time constant of *LR* circuit is $\tau = L/R$.

$\therefore \tau = 5$ sec.

48. (b) : Induced emf is given by $\Rightarrow V = \frac{\Delta\phi}{\Delta t}$

$\Rightarrow \text{current}(i) = \frac{Q}{\Delta t} = \frac{\Delta\phi}{\Delta t} \times \frac{1}{R}$

[where Q is total charge in time Δt]

$\Rightarrow Q = \frac{\Delta\phi}{R}$

49. (c) : The impedence Z of a series *LCR* circuit is given by, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

where $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$, ω is angular frequency.

At resonance, $X_L = X_C$, hence $Z = R$.

$\therefore V_R = V$ (supply voltage)

$\therefore$ R.M.S. current, $I = \frac{V_R}{R} = \frac{V}{R}$

$\therefore$ Power loss $= I^2R = V^2/R$.

50. (a) : $I = t^2e^{-t}$

$|\varepsilon| = L\frac{dI}{dt}$ here emf is zero when $\frac{dI}{dt} = 0$

$\frac{dI}{dt} = 2te^{-t} - t^2e^{-t} = 0$; $2te^{-t} = t^2e^{-t}$

i.e. $te^{-t}(t-2) = 0 \Rightarrow t \neq \infty$ $t \neq 0$, $t = 2$ sec.

51. (c) : $X = \frac{1}{C\omega}$ $X' = \frac{1}{4C\omega}$ $\therefore X' = \frac{X}{4}$

52. (a, b) : Quality factor $Q = \frac{\omega L}{R}$

Since $\omega^2 = \frac{1}{LC}$

$\therefore$ Quality factor $Q = \frac{1}{\omega RC}$

53. (d) : At $t = 0$

(i) capacitor offers negligible resistance.

(ii) inductor offers large resistance to current flow.

54. (b) : $\frac{E_P}{E_S} = \frac{N_P}{N_S} = \frac{1}{25}$; $E_S = 5750$ V

$I_S = 2$ amp, $P_S = 2 \times 5750$

$$I_P = \frac{P_P}{V_P} = \frac{P_S}{V_P} = \frac{2\times5750}{230} = 50\text{ A}.$$

55. (b) : As

$$|\varepsilon| = M\frac{dI}{dt} = M\frac{d}{dt}(I_0\sin\omega t) = MI_0\omega\cos\omega t$$

$\therefore \varepsilon_{max} = 0.005 \times 10 \times 100\pi \times 1 = 5\pi$.

56. (c) : Turns on primary winding = 500; Turns on secondary winding = 5000; Primary winding voltage (E_p) = 20 V and frequency = 50 Hz.

$$\frac{N_s}{N_p} = \frac{E_s}{E_p} \text{ or } \frac{5000}{500} = \frac{E_s}{20}$$

or $E_s = \frac{5000\times20}{500} = 200$ V and frequency remains the same. Therefore secondary winding will have an output of 200 V, 50 Hz.

57. (b) : The dissipation of power in an a.c. circuit is $(P) = V \times I \times \cos\theta$. Therefore current flowing in the circuit depends upon the phase voltage (V) and current (I) of the a.c. circuit.

58. (c) : When the magnet is dropped through the ring an induced current is developed into the ring in the direction opposing the motion of magnet (Lenz's law). Therefore this induced current decreases the acceleration of bar magnet.

59. (b) : Current (I) = 5 sin $(100t - \pi/2)$ and voltage (V) = 200 sin (100 t). Comparing the given equation, with the standard equation, we find that between current and voltage is $\phi = \frac{\pi}{2} = 90^\circ$.

Power consumption $P = I_{rms}V_{rms}\cos\phi$

$$= I_{rms}V_{rms}\cos 90^\circ = 0$$

60. (b) : Initially, the current will pass through the capacitor (and not through the resistance which is parallel to capacitor). So effective resistance in the circuit is R_{AB}. Therefore the current in the resistor is 2 mA. After some time, the capacitor will become fully charged and will be in its steady state. Now no current will pass through the capacitor and the effective resistance of the circuit will be (1000 + 1000) = 2000 Ω. Therefore current in the resistor

$$= \frac{V}{R} = \frac{2}{2000} = 1 \times 10^{-3}\text{ A} = 1\text{ mA}.$$

61. (d) : Length of conductor (l) = 0.4 m;
Speed = 7 m/s and magnetic field (B) = 0.9 Wb/m^2.
Induced e.m.f. (ε) = $Blv = 0.9 \times 0.4 \times 7 = 2.52$ V.

62. (a) : In an A.C. circuit with inductance coil, the voltage V leads the current I by a phase difference of 90°. Or the current I lags behind the voltage V by a phase difference of 90°. Thus the voltage goes on decreasing with the increase in time as shown in the graph (a).

63. (d) : $I_{rms} = \frac{I_0}{\sqrt{2}}$

64. (b) : For resonance condition, the impedance will be minimum and the current be maximum. This is only possible when $X_L = X_C$.

Therefore $\tan\theta = \frac{X_L + X_C}{R} = 0$ or $\theta = 0$.

65. (a) : The major portion of the A.C. flows on the surface of the wire. So where a thick wire is required, a number of thin wires are joined together to give an equivalent effect of a thick wire. Therefore multiple strands are suitable for transporting A.C. Similarly multiple strands can also be used for D.C.

66. (c) : $L = \frac{N\phi}{i}; \phi = BA; B = \mu_0 ni = \frac{\mu_0 Ni}{l}$

$$L = \frac{\mu_0 N^2}{l}A = \mu_0 n^2\, A\, l$$

where n is the number of turns/unit length $L \propto N^2$

67. (b) : $\varepsilon = -L\frac{di}{dt}$

$$L = \frac{-\varepsilon}{\frac{di}{dt}} = \frac{-5\times10^{-3}}{(2-3)}\text{H} = 5\text{ mH}$$

68. (c) : The time constant for resonance circuit, $\tau = CR$

Growth of charge in a circuit containing capacitance and resistance is given by the formula, $q = q_0(1 - e^{-t/CR})$

CR is known as time constant in this formula.

69. (c) : $q = \int i dt = \frac{1}{R}\int \varepsilon dt = \left(\frac{-d\phi}{dt}\right)\frac{1}{R}\int dt = \frac{1}{R}\int d\phi$

Hence total charge induced in the conducting loop depend upon the total change in magnetic flux.
As the emf or iR depends on rate of change of ϕ, charge induced depends on change of flux.

70. (c) : $i = \frac{\varepsilon}{R} = \frac{\frac{NAdB}{dt}}{R}$

$$= \frac{20\times(25\times10^{-4})\times1000}{100} = 0.5\text{ A}$$

71. (d) : According to Faraday's laws, it is the conservation of energy.

72. (d) : Self inductance of a solenoid = $\mu_0 n^2 Al$
where n is the number of turns/length.
So self induction $\propto n^2$
So inductance becomes 4 times when n is doubled.

73. (c) : $E = \frac{1}{2}Li^2 = \frac{1}{2}\times(100\times10^{-3})\times1^2 = 0.05$ J

74. (b) : $\varepsilon = \frac{-(\phi_2 - \phi_1)}{t} = \frac{-(0 - NBA)}{t} = \frac{NBA}{t}$

$$t = \frac{NBA}{\varepsilon} = \frac{50\times2\times10^{-2}\times10^{-2}}{0.1} = 0.1\text{ s}$$

75. (a) : $|\varepsilon| = L\frac{di}{dt}$

Given that, $L = 40 \times 10^{-3}$ H,
$di = 11\text{ A} - 1\text{ A} = 10$ A
and $dt = 4 \times 10^{-3}$ s

$$\therefore |\varepsilon| = 40\times10^{-3}\times\left(\frac{10}{4\times10^{-3}}\right) = 100\text{ V}$$

76. (c)

77. (c) : $I_0 = \frac{E_0}{R} = N\frac{BA\omega}{R}$

Given, $N = 1, B = 10^{-2}$ T,
$A = \pi(0.3)^2$ m^2, $R = \pi^2$
$f = (200/60)$ and $\omega = 2\pi(200/60)$
Substituting these values and solving, we get
$I_0 = 6 \times 10^{-3}$ A = 6 mA

78. (a) : Eddy currents are produced when a metal is kept in a varying magnetic field.