CHAPTER

7

Alternating Current

A Quick Recapitulation of the Chapter

1. **Alternating Current** (AC) is the current which varies in both magnitude as well as direction alternatively and periodically.
$$i = i_0 \sin\omega t \text{ or } i = i_0 \cos\omega t$$
where, i_0 = peak value or maximum value of AC.
2. **RMS Value of AC** is defined as the value of steady current that would generate the same amount of heat in a given resistor as would be generated by the given AC current over a complete cycle.
3. **Average** or **Mean Value of AC** is defined as the value of steady current which would send same amount of charge through a circuit that is sent by the AC in the in half-cycle.
$$i_{av} = \frac{2i_0}{\pi} = 0.637 i_0$$
4. The **instantaneous alternating emf** is given by
$$V = V_0 \sin\omega t \text{ or } V = V_0 \cos\omega t$$
Also , $V_{rms} = \frac{V_0}{\sqrt{2}} = 0.707$ or $V_{rms} = 70.7\%$ of V_0
and $V_{av} = \frac{2V_0}{\pi} = 0.637$ or $V_{rms} = 63.7\%$ of V_0
5. **Power** In a AC circuit, both emf and current change continuously w.r.t. time, so in circuit, we have to calculate average power in complete cycle ($0 \to T$).
$$P_{av} = V_{rms}\, i_{rms} \cos\phi$$
where, $\cos\phi$ = Power factor.
6. **In an AC Circuit Containing Resistance Only**
Instantaneous value E is given by $E = E_0 \sin\omega t$
Then, voltage and current are in same phase
$$i = i_0 \sin\omega t$$
7. **In an AC Circuit Containing Inductor Only**
Instantaneous value E is given by $E = E_0 \sin\omega t$
Then,
   (i) Inductive reactance, $X_L = \omega L = 2\pi f L$
   (ii) Voltage leads the current by phase $\frac{\pi}{2}$.
   If $V = V_0 \sin\omega t$, then $i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$
   (iii) Power factor, $\cos\phi = \cos\frac{\pi}{2} = 0$
   Thus, average power consumption,
   $$P_{av} = V_{rms} i_{rms} \cos\phi = 0$$
8. **In an *L*-*R* Series AC Circuit**
Impedance, $Z = \sqrt{R^2 + X_L^2} = \frac{V_{rms}}{i_{rms}}$
For the phase angle, $\tan\phi = \frac{X_L}{R} = \frac{\omega L}{R}$, voltage leads current by phase ϕ.
9. **In an AC Circuit Containing Capacitor Only**
Instantaneous value E is given by $E = E_0 \sin\omega t$
Then, (i) Capacitive reactance, $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$
   (ii) Capacitor offers infinite reactance in DC circuit as $f = 0$.
   (iii) Voltage lags behind the current by phase $\frac{\pi}{2}$.
   If $V = V_0 \sin\omega t$, then $i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$
   (iv) Power factor $(\cos\phi)$ is minimum and equal to zero.
   $\therefore$ Average power consumption (during a complete cycle),
   $$P_{av} = V_{rms} i_{rms} \cos\phi = 0$$

10. **In an *C-R* Series AC Circuit**

Impedance, $Z = \frac{V_{rms}}{i_{rms}} = \sqrt{R^2 + X_C^2}$

For the phase angle, $\tan\phi = \frac{X_C}{R} = \frac{1}{\omega CR}$

11. **In an *L-C* Series AC Circuit**

Impedance, $Z = \frac{V_{rms}}{i_{rms}} = X_L - X_C$

Phase difference between voltage and current is $\pi/2$.

Thus, power factor, $\cos\phi = 0$

12. **In an *L-C-R* Series AC Circuit**

(i) Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2} = \frac{V_{rms}}{i_{rms}}$

(ii) If $X_L > X_C$, then V leads i by ϕ and if $X_L < X_C$, then V lags behind i by ϕ.

where, $\tan\phi = \frac{X_L - X_C}{R} = \frac{V_L - V_C}{V_R}$

13. **In Resonant *L-C-R* Series AC Circuit**

(i) $X_L = X_C$

(ii) Impedance, $Z = Z_{min} = R$

(iii) The phase difference between V and i is 0°.

(iv) Resonant angular frequency, $\omega_0 = \frac{1}{\sqrt{LC}}$.

(v) Average power consumption P_{av} becomes maximum.

(vi) Current becomes maximum and $i_{max} = \frac{V_{rms}}{R}$

14. ***L-C* Oscillations** When the charged capacitor is connected with the inductor, current flows through the inductor and energy stored in the inductor in the form of magnetic field and capacitor discharges and *vice-versa*. In this way, energy oscillates between capacitor and inductor.

The frequency of oscillation is $\omega_0 = \frac{1}{\sqrt{LC}}$

15. **Quality Factor** It indicates the sharpness of resonance in an *L-C-R* series AC circuit.

Quality factor $= \frac{V_L}{V_R} = \frac{V_C}{V_R} = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR} = \frac{1}{R}\sqrt{\frac{L}{C}}$

Quality factor is also defined as

$$Q = 2\pi\left(\frac{\text{Maximum energy stored}}{\text{Energy dissipated / cycle}}\right)$$

16. A **transformer** is device used either to obtain a high AC voltage from a low voltage AC source or *vice-versa*.

For an ideal transformer,

$$\frac{e_s}{e_p} = \frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{i_p}{i_s} = k$$

where, k is known as transformation ratio.

For a step-up transformer, $k > 1$ but for a step-down transformer $k < 1$.

The efficiency of a transformer is given by

$$\eta = \frac{\text{Output power}}{\text{Input power}} = \frac{V_s \cdot i_s}{V_p \cdot i_p}$$

For an ideal transformer, $\eta = 100\%$ or 1. However, for practical transformer, $\eta \approx$ 85-90%.

Objective Questions Based on NCERT Text

Topic 1
AC Voltage Applied to a Resistor

1. Which current do not change direction with time?

(a) DC current (b) AC current
(c) Both (a) and (b) (d) Neither (a) nor (b)

2. The electric mains supply in our homes and offices is a voltage that varies like a sine function with time. Such a voltage is called ..... and the current driven by it in a circuit is called the ..... .

(a) DC voltage, AC current (b) AC voltage, DC current
(c) AC voltage, DC voltage (d) AC voltage, AC current

3. Potential difference between two points is called

(a) AC current (b) voltage
(c) DC current (d) resistor

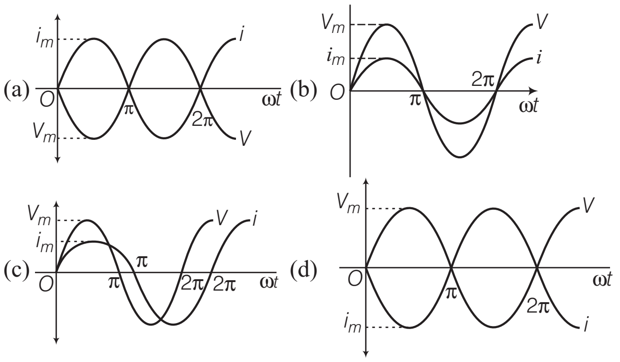
4. When the current changes continuously in magnitude and periodically in direction, several times per second, the current is known as the

(a) direct current (b) induced current
(c) displacement current (d) alternating current

5. Consider a source which produces sinusoidally varying potential difference across its terminals, this potential difference called AC voltage, be given by the expression

(a) $V_m \sin \omega t$ (b) $V_m \cos \omega t$
(c) $2V_m \cos \omega t$ (d) $2V_m \sin \omega t$

6. Which of the following graphs shows, in a pure resistor, the voltage and current are in phase?



7. The sum of instantaneous current values over one complete cycle is

(a) negative (b) positive
(c) zero (d) Both (a) and (b)

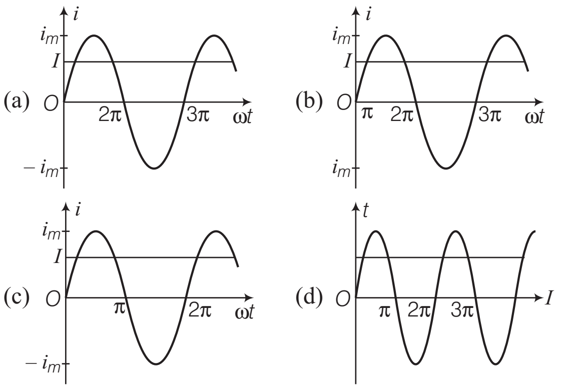
8. When an AC current passes through a resistor there is dissipation of

(a) joule heating (b) electrical energy
(c) power (d) Both (a) and (b)

9. To express AC power in the same form as DC power, a special value of current is defined and used, is called

(a) root mean square current (I_{rms})
(b) effective current
(c) induced current
(d) Both (a) and (b)

10. Which of the following graphs, shows i/t?



11. The household line voltage of 220 V is a rms value with a peak voltage of

(a) 310 V (b) 311 V
(c) 307 V (d) 302 V

12. A light bulb is rated at 100 W for a 220 V supply. Find the resistance of the bulb.

(a) 48 Ω (b) 484 Ω
(c) 480 Ω (d) 350 Ω

13. A group of electric lamps having total power rating of 600 W, 200V is supplied by an AC voltage $V = 169 \sin(314t + 60°)$. The rms value of the current is

(a) 10 A (b) 9.04 A (c) 1.48 A (d) 8 mA

14. The electric mains in the house is marked 220 V, 50 Hz. Write down the equation for instantaneous voltage.

(a) $3.1V \sin(100\pi)t$ (b) $31.1V \cos(100\pi)t$
(c) $311.1V \sin(100\pi)t$ (d) $311.1V \cos(100\pi)t$

15. The electric current in a circuit is given by $i = i_0 (t/\tau)$ for same time. The rms current for the period $t = 0$ to $t = \tau$ is

(a) $\frac{i_0}{\sqrt{3}}$ (b) $\frac{3i_0}{2}$ (c) $\sqrt{\frac{i_0}{2}}$ (d) $\frac{3}{4}\sqrt{i_0}$

16. In a purely resistive AC circuit, the current

(a) lags behind the emf in phase
(b) is in phase with the emf
(c) leads the emf in phase
(d) leads the emf in half the cycle behind it in the other half

17. The frequency of an alternating voltage is 50 cycles/s and its amplitude is 120 V. Then, the rms value of voltage is

(a) 101.3 V (b) 84.8 V
(c) 70.7 V (d) 56.5 V

18. In order to show phase relationship between voltage and current in AC circuit, we use the notion of

(a) phasors (b) sine function
(c) Both (a) and (b) (d) Neither (a) nor (b)

19. What is the speed of a phasor which rotates about the origin?

(a) 2ω (b) $\omega/2$ (c) ω (d) $\omega/4$

20. Which of the following represent the value of voltage and current at an instant in a purely resistive AC circuit?

(a) $V_m \sin \omega t, i_m \sin \omega t$ (b) $V_m \cos \omega t, i_m \cos \omega t$
(c) $-V_m \sin \omega t, -i_m \sin \omega t$ (d) $-V_m \cos \omega t, -i_m \cos \omega t$

21. What will be the phase angle between the voltage and the current in resistive AC circuit?

(a) $\pi/2$ (b) $\pi/4$
(c) $\pi/3$ (d) Zero

22. Voltage and current in an AC circuit are given by

$$V = 5\sin(100\pi t - \pi/6)$$

and $I = 4\sin(100\pi t + \pi/6)$

(a) voltage leads the current by 30°
(b) current leads the voltage by 30°
(c) current leads the voltage by 60°
(d) voltage leads the current by 60°

23. Alternating current cannot be measured by DC ammeter, because

(a) AC cannot pass through DC ammeter
(b) average value of current in complete cycle is zero
(c) AC is virtual
(d) AC changes its direction

24. In an AC circuit, $I = 100 \sin 200\, \pi t$. The time required for the current to achieve its peak value will be

(a) $\frac{1}{100}$ s (b) $\frac{1}{200}$ s
(c) $\frac{1}{300}$ s (d) $\frac{1}{400}$ s

25. A generator produces a voltage that is given by $V = 240 \sin 120\, t$, where t is in seconds. The frequency and rms voltage are

(a) 60 Hz and 240 V
(b) 19 Hz and 120 V
(c) 19 Hz and 170 V
(d) 754 Hz and 70 V

26. An alternating current is given by the equation $i = i_1 \cos \omega t + i_2 \sin \omega t$. The rms current is given by

(a) $\frac{1}{\sqrt{2}}(i_1 + i_2)$ (b) $\frac{1}{\sqrt{2}}(i_1 + i_2)^2$
(c) $\frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$ (d) $\frac{1}{2}(i_1^2 + i_2^2)^{1/2}$

27. In a circuit, the value of the alternating current is measured by hot wire ammeter as 10 A. Its peak value will be

(a) 10 A (b) 20 A (c) 14.14 A (d) 7.07 A

28. A resistance of 20 Ω is connected to a source of an alternating potential, $V = 220 \sin (100\pi\, t)$. The time taken by current to change from its peak value to rms value is

(a) 0.2 s (b) 0.25 s
(c) 25×10^{-3} s (d) 2.5×10^{-3} s

29. If an AC main supply is given to be 220 V. What would be the average emf during a positive half-cycle?

(a) 198 V (b) 386 V
(c) 256 V (d) None of these

30. If an alternating voltage is represented as $E = 141 \sin (628\, t)$, then the rms value of the voltage and the frequency are respectively

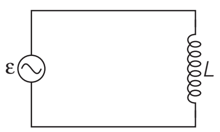
(a) 141 V, 628 Hz (b) 100 V, 50 Hz
(c) 100 V, 100 Hz (d) 141 V, 100 Hz

31. The voltage of an AC source varies with time according to equation $V = 100 \sin \pi t \cos 100\, \pi t$. where t is in seconds and V is in volts. Then

(a) the peak voltage of the source is 100 V
(b) the peak voltage of the source is 50 V
(c) the peak voltage of the source is $100/\sqrt{2}$ V
(d) the frequency of the source is 100 Hz.

Topic 2
AC Voltage Applied to an Inductor

32.



From the above figure, which one of the following option is correct?

(a) $V - L\frac{di}{dt} = 0$ (b) $L - V\frac{di}{dt} = 0$
(c) $L + V\frac{di}{dt}$ (d) $2L - V\frac{di}{dt} = 0$

33. Equation $di/dt = \frac{V}{L} = (V_m/L) \sin \omega t$ implies that the equation for $i\,(t)$, the current as a function of time, must be such that

(a) its slope di/dt is a sinusoidally varying quantity with the same phase as the source voltage
(b) an amplitude given by V_m/L
(c) Both (a) and (b)
(d) Neither (a) nor (b)

34. $i = -\frac{V_m}{\omega L} \cos (\omega t) + \text{constant}$, in the given equation, the integration constant has the dimension of

(a) resistor (b) current (c) voltage (d) inductor

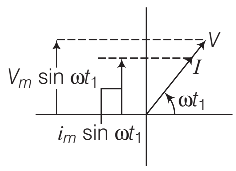
35. The integration constant in above question, is

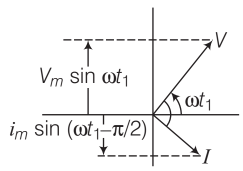
(a) time-independent (b) time-dependent
(c) may be time-independent (d) never time dependent

36. The inductive reactance is directly proportional to the

(a) inductance (b) frequency of the current
(c) Both (a) and (b) (d) amplitude of current

37. Which of the following figure shows that the current phasor I is $\pi/2$ behind the voltage phasor V?

(a) 

(b) 

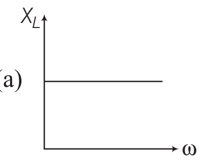
(c) Both (a) and (b) (d) Neither (a) nor (b)

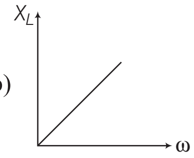
38. In a purely inductive AC circuit, the current reaches its maximum value later than the voltage by
(a) one-fourth of a period
(b) half of a period
(c) three by fourth of a period
(d) complete a period

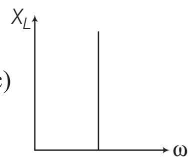
39. A pure inductor of 25.0 mH is connected to a source of 220 V. Find the inductive reactance if the frequency of the source is 50 Hz.
(a) 785 Ω (b) 6.50 Ω
(c) 7.85 Ω (d) 8.75 Ω

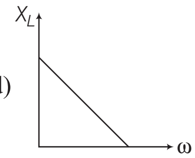
40. Refer the above question, the rms current in the circuit is
(a) 25 A (b) 16 A
(c) 11 A (d) 28 A

41. Which of the following graphs represents the correct variation of inductive reactance X_L with angular frequency ω?

(a)


(b)


(c)


(d)


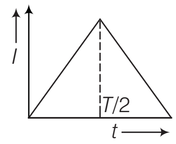
42. In a purely inductive AC circuit, $L = 30.0$ mH and the rms voltage is 150 V, frequency $\nu = 50$ Hz. The inductive reactance is
(a) 15.9 Ω (b) 9.42 Ω
(c) 10 Ω (d) 8.85 Ω

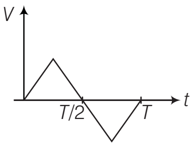
43. An inductance of negligible resistance whose reactance is 120 Ω at 200 Hz is connected to a 240 V, 60 Hz, power line. The current in the inductor is
(a) 6.66 A (b) 6.60 A
(c) 5.45 A (d) 54.5 A

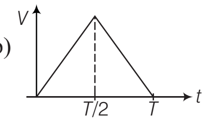
44. In a circuit containing an inductance of zero resistance, the emf of the applied AC voltage leads the current by
(a) 90° (b) 45°
(c) 30° (d) 0°

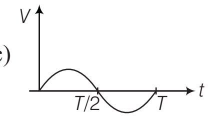
45. In an AC circuit, the current lags behind the voltage by $\pi/2$. The components of the circuit are
(a) R and L (b) L and C
(c) R and C (d) only R

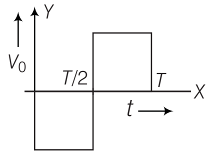
46. The current (I) in the inductance is varying with time according to the plot shown in figure. Which one of the following is the correct variation of voltage with time in the coil?



(a)


(b)


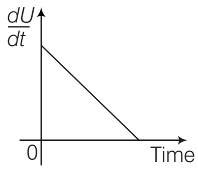
(c)


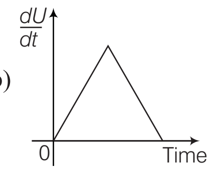
(d)


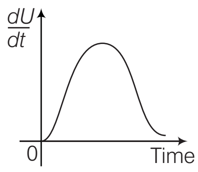
47. A resistance of 300 Ω and an inductance of $1/\pi$ henry are connected in a series to an AC voltage of 20 V and 200 Hz frequency. The phase angle between the voltage and current is
(a) $\tan^{-1} 4/3$ (b) $\tan^{-1} 3/4$
(c) $\tan^{-1} 3/2$ (d) $\tan^{-1} 2/5$

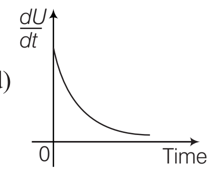
48. Two inductors L_1 (inductance 1mH, internal resistance 3 Ω) and L_2 (inductance 2 mH, internal resistance 4 Ω), and a resistor R (resistance 12 Ω) are all connected in parallel across a 5 V battery. The circuit is switched on at time $t = 0$. The ratio of the maximum to the minimum current (I_{max}/I_{min}) drawn from the battery is **[JEE Advanced 2016]**
(a) 2 (b) 4 (c) 6 (d) 8

49. In an L-R circuit connected to a battery, the rate at which energy is stored in the inductor is plotted against time during the growth of current in the circuit. Which of the following figure best represents the resulting curve?

(a)


(b)


(c)


(d)


Topic 3

AC Voltage Applied to a Capacitor

50. Current I across the capacitor in a purely capacitive AC circuit is

(a) $i_m \sin(\omega t + \pi/4)$ (b) $i_m \sin(\omega t + \pi/2)$
(c) $i_m \cos(\omega t + \pi/4)$ (d) $i_m \cos(\omega t + \pi/2)$

51. The amplitude of the oscillating current in the above capacitive AC circuit is

(a) $\omega C V_m$ (b) $2\omega C V_m$
(c) $\frac{\omega C V_m}{4}$ (d) $\frac{3\omega C V_m}{2}$

52. Which of the following is called capacitive reactance and is denoted by X_C?

(a) ωC (b) $1/\omega C$
(c) $2/\omega C$ (d) $\omega C/R$

53. The dimension of capacitive reactance is the same as that of

(a) current (b) inductance reactance
(c) voltage (d) resistance

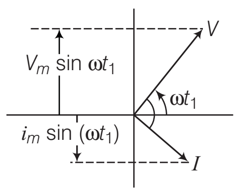
54. Capacitive reactance is inversely proportional to

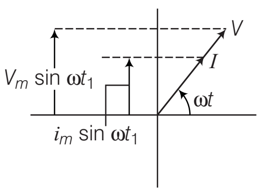
(a) frequency (b) capacitance
(c) voltage (d) Both (a) and (b)

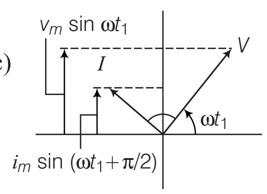
55. For AC voltage applied to a capacitor, the current is ahead of voltage by

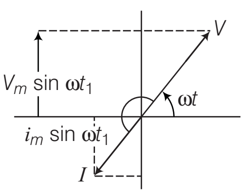
(a) $\pi/2$ (b) $\pi/4$
(c) $\frac{3\pi}{4}$ (d) π

56. Which of the following diagram shows that the current phasor I is $\pi/2$ ahead of the voltage phasor V as they rotate counter-clockwise?

(a) 

(b) 

(c) 

(d) 

57. In capacitive AC circuit the current reaches its maximum value earlier than the voltage by

(a) half of a period (b) three-fourth of a period
(c) three-two of a period (d) one-fourth of a period

58. A 15.0 μF capacitor is connected to a 220 V, 50 Hz source. The capacitive reactance is

(a) 220 Ω (b) 215 Ω (c) 212 Ω (d) 204 Ω

59. Refer the above question, the current (rms and peak) in the circuit is

(a) 1.47 A, 2.04 A (b) 1.08 A, 1.0 A
(c) 1.04 A, 1.47 A (d) 2.4 A, 1.08 A

60. Same current is flowing in two alternating circuits. The first circuit contains only inductance and the other contains only a capacitance. If the frequency of the emf of AC is increased, the effect on the value of the current will be

(a) increase in the first circuit and decrease in the other
(b) increase in both the circuits
(c) decrease in both the circuits
(d) decrease in the first circuit and increase in the other

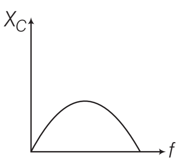
61. An alternating voltage $E = 200\sqrt{2}\sin(100\,t)$ is connected to a 1μF, capacitor through an AC ammeter. The reading of the ammeter shall be

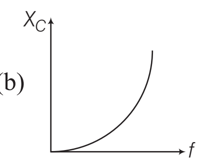
(a) 10 mA (b) 20 mA
(c) 40 mA (d) 80 mA

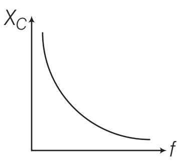
62. If the frequency is doubled, what happens to the capacitive reactance and the current?

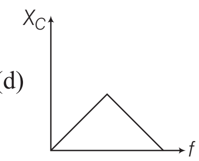
(a) Capacitive reactance is halved, the current is doubled
(b) Capacitive reactance is doubled, the current is halved
(c) Capacitive reactance and the current are halved
(d) Capacitive reactance and the current are doubled

63. Which of the following graphs represents the correct variation of capacitive reactance X_C with frequency f?

(a) 

(b) 

(c) 

(d) 

64. A 60 μF capacitor is connected to a 110 V, 60 Hz AC supply. The rms value of the current in the circuit is

(a) 2 A (b) 2.49 A (c) 1.85 A (d) 2.05 A

65. A resistor and a capacitor are connected in series with an AC source. If the potential drop across the capacitor is 5V and that across the resistor is 12 V, then applied voltage is

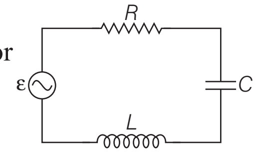
(a) 13 V (b) 17 V (c) 5 V (d) 12 V

66. A resistor of $200\ \Omega$ and a capacitor of $15\ \mu F$ are connected in series to a 220 V, 50 Hz AC source. The current in the circuit is

(a) 755 A (b) 7.55 mA
(c) 0.755A (d) 0.755 mA

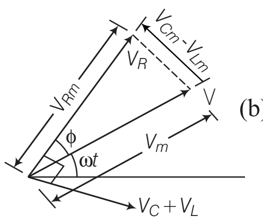
Topic 4
AC Voltage Applied to a Series *L-C-R* Circuit

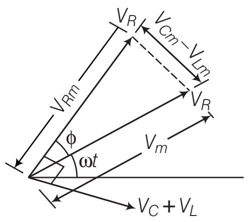
67. Consider the figure, the resistor, inductor and capacitor are in series, therefore

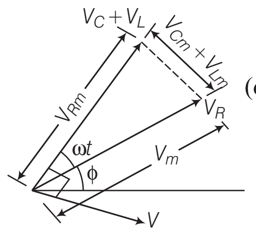


(a) the AC current in each element is same at any time
(b) amplitude and phase are same in each element
(c) Both (a) and (b)
(d) Neither (a) nor (b)

68. Which one of the following phasor diagrams correctly represents the relation between the phasors V_R, V_L and V_C of a series *L-C-R* circuit?

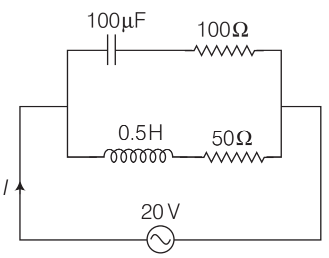
(a)


(b)


(c)


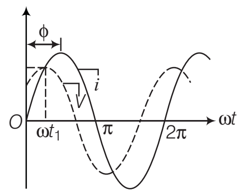
(d) All of these

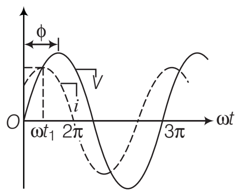
69. In the given circuit, the AC source has $\omega = 100$ rad/s. Considering the inductor and capacitor to be ideal, the correct choice(s) is (are) **[IIT JEE 2012]**

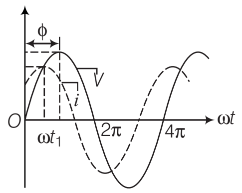


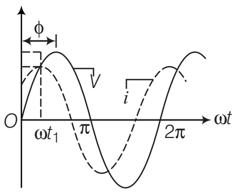
(a) The current through the circuit, I is 0.3 A
(b) The current through the circuit, I is $0.3\sqrt{2}$ A
(c) The voltage across 100 Ω resistor = $10\sqrt{2}$ V
(d) The voltage across 50 Ω resistor = 10 V

70. Which of the following graph, is correct for a series *L-C-R* circuit, where $X_C > X_L$?

(a)


(b)


(c)


(d)


71. The current in the series *L-C-R* circuit is

(a) $i = i_m \sin(\omega t + \phi)$
(b) $i = \dfrac{V_m}{\sqrt{R^2 + (X_c - X_L)^2}} \sin(\omega t + \phi)$
(c) $i = 2i_m \cos(\omega t + \phi)$
(d) Both (a) and (b)

72. In an *L-C-R* series AC circuit, then voltage across each of the components. *L*, *C* and *R* is 50 V. The voltage across the *C-R* combination will be

(a) 50 V (b) $50\sqrt{2}$ V (c) 100 V (d) zero

73. In a series *L-C-R* circuit, the frequency of 10 V AC voltage source is adjusted in such a fashion that the reactance of the inductor measures 15 Ω and that of the capacitor 11 Ω. If $R = 3\ \Omega$, the potential difference across the series combination of *L* and *C* will be

(a) 8 V (b) 10 V
(c) 22 V (d) 52 V

74. 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

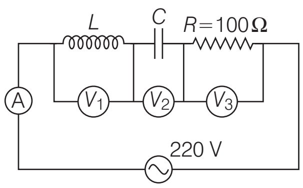
(a) $\dfrac{1}{2\pi f\ (2\pi fL + R)}$ (b) $\dfrac{1}{\pi f\ (2\pi fL + R)}$

(c) $\dfrac{1}{2\pi f\ (2\pi fL - R)}$ (d) $\dfrac{1}{\pi f\ (2\pi fL - R)}$

75. In an *L-C-R* series AC circuit, the voltage across each of the components, L, C and R is 50 V. The voltage across the *L-C* combination will be

(a) 50 V (b) $50\sqrt{2}$ V
(c) 100 V (d) 0 V

76. In the given circuit, the readings of voltmeters V_1 and V_2 are 300 V each. The readings of the voltmeter V_3 and ammeter A are respectively



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

77. A sinusoidal voltage of peak value 300 V and an angular frequency $\omega = 400 \text{ rads}^{-1}$ is applied to series *L-C-R* circuit, in which $R = 3\ \Omega$, $L = 20$ mH and $C = 625\ \mu$F. The peak current in the circuit is

(a) $30\sqrt{2}$ A (b) 60 A
(c) 100 A (d) $60\sqrt{2}$ A

78. For series *L-C-R* circuit, right statement is

(a) applied emf and potential difference across resistance are is same phase
(b) applied emf and potential difference at inductor coil have phase difference of $\pi/2$
(c) potential difference at capacitor and inductor have phase difference of $\pi/2$
(d) Potential difference across resistance and capacitor have phase difference of $\pi/2$.

79. In an *L-C-R* series circuit, the potential difference between the terminals of the inductance is 60 V, between the terminals of the capacitor is 30 V and that across the resistance is 40 V. Then, supply voltage will be equal to

(a) 50 V (b) 70 V (c) 130 V (d) 10 V

80. 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 $\omega/3$ (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.

(a) $\sqrt{\frac{3}{5}}$ (b) $\sqrt{\frac{2}{5}}$ (c) $\sqrt{\frac{1}{5}}$ (d) $\sqrt{\frac{4}{5}}$

Topic 5
Resonance

81. The phenomenon of resonance is common among systems that have a tendency

(a) to oscillate at a particular frequency
(b) to get maximum amplitude
(c) Both (a) and (b)
(d) Neither (a) nor (b)

82. At resonant frequency, the current amplitude of an *R-L-C* circuit is

(a) minimum (b) maximum
(c) may be minimum (d) never maximum

83.

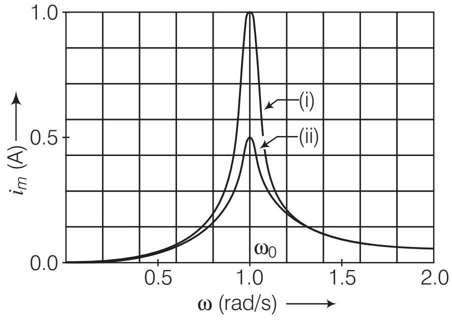


Figure shows the variation of i_m with ω in a

(a) *R-L-C* circuit (b) *R-L* circuit
(c) *R-C* circuit (d) None of these

84. In *R-L-C* series circuit with $L = 1.00$ mH, $C = 1.00$ nF two values of R are (i) $R = 100\ \Omega$ and (ii) $R = 200\ \Omega$. For the source applied with $V_m = 100$ V. Resonant frequency is

(a) 1×10^3 rad/s (b) 1×10^6 rad/s
(c) 1.56×10^6 rad/s (d) 1.75×10^3 rad/s

85. Resonant circuits are used in

(a) the tuning mechanism of a radio
(b) TV set
(c) Both (a) and (b)
(d) Neither (a) nor (b)

86. In tuning, we vary the capacitance of a capacitor in the tuning circuit such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal received. When this happens, the...*A*... with the frequency of the signal of the particular radio station in the circuit is maximum. Here, A refers to

(a) resonant frequency (b) impedance
(c) amplitude of the current (d) reactance

87. Bandwidth of the resonant L-C-R circuit is

(a) $\frac{R}{L}$ (b) $R/2L$ (c) $\frac{2R}{L}$ (d) $\frac{4R}{L}$

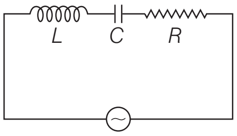
88. If resonant frequency of a R-L-C circuit is ω_0 and bandwidth is $A\omega$, then which of the following quantity is regarded as a measure of the sharpness of resonance?

(a) $\frac{\omega_0}{\Delta\omega}$ (b) $\frac{\omega_0}{2\Delta\omega}$ (c) $\frac{2\omega_0}{\Delta\omega}$ (d) $\frac{\Delta\omega}{2\omega_0}$

89. Which of the following ratio is called the quality factor, Q of the circuit?

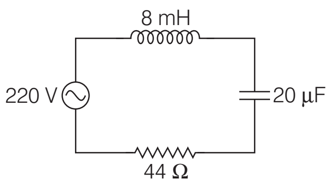
(a) $Q = \frac{\omega_0 L}{R}$ (b) $Q = \frac{2\omega_0 L}{R}$
(c) $Q = \frac{\omega_0 L}{2R}$ (d) $Q = \frac{\omega_0 L}{4R}$

90. A 100 V, AC source of frequency 500 Hz is connected to an L-C-R circuit with $L = 8.1$ mH, $C = 12.5\,\mu$F, $R = 10\,\Omega$ all connected in series as shown in figure. What is the quality factor of circuit?



(a) 2.02 (b) 2.5434 (c) 20.54 (d) 200.54

91. For the series L-C-R circuit shown in the figure, what is the angular resonant frequency and amplitude of the current at the resonating frequency?



(a) 2500 rad/s and $5\sqrt{2}$ A (b) 2500 rad/s and 5A
(c) 2500 rad/s and $\frac{5}{\sqrt{2}}$ A (d) 25 rad/s and $5\sqrt{2}$ A

92. In an L-C-R circuit, capacitance is changed from C to $2C$. For the resonant frequency to remain unchanged, the inductance should be change from L to

(a) $4L$ (b) $2L$ (c) $L/2$ (d) $L/4$

93. In non-resonant circuit, what will be the nature of circuit for frequencies higher than the resonant frequency?

(a) Resistive (b) Capacitive
(c) Inductive (d) None of these

94. In a series L-C-R circuit, the voltage across R is 100 V and $R = 1\,\text{k}\,\Omega$, $C = 2\,\mu$F. The resonant frequency ω is 200 rad/s. At resonance the voltage across L is

(a) 40 V (b) 250 V
(c) 4×10^{-3} V (d) 2.5×10^{-2} V

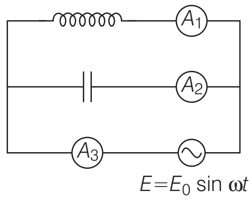
95. An L-C-R series circuit consists of a resistance of $10\,\Omega$ a capacitor of reactance $6.0\,\Omega$ and an inductor coil. The circuit is found to resonate when put across a 300 V, 100 Hz supply. The inductance of coil is (take, $\pi = 3$)

(a) 0.1 H (b) 0.01 H (c) 0.2 H (d) 0.02 H

96. In an L-C-R circuit, capacitance is changed from C to $16C$. For the resonant frequency to remain unchanged, the inductance should be changed from L to

(a) $4L$ (b) $16L$ (c) $L/16$ (d) $L/4$

97. An inductor L and a capacitor C are connected in the circuit as shown in the figure. The frequency of the power supply is equal to the resonant frequency of the circuit. Which ammeter will read zero ampere?

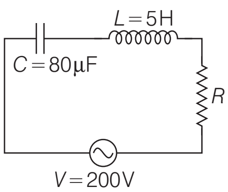


(a) A_1 (b) A_2
(c) A_3 (d) None of these

98. An alternating emf of frequency $\nu = \left(\frac{1}{2\pi\sqrt{LC}}\right)$ is applied to a series L-C-R circuit. For this frequency of the applied emf

(a) the circuit is at resonance and its impedance is made up only of a reactive part.
(b) the current in the circuit is in phase with the applied emf and voltage across R equals the applied emf
(c) the sum of the potential difference across the inductance and capacitance equals the applied emf which is 180° ahead of phase of the current in the circuit
(d) the quality factor of the circuit is $\omega L/R$ or $1/\omega CR$ and this is measure of the voltage magnification (Produced by the circuit at reasonance) as well as the sharpness of resonance of the circuit.

99. Figure shows a series L-C-R circuit, connected to a variable frequency 200 V source. $C = 80\,\mu$F and $R = 40\,\Omega$. The source frequency which drives the circuit at resonance is



(a) 25 Hz (b) $\frac{25}{\pi}$ Hz
(c) 50 Hz (d) $\frac{50}{\pi}$ Hz

100. Calculate the wavelength of the radiowaves radiated out by a circuit containing $0.02\,\mu F$ capacitor and $8\,\mu H$ inductance in series.

(a) 703.8 m (b) 460 m
(c) 398 m (d) 753.8 m

101. In a series resonant L-C-R circuit, the voltage across R is 100 V and $R = 1\,k\Omega$ with $C = 2\,\mu F$. The resonant freuency ω is 200 rads^{-1}. At resonance the voltage across L is

(a) 2.5×10^{-2} V (b) 40 V (c) 250 V (d) 4×10^{-3} V

Topic 6
Power in AC Circuit

102. In an AC circuit, the average power dissipated depends

(a) on the voltage
(b) current
(c) cosine of the phase angle ϕ between them
(d) All of the above

103. In an AC circuit, the instantaneous values of emf and current are $e = 200 \sin (314)\, t$ V and $I = \sin (314t + \pi/3)$ A. The average power consumed is

(a) 200 W (b) 100 W (c) 50 W (d) 25 W

104. The potential difference V and the current i flowing through an instruments in an AC circuit of frequency f are given by $V = 5 \cos \omega t$ volts and $i = 2 \sin \omega t$ amperes (where, $\omega = 2\pi f$).

The power dissipated in the instrument is

(a) zero (b) 10 W (c) 5 W (d) 2.5 W

105. In an AC circuit, V and I are given by

$V = 100 \sin (100\, t)$ V, $i = 100 \sin \left(100t + \dfrac{\pi}{3}\right)$ mA. The power dissipated in circuit is

(a) 10^4 W (b) 10 W (c) 2.5 W (d) 5 W

106. In an AC circuit, the current is given by

$i = 5 \sin \left(100\, t - \dfrac{\pi}{2}\right)$ and the AC potential is

$V = 200 \sin (100)$ V. Then, the power consumption is

(a) 20 W (b) 40 W
(c) 1000 W (d) 0 W

107. The average power supplied to an inductor over one complete cycle is

(a) $i_m V_m / 2$ (b) $i_m V_m$
(c) $3 i_m V_m / 4$ (d) zero

108. If a current I is given by $I_0 \sin (\omega t - \pi/2)$ flows in an AC circuit across which an AC potential of $E = E_0 \sin \omega t$ has been applied, then the power consumption P in the circuit will be

(a) $P + \dfrac{E_0 I_0}{\sqrt{2}}$ (b) $P = \sqrt{2}\, E_0 I_0$

(c) $P = \dfrac{E_0 I_0}{2}$ (d) $P = 0$

109. As in the case of inductor, the average power in capacitor

(a) $\dfrac{i_m V_m}{2} < \sin (2\omega t) >$ (b) $i_m V_m < \sin (\omega t) >$

(c) $i_m V_m < \sin (2\omega t) >$ (d) 0

110. Power dissipated in an L-C-R series circuit connected to an AC source of emf ε is

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

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

111. Which of the following components of a L-C-R circuit, with AC supply, do not dissipatesel energy?

(a) L, C (b) R, C
(c) L, R (d) L, C, R

112. Which of the following components of a L-C-R circuit with AC supply, dissipates energy?

(a) L (b) R
(c) C (d) All of these

113. A coil of self-inductance L is connected in series with a bulb B and an AC source. Brightness of the bulb decreases when **[NEET 2013]**

(a) frequency of the AC source is decreased
(b) number of turns in the coil is reduced
(c) a capacitance of reactance $X_C - X_L$ is included in the same circuit
(d) an iron rod is inserted in the coil

114. A lamp consumes only 50% of peak power in an AC circuit. What is the phase difference between the applied voltage and the circuit current?

(a) $\dfrac{\pi}{6}$ (b) $\dfrac{\pi}{3}$ (c) $\dfrac{\pi}{4}$ (d) $\dfrac{\pi}{2}$

115. A choke is preferred to a resistance for limiting current in AC circuit, because
(a) choke is cheap
(b) there is no wastage of power
(c) choke is compact in size
(d) choke is a good absorber of heat

116. A value of ω for which the current amplitude is $1/\sqrt{2}$ times its maximum value. At this value, the power dissipated by the circuit becomes
(a) double (b) one-fourth
(c) one-third (d) half

117. In an electrical circuit R, L, C and an 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
[CBSE AIPMT 2012]
(a) 1/2 (b) $1/\sqrt{2}$ (c) 1 (d) $\sqrt{3}/2$

118. In an AC circuit the power factor
(a) is zero when the circuit contains an ideal resistance only
(b) is unity when the circuit contains an ideal resistance only
(c) is unity when the circuit contains a capacitance only
(d) is unity when the circuit contains an ideal inductance only

119. Power factor is maximum in a L-C-R circuit when
(a) $X_L = X_C$ (b) $R = 0$ (c) $X_L = 0$ (d) $X_C = 0$

120. A coil of inductive reactance 31 Ω has a resistance of 8 Ω. It is placed in series with a condenser of capacitive reactance 25 Ω. The combination is connected to an AC source of 110 V. The power factor of the circuit is
(a) 0.56 (b) 0.64 (c) 0.80 (d) 0.33

121. A voltage of peak value 283 V and varying frequency is applied to a series L-C-R combination in which $R = 3\ \Omega$, $L = 25$ mH and $C = 400\ \mu$F. The frequency (in Hz) of the source at which maximum power is dissipated in the above circuit is
(a) 51.5 Hz (b) 50.7 Hz (c) 51.1 Hz (d) 50.3 Hz

122. When a capacitor (initially charged) is connected to a inductor, the change on the capacitor and the current in the circuit exhibit the phenomenon of
(a) electrical oscillations (b) induction
(c) power factor (d) All of these

123. $d^2x/dt^2 + \omega_0^2 x = 0$, in the equation of SHM, ω_0 refers to
(a) k/m (b) $\sqrt{k/m}$
(c) $\sqrt{2k/m}$ (d) $2k/m$

124. $\omega_0 = \sqrt{k/m}$, angular frequency in SHM, k refers to
(a) power constant (b) spring constant
(c) quality factor (d) None of these

125. 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 AC circuit is
[NEET 2016]
(a) 0.67 W (b) 0.76 W
(c) 0.89 W (d) 0.51 W

126. A charged 30 μF capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit?
(a) 1.1 s (b) $1.1 \times 10^3\ s^{-1}$
(c) $2 \times 10^3\ s^{-1}$ (d) $2.5 \times 10^3\ s^{-1}$

127. Suppose the initial charge on the capacitor in above question is 6 mC. What is the total energy stored in the circuit initially? What is the total energy at later time?
(a) 0.6 J, 0.6 J (b) 66.7 J, 67 J
(c) 5.75 J, 0.92 J (d) 14.4 J, 10.5 J

128. A 10 μF capacitor is charged to 25 V of potential. The battery is then disconnected and a pure 10 mH coil is connected across the capacitor so that L-C oscillation are set up. The maximum current in the coil is
(a) 0.25 A (b) 0.01 A
(c) 2.5 A (d) 1.6 A

129. A resonant AC circuit contains a capacitor of capacitance 10^{-6} F and an inductor of 10^{-4} H. The frequency of electrical oscillations will be
(a) 10^5 Hz (b) 10 Hz
(c) $\frac{10^5}{2\pi}$ Hz (d) $\frac{10}{2\pi}$ Hz

130. A charged 60 μF capacitor is connected to a 54 mH inductor. What is the angular frequency of free oscillations of the circuit?
(a) $5.5\ s^{-1}$
(b) $5.5 \times 10^2\ s^{-1}$
(c) $1.2\ s^{-1}$
(d) $1.1 \times 10^{-3}\ s^{-1}$

Topic 7

Transformers

131. Which of the following device, use the principle of mutual induction?
(a) Dynamo (b) Transformer
(c) Capacitor (d) Voltmeter

132. The value of emf in the secondary coil depends on
(a) the number of turns (b) material used
(c) voltage (d) induced flux

133. If the transformer is assumed to be 100% efficient(on energy losses), then
(a) the power input is equal to the power output
(b) the power input is less than the power output
(c) the power output is less than the power input
(d) All of the above

134. The large scale transmission and distribution of electrical energy over long distances is done with the use of
(a) dynamo (b) transformers
(c) generator (d) capacitor

135. If the secondary coil has less turns than the primary, then it is called
(a) step-up transformer (b) step-down transformer
(c) ideal transformer (d) Both (b) and (c)

136. A power transmission line feeds input power at 2300 V to a step-down transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V?
(a) 600 (b) 550
(c) 400 (d) 375

137. How much current is drawn by the primary coil of a transformer which steps down 220 V to 22 V to operate a device with an impedance of 220 Ω ?
(a) 1 A (b) 0.25 A (c) 0.01 A (d) 1.50 A

138. A 60 W load is connected to the secondary of a transformer whose primary draws line voltage of 220 V. If a current of 0.54 A flows in the load, then what is the current in the primary coil?
(a) 2.7 A (b) 0.27 A (c) 1.65 A (d) 2.85 A

139. 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 and the current in the primary coil respectively are **[CBSE AIPMT 2014]**
(a) 300 V, 15 A (b) 450 V, 15 A
(c) 450 V, 13.5 A (d) 600 V, 15 A

140. A step-down transformer is used on a 1000 V line to deliver 20 A at 120 V the secondary coil. If the efficiency of the transformer is 80%, then the current drawn from the line is
(a) 3 A (b) 30 A (c) 0.3 A (d) 2.4 A

141. The ratio of secondary to primary turns is 4 : 5. If power input is P, then the ratio of power output to power input is
(a) 4 : 9 (b) 9 : 4 (c) 5 : 4 (d) 1 : 1

142. A 220 V input is supplied to a transformer. The output circuit draws a current of 2.0 A at 440 V. If the efficiency of the transformer is 80%, the current drawn by the primary windings of the transformer is
(a) 5.0 A (b) 3.6 A (c) 2.8 A (d) 2.5 A

[Special Format Questions]

I. Assertion and Reason

Directions (Q. Nos. 143-151) *In the following questions, a statement of assertion is followed by a corresponding statement of reason. Of the following statements, choose the correct one.*
(a) Both Assertion and Reason are correct and Reason is the correct explanation of Assertion.
(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion.
(c) Assertion is correct but Reason is incorrect.
(d) Assertion is incorrect but Reason is correct.

143. Assertion Today, most of the electrical devices use/require AC voltage.

Reason Most of the electrical energy sold by power companies is transmitted and distributed as alternating current.

144. Assertion Phasors V and I for the case of a resistor are in the same direction.

Reason The phase angle between the voltage and the current is zero.

145. Assertion When the capacitor is connected to an AC source, it limits or regulates the current, but does not completely prevent the flow of charge.

Reason The capacitor is alternately charged and discharged as the current reverses each half-cycle.

146. Assertion Capacitor serves as a barrier for DC and offers an easy path to AC.

Reason Capacitor reactance is inversely proportional to frequency.

147. Assertion If $X_C > X_L$, ϕ is positive and the circuit is predominantly capacitive. The current in the circuit leads the source voltage.

Reason If $X_C < X_L$, ϕ is negative and the circuit is predominantly inductive, the current in the circuit lags the source voltage.

148. Assertion In a series *R-L-C* circuit, the voltages across resistor, inductor and capacitor are 8V, 16V and 10V, respectively. The resultant emf in the circuit is 10 V.

Reason Resultant emf of the circuit is given by the relation.

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

149. Assertion Resonance phenomenon is exhibited by a circuit only if both *L* and *C* are present in the circuit.

Reason Voltage across *L* and *C* cancel each other and the current amplitude is V_m / R, the total source voltage appearing across *R* causes resonance.

150. Assertion In series *L-C-R* circuit resonance can take place.

Reason Resonance takes place if inductance and capacitive reactances are equal and opposite.

151. Assertion The wire used for the windings of transformer has some resistance.

Reason Energy is lost due to heat produced in the wire (I^2R).

II. Statement Based Questions Type I

■ **Directions** (Q. Nos. 152-155) *In the following questions, a statement I is followed by a corresponding statement II. Of the following statements, choose the correct one.*

(a) Both Statement I and Statement II are correct and Statement II is the correct explanation of Statement I.
(b) Both Statement I and Statement II are correct but Statement II is not the correct explanation of Statement I.
(c) Statement I is correct but Statement II is incorrect.
(d) Statement I is incorrect but Statement II is incorrect.

152. Statement I The alternating current lags behind the emf by a phase angle of $\pi/2$, when AC flows through an inductor.

Statement II The inductive reactance increases as the frequency of AC source decreases.

153. Statement I The opposition offered by AC circuits to the flow of AC through it is defined as impedance. It's unit is ohm.

Statement II The opposition offered by inductor or capacitor or both to the flow of AC through it is defind as reactance.

154. Statement I A capacitor of suitable capacitance can be used in an AC circuit in place of the choke coil.

Statement II A capacitor blocks DC and allows AC only.

155. Statement I There is always some flux leakage; *i.e.*, not all of the flux due to primary passes through the secondary due to poor design of the core or the air gaps in the core.

Statement II Flux leakage can be reduced by winding the primary and secondary coils one over the other.

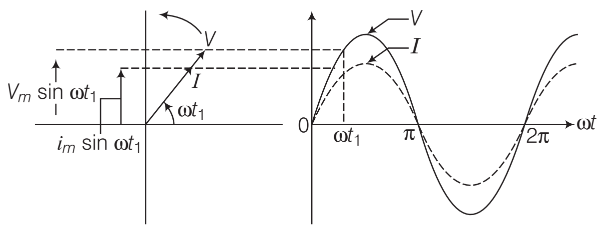
Statement Based Questions Type II

156. Consider the statements.

I. Most of the electrical devices we use require AC voltage.
II. Most of the electrical energy sold by power companies is transmitted and distributed as alternating current.
III. AC voltages can be easily and efficiently converted from one voltage to the other by means of transformers.

(a) I is correct, II and III are incorrect
(b) I, III are correct, II is incorrect
(c) I, II are correct, III is incorrect
(d) I,II and III are correct

157.



(a) (b)

Consider the figure,

I. The vertical components of phasors *V* and *I* represent the sinusoidally varying quantities *V* and *i*.
II. The magnitudes of phasors *V* and *I* represent the amplitudes or the peak values V_m and i_m of these oscillating quantities.

III. The projection of voltage and current phasors on vertical axis, *i.e.*, $V_m \sin \omega t$ and $i_m \sin \omega t$, respectively represent the value of voltage and current at that instant.

Which of the above statements is/are correct? Choose the correct option.

(a) I and II (b) I and III
(c) II and III (d) All of these

158. I. When a capacitor is connected to a voltage source in a DC circuit, current will flow for the short time required to charge the capacitor.

II. As charge accumulates on the capacitor plates, the voltage across them increases, opposing the current.

III. A capacitor in a DC circuit will limit or oppose the current as it charges.

IV. When the capacitor is fully charged, the current in the circuit falls to zero.

Which of the above statements are incorrect? Choose the correct option.

(a) I, II and III (b) II, III and IV
(c) I and IV (d) None of these

III. Matching Types

159. Match the following.

Column I	Column II
A. V_R	1. $\pi/2$ ahead of I
B. V_C	2. Parallel to I
C. V_L	3. $\pi/2$ behind I

	A	B	C		A	B	C
(a)	1	2	3	(b)	2	3	1
(c)	3	2	1	(d)	1	3	2

160. Match the following.

Column I	Column II
A. V_{Rm}	1. $i_m X_L$
B. V_{Cm}	2. $i_m R$
C. V_{Lm}	3. $i_m X_C$

	A	B	C		A	B	C
(a)	1	2	3	(b)	3	2	1
(c)	1	3	2	(d)	2	3	1

161. Match the following.

Column I	Column II
A. Resistive circuit	1. No power is dissipation
B. Purely inductive or capacitive circuit	2. Maximum power dissipation because of $X_C = X_L$
C. *L-C-R* series circuit	3. Power dissipated only in the resistor
D. Power dissipated at resonance in *L-C-R* circuit	4. Maximum power dissipation

	A	B	C	D		A	B	C	D
(a)	1	2	4	3	(b)	4	1	3	2
(c)	3	1	4	2	(d)	2	1	3	4

162. Match the following Column I and Column II.
When oscillations on spring are compared with *L-C* oscillations.

Column I	Column II
A. Mass m	1. Reciprocal of capacitance *i.e.*, $1/C$
B. Force constant k	2. Current, $i = dq/dt$
C. Displacement x	3. Inductance L
D. Velocity, $v = dx/dt$	4. Electromagnetic energy
E. Mechanical energy	5. $U = \frac{1}{2} q^2/C + \frac{1}{2} Li^2$
F. $E = \frac{1}{2} kx^2 + \frac{1}{2} mv^2$	6. Charge q

	A	B	C	D	E	F
(a)	1	5	4	3	2	6
(b)	6	4	2	3	1	5
(c)	3	1	6	2	4	5
(d)	2	4	5	6	3	1

IV. Passage Based Questions

■ **Directions** (Q. Nos. 163-166) *Answer the following questions based on given passage.*

A sinusoidal voltage of peak value 283 V and frequency 50 Hz is applied to a series *L-C-R* circuit in which $R = 3\Omega$, $L = 25.48$ mH and $C = 796\,\mu$F.

163. The impedance of the circuit and the phase difference between the voltage across the source and the current will be

(a) 5 Ω, 53.1° (b) 3 Ω, 50.3°
(c) 4 Ω, – 50.3° (d) 5Ω, – 53.1°

164. The power dissipated in the circuit and the power factor will be

(a) 480 W, 6.7 (b) 13.35 W, 66.6
(c) 4800 W, 0.6 (d) 11.09 W, 0.89

165. Let the frequency of the source can be varied. What is the frequency of the source at which resonance occurs?

(a) 13.35 Hz (b) 66.7 Hz
(c) 35.4 Hz (d) 25.5 Hz

166. Calculate the impedance, the current and the power dissipated at the resonant condition.

(a) 4 Ω, 13.35 A, 60 W
(b) 2Ω, 65 A, 13 kW
(c) 8 Ω, 66.7 A, 13.35 kW
(d) 3 Ω, 66.7 A, 13.35 kW

■ **Directions** (Q. Nos. 167-171) *Read the following paragraph and answer the following questions given below.*

A transformer is based on the principle of mutual induction. Input is supplied to primary coil and output is taken across the secondary coil of transformers. It is found that $E_s / E_p = i_p / i_s$ when there is no energy loss, the efficiency of a transformer is given by

$$\eta = \frac{P_{\text{output}}}{P_{\text{input}}} = \frac{E_s i_s}{E_p i_p}$$

167. How much current is drawn by the primary coil of a transformer which steps down 220 V to 44 V to operate a device with an impedance of 880 Ω?

(a) 1 A (b) 0.1 A
(c) 0.01 A (d) 0.02 A

168. A 110 V AC is connected to a transformer of ratio 10. If resistance of secondary coil is 550 Ω, current through secondary coil will be

(a) 10 A (b) 2 A
(c) zero (d) 55 A

169. A battery of 10 V is connected to primary of a transformer of ratio is 20. The output across secondary coil is

(a) 20 V (b) 5 V
(c) 10 V (d) zero

170. A transformer is having 2100 turns in primary and 4200 turns in secondary. An AC source of 120 V, 10 A is connected to its primary. The secondary voltage and current are

(a) 240 V, 5 A
(b) 120 V, 10 A
(c) 240 V, 10 A
(d) 120 V, 20 A

171. A transformer is used to light 140 W, 24 V lamp from 240 V AC mains. The current in the mains is 0.7 A. The efficiency of transformer is nearer to

(a) 90% (b) 80%
(c) 70% (d) 60%

V. More than One Option Correct

172. Choose the correct options.

(a) Phasor diagram say nothing about the initial condition.
(b) Any arbitrary value of t, draw different phasors which show the relative angle between different phasors. The solution, so obtained is called the steady-state solution.
(c) We do have a transient solution which exists even for $V = 0$. The general solution is the sum of transient solution and the steady-state solution.
(d) None of the above

173. Choose the correct options.

(a) The antenna of a radio accepts signals from many broadcasting stations.
(b) To hear one particular radio station, tune the radio.
(c) The signals picked up in the antenna acts as a source in the tuning circuit of the radio, so the circuit can be driven at many frequencies.
(d) In tuning, we vary the capacitance of a capacitor in the tuning circuit such that the resonant frequency of the circuit becomes nearly equal to the frequency of the radio signal received.

174. Choose the correct options.

(a) If the resonance is less sharp, not only is the maximum current less, the circuit is close to resonance for a larger range $\Delta\omega$ of frequencies and the tuning of the circuit will not be good.
(b) Less sharp the resonance, less is the selectivity of the circuit or *vice-versa.*
(c) If quality factor is large, *i.e.*, R is low or L is large, the circuit is more selective.
(d) None of the above

175. *L-C* oscillations is not realistic for the following reasons. Which of the following reasons is (are) correct?

(a) Every inductor has some resistance.
(b) The effect of resistance is to introduce a damping effect on the charge and current in the circuit and the oscillations finally die away.
(c) Even if the resistance is zero, the total energy of the system would not remain constant. It is radiated away from the system in the form of electromagnetic waves.
(d) None of the above

NCERT & NCERT Exemplar Questions

NCERT

176. A 100 Ω resistor is connected to a 220 V, 50 Hz AC supply, then the rms value of current in the circuit is
(a) 2.2 A (b) 4.2 A (c) 3.2 A (d) 2.4 A

177. The peak voltage of an AC supply is 300 V, then the rms voltage will be
(a) 212.1 V (b) 312.1 V
(c) 84.2 V (d) 85.2 V

178. A 44 mH inductor is connected to 220 V, 50 Hz AC supply. Determine the rms value of the current in the circuit.
(a) 20.4 A (b) 15.9 A (c) 21.4 A (d) 22.4 A

179. A 60 μF capacitor is connected to a 110 V, 60 Hz AC supply. The rms value of the current in the circuit will be
(a) 4.49 A (b) 2.29 A
(c) 2.49 A (d) 3.49 A

180. Obtain the resonant frequency ω of a series *L-C-R* circuit with $L = 2.0$ H, $C = 32$ μF and $R = 10$ Ω. What is the *Q*-value of this circuit?
(a) 36 (b) 27 (c) 24 (d) 25

181. A charged 30 μF capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit?
(a) 1.1×10^4 rads^{-1} (b) 1.1×10^3 rads^{-1}
(c) 1.1×10^2 rads^{-1} (d) 1.1×10 rads^{-1}

182. A series *L-C-R* circuit with $R = 20$ Ω, $L = 1.5$ H and $C = 35$ μF is connected to a variable frequency 200 V AC supply. When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle?
(a) 2 kW (b) 3 kW
(c) 4 kW (d) 5 kW

183. A radio can tune over the frequency range of a portion of MW broadcast band: (800 kHz to 1200 kHz). If its *L-C* circuit has an effective inductance of 200 μH, what must be the range of its variable capacitor?
(a) 49 to 79 (b) 88 to 198
(c) 100 to 200 (d) 110 to 200

184. A coil of inductance 0.50 H and resistance 100 Ω is connected to a 240 V, 50 Hz AC supply. What is the maximum current in the coil?
(a) 1.824 A (b) 2.824 A
(c) 3.824 A (d) 4.824 A

185. A 100 μF capacitor in series with a 40 Ω resistance is connected to a 110 V, 60 Hz supply. What is the maximum current in the circuit?
(a) 3.00 A (b) 3.24 A (c) 4.24 A (d) 2.24 A

186. A power transmission line feeds input power at 2300 V to a step-down transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V?
(a) 400 (b) 450 (c) 800 (d) 230

187. At a hydroelectric power plant, the water pressure head is at a height of 300 m and the water flow available is 100 m^3/s. If the turbine generator efficiency is 60%, the electric power available from the plant will be
(a) 184.4 MW (b) 176.4 MW
(c) 190.4 MW (d) 290.4 MW

NCERT Exemplar

188. If the rms current in a 50 Hz AC circuit is 5 A, the value of the current 1/300 s after its value becomes zero is
(a) $5\sqrt{2}$ A (b) $5\sqrt{3/2}$ A (c) $5/6$ A (d) $5/\sqrt{2}$ A

189. An alternating current generator has an internal resistance R_g and an internal reactance X_g. It is used to supply power to a passive load consisting of a resistance R_g and a reactance X_L. For maximum power to be delivered from the generator to the load, the value of X_L is equal to
(a) zero (b) X_g (c) $-X_g$ (d) R_g

190. When a voltage measuring device is connected to AC mains, the meter shows the steady input voltage of 220 V. This means
(a) input voltage cannot be AC voltage, but a DC voltage
(b) maximum input voltage is 220 V
(c) the meter reads not v but $< v^2 >$ and is calibrated to read $\sqrt{< v^2 >}$
(d) the pointer of the meter is stuck by some mechanical defect

191. To reduce the resonant frequency in an *L-C-R* series circuit with a generator.
(a) The generator frequency should be reduced
(b) Another capacitor should be added in parallel to the first
(c) The iron core of the inductor should be removed
(d) Dielectric in the capacitor should be removed

192. 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) $R = 25\,\Omega, L = 1.5\,H, C = 45\mu F$

193. An inductor of reactance 1Ω and a resistor of 2Ω are connected in series to the terminals of a 6V (rms) AC source. The power dissipated in the circuit is

(a) 8 W (b) 12 W (c) 14.4 W (d) 18 W

194. The output of a step-down transformer is measured to be 24 V when connected to a 12 W light bulb. The value of the peak current is

(a) $1/\sqrt{2}$ A (b) $\sqrt{2}$ A (c) 2 A (d) $2\sqrt{2}$ A

195. As the frequency of an AC circuit increases, the current first increases and then decreases. What combination of circuit elements is most likely to comprise the circuit?

(a) Inductor and capacitor
(b) Resistor and inductor
(c) Resistor and capacitor
(d) Resistor, inductor and capacitor

196. In an alternating current circuit consisting of elements in series, the current increases on increasing the frequency of supply. Which of the following elements are likely to constitute the circuit?

(a) Only resistor (b) Resistor and an inductor
(c) Resistor and a capacitor (d) Only a capacitor

197. Electrical energy is transmitted over large distances at high alternating voltages. Which of the following statements is (are) correct?

(a) For a given power level, there is a lower current
(b) Lower current implies less power loss
(c) Transmission lines can be made thinner
(d) It is easy to reduce the voltage at the receiving end using step-down transformers

198. For a L-C-R circuit, the power transferred from the driving source to the driven oscillator is $P = I^2 Z \cos\phi$.

(a) Here, the power factor $\cos\phi \geq 0, P \geq 0$
(b) The driving force can give no energy to the oscillator $(P = 0)$ in some cases
(c) The driving force cannot syphon out $(P < 0)$ the energy out of oscillator
(d) The driving force can take away energy out of the oscillator

199. When an AC voltage of 220 V is applied to the capacitor C

(a) the maximum voltage between plates is 220 V
(b) the current is in phase with the applied voltage
(c) the charge on the plates is in phase with the applied voltage
(d) power delivered to the capacitor is zero

200. The line that draws power supply to your house from street has

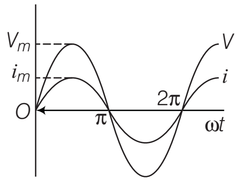
(a) zero average current
(b) 220 V average voltage
(c) voltage and current out of phase by 90°
(d) voltage and current possibly differing in phase ϕ such that $|\phi| < \pi/2$

Answers

1.	(a)	2.	(d)	3.	(b)	4.	(d)	5.	(a)	6.	(b)	7.	(c)	8.	(d)	9.	(d)	10.	(c)	11.	(b)	12.	(b)	13.	(c)	14.	(c)	15.	(a)
16.	(b)	17.	(b)	18.	(a)	19.	(c)	20.	(a)	21.	(d)	22.	(c)	23.	(b)	24	(d)	25.	(c)	26.	(c)	27.	(c)	28.	(d)	29.	(a)	30.	(c)
31.	(a)	32.	(a)	33.	(c)	34.	(b)	35.	(a)	36.	(c)	37.	(b)	38.	(a)	39.	(c)	40.	(d)	41.	(b)	42.	(b)	43.	(a)	44.	(a)	45.	(a)
46.	(d)	47.	(a)	48.	(c)	49.	(c)	50.	(b)	51.	(a)	52.	(b)	53.	(d)	54.	(d)	55.	(a)	56.	(c)	57.	(d)	58.	(c)	59.	(c)	60.	(d)
61.	(b)	62.	(a)	63.	(c)	64.	(b)	65.	(a)	66.	(c)	67.	(c)	68.	(a)	69.	(a,c)	70.	(d)	71.	(d)	72.	(b)	73.	(a)	74.	(a)	75.	(d)
76.	(c)	77.	(b)	78.	(d,a)	79.	(a)	80.	(a)	81.	(a)	82.	(b)	83.	(a)	84.	(a)	85.	(c)	86.	(c)	87.	(b)	88.	(b)	89.	(a)	90.	(b)
91.	(a)	92.	(c)	93.	(c)	94.	(b)	95.	(a)	96.	(c)	97.	(c)	98.	(a)	99.	(b)	100.	(d)	101.	(c)	102.	(d)	103.	(c)	104.	(a)	105.	(c)
106.	(d)	107.	(d)	108.	(d)	109.	(d)	110.	(a)	111.	(b)	112.	(b)	113.	(d)	114.	(b)	115.	(b)	116.	(d)	117.	(c)	118.	(b)	119.	(a)	120.	(c)
121.	(d)	122.	(a)	123.	(b)	124.	(b)	125.	(d)	126.	(b)	127.	(a)	128.	(a)	129.	(c)	130.	(b)	131.	(b)	132.	(a)	133.	(a)	134.	(b)	135.	(b)
136.	(c)	137.	(c)	138.	(b)	139.	(b)	140.	(a)	141.	(d)	142.	(a)	143.	(a)	144.	(a)	145.	(a)	146.	(a)	147.	(b)	148.	(a)	149.	(a)	150.	(a)
151.	(b)	152.	(c)	153.	(b)	154.	(b)	155.	(b)	156.	(d)	157.	(d)	158.	(d)	159.	(b)	160.	(a)	161.	(b)	162.	(c)	163.	(d)	164.	(c)	165.	(c)
166.	(d)	167.	(c)	168.	(b)	169.	(d)	170.	(a)	171.	(b)	172.	(a,b,c)	173.	(a,b,c,d)	174.	(a,b,c)	175.	(a,b,c)	176.	(a)	177.	(a)	178.	(b)	179.	(c)	180.	(d)

Hints *and* Explanations

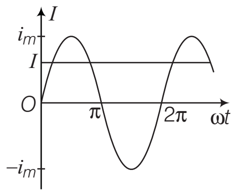
6. (*b*)



In a pure resistor, the voltage and current are in phase. The minima zero and maxima occur at the same respective times.

8. (*d*) Joule heating is given by $i^2 R$ and depends on i^2 (which is always positive whether i is positive or negative) and not on i. Thus, there is joule heating and dissipation of electrical energy when an AC current passes through a resistor.

10. (*c*)



The rms current I is related to the peak current i_m by

$$I = i_m/\sqrt{2} = 0.707\, i_m.$$

11. (*b*) $V_m = \sqrt{2}\;\; V = (1.414)\,(220\text{ V}) = 311\text{ V}$

12. (*b*) We are given $P = 100$ W and 220 V. The resistance of the bulb is

$$R = \frac{V^2}{P} = \frac{(220\text{ V})^2}{100\text{ W}} = 484\ \Omega$$

13. (*c*) The general equation for the AC voltage is $\varepsilon = \varepsilon_0 \sin(\omega t + \theta)$.

Comparing it with the given equation, we find that

$$\varepsilon = V,\ \varepsilon_0 = 169\text{ V},\ \omega = 314,\ \theta = 60°$$

Let ε_{rms} and I_{rms} represent the rms value of AC voltage and current, respectively. Clearly,

$$\varepsilon_{rms} = \frac{\varepsilon_0}{\sqrt{2}} = \frac{169}{\sqrt{2}}\text{ V} = 119.5\text{ V}$$

$$P = \frac{V^2}{R}$$

$$\Rightarrow \quad R = \frac{V^2}{P} = \frac{(220)^2}{600}$$

$$i_{rms} = \frac{119.5 \times 600}{(220)^2} = 1.48\text{ A} \qquad (\because V_{rms} = I_{rms} R)$$

14. (*c*) We are given that, $\varepsilon_{rms} = 220$ V, $\nu = 50$ Hz

As, $\quad \varepsilon_{rms} = \dfrac{\varepsilon_0}{\sqrt{2}},\ \varepsilon_0 = \varepsilon_{rms}\sqrt{2}$

$$(220\text{ V})\,(1.414) = 311.1\text{ V}$$

Further, $\omega = 2\pi\nu = 2\pi \times 50 = 100\,\pi\ \text{rads}^{-1}$

Thus, the equation for the instantaneous voltage is given as $\varepsilon = \varepsilon_0 \sin \omega t = 311.1\text{ V} \sin(100\pi)\, t$

15. (*a*) As, $\quad i = i_0 (t/\tau)$

$$i^2 = \frac{\int_0^\tau i^2\, dt}{\tau} = \frac{\int_0^\tau i_0^2\,(t/\tau)^2\, dt}{\tau}$$

$$= \frac{i_0^2}{\tau^3}\int_0^\tau t^2 dt = \frac{i_0^2}{\tau^3} \times \frac{\tau^3}{3} = \frac{i_0^2}{3}$$

Thus, $\quad i_{rms} = \sqrt{i^2} = \sqrt{\dfrac{i_0^2}{3}} = \dfrac{i_0}{\sqrt{3}}$

17. (*b*) The rms value of voltage *i.e.*,

$$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{120}{1.414} = 84.8\text{ V}$$

22. (*c*) Phase difference $\Delta\phi = \phi_2 - \phi_1 = \pi/6 - (-\pi/6) = \pi/3$

24. (*d*) The current takes $\dfrac{T}{4}$ seconds to reach the peak value. In the given question, $\dfrac{2\pi}{T} = 200\,\pi \;\Rightarrow\; T = \dfrac{1}{100}$ s

$\therefore$ Time to reach the peak value $= \dfrac{1}{400}$ s.

25. (*c*) Frequency of a generator *i.e.,*

$$\nu = \frac{\omega}{2\pi} = \frac{120 \times 7}{2 \times 22} = 19\text{ Hz} \quad \Rightarrow \nu_{rms} = \frac{240}{\sqrt{2}} = 120\sqrt{2} \approx 170\text{ V}$$

26. (*c*) Let $i_1 = A\sin\phi$; $i_2 = A\sin\phi$

$i = A\sin(\omega t + \phi)$, where $A = \sqrt{i_1^2 + i_2^2}$

So, $i = \sqrt{i_1^2 + i_2^2}\,\sin(\omega t + \phi)$; $i_{rms} = \dfrac{i_0}{\sqrt{2}} = \dfrac{\sqrt{i_1^2 + i_2^2}}{\sqrt{2}}$

27. (*c*) Hot wire ammeter reads rms value of current. Hence, its peak value $i_0 = i_{rms} \times \sqrt{2} = 10 \times 1.414 = 14.14$ A.

28. (*d*) Current in at peak value so its equation is

$$i = i_0(100\pi t + \pi/2)$$

Peak value to rms value means current becomes $1/\sqrt{2}$ times.

So, from $\quad i = i_0 \sin(100\,\pi t + \pi/2)$

$$\frac{i_0}{\sqrt{2}} = i_0 \sin(100\pi t + \pi/2)$$

$$\sin 3\pi/4 = \sin(100\pi t + \pi/2) \quad \Rightarrow \quad t = \frac{1}{400}\text{ s}$$

Time taken by current to change from its peak value to rms value,

i.e., $\quad t = \dfrac{1}{400}\text{ s} = 2.5 \times 10^{-3}$ s

29. (*a*) $V_{av} = \dfrac{2}{\pi}V_0 = \dfrac{2}{\pi} \times (V_{rms} \times \sqrt{2}) = \dfrac{2\sqrt{2}}{\pi}V_{rms}$

$$= \frac{2\sqrt{2}}{\pi} \times 220 = 198\text{ V}$$

30. (*c*) Here, $E = 141 \sin(628\, t)$

$$E_{rms} = \frac{E_0}{\sqrt{2}} = \frac{141}{1.41} = 100\text{ V}$$

Angular displacement *i.e.,* $\omega = 628$ and $2\pi f = 628$

$$\therefore \quad f = \frac{628}{2\times 3.14} = 100 \text{ Hz}$$

32. (*a*) Using the Kirchhoff's loop rule, $\Sigma\varepsilon\,(t) = 0$ and since there is no resistor in the circuit.

An AC source connected to an inductor

$$V - L\,(di/dt) = 0$$

36. (*c*) Inductive reactance $X_L = \omega L = 2\pi f L$

39. (*c*) The inductive reactance,

$$X_L = 2\pi\nu L = 2\times 3.14\times 50\times 25\times 10^{-3} = 7.85\ \Omega$$

40. (*d*) The rms current in the circuit is

$$I = \frac{V}{X_L} = \frac{220\text{ V}}{7.85\,\Omega} = 28 \text{ A}$$

41. (*b*) Inductive reactance, $X_L = \omega L \Rightarrow X_L \propto \omega$

Hence, inductive reactance increases linearly with angular frequency.

42. (*b*) The inductive reactance,

$$X_L = 2\pi\nu L = 2\times 3.14\times(50\text{s}^{-1})\times(30.0\times 10^{-3}\text{ H}) = 9.42\ \Omega$$

43. (*a*) The reactance (X_L) of the inductance at 200 Hz is 120 Ω .

As, $X_L = \omega L = 2\pi\nu\times L$

$$L = \frac{X_L}{2\pi\nu} = \frac{120\ \Omega}{2\pi\times 200\text{ s}^{-1}} = \frac{3}{10\pi}\text{ H}$$

If X'_L denotes the reactance of the same inductance at 60 Hz,

$$X'_L = \omega' L = 2\pi\nu' L$$

or

$$X'_L = (2\pi\times 60\text{ s}^{-1})\left(\frac{3\text{H}}{10\pi}\right) = 36\ \Omega$$

If I_{rms} is the current that flows through the inductance when connected to 240 V and 60 Hz power line, then

$$I_{\text{rms}} = \frac{\varepsilon_{\text{rms}}}{X'_L} = \frac{240\ V}{36\ \Omega} = 6.66 \text{ A}$$

46. (*d*) $V = -L\,(di/dt)$, V is proportional to the slope of the i - t graph, which is constant and positive for the first half (0 to $T/2$) and negative and constant for the second half ($T/2$ to T). Note : $|V| = L\,(di/dt)$ in this case.

For first half V is –ve and for the second half it is + ve.

47. (*a*) Phase angle,

$$\tan\phi = \frac{\omega L}{R} = \frac{2\pi\nu L}{R} = \frac{2\pi\times 200}{300}\times\frac{1}{\pi} = \frac{4}{3} \Rightarrow \phi = \tan^{-1} 4/3$$

48. (*c*) When $t = 0$ due to large impedance of two inductor current will flow only in 12Ω.

$$\therefore \quad I_{\min} = 5/12.$$

After sometime current become is steady then $R = 12\ \Omega$ will go out of circuit only r_1 and r_2 will be effective route of current flow.

$$r_{\text{eff}} = 2\ \Omega \Rightarrow I_{\max} = \frac{5}{2} \Rightarrow \frac{I_{\max}}{I_{\min}} = 6$$

49. (*c*) Energy stored in an inductor L carrying current i is

$$U = (1/2)\,Li^2$$

Rate at which energy is stored $= \dfrac{dU}{dt} = \dfrac{1}{2}L\,2i\left(\dfrac{di}{dt}\right) = Li\left(\dfrac{di}{dt}\right)$

At $t = 0, i = 0 \Rightarrow dU/dt = 0$

At $t = \infty, i = i_0$ (constant)

$$\therefore \quad \frac{di}{dt} = 0 \Rightarrow \frac{dU}{dt} = 0$$

50. (*b*) Current I across the capacitor is $i_m \sin(\omega t + \pi/2)$.

51. (*a*) The amplitude of the oscillating current is

$$I_m = V_m/X_C = \omega C V_m.$$

57. (*d*) The current reaches its maximum value earlier than the volage by one-fourth of a period.

58. (*c*) The capacitive reactance is

$$X_C = \frac{1}{2\pi\nu C} = \frac{1}{2\pi\ (50\text{ Hz})\ (15.0\times 10^{-6}\text{ F})} = 212\ \Omega$$

59. (*c*) The rms current is $i = \dfrac{V}{X_C} = \dfrac{220\text{ V}}{212\,\Omega} = 1.04$ A

The peak current is $i_m = \sqrt{2}\,i = (1.41)\,(1.04\text{ A}) = 1.47$ A

60. (*d*) For the first circuit, $i = \dfrac{V}{Z} = \dfrac{V}{\omega L}$

So, increase in ω will cause a decrease in i.

For the second circuit, $i = \dfrac{V}{1/\omega C}$

Hence, increase in ω will cause an increase in i.

61. (*b*) Reading of ammeter $= i_{\text{rms}} = \dfrac{V_{\text{rms}}}{X_C} = \dfrac{V_0\omega C}{\sqrt{2}}$ $\left(\because X_C = \dfrac{1}{\omega C}\right)$

$$= \frac{200\sqrt{2}\times 100\times(1\times 10^{-6})}{\sqrt{2}}$$

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

62. (*a*) If the frequency is doubled, the capacitive reactance is halved and the current is doubled.

63. (*c*) Capacitive reactance, $X_C = \dfrac{1}{\omega C} = \dfrac{1}{2}\pi f C \Rightarrow X_C \propto \dfrac{1}{f}$

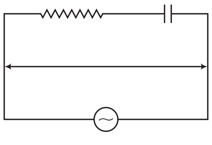
With increase in frequency, X_C decreases.

Hence, option (c) represents the correct graph.

64. (*b*) $X_C = \dfrac{1}{2\pi\nu C} = \dfrac{1}{2\ (3.14)\ (60\text{ s}^{-1})\ (60\times 10^{-6}\text{ F})} = 44.2\ \Omega$

$$I_{\text{rms}} = \frac{\varepsilon_{\text{rms}}}{X_C} = \frac{110\text{ V}}{44.2\ \Omega} = 2.49 \text{ A}$$

65. (*a*) Let the applied voltage be V volt.



Here, $V_R = 12$ V, $V_C = 5$ V

$$V = \sqrt{V_R^2 + V_C^2} = \sqrt{(12)^2 + (5)^2}$$

$$= \sqrt{144 + 25} = \sqrt{169} = 13 \text{ V}$$

66. (*c*) Impedance of the circuit

$$Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + (2\pi\nu C)^{-2}}$$

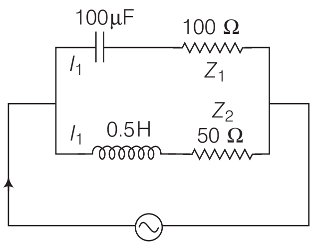
$$= \sqrt{(200\ \Omega)^2 + (2\times 3.14\times 50\times 15\times 10^{-6}\text{ F})^{-2}}$$

$$= \sqrt{(200\ \Omega)^2 + (212\ \Omega)^2} = 291.5\ \Omega$$

Therefore, the current in the circuit is

$$i = V/Z = \frac{220\text{ V}}{291.5\,\Omega} = 0.755 \text{ A}$$

69. (*a,c*)



Circuit 1

$$X_C = \frac{1}{\omega C} = 100\ \Omega \Rightarrow Z_1 = \sqrt{(100)^2 + (100)^2} = 100\sqrt{2}\ \Omega$$

$$\phi_1 = \cos^{-1}\left(\frac{R_1}{Z_1}\right) = 45°$$

In this circuit current leads the voltage.

$$i_1 = \frac{V}{Z_1} = \frac{20}{100\sqrt{2}} = \frac{1}{5\sqrt{2}}\text{ A} \Rightarrow V_{100\Omega} = (100)i_1 = (100)\frac{1}{5\sqrt{2}}$$

V

$$= 10\sqrt{2}\text{ V}$$

Circuit 2

$$X_L = \omega L = (100)(0.5) = 50\ \Omega$$

$$Z_2 = \sqrt{(50)^2 + (50)^2} = 50\sqrt{2}\ \Omega$$

$$\phi_2 = \cos^{-1}\left(\frac{R_2}{Z_2}\right) = 45°$$

In this circuit voltage leads the current.

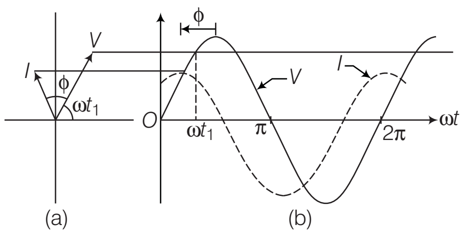
$$i_2 = \frac{V}{Z_2} = \frac{20}{50\sqrt{2}} = \frac{\sqrt{2}}{5}\text{A}$$

$$V_{50\,\Omega} = (50)i_2 = 50\left(\frac{\sqrt{2}}{5}\right) = 10\sqrt{2}\text{ V}$$

Further, i_1 and i_2 have a mutual phase difference of 90°.

$$\therefore \qquad i = \sqrt{i_1^2 + i_2^2} = \sqrt{\frac{1}{50} + \frac{4}{50}} = \frac{1}{\sqrt{10}}\text{ A} \approx 0.3\text{ A}$$

70. (*d*)



For $X_C > X_L$, peak of i comes before peak of V.

72. (*b*) $V_{CR} = \sqrt{V_C^2 + V_R^2} = \sqrt{(50)^2 + (50)^2}$

$$= \sqrt{2500 + 2500} = \sqrt{5000} = 10\sqrt{50} = 50\sqrt{2}\text{ V}$$

73. (*a*) Given, $R = 3\Omega$, $X_L = 15\Omega$, $X_C = 11\,\Omega \Rightarrow V_{\text{rms}} = 10\text{ V}$

∴Current through the circuit

$$i = \frac{V_{\text{rms}}}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{10}{\sqrt{(3)^2 + (15-11)^2}}$$

$$= \frac{10}{\sqrt{9+16}} = \frac{10}{5} = 2\text{ A}$$

Since L,C and R are connected in series combination, then potential difference across R is

$$V_R = i\,X_R = 2 \times 3 = 6\text{V}$$

Across L, $V_L = i\,X_L = 2 \times 15 = 30$ V

Across C, $V_C = i\,X_C = 2 \times 11 = 22$ V

So, potential difference across series combination of L and C

$$= V_L - V_C = 30 - 22 = 8\text{ V}$$

74. (*a*) $\tan\phi = \dfrac{X_C - X_L}{R}$

$$\Rightarrow \tan 45° = \frac{\frac{1}{2\pi f C} - 2\pi f L}{R} \Rightarrow C = \frac{1}{2\pi f\,(2\pi f\,L + R)}$$

75. (*d*) Net voltage across *L-C* combination $= V_L - V_C = 0$ V.

76. (*c*) As $V = \sqrt{(V_L - V_C)^2 + V_R^2}$, $220 = \sqrt{(300-300)^2 + V_R^2}$

or $\quad V_R = 220$ V, $i = \dfrac{V_R}{R} = \dfrac{220\text{ V}}{100\ \Omega} = 2.2$ A

77. (*b*) The impedance of the circuit is

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

$$X_L = \omega L = 400 \times 20 \times 10^{-3} = 8\text{ H}$$

$$\Rightarrow \qquad X_C = \frac{1}{\omega C} = \frac{1}{400 \times 625 \times 10^{-6}} = 4\text{ F}$$

$$\Rightarrow \qquad Z = \sqrt{(3)^2 + (8-4)^2} = 5 \Rightarrow i = \frac{E}{Z} = \frac{300}{5} = 60\text{ A}$$

79. (*a*) In *L-C-R* series circuit

$$V = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{(40)^2 + (60-30)^2}$$

$$= \sqrt{1600 + 900} = \sqrt{2500} = 50\text{ V}$$

80. (*a*) At angular frequency ω, the current in *R-C* circuit is given by

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

Also, $$\frac{I_{\text{rms}}}{2} = \frac{V_{\text{rms}}}{\sqrt{R^2 + \left[\frac{1}{\omega C/3}\right]^2}} = \frac{V_{\text{rms}}}{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}} \qquad \text{...(ii)}$$

From Eqs. (i) and (ii), we get

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

84. (*a*) $\omega_0 = \dfrac{1}{\sqrt{LC}} = 1.00 \times 10^3$ rad / s.

86. (*c*) At resonance, current in the circuit is maximum.

87. (*b*) Bandwidth of the resonant *R-L-C* circuit is $\Delta\omega = \dfrac{R}{2L}$.

88. (*b*) The quantity $(\omega_0/2\Delta\omega)$ is regarded as measure of the sharpness of resonance. The smaller the Δω, the sharper is the resonance.

90. (*b*) The Q-factor of series resonant circuit is given as

$$Q = \frac{\text{voltage across } L \text{ or } C}{\text{applied voltage} (= \text{voltage across } R)}$$

$$= \frac{(\omega_r L) i}{R i} = \frac{\omega_r L}{R}$$

Here, $L = 8.1\,\text{mH}, C = 12.5\,\mu\text{F}, R = 10\,\Omega,\ f = 500\,\text{Hz}$

$$\therefore \quad Q = \frac{\omega_r L}{R} = \frac{2\pi f L}{R} = \frac{2 \times \pi \times 500 \times 8.1 \times 10^{-3}}{10} = 2.5434$$

91. (*a*) Resonance frequency

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8 \times 10^{-3} \times 20 \times 10^{-6}}} = 2500 \text{ rads}^{-1}$$

Resonant current $= V_m / R = \dfrac{220\sqrt{2}}{44} = 5\sqrt{2}$ A

92. (*c*) Resonance $X_L = X_C \Rightarrow \omega L = \dfrac{1}{\omega C}$

Since, resonant frequency remains unchanged

$$\sqrt{LC} = \text{constant}$$

$$L_1 C_1 = L_2 C_2 \Rightarrow LC = L_2 (2C) \Rightarrow K_2 = L/2.$$

93. (*c*) In non-resonant circuits,

Impedance, $Z = \sqrt{R^2 + \left(\omega L - \dfrac{1}{\omega C}\right)^2}$, with rise in frequency Z increases *i.e.*, current decrease, so circuit behaves as inductive circuit.

At lower frequency $\dfrac{1}{\omega L} > \omega L$ the circuit becomes capacitative. At higher frequency, the circuit is inductive.

94. (*b*) At resonance, $X_L = X_C$ or $\omega L = \dfrac{1}{\omega C}$

or $\quad L = \dfrac{1}{\omega^2 C} = \dfrac{1}{(200)^2 \times 2 \times 10^{-6}} = 12.5$ H

As, $\quad I_0 = \dfrac{V_R}{R} = \dfrac{100 \text{ V}}{1000\ \Omega} = 0.1$ A

$$V_L = i_0 X_L = i_0 \omega L = (0.1 \text{ A})\,(200 \text{ s}^{-1})\,(12.5 \text{ H}) = 250 \text{ V}$$

95. (*a*) Angular velocity, $\omega_0 = 2\pi n = 2\pi \times 100$

$$\omega_0 = 2 \times 3 \times 100 = 600 \text{ rads}^{-1} \qquad (\because \pi = 3)$$

Further $\quad \omega_0 = \dfrac{1}{\sqrt{LC}} \quad \ldots$(i)

Also $\quad X_C = \dfrac{1}{C\omega_0} = 60\,\Omega$

$$\Rightarrow \quad C = \frac{1}{\omega_0 \times 60} = \frac{1}{600 \times 60} \quad \Rightarrow \quad C = \frac{1}{36 \times 10^3} \text{ F}$$

So, put values in Eq. (i), we get

$$600 = \frac{1}{\sqrt{L\left(\dfrac{1}{36 \times 10^3}\right)}}$$

$$\Rightarrow \quad 36 \times 10^4 = \frac{36 \times 10^3}{L} \quad \Rightarrow \quad L = \frac{36 \times 10^3}{36 \times 10^4} = \frac{1}{10} = 0.1\,\text{H}$$

96. (*c*) In the condition of resonance,

$$X_L = X_C \quad \Rightarrow \quad \omega L = 1/\omega C$$

Since, resonant frequency remains unchanged,

So, $\quad \sqrt{LC} = \text{constant}$

$$\Rightarrow \quad L_1 C_1 = L_2 C_2 \Rightarrow L \times C = L_2 \times 16C \quad \Rightarrow \quad L_2 = \frac{L}{16}$$

97. (*c*) This is a parallel resonant circuit in which current becomes zero at resonance.

99. (*b*) Resonant frequency $\nu = \dfrac{1}{2\pi\sqrt{LC}}$

$$\therefore \quad \nu = \frac{1}{2 \times 3.14 \times \sqrt{5 \times 80 \times 10^{-6}}}$$

$$= \frac{1}{2 \times 3.14 \sqrt{(400 \times 10^{-6})}} = \frac{1}{2 \times 3.14 \times 2 \times 10^{-2}}$$

$$= \frac{100}{3.14 \times 4} = \frac{25}{3.14} = \frac{25}{\pi} \text{ Hz}$$

100. (*d*) $C = 0.2\,\mu\text{F} = 0.02 \times 10^{-6}$ F, $L = 8\mu\text{H} = 8 \times 10^{-6}$ H

Thus, frequency of a circuit *i.e.*, $\nu = \dfrac{1}{2\pi\sqrt{LC}}$

$$= \frac{1}{2 \times 3.14 \sqrt{(8 \times 10^{-6})\,(0.02 \times 10^{-6})}} \text{ Hz}$$

$$= \frac{1}{2 \times 3.14 \times 0.4} \times 10^6 \text{ Hz} = 3.98 \times 10^5 \text{ Hz}$$

Wavelength of electromagnetic wave,

$$\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{3.98 \times 10^5} = 753.8 \text{ m}$$

101. (*c*) At resonance, $\omega L = \dfrac{1}{\omega C}$

Current flowing through the circuit,

$$I = \frac{V_R}{R} = \frac{100}{1000} = 0.1\,\text{A}$$

So, voltage across L is given by

$$V_L = I X_L = I \omega L$$

but $\quad \omega L = \dfrac{1}{\omega C} \quad \Rightarrow \quad V_L = V_C = \dfrac{0.1}{200 \times 2 \times 10^{-6}} = 250$ V

103. (*c*) $V_{\text{rms}} = \dfrac{200}{\sqrt{2}}, i_{\text{rms}} = \dfrac{1}{\sqrt{2}}$

$\therefore$ Average power consumed *i.e.*, A

$$P = V_{\text{rms}}\, i_{\text{rms}} \cos\phi = \frac{200}{\sqrt{2}} \frac{1}{\sqrt{2}} \cos \pi/3 = 50 \text{ W}$$

104. (*a*) Given, $V = 5 \cos \omega t = 5 \sin\left(\omega t + \dfrac{\pi}{2}\right)$ and $i = 2 \sin \omega t$

Power dissipated in the instrument *i.e.*,

$$= V_{\text{rms}} \times i_{\text{rms}} \times \cos\phi = 0$$

$$\left(\text{since, } \phi = \frac{\pi}{2}, \text{ therefore } \cos\phi = \cos\frac{\pi}{2} = 0\right)$$

105. (*c*) Power dissipated in the circuit

$$P = V_{\text{rms}} \times i_{\text{rms}} \times \cos\phi = \frac{100}{\sqrt{2}} \times \frac{100 \times 10^{-3}}{\sqrt{2}} \times \cos\frac{\pi}{3}$$

$$= \frac{10^4 \times 10^{-3}}{2} \times \frac{1}{2} = \frac{10}{4} = 2.5 \text{ W}$$

106. (*d*) Power consumption *i.e.,* $P = Vi \cos\phi$

Phase difference, $\phi = \pi/2 \Rightarrow P = Vi\cos\pi/2 = Vi \times 0 = 0$

107. (*d*) The average power over a complete cycle is

$$P_L = \left[-\frac{i_m V_m}{2}\sin(2\omega t)\right] = -\frac{i_m V_m}{2}\langle\sin(2\omega t)\rangle = 0$$

Since, the average of $\sin(2\omega t)$ over a complete cycle is zero. Thus, the average power supplied to an inductor over one complete cycle is zero.

108. (*d*) Phase angle $\phi = 90°$, so power $P = VI\cos\phi = 0$ or the given circuit is a pure inductive circuit, hence power dissipate is zero.

109. (*d*) As in the case of an inductor, the average power in capacitor

$$P_C = \left\langle\frac{i_m V_m}{2}\sin(2\omega t)\right\rangle = \frac{i_m V_m}{2}\langle\sin(2\omega t)\rangle = 0$$

Since, $<\sin(2\omega t)> = 0$ over a complete cycle.

111. (*b*) The resistor dissipates energy in the circuit. The inductor and capacitor both store energy but they eventually return it to the circuit without dissipation.

113. (*d*) As $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi f v L)^2}$

As $\quad i = \frac{V}{Z}, P = i^2 R$

i.e., $V\uparrow, L\uparrow \Rightarrow Z\uparrow, i\downarrow$ and $P\downarrow$

114. (*b*) Power consumed by lamp

i.e., $\quad P = (1/2)V_0 i_0 \cos\phi \Rightarrow P = P_{peak}\cdot\cos\phi$

$\Rightarrow \frac{1}{2}(P_{peak}) = P_{peak}\cos\phi$

$\Rightarrow \cos\phi = \frac{1}{2} \Rightarrow \cos\phi = \frac{1}{2} \Rightarrow \phi = \frac{\pi}{3}$

116. (*d*) The amplitude of the current in the series *L-C-R* circuit is given by

$$i_m = \frac{V_m}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \Rightarrow i_{max} = \frac{V_m}{R} \text{ now } \frac{1}{\sqrt{2}} i_{max} = i_m$$

$$\Rightarrow \frac{1}{2}\frac{V_m^2}{R^2} = \frac{V_{m^2}}{R^2 + (\omega L - 1/\omega C)^2} \Rightarrow R^2 = (\omega L - 1/\omega C)^2$$

$$\Rightarrow R = (\omega L - 1/\omega C)^2 \Rightarrow \tan\phi = \frac{(\omega L - 1/\omega C^2)}{R} = 1 \Rightarrow \phi = 45°$$

$$P = \frac{I_{rms}}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}} = \frac{I_{rms}^2}{\sqrt{2}R} \times \frac{1}{\sqrt{2}} = \frac{I_{rms}}{2R} = \frac{P_{max}}{2}$$

117. (*c*) Here, phase difference

$$\tan\phi = \frac{X_L - X_C}{R} \Rightarrow \tan\frac{\pi}{3} = \frac{X_L - X_C}{R}$$

When L is removed

$$\sqrt{3} = X_C/R \Rightarrow X_C = \sqrt{3}R$$

When C is removed

$$\tan\frac{\pi}{3} = \sqrt{3} = \frac{X_L}{R} \Rightarrow X_L = R\sqrt{3}$$

Hence in resonant circuit

$$\tan\phi = \frac{\sqrt{3}R - \sqrt{3}R}{R} = 0 \Rightarrow \phi = 0$$

$\therefore$ Power factor $\cos\phi = 1$

It is the condition of resonance therefore phase difference between voltage and current is zero and power factor is $\cos\phi = 1$.

119. (*a*) In *L-C-R* circuit, in the condition of resonance $X_L = X_C$ *i.e.*, circuit behaves as resistive circuit. In resistive circuit power factor is maximum.

120. (*c*) Power factor of AC circuit is given by

$$\cos\phi = \frac{R}{Z} \quad \ldots(i)$$

where, R is resistance employed and Z the impedance of the circuit.

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

Eqs. (i) and (ii) meet to give

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

Given, dc $R = 8\,\Omega$, $X_L = 31\,\Omega$, $X_C = 25\,\Omega$

$$\therefore \quad \cos\phi = \frac{8}{\sqrt{(8)^2 + (31-25)^2}} = \frac{8}{\sqrt{64+36}}$$

Hence, $\quad \cos\phi = 0.80$

121. (*d*) A series resonance circuit admits maximum current, as

$$P = i^2 R$$

So, power dissipated is maximum at resonance.
So, frequency of the source at which maximum power is dissipated in the circuit is

$$\nu = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\times 3.14\sqrt{25\times 10^{-3}\times 400\times 10^{-6}}}$$

$$= \frac{1}{2\times 3.14\sqrt{10^{-5}}} = 50.3 \text{ Hz}$$

123. (*b*) As, we know that angular displacement in equation of SHM, we get

$$\omega^2 = \frac{k}{m} \Rightarrow \omega = \sqrt{\frac{k}{m}}$$

where, k is the spring constant and m is a mass of the block.

126. (*b*) Here, $C = 30\,\mu\text{F} = 30\times 10^{-6}\text{F}$, $L = 27 \text{ mH} = 27\times 10^{-3}$ H

Angular frequency of oscillating circuit *i.e.*,

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(54\times 10^{-3})(15\times 10^{-6})}} = \frac{10^4}{9} = 1.1\times 10^3 \text{ s}^{-1}$$

127. (*a*) Here, $C = 30\mu\text{F} = 30\times 10^{-6}$ F, $Q_0 = 6$ mC $= 6\times 10^{-3}$ C

Total energy stored in the circuit

i.e., $\quad U = \frac{Q_0^2}{2C} = \frac{(6\times 10^{-3}\text{C})^2}{2(30\times 10^{-6}\text{ F})} = 0.6 \text{ J}$

At a later time, the total energy is the same, *i.e.*, 0.6 J and is shared between C and L.

128. (*a*) For *L-C* oscillations

$$\frac{1}{2}Li_0^2 = \frac{1}{2}CV_0^2$$

or $\quad i_0 = V_0\sqrt{\frac{C}{L}} = \sqrt{\frac{10^{-5}\text{F}}{10^{-1}\text{ H}}}$

$$= 25\times 10^{-2} \text{ A} = 0.25 \text{ A}$$

129. (*c*) Frequency of electrical oscillator *i.e.,*

$$\nu = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10^{-6} \times 10^{-4}}} = \frac{10^5}{2\pi} \text{ Hz}$$

130. (*b*) Angular frequency of free oscillations of the circuit *i.e.,*

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(54 \times 10^{-3})(60 \times 10^{-6})\ \text{s}^{-1}}}$$

$$= \frac{10^4}{18} \text{ s}^{-1} = 0.55 \times 10^3 \text{ s}^{-1}$$

136. (*c*) Here, $\varepsilon_p = 2300$ V, $N_p = 4000$, $\varepsilon_s = 230$ V

Let N_s be the required number of turns in the secondary

As, $\frac{\varepsilon_s}{\varepsilon_p} = \frac{N_s}{N_p}$, $N_s = N_p\left(\frac{\varepsilon_s}{\varepsilon_p}\right) = 4000\left(\frac{230 \text{ V}}{2300 \text{ V}}\right) = 400$

137. (*c*) Here, $\varepsilon_p = 220$ V, $\varepsilon_s = 22$ V and $Z = 220\ \Omega$

If i_s is the current through the secondary, then

$$i_s = \frac{\varepsilon_s}{Z} = \frac{22 \text{ V}}{220\ \Omega} = 0.1 \text{ A}$$

We know that, $\varepsilon_p i_p = \varepsilon_s i_s$

where, i_p is the current drawn by the primary coil

Thus, $220 \times i_p = 22 \times 0.1 \text{ A} \Rightarrow i_p = 0.01 \text{ A}$

138. (*b*) $P = 60$ W, $\varepsilon_p = 220$ V, $i_s = 0.54$ A

As, $P = \varepsilon_s i \Rightarrow \varepsilon_s = \frac{60 \text{ W}}{0.54 \text{ A}} = 110 \text{ V}$

Since, $\frac{\varepsilon_s}{\varepsilon_p} = \frac{110 \text{ V}}{220 \text{ V}} = \frac{1}{2}$

As, $\varepsilon_p i_p = \varepsilon_s i_s$

$$i_p = \left(\frac{\varepsilon_s}{\varepsilon_p}\right) i_s = \left(\frac{110 \text{ V}}{220 \text{ V}}\right)(0.54 \text{ A}) = 0.27 \text{ A}$$

139. (*b*) Initial power = 3000 W

As efficiency is 90% then final power $= 3000 \times \frac{90}{100} = 2700$ W

$$\Rightarrow \left.\begin{array}{l} V_1 i_1 = 3000 \text{ W} \\ V_1 i_1 = 2700 \text{ W} \end{array}\right] \quad \ldots\text{(i)}$$

So, $V_2 = \frac{2700}{6} = \frac{900}{2} = 450$ V and $i_1 = \frac{3000}{2000} = 15$ A

140. (*a*) Here, $\varepsilon_p = 1000$ V, $i_s = 20$ A and $\varepsilon_s = 120$ V, $\eta = 80\%$, $i_p = ?$

As $\eta = \frac{\varepsilon_s i_s}{\varepsilon_p i_p} \Rightarrow \frac{80}{100} = \frac{120 \times 20}{1000\, i_p}$

Current drawn by primary coil *i.e.,* $i_p = \frac{2.4 \times 10}{8} = 3$ A

141. (*d*) In an ideal transformer, there is no energy loss and flux is completely confined with the magnetic core *i.e.,* perfectly coupled

$$\frac{P_{\text{out}}}{P_{\text{in}}} = 1$$

142. (*a*) The current drawn by the primary winding of the transformer *i.e.,*

$$i_p = \left(\frac{1}{\eta}\right)\left(\frac{\varepsilon_s}{\varepsilon_p}\right) i_s = \left(\frac{100}{80}\right)\left(\frac{440 \text{ V}}{220 \text{ V}}\right)(2\text{A}) = 5 \text{ A}$$

148. (*a*) The resultant emf in the *L*-*C*-*R* circuit is given by

$$E = \sqrt{V_R^2 + (V_L - V_C)^2} \Rightarrow E = \sqrt{(8)^2 + (16-10)^2}$$

$$\Rightarrow \quad E = \sqrt{64 + 36} \Rightarrow E = 10 \text{ V}$$

149. (*a*) It is important to note that resonance phenomenon is exhibited by a circuit only if both L and C are present in the circuit. Only then do the voltage across L and C cancel each other (both being out of phase) and the current amplitude is V_m/R, the total source voltage appearing across R. This means that we cannot have resonance in a *R*-*L* or *R*-*C* circuit.

154. (*b*) Capacitance or inductor can be used in AC in place chock coil as they have high reactance but uses no energy unlike high resistance.

158. (*d*) When a capacitor is connected to a voltage source in a DC circuit, current will flow for the short time required to charge the capacitor.

As charge accumulates on the capacitor plates, the voltage across them increases, opposing the current. That is, a capacitor in a DC circuit will limit or oppose the current as it charges. When the capacitor is fully charged, the current in the circuit falls to zero.

161. (*b*) **Case I Resistive circuit** If the circuit contains only pure R, it is called resistive. In that case $\phi = 0$, $\cos\phi = 1$. There is maximum power dissipation.

Case II Purely inductive or capacitive circuit. If the circuit contains only an inductor or capacitor, we know that, the phase difference between voltage and current is $\pi/2$.

Therefore, $\cos\phi = 0$ and no power is dissipated even though a current is flowing in the circuit. This current is sometimes referred to as wattless current.

Case III *L*-*C*-*R* series circuit In an *L*-*C*-*R* series circuit, power dissipated is given by equation $P = I^2 \cos\phi$, where $\phi = \tan^{-1}(X_C - X_L)/R$.

So, ϕ may be non-zero in a *R*-*L* or *R*-*C* or *L*-*C*-*R* circuit. Even in such cases, power is dissipated only in the resistor.

Case IV Power dissipated at resonance in *L*-*C*-*R* circuit At resonance $X_C - X_L = 0$, and $\phi = 0$. Therefore, $\cos\phi = 1$ and $P = I^2 Z = I^2 R$. That is maximum power is dissipated in a circuit (through R) at resonance.

162. (*c*) Analogies between mechanical and electrical quantities,

Mechanical system	Electrical system
Mass m	Inductance L
Force constant k	Reciprocal capacitance $1/C$
Displacement x	Charge q
Velocity $v = dx/dt$	Current $i = dq/dt$
Mechanical energy	Electromagnetic energy
$E = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$	$U = \frac{1}{2}\frac{q^2}{C} + \frac{1}{2}Li^2$

As mass resists force to create acceleration (known as inertia) L resists to build up current in a circuit. It also resists to reduce current in a circuit.

$$(1/2)kx^2 \approx (1/2)\, q^2/c$$

So, $x \approx q$ and $k \approx 1/c$.

163. (*d*) To find the impedance of the circuit, we first calculate X_L and X_C. $X_L = 2\pi\nu L$

$$= 2\times 3.14\times 50\times 25.48\times 10^{-3}\ \Omega = 8\ \Omega$$

$$X_C = \frac{1}{2\pi\nu C} = \frac{1}{2\times 3.14\times 50\times 796\times 10^{-6}} = 4\ \Omega$$

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

$$= \sqrt{3^2 + (8-4)^2} = 5\ \Omega$$

Phase difference, $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$

$$= \tan^{-1}\left(\frac{8-4}{3}\right) = 53.1°$$

Since, ϕ is negative, the current in the circuit lags the voltage across the source.

164. (*c*) The power dissipated in the circuit is, $P = i^2R$

Now, $i_m = \frac{i_o}{\sqrt{2}} = \frac{1}{\sqrt{2}}\left(\frac{283}{3}\right) = 40\text{ A}$

Therefore, $P = (40\text{ A})^2 \times 3\ \Omega = 4800\text{ W}$

Power factor $= \cos\phi = \cos 53.1° = 0.6$

165. (*c*) The frequency at which the resonance occurs is

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{25.48\times 10^{-3}\times 796\times 10^{-6}}}$$

$$= 222.1\text{ rads}^{-1}$$

$$\nu_r = \frac{\omega_0}{2\pi} = \frac{221.1}{2\times 3.14} = 35.4\text{ Hz}$$

166. (*d*) The impedance Z at resonant condition is equal to the resistance $Z = R = 3\ \Omega$

The rms current at resonance is $= \frac{V}{Z} = \frac{V}{R} = \left(\frac{283}{\sqrt{2}}\right)\frac{1}{3} = 66.7\text{ A}$

The power dissipated at resonance is

$$P = I^2 \times R = (66.7)^2 \times 3 = 13.35\text{ kW}.$$

167. (*c*) Here, $i_p = ?$, $E_p = 220$ V, $E_s = 44$ V, $R_s = 880\ \Omega$

Current in secondary coil,

i.e., $i_s = \frac{E_s}{R_s} = \frac{44}{880} = \frac{1}{20}$ A

As, $E_p i_p = E_s\, i_s$

Current drawn by primary coil *i.e.,*

$\therefore$ $i_p = \frac{E_s i_s}{E_p} = \frac{44}{220}\times\frac{1}{20} = 0.01$ A

168. (*b*) Here, $E_p = 110$ V, $k = \frac{N_s}{N_p} = 10, R_s = 550\ \Omega, i_s = ?$

$$E_s = E_p \times \frac{N_s}{N_p} = 110 \times 10 = 1100\text{ V}$$

Current through secondary coil

i.e., $i_s = \frac{E_s}{R_s} = \frac{1100}{550} = 2\text{A}$

169. (*d*) As, we know $k = N_s/N_p = 2$. As a transformer does not work on battery, output voltage across secondary is zero. Battery produce direct steady current no induction occurs.

170. (*a*) Secondary voltage

i.e., $E_s = \frac{N_s}{N_p}E_p = \frac{4200}{2100}\times 120 = 240$ V

Secondary current

i.e., $i_s = \frac{N_p}{N_s}i_p = \frac{2100}{4200}\times 10 = 5$ A

171. (*b*) $P_i = 240 \times 0.7 = 168$ W, $P_O = 140$ W

Efficiency of transformer

i.e., $\eta = \frac{P_O}{P_i}\times 100 = \frac{140}{168}\times 100 \approx 80\%$

172. (*a,b,c*) When one has obtained the amplitude and phase of current for an *L-C-R* series circuit using the technique of phasors. But this method of analysing AC circuits suffers from certain disadvantages. First, the phasor diagram say nothing about the initial condition. One can take any arbitrary value of t (say, t_1) and draw different phasors which show the relative angle between different phasors.

The solution so obtained is called the steady-state solution. This is not a general solution. Additionally, we do have a transient solution which exists even for $V = 0$. The general solution is the sum of the transient solution and the steady-state solution.

After a sufficiently long time, the effects of the transient solution die out and the behaviour of the circuit is described by the steady-state solution.

175. (*a,b,c*) *L-C oscillation is not realistic for two reasons*.

(i) Every inductor has some resistance. The effect of this resistance is to introduce a damping effect on the charge and current in the circuit and the oscillations finally die away.

(ii) Even, if the resistance in *L-C* circuit were zero, the total energy of the system would not remain constant. It is radiated away from the system in the form of electromagnetic waves. In fact during the process of charging and discharging of capacitor, electrons travel between plates with acceleration. Their accelerated movement causes radiation of energy by EM waves.

176. (*a*) Current in the circuit

$$i_{\text{rms}} = \frac{V_{\text{rms}}}{R} = \frac{220}{100} = 2.2\text{ A}$$

177. (*a*) The rms value of voltage

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}} = \frac{300}{\sqrt{2}} = 212.1\text{ V}$$

178. (*b*) Inductive reactance $X_L = 2\pi fL$

$$= 2\times 3.14\times 50\times 44\times 10^{-3} = 13.83\ \Omega$$

The rms value of current in the circuit

$$i_{\text{rms}} = \frac{V_{\text{rms}}}{X_L} = \frac{220}{13.83} = 15.9\text{ A}$$

179. (*c*) Capacitive reactance

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\times 3.14\times 60\times 60\times 10^{-6}} = 44.23\ \Omega$$

The rms value of the current in the circuit

$$i_{\text{rms}} = \frac{V_{\text{rms}}}{X_C} = \frac{110}{44.23} = 2.49\text{ A}$$

180. (*d*) Resonant angular frequency

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2 \times 32 \times 10^{-6}}} = 125 \text{ rad/s}$$

Q-factor of this circuit,

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{2}{32 \times 10^{-5}}} = \frac{10^3}{40} = 25$$

181. (*b*) Resonant angular frequency of oscillation of the circuit

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{27 \times 10^{-3} \times 30 \times 10^{-6}}} = \frac{10^4}{9}$$

$$= 1.1 \times 10^3 \text{ rad/s}$$

182. (*a*) At the condition of resonance impedance $Z = R = 20\,\Omega$

The rms value of current in the circuit

$$i_{rms} = \frac{V_{rms}}{Z} = \frac{200}{20} = 10 \text{ A} \quad \Rightarrow \quad \phi = 0° \qquad \text{(for resonance)}$$

Power transferred to the circuit in one complete cycle

$P = i_{rms} . V_{rms} \cos\phi = 10 \times 200 \times \cos 0° = 2000 \text{ W} = 2 \text{ kW}$

183. (*b*) For tuning, the natural frequency is equal to the frequency of oscillations that means it is the case of resonance.

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

For capacitance C_1, $\quad f_1 = \frac{1}{2\pi\sqrt{LC_1}}$

$$C_1 = \frac{1}{4\pi^2 f_1^2 L} = \frac{1}{4 \times 3.14 \times 3.14 \times (8 \times 10^5)^2 \times 2 \times 10^{-4}}$$

$$= 197.7 \times 10^{-12} \text{ F} = 197.7 \text{ pF}$$

For capacitance C_2, $\quad f_2 = \frac{1}{2\pi\sqrt{LC_2}}$

$$C_2 = \frac{1}{4\pi^2 f_2^2 L} = \frac{1}{4 \times 3.14 \times 3.14 \times (12 \times 10^5)^2 \times 2 \times 10^{-4}}$$

$$= 87.8 \times 10^{-12} \text{ F} = 87.8 \text{ pF}$$

Thus, the range of capacitor is 87.8 pF to 197.7 pF.

184. (*a*) The rms value of voltage $V_{rms} = 240$ V, $f = 50$ Hz

Impedance of circuit $Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi f L)^2}$

$$= \sqrt{(100)^2 + (2 \times 3.14 \times 50 \times 0.50)^2}$$

$$= 186.14\,\Omega$$

The rms value of current $i_{rms} = \frac{V_{rms}}{Z} = \frac{240}{186.14} = 1.29$ A

The maximum value of current in the circuit

$$i_0 = \sqrt{2}\, i_{rms} = 1.414 \times 1.29 = 1.824 \text{ A}$$

185. (*b*) Impedance $Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + \left(\frac{1}{2\pi f C}\right)^2}$

$$= \sqrt{(40)^2 + \left(\frac{1}{2 \times 3.14 \times 60 \times 10^{-6} \times 100}\right)^2}$$

$$= \sqrt{1600 + 704.33} = 48\,\Omega$$

The rms value of current, $i_{rms} = \frac{V_{rms}}{Z} = \frac{110}{48}$

The maximum current in the circuit

$$I_0 = \sqrt{2} i_{rms} = 1.414 \times \frac{110}{48} = 3.24 \text{ A}$$

186. (*a*) As, $\frac{V_S}{V_P} = \frac{N_S}{N_P} \Rightarrow \frac{230}{2300} = \frac{N_S}{4000} \Rightarrow N_S = 400$

Thus, the number of turns in secondary are 400.

187. (*b*) Power $= \frac{m \times g \times h}{t} = \frac{\text{Volume} \times \text{Density} \times g \times h}{t}$

$$P_{in} = 100 \times 1000 \times 9.8 \times 300 = 2.94 \times 10^8 \text{ W}$$

($\because$ volume/second = 100 m³/s, density = 1000 kg/m³)

Suppose, the power output is P_{out}, which is equal to the power available from the plant.

The efficiency of generator

$$\eta = \frac{P_{out}}{P_{in}} \Rightarrow \frac{60}{100} = \frac{P_{out}}{2.94 \times 10^8}$$

$$P_{out} = \frac{60}{100} \times 2.94 \times 10^8 = 1764 \times 10^5 \text{ W}$$

$$= 176.4 \text{ MW}$$

188. (*b*) $i_{rms} = 5$A

$$i_0 = \text{Peak value} = \sqrt{2},\ i_{rms} = \sqrt{2} \times 5 = 5\sqrt{2} \text{ A}$$

$$i = i_0 \sin \omega t = 5\sqrt{2} \sin 2\pi \nu t$$

$$= 5\sqrt{2} \sin 2\pi \times 50 \times \frac{1}{300}$$

$$= 5\sqrt{2} \sin\frac{\pi}{3} = 5\sqrt{2} \times \frac{\sqrt{3}}{2} = 5\sqrt{3/2} \text{ A}$$

189. (*c*) For delivering maximum power from the generator to the load, total internal reactance must be equal to conjugate of total external reactance.

Hence, $\quad X_{int} = {}^{*}X_{ext}$

$\Rightarrow \quad X_g = (X_L)^* = -X_L$

$\Rightarrow \quad X_L = -X_g$

190. (*c*) The voltmeter connected to AC mains reads mean value ($\langle v^2 \rangle$) and is calibrated in such a way that it gives value of $\langle v^2 \rangle$, which is multiplied by form factor to give rms value.

191. (*b*) We know that resonant frequency in an *L*-*C*-*R* circuit is given by

$$\nu_0 = \frac{1}{2\pi\sqrt{LC}}$$

Now to reduce ν_0 either we can increase *L* or we can increase *C*.

To increase capacitance, we must connect another capacitor parallel to the first.

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

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

where, *R* is resistance, *L* is inductance and *C* is capacitance of the circuit. To make *Q* high, *R* should be low, *L* should be high and *C* should be low.

193. (*c*) Average power dissipated in the circuit

$$P_{av} = E_{rms}\, i_{rms} \cos\phi \quad \text{...(i)}$$

$$i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{E_{rms}}{Z}$$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{4+1} = \sqrt{5}$$

$$i_{rms} = \frac{6}{\sqrt{5}}\,\text{A} \Rightarrow \cos\phi = \frac{R}{Z} = \frac{2}{\sqrt{5}}$$

$$P_{av} = 6 \times \frac{6}{\sqrt{5}} \times \frac{2}{\sqrt{5}} \quad \text{[from Eq. (i)]}$$

$$= \frac{72}{\sqrt{5}\sqrt{5}} = \frac{72}{5} = 14.4\ \text{W}$$

194. (*a*) Secondary voltage $V_S = 24\text{V}$

Power associated with secondary $P_S = 12\ \text{W}$

$$i_S = \frac{P_S}{V_S} = \frac{12}{24} = \frac{1}{2}\,\text{A} = 0.5\ \text{A}$$

Peak value of the current in the secondary

$$i_0 = i_S\sqrt{2} = (0.5)\,(1.414) = 0.707 = \frac{1}{\sqrt{2}}\,\text{A}$$

195. (*a,d*) Reactance of an inductor of inductance L is, $X_L = 2\pi\nu L$

where, v is frequency of the AC circuit.

X_C = Reactance of the capacitive circuit $= \frac{1}{2\pi f C}$

On increasing frequency ν, clearly X_L increases and X_C decreases.

For an *L-C-R* circuit,

$$Z = \text{Impedance of the circuit}$$

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

$$= \sqrt{R^2 + \left(2\pi\nu L - \frac{1}{2\pi\nu C}\right)^2}$$

As frequency (ν) increases, Z decreases and at certain value of frequency known as resonant frequency (ν_0), impedance Z is minimum that is $Z_{min} = R$ current varies inversely with impedance and at Z_{min} current is maximum.

196. (*c,d*) According to the question, the current increases on increasing the frequency of supply. Hence, the reactance of the circuit must be decreases as increasing frequency.

For a capacitive circuit,

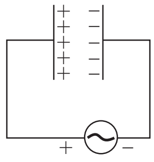
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

Clearly when frequency increases, X_C decreases.

For *R-C* circuit, $\quad X = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$

when frequency increases, X decreases.

197. (*a,b,d*) We have to transmit energy (power) over large distances at high alternating voltages, so current flowing through the wires will be low because for a given power (P).



$P = E_{rms} i_{rms}$, i_{rms} is low, when E_{rms} is high.

Power loss $= i^2_{rms} R$ = low $\quad$ ($\because i_{rms}$ is low)

Now at the receiving end high voltage is reduced by using step-down transformers.

198. (*a,b,c*) According to question power transferred,

$$P = i^2 Z \cos\phi$$

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

where $\quad R > 0$ and $Z > 0 \quad \Rightarrow \quad \cos\phi > 0 \quad \Rightarrow \quad P > 0$

199. (*c,d*) When the AC voltage is applied to the capacitor, the plate connected to the positive terminal will be at higher potential and the plate connected to the negative terminal will be at lower potential.

The plate with positive charge will be at higher potential and the plate with negative charge will be at lower potential. So, we can say that the charge is in phase with the applied voltage.

Power applied to a circuit is

$$P_{av} = V_{rms}\, i_{rms} \cos\phi$$

For capacitive circuit, $\quad \phi = 90° \quad \Rightarrow \quad \cos\phi = 0$

$\Rightarrow \quad P_{av}$ = Power delivered = 0

200. (*a, d*) For house hold supplies, AC currents are used which are having zero average value over a cycle.

The line is having some resistance so power factor

$$\cos\phi = R/Z \neq 0$$

so, $\quad \phi \neq \pi/2 \Rightarrow \phi\, , < \pi/2$

i.e., phase lies between 0 and $\pi/2$.