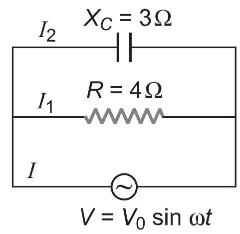
LEVEL 2

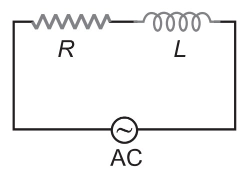
Single Correct Option

1. A capacitor and resistor are connected with an AC source as shown in figure. Reactance of capacitor is $X_C = 3\,\Omega$ and resistance of resistor is $4\,\Omega$. Phase difference between current I and I_1 is $\left[\tan^{-1}\left(\frac{3}{4}\right) = 37°\right]$



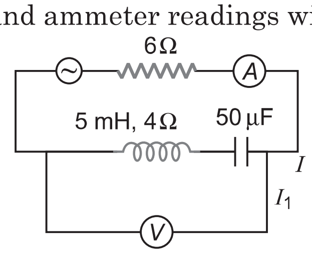
(a) 90° (b) zero (c) 53° (d) 37°

2. A circuit contains resistance R and an inductance L in series. An alternating voltage $V = V_0 \sin \omega t$ is applied across it. The currents in R and L respectively will be



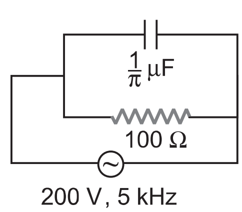
(a) $I_R = I_0 \cos \omega t, I_L = I_0 \cos \omega t$
(b) $I_R = - I_0 \sin \omega t, I_L = I_0 \cos \omega t$
(c) $I_R = I_0 \sin \omega t, I_L = - I_0 \cos \omega t$
(d) None of the above

3. In the circuit shown in figure, the AC source gives a voltage $V = 20 \cos(2000t)$. Neglecting source resistance, the voltmeter and ammeter readings will be



(a) 0 V, 2.0 A (b) 0 V, 1.4 A (c) 5.6 V, 1.4 A (d) 8 V, 2.0 A

4. A signal generator supplies a sine wave of 200 V, 5 kHz to the circuit shown in the figure. Then, choose the **wrong** statement.

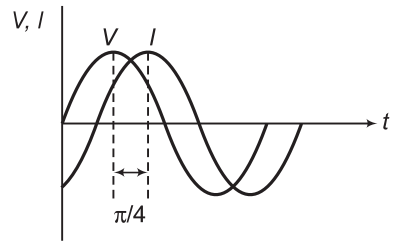


(a) The current in the resistive branch is 0.2 A
(b) The current in the capacitive branch is 0.126 A
(c) Total line current is ≈ 0.283 A
(d) Current in both the branches is same

5. A complex current wave is given by $i = (5 + 5\sin 100\,\omega t)$ A. Its average value over one time period is given as

(a) 10 A (b) 5 A
(c) $\sqrt{50}$ A (d) 0

6. An AC voltage $V = V_0 \sin 100\,t$ is applied to the circuit, the phase difference between current and voltage is found to be $\pi/4$, then

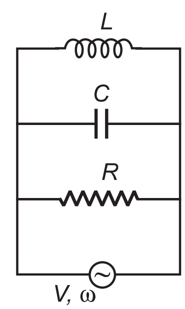


(a) $R = 100\ \Omega, C = 1\ \mu F$ (b) $R = 1\ k\Omega, C = 10\ \mu F$
(c) $R = 10\ k\Omega, L = 1$ H (d) $R = 1\ k\Omega, L = 10$ H

7. In series *L-C-R* circuit, voltage drop across resistance is 8 V, across inductor is 6 V and across capacitor is 12 V. Then,

(a) voltage of the source will be leading in the circuit
(b) voltage drop across each element will be less than the applied voltage
(c) power factor of the circuit will be 3 /4
(d) None of the above

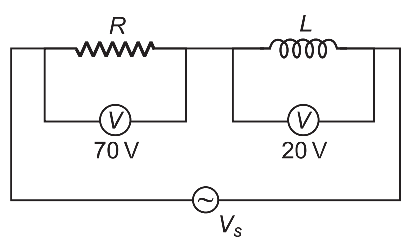
8. Consider an *L-C-R* circuit as shown in figure with an AC source of peak value V_0 and angular frequency ω. Then, the peak value of current through the AC source is



(a) $\dfrac{V_0}{\sqrt{\dfrac{1}{R^2} + \left(\omega L - \dfrac{1}{\omega C}\right)^2}}$ (b) $V_0\left[\dfrac{1}{R^2} + \left(\omega C - \dfrac{1}{\omega L}\right)\right]^2$

(c) $\dfrac{V_0}{\sqrt{R^2 + \left(\omega L - \dfrac{1}{\omega C}\right)^2}}$ (d) None of these

9. The adjoining figure shows an AC circuit with resistance *R*, inductance *L* and source voltage V_s. Then,

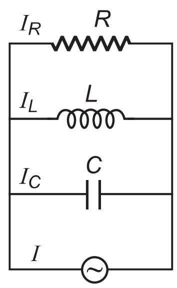


(a) the source voltage $V_s = 72.8$ V
(b) the phase angle between current and source voltage is $\tan^{-1}(7/2)$
(c) Both (a) and (b) are correct
(d) Both (a) and (b) are wrong

10. When an alternating voltage of 220 V is applied across a device P, a current of 0.25 A flows through the circuit and it leads the applied voltage by an angle $\pi/2$ radian. When the same voltage source is connected across another device Q, the same current is observed in the circuit but in phase with the applied voltage. What is the current when the same source is connected across a series combination of P and Q?

(a) $\frac{1}{4\sqrt{2}}$ A lagging in phase by $\pi/4$ with voltage
(b) $\frac{1}{4\sqrt{2}}$ A leading in phase by $\pi/4$ with voltage
(c) $\frac{1}{\sqrt{2}}$ A leading in phase by $\pi/4$ with voltage
(d) $\frac{1}{4\sqrt{2}}$ A leading in phase by $\pi/2$ with voltage

11. In a parallel L-C-R circuit as shown in figure if I_R, I_L, I_C and I represent the rms values of current flowing through resistor, inductor, capacitor and the source, then choose the appropriate correct answer.

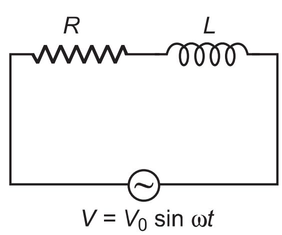


(a) $I = I_R + I_L + I_C$
(b) $I = I_R + I_L - I_C$
(c) I_L or I_C may be greater than I
(d) None of these

12. In a series L-C-R circuit, current in the circuit is 11 A when the applied voltage is 220 V. Voltage across the capacitor is 200 V. If the value of resistor is 20 Ω, then the voltage across the unknown inductor is

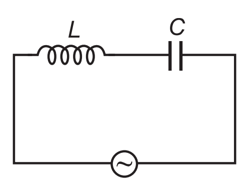
(a) zero
(b) 200 V
(c) 20 V
(d) None of these

13. In the circuit shown in figure, the power consumed is



(a) zero
(b) $\frac{V_0^2}{2R}$
(c) $\frac{V_0^2 R}{2(R^2 + \omega^2 L^2)}$
(d) None of these

14. In a series L-C circuit, the applied voltage is V_0. If ω is very low, then the voltage drop across the inductor V_L and capacitor V_C are

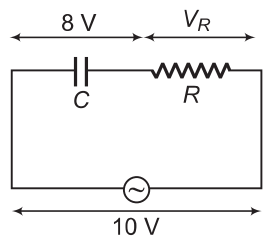


(a) $V_L = \frac{V_0}{2}; V_C = \frac{V_0}{2}$
(b) $V_L = 0; V_C = V_0$
(c) $V_L = V_0; V_C = 0$
(d) $V_L = -V_C = \frac{V_0}{2}$

15. A coil, a capacitor and an AC source of rms voltage 24 V are connected in series. By varying the frequency of the source, a maximum rms current of 6 A is observed. If coil is connected to a DC battery of emf 12 volt and internal resistance 4 Ω, then current through it in steady state is

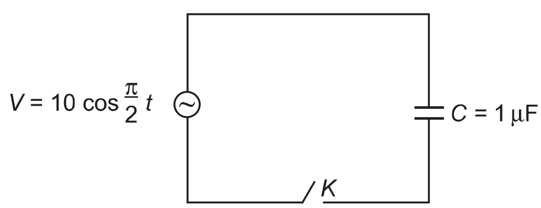
(a) 2.4 A
(b) 1.8 A
(c) 1.5 A
(d) 1.2 A

16. In a series *C*-*R* circuit shown in figure, the applied voltage is 10 V and the voltage across capacitor is found to be 8 V. The voltage across *R*, and the phase difference between current and the applied voltage will respectively be



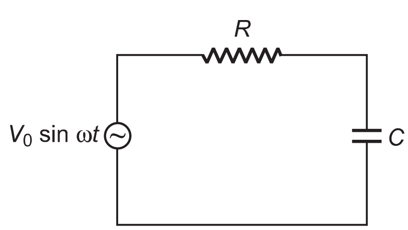
(a) 6 V, $\tan^{-1}\left(\frac{4}{3}\right)$
(b) 3 V, $\tan^{-1}\left(\frac{3}{4}\right)$
(c) 6 V, $\tan^{-1}\left(\frac{3}{4}\right)$
(d) None of these

17. An AC voltage source described by $V = 10\cos(\pi/2)\,t$ is connected to a 1 μF capacitor as shown in figure. The key K is closed at $t = 0$. The time ($t > 0$) after which the magnitude of current I reaches its maximum value for the first time is



(a) 1 s
(b) 2 s
(c) 3 s
(d) 4 s

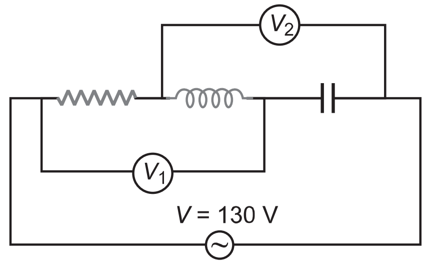
18. An AC voltage source $V = V_0 \sin \omega t$ is connected across resistance R and capacitance C as shown in figure. It is given that $R = 1/\omega C$. The peak current is I_0. If the angular frequency of the voltage source is changed to $\omega/\sqrt{3}$, then the new peak current in the circuit is



(a) $\frac{I_0}{2}$
(b) $\frac{I_0}{\sqrt{2}}$
(c) $\frac{I_0}{\sqrt{3}}$
(d) $\frac{I_0}{3}$

More than One Correct Options

1. In a R-L-C series circuit shown, the readings of voltmeters V_1 and V_2 are 100 V and 120 V. Choose the correct statement(s).



(a) Voltage across resistor, inductor and capacitor are 50 V, 86.6 V and 206.6 V respectively
(b) Voltage across resistor, inductor and capacitor are 10 V, 90 V and 30 V respectively
(c) Power factor of the circuit is $\frac{5}{13}$
(d) Circuit is capacitive in nature

2. Current in an AC circuit is given by $i = 3 \sin \omega t + 4 \cos \omega t$, then
(a) rms value of current is 5 A
(b) mean value of this current in positive one-half period will be $\frac{6}{\pi}$
(c) if voltage applied is $V = V_m \sin \omega t$, then the circuit may contain resistance and capacitance
(d) if voltage applied is $V = V_m \cos \omega t$, then the circuit may contain resistance and inductance only

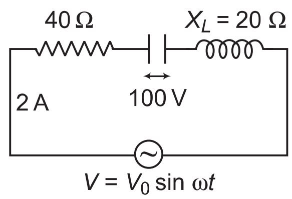
3. A tube light of 60 V, 60 W rating is connected across an AC source of 100 V and 50 Hz frequency. Then,
(a) an inductance of $\frac{2}{5\pi}$ H may be connected in series
(b) a capacitor of $\frac{250}{\pi}$ μF may be connected in series to it
(c) an inductor of $\frac{4}{5\pi}$ H may be connected in series
(d) a resistance of 40 Ω may be connected in series

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

5. In an AC series circuit, $R = 10\ \Omega$, $X_L = 20\ \Omega$ and $X_C = 10\ \Omega$. Then, choose the correct options
(a) Voltage function will lead the current function
(b) Total impedance of the circuit is $10\sqrt{2}\ \Omega$
(c) Phase angle between voltage function and current function is 45°
(d) Power factor of circuit is $\frac{1}{\sqrt{2}}$

6. In the above problem further choose the correct options.
(a) The given values are at frequency less than the resonance frequency
(b) The given values are at frequency more than the resonance frequency
(c) If frequency is increased from the given value, impedance of the circuit will increase
(d) If frequency is decreased from the given value, current in the circuit may increase or decrease

7. In the circuit shown in figure,



(a) $V_R = 80$ V (b) $X_C = 50\ \Omega$
(c) $V_L = 40$ V (d) $V_0 = 100$ V

8. In *L-C-R* series AC circuit,
(a) If R is increased, then current will decrease (b) If L is increased, then current will decrease
(c) If C is increased, then current will increase (d) If C is increased, then current will decrease

Comprehension Based Questions

Passage I (Q. No. 1 to 3)

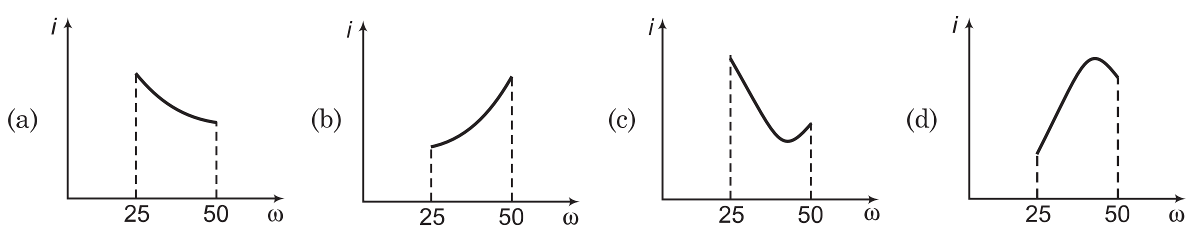
A student in a lab took a coil and connected it to a 12 V DC source. He measures the steady state current in the circuit to be 4 A. He then replaced the 12 V DC source by a 12 V, ($\omega = 50$ rad/s) AC source and observes that the reading in the AC ammeter is 2.4 A. He then decides to connect a 2500 μF capacitor in series with the coil and calculate the average power developed in the circuit. Further he also decides to study the variation in current in the circuit (with the capacitor and the battery in series).

Based on the readings taken by the student, answer the following questions.

1. The value of resistance of the coil calculated by the student is
(a) 3 Ω (b) 4 Ω
(c) 5 Ω (d) 8 Ω

2. The power developed in the circuit when the capacitor of 2500 μF is connected in series with the coil is
(a) 28.8 W (b) 23.04 W
(c) 17.28 W (d) 9.6 W

3. Which of the following graph roughly matches the variations of current in the circuit (with the coil and capacitor connected in the series) when the angular frequency is decreased from 50 rad/s to 25 rad/s?



Passage II (Q. No. 4 to 6)

It is known to all of you that the impedance of a circuit is dependent on the frequency of source. In order to study the effect of frequency on the impedance, a student in a lab took 2 impedance boxes P and Q and connected them in series with an AC source of variable frequency. The emf of the source is constant at 10 V. Box P contains a capacitance of 1 μF in series with a resistance of 32 Ω. And the box Q has a coil of self-inductance 4.9 mH and a resistance of 68 Ω in series. He adjusted the frequency so that the maximum current flows in P and Q. Based on his experimental set up and the reading by him at various moment, answer the following questions.

4. The angular frequency for which he detects maximum current in the circuit is

(a) $10^5/7$ rad/s (b) 10^4 rad/s
(c) 10^5 rad/s (d) $10^4/7$ rad/s

5. Impedance of box P at the above frequency is

(a) 70 Ω (b) 77 Ω
(c) 90 Ω (d) 100 Ω

6. Power factor of the circuit at maximum current is

(a) 1/2 (b) 1
(c) 0 (d) $1/\sqrt{2}$

Match the Columns

1. Match the following two columns for a series AC circuit.

Column I	Column II
(a) Only C in the circuit	(p) current will lead
(b) Only L in the circuit	(q) voltage will lead
(c) Only R in the circuit	(r) $\phi = 90°$
(d) R and C in the circuit	(s) $\phi = 0°$

2. Applied AC voltage is given as

$$V = V_0 \sin \omega t$$

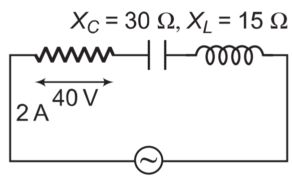
Corresponding to this voltage, match the following two columns.

Column I	Column II
(a) $I = I_0 \sin \omega t$	(p) only R circuit
(b) $I = -I_0 \cos \omega t$	(q) only L circuit
(c) $I = I_0 \sin (\omega t + \pi/6)$	(r) may be C-R circuit
(d) $I = I_0 \sin (\omega t - \pi/6)$	(s) may be L-C-R circuit

3. For an L-C-R series AC circuit, match the following two columns.

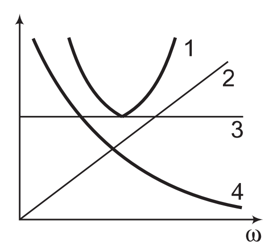
Column I	Column II
(a) If resistance is increased	(p) current will increase
(b) If capacitance is increased	(q) current will decrease
(c) If inductance is increased	(r) current may increase or decrease
(d) If frequency is increased	(s) power may decrease or increase

4. In the circuit shown in figure, match the following two columns. In Column II, quantities are given in SI units.



Column I	Column II
(a) Value of resistance R	(p) 60
(b) Potential difference across capacitor	(q) 20
(c) Potential difference across inductor	(r) 30
(d) Applied potential difference	(s) None of the above

5. Corresponding to the figure shown, match the two columns.



Column I	Column II
(a) Resistance	(p) 4
(b) Capacitive reactance	(q) 1
(c) Inductive reactance	(r) 2
(d) Impedance	(s) 3

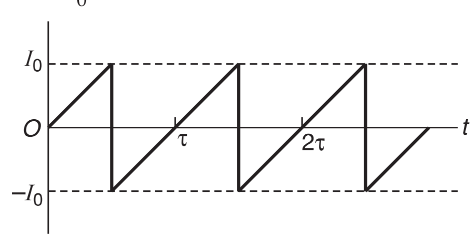
Subjective Questions

Note *Power factor leading means current is leading.*

1. A coil is in series with a 20 μF capacitor across a 230 V, 50 Hz supply. The current taken by the circuit is 8 A and the power consumed is 200 W. Calculate the inductance of the coil if the current in the circuit is

(a) leading (b) lagging

2. The current in a certain circuit varies with time as shown in figure. Find the average current and the rms current in terms of I_0.

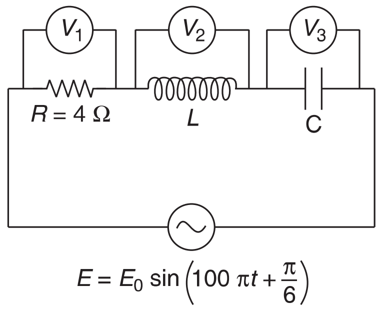


3. Two impedances Z_1 and Z_2 when connected separately across a 230 V, 50 Hz supply consume 100 W and 60 W at power factor of 0.5 lagging and 0.6 leading respectively. If these impedances are now connected in series across the same supply, find

(a) total power absorbed and overall power factor

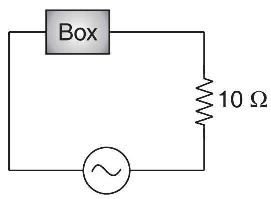
(b) the value of reactance to be added in series so as to raise the overall power factor to unity.

4. In the figure shown, the reading of voltmeters are $V_1 = 40$ V, $V_2 = 40$ V and $V_3 = 10$ V. Find

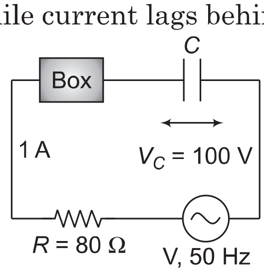


(a) the peak value of current
(b) the peak value of emf
(c) the value of L and C

5. In the circuit shown in figure power factor of box is 0.5 and power factor of circuit is $\sqrt{3}/2$. Current leading the voltage. Find the effective resistance of the box.



6. A circuit element shown in the figure as a box is having either a capacitor or an inductor. The power factor of the circuit is 0.8, while current lags behind the voltage. Find



(a) the source voltage V,
(b) the nature of the element in box and find its value.

7. The maximum values of the alternating voltages and current are 400 V and 20 A respectively in a circuit connected to 50 Hz supply and these quantities are sinusoidal. The instantaneous values of the voltage and current are $200\sqrt{2}$ V and 10 A, respectively. At $t = 0$, both are increasing positively.
(a) Write down the expression for voltage and current at time t.
(b) Determine the power consumed in the circuit.

8. An L-C circuit consists of an inductor coil with $L = 5.00$ mH and a 20.0 μF capacitor. There is negligible resistance in the circuit. The circuit is driven by a voltage source with $V = V_0 \cos \omega t$. If $V_0 = 5.00$ mV and the frequency is twice the resonance frequency, determine
(a) the maximum charge on the capacitor
(b) the maximum current in the circuit
(c) the phase relationship between the voltages across the inductor, the capacitor and the source.