Chapter 21

Alternating Current

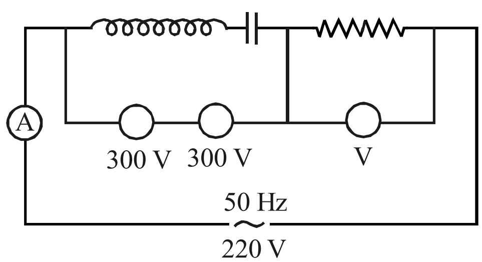
TYPE A : MULTIPLE CHOICE QUESTIONS

1. An A.C. circuit containing only capacitance, the current : ***[1997]***
(a) lags the voltage by 90°
(b) leads the voltage by 90°
(c) remains in phase with voltage
(d) leads the voltage in 180°

2. A choke coil has: ***[1999]***
(a) Low inductance and low resistance
(b) High inductance and high resistance
(c) Low inductance and high resistance
(d) High inductance and low resistance

3. Turn ratio in a step up transformer is 1 : 2 if a Lechlanche cell of 1.5 V is connected across the input, then the voltage across the output will be
(a) 0.1 V (b) 1.5 V ***[2000]***
(c) 0.75 V (d) zero

4. In the circuit shown below what will be the reading of the voltmeter and ammeter ? ***[2000]***
(Total impedance of circuit Z = 100Ω)



(a) 200 V, 1A (b) 800 V, 2A
(c) 100 V, 2A (d) 220 V, 2.2 A

5. In a circuit the coil of a choke : ***[2001]***
(a) decreases the current
(b) increases the current
(c) has high resistance to D. C. circuit
(d) no effect with the current

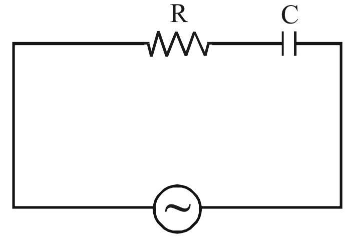
6. In a circuit, the current lags behind the voltage by a phase difference of $\pi/2$, the circuit will contain which of the following : ***[2001]***
(a) only R (b) only C
(c) R and C (d) only L

7. The coefficient of mutual inductance, when magnetic flux changes by 2×10^{-2} Wb and current changes by 0.01 A is ***[2002]***
(a) 8 henry (b) 4 henry
(c) 3 henry (d) 2 henry

8. In an ideal parallel LC circuit, the capacitor is charged by connecting it to a D.C. source which is then disconnected. The current in the circuit
(a) becomes zero instantaneously ***[2003]***
(b) grows monotonically
(c) decays monotonically
(d) oscillates instantaneously

9. A capacitor of capacitance 2μF is connected in the tank circuit of an oscillator oscillating with a frequency of 1 kHz. If the current flowing in the circuit is 2 m A, the voltage across the capacitor will be : ***[2003]***
(a) 0.16 V (b) 0.32 V
(c) 79.5 V (d) 159 V

10. A 50 Hz a.c. source of 20 volt is connected across R and C as shown in figure. The voltage across R is 12 volt. The voltage across C is : ***[2004]***



(a) 8 V
(b) 16 V
(c) 10 V
(d) not possible to determine unless values of R and C are given

11. In an AC circuit the potential differences across an inductance and resistance joined in series are respectively 16 V and 20 V. The total potential difference of the source is ***[2007]***
(a) 20.0 V (b) 25.6 V
(c) 31.9 V (d) 53.5 V

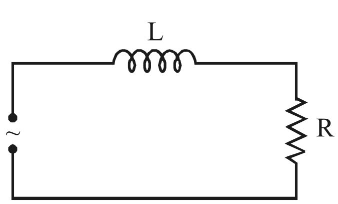
12. With the decrease of current in the primary coil from 2 amperes to zero value in 0.01s the emf generated in the secondary coil is 1000 volts. The mutual inductance of the two coils is
(a) 1.25 H (b) 2.50 H ***[2007]***
(c) 5.00 H (d) 10.00 H

13. An AC source of angular frequency ω is fed across a resistor R and a capacitor C in series. The current registered is I. If now the frequency of source is changed to ω/3 (but maintaining the same voltage), the current in the circuit is found to be halved. Calculate the ratio of reactance to resistance at the original frequency ω ***[2008]***
(a) $\sqrt{\frac{3}{5}}$ (b) $\sqrt{\frac{2}{5}}$
(c) $\sqrt{\frac{1}{5}}$ (d) $\sqrt{\frac{4}{5}}$

14. If an AC main supply is given to be 220 V. The average emf during a positive half cycle will be
(a) 198 V (b) 220 V ***[2009]***
(c) 240 V (d) $220\sqrt{2}$ V

15. A coil has an inductance of 0.7 henry and is joined in series with a resistance of 220 Ω. When the alternating emf of 220 V at 50 Hz is applied to it then the phase through which current lags behind the applied emf and the wattless component of current in the circuit will be respectively ***[2010]***
(a) 30°, 1 A (b) 45°, 0.5 A
(c) 60°, 1.5 A (d) none of these

16. An inductor and a resistor in series are connected to an A.C. supply of variable frequency. As the frequency of the source is increased, the phase angle between current and the potential difference across L will: ***[2010]***



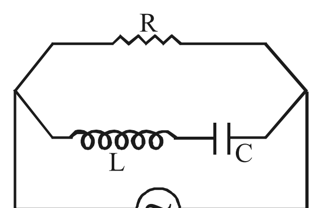
(a) first increase and then decrease
(b) first decrease and then increase
(c) go on decreasing
(d) go on increasing

17. In a AC circuit the voltage and current are described by $V = 200\sin\left(319t - \frac{\pi}{6}\right)$ volts ***[2010]***
and $i = 50\sin\left(314t + \frac{\pi}{6}\right)$ mA
respectively. The average power dissipated in the circuit is : ***[2011]***
(a) 2.5 watts (b) 5.0 watts
(c) 10.0 watts (d) 50.0 watts

18. If we decrease the frequency of the applied A.C. with a purely capacitive load, do (1) the amplitude of V_c and (2) amplitude of I_c increase, decrease of remain the same. ***[2011]***
(a) (1) increase (2) same
(b) (1) same (2) increase
(c) (1) same (2) decrease
(d) (1) decrease (2) same

19. An inductor coil of inductance L is cut into two equal parts and both the parts are connected in parallel. The net inductance is : ***[2011]***
(a) L (b) L/2
(c) L/4 (d) 2 L.

20. The current in resistance R at resonance is



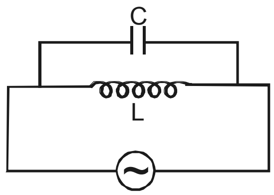
$V = V_0 \sin \omega t$

(a) zero ***[2012]***
(b) minimum but finite
(c) maximum but finite
(d) infinite

21. An inductance L having a resistance R is connected to an alternating source of angular frequency ω. The Quality factor Q of inductance is ***[2012]***
(a) R/ωL (b) $(\omega L/R)^2$
(c) $(R/\omega L)^{1/2}$ (d) ωL/R

22. In an A.C. circuit, the current flowing in inductance is I = 5 sin (100 t – π/2) amperes and the potential difference is V = 200 sin (100 t) volts. The power consumption is equal to ***[2013]***
(a) 1000 watt (b) 40 watt
(c) 20 watt (d) zero

23. For the circuit shown in the fig., the current through the inductor is 0.9 A while the current through the condenser is 0.4 A. Then ***(2013)***



$V = V_0 \sin \omega t$

(a) current drawn from generator I = 1.13 A
(b) $\omega = 1/(1.5\,LC)$
(c) I = 0.5 A
(d) I = 0.6 A

24. L, C, R represent physical quantities inductance, capacitance and resistance respectively. The combinations which have the dimensions of frequency are ***[2013]***

(a) 1/RC (b) R/L
(c) $1/\sqrt{LC}$ (d) C/L

25. An inductance L having a resistance R is connected to an alternating source of angular frequency ω. The Quality factor Q of inductance is ***[2014]***

(a) $R/\omega L$ (b) $(\omega L/R)^2$
(c) $(R/\omega L)^{1/2}$ (d) $\omega L/R$

26. A step down transformer is connected to 2400 volts line and 80 amperes of current is found to flow in output load. The ratio of the turns in primary and secondary coil is 20 : 1. If transformer efficiency is 100%, then the current flowing in the primary coil will be ***[2015]***

(a) 1600 amp (b) 20 amp
(c) 4 amp (d) 1.5 amp

27. The mutual inductance of a pair of coils, each of N turns, is M henry. If a current of I ampere in one of the coils is brought to zero in t second, the emf induced per turn in the other coil, in volt, will be ***[2015]***

(a) $\frac{MI}{t}$ (b) $\frac{NMI}{t}$
(c) $\frac{MN}{It}$ (d) $\frac{MI}{Nt}$

28. The tuning circuit of a radio receiver has a resistance of 50Ω, an inductor of 10 mH and a variable capacitor. A 1 MHz radio wave produces a potential difference of 0.1 mV. The values of the capacitor to produce resonance is (Take $\pi^2 = 10$) ***[2015]***

(a) 2.5 pF (b) 5.0 pF
(c) 25 pF (d) 50 pF

29. 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 ***[2016]***

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

30. An ideal coil of 10H is connected in series with a resistance of 5Ω and a battery of 5V. After 2 sec the connection is made, the current flowing in ampere in the circuit is ***[2016]***

(a) $(1 - e^{-1})$ (b) $(1 - e)$
(c) e (d) e^{-1}

31. An inductor, a resistor and a capacitor are joined in series with an AC source. As the frequency of the source is slightly increased from a very low value, the reactance of the ***[2017]***

(a) inductor increases
(b) resistor increases
(c) capacitor increases
(d) circuit increases

TYPE B : ASSERTION REASON QUESTIONS

Directions for (Qs. 32-34) : These questions consist of two statements, each printed as Assertion and Reason. While answering these questions, you are required to choose any one of the following five responses.

(a) If both Assertion and Reason are correct and the Reason is a correct explanation of the Assertion.
(b) If both Assertion and Reason are correct but Reason is not a correct explanation of the Assertion.
(c) If the Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.
(e) If the Assertion is incorrect but the Reason is correct.

32. **Assertion :** In series LCR circuit resonance can take place.
Reason : Resonance takes place if inductance and capacitive reactances are equal and opposite. ***[1998]***

33. **Assertion :** Faraday's laws are consequences of conservation of energy.

Reason : In a purely resistive A.C. circuit, the current lags behind the e.m.f. in phase. ***[2002]***

34. **Assertion :** No power loss associated with pure capacitor in ac circuit.

Reason : No current is flowing in this circuit. ***[2007]***

Directions for (Qs. 35-41) : Each of these questions contains an Assertion followed by Reason. Read them carefully and answer the question on the basis of following options. You have to select the one that best describes the two statements.

(a) If both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) If both Assertion and Reason are correct, but Reason is not the correct explanation of Assertion.
(c) If Assertion is correct but Reason is incorrect.
(d) If both the Assertion and Reason are incorrect.

35. **Assertion :** Ohm's law cannot be applied to a.c circuit.

Reason : Resistance offered by capacitor for a.c source depends upon the frequency of the source. ***[2009]***

36. **Assertion :** The resistance offered by an inductor in a d.c circuit is always constant.

Reason : The resistance of inductor in steady state is non-zero. ***[2010]***

37. **Assertion :** Long distance power transmission is done at high voltage.

Reason : At high voltage supply power losses are less. ***[2011, 2013]***

38. **Assertion :** A capacitor blocks direct current in the steady state.

Reason : The capacitive reactance of the capacitor is inversely proportional to frequency f of the source of emf. ***[2011]***

39. **Assertion :** In the purely resistive element of a series LCR, AC circuit the maximum value of rms current increases with increase in the angular frequency of the applied e.m.f.

Reason :

$$I_{max} = \frac{\varepsilon_{max}}{z},\ z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}\ ,$$

where I_{max} is the peak current in a cycle. ***[2012]***

40. **Assertion :** In the purely resistive element of a series LCR, AC circuit the maximum value of rms current increases with increase in the angular frequency of the applied emf.

Reason :

$$I_{max} = \frac{\varepsilon_{max}}{z},\ z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}\ ,$$

where I_{max} is the peak current in a cycle. ***[2016]***

41. **Assertion :** A laminated core is used in transformers to increase eddy currents.

Reason : The efficiency of a transformer increases with increase in eddy currents. ***[2017]***

HINTS & SOLUTIONS

Type A : Multiple Choice Questions

1. **(b)** In an a.c. circuit containing resistance only voltage & current remain in the same phase. If circuit contains inductance only, voltage remains ahead of current by phase difference of 90°.

   If circuit contains capacitance only, current remains ahead of voltage by a phase difference of 90°.

2. **(d)** A choke coil has high inductance and low resistance so, it is capable of producing very high induced e.m.f. which produces discharge in the tube.

3. **(d)** A transformer can not step up a d.c. input so output potential here will be zero. No potential will be induced in the secondary coil.

4. **(d)** Total impedence of the circuit = 100Ω

   $\text{Current} = \frac{220}{100} = 2.2\,\text{A}$

   Potential drop over inductance and capacitance is 300 V. As they are in opposite phase they will sum up to zero. So whole of 220 volt (external source) will come over the resistance.

   $(V_L - V_C)^2 + {V_R}^2 = (220)^2$

   As $V_L = V_C$ so $V_R = 220\,\text{volt}$

5. **(a)** In a circuit with a.c. source, choke coil which is essentially an inductor with high reactance, is used to decrease the current without loss of energy. No heat is generated so no loss of energy. When we use resistance to reduce current, there is loss of electrical energy in the form of heat generated.

6. **(d)** If a circuit contains L, voltage leads current by a phase angle of $\frac{\pi}{2}$.

7. **(d)** We know that

   $\phi = Mi$

   $d\phi = Mdi$

   $M = \frac{d\phi}{di} = \frac{2\times10^{-2}}{1\times10^{-2}} = 2 \text{ henry}$

8. **(d)** In an LC circuit current oscillates between maximum and minimum value. So, LC circuit needs oscillations (electrical). It occurs due to discharging and charging of capacitor and magnetisation and demagnetisation of inductor.

9. **(a)** Here, oscillating frequency $= 1\text{ kHz} = 10^3\text{ Hz}$

   Reactance of capacitor $= \frac{1}{\omega C}$

   $= \frac{1}{2\pi\times10^3\times2\times10^{-6}} = \frac{10^3}{4\pi}$

   Potential over capacitance

   $\frac{1}{\omega C}\times i = \frac{10^3}{4\pi}\times2\times10^{-3} = \frac{2}{4\pi} = \frac{7}{44} = 0.16\text{ V}$

10. **(b)** $E^2 = {V_R}^2 + \left(\frac{1}{\omega C}\right)^2 = {V_R}^2 + {V_C}^2$

    [Phase difference between V_R & V_C is 90°]

    $(20)^2 = (12)^2 + {V_C}^2$

    $\Rightarrow {V_C}^2 = 400 - 144 = 256$

    $\Rightarrow V_C = 16$

11. **(b)** In any ac (LR) circuit, total potential is given by $V = \sqrt{V_R^2 + V_L^2}$ where V_R and V_L are potential across resistance and inductance respectively.

    Hence $V = \sqrt{(16)^2 + (20)^2} = \sqrt{256+400}$
    $= 25.6\text{ V}$

12. **(c)** The emf induced in secondary is given by

    $e = \frac{-MdI}{dt} \Rightarrow 1000 = M\left(\frac{2-0}{0.01}\right)$

    (since current is reduced dI = – ve)

    $\Rightarrow M = \frac{1000\times0.01}{2} = 5.00\text{ H.}$

13. **(a)** At angular frequency ω, current through RC circuit is given by

    $$I_{rms} = \frac{V_{rms}}{\sqrt{R^2 + {X_C}^2}} = \frac{V_{rms}}{\sqrt{R^2 + (1/\omega C)^2}} \quad \ldots(1)$$

    When angular frequency is changed to $\frac{\omega}{3}$, then the current becomes,

$$\frac{I_{rms}}{2} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\left(\frac{\omega}{3}\right)C}\right)^2}} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{3}{\omega C}\right)^2}} \quad ...(2)$$

Dividing (i) by (ii)

$$2 = \frac{\sqrt{R^2 + (3/\omega C)^2}}{\sqrt{R^2 + (1/\omega C)^2}}$$

or $4\left[R^2 + \left(\frac{1}{\omega C}\right)^2\right] = R^2 + \left(\frac{3}{\omega C}\right)^2$

$$3R^2 = \frac{5}{\omega^2 C^2} \Rightarrow \frac{1/\omega C}{R} = \sqrt{\frac{3}{5}}$$

$$\Rightarrow \frac{X_C}{R} = \sqrt{\frac{3}{5}}$$

14. **(a)** $E_{rms} = 220\text{ V}$

$$\therefore E_{rms} = \frac{E_0}{\sqrt{2}} \Rightarrow E_0 = \sqrt{2}\,E_{rms}$$

Average e.m.f over half cycle

$$= \frac{2}{\pi}E_0 = 0.637 \times 1.41 \times 220 = 198.15\text{ V}$$

15. **(b)** $L = 0.7H, R = 220\Omega, E_0 = 220V, v = 50\text{ Hz}$.
This is an L – R circuit
Phase difference,

$$\tan\phi = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{2\pi v L}{R}$$

$$[X_L = 2\pi v L = 2 \times \frac{22}{7} \times 50 \times 0.7 = 220\Omega]$$

$$= \frac{220}{220} = 1 \text{ or, } \phi = 45°$$

Wattless component of current

$$= I_0 \sin\phi = \frac{I_0}{\sqrt{2}} = \frac{1}{\sqrt{2}}.\frac{E_0}{Z}$$

$$= \frac{1}{\sqrt{2}} \frac{220}{\sqrt{X_L^2 + R^2}} = \frac{1}{\sqrt{2}}.\frac{220}{\sqrt{220^2 + 220^2}}$$

$$= \frac{1}{2} = 0.5\text{ A}$$

16. **(d)** $\tan\theta = \frac{X_L}{R}$

17. **(a)** $P = \frac{V_0 i_0 \cos\phi}{2} = \frac{200 \times 50 \times 10^3}{2}\cos\frac{\pi}{3}$

18. **(c)** $X_c = \frac{1}{\omega c}$ and $i_c = \frac{Vc}{Xc}$

With decrease in frequency, X_c increases and hence i_c decreases.

19. **(c)** The inductance is proportional to the length of the coil. So each part will have inductance $\frac{L}{2}$. In parallel their equivalent becomes $\frac{L_1 L_2}{L_1 + L_2} = \frac{L}{4}$.

20. **(c)** At resonance $X_L = X_C$
$\Rightarrow$ R & current is maximum but finite, which is $I_{max} = \frac{E}{R}$, where E is applied voltage.

21. **(d)**

$$Q = \frac{\text{Potential drop across capacitor or inductor}}{\text{Potential drop across R.}}$$

$$= \frac{\omega L}{R}$$

22. **(d)** Power, $P = \mathbf{I}_{r.m.s.} \times V_{r.m.s.} \times \cos\phi$
In the given problem, the phase difference between voltage and current is p/2. Hence $P = \mathbf{I}_{r.m.s.} \times V_{r.m.s.} \times \cos(\pi/2) = 0$.

23. **(c)** The current drawn by inductor and capacitor will be in opposite phase. Hence net current drawn from generator
$= I_L - I_C = 0.9 - 0.4 = 0.5$ amp.

24. **(c)** $\frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(ML^2T^{-2}A^{-2}) \times (M^{-1}L^{-2}T^4A^2)}}$

$$= \frac{1}{\sqrt{T^2}} = T^{-1}$$

25. **(d)**

$$Q = \frac{\text{Potential drop across capacitor or inductor}}{\text{Potential drop across R.}}$$

$$= \frac{\omega L}{R}$$

26. **(c)** $\frac{\mathbf{I}_s}{\mathbf{I}_p} = \frac{n_p}{n_s}$; $\frac{80}{\mathbf{I}_p} = \frac{20}{1}$ or $\mathbf{I}_p = 4$ amp.

27. **(a)** $E = \frac{d}{dt}(NMI) \Rightarrow E = NM\frac{dI}{dt} \Rightarrow E = \frac{NMI}{t}$

emf induced per unit turn $= \frac{E}{N} = \frac{MI}{t}$

28. (a) $L = 10\text{ mHz} = 10^{-2}\text{ Hz}$

$f = 1\text{MHz} = 10^6\text{ Hz}$

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

$$f^2 = \frac{1}{4\pi^2 LC}$$

$$\Rightarrow C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4\times 10\times 10^{-2}\times 10^{12}}$$

$$= \frac{10^{-12}}{4} = 2.5\ pF$$

29. (a) If $\omega = 50\times 2\pi$ then $\omega L = 20\Omega$

If $\omega' = 100\times 2\pi$ then $\omega' L = 40\Omega$

Current flowing in the coil is

$$I = \frac{200}{Z} = \frac{200}{\sqrt{R^2 + (\omega' L)^2}} = \frac{200}{\sqrt{(30)^2 + (40)^2}}$$

$I = 4A$.

30. (a) We have, $I = I_0\left(1 - e^{-\frac{R}{L}t}\right)$

(When current is in growth in LR circuit)

$$= \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right) = \frac{5}{5}\left(1 - e^{-\frac{5}{10}\times 2}\right)$$

$= (1 - e^{-1})$

31. (c) The phase angle is given by

$$\tan\phi = \frac{\omega L}{R} = \frac{2\pi\times 50\times 0.21}{12} = 5.5$$

$\phi = \tan^{-1} 5.5 = 80°$

Type B : Assertion Reason Questions

32. (a) In series resonance circuit, current becomes maximum because total impedence becomes zero. In case of LC circuit,

$$\text{Total impedence} = \omega L - \frac{1}{\omega C} = 0$$

$$\Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow \omega^2 = \frac{1}{LC}$$

33. (c) Faraday's laws of electromagnetic induction are consequences of conservation of energy. It involves only transformation of energy into electrical energy.

In purely resistive circuit, current and voltage are in the same phase.

34. (c) For a pure capacitor circuit average power is given by $P_{av} = E_v I_v \cos(-\pi/2)$,

(as $\phi = -\pi/2$)

$\therefore\ E_v I_v (0) = 0 \Rightarrow P_{av} = 0$

thus no power loss occurs. A pure capacitor acts as a block of direct current (d.c) and easy path to a.c since reactance

$X_C = \frac{1}{2\pi f_c} = \infty$ for d.c ($f = 0$ for d.c). Hence we can say no d.c. flows but a.c part is there hence reason is false.

35. (d) Assertion is false and Reason is false.

36. (d) Resistance offered by an inductor in a d.c. circuit at $t = 0$ is infinity, which decreases to zero at steady state.

37. (a) Power loss $= I^2 R = \left(\frac{P}{V}\right)^2 R$

[P = Transmitted power]

38. (a)

39. (c)

40. (c)

41. (d) Large eddy currents are produced in non-laminated iron core of the transformer by the induced emf, as the resistance of bulk iron core is very small. By using thin iron sheets as core the resistance is increased. Laminating the core substantially reduces the eddy currents. Eddy current heats up the core of the transformer. More the eddy currents greater is the loss of energy and the efficiency goes down.