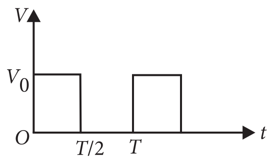
CHAPTER 7

Alternating Current

7.2 AC Voltage Applied to a Resistor

1. 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)*

2. 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)*

3. 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)*

7.4 AC Voltage Applied to an Inductor

4. A coil of self-inductance L is connected in series with a bulb B and an AC source. Brightness of the bulb decreases when

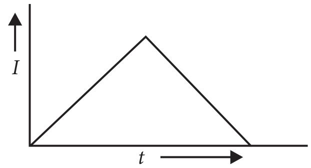
(a) a capacitance of reactance $X_C = X_L$ is included in the same circuit.

(b) an iron rod is inserted in the coil.

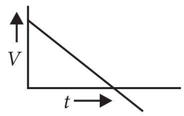
(c) frequency of the AC source is decreased.

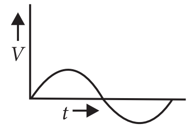
(d) number of turns in the coil is reduced. *(NEET 2013)*

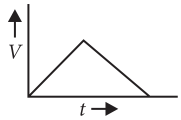
5. The current I in an A.C. circuit with inductance coil varies with time according to the graph given below.

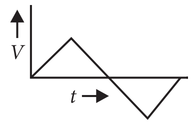


Which one of the following graphs gives the variation of voltage with time?

(a)


(b)


(c)


(d)


(1994)

7.5 AC Voltage Applied to a Capacitor

6. A 40 μF capacitor is connected to a 200 V, 50 Hz ac supply. The r.m.s value of the current in the circuit is, nearly

(a) 1.7 A (b) 2.05 A

(c) 2.5 A (d) 25.1 A *(NEET 2020)*

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. In an ac circuit an alternating voltage $200\sqrt{2}\sin 100\,t$ 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)*

9. 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)*

7.6 AC Voltage Applied to a Series LCR Circuit

10. A series *LCR* circuit is connected to an ac voltage source. When *L* is removed from the circuit, the phase difference between current and voltage is $\pi/3$. If instead *C* is removed from the circuit, the phase difference is again $\pi/3$ between current and voltage. The power factor of the circuit is
(a) zero (b) 0.5
(c) 1.0 (d) −1.0 *(NEET 2020)*

11. A circuit when connected to an AC source of 12 V gives a current of 0.2 A. The same circuit when connected to a DC source of 12 V, gives a current of 0.4 A. The circuit is
(a) series *LR* (b) series *RC*
(c) series *LC* (d) series *LCR*
(Odisha NEET 2019)

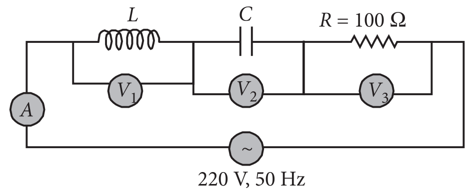
12. Which of the following combinations should be selected for better tuning of an *L-C-R* circuit used for communication ?
(a) $R = 20\ \Omega$, $L = 1.5$ H, $C = 35\ \mu$F
(b) $R = 25\ \Omega$, $L = 2.5$ H, $C = 45\ \mu$F
(c) $R = 15\ \Omega$, $L = 3.5$ H, $C = 30\ \mu$F
(d) $R = 25\ \Omega$, $L =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

13. A series *R-C* circuit is connected to an alternating voltage source. Consider two situations :
(i) When capacitor is air filled.
(ii) 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)*

14. 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) $\pi/6$ (b) $\pi/4$
(c) $\pi/2$ (d) zero *(2011)*

15. 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)*

16. 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)*

17. 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)*

18. 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)*

19. The value of quality factor is
(a) $\frac{\omega L}{R}$ (b) $\frac{1}{\omega RC}$ (c) $\sqrt{LC}$ (d) L/R
(2000)

20. 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)

7.7 Power in AC Circuit : The Power Factor

21. An inductor 20 mH, a capacitor 100 μF and a resistor 50 Ω are connected in series across a source of emf, $V = 10 \sin 314t$. The power loss in the circuit is
(a) 0.79 W (b) 0.43 W
(c) 2.74 W (d) 1.13 W *(NEET 2018)*

22. 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)

23. 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)*

24. 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 $\pi/3$. If instead, C is removed from the circuit, the phase difference is again $\pi/3$. The power factor of the circuit is

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

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

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

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

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)*

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

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

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

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

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

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

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

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)*

28. 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)*

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

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

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

30. 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)*

31. 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)*

7.8 LC Oscillations

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

(c) $\dfrac{C(V_1^2+V_2^2)}{L}$ (d) $\left(\dfrac{C(V_1^2-V_2^2)}{L}\right)^{\frac{1}{2}}$ *(Mains 2010)*

33. A transistor-oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produces 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)*

7.9 Transformers

34. 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)*

35. 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 circuit 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)*

36. 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)*

37. 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)*

38. 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)*

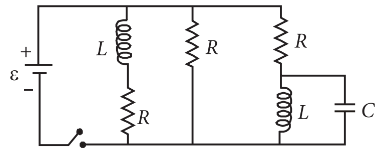
39. The core of a transformer is laminated because
(a) ratio of voltage in primary and secondary may be increased
(b) energy losses due to eddy currents may be minimised
(c) the weight of the transformer may be reduced
(d) rusting of the core may be prevented. *(2006)*

40. 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)*

41. The primary winding of a transformer has 500 turns whereas its secondary has 5000 turns. The primary is connected to an A.C. supply of 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)*

7.A RC/RL Circuits with DC Source

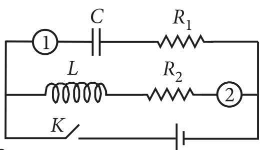
42. Figure shows a circuit that contains three identical resistors with resistance $R = 9.0\ \Omega$ each, two identical inductors with inductance $L = 2.0$ mH each, and an ideal battery with emf $\varepsilon = 18$ V. The current i through the battery just after the switch closed is



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

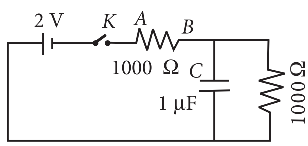
43. A coil of 40 henry inductance is connected in series with a resistance of 8 ohm and the combination is joined to the terminals of a 2 volt battery. The time constant of the circuit is
(a) 5 seconds (b) 1/5 seconds
(c) 40 seconds (d) 20 seconds *(2004)*

44. 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)*

45. 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)*

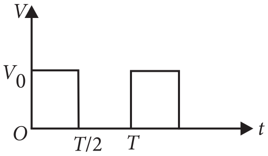
46. The time constant of C-R circuit is
(a) $1/CR$ (b) C/R
(c) CR (d) R/C *(1992)*

ANSWER KEY

1.	(c)	**2.**	(d)	**3.**	(a)	**4.**	(b)	**5.**	(a)	**6.**	(c)	**7.**	(d)	**8.**	(d)	**9.**	(c)	**10.**	(c)
11.	(a)	**12.**	(c)	**13.**	(d)	**14.**	(b)	**15.**	(b)	**16.**	(b)	**17.**	(d)	**18.**	(d)	**19.**	(a,b)	**20.**	(b)
21.	(a)	**22.**	(c)	**23.**	(c)	**24.**	(c)	**25.**	(d)	**26.**	(d)	**27.**	(a)	**28.**	(d)	**29.**	(c)	**30.**	(b)
31.	(b)	**32.**	(d)	**33.**	(d)	**34.**	(b)	**35.**	(c)	**36.**	(d)	**37.**	(a)	**38.**	(b)	**39.**	(b)	**40.**	(b)
41.	(c)	**42.**	(*)	**43.**	(a)	**44.**	(d)	**45.**	(b)	**46.**	(c)								

Hints & Explanations

1. (c) :



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

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

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

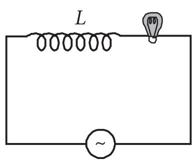
$$= \left[\frac{V_0^2}{T}[t]_0^{T/2}\right]^{1/2} = \left[\frac{V_0^2}{T}\left(\frac{T}{2}\right)\right]^{1/2} = \left[\frac{V_0^2}{2}\right]^{1/2}$$

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

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

3. (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.

4. (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.

5. (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).

6. (c) : Here, $C = 40\mu F = 40 \times 10^{-6}$ F

$V_{rms} = 200$ V; $\upsilon = 50$ Hz

The value of the current, $I_{rms} = \dfrac{\varepsilon_{rms}}{\dfrac{1}{\omega C}} = \varepsilon_{rms}\omega C$

or $I_{rms} = 200\ (2\pi \times 50) \times (40 \times 10^{-6}) = 2.51$ A

$(\because \omega = 2\pi\upsilon)$

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

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

The standard equation of alternating voltage is

$e = e_0 \sin\omega t$ ...(ii)

Comparing (i) and (ii), we get

$e_0 = 200\sqrt{2}$ V, $\omega = 100$ 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

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

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

9. (c) : $X = \dfrac{1}{C\omega}$ and $X' = \dfrac{1}{4C\omega}$ $\quad\therefore\ X' = \dfrac{X}{4}$

10. (c) : When L is removed

$\tan\phi = \dfrac{|X_C|}{R} \Rightarrow \tan\dfrac{\pi}{3} = \dfrac{X_C}{R}$ ...(i)

When C is removed,

$\tan\phi = \dfrac{|X_L|}{R} \Rightarrow \tan\dfrac{\pi}{3} = \dfrac{X_L}{R}$ ...(ii)

From (i) and (ii), $X_C = X_L$.

Since, $X_L = X_C$, the circuit is in resonance.

$Z = R$

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

11. (a) : When circuit is connected to an AC source of 12 V, gives a current of 0.2 A.

$\therefore$ Impedance, $Z = \dfrac{12}{0.2} = 60\ \Omega$

When the same circuit is connected to a DC source of 12 V, gives a current of 0.4 A.

$\therefore$ Resistance, $R = \dfrac{12}{0.4} = 30\ \Omega$

As, power factor, $\cos\phi = \frac{R}{Z} = \frac{30}{60} = \frac{1}{2} = \cos 60°$

$\Rightarrow$ $\phi = 60°$, *i.e.*, current lags behind the emf.
So, we can conclude that the circuit is a series *LR*.

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

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

$$Q_1 = \frac{1}{20}\sqrt{\frac{1.5}{35\times10^{-6}}} = 50\times\sqrt{\frac{3}{70}} = 10.35$$

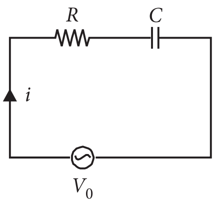
$$Q_2 = \frac{1}{25}\times\sqrt{\frac{2.5}{45\times10^{-6}}} = 40\times\sqrt{\frac{5}{90}} = 9.43$$

$$Q_3 = \frac{1}{15}\sqrt{\frac{3.5}{30\times10^{-6}}} = \frac{100}{15}\sqrt{\frac{35}{3}} = 22.77$$

$$Q_4 = \frac{1}{25}\times\sqrt{\frac{1.5}{45\times10^{-6}}} = \frac{40}{\sqrt{30}} = 7.30$$

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.

13. (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 $C_a < C_b$

$\therefore$ $i_a < i_b$ and $V_a > V_b$

14. (b) : Here, $R = 3\ \Omega$, $X_L = 3\ \Omega$
The phase difference between the applied voltage and the current in the circuit is

$$\tan\phi = \frac{X_L}{R} = \frac{3\ \Omega}{3\ \Omega} = 1 \quad \text{or} \quad \phi = \tan^{-1}(1) = \frac{\pi}{4}$$

15. (b) : Here, Resistance, $R = 30\ \Omega$
Inductive reactance, $X_L = 20\ \Omega$ at 50 Hz

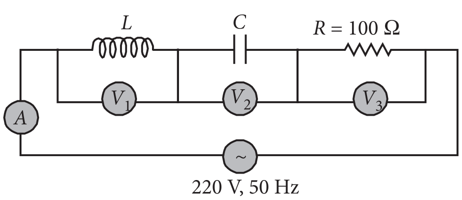
$\because$ $X_L = 2\pi\upsilon L$

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

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

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

16. (b) :



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

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

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

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

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

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

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

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

$\therefore$ $L = \frac{1}{1000\times1000\times10\times10^{-6}} = 0.1\ \text{H} = 100\ \text{mH}$

18. (d) : $\tan\phi = \frac{X_C - X_L}{R}$ or $\tan\left(\frac{\pi}{4}\right) = \frac{\frac{1}{\omega C} - \omega L}{R}$

$R = \frac{1}{\omega C} - \omega L$ or $(R + 2\pi f L) = \frac{1}{2\pi f C}$ or $C = \frac{1}{2\pi f(R + 2\pi f L)}$

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

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

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

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

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

21. (a) : Impedance *Z* in an ac circuit is

$Z = \sqrt{R^2 + (X_C - X_L)^2}$; where X_C = capacitive reactance and X_L = inductive reactance.

Also $X_C = \frac{1}{\omega C}$ and $X_L = \omega L$

$$\therefore\ Z = \sqrt{(50)^2 + \left(\frac{1}{314\times100\times10^{-6}} - 314\times20\times10^{-3}\right)^2}$$

or $Z = 56\ \Omega$

The power loss in the circuit is $P_{av} = \left(\frac{V_{rms}}{Z}\right)^2 R$

$\therefore$ $P_{av} = \left(\frac{10}{(\sqrt{2})56}\right)^2 \times 50 = 0.79$ W

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

Power factor, $\cos\phi = \frac{R}{Z} = \frac{V_R}{V} = \frac{V_R}{\sqrt{V_R^2 + (V_L - V_C)^2}}$

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

23. (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,

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

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

24. (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

$$\tan\phi_2 = \frac{X_L}{R} \text{ or } \tan\frac{\pi}{3} = \frac{X_L}{R} \text{ or } X_L = R\tan 60° = \sqrt{3}R$$

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

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

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

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

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

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

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

Compare it with $e = e_0\sin(\omega t + \phi)$, we get

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

$$\therefore\ i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{1}{2}\ \text{A and } e_{rms} = \frac{e_0}{\sqrt{2}} = \frac{1}{2}\ \text{V}$$

Average power consumed in the circuit,
$P = i_{rms}\, e_{rms} \cos\phi$

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

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

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

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

$$\therefore\ P = E_{r.m.s}^2 \frac{R}{\{R^2 + (X_L - X_C)^2\}} = \frac{\varepsilon^2 R}{\left[R^2 + \left(L\omega - \frac{1}{C\omega}\right)^2\right]}$$

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

28. (d) : $X_L = 31\ \Omega$, $X_C = 25\ \Omega$, $R = 8\ \Omega$
Impedance of series LCR is

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

$$= \sqrt{(8)^2 + (31 - 25)^2} = \sqrt{64 + 36} = 10\ \Omega$$

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

29. (c) : The impedance 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)

$$\therefore \text{ r.m.s. current, } I = \frac{V_R}{R} = \frac{V}{R}$$

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

30. (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 angle between voltage (V) and current (I) of the a.c. circuit.

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

Power consumption $P = I_{rms}V_{rms}\cos\phi = I_{rms}V_{rms}\cos 90° = 0$

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

$$q = q_0\cos\omega t;\ \text{where, } \omega = \frac{1}{\sqrt{LC}}$$

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

Current through the inductor

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

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

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

33. (d) : Frequency of LC oscillation $= \dfrac{1}{2\pi\sqrt{LC}}$

or, $\dfrac{f_1}{f_2} = \left(\dfrac{L_2C_2}{L_1C_1}\right)^{1/2} = \left(\dfrac{2L \times 4C}{L \times C}\right)^{1/2} = (8)^{1/2}$

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

34. (b) : Here, Efficiency of the transformer, $\eta = 90\%$
Input power, $P_{in} = 3$ 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 $P_{in} = I_p V_p$
$\therefore$ Current in the primary coil,

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

Efficiency of the transformer,

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

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

35. (c) : Transformer cannot work on dc.
$\therefore$ $V_s = 0$ and $I_s = 0$

36. (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, $\eta = \dfrac{\text{Output power}}{\text{Input power}}$

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

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

37. (a) : 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,

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

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \text{ or } V_s = \left(\frac{1500}{50}\right) \times 4 = 120\text{ V}$$

38. (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

$$\eta = \frac{\text{output power}}{\text{input power}} \times 100$$

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

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

40. (b) : $\dfrac{E_P}{E_S} = \dfrac{I_S}{I_P} = \dfrac{N_P}{N_S} = \dfrac{1}{25}$;
Here, $I_S = 2$ A
$I_P = 25 I_S = 50$ A

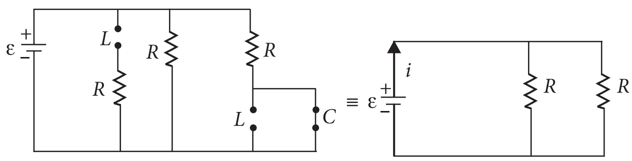
41. (c) : Turns on primary winding = 500; Turns on secondary winding = 5000; Primary winding voltage (E_p) = 20 V and frequency = 50 Hz.

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

or $E_s = \dfrac{5000 \times 20}{500} = 200$ V

and frequency remains the same. Therefore secondary winding will have an output of 200 V, 50 Hz.

42. (*) : 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.

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

$$\therefore \tau = \frac{40}{8} = 5\text{ s}$$

44. (d) : At $t = 0$
(i) capacitor offers negligible resistance.
(ii) inductor offers large resistance to current flow.

45. (b) : Initially, the current will pass through the capacitor (and not through the resistance which is parallel to the 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 that is
(1000 + 1000) = 2000 Ω.
Therefore final current in the resistor

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

46. (c) : The time constant for R–C. 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.

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