SOLVED EXAMPLES

Ex. 1 The peak voltage in a 220 V AC source is

(A) 220 V **(B)** about 160 V
(C) about 310 V **(D)** 440 V

Sol. $V_0 = \sqrt{2}\ V_{rms} = \sqrt{2} \times 220 \simeq 330$ V

Ans is **(C)**

Ex. 2 An AC source is rated 220 V, 50 Hz. The average voltage is calculated in a time interval of 0.01 s. It

(A) must be zero **(B)** may be zero
(C) is never zero **(D)** is $(220/\sqrt{2})$V

Sol. May be zero

Ans. is **(B)**

Ex. 3 Find the effective value of current $i = 2 + 4 \cos 100\,\pi t$.

Sol. $$I_{rms} = \left[\int_0^T \frac{(2+4\cos 100\pi t)^2\, dt}{T}\right]^{1/2} = 2\sqrt{3}$$

Ex. 4 The peak value of an alternating current is 5 A and its frequency is 60 Hz. Find its rms value. How long will the current take to reach the peak value starting from zero?

Sol. $$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{5}{\sqrt{2}}\ \text{A}, \qquad t = \frac{T}{4} = \frac{1}{240}\ \text{s}$$

Ex. 5 An alternating current having peak value 14 A is used to heat a metal wire. To produce the same heating effect, a constant current i can be used where i is

(A) 14 A **(B)** about 20 A
(C) 7 A **(D)** about 10 A

Sol. $$I_{RMS} = \frac{I_0}{\sqrt{2}} = \frac{14}{\sqrt{2}} \simeq 10$$ Ans. is **(D)**

Ex. 6 Find the average power concumed in the circuit if a voltage $v_s = 200\sqrt{2}\ \sin \omega t$ is applied to an AC circuit and the current in the circuit is found to be $i = 2 \sin(\omega t + \pi/4)$.

Sol. $$P = V_{RMS} I_{RMS} \cos\phi = \frac{200\sqrt{2}}{\sqrt{2}} \times \frac{2}{\sqrt{2}} \times \cos\frac{\pi}{4} = 200\ \text{W}$$

Ex. 7 A capacitor acts as an infinite resistance for

(A) DC **(B)** AC
(C) DC as well as AC **(D)** neither AC nor DC

Sol. $x_C = \dfrac{1}{\omega c}$ for DC $\omega = 0$. so, $x_C = \infty$

Ans. is **(A)**

Ex. 8 A 10 μF capacitor is connected with an ac source $E = 200\sqrt{2}\sin(100\,t)$ V through an ac ammeter (it reads rms value). What will be the reading of the ammeter?

Sol. $I_0 = \dfrac{V_0}{x_C} = \dfrac{200\sqrt{2}}{1/\omega C}$; $I_{RMS} = \dfrac{I_0}{\sqrt{2}} = 200$ mA

Ex. 9 Find the reactance of a capacitor (C = 200 μF) when it is connected to **(A)** 10 Hz AC source, **(B)** a 50 Hz AC source and **(C)** a 500 Hz AC source.

Sol. **(A)** $x_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C} \simeq 80\,\Omega$ for f = 10 Hz AC source,

(B) $x_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C} \simeq 16\,\Omega$ for f = 50 Hz and

(C) $x_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C} \simeq 1.6\,\Omega$ for f= 500 Hz.

Ex. 10 An inductor (L = 200 mH) is connected to an AC source of peak current. What is the intantaneous voltage of the source when the current is at its peak value?

Sol. Because phase difference between volatage and current is π/2 for pure inductor.

So, Ans. is zero

Ex. 11 An AC source producing emf $E = E_0[\cos(100\,\pi\,s^{-1})t + \cos(500\,\pi\,s^{-1})t]$ is connected in series with a capacitor and a resistor. The current in the circuit is found to be $i = i_1\cos[(100\,\pi\,s^{-1})t + \varphi_1] + i_2\cos[(500\,\pi\,s^{-1})t + \varphi_1]$

(A) $i_1 > i_2$
(B) $i_1 = i_2$
(C) $i_1 < i_2$
(D) the information is insufficient to find the relation between i_1 and i_2

Sol. Impedence z is given by $z = \sqrt{\left(\dfrac{1}{\omega C}\right)^2 + R^2}$

For higher ω, z will be lower so current will be higher

Ans is **(C)**

Ex. 12 An alternating voltage of 220 volt r.m.s. at a frequency of 40 cycles/sec is supplied to a circuit containing a pure inductance of 0.01 H and a pure resistance of 6 ohms in series. Calculate (i) the current, (ii) potential difference across the resistance, (iii) potential difference across the inductance, (iv) the time lag, (v) power factor.

Sol. **(i)** $z = \sqrt{(\omega L)^2 + R^2} = \sqrt{(2\pi \times 40 \times 0.01^2)^2 + 6^2} = \sqrt{(42.4)}$

$I_{rms} = \dfrac{220}{z} = 33.83$ amp.

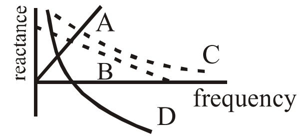
(ii) $V_{rms} = I_{rms} \times R = 202.98$ volts

(iii) $\omega L \times I_{rms} = 96.83$ volts

(iv) $t = T\dfrac{\phi}{2\pi} = 0.01579$ sec

(v) $\cos\phi = \dfrac{R}{Z} = 0.92$

Ex. 13 Which of the following plots may represnet the reactance of a series LC combination ?



Sol. D

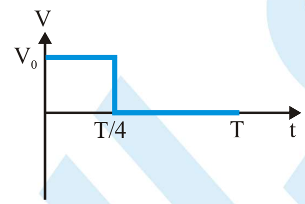
Ex. 14 A series AC circuit has resistance of 4 Ω and a reactance of 3 Ω. the impedance of the circuit is

(A) 5 Ω **(B)** 7 Ω

(C) 12/7 Ω **(D)** 7/12 Ω

Sol. $Z = \sqrt{4^2 + 3^2} = 5\,\Omega$ Ans. is **(A)**

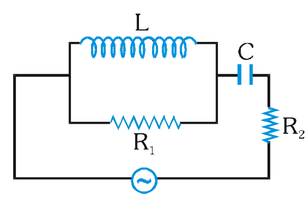
Ex.15 A periodic voltage V varies with time t as shown in the figure. T is the time period. The r.m.s. value of the voltage is:-



(A) $\dfrac{V_0}{8}$ **(B)** $\dfrac{V_0}{2}$ **(C)** V_0 **(D)** $\dfrac{V_0}{4}$

Sol. Root mean square value <V> = $\sqrt{\dfrac{\int_0^{T/4} V_0^2\,dt}{\int_0^{T} dt}} = \sqrt{\dfrac{V_0^2\left(\frac{T}{4}\right)}{T}} == \sqrt{\dfrac{V_0^2\left(\frac{T}{4}\right)}{T}} = \sqrt{\dfrac{V_0^2}{4}} = \dfrac{V_0}{2}$

Ex.16 For the given circuit



(A) The phase difference between I_L & I_{R_1} is 0°

(B) The phase difference between V_C & V_{R_2} is 90°

(C) The phase difference between I_L & I_{R_1} is 180°

(D) The phase difference between V_C & V_{R_2} is 180°

Sol. The phase difference between V_C and V_{R_2} is $\pi/2$ rad or 90°

Ex.17 The potential difference V and current I flowing through the AC circuit is given by V = 5 cos(ωt – π/6) volt and I = 10sinωt ampere. The average power dissipated in the circuit is

(A) $\dfrac{25\sqrt{3}}{2}$ W **(B)** 12.5 W **(C)** 25 W **(D)** 50 W

Sol. $V = 5\cos(\omega t - \pi/6)$; $i = 10\sin\omega t = 10\cos(\omega t - \pi/2)$

$$\phi = \frac{\pi}{2} - \frac{\pi}{6} = \frac{\pi}{3};\ P = \frac{VI}{2}\cos\phi = \frac{5\times10}{2}\times\frac{1}{2} = 12.5\,W$$

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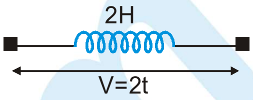
Ex.18 A time varying voltage V = 2t volt is applied across an ideal inductor of inductance L = 2H as shown in figure. Then select incorrect statement



(A) current versus time graph is a parabola

(B) energy stored in magnetic field at t = 2 s is 4J

(C) potential energy at time t = 1 s in magnetic field is increasing at a rate of 1 J/s

(D) energy stored in magnetic field is zero all the time

Sol. $V = 2t \Rightarrow L\frac{di}{dt} = 2t \Rightarrow 2 \times \frac{di}{dt} = 2t \Rightarrow \frac{di}{dt} \Rightarrow i = \frac{t^2}{2} \Rightarrow i - t$ graph parabola

$U = \frac{1}{2}Li^2 = \frac{1}{2} \times 2 \times 4 = 4J$ and $\frac{dU}{dt} = Li\frac{di}{dt} = 2 \times \frac{t^2}{2} \times t = t^3 = 1$ J/s

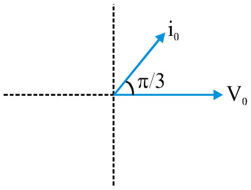
Ex.19 The radius of a coil decreases steadily at the rate of 10^{-2} m/s. A constant and uniform magnetic field of induction 10^{-3} Wb/m^2 acts perpendicular to the plane of the coil. The radius of the coil when the induced e.m.f. in the coil is 1μV, is :-

(A) $\frac{2}{\pi}$ cm **(B)** $\frac{3}{\pi}$ cm **(C)** $\frac{4}{\pi}$ cm **(D)** $\frac{5}{\pi}$ cm

Sol. $e = \frac{d\phi}{dt} = \frac{d}{dt}(\pi r^2 B) = 2\pi r B\frac{dr}{dt} \Rightarrow r = \frac{e}{\left(2\pi B\frac{dr}{dt}\right)} \Rightarrow r = \frac{10^{-6}}{2\pi \times 10^{-3} \times 10^{-2}} = \frac{5}{\pi}$cm

Ex.20 For an LCR series circuit, phasors of current i and applied voltage $V = V_0 \sin\omega t$ are shown in diagram at t =0. Which of the following is/are correct?

(A) At $t = \frac{\pi}{2\omega}$, instantaneous power supplied by source is negative.

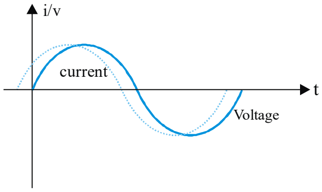


(B) From $0 < t < \frac{2\pi}{3\omega}$, average power supplied by source is positive.

(C) At $t = \frac{5\pi}{6\omega}$, instantaneous power supplied by source is negative.

(D) If ω is increased slightly, angle between the two phasors decreases.

Sol. The graph shows V & I as function of time.



Current leads the voltage by $\pi/3$

Power is positive if V & I are of same sign.

Power is negative if V & I are of opposite sign

If $\omega\uparrow \Rightarrow \frac{1}{\omega C}\downarrow$ thus angle decreases.

Exercise # 1

[Single Correct Choice Type Questions]

1. The peak value of an alternating e.m.f given by $E = E_0 \cos \omega t$, is 10 volt and frequency is 50 Hz. At time t = (1/600) sec, the instantaneous value of e.m.f is :

(A) 10 volt **(B)** $5\sqrt{3}$ volt **(C)** 5 volt **(D)** 1 volt

2. r.m.s. value of current $i = 3 + 4 \sin(\omega t + \pi/3)$ is:

(A) 5 A **(B)** $\sqrt{17}$ A **(C)** $\frac{5}{\sqrt{2}}$ A **(D)** $\frac{7}{\sqrt{2}}$ A

3. The voltage of an AC source varies with time according to the equation, $V = 100 \sin 100\pi t \cos 100\pi t$. Where t is in second and V is in volt. Then :

(A) the peak voltage of the source is 100 volt

(B) the peak voltage of the source is $(100/\sqrt{2})$ volt

(C) the peak voltage of the source is 50 volt

(D) the frequency of the source is 50 Hz

4. An AC voltage is given by :

$$E = E_0 \sin \frac{2\pi t}{T}$$

Then the mean value of voltage calculated over time interval of T/2 seconds :

(A) is always zero **(B)** is never zero **(C)** is $(2E_0/\pi)$ always **(D)** may be zero

5. An alternating voltage is given by : $e = e_1 \sin \omega t + e_2 \cos \omega t$. Then the root mean square value of voltage is given by :

(A) $\sqrt{e_1^2 + e_2^2}$ **(B)** $\sqrt{e_1 e_2}$ **(C)** $\sqrt{\frac{e_1 e_2}{2}}$ **(D)** $\sqrt{\frac{e_1^2 + e_2^2}{2}}$

6. Energy dissipates in LCR circuit in :

(A) L only **(B)** C only **(C)** R only **(D)** all of these

7. The average power delivered to a series AC circuit is given by (symbols have their usual meaning) :

(A) $E_{rms} I_{rms}$ **(B)** $E_{rms} I_{rms} \cos\phi$ **(C)** $E_{rms} I_{rms} \sin\phi$ **(D)** zero

8. An AC voltage of $V = 220\sqrt{2} \sin\left(100\pi t + \frac{\pi}{2}\right)$ is applied across a DC voltmeter, its reading will be:

(A) $220\sqrt{2}$ V **(B)** $\sqrt{2}$ V **(C)** 220 V **(D)** zero

9. The potential difference V across and the current I flowing through an instrument in an AC circuit are given by:

$V = 5 \cos \omega t$ volt

$I = 2 \sin \omega t$ Amp.

The power dissipated in the instrument is :

(A) zero **(B)** 5 watt **(C)** 10 watt **(D)** 2.5 watt

10. What is the rms value of an alternating current which when passed through a resistor produces heat, which is thrice that produced by a D.C. current of 2 ampere in the same resistor in the same time interval?

(A) 6 ampere **(B)** 2 ampere **(C)** $2\sqrt{3}$ ampere **(D)** 0.65 ampere

11. A direct current of 2 A and an alternating current having a maximum value of 2 A flow through two identical resistances. The ratio of heat produced in the two resistances in the same time interval will be:

(A) 1 : 1 **(B)** 1 : 2 **(C)** 2 : 1 **(D)** 4 : 1

12. A sinusoidal AC current flows through a resistor of resistance R. If the peak current is I_p, then average power dissipated is :

(A) $I_p^2 R \cos\theta$ **(B)** $\frac{1}{2} I_p^2 R$ **(C)** $\frac{4}{\pi} I_p^2 R$ **(D)** $\frac{1}{\pi^2} I_p^2 R$

13. The impedance of a series circuit consists of 3 ohm resistance and 4 ohm reactance. The power factor of the circuit is :

(A) 0.4 **(B)** 0.6 **(C)** 0.8 **(D)** 1.0

14. A resistor and a capacitor are connected to an AC supply of 200 volt, 50 Hz in series. The current in the circuit is 2 ampere. If the power consumed in the circuit is 100 watt, then the resistance in the circuit is:

(A) 100 Ω **(B)** 25 Ω **(C)** $\sqrt{125 \times 75}$ Ω **(D)** 400 Ω

15. An electric bulb and a capacitor are connected in series with an AC source. On increasing the frequency of the source, the brightness of the bulb :

(A) increase **(B)** decreases
(C) remains unchanged **(D)** sometimes increases and sometimes decreases

16. A coil of inductance 5.0 mH and negligible resistance is connected to an alternating voltage $V = 10 \sin(100t)$. The peak current in the circuit will be :

(A) 2 amp **(B)** 1 amp **(C)** 10 amp **(D)** 20 amp

17. By what percentage the impedance in an AC series circuit should be increased so that the power factor changes from (1/2) to (1/4) (when R is constant) ?

(A) 200% **(B)** 100% **(C)** 50% **(D)** 400%

18. A 0.21-H inductor and a 88-Ω resistor are connected in series to a 220-V, 50-Hz AC source. The current in the circuit and the phase angle between the current and the source voltage are respectively.
(Use $\pi = 22/7$)

(A) 2 A, $\tan^{-1} 3/4$ **(B)** 14.4 A, $\tan^{-1} 7/8$ **(C)** 14.4 A, $\tan^{-1} 8/7$ **(D)** 3.28 A, $\tan^{-1} 2/11$

19. If the frequency of the source e.m.f. in an AC circuit is n, the power varies with a frequency :

(A) n **(B)** 2 n **(C)** n/2 **(D)** zero

20. A 100 volt AC source of angular frequency 500 rad/s is connected to a LCR circuit with L = 0.8 H, C = 5 μF and R = 10 Ω, all connected in series. The potential difference across the resistance is

(A) $\frac{100}{\sqrt{2}}$ volt **(B)** 100 volt **(C)** 50 volt **(D)** $50\sqrt{3}$

21. An LCR series circuit with 100 Ω resistance is connected to an AC source of 200 V and angular frequency 300 radians per second. When only the capacitance is removed, the current lags the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60°. Then the current and power dissipated in LCR circuit are respectively

(A) 1A, 200 watt. **(B)** 1A, 400 watt. **(C)** 2A, 200 watt. **(D)** 2A, 400 watt.

22. In an L-R series circuit ($L = \frac{175}{11}$ mH and R = 12Ω), a variable emf source ($V = V_0 \sin \omega t$) of $V_{rms} = 130\sqrt{2}$ V and frequency 50 Hz is applied. The current amplitude in the circuit and phase of current with respect to voltage are respectively (Use π = 22/7)

(A) 14.14A, 30° **(B)** $10\sqrt{2}$ A, $\tan^{-1}\frac{5}{12}$ **(C)** 10 A, $\tan^{-1}\frac{5}{12}$ **(D)** 20 A, $\tan^{-1}\frac{5}{12}$

23. A pure resistive circuit element X when connected to an AC supply of peak voltage 200 V gives a peak current of 5 A which is in phase with the voltage. A second circuit element Y, when connected to the same AC supply also gives the same value of peak current but the current lags behind by 90°. If the series combination of X and Y is connected to the same supply, what will be the rms value of current ?

(A) $\frac{10}{\sqrt{2}}$ amp **(B)** $\frac{5}{\sqrt{2}}$ amp **(C)** $\frac{5}{2}$ amp **(D)** 5 amp

24. In an AC circuit the potential differences across an inductor and resistor joined in series are respectively 16 V and 20 V. The total potential difference across the circuit is

(A) 20 V **(B)** 25.6 V **(C)** 31.9 V **(D)** 53.5 V

25. In an AC circuit, a resistance of R ohm is connected in series with an inductance L. If phase angle between voltage and current be 45°, the value of inductive reactance will be.

(A) R/4 **(B)** R/2
(C) R **(D)** cannot be found with the given data

26. An AC voltage source $V = 200\sqrt{2} \sin 100t$ is connected across a circuit containing an AC ammeter (it reads rms value) and capacitor of capacity 1 μF. The reading of ammeter is :

(A) 10 mA **(B)** 20 mA **(C)** 40 mA **(D)** 80 mA

27. If in a series LCR AC circuit, the rms voltage across L, C and R are V_1, V_2 and V_3 respectively, then the voltage of the source is always :

(A) equal to $V_1 + V_2 + V_3$ **(B)** equal to $V_1 - V_2 + V_3$
(C) more than $V_1 + V_2 + V_3$ **(D)** none of these is true

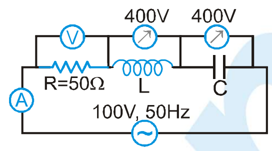
28. When 100 V DC is applied across a solenoid, a steady current of 1 A flows in it. When 100 V AC is applied across the same solenoid, the current drops to 0.5 A. If the frequency of the AC source is $150\sqrt{3}/\pi$ Hz, the impedance and inductance of the solenoid are :

(A) 200 Ω and 1/3 H **(B)** 100 Ω and 1/16 H
(C) 200 Ω and 1.0 H **(D)** 1100 Ω and 3/117 H

29. The value of power factor cosϕ in series LCR circuit at resonance is :

(A) zero **(B)** 1 **(C)** 1/2 **(D)** 1/2 ohm

30. In the series LCR circuit as shown in figure, the voltmeter and ammeter readings are :



(A) V = 100 volt, I = 2 amp (B) V = 100 volt, I = 5 amp

(C) V = 1000 volt, I = 2 amp (D) V = 300 volt, I = 1 amp

31. A resistor R, an inductor L and a capacitor C are connected in series to an oscillator of frequency υ. If the resonant frequency is υ_r, then the current lags behind voltage, when :

(A) $\upsilon = 0$ (B) $\upsilon < \upsilon_r$ (C) $\upsilon = \upsilon_r$ (D) $\upsilon > \upsilon_r$

32. A series LCR circuit containing a resistance of 120 ohm has angular resonance frequency 4×10^3 rad s^{-1}. At resonance, the voltage across resistance and inductance are 60V and 40 V respectively. The values of L and C are respectively :

(A) 20 mH, 25/8 μF (B) 2mH, 1/35 μF (C) 20 mH, 1/40 μF (D) 2mH, 25/8 nF

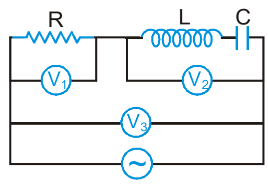
33. In an LCR circuit, the capacitance is made one-fourth, when in resonance. Then what should be the change in inductance, so that the circuit remains in resonance ?

(A) 4 times (B) 1/4 times (C) 8 times (D) 2 times

34. A power transformer (step up) with an 1 : 8 turn ratio has 60 Hz, 120 V across the primary; the load in the secondary is 10^4 Ω. The current in the secondary is

(A) 96 A (B) 0.96 A (C) 9.6 A (D) 96 mA

35. A resistor R, an inductor L, a capacitor C and voltmeters V_1, V_2 and V_3 are connected to an oscillator in the circuit as shown in the adjoining diagram. When the frequency of the oscillator is increased, upto resonance frequency, the voltmeter reading (at resonance frequency) is zero in the case of :



(A) voltmeter V_1 (B) voltmeter V_2 (C) voltmeter V_3 (D) all the three voltmeters

36. In a step-up transformer the voltage in the primary is 220 V and the current is 5A. The secondary voltage is found to be 22000 V. The current in the secondary (neglect losses) is

(A) 5 A (B) 50 A (C) 500 A (D) 0.05 A

37. A transformer is used to light a 140 watt, 24 volt lamp from 240 V AC mains. The current in the main cable is 0.7 amp. The efficiency of the transformer is :

(A) 48% (B) 63.8% (C) 83.3% (D) 90%

38. A capacitor is a perfect insulator for :

(A) constant direct current (B) alternating current

(C) direct as well as alternating current (D) variable direct current

39. The core of a transformer is laminated to reduce

(A) eddy current loss (B) hysteresis loss (C) copper loss (D) magnetic loss

40. A choke coil is preferred to a rheostat in AC circuit as :

(A) it consumes almost zero power (B) it increases current

(C) it increases power (D) it increases voltage

41. A choke coil sould have :

(A) high inductance and high resistance
(B) low inductance and low resistance
(C) high inductance and low resistance
(D) low inductance and high resistance

42. With increase in frequency of an AC supply, the capacitive reactance :

(A) varies inversely with frequency
(B) varies directly with frequency
(C) varies directly as square of frequency
(D) remains constant

43. With increase in frequency of an AC supply, the inductive reactance :

(A) decreases
(B) increases directly proportional to frequency
(C) increases as square of frequency
(D) decreases inversely with frequency

44. In an a.c. circuit consisting of resistance R and inductance L, the voltage across R is 60 volt and that across L is 80 volt. The total voltage across the combination is

(A) 140 V **(B)** 20 V **(C)** 100 V **(D)** 70 V

45. An AC ammeter is used to measure current in a circuit. When a given direct constant current passes through the circuit, the AC ammeter reads 3 ampere. When an alternating current passes through the circuit, the AC ammeter reads 4 ampere. Then the reading of this ammeter if DC and AC flow through the circuit simultaneously, is :

(A) 3 A **(B)** 4 A **(C)** 7 A **(D)** 5 A

Exercise # 2

Part # I [Multiple Correct Choice Type Questions]

1. In an AC series circuit when the instantaneous source voltage is maximum, the instantaneous current is zero. Connected to the source may be a

(A) pure capacitor
(B) pure inductor
(C) combination of pure an inductor and pure capacitor
(D) pure resistor

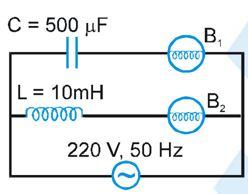
2. Average power consumed in an A.C. series circuit is given by (symbols have their usual meaning) :

(A) $E_{rms} I_{rms} \cos\phi$ **(B)** $(I_{rms})^2 R$ **(C)** $\frac{E_{max}{}^2 R}{2(|z|)^2}$ **(D)** $\frac{I_{max}{}^2 |z| \cos\varphi}{2}$

3. Power factor may be equal to 1 for :

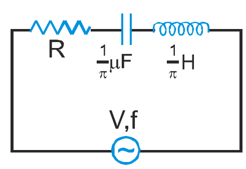
(A) pure inductor **(B)** pure capacitor **(C)** pure resistor **(D)** An LCR circuit

4. In the circuit shown in figure, if both the bulbs B_1 and B_2 are identical :



(A) their brightness will be the same
(B) B_2 will be brighter than B_1
(C) as frequency of supply voltage is increased the brightness of bulb B_1 will increase and that of B_2 will decrease.
(D) only B_2 will glow because the capacitor has infinite impedance

5. In the AC circuit shown below, the supply voltage has constant rms value V but variable frequency f. At resonance, the circuit :



(A) has a current I given by $I = \frac{V}{R}$
(B) has a resonance frequency 500 Hz
(C) has a voltage across the capacitor which is 180^0 out of phase with that across the inductor
(D) has a current given by $I = \frac{V}{\sqrt{R^2 + \left(\frac{1}{\pi} + \frac{1}{\pi}\right)^2}}$

6. In a series LCR circuit with an AC source (E_{rms} = 50 V and ν = 50/π Hz), R = 300 Ω, C = 0.02 mF, L = 1.0 H, Which of the following is correct

(A) the rms current in the circuit is 0.1 A
(B) the rms potential difference across the capacitor is 50 V
(C) the rms potential difference across the capacitor is 14.1 V
(D) the rms current in the circuit is 0.14 A

7. Which of the following quantities have zero average value over a cycle. If an inductor coil having some resistance is connected to a sinusoidal AC source.

(A) induced emf in the inductor
(B) current
(C) joule heat
(D) magnetic energy stored in the inductor

8. An AC source supplies a current of 10 A (rms) to a circuit, rms voltage of source is 100 V. The average power delivered by the source :

(A) must be 1000 W
(B) may be less than 1000 W
(C) may be greater than 1000 W
(D) may be 1000 W

9. A circuit is set up by connecting L = 100 mH, C = 5 μF and R = 100 Ω in series. An alternating emf of ($150\sqrt{2}$) volt, $\frac{500}{\pi}$ Hz is applied across this series combination. Which of the following is correct

(A) the impedance of the circuit is 141.4 Ω
(B) the average power dissipated across resistance 225 W
(C) the average power dissipated across inductor is zero.
(D) the average power dissipated across capacitor is zero.

10. A pure inductance of 1 henry is connected across a 110 V, 70Hz source. Then correct option are (Use $\pi = 22/7$):

(A) reactance of the circuit is 440 Ω
(B) current of the circuit is 0.25 A
(C) reactance of the circuit is 880 Ω
(D) current of the circuit is 0.5 A

11. In a series RC circuit with an AC source(peak voltage E_0 = 50 V and f = $50/\pi$ Hz), R = 300 Ω, C = 25 μF. Then :

(A) the peak current is 0.1 A
(B) the peak current is 0.7 A
(C) the average power dissipated is 1.5 W
(D) the average power dissipated is 3 W

12. A coil of inductance 5.0 mH and negligible resistance is connected to an oscillator giving an output voltage E = (10V) sin ωt. Which of the following is correct

(A) for ω = 100 s^{-1} peak current is 20 A
(B) for ω = 500 s^{-1} peak current is 4 A
(C) for ω = 1000 s^{-1} peak current is 2 A
(D) for ω = 1000 s^{-1} peak current is 4 A

13. 11 kW of electric power can be transmitted to a distant station at (i) 220 V or (ii) 22000 V. Which of the following is correct

(A) first mode of transmission consumes less power
(B) second mode of transmission consumes less power
(C) first mode of transmission draws less current
(D) second mode of transmission draws less current

14. A town situated 20 km away from a power house at 440 V, requires 600 KW of electric power at 220 V. The resistance of transmission line carrying power is 0.4 Ω per km. The town gets power from the line through a 3000 V–220 V step-down transformer at a substation in the town. Which of the following is/are correct

(A) The loss in the form of heat is 640 kW
(B) The loss in the form of heat is 1240 kW
(C) Plant should supply 1240 kW
(D) Plant should supply 640 kW

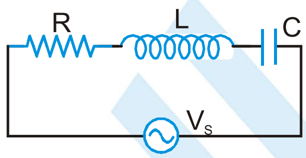
Part # II [Assertion & Reason Type Questions]

In each of the following questions, a Assertion of Statement -1 and Statement - 2 of Reason.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

1. **Statement-1 :** An inductor is connected to an ac source. When the magnitude of current decreases in the circuit, energy is absorbed by the ac source.
Statement-2 : When current through an inductor decreases, the energy stored in inductor decreases.

2. **Statement-1 :** In a series R,L,C circuit if V_R, V_L, and V_C denote rms voltage across R, L and C repectively and V_S is the rms voltage across the source, then $V_S = V_R + V_L + V_C$.



Statement-2 : In AC circuits, kirchoff voltage law is correct at every instant of time.

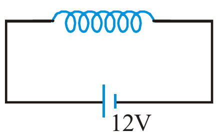
3. **Statement-1 :** The electrostatic energy stored in capacitor plus magnetic energy stored in inductor will always be zero in a series LCR circuit driven by ac voltage source under condition of resonance.

Statement-2 : The complete voltage of ac source appears across the resistor in a series LCR circuit driven by ac voltage source under condition of resonance.

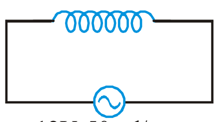
4. **Statement-1 :** Average power consumed in an ac circuit is equal to average power consumed by resistors in the circuit.
Statement-2 : Average power consumed by capacitor and inductor in an ac circuit is zero.

Exercise # 3 Part # I [Matrix Match Type Questions]

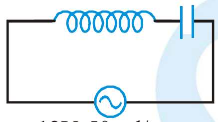
1. A steady current 4 A flows in an inductor coil when connected to a 12 V dc source as shown in figure 1. If the same coil is connected to an ac source of 12 V, 50 rad/s, a current of 2.4 A flows in the circuit as shown in figure 2. Now after these observations, a capacitor of capacitance $\frac{1}{50}$F is connected in series with the coil as shown in figure 3 with the same AC source :



(Figure 1)



(Figure 2)



(Figure 3)

	Column-I		Column-II (in S.I units)
(A)	The inductance of the coil (nearly)	(P)	24
(B)	The resistance of the coil	(Q)	3
(C)	Average power (nearly)	(R)	0.08
(D)	Total reactance		

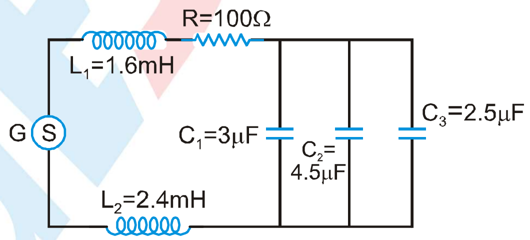
2. Match the Physical quantities given in column-I with the parameters they depend on as given in column-II.

Column I		Column II
(A) Inductance of a coil	(P)	Depends on resistivity
(B) Capacitance	(Q)	Depends on shape
(C) Impedance of a coil	(R)	Depends on medium inserted
(D) Reactance of a capacitor	(S)	Depends on external AC voltage source

Part # II [Comprehension Type Questions]

Comprehension # 1

An ac generator G with an adjustable frequency of oscillation is used in the circuit, as shown.



1. Current drawn from the ac source will be maximum if its angular frequency is -

(A) 10^5 rad/s (B) 10^4 rad/s (C) 5000 rad/s (D) 500 rad/s

2. To increase resonant frequency of the circuit, some of the changes in the circuit are carried out. Which change(s) would certainly result in the increase in resonant frequency ?

(A) R is increased.
(B) L_1 is increased and C_1 is decreased.
(C) L_2 is decreased and C_2 is increased.
(D) C_3 is removed from the circuit.

3. If the ac source G is of 100 V rating at resonant frequency of the circuit, then average power supplied by the source is -

(A) 50 W **(B)** 100 W **(C)** 500 W **(D)** 1000 W

4. Average energy stored by the inductor L_2 (Source is at resonance frequency) is equal to

(A) zero **(B)** 1.2 mJ **(C)** 2.4 mJ **(D)** 4 mJ

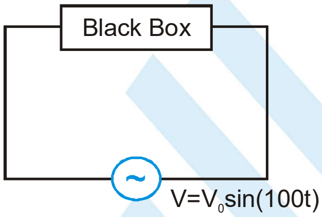
5. Thermal energy produced by the resistance R in time duration 1 μs, using the source at resonant condition, is

(A) 0 J **(B)** 1 μJ

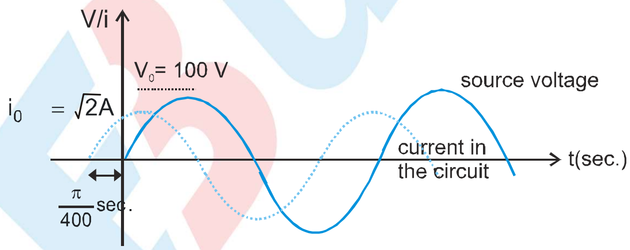
(C) 100 μJ **(D)** not possible to calculate from the given information

Comprehension # 2

A voltage source $V = V_0 \sin(100\,t)$ is connected to a black box in which there can be either one element out of L, C, R or any two of them connected in series.



At steady state. the variation of current in the circuit and the source voltage are plotted together with time, using an oscilloscope, as shown



1. The element(s) present in black box is/are :

(A) only C **(B)** L and C **(C)** L and R **(D)** R and C

2. Values of the parameters of the elements, present in the black box are -

(A) $R = 50\Omega$, $C = 200\ \mu f$ **(B)** $R = 50\Omega$, $L = 2m\mu$

(C) $R = 400\ \Omega$, $C = 50\ \mu\ f$ **(D)** None of these

3. If AC source is removed, the circuit is shorted for some time so that capacitor is fully discharged and then a battery of constant EMF is connected across the black box, at $t = 0$. The current in the circuit will -

(A) increase exponentially with time constant = 0.02 sec.

(B) decrease exponentially with time constant = 0.01 sec.

(C) oscillate with angular frequency 20 rad/sec

(D) first increase and then decrease

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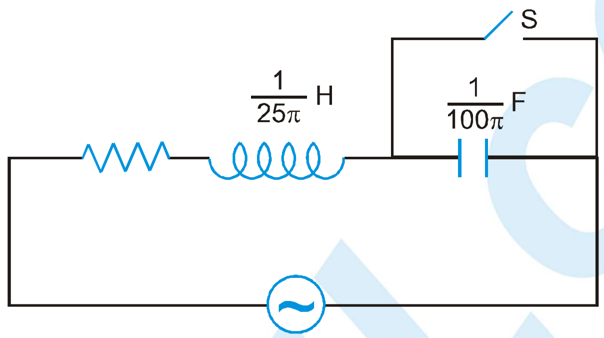
Comprehension # 3

In the LCR circuit shown in figure unknown resistance and alternating voltage source are connected. When switch 'S' is closed then there is a phase difference of $\frac{\pi}{4}$ between current and applied voltage and voltage across resister is $\frac{100}{\sqrt{2}}$ V. When switch is open current and applied voltage are in same phase. Neglecting resistance of connecting wire answer the following questions :



1. Peak voltage of applied voltage sources is :

(A) $200\sqrt{2}$ V (B) 100 V (C) $100\sqrt{2}$ V (D) $\frac{100}{\sqrt{2}}$ V

2. Resonance frequency of circuit is :

(A) 50 Hz (B) 25 Hz
(C) 75 Hz (D) Data insufficient for calculation

3. Average power consumption in the circuit when 'S' is open :

(A) 2500 W (B) 3000 W (C) 5000 W (D) 1250 W

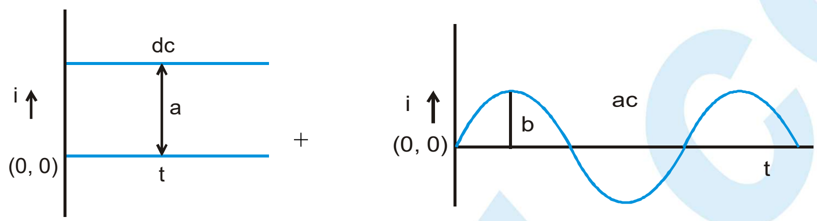
Exercise # 4

[Subjective Type Questions]

1. In a LR circuit discharging current is given by $I = I_0 e^{-t/\tau}$ where τ is the time constant of the circuit find the rms current for the period $t = 0$ to $t = \tau$.

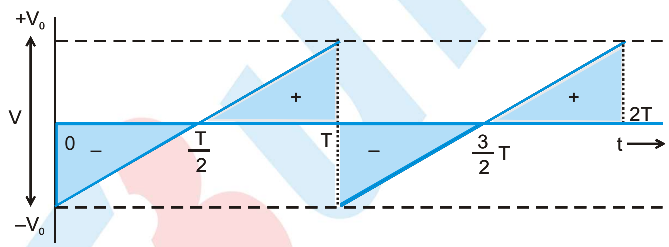
2. The household supply of electricity is at 220 V rms value and 50 Hz .Calculate the peak voltage and the minimum possible time in which the voltage can change from the rms value to zero.

3. If a direct current of value 'a' ampere is superimposed on an alternating current $I = b \sin \omega t$ flowing through a wire, what is the effective (rms) value of the resulting current in the circuit?



4. A bulb is designed to operate at 12 volts constant direct current. If this bulb is connected to an alternating current source and gives same brightness. What would be the peak voltage of the source ?

5. Find the average for the saw-tooth voltage of peak value V_0 from t=0 to t=2T as shown in figure.



6. The dielectric strength of air is 3.0×10^6 V/m. A parallel plate air capacitor has area 20 cm^2 and plate separation $\sqrt{2}$ mm. Find the maximum rms voltage of an AC source which can be safely connected to this capacitor .

7. In an ac circuit the instantaneous values of current and applied voltage are respectively $i = 2(\text{Amp}) \sin (250 \pi s^{-1})t$ and $\varepsilon = (10V) \sin [(250 \pi s^{-1})t + \frac{\pi}{3}]$. Find the instantaneous power drawn from the source at $t = \frac{2}{3}$ ms and its average value.

8. A resistor of resistance 100 Ω is connected to an AC source $\varepsilon = (12V) \sin (250 \pi s^{-1})t$. Find the power consumed by the bulb.

9. An electric bulb is designed to consume 55 W when operated at 110 volts. It is connected to a 220 V, 50 Hz line through a choke coil in series. What should be the inductance of the coil for which the bulb gets correct voltage?

10. A 20 volts 5 watt lamp (lamp to be treated as a resistor) is used on AC mains of 200 volts and $\frac{50}{\pi}\sqrt{11}$ c.p.s. Calculate the **(i)** capacitance of the capacitor, or inductance of the inductor, to be put in series to run the lamp. **(ii)** How much pure resistance should be included in place of the above device so that the lamp can run on its rated voltage. **(iii)** which is more economical (the capacitor, the inductor or the resistor).

11. A resistor, a capacitor and an inductor (R = 300 Ω, C = 20 μF, L = 1.0 henry) are connected in series with an AC source of, E_{rms} = 50 V and $\nu = \frac{50}{\pi}$ Hz. Find

(A) the rms current in the circuit and

(B) the rms potential differences across the capacitor, the resistor and the inductor.

12. Consider the situation of the previous problem calculate the average electric field energy stored in the capacitor and the average magnetic field energy stored in the inductor coil.

13. A coil draws a current of 1.0 ampere and a power of 100 watt from an A.C. source of 110 volt and $\frac{5\sqrt{22}}{\pi}$ hertz. Find the inductance and resistance of the coil.

14. A circuit has a resistance of 50 ohms and an inductance of $\frac{3}{\pi}$ henry. It is connected in series with a condenser of $\frac{40}{\pi}$ μF and AC supply voltage of 200 V and 50 cycles/sec. Calculate

(i) the impedance of the circuit,

(ii) the p.d. across inductor coil and condenser.

(iii) Power factor

15. A series circuit consists of a resistance, inductance and capacitance. The applied voltage and the current at any instant are given by

$$E = 141.4 \cos(5000\,t - 10^\circ)$$

and

$$I = 5 \cos(5000\,t - 370^\circ)$$

The inductance is 0.01 henry. Calculate the value of capacitance and resistance.

16. An inductor 2/π Henry, a capacitor 100/π μF and a resistor 75 Ω are connected in series across a source of emf $V = 10 \sin 100\pi t$. Here t is in second.

(A) find the impedance of the circuit.

(B) find the energy dissipated in the circuit in 20 minutes.

17. An inductance of 2.0 H, a capacitance of 18 μF and a resistance of 10 kΩ are connected to an AC source of 20 V with adjustable frequency

(A) What frequency should be chosen to maximise the current(RMS) in the circuit?

(B) What is the value of this maximum current (RMS) ?

18. An electro magnetic wave of wavelength 300 metre can be transmitted by a transmission centre. A condenser of capacity 2.5 μF is available. Calculate the inductance of the required coil for a resonant circuit.Use π^2=10.

19. An inductor-coil, a capacitor are connected in series with an AC source of rms voltage 24 V. When the frequency of the source is varied a maximum rms current of 6.0 A is observed. If this inductor coil is connected to a DC source of 12 V and having internal resistance 4.0 Ω, what will be the current in steady state?

20. In a transformer ratio of secondary turns (N_2) and primary turns (N_1) i.e. $\frac{N_2}{N_1} = 4$. If the voltage applied in primary is 200 V, 50 Hz, find

(A) voltage induced in secondary

(B) If current in primary is 1A, find the current in secondary if the transformer is (i) ideal and (ii) 80% efficient and there is no flux leakage.

21. A transformer has 50 turns in the primary and 100 turns in the secondary. If the primary is connected to a 220 V DC supply, what will be the voltage across the secondary ?

22. A series LCR circuit with $L = 0.125/\pi$ H, $C = 500/\pi$ nF, $R = 23\ \Omega$ is connected to a 230 V variable frequency supply.

(A) What is the source frequency for which current amplitude is maximum? Obtain this maximum value.

(B) What is the source frequency for which average power absorbed by the circuit is maximum? Obtain the value of this maximum power.

(C) For what reactance of the circuit , the power transferred to the circuit is half the power at resonance? What is the current amplitude at this reactance?

(D) If ω is the angular frequency at which the power consumed in the circuit is half the power at resonance, write an expression for ω

(E) What is the Q-factor (Quality factor) of the given circuit?

23. A circuit containing a 0.1 H inductor and a 500 μF capacitor in series is connected to a 230 volt, $100/\pi$ Hz supply. The resistance of the circuit is negligible.

(A) Obtain the current amplitude and rms values.

(B) Obtain the rms values of potential drops across each element.

(C) What is the average power transferred to the inductor?

(D) What is the average power transferred to the capacitor?

(E) What is the total average power absorbed by the circuit? ['Average' implies average over one cycle.]

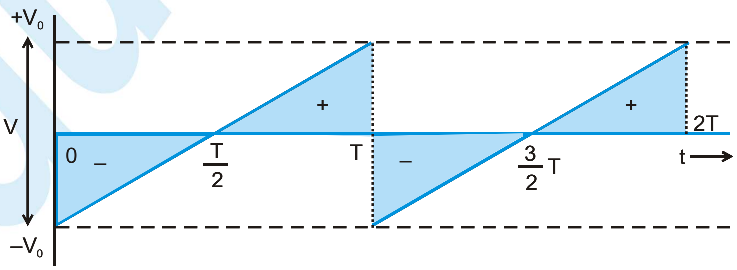
24. A 2000 Hz, 20 volt source is connected to a resistance of 20 ohm, an inductance of $0.125/\pi$ H and a capacitance of $500/\pi$ nF all in series. Calculate the time in which the resistance (thermal capacity = 100 joule/ºC) will get heated by 10º C. (Assume no loss of heat)

25. An LCR circuit has L = 10 mH, $R = 150\ \Omega$ and $C = 1\ \mu$F connected in series to a source of $150\sqrt{2}\cos\omega t$ volt. At a frequency that is 50% of the resonant frequency, calculate

(A) the net reactance of the circuit.

(B) the current amplitude and the average power dissipated per cycle

26. Find the rms value for the saw-tooth voltage of peak value V_0 from t=0 to t=2T as shown in figure.



Exercise # 5 Part # I [Previous Year Questions] [AIEEE/JEE-MAIN]

1. In an oscillating LC circuit the maximum charge on the capacitor is Q. The charge on the capacitor when the energy is stored equally between the electric and magnetic field is : **[AIEEE 2003]**

(1) Q/2 (2) $Q/\sqrt{3}$ (3) $Q/\sqrt{2}$ (4) Q

2. The core of any transformer is laminated so as to : **[AIEEE 2003]**

(1) reduce the energy loss due to eddy currents (2) make it light weight
(3) make is robust and strong (4) increase the secondary voltage

3. In an LCR series a.c. circuit, the voltage across each of the components. L, C and R is 50 V. The voltage across the LC combination will be : **[AIEEE 2004]**

(1) 50 V (2) $50\sqrt{3}$ s (3) 100 V (4) 0 V (zero)

4. Alternating current can not be measured by D.C. ammeter because : **[AIEEE 2004]**

(1) A.C. current pass through d.C. ammeter
(2) A.C. change direction
(3) average value of current for complete cycle is zero
(4) D.C. ammeter will get damaged

5. In an LCR circuit, capacitance is changed from C to 2C. For the resonant frequency to remain unchanged, the inductance should be changed from L to : **[AIEEE 2004]**

(1) 4L (2) 2L (3) L/2 (4) L/4

6. A circuit has a resistance of 12 ohm and an impedance of 15 ohm. The power factor of the circuit will be : **[AIEEE 2005]**

(1) 0.8 (2) 0.4 (3) 1.25 (4) 0.125

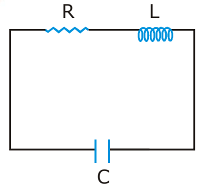
7. The phase difference between the alternating current and emf is $\pi/2$. Which of the following cannot be the constituent of the circuit? **[AIEEE 2005]**

(1) C alone (2) R, L (3) L, C (4) L alone

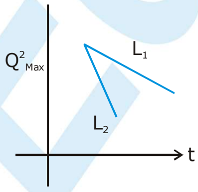
8. In a series LCR circuit R = 200 Ω and the voltage and the frequency of the main supply is 220 V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags behind the voltage by 30º. On taking out the inductor from the circuit the current leads the voltage by 30º. The power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

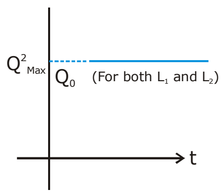
(1) 305 W (2) 210 W (3) Zero W (4) 242 W

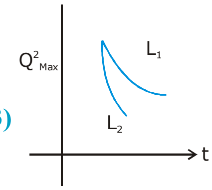
9. An LCR circuit is equivalent to a damped pendulum. In an LCR circuit the capacitor is charged to Q_0 and then connected to the L and R as shown below : **[JEE-MAIN : 2015]**

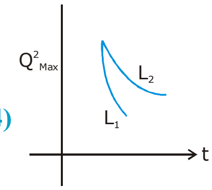


If a student plots graphs of the square of maximum charge (Q^2_{max}) on the capacitor with time (T) for two different values L_1 and L_2 ($L_1 > L_2$) of L then which of the following represents this graph correctly ? (Plots are shematic and not drawn to scale)

(1) 

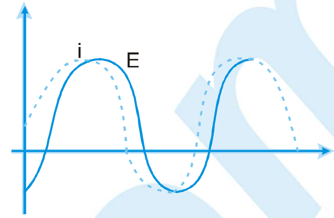
(2) 

(3) 

(4) 

Part # II [Previous Year Questions][IIT-JEE ADVANCED]

1. When an AC source of emf $E = E_0 \sin(100\,t)$ is connected across a circuit, the phase difference between the E and the current i in the circuit is observed to be $\frac{\pi}{4}$, as shown in the diagram. If the circuit consists possibly only of R-C or R-L or L-C series, find the relationship between the two elements.

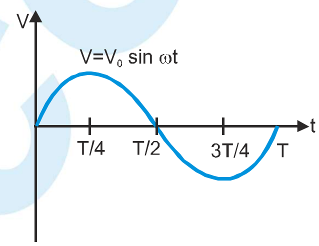


[JEE 2003]

(A) $R = 1k\Omega, C = 10\ \mu F$ **(B)** $R = 1k\Omega, C = 1\ \mu F$

(C) $R = 1k\Omega, L = 10\ H$ **(D)** $R = 1k\Omega, L = 1H$

2. In an L–R series circuit, a sinusoidal voltage $V = V_0 \sin\omega t$ is applied. It is given that $L = 35$ mH, $R = 11\Omega$, $V_{rms} = 220$ V, $\omega/2\pi = 50$ Hz and $\pi = 22/7$. Find the amplitude of current in the steady state and obtain the phase difference between the current and the voltage. Also plot the variation of current for one cycle on the given graph. **[JEE 2004]**



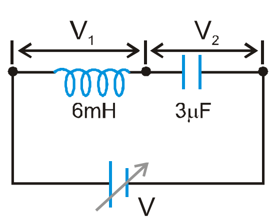
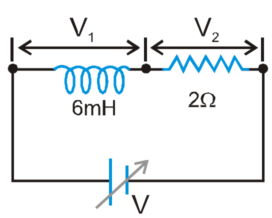
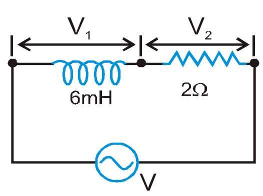
3. An AC voltage source of variable angular frequency ω and fixed amplitude V connected in series with a capacitance C and an electric bulb of resistance R (inductance zero). When ω is increased :

(A) the bulb glows dimmer **(B)** the bulb glows brighter **[JEE 2010]**

(C) total impedence of the circuit is unchanged **(D)** total impedence of the circuit increases

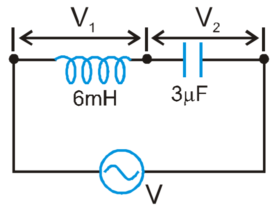
4. You are given many resistances, capacitors and inductors. These are connected to a variable DC voltage source (the first two circuits) or an AC voltage source of 50 Hz frequency (the next three circuits) in different ways as shown in Column II. When a current I (steady state for DC or rms for AC) flows through the circuit, the corresponding voltage V_1 and V_2. (indicated in circuits) are related as shown in Column I. Match the two column.

[JEE 2010]

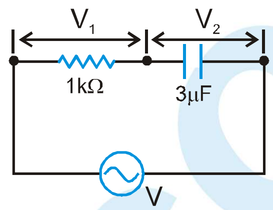
Column I	Column II
(A) $I \neq 0, V_1$ is proportional to I	**(P)** 
(B) $I \neq 0, V_2 > V_1$	**(Q)** 
(C) $V_1 = 0, V_2 = V$	**(R)** 

(D) $I \neq 0, V_2$ is proportional to I

(S)



(T)

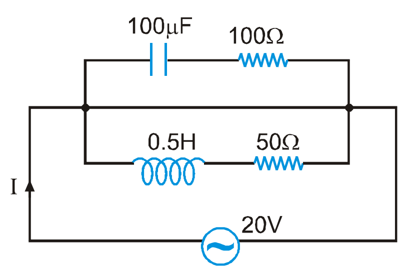


5. A series R-C circuit is connected to AC voltage source. Consider two cases; **(A)** when C is without a dielectric medium and **(B)** when C is filled with dielectric of constant 4. The current **IR** through the resistor and voltage V_C across the capacitor are compared in the two cases. Which of the following is/are true? **[JEE 2011]**

(A) $I_R^A > I_R^B$ **(B)** $I_R^A < I_R^B$ **(C)** $V_C^A > V_C^B$ **(D)** $V_C^A < V_C^B$

6. A series R-C combination is connected to an AC voltage of angular frequency $\omega = 500$ radian/s. If the impedance of the R-C circuit is $R\sqrt{1.25}$, the time constant (in millisecond) of the circuit is: **[JEE 2011]**

7. 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]**



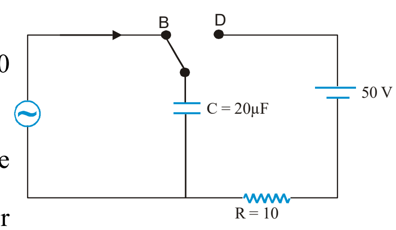
(A) The current through the circuit, I is 0.3 A

(B) The current through the circuit, I is $0.3\sqrt{2}$ A.

(C) The voltage across 100Ω resistor = $10\sqrt{2}$ V

(D) The voltage across 50Ω resistor = 10V

8. At time t = 0, terminal A in the circuit shown in the figure is connected to B by a key and an alternating current $I(t) = I_0 \cos(\omega t)$ with $I_0 = 1$A and $\omega = 500$ rad/s starts flowing in it with the initial direction shown in the figure.



At $t = \frac{7\pi}{6\omega}$, the key is switched from B to D. Now onwards only A and D are connected. A total charge Q flows from the battery to charge the capacitor fully. If C = 20 μF, R = 10 Ω and the battery is ideal with emf of 50 V, identify the correct statement(s). **[IIT-JEE 2014]**

(A) Magnitude of the maximum charge on the capacitor before $t = \frac{7\pi}{6\omega}$ is 1×10^{-3} C.

(B) The current in the left part of the circuit just before $t = \frac{7\pi}{6\omega}$ is clockwise.

(C) Immediately after A is connected to D, the current in R is 10 A.

(D) $Q = 2 \times 10^{-3}$ C.

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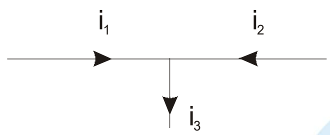
MOCK TEST : BASIC MATHS

SECTION - I : STRAIGHT OBJECTIVE TYPE

1. If $i_1 = 3 \sin \omega t$ and $i_2 = 4 \cos \omega t$, then i_3 is



(A) $5 \sin(\omega t + 53°)$ **(B)** $5 \sin(\omega t + 37°)$ **(C)** $5 \sin(\omega t + 45°)$ **(D)** $5 \cos(\omega t + 53°)$

2. An alternating EMF of angular frequency $\omega \left(= \frac{1}{\sqrt{LC}}\right)$ is applied to a series LCR 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 the voltage across R equals this applied EMF

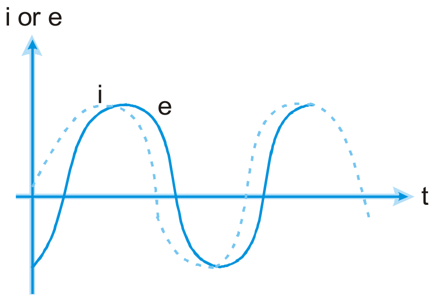
(C) The sum of the potential differences across the inductance and capacitance equals the applied EMF which is 180° ahead of phase of the current in the circuit

(D) Impedance of the circuit is less than R

3. An LCR series circuit with 100 Ω resistance is connected to an AC source of 200 V and angular frequency 300 radians per second. When only the capacitance is removed, the current lags the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60º. Then the current and power dissipated in LCR circuit are respectively

(A) 1A, 200 watt. **(B)** 1A, 400 watt. **(C)** 2A, 200 watt. **(D)** 2A, 400 watt.

4. When an AC source of emf $E = E_0 \sin(100\,t)$ is connected across a circuit, the phase difference between the emf E and the current i in the circuit is observed to be $\frac{\pi}{4}$, as shown in the diagram. If the circuit consists possibly only of R-C or R-L or L-C series, find the relationship between the two elements.



(A) $R = 1k\Omega, C = 10\ \mu F$ **(B)** $R = 1k\Omega, C = 1\ \mu F$

(C) $R = 1k\Omega, L = 10\ H$ **(D)** $R = 1k\Omega, L = 1H$

5. A bulb is rated at 100 V,100 W , it can be treated as a resistor. Find out the inductance of an inductor (called choke coil) that should be connected in series with the bulb to operate the bulb at its rated power with the help of an ac source of 200 V and 50 Hz.

(A) $\frac{\pi}{\sqrt{3}}$ H **(B)** 100 H **(C)** $\frac{\sqrt{2}}{\pi}$ H **(D)** $\frac{\sqrt{3}}{\pi}$ H

6. An ac source of angular frequency ω is fed across a resistor R and a capacitor C in series. The current registered is I. If now the frequency of source is changed to ω/3 (but maintaining the same voltage), the current in the circuit is found to be halved. Then the ratio of reactance to resistance at the original frequency ω is :

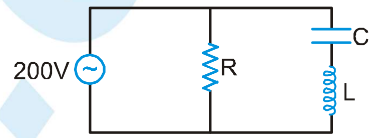
(A) $\sqrt{3/5}$ **(B)** $\sqrt{5/3}$ **(C)** $\sqrt{2/3}$ **(D)** $\sqrt{3/2}$

7. In an AC circuit the potential differences across an inductance and resistance joined in series are respectively 16 V and 20 V. The total potential difference across the circuit is
(A) 20 V **(B)** 25.6 V **(C)** 31.9 V **(D)** 53.5 V

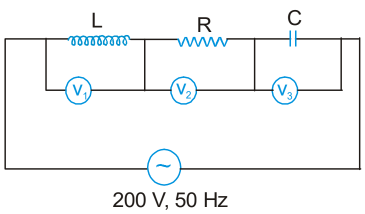
8. Current in an ac circuit is given by $i = 3 \sin \omega t + 4 \cos \omega t$ then :
(A) rms value of current is 5 A.
(B) mean value of this current in one half period will be $6/\pi$.
(C) if voltage applied is $V = V_m \sin \omega t$ then the circuit must be containing resistance and capacitance.
(D) if voltage applied is $V = V_m \sin \omega t$, the circuit may contain resistance and inductance.

9. A current source sends a current $i = i_0 \cos(\omega t)$. When connected across an unknown load gives a voltage output of, $v = v_0 \sin(\omega t + \pi/4)$ across that load. Then voltage across the current source may be brought in phase with the current through it by:
(A) connecting an inductor in series with the load
(B) connecting a capacitor in series with the load
(C) connecting an inductor in parallel with the load
(D) connecting a capacitor in parallel with the load.

10. In the circuit diagram shown, $X_C = 100\ \Omega$, $X_L = 200\ \Omega$ & $R = 100\ \Omega$. The effective current through the source is:
(A) 2 A **(B)** $2\sqrt{2}$ A
(C) 0.5 A **(D)** $\sqrt{0.4}$ A



11. If the readings of v_1 and v_3 are 100 volt each then reading of v_2 is :
(A) 0 volt
(B) 100 volt
(C) 200 volt
(D) cannot be determined by given information.

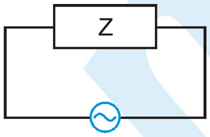


12. For a LCR series circuit with an A.C. source of angular frequency ω.
(A) circuit will be capacitive if $\omega > \frac{1}{\sqrt{LC}}$
(B) circuit will be inductive if $\omega = \frac{1}{\sqrt{LC}}$
(C) power factor of circuit will by unity if capacitive reactance equals inductive reactance
(D) current will be leading voltage if $\omega > \frac{1}{\sqrt{LC}}$

13. The value of current in two series L C R circuits at resonance is same when connected across a sinusoidal voltage source. Then:
(A) both circuits must be having same value of capacitance and inductor
(B) in both circuits ratio of L and C will be same
(C) for both the circuits X_L/X_C must be same at that frequency
(D) both circuits must have same impedance at all frequencies.

14. In series L C R circuit voltage drop across resistance is 8 volt, across inductor is 6 volt and across capacitor is 12 volt. Then:
(A) voltage of the source will be leading current in the circuit
(B) voltage drop across each element will be less than the applied voltage
(C) power factor of circuit will be 4/3
(D) none of these

15. In a black box of unknown elements (L, C or R or any other combination) an AC voltage $E = E_0 \sin(\omega t + \phi)$ is applied and current in the circuit was found to be $i = i_0 \sin(\omega t + \phi + \pi/4)$. Then the unknown elements in the box may be :



(A) only capacitor

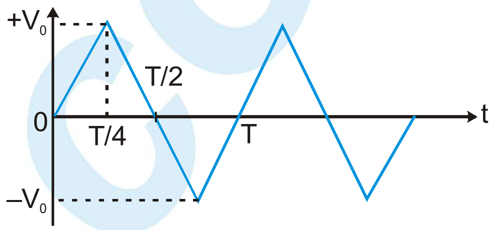
(B) inductor and resistor both

(C) either capacitor, resistor and inductor **or** only capacitor and resistor

(D) only resistor

16. The voltage time (V - t) graph for triangular wave having peak value. V_0 is as shown in figure.

The rms value of V in time interval from t = 0 to $\frac{T}{4}$ is :



(A) $\frac{V_0}{\sqrt{3}}$ **(B)** $\frac{V_0}{2}$

(C) $\frac{V_0}{\sqrt{2}}$ **(D)** None of these

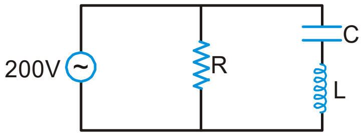
17. In the above questions the average value of voltage (v) in one time period will be :

(A) $\frac{V_0}{\sqrt{3}}$ **(B)** $\frac{V_0}{2}$ **(C)** $\frac{V_0}{\sqrt{2}}$ **(D)** zero

18. A series AC circuit has resistance of 4 Ω and a reactance of 3 Ω. The impedance(Z) of the circuit is

(A) 5 Ω **(B)** 7 Ω **(C)** 12/7 Ω **(D)** 7/12 Ω

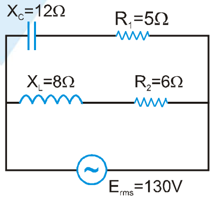
19. In the circuit diagram shown, $X_C = 100\ \Omega$, $X_L = 200\ \Omega$ and $R = 100\ \Omega$. The effective current through the source is:



(A) 2 A **(B)** $2\sqrt{2}$ A

(C) 0.5 A **(D)** $\sqrt{0.4}$ A

20. What is the amount of power delivered by the ac source in the circuit shown (in watts).



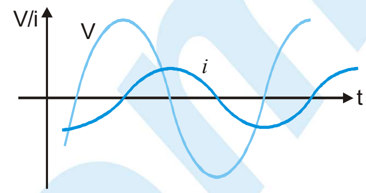
(A) 500 watt **(B)** 1014 watt **(C)** 1514 watt **(D)** 2013 watt

21. The secondary coil of an ideal step down transformer is delivering 500 watt power at 12.5 A current. If the ratio of turns in the primary to the secondary is 5 : 1, then the current flowing in the primary coil will be :

(A) 62.5 A **(B)** 2.5 A **(C)** 6 A **(D)** 0.4 A

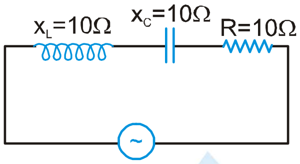
SECTION - II : MULTIPLE CORRECT ANSWER TYPE

22. Graph shows variation of source emf V and current i in a series RLC circuit, with time.



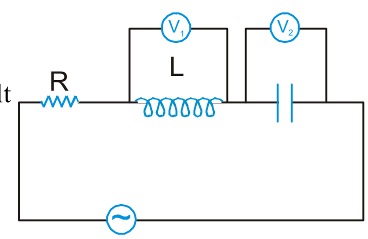
(A) The current leads the emf in the circuit.
(B) The circuit is more inductive than capacitive.
(C) To increase the rate at which energy is transferred to the resistive load, L should be decreased.
(D) To increase the rate at which energy is transferred to the resistive load, C should be decreased.

23. In the given AC circuit, which of the following is incorrect :



(A) Voltage across resistance is lagging by 90° than the voltage across capacitor.
(B) voltage across capacitor is lagging by 180° than voltage across inductor.
(C) voltage across inductor is leading by 90° than voltage across resistance.
(D) Resistance of the circuit is equal to reactance of circuit.

24. In the circuit shown, resistance R = 100 Ω, inductance $L = \frac{2}{\pi}$ H and capacitance $C = \frac{8}{\pi}\mu F$ are connected in series with an ac source of 200 volt and frequency 'f'. If the readings of the hot wire voltmeters V_1 and V_2 are same then :



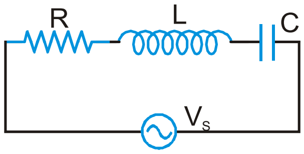
(A) f = 125 Hz
(B) f = 250 π Hz
(C) current through R is 2A
(D) $V_1 = V_2 = 1000$ volt

25. An alternating emf of frequency $\left(\nu = \frac{1}{2\pi\sqrt{LC}}\right)$ is applied to a series LCR circuit. For the frequency of the applied emf,
(A) the current 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 the voltage across R equals this applied emf.
(C) the sum of the p.d.'s 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 ωL/R or 1/ωCR and this is a measure of the voltage magnification (produced by the circuit at resonance) as well as the sharpness of resonance of the circuit

SECTION - III : ASSERTION AND REASON TYPE

26. **Statement-1 :** The D.C. and A.C. both can be measured by a hot wire instrument.
Statement-2 : The hot wire instrument is based on the principle of magnetic effect of current.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

27. **Statement-1 :** In a series R,L,C circuit if V_R, V_L, and V_C denote rms voltage across R, L and C respectively and V_S is the rms voltage across the source, then $V_S = V_R + V_L + V_C$.



Statement-2 : In AC circuits, kirchoff voltage law is correct at every instant of time.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

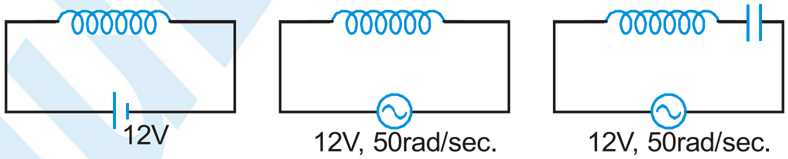
28. **Statement-1 :** The electrostatic energy stored in capacitor plus magnetic energy stored in inductor will always be zero in a series LCR circuit driven by ac voltage source under condition of resonance.
Statement-2 : The complete voltage of ac source appears across the resistor in a series LCR circuit driven by ac voltage source under condition of resonance.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

29. **Statement-1 :** An inductor is connected to an ac source. When the magnitude of current decreases in the circuit, energy is absorbed by the ac source.
Statement-2 : When current through an inductor decreases, the energy stored in inductor decreases.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 is NOT a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

SECTION - IV : COMPREHENSION TYPE

Comprehension # 1

A steady current 4 A flows in an inductor coil when connected to a 12 V dc source as shown in figure 1. If the same coil is connected to an ac source of 12 V, 50 rad/s, a current of 2.4 A flows in the circuit as shown in figure 2. Now after these observations, a capacitor of capacitance $\frac{1}{50}$F is connected in series with the coil and with the same AC source as shown in figure 3 :



(Figure 1) (Figure 2) (Figure 3)

30. The inductance of the coil is nearly equal to
(A) 0.01 H **(B)** 0.02 H **(C)** 0.04 H **(D)** 0.08 H

31. The resistance of the coil is :
(A) 1 Ω **(B)** 2 Ω **(C)** 3 Ω **(D)** 4 Ω

32. The average power supplied to the circuit after connecting capacitance in series is approximately equal to:
(A) 24 W **(B)** 72 W **(C)** 144 W **(D)** None of these

Comprehension # 2

In a series L-R circuit, connected with a sinusoidal ac source, the maximum potential difference across L and R are respectively 3 volts and 4 volts.

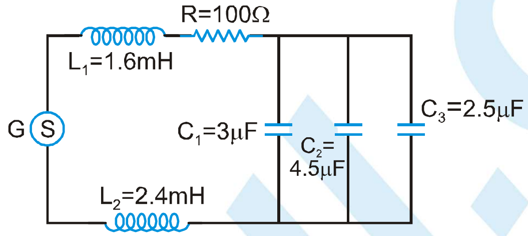
33. At an instant the potential difference across resistor is 2 volts. The potential difference in volt, across the inductor at the same instant will be :
(A) 3 cos 30° (B) 3 cos 60° (C) 6 cos 45° (D) 6

34. At the same instant, the magnitude of the potential difference in volt, across the ac source will be
(A) 3 cos 67° (B) 5 sin 67° (C) 6 cos 97° (D) 0

35. If the current at this instant is decreasing the magnitude of potential difference at that instant across the ac source is
(A) Increasing (B) Decreasing (C) constant (D) cannot be said

Comprehension # 3

An ac generator G with an adjustable frequency of oscillation is used in the circuit, as shown.



36. Current drawn from the ac source will be maximum if its angular frequency is -
(A) 10^5 rad/s (B) 10^4 rad/s (C) 5000 rad/s (D) 500 rad/s

37. To increase resonant frequency of the circuit, some of the changes in the circuit are carried out. Which change(S) would certainly result in the increase in resonant frequency ?
(A) R is increased. (B) L_1 is increased and C_1 is decreased.
(C) L_2 is decreased and C_2 is increased. (D) C_3 is removed from the circuit.

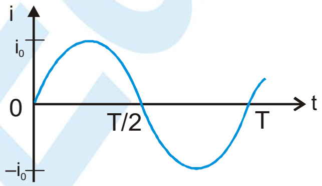
38. If the ac source G is of 100 V rating at resonant frequency of the circuit, then average power supplied by the source is -
(A) 50 W (B) 100 W (C) 500 W (D) 1000 W

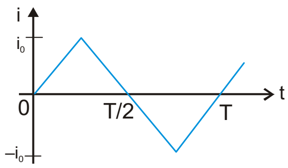
39. Average energy stored by the inductor L_2 (Source is at resonance frequency) is equal to
(A) zero (B) 1.2 mJ (C) 2.4 mJ (D) 4 mJ

40. Thermal energy produced by the resistance R in time duration 1 μs, using the source at resonant condition, is
(A) 0 J (B) 1 μ J
(C) 100 μ J (D) not possible to calculate from the given information

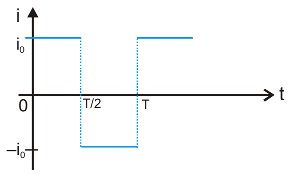
SECTION - V : MATRIX - MATCH TYPE

41. In Column I, variation of current i with time t is given in figures. In column II root mean square current i_{rms}, and average current is given. Match the column I with corresponding quantities given in Column II

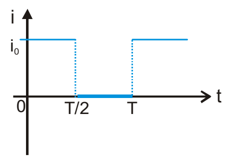
Column I	Column II
(A) 	(P) $i_{rms} = \frac{i_0}{\sqrt{3}}$

(B) 

(Q) Average current for positive half cycle is i_0

(C) 

(R) Average current for positive half cycle is $\frac{i_0}{2}$

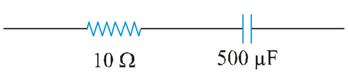
(D) 

(S) Full cycle average current is zero.

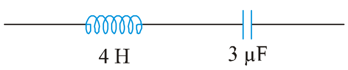
(T) Root mean square value of current for positive half cycle is i_0

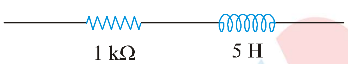
42. Four different circuit components are given in each situation of column-I and all the components are connected across an AC source of same angular frequency $\omega = 200$rad/sec. The information of phase difference between the current and source voltage in each situation of column-I is given in column-II. Match the circuit components in column-I with corresponding results in column-II.

Column - I

(A) 

(B) 

(C) 

(D) 

Column - II

(P) the magnitude of required phase difference is $\frac{\pi}{2}$.

(Q) the magnitude of required phase difference is $\frac{\pi}{4}$.

(R) the current leads in phase to source voltage.

(S) the magnitude of required phase difference is zero.

(T) the current lags in phase to source voltage.

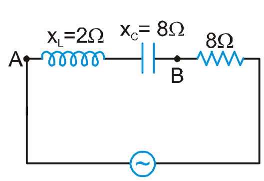
SECTION - VI : INTEGER TYPE

43. Find the average value of current from t = 0 to $t = \frac{2\pi}{\omega}$ if the current varies as $i = I_m \sin \omega t$.

44. Find the rms value of current from t = 0 to $t = \frac{2\pi}{\omega}$ if the current varies as $i = I_m \sin \omega t$.

45. In a series LCR circuit with an ac source $E_0 = 50$ V, R = 300Ω, frequency $\nu = \frac{50}{\pi}$ Hz. The average electric field energy stored in the capacitor and average magnetic energy stored in the coil are 25 mJ and 5 mJ respectively of RMS current in the circuit is .10 A. Then find:
(A) Capacitance (C) of capacitor in μ f
(B) Inductance (L) of inductor.in Henri

46. An inductor ($x_L = 2\Omega$), a capacitor ($x_C = 8\Omega$) and a resistance (8Ω) are connected in series with an AC source. The voltage output of A.C source is given by v = 10 cos 100πt.
(A) Find the impedance of the circuit(inΩ).
(B) the instantaneous p.d. between A and B when it is half of the voltage output from source at that instant is $\frac{x}{5}$ volt then x is.



ANSWER KEY

EXERCISE - 1

1. B **2.** B **3.** C **4.** D **5.** D **6.** C **7.** B **8.** D **9.** A **10.** C **11.** C **12.** B **13.** B
14. B **15.** A **16.** D **17.** B **18.** A **19.** B **20.** B **21.** D **22.** D **23.** C **24.** B **25.** C **26.** B
27. D **28.** A **29.** B **30.** A **31.** D **32.** A **33.** A **34.** D **35.** B **36.** D **37.** C **38.** A **39.** A
40. A **41.** C **42.** A **43.** B **44.** C **45.** D

EXERCISE - 2 : PART # I

1. A,B,C **2.** A,B,C,D **3.** C,D **4.** B,C **5.** A,B,C **6.** A,B **7.** A,B **8.** B,D **9.** A,B,C,D
10. A,B **11.** A,C **12.** A,B,C **13.** B,D **14.** A,C

PART # II

1. A **2.** D **3.** D **4.** A

EXERCISE - 3 : PART # I

1. $A \to R$; $B \to Q$; $C \to P$; $D \to Q$ **2.** $A \to Q,R$; $B \to Q,R$; $C \to P,Q,R,S$; $D \to Q,R,S$

PART # II

Comp. #1 : 1. C **2.** D **3.** B **4.** B **5.** D **Comp.#2 : 1.** D **2.** A **3.** B
Comp.#3 : 1. C **2. B** **3.** C

EXERCISE - 4

1. $\frac{I_o}{e}\sqrt{(e^2-1)/2}$ **2.** $220\sqrt{2}$ V, 2.5 ms **3.** $I_{eff} = \left[a^2 + \frac{1}{2}b^2\right]^{1/2}$ **4.** $12\sqrt{2}$ volts **5.** 0 **6.** 3.0 kV **7.** 10 W, 5 W

8. 0.72 W **9.** $\frac{2.2\sqrt{3}}{\pi} = 1.2\text{ H} = \frac{7\sqrt{3}}{10}$ H

10. **(i)** $\frac{125}{33}$ μF or 2.4 H **(ii)** 720 Ω **(iii)** It will be more economical to use inductance or capacitance in series with the lamp to run it as it.It consumes no power while there would be dissipation of power when resistance is inserted in series with the lamp.

11. **(A)** 0.1 A **(B)** 50 V, 30 V, 10 V (Note that the sum of the RMS potential differences across the three elements is greater than the rms voltage of the source.)

12. 25 mJ, 5mJ **13.** $\sqrt{\frac{21}{22}}$ H, -100 Ω **14.** $Z = 50\sqrt{2}$ ohm, $V_C = 500\sqrt{2}$ volt and $V_L = 600\sqrt{2}$ volt, $\frac{1}{\sqrt{2}}$

15. 4 μF, $R = \frac{141.4}{5}\Omega$ **16.** 125 Ω, 288 J **17.** **(A)** $\frac{250}{3\pi}$ Hz **(B)** 2 mA **18.** 1×10^{-8} henry **19.** 1.5 A

20. **(A)** 800 V **(B)** (i) 0.25 A (ii) 0.2 A **21.** zero **22.** **(A)** 2000 Hz, $10\sqrt{2}$ A **(B)** 2000 Hz, 2300 watt **(C)** 23 Ω, 10 A.

(D) $\frac{0.125}{\pi}\omega - \frac{1\times10^9}{\omega\frac{500}{\pi}} = \pm 23$ **(E)** 500/23 **23. (A)** $23\sqrt{2}$ A, 23 A **(B)**460 volt, 230 volt **(C)** zero **(D)** zero **(E)** zero

24. 50 sec. **25.** (a) 150 Ω (b) 1 amp, 75 watt. **26.** $\frac{V_0}{\sqrt{3}}$

EXERCISE - 5 : PART # I

1. 3 **2.** 1 **3.** 4 **4.** 3 **5.** 3 **6.** 1 **7.** 2 **8.** 4
9. 3

PART # II

1. A **2.** 20 A, $\frac{\pi}{4}$ **3.** B **4.** $A \to R,S,T$; $B \to Q,R,S,T$; $C \to P,Q$; $D \to Q,R,S,T$

5. B,C **6.** 4 **7.** A,C or C Since $I_{rms} \approx 0.3$ A so A may or may not be correct. **8.** C,D

MOCK TEST

1. A **2.** B **3.** D **4.** A **5.** D **6** A **7.** B **8.** C **9.** A
10. B **11.** C **12.** C **13.** C **14.** D **15.** C **16.** A **17.** D **18.** A
19. B **20.** C **21.** B **22.** B,C **23.** A,D **24.** A,C,D **26.** C **27.** D **28.** D
29. A **30.** D **31.** C **32.** A **33.** A **34.** B **35.** D **36.** C **37.** D
38. B **39.** B **40.** D
41. $A \to S$; $B \to P, R, S$; $C \to Q, S, T$; $D \to Q, T$ **42.** $A \to Q,R$; $B \to P,T$; $C \to P,R$; $D \to Q, T$ **43.** 0.
44. $1\frac{I_m}{\sqrt{2}}$

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