Chapter 20

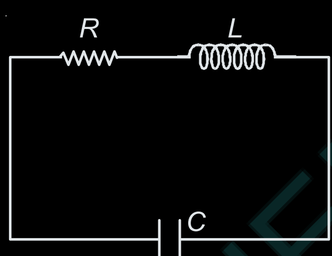
Alternating Current

1. In a series LCR circuit R = 200 Ω and the voltage and the frequency of the main supply is 220 V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags behind the voltage by 30º. On taking out the inductor from the circuit the current leads the voltage by 30º. The power dissipated in the LCR circuit is **[AIEEE-2010]**

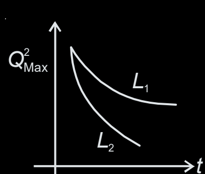
   (1) 242 W (2) 305 W

   (3) 210 W (4) 0 W

2. An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below :



If a student plots graphs of the square of maximum charge (Q^2_{Max}) on the capacitor with time (t) for two different values L_1 and L_2 ($L_1 > L_2$) of L then which of the following represents this graph correctly? (Plots are schematic and not drawn to scale) **[JEE (Main)-2015]**

(1)


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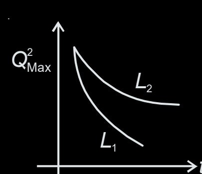

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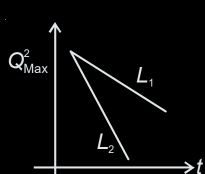

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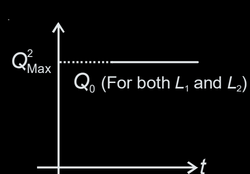


3. An arc lamp requires a direct current of 10 A at 80 V to function. If it is connected to a 220 V (rms), 50 Hz AC supply, the series inductor needed for it to work is close to **[JEE (Main)-2016]**

   (1) 0.08 H (2) 0.044 H

   (3) 0.065 H (4) 80 H

4. In an a.c. circuit, the instantaneous e.m.f. and current are given by

   $e = 100\sin 30t$

   $$i = 20\sin\left(30t - \frac{\pi}{4}\right)$$

   In one cycle of a.c., the average power consumed by the circuit and the wattless current are, respectively **[JEE (Main)-2018]**

   (1) 50, 10 (2) $\frac{1000}{\sqrt{2}}, 10$

   (3) $\frac{50}{\sqrt{2}}, 0$ (4) 50, 0

5. For an RLC circuit driven with voltage of amplitude v_m and frequency $\omega_0 = \frac{1}{\sqrt{LC}}$ the current exibits resonance. The quality factor, Q is given by **[JEE (Main)-2018]**

   (1) $\frac{\omega_0 L}{R}$ (2) $\frac{\omega_0 R}{L}$

   (3) $\frac{R}{(\omega_0 C)}$ (4) $\frac{CR}{\omega_0}$

6. A series AC circuit containing an inductor (20 mH), a capacitor (120 μF) and a resistor (60 Ω) is driven by an AC source of 24 V/50 Hz. The energy dissipated in the circuit in 60 s is **[JEE (Main)-2019]**

   (1) 5.65×10^2 J (2) 5.17×10^2 J

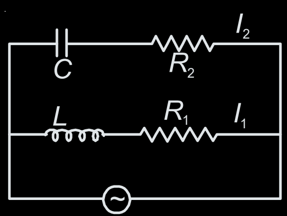
   (3) 2.26×10^3 J (4) 3.39×10^3 J

7. A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. The output power is delivered at 230 V by the transformer. If the current in the primary winding of the transformer is 5 A and its efficiency is 90%, the output current would be

[JEE (Main)-2019]

(1) 25 A (2) 50 A

(3) 45 A (4) 35 A

8. 

In the above circuit, $C = \frac{\sqrt{3}}{2}$ μF, R_2 = 20 Ω, $L = \frac{\sqrt{3}}{10}$ H and R_1 = 10 Ω. Current in L-R_1 path is I_1 and in C–R_2 path it is I_2. The voltage of A.C source is given by $V = 200\sqrt{2}\sin(100t)$ volts. The phase difference between I_1 and I_2 is **[JEE (Main)-2019]**

(1) 0° (2) 60°

(3) 150° (4) 90°

9. An alternating voltage $v(t)$ = 220 sin 100πt volt is applied to a purely resistive load of 50 Ω. The time taken for the current to rise from half of the peak value to the peak value is **[JEE (Main)-2019]**

(1) 2.2 ms (2) 7.2 ms

(3) 5 ms (4) 3.3 ms

10. A circuit connected to an ac source of emf $e = e_0\sin(100t)$ with t in seconds, gives a phase difference of $\frac{\pi}{4}$ between the emf e and current i. Which of the following circuits will exhibit this?

[JEE (Main)-2019]

(1) RL circuit with R = 1 kΩ and L = 10 mH

(2) RL circuit with R = 1 kΩ and L = 1 mH

(3) RC circuit with R = 1 kΩ and C = 10 μF

(4) RC circuit with R = 1 kΩ and C = 1 μF

11. A transformer consisting of 300 turns in the primary and 150 turns in the secondary gives output power of 2.2 kW. If the current in the secondary coil is 10 A, then the input voltage and current in the primary coil are : **[JEE (Main)-2019]**

(1) 440 V and 5 A

(2) 220 V and 20 A

(3) 220 V and 10 A

(4) 440 V and 20 A

12. A LCR circuit behaves like a damped harmonic oscillator. Comparing it with a physical spring-mass damped oscillator having damping constant 'b' the correct equivalence would be **[JEE (Main)-2020]**

(1) $L \leftrightarrow m, C \leftrightarrow \frac{1}{k}, R \leftrightarrow b$

(2) $L \leftrightarrow k, C \leftrightarrow b, R \leftrightarrow m$

(3) $L \leftrightarrow \frac{1}{b}, C \leftrightarrow \frac{1}{m}, R \leftrightarrow \frac{1}{k}$

(4) $L \leftrightarrow m, C \leftrightarrow k, R \leftrightarrow b$

13. In LC circuit the inductance L = 40 mH and capacitance C = 100 μF. If a voltage $V(t)$ = 10 sin (314 t) is applied to the circuit, the current in the circuit is given as **[JEE (Main)-2020]**

(1) 0.52 sin 314 t

(2) 5.2 cos 314 t

(3) 10 cos 314 t

(4) 0.52 cos 314 t

14. An inductance coil has a reactance of 100 Ω. When an AC signal of frequency 1000 Hz is applied to the coil, the applied voltage leads the current by 45°. The self-inductance of the coil is

[JEE (Main)-2020]

(1) 6.7×10^{-7} H

(2) 5.5×10^{-5} H

(3) 1.1×10^{-1} H

(4) 1.1×10^{-2} H

15. A 750 Hz, 20 V (rms) source is connected to a resistance of 100 Ω, an inductance of 0.1803 H and a capacitance of 10 μF all in series. The time in which the resistance (heat capacity 2 J/°C) will get heated by 10°C. (assume no loss of heat to the surroudings) is close to

[JEE (Main)-2020]

(1) 348 s (2) 418 s

(3) 245 s (4) 365 s

16. An AC circuit has $R = 100\ \Omega$, $C = 2\ \mu F$ and $L = 80$ mH, connected in series. The quality factor of the circuit is **[JEE (Main)-2020]**

(1) 20 (2) 2

(3) 0.5 (4) 400

17. An electrical power line, having a total resistance of 2 Ω, delivers 1 kW at 220 V. The efficiency of the transmission line is approximately **[JEE (Main)-2020]**

(1) 85% (2) 96%

(3) 72% (4) 91%

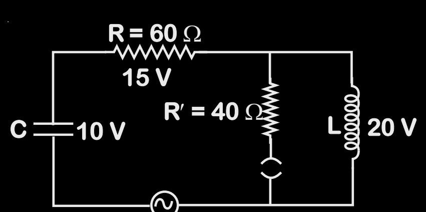
18. In a series *LR* circuit, power of 400 W is dissipated from a source of 250 V, 50 Hz. The power factor of the circuit is 0.8. In order to bring the power factor to unity, a capacitor of value C is added in series to the *L* and *R*. Taking the value of *C* as $\left(\frac{n}{3\pi}\right)\mu F$, then value of *n* is _____. **[JEE (Main)-2020]**

19. A resonance circuit having inductance and resistance 2×10^{-4} H and 6.28 Ω respectively oscillates at 10 MHz frequency. The value of quality factor of this resonator is _____.
[$\pi = 3.14$] **[JEE (Main)-2021]**

20. A common transistor radio set requires 12 V (D.C.) for its operation. The D.C. source is constructed by using a transformer and a rectifier circuit, which are operated at 220 V (A.C.) on standard domestic A.C. supply. The number of turns of secondary coil are 24, then the number of turns of primary are ________. **[JEE (Main)-2021]**

21. A series LCR circuit is designed to resonate at an angular frequency $\omega_0 = 10^5$ rad/s. The circuit draws 16 W power from 120 V source at resonance. The value of resistance 'R' in the circuit is _____ Ω. **[JEE (Main)-2021]**

22. The angular frequency of alternating current in a L-C-R circuit is 100 rad/s. The components connected are shown in the figure. Find the value of inductance of the coil and capacity of condenser. **[JEE (Main)-2021]**



(1) 1.33 H and 250 μF

(2) 0.8 H and 150 μF

(3) 0.8 H and 250 μF

(4) 1.33 H and 150 μF

23. An LCR circuit contains resistance of 110 Ω and a supply of 220 V at 300 rad/s angular frequency. If only capacitance is removed from the circuit, current lags behind the voltage by 45°. If on the other hand, only inductor is removed the current leads by 45° with the applied voltage. The rms current flowing in the circuit will be **[JEE (Main)-2021]**

(1) 1.5 A (2) 1 A

(3) 2 A (4) 2.5 A

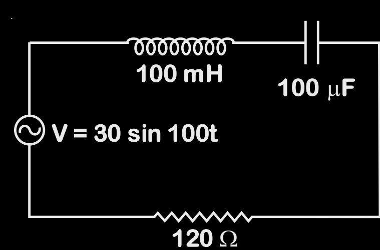
24. An alternating current is given by the equation $i = i_1 \sin\omega t + i_2 \cos\omega t$. The rms current will be : **[JEE (Main)-2021]**

(1) $\frac{1}{\sqrt{2}}(i_1 + i_2)^2$ (2) $\frac{1}{\sqrt{2}}(i_1 + i_2)$

(3) $\frac{1}{2}\left(i_1^2 + i_2^2\right)^{\frac{1}{2}}$ (4) $\frac{1}{\sqrt{2}}\left(i_1^2 + i_2^2\right)^{\frac{1}{2}}$

25. In a series LCR resonant circuit, the quality factor is measured as 100. If the inductance is increased by two fold and resistance is decreased by two fold, then the quality factor after this change will be ________. **[JEE (Main)-2021]**

26. Find the peak current and resonant frequency of the following circuit (as shown in figure). **[JEE (Main)-2021]**



(1) 0.2 A and 50 Hz

(2) 2 A and 100 Hz

(3) 2 A and 50 Hz

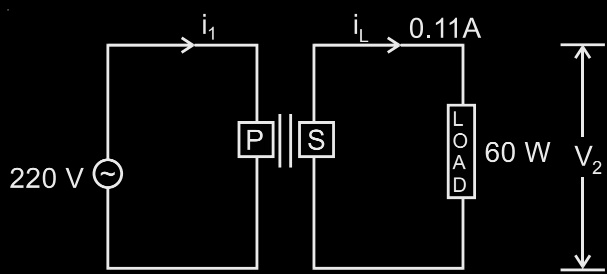
(4) 0.2 A and 100 Hz

27. A sinusoidal voltage of peak value 250 V is applied to a series LCR circuit , in which R = 8 Ω, L = 24 mH and C = 60 μF. The value of power dissipated at resonant conditions is x kW.

The value of x to the nearest integer is ________

[JEE (Main)-2021]

28. For the given circuit, comment on the type of transformer used. [JEE (Main)-2021]



(1) Step-up transformer

(2) Auto transformer

(3) Step down transformer

(4) Auxilliary transformer

29. An AC current is given by $I = I_1 \sin\omega t + I_2 \cos\omega t$. A hot wire ammeter will give a reading

[JEE (Main)-2021]

(1) $\sqrt{\frac{I_1^2 + I_2^2}{2}}$

(2) $\frac{I_1 + I_2}{\sqrt{2}}$

(3) $\frac{I_1 + I_2}{2\sqrt{2}}$

(4) $\sqrt{\frac{I_1^2 - I_2^2}{2}}$

30. What happens to the inductive reactance and the current in a purely inductive circuit if the frequency is halved? [JEE (Main)-2021]

(1) Inductive reactance will be doubled and current will be halved

(2) Both, inducting reactance and current will be doubled

(3) Inductive reactance will be halved and current will be doubled

(4) Both, inductive reactance and current will be halved

31. Match List-I with List-II [JEE (Main)-2021]

	List-I		List-II
(a)	Phase difference between current and voltage in a purely resistive AC circuit	(i)	$\frac{\pi}{2}$; current leads voltage
(b)	Phase difference between current and voltage in a pure inductive AC circuit	(ii)	Zero
(c)	Phase difference between current and voltage in a pure capacitive AC circuit	(iii)	$\frac{\pi}{2}$; current lags voltage
(d)	Phase difference between current and voltage in an LCR series circuit	(iv)	$\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

Choose the most appropriate answer from the options given below:

(1) (a)-(i), (b)-(iii), (c)-(iv), (d)-(ii)

(2) (a)-(ii), (b)-(iv), (c)-(iii), (d)-(i)

(3) (a)-(ii), (b)-(iii), (c)-(iv), (d)-(i)

(4) (a)-(ii), (b)-(iii), (c)-(i), (d)-(iv)

32. An AC source rated 220 V, 50 Hz is connected to a resistor. The time taken by the current to change from its maximum to the rms value is

[JEE (Main)-2021]

(1) 2.5 s

(2) 2.5 ms

(3) 0.25 ms

(4) 25 ms

33. In a series LCR resonance circuit, if we change the resistance only, from a lower to higher value:

[JEE (Main)-2021]

(1) The quality factor and the resonance frequency will remain constant

(2) The resonance frequency will increase

(3) The bandwidth of resonance circuit will increase

(4) The quality factor will increase

34. In a series LCR circuit, the inductive reactance (X_L) is 10Ω and the capacitive reactance (X_C) is 4Ω. The resistance (R) in the circuit is 6Ω.

The power factor of the circuit is :

[JEE (Main)-2021]

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

(3) $\frac{1}{2\sqrt{2}}$ (4) $\frac{\sqrt{3}}{2}$

35. AC voltage $V(t) = 20 \sin\omega t$ of frequency 50 Hz is applied to a parallel plate capacitor. The separation between the plates is 2 mm and the area is 1 m^2. The amplitude of the oscillating displacement current for the applied AC voltage is_____.

[JEE (Main)-2021]

[Take $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m]

(1) 21.14 μA (2) 83.37 μA

(3) 27.79 μA (4) 55.58 μA

36. In an LCR series circuit, an inductor 30 mH and a resistor 1 Ω are connected to an AC source of angular frequency 300 rad/s. The value of capacitance for which, the current leads the voltage by 45° is $\frac{1}{x} \times 10^{-3}$ F. Then the value of x is ____

[JEE (Main)-2021]

37. For a series LCR circuit with R = 100 Ω, L = 0.5 mH and C = 0.1 pF connected across 220 V - 50 Hz AC supply, the phase angle between current and supplied voltage and the nature of the circuit is **[JEE (Main)-2021]**

(1) ≈ 90°, predominantly capacitive circuit

(2) 0°, resonance circuit

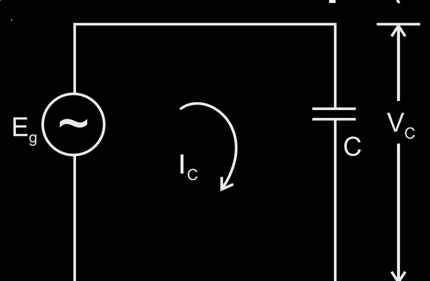
(3) 0°, resistive circuit

(4) ≈ 90°, predominantly inductive circuit

38. A series LCR circuit of R = 5 Ω, L = 20 mH and C = 0.5 μF is connected across an AC supply of 250 V, having variable frequency. The power dissipated at resonance condition is ____ × 10^2 W.

[JEE (Main)-2021]

39. In a circuit consisting of a capacitance and a generator with alternating emf $E_g = E_{g_0} \sin\omega t$, V_C and I_C are the voltage and current. Correct phasor diagram for such circuit is **[JEE (Main)-2021]**



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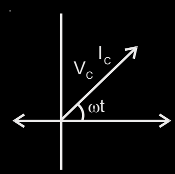

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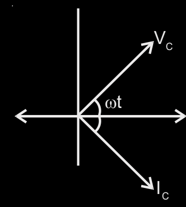

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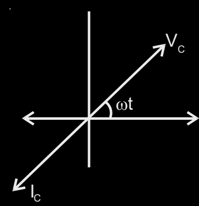

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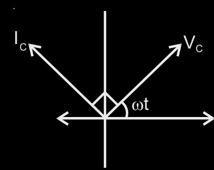


40. Match List-I with List-II **[JEE (Main)-2021]**

List-I	**List-II**
(a) $\omega L > \frac{1}{\omega C}$	(i) Current is in phase with emf
(b) $\omega L = \frac{1}{\omega C}$	(ii) Current lags behind the applied emf
(c) $\omega L < \frac{1}{\omega C}$	(iii) Maximum current occurs
(d) Resonant frequency	(iv) Current leads the emf

Choose the **correct** answer from the options given below

(1) a(ii), b(i), c(iv), d(iii)

(2) a(ii), b(i), c(iii), d(iv)

(3) a(iii), b(i), c(iv), d(ii)

(4) a(iv), b(iii), c(ii), d(i)

41. A 10 Ω resistance is connected across 220 V - 50 Hz AC supply. The time taken by the current to change from its maximum value to the rms value is **[JEE (Main)-2021]**

(1) 2.5 ms

(2) 4.5 ms

(3) 1.5 ms

(4) 3.0 ms

42. Two circuits are shown in the figure (a) and (b). At a frequency of _______ rad/s the average power dissipated in one cycle will be same in both the circuits. **[JEE (Main)-2021]**

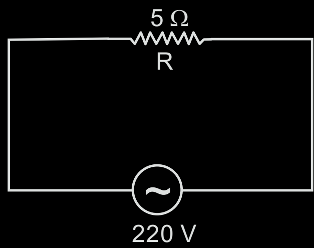


figure (a)

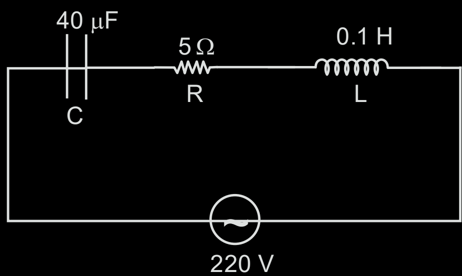


figure (b)

43. A 0.07 H inductor and a 12 Ω resistor are connected in series to a 220 V, 50 Hz ac source. The approximate current in the circuit and the phase angle between current and source voltage are respectively $\left[\text{Take } \pi \text{ as } \dfrac{22}{7}\right]$

[JEE (Main)-2021]

(1) 8.8 A and $\tan^{-1}\left(\dfrac{11}{6}\right)$

(2) 8.8 A and $\tan^{-1}\left(\dfrac{6}{11}\right)$

(3) 88 A and $\tan^{-1}\left(\dfrac{11}{6}\right)$

(4) 0.88 A and $\tan^{-1}\left(\dfrac{11}{6}\right)$

44. A 100 Ω resistance, a 0.1 μF capacitor and an inductor are connected in series across a 250 V supply at variable frequency. Calculate the value of inductance of inductor at which resonance will occur. Given that the resonant frequency is 60 HZ. **[JEE (Main)-2021]**

(1) 70.3 mH (2) 70.3 H

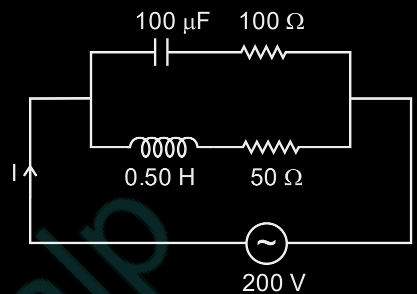
(3) 7.03×10^{-5} H (4) 0.70 H

45. A series LCR circuit driven by 300 V at a frequency of 50 Hz contains a resistance R = 3 kΩ, an inductor of inductive reactance $X_L = 250\pi$ Ω and an unknown capacitor. The value of capacitance to maximize the average power should be : (take $\pi^2 = 10$) **[JEE (Main)-2021]**

(1) 25 μF (2) 4 μF

(3) 40 μF (4) 400 μF

46. In the given circuit the AC source has $\omega = 100$ rad s^{-1}. Considering the inductor and capacitor to be ideal, what will be the current I flowing through the circuit? **[JEE (Main)-2021]**



(1) 3.16 A (2) 0.94 A

(3) 5.9 A (4) 6 A

47. The alternating current is given by $i = \left\{\sqrt{42}\sin\left(\dfrac{2\pi}{T}t\right) + 10\right\}$ A

The r.m.s. value of this current is ____ A.

[JEE (Main)-2021]

48. An ac circuit has an inductor and a resistor of resistance R in series, such that $X_L = 3R$. Now, a capacitor is added in series such that $X_C = 2R$. The ratio of new power factor with the old power factor of the circuit is $\sqrt{5} : x$. The value of x is ____ **[JEE (Main)-2021]**

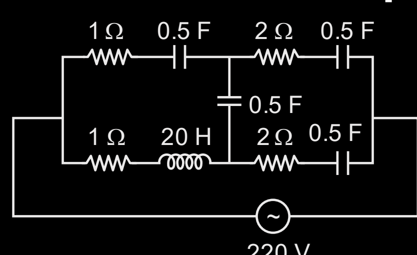
49. In an ac circuit, an inductor, a capacitor and a resistor are connected in series with $X_L = R = X_C$. Impedance of this circuit is : **[JEE (Main)-2021]**

(1) $R\sqrt{2}$ (2) $2R^2$

(3) R (4) Zero

50. At very high frequencies, the effective impedance of the given circuit will be _____ Ω.

[JEE (Main)-2021]



51. A resistance of 40 Ω is connected to a source of alternating current rated 220 V, 50 Hz. Find the time taken by the current to change from its maximum value to the rms value : **[JEE (Main)-2022]**

(1) 2.5 ms (2) 1.25 ms

(3) 2.5 s (4) 0.25 s

52. As shown in the figure an inductor of inductance 200 mH is connected to an AC source of emf 220 V and frequency 50 Hz. The instantaneous voltage of the source is 0 V when the peak value of current is $\frac{\sqrt{a}}{\pi}$ A. The value of a is ____. **[JEE (Main)-2022]**

53. Match **List-I** with **List-II**

	List-I		**List-II**
(A)	AC generator	(I)	Detects the presence of current in the circuit
(B)	Galvanometer	(II)	Converts mechanical energy into electrical energy
(C)	Transformer	(III)	Works on the principle of resonance in AC circuit
(D)	Metal detector	(IV)	Changes an alternating voltage for smaller or greater value

Choose the **correct** answer from the options given below **[JEE (Main)-2022]**

(1) (A) - (II), (B) - (I), (C) - (IV), (D) - (III)

(2) (A) - (II), (B) - (I), (C) - (III), (D) - (IV)

(3) (A) - (III), (B) - (IV), (C) - (II), (D) - (I)

(4) (A) - (III), (B) - (I), (C) - (II), (D) - (IV)

54. If wattless current flows in the AC circuit, then the circuit is **[JEE (Main)-2022]**

(1) Purely Resistive circuit

(2) Purely Inductive circuit

(3) LCR series circuit

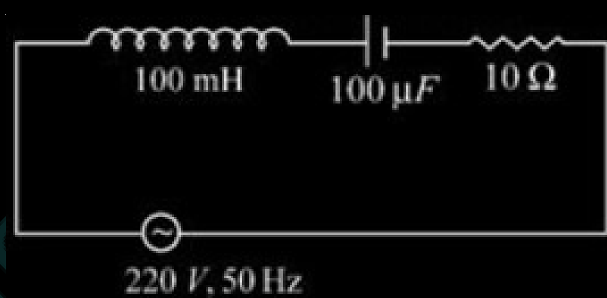
(4) RC series circuit only

55. A sinusoidal voltage $V(t)$ = 210 sin 3000 t volt is applied to a series LCR circuit in which L = 10 mH, C = 25 μF and R = 100 Ω. The phase difference (Φ) between the applied voltage and resultant current will be **[JEE (Main)-2022]**

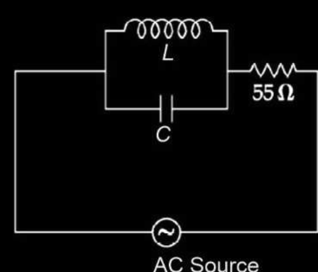
(1) $\tan^{-1}(0.17)$ (2) $\tan^{-1}(9.46)$

(2) $\tan^{-1}(0.30)$ (4) $\tan^{-1}(13.33)$

56. In a series LCR circuit, the inductance, capacitance and resistance are L = 100 mH, C = 100 μF and R = 10 W respectively. They are connected to an AC source of voltage 220 V and frequency of 50 Hz. The approximate value of current in the circuit will be ______ A. **[JEE (Main)-2022]**



57. A 110 V, 50 Hz, AC source is connected in the circuit (as shown in figure). The current through the resistance 55 Ω, at resonance in the circuit, will be _______ A. **[JEE (Main)-2022]**



58. The current flowing through an ac circuit is given by

I = 5 sin(120πt)A

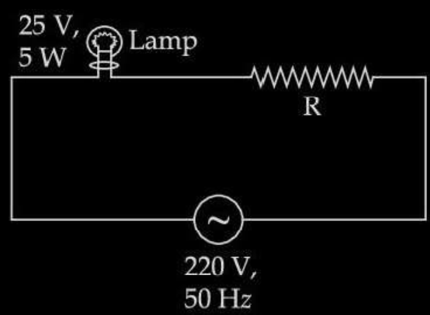
How long will the current take to reach the peak value starting from zero? **[JEE (Main)-2022]**

(1) $\frac{1}{60}$s (2) 60s

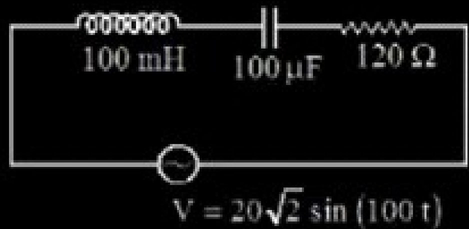
(3) $\frac{1}{120}$s (4) $\frac{1}{240}$s

59. A 220 V, 50 Hz AC source is connected to a 25 V, 5 W lamp and an additional resistance R in series (as shown in figure) to run the lamp at its peak brightness, then the value of R (in ohm) will be ___.

[JEE (Main)-2022]



60. An AC source is connected to an inductance of 100 mH, a capacitance of 100 μF and a resistance of 120 Ω as shown in figure. The time in which the resistance having a thermal capacity 2 J/°C will get heated by 16°C is ___ s. **[JEE (Main)-2022]**

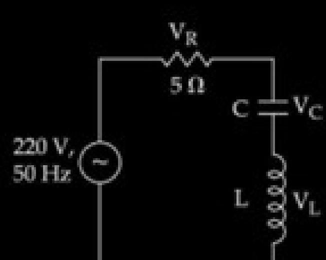


$V = 20\sqrt{2}\sin(100t)$

61. A telegraph line of length 100 km has a capacity of 0.01 μF/km and it carries an alternating current at 0.5 kilo cycle per second. If minimum impedance is required, then the value of the inductance that needs to be introduced in series is_______ mH. (if $\pi = \sqrt{10}$) **[JEE (Main)-2022]**

62. In the given circuit, the magnitude of V_L and V_C are twice that of V_R. Given that $f = 50$ Hz, the inductance of the coil is $\frac{1}{K\pi}$ mH. The value of K is ________.

[JEE (Main)-2022]



63. For a series LCR circuit, I vs ω curve is shown :

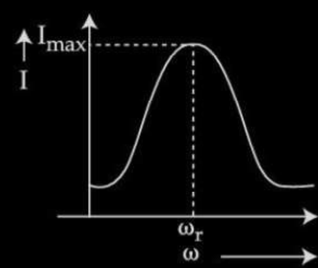
[JEE (Main)-2022]

(1) To the left of ω_r, the circuit is mainly capacitive.

(2) To the left of ω_r, the circuit is mainly inductive.

(3) At ω_r, impedance of the circuit is equal to the resistance of the circuit.

(4) At ω_r, impedance of the circuit is 0.



Choose the **most appropriate** answer from the options given below

(1) (a) and (d) only

(2) (b) and (d) only

(3) (a) and (c) only

(4) (b) and (c) only

64. An inductor of 0.5 mH, a capacitor of 200 μF and a resistor of 2 Ω are connected in series with a 220 V ac source. If the current is in phase with the emf, the frequency of ac source will be ______ × 10^2 Hz.

[JEE (Main)-2022]

65. To increase the resonant frequency in series LCR circuit, **[JEE (Main)-2022]**

(1) Source frequency should be increased.

(2) Another resistance should be added in series with the first resistance.

(3) Another capacitor should be added in series with the first capacitor.

(4) The source frequency should be decreased.

66. The rms value of conduction current in a parallel plate capacitor is 6.9 μA. The capacity of this capacitor, if it is connected to 230 V ac supply with an angular frequency of 600 rad/s, will be : **[JEE (Main)-2022]**

(1) 5 pF (2) 50 pF

(3) 100 pF (4) 200 pF

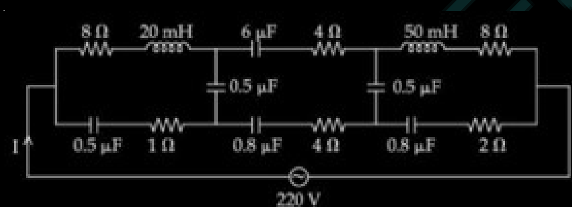
67. In a series *LR* circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance *C* such that $X_L = X_C$ is put in series, the power factor becomes P_2. The ratio $\frac{P_1}{P_2}$ is **[JEE (Main)-2022]**

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

(3) $\frac{\sqrt{3}}{\sqrt{2}}$ (4) 2 : 1

68. The effective current *I* in the given circuit at very high frequencies will be ________ A.

[JEE (Main)-2022]



69. A direct current of 4 A and an alternating current of peak value 4 A flow through resistance of 3 Ω and 2 Ω respectively. The ratio of heat produced in the two resistances in same interval of time will be :

[JEE (Main)-2022]

(1) 3 : 2 (2) 3 : 1

(3) 3 : 4 (4) 4 : 3

70. A 50 W, 100 V lamp is to be connected to an AC mains of 200 V, 50 Hz. What capacity (in μF) capacitor is essential to be put in series with the lamp? **[JEE (Main)-2022]**

71. A series *LCR* circuit has *L* = 0.01 H, *R* = 10 Ω and *C* = 1 μF and it is connected to ac voltage of amplitude (V_m) 50 V. At frequency 60% lower than resonant frequency, the amplitude of current will be approximately **[JEE (Main)-2022]**

(1) 466 mA (2) 312 mA

(3) 238 mA (4) 196 mA

72. The equation of current in a purely inductive circuit is $5\sin(49\pi t - 30°)$. If the inductance is 30 mH then the equation for the voltage across the inductor, will be:

[JEE (Main)-2022]

$\left\{\text{Let } \pi = \frac{22}{7}\right\}$

(1) $1.47\sin(49\pi t - 30°)$

(2) $1.47\sin(49\pi t + 60°)$

(3) $23.1\sin(49\pi t - 30°)$

(4) $23.1\sin(49\pi t + 60°)$

73. The frequencies at which the current amplitude in an LCR series circuit becomes $\frac{1}{\sqrt{2}}$ times its maximum value, are 212 rad s^{-1} and 232 rad s^{-1}. The value of resistance in the Question: circuit is $R = 5\,\Omega$. The self-inductance in the circuit is_____ mH.
[JEE (Main)-2022]

74. A transformer operating at primary voltage 8 kV and secondary voltage 160 V serves a load of 80 kW. Assuming the transformer to be ideal with purely resistive load and working on unity power factor, the loads in the primary and secondary circuit would be

[JEE (Main)-2022]

(1) 800 Ω and 1.06 Ω

(2) 10 Ω and 500 Ω

(3) 800 Ω and 0.32 Ω

(4) 1.06 Ω and 500 Ω

75. An alternating emf $E = 440 \sin 100\pi t$ is applied to a circuit containing an inductance of $\frac{\sqrt{2}}{\pi}$ H. If an a.c. ammeter is connected in the circuit, its reading will be : **[JEE (Main)-2022]**

(1) 4.4 A
(2) 1.55 A
(3) 2.2 A
(4) 3.11 A

76. A circuit element X when connected to an a.c. supply of peak voltage 100 V gives a peak current of 5 A which is in phase with the voltage. A second element Y when connected to the same a.c. supply also gives the same value of peak current which lags behind the voltage by $\frac{\pi}{2}$. If X and Y are connected in series to the same supply, what will be the rms value of the current in ampere? **[JEE (Main)-2022]**

(1) $\frac{10}{\sqrt{2}}$
(2) $\frac{5}{\sqrt{2}}$
(3) $5\sqrt{2}$
(4) $\frac{5}{2}$

77. A capacitor of capacitance 500 μF is charged completely using a dc supply of 100 V. It is now connected to an inductor of inductance 50 mH to form an LC circuit. The maximum current in the LC circuit will be _______A **[JEE (Main)-2022]**

78. Given below are two statements:

Statement-I : The reactance of an ac circuit is zero. It is possible that the circuit contains a capacitor and an inductor.

Statement-II : In ac circuit, the average power delivered by the source never becomes zero.

In the light of the above statements, choose the correct answer from the options given below.

[JEE (Main)-2022]

(1) Both Statement I and Statement II are true
(2) Both Statement I and Statement II are false
(3) Statement I is true but Statement II is false
(4) Statement I is false but Statement II is true

❑ ❑ ❑

Chapter 20

Alternating Current

1. Answer (1)

The series LCR will be in resonance

So, $P = \varepsilon_V I_V \cos\phi$

$$= \frac{\varepsilon_V{}^2}{Z}\cos\phi = \frac{\varepsilon_V{}^2}{R}$$

$$= \frac{(220)^2}{200} = \frac{48400}{200} = 242\,\text{W}$$

2. Answer (1)

For a damped pendulum, $A = A_0 e^{-bt/2m}$

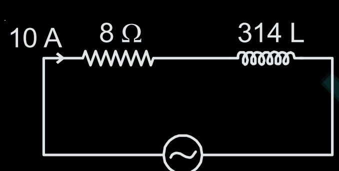
$$\Rightarrow \quad A = A_0 e^{-\left(\frac{R}{2L}\right)t}$$

(Since L plays the same role as m)

3. Answer (3)

$$R = \frac{V}{I} = 8\,\Omega$$

$P = 800$ W



$(220)^2 = (10 \times 8)^2 + (314 \times L \times 10)^2$

$\Rightarrow \; L = 0.065$ H

4. Answer (2)

$P_{av} = E_{rms}\, I_{rms} \cos\phi$

$$= \frac{100}{\sqrt{2}} \times \frac{20}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = \frac{1000}{\sqrt{2}}$$

$$i_{wattless} = i_{rms} \sin\phi = \frac{20}{\sqrt{2}} \times \frac{1}{\sqrt{2}} = 10$$

5. Answer (1)

Quality factor, $Q = \dfrac{\omega_0}{(2\Delta\omega)}$

$$Q = \frac{\omega_0 L}{R}$$

6. Answer (2)

$$X_L = \omega L = 20 \times 10^{-3} \times 2\pi \times 50 = 2\pi\,\Omega = 6.28\,\Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1 \times 10^6}{2\pi \times 50 \times 120} = \frac{1000}{2\pi \times 6}\,\Omega = 26.53\,\Omega$$

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

$$\therefore \quad |Z| = \sqrt{(60)^2 + (20.25)^2} = 63.32\,\Omega$$

$$\therefore \quad I_{rms} = \frac{24}{63.32},\; \cos\theta = \frac{60}{63.32}$$

$$\therefore \quad \Delta E = \frac{24}{63.32} \times 24 \times \frac{60}{63.32} \times 60$$

$= 5.17 \times 10^2$ J

7. Answer (3)

$P_{input} = V_p \cdot I_p = 2300 \times 5$ W

$P_{output} = 0.9\, P_{input} = V_s I_s$

$$\Rightarrow \quad I_s = \frac{0.9 \times 2300 \times 5}{230} = 45\text{ A}$$

8. Answer (3)

$$X_c = \frac{1}{\omega C} = \frac{1 \times 2}{100 \times \sqrt{3}} \times 10^6 = \frac{20}{\sqrt{3}}\,\text{k}\Omega$$

$$X_L = \omega L = 10\sqrt{3}\,\Omega$$

As $X_C >> R_2$, I_2 leads V by 90°.

I_1 lags V by 60°

$\Rightarrow$ Phase difference between I_1 and I_2 150°.

9. Answer (4)

$I = I_m \sin(100\pi t)$

$$\Rightarrow \quad \frac{I_m}{2} = I_m \sin(100\pi t_1)$$

$\Rightarrow \quad \dfrac{\pi}{6} = 100\pi t_1$

$\Rightarrow \quad t_1 = \dfrac{1}{600}$ s

$T = \dfrac{2\pi}{100\pi} = \dfrac{1}{50}$ s

$\therefore \quad t_{req} = \dfrac{T}{4} - t_1 = \dfrac{1}{200} - \dfrac{1}{600} = \dfrac{2}{600} = \dfrac{1}{300}$ s = 3.3 ms

10. Answer (3)

As $\phi = \dfrac{\pi}{4}$, $x_c = R$

11. Answer (1)

Power output ($V_2 I_2$) = 2.2 kW

$\therefore \quad V_2 = \dfrac{2.2 \text{ kW}}{(10 \text{ A})} = 220$ volts

$\therefore$ Input voltage for step-down transformer

$\dfrac{V_1}{V_2} = \dfrac{N_1}{N_2} = 2$

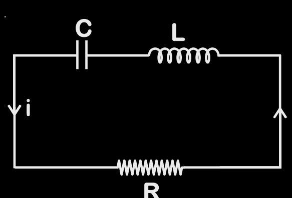
$V_{input} = 2 \times V_{output} = 2 \times 220$

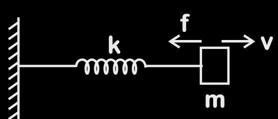
$= 440$ V

Also, $\dfrac{I_1}{I_2} = \dfrac{N_2}{N_1}$

$\therefore \quad I_1 = \dfrac{1}{2} \times 10 = 5$ A

12. Answer (1)





In damped oscillation,

$$\frac{md^2x}{dt^2} = -kx - bv$$

$$\Rightarrow \quad \frac{md^2x}{dt^2} + b\frac{dx}{dt} + kx = 0 \quad \text{... (i)}$$

In LCR circuit, $\dfrac{-q}{C} - iR - \dfrac{Ldi}{dt} = 0$

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = 0$$

$\therefore \quad m \equiv L, b \equiv R, k \equiv \dfrac{1}{C}$

13. Answer (4)

$Z = x_C - x_L$

$Z = \dfrac{1}{\omega C} - \omega L$

$= \dfrac{1}{314 \times 100 \times 10^{-6}} - 314 \times 40 \times 10^{-3}$

$= 19.28\ \Omega$

$i = \dfrac{V_0}{Z} \sin(\omega t + \pi/2)$

14. Answer (4)

Impedance of coil = 100 Ω

$\phi = 45° \quad \Rightarrow \quad R = X_L = 50\sqrt{2}$

$\Rightarrow \quad 50\sqrt{2} = \omega \times L$

$\Rightarrow \quad L = \dfrac{50\sqrt{2}}{2\pi \times 1000} = 1.1 \times 10^{-2}$ H

Nearest value given is 1.1×10^{-2} H.

15. Answer (1)

$H = (I_{rms})^2 Rt$

$mS\Delta T = (I_{rms})^2 Rt$

$t = \dfrac{mS\Delta T}{(I_{rms})^2 R}$

$= \dfrac{2 \times 10}{(I_{rms})^2\, 100} \quad \text{...(i)}$

$I_{rms} = \dfrac{20}{\sqrt{(X_L - X_C)^2 + R^2}}$, $\quad X_L = 2 \times \pi \times 750 \times .1803$

$X_C = \dfrac{1}{2 \times \pi \times 750 \times 10^{-6}}$

Put value in (i), t come out $\simeq 348$ s

16. Answer (2)

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

$$= \frac{1}{100}\sqrt{\frac{80\times10^{-3}}{2\times10^{-6}}}$$

= 2

17. Answer (2)

$$I = \frac{P}{V} = \frac{(1000)}{220}$$

$$P_{Loss} = I^2R_{trans} = \left(\frac{1000}{220}\right)^2\times2$$

$$\Rightarrow \text{ efficiency} = \left(\frac{1000}{1000+P_{Loss}}\right)\times100$$

$$\simeq 96\%$$

18. Answer (400)

$$P = \frac{(250)^2}{Z}\cos\phi$$

$$500 = \frac{(250)^2}{Z}$$

$Z = 125\ \Omega$

$R = 100\ \Omega$

$X_L = 75\ \Omega$

$$75 = \frac{1}{2\pi fC}$$

$$C = \frac{1}{2\pi\times75\times50} = \frac{1}{7500\pi}$$

$$C = \left(\frac{10^6}{2500}\times\frac{1}{3\pi}\right)\mu F$$

$$C = \frac{400}{3\pi}\mu F$$

19. Answer (2000)

$$Q = \frac{X_L}{R} = 2000$$

20. Answer (440)

$$\frac{V_S}{V_P} = \frac{N_S}{N_P}$$

$$N_P = \frac{V_P}{V_S}.N_S = \frac{220}{12}\times24 = 440$$

21. Answer (900)

At resonance $P = \dfrac{V^2}{R}$

$$R = \frac{V^2}{P} = \frac{(120)^2}{16} = 900\ \Omega$$

22. Answer (3)

$$\frac{X_L}{R} = \frac{4}{3}$$

$X_L = 80\ \Omega$

$100 \times L = 80\ \Omega$

$L = 0.8$ H

$$\frac{1}{\omega C} = \frac{2}{3}\times60$$

$$\frac{1}{100\times40} = C$$

$C = 250\ \mu F$

23. Answer (3)

LCR circuit is in resonance.

$$\therefore\quad I_{rms} = \frac{V_{rms}}{R} = \frac{220}{110} = 2\text{ A}$$

24. Answer (4)

$$i = i_1\sin\omega t + i_2\cos\omega t$$

$$\therefore\quad (i_{rms})^2 = \frac{\int_0^T i^2 dt}{T}$$

$$= \frac{\int_0^T\left(i_1^2\sin^2\omega t + i_2^2\cos^2\omega t + 2i_1i_2\sin\omega t\times\cos\omega t\right)dt}{T}$$

$$= \frac{i_1^2}{2} + \frac{i_2^2}{2} + 0$$

$$\therefore\quad i_{rms} = \frac{1}{\sqrt{2}}\left(i_1^2 + i_2^2\right)^{\frac{1}{2}}$$

25. Answer (400)

$$Q = \frac{X_L}{R} = 100$$

$$Q' = \frac{2X_L}{R/2} = 4Q$$

$= 400$

26. Answer (1)

$$I_{max} = \frac{V_{max}}{Z} = \frac{30}{\sqrt{R^2 + (X_L - X_C)^2}}$$

$X_L = 100 \times 0.1 = 10\ \Omega$

$$X_C = \frac{1}{100 \times 10^{-4}} = 100\ \Omega$$

$$I_{max} = \frac{30}{\sqrt{(120)^2 + (90)^2}} = 0.2\ \text{A}$$

$$\omega = \frac{1}{\sqrt{LC}} \quad \Rightarrow \quad f = \frac{1}{2\pi\sqrt{LC}} \approx 50\ \text{Hz}$$

27. Answer (4)

Power dissipated at resonance

$$= \frac{V_{rms}^2}{R} = \frac{(250)^2}{2 \times 8} = 3.906 \times 10^3\ \text{W}$$

28. Answer (1)

$V_2I_2 = V_1I_1$

Here $V_2 > V_1$

29. Answer (1)

$$I_{rms} = \sqrt{\frac{\int I^2\, dt}{T}}$$

$$(I_{rms})^2 = \frac{\int_0^T [I_1^2 \sin^2 \omega t + I_2 \cos^2 \omega t + 2I_1I_2 \sin(\omega t) \times \cos(\omega t)]\, dt}{T}$$

$$\Rightarrow \quad I_{rms} = \sqrt{\frac{I_1^2}{2} + \frac{I_2^2}{2} + 0} = \sqrt{\frac{I_1^2 + I_2^2}{2}}$$

30. Answer (3)

$X_L = \omega L$

$$I = \frac{\varepsilon}{X_L}$$

$\therefore$ Reactance gets halved and current gets doubled.

31. Answer (4)

For purely resistive circuit, current is in phase with voltage.

Whereas for inductive and capacitive circuit phase difference between voltage and current is $\frac{\pi}{2}$.

32. Answer (2)

For change in current from its maximum to rms value, the current phasor will rotate by angle $\frac{\pi}{4}$ or the time required will be $\frac{T}{8}$

Time required $= \frac{T}{8} = \frac{1}{8\nu} = \frac{1}{400}$ s

Time required = 2.5 ms

33. Answer (3)

$$Q = \frac{X_L}{R}$$

$$\text{Band width} = \frac{\text{Resonance Frequency}}{\text{Quality Factor}}$$

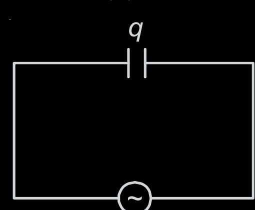
With increase in value of R, the band width will increase.

34. Answer (1)

$$\cos\phi = \frac{R}{Z} = \frac{6}{\sqrt{(10-4)^2 + (6)^2}}$$

$$= \frac{6}{\sqrt{36 \times 2}} = \frac{1}{\sqrt{2}}$$

35. Answer (3)



$$C = \frac{\varepsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 1}{2 \times 10^{-3}} = \frac{8.85 \times 10^{-9}}{2}$$

$q = CV$

$$i = C\frac{dv}{dt} = C\, 20\omega \cos \omega t$$

$i = 20\ \omega C \cos\omega t$

So, amplitude of displacement current

$= 20\omega C$

$$= 20\times 2\pi\times 50\times \frac{\varepsilon_0 A}{d}$$

$$= 20\times 2\pi\times 50\times \frac{8.85\times 10^{-9}}{2}$$

$= \pi \times 8.85 \times 10^{-6}$

$= 27.79 \times 10^{-6}$ A = 27.79 μA

36. Answer (3)

$$\tan\phi = \frac{|X_L - X_C|}{R}$$

$$\Rightarrow \quad X_C = X_L + R = 9 + 1 = 10\ \Omega$$

$$C = \frac{1}{\omega X_C}$$

$$= \frac{1}{300\times 10} = \frac{1}{3}\times 10^{-3}\ \text{F}$$

37. Answer (1)

$X_L = 2 \times \pi \times 50 \times 0.5 \times 10^{-3}$

$= 0.05\pi\ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{10^{12}}{2\pi\times 50\times 0.1}$$

$$= \frac{10^{11}}{\pi}\Omega$$

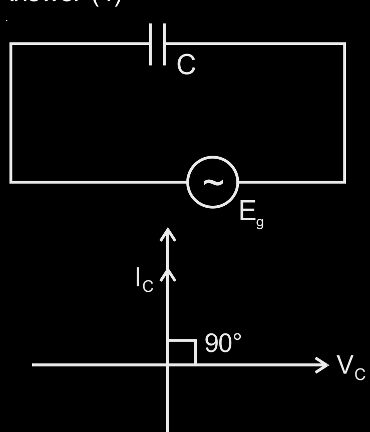
$X_C - X_L >> R$

38. Answer (125)

$$P_r = \frac{V_{rms}^2}{R} \text{ as at resonance } Z = R$$

$$= \frac{250\times 250}{5} = 125\times 10^2\ \text{W}$$

39. Answer (4)



and phasors rotate by ωt.

40. Answer (1)

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

So current in phase with EMF

At resonance, current have maximum value.

41. Answer (1)

$$i = \frac{220\sqrt{2}}{R}\sin\omega t\ , \quad T = \frac{1}{50}\ \text{s}$$

time required for maximum to rms

$$= \frac{T}{8}$$

$$= \frac{1}{50\times 8}\ \text{s}$$

$$= \frac{1}{400}\ \text{s}$$

= 2.5 ms

42. Answer (500)

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

$$\Rightarrow \quad Z = R$$

$$\Rightarrow \quad \omega = \frac{1}{\sqrt{LC}} = 500\ \text{rad/s}$$

43. Answer (1)

$$Z = \sqrt{12^2 + (100\pi\times 0.07)^2} \approx 25\ \Omega$$

$$\therefore \quad I = \frac{220}{25} = 8.8\ \text{A}$$

$$\tan\phi = \frac{X_L}{R} = \frac{100\times\frac{22}{7}\times\frac{7}{100}}{12} = \frac{11}{6}$$

44. Answer (2)

$$\omega = \frac{1}{\sqrt{LC}}$$

$$L = \frac{1}{\omega^2 C} = \frac{1}{[120\pi]^2 10^{-7}}$$

$$L = \frac{10^7}{120^2\pi^2}\text{H}$$

= 70.3 H

45. Answer (2)

For power to be maximum

$X_L = X_C$

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

$$250\pi = \frac{1}{2\pi f \times C}$$

$$C = \frac{1}{2 \times 250 \times 50 \times \pi^2}$$

$$= \frac{1}{25000 \times 10}$$

$C = 4\ \mu F$

46. Answer (1)

For upper elements

$R_1 = 100$

$$X_C = \frac{10^6}{100 \times 100} = 100$$

$$Z_1 = \sqrt{100^2 + \frac{10^6}{100 \times 100}}$$

$$= 100\sqrt{2}$$

$$\tan\phi_1 = \frac{100}{100} = 1 \quad \Rightarrow \phi_1 = 45°$$

So, $I_{10} = \frac{200\sqrt{2}}{100\sqrt{2}} = 2 \qquad \therefore I_1 = 2\sin(\omega t + 45°)$

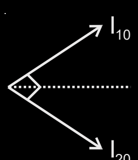
for lower elements, $\qquad \therefore R_2 = 50\ \Omega$

$Z_2 = \sqrt{50^2 + 50^2} = 50\sqrt{2} \qquad X_L = \omega L = 50\Omega$

$\tan\phi_2 = -1°,\ I_{20} = \frac{200\sqrt{2}}{50\sqrt{2}} = 4$

$\Rightarrow \phi_2 = -45°$

So, $I = I_1 + I_2$



So, $I_0 = \sqrt{20}$

So, $I_{rms} = \frac{I_0}{\sqrt{2}} = \sqrt{10}$ A

= 3.16 A

47. Answer (11)

$$i = 10 + \sqrt{42}\sin\left(\frac{2\pi}{T}t\right)\text{A}$$

$$i_{rms} = \sqrt{10^2 + \frac{(\sqrt{42})^2}{2}} = 11\text{ A}$$

48. Answer (1)

$$\cos\phi_2 = \frac{R}{Z_2} = \frac{R}{\sqrt{R^2 + (x_L - x_C)^2}} = \frac{1}{\sqrt{2}}$$

$$\cos\phi_1 = \frac{R}{Z_1} = \frac{R}{\sqrt{10}R} = \frac{1}{\sqrt{10}}$$

$$\frac{\cos\phi_2}{\cos\phi_1} = \frac{\sqrt{5}}{1}$$

49. Answer (3)

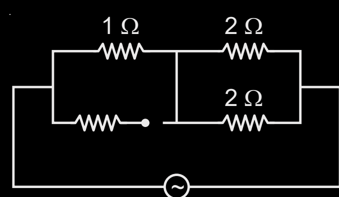
$$Z = \sqrt{(X_L - X_C)^2 + R^2}$$

$X_L = X_C$

$\Rightarrow Z = R$

50. Answer (2)

At high frequencies, $X_C \to 0$ & $X_L \to \infty$



$$Z = 1 + \frac{2 \times 2}{2 + 2}$$

$= 2\ \Omega$

51. Answer (A)

$I = I_0\cos(\omega t)$ say

$\Rightarrow$ At maximum $\omega t_1 = 0$ or $t_1 = 0$

Then at rms value $I = I_0/\sqrt{2}$

$\Rightarrow \omega t_2 = \pi/4$

$\Rightarrow \omega(t_2 - t_1) = \pi/4$

$$\Delta t = \frac{\pi}{4\omega} = \frac{\pi T}{4 \times 2\pi}$$

$$= \frac{1}{400}\text{s or 2.5 ms}$$

$\Rightarrow$ Option A is right answer

52. Answer (242)

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{z}$$

$z = X_2 = \omega_2$

$$= 2\pi \times 50 \times \frac{200}{1000}$$

$= 20\,\pi$

$$\therefore \quad I_{\text{rms}} = \frac{220}{20\pi} = \frac{11}{\pi}$$

$$\therefore \quad I_{\text{peak}} = \sqrt{2} \times \frac{11}{\pi}$$

$$= \frac{\sqrt{2 \times 121}}{\pi}$$

$$= \frac{\sqrt{242}}{\pi}$$

53. Answer (A)

AC generator	$\rightarrow$	Converts mechanical energy into electrical energy
Galvanometer	$\rightarrow$	Detects the presence of current in the circuit
Transformer	$\rightarrow$	Change AC voltage for smaller or greater value
Metal detector	$\rightarrow$	Works on the principle of resonance in AC circuit

$\Rightarrow$ Option (A) is correct

54. Answer (B)

For wattless current to flow in AC circuit the circuit will be Purely Inductive circuit

55. Answer (A)

$X_L = 3000 \times 10 \times 10^{-3} = 30\Omega$

$$X_C = \frac{1}{3000 \times 25} \times 10^6 = \frac{40}{3}\Omega$$

$$\text{So } X_L - X_C = 30 - \frac{40}{3} = \frac{50}{3}\Omega$$

$$\tan\theta = \frac{X_L - X_C}{R} = \frac{50/3}{100} = \frac{1}{6}$$

So $\theta = \tan^{-1}(0.17)$

56. Answer (22)

$$Z = \sqrt{R^2 + (x_L - x_C)^2}$$

$$= \sqrt{10^2 + \left[10\pi - \frac{100}{\pi}\right]^2}\,\Omega$$

$\simeq 10\,\Omega$

$$\Rightarrow \text{Current} = \frac{220}{10}\text{A} = 22\text{ A}$$

57. Answer (0)

At resonance $\left(\omega = \frac{1}{\sqrt{LC}}\right)$, impedance of the circuit is infinite.

$\Rightarrow$ Current through resistance = 0.

58. Answer (D)

$\omega = 120\pi$

$$\Rightarrow \quad T = \frac{1}{60}\text{sec}$$

The current will take its peak value in $\frac{T}{4}$ time

$$\text{So } t = \frac{T}{4}$$

$$= \frac{1}{240}\text{s}$$

59. Answer (975)

$$R_b = \frac{(25)^2}{5} = 125\ \Omega$$

$$I_{\text{rms}} = \sqrt{\frac{5}{125}} = \frac{1}{5}\text{A}$$

$$\Rightarrow \frac{220}{R+125} = \frac{1}{5}$$

$$\Rightarrow R = 1100 - 125$$

$$= 975\ \Omega$$

60. Answer (15)

$L = 100 \times 10^{-3}$ H

$C = 100 \times 10^{-6}$ F

$R = 120\ \Omega$

$\omega L = 10\ \Omega$

$$\frac{1}{\omega C} = \frac{1}{10^4 \times 10^{-6}} = 100\ \Omega$$

$$\Rightarrow X_C - X_L = 90\ \Omega$$

$$\Rightarrow Z = \sqrt{90^2 + 120^2} = 150\ \Omega$$

$$\Rightarrow I_{\text{rms}} = \frac{20}{150} = \frac{2}{15}\text{ A}$$

For heat resistance by 16°C heat required = 32 J

$$\Rightarrow \left(\frac{2}{15}\right)^2 \times (120) \times t = 32$$

$$t = \frac{32 \times 15 \times 15}{4 \times 120}$$

$$= 15$$

61. Answer (100)

Total capacitance = 0.01 × 100 = 1 μF

$\omega = 500 \times 2\pi = 1000\pi$ rad/s

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

$$\Rightarrow L = \frac{1}{\omega^2 C} = \frac{1}{10^6 \pi^2 \times 10^{-6}} = \frac{1}{10}\text{H} = 100\text{ mH}$$

62. Answer (0)

$V_L = 2V_R$

So $\omega Li = 2\ Ri$

$$\Rightarrow L = \frac{2R}{\omega} = \frac{2 \times 5}{2\pi \times 50} = \frac{1}{10\pi}\text{H} = \frac{100}{\pi}\text{H}$$

So $k = \frac{1}{100} \simeq 0$

63. Answer (C)

We know that $X_C = \frac{1}{\omega C}$ and $X_L = \omega L$

Also, at $\omega = \omega_r : X_L = X_C$

$\Rightarrow$ For $\omega < \omega_r$: capacitive

and At $\omega = \omega_r : z = \sqrt{R^2 + (X_L - X_C)^2} = R$

64. Answer (5)

Current will be in phase with emf when

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

$$\Rightarrow \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5 \times 10^{-4} \times 2 \times 10^{-4}}}$$

$$\Rightarrow \omega = \frac{10^4}{\sqrt{10}}\text{ rad/s}$$

$$\Rightarrow f = \frac{1}{2\pi} \times \frac{10^4}{\sqrt{10}}\text{ Hz}$$

$$\Rightarrow f \simeq 500\text{ Hz}$$

65. Answer (C)

Resonant frequency $= \frac{1}{\sqrt{LC}} = \omega_0$

$\Rightarrow$ If we decrease C, ω_0 would increase

$\Rightarrow$ Another capacitor should be added in series.

66. Answer (B)

$$Z_C = \frac{V}{I}$$

$$\Rightarrow \frac{1}{\omega C} = \frac{230}{6.9} M\ \Omega$$

$$\Rightarrow C = \frac{6.9}{230\ \omega}\ \mu\text{F}$$

$$= \frac{6.9}{230 \times 600}\mu\text{F}$$

$C = 50$ pF

67. Answer (B)

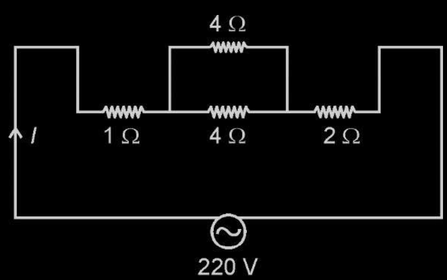
$$P_1 = \cos\phi = \frac{1}{\sqrt{2}}(X_L = R)$$

$P_2 = \cos\phi' = 1$ (will become resonance circuit)

So, $\dfrac{P_1}{P_2} = \dfrac{1}{\sqrt{2}}$

68. Answer (44)

Equivalent circuit will be



$$I = \frac{220}{5} = 44\text{ A}$$

69. Answer (B)

$$\text{Ratio} = \frac{i_1^2 R_1}{\left(\frac{i_2}{\sqrt{2}}\right)^2 R_2} = \frac{4^2 \times 3}{\left(\frac{4}{\sqrt{2}}\right)^2 \times 2}$$

$\Rightarrow$ Ratio = 3 : 1

70. Answer (9.2)

$$X_C = \frac{1}{wc} = \frac{\pi\sqrt{x}}{2\pi \times 50 \times 50} \times 10^6$$

$$v_R^2 + v_C^2 = (200)^2$$

$$v_C^2 = 200^2 - 100^2$$

$$v_C = 100\sqrt{3}\text{ V}$$

$$v_R = 100\text{ V}$$

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

$$R = \frac{100 \times 100}{50} = 200\ \Omega$$

$$i_{rm} = \frac{1}{2}\text{A}$$

$$\frac{1}{2} \times x_C = 100\sqrt{3}$$

$$X_C = \frac{1}{\omega C}$$

$C = 9.2\ \mu$F

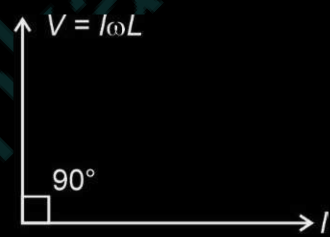
71. Answer (C)

$\omega = 0.4\omega_0$ …(i)

$$\Rightarrow \quad I = \frac{V}{Z} = \frac{50}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}} \text{ …(ii)}$$

$\Rightarrow$ I = 238 mA

72. Answer (D)



$V(t) = I\omega L\sin(49\pi t - 30° + 90°)$

$$= 5 \times 49\pi \times \frac{30}{1000}\sin(49\pi t + 60°)$$

$= 23.1\sin(49\pi t + 60°)$

73. Answer (250)

$$\frac{i}{i_{\max}} = \frac{1}{\sqrt{2}} = \frac{V_0/Z}{V_0/R}$$

$$\Rightarrow \quad \frac{R}{Z} = \frac{1}{\sqrt{2}}$$

and $\dfrac{1}{212C} - 212L = 232L - \dfrac{1}{232C}$

so $212L = \dfrac{1}{232C}$

$$\text{so } \frac{R}{\sqrt{R^2+\left(232L+\frac{1}{232C}\right)^2}}=\frac{1}{\sqrt{2}}$$

$$\frac{R^2}{R^2+(20L)^2}=\frac{1}{2}$$

$400\,L^2 = R^2$

$$L=\frac{5}{20}$$

$$H=\frac{5}{20}\times 1000 \text{ mH}$$

$= 250$ mH

74. Answer (C)

$$V_1 i_1 = V_2 i_2 = 80 \text{ kW}$$

$$\Rightarrow \quad i_1 = 10 \text{ A and } i_2 = \frac{80\times 1000}{160} = 500 \text{ A}$$

$$\Rightarrow \quad R_1 = \frac{V_1}{i_1} = 800\ \Omega \text{ and } R_2 = \frac{160}{500} = 0.32\ \Omega$$

75. Answer (C)

$$I=\frac{V}{\omega L}$$

$$=\frac{440}{100\pi\times\frac{\sqrt{2}}{\pi}}=\frac{44}{10\sqrt{2}}$$

$$\Rightarrow \quad I_{\text{rms}}=\frac{I}{\sqrt{2}}=\frac{44}{20}=2.2 \text{ A}$$

76. Answer (D)

$$R=\frac{100}{5}=20\ \Omega$$

$$X_L=\frac{100}{5}=20\ \Omega$$

When in series

$$z=\sqrt{20^2+20^2}=20\sqrt{2}\ \Omega$$

$$i=\frac{100}{z}=\frac{100}{20\sqrt{2}}=\frac{5}{\sqrt{2}}$$

$$i_{\text{rms}}=\frac{1}{\sqrt{2}}i$$

$$=\frac{5}{2}$$

77. Answer (10)

$q_0 = CV$

$= 500 \times 100 \times 10^{-6}$ C

$= 5 \times 10^{-2}$ C

For i_{max},

$$\frac{1}{2}Li_m^2=\frac{1}{2}\frac{q_0^2}{C}$$

$$50\times 10^{-3}\times i_m^2=\frac{(5\times 10^{-2})^2}{500\times 10^{-6}}$$

$$\Rightarrow \quad i_m=\frac{5\times 10^{-2}}{5\times 10^{-3}}=10 \text{ A}$$

78. Answer (3)

$X = |X_C - X_L|$

So, it can be zero if $X_C = X_L$

And, average power in ac circuit can be zero.

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