BYJU'S Study Planner for Board Term I
(CBSE Grade 12)

Date: 23/11/2021

Subject: Physics

Topic : Alternating current

Class: Standard XII

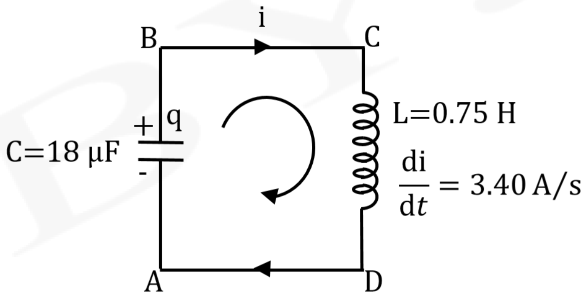
1. In a $L-C$ circuit, $L=0.75 \mathrm{~H}$ and $C=18 \mu \mathrm{F}$, at the instant when the current in the inductor is changing at a rate of $3.40 \mathrm{~A} / \mathrm{s}$. What is the charge on capacitor ?

A. $26 \mu \mathrm{C}$

B. $36 \mu \mathrm{C}$

C. $46 \mu \mathrm{C}$

D. $56 \mu \mathrm{C}$



On applying Kirchhoff's law starting from A,

$$+\frac{q}{C}-L \frac{d i}{d t}=0$$

$$\Rightarrow q=C L \frac{d i}{d t}$$

$$=18 \times 10^{-6} \times 0.75 \times 3.4$$

$$\approx 4.6 \times 10^{-5} \mathrm{~C}=46 \mu \mathrm{C}$$

Hence, (C) is the correct answer.

2. Assertion (A): The r.m.s. value of alternating current is defined as the square root of the average of I^2 during a complete cycle.

Reason (R): For sinusoidal a.c.
$(I = I_0 \sin \omega t)$ and $I_{\text{rms}} = \dfrac{I_0}{\sqrt{2}}$.

A. Both (A) and (R) are true, and (R) is the correct explanation of (A)

B. Both (A) and (R) are true, but (R) is not the correct explanation of (A)

C. (A) is true but (R) is false

D. (A) is false but (R) is true

The r.m.s value of a.c. current is,

$$I_{\text{rms}}^2 = \frac{\int_0^T I^2 dt}{\int_0^T dt}$$

$$I = I_0 \ \sin \ (\omega t)$$

$$I_{\text{rms}}^2 = \frac{\int_0^T I_0^2 \ \sin^2(\omega t) dt}{\int_0^T dt} = \frac{I_0^2}{T} \int_0^T \left[\frac{1 - \cos 2\omega t}{2}\right] dt$$

$$= \frac{I_0^2}{2T} \left[\frac{t - \sin 2\omega t}{2\omega}\right]_0^T$$

$$\Rightarrow \quad I_{\text{rms}}^2 = \frac{I_0^2}{2}$$

$$\Rightarrow \quad I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

Hence, (A) is the correct answer.

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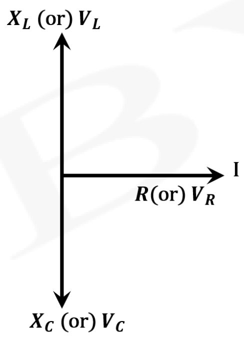
3. Assertion (A): In series LCR circuit resonance can take place.

Reason (R): Resonance takes place iff inductive reactance and capacitive reactances are equal with phase difference 180°.

- **A.** Both (A) and (R) are true, and (R) is the correct explanation of (A)
- **B.** Both (A) and (R) are true, but (R) is not the correct explanation of (A)
- **C.** (A) is true but (R) is false
- **D.** (A) is false but (R) is true

For resonance condition in LCR circuit,

$X_L = X_C$



As we can see, X_L and X_C are in opposite direction. Hence, phase difference between them is $\phi = 180^{\circ}$

Hence, (A) is the correct answer.

4. Assertion (A): In series LCR resonance circuit, the impedance is equal to the ohmic resistance.

Reason (R): At resonance, the inductive reactance is equal and opposite to the capacitive reactance.

- **A.** Both (A) and (R) are true, and (R) is the correct explanation of (A)
- **B.** Both (A) and (R) are true, and (R) is not the correct explanation of (A)
- **C.** (A) is true but (R) is false
- **D.** (A) is false but (R) is true

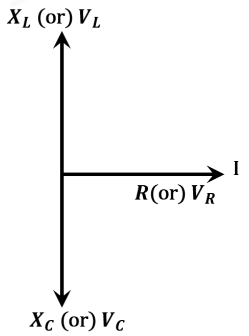
For resonance Condition in LCR circuit,

$X_L = X_C$

The net impedance of the circuit is,

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

$\Rightarrow \quad Z = R$



As we can see, X_L and X_C are in opposite direction. Hence, phase difference between them is $\phi = 180^\circ$

Hence, (A) is the correct answer.

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5. Assertion (A): Power loss in an ideal choke coil will be zero.

Reason (R): Ideal choke coil has zero power factor.

A. Both (A) and (R) are true, and (R) is the correct explanation of (A)

B. Both (A) and (R) are true, and (R) is not the correct explanation of (A)

C. (A) is true but (R) is false

D. (A) is false but (R) is true

For an ideal choke coil, $R = 0$

Average power dissipated in an a.c. circuit is,

$P_{avg} = V_{\mathrm{rms}} \times I_{\mathrm{rms}} \cos\ \phi$

Where, $\cos\ \phi = \mathrm{Power\ factor}$ and

$$\cos(\phi) = \frac{R}{Z} = 0 \quad [\because\ R = 0]$$

$P_{avg} = V_{\mathrm{rms}} \times I_{\mathrm{rms}} \cos\ \phi = 0$

Hence, (A) is the correct answer.

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6. Assertion (A): KVL rule can also be applied to an a.c. circuits.

   Reason (R): Varying electrostatic field is non-conservative

   A. Both (A) and (R) are true, and (R) is the correct explanation of (A)

   B. Both (A) and (R) are true, but (R) is not the correct explanation of (A)

   C. (A) is true but (R) is false

   D. (A) is false but (R) is true

   (i). KVL can be applied for circuits, it can be a.c. (or) d.c. circuit. Basically KVL is energy conservation.

   (ii). Varying electrostatic field can be conservative. But electrostatic field induced by the time varying magnetic field is non - conservative.

   Hence, (C) is the correct answer.

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7. Comprehension :

An alternating voltage of $260\ \mathrm{V}$ and $\omega = 500\ \mathrm{rad\ s^{-1}}$ is applied in series LCR circuit, where $L = 0.01\ \mathrm{H},\ C = 4 \times 10^{-4}\ \mathrm{F}$ and $R = 10\ \Omega$

(i) Find the resonance frequency of the circuit (in Hz)-

A. $\frac{25}{\pi}$

B. $\frac{250}{\pi}$ ✔

C. $\frac{40}{\pi}$

D. $\frac{200}{\pi}$

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Given, $L = 0.01\ \mathrm{H}\ ;\ C = 4 \times 10^{-4}\ \mathrm{F}$

$R = 10\ \Omega\ ;\ V = 120\ \mathrm{V}\ ;\ \omega = 500\ \mathrm{rad\ s}^{-1}$

At the resonance condition,

$$X_L = X_C$$

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

$$\omega^2 = \frac{1}{LC}$$

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

Substituting the given data gives,

$$\omega = \frac{1}{\sqrt{0.01 \times 4 \times 10^{-4}}}$$

$$\omega = \frac{1}{\sqrt{4 \times 10^{-6}}}$$

$$\omega = \frac{1}{2 \times 10^{-3}} = 500$$

$$2\pi f = 500$$

$$f = \frac{500}{2\pi} = \frac{250}{\pi}$$

Hence, (B) is the correct answer.

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8. Comprehension :

An alternating voltage of 260 V and $\omega = 500 \text{ rad s}^{-1}$ is applied in an series LCR circuit, where $L = 0.01 \text{ H},\ C = 4 \times 10^{-4} \text{ F}$ and $R = 10\ \Omega$

(ii) Find the power supplied by the source is- (in W)-

A. 1000

B. 6760

C. 3380

D. 3000

Given, $L = 0.01 \text{ H}\ ;\ \ C = 4 \times 10^{-4} \text{ F}$

$R = 10\ \Omega\ ;\ V_{rms} = 120 \text{ V}\ ;\ \ \omega = 500 \text{ rad s}^{-1}$

Power in an a.c. circuit is,

$P = V_{rms} I_{rms} \cos\phi$

Where, $\cos\phi = \dfrac{R}{Z}$

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

$X_L = \omega L = 500 \times 1 \times 10^{-2} = 5$

$X_C = \dfrac{1}{\omega C} = \dfrac{1}{500 \times 4 \times 10^{-4}} = 5$

$\Rightarrow \quad Z = \sqrt{(10)^2 + (5-5)^2} = 10\ \Omega$

$\Rightarrow \quad \cos\phi = \dfrac{R}{Z} = \dfrac{10}{10} = 1$

$I_{rms} = \dfrac{V_{rms}}{Z} = \dfrac{260}{10} = 26 \text{ A}$

Hence, power dissipated in the circuit is,

$P = 260 \times 26 \times 1 = 6760 \text{ W}$

Hence, (B) is the correct answer.

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9. Comprehension :

A $100\ \Omega$ resistance is connected in series with a $4\ \mathrm{H}$ inductor. The voltage across the resistor is, $V_R = 2.0\sin(10^3 t)\ \mathrm{V}$.

(i) Find the expression of circuit current-

A. $0.2\sin(1000\ t)\ \mathrm{mA}$

B. $2\sin(100\ t)\ \mathrm{mA}$

C. $2\sin(1000\ t)\ \mathrm{mA}$

D. $0.2\sin(100\ t)\ \mathrm{mA}$

Given, $V_R = 2.0\sin(10^3 t)\ \mathrm{V}\ ;\ R = 100\ \Omega$

$L = 4\ \mathrm{H}\ ;\ \omega = 10^3$

Current through the resistor will be,

$I = I_0 \sin(10^3 t)$

Where, $I_0 = \dfrac{V_0}{R} = \dfrac{2}{100} = 2 \times 10^{-2}$

$\therefore\ I = 2 \times 10^{-2}\sin(10^3 t)\ \mathrm{A}$ or $0.2\sin(1000\ t)\ \mathrm{mA}$

Hence, (A) is the correct answer.

10. Comprehension :

A $100\ \Omega$ resistance is connected in series with a $4\ \mathrm{H}$ inductor. The voltage across the resistor is, $V_R = 2.0 \sin(10^3 t)\ \mathrm{V}$.

(ii) Find the inductive reactance-

A. $2 \times 10^3\ \Omega$

B. $3 \times 10^3\ \Omega$

C. $4 \times 10^3\ \Omega$

D. $5 \times 10^3\ \Omega$

Givn, $L = 4\ \mathrm{H}\ \ ;\ \ \omega = 10^3$

Inductive reactance is,

$X_L = \omega L = 10^3 \times 4$

$X_L = 4 \times 10^3\ \Omega$

Hence, (C) is the correct answer.

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11. Comprehension :

A $100\ \Omega$ resistance is connected in series with a $4\ \mathrm{H}$ inductor. The voltage across the resistor is, $V_R = 2.0 \sin(10^3 t)\ \mathrm{V}$.

(iii) Find amplitude of the voltage across the inductor.

A. $40\ \mathrm{V}$

B. $60\ \mathrm{V}$

C. $80\ \mathrm{V}$ ✔

D. $90\ \mathrm{V}$

The potential drop across the inductor is,

$V_L = I_0 X_L$

$\because\ \ I_0 = 2 \times 10^{-2}\ \mathrm{A}\ \ ;\ \ X_L = 4 \times 10^3\ \Omega$

$\therefore\ \ V_L = 80\ \mathrm{V}$

Hence, (C) is the correct answer.

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12. If the voltage of a source in an AC circuit is represented by the equation, $\mathcal{E} = 220\sqrt{2}\sin(314t)$. Calculate the peak value of the current if the net resistance of the circuit is $220\ \Omega$.

Take $\sqrt{2} = 1.4$

- **A.** $1.8\ \mathrm{A}$
- **B.** $1.6\ \mathrm{A}$
- **C.** $1.4\ \mathrm{A}$
- **D.** $1.2\ \mathrm{A}$

Given:

Voltage, $\mathcal{E} = 220\sqrt{2}\sin(314t)$

Comparing with $\mathcal{E} = \mathcal{E}_0 \sin \omega t$, we get, peak value of voltage,

$\mathcal{E}_0 = 220\sqrt{2}\ \mathrm{V}$

So, peak value of current,

$$i_0 = \frac{\mathcal{E}_0}{R} = \frac{220\sqrt{2}}{220} = 1.4\ \mathrm{A}$$

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13. Two alternating currents having the value $I_1 = 3\sin\omega t$ and $I_2 = 4\sin(\pi/2 - \omega t)$ are superimposed and passed through a hot wire ammeter. Then the reading of the ammeter will be

- ✗ **A.** 5 A
- ✓ **B.** $5/\sqrt{2} \text{ A}$
- ✗ **C.** $7/\sqrt{2} \text{ A}$
- ✗ **D.** 7 A

Given:

$I_1 = 3\sin\omega t$, and

$I_2 = 4\sin(\pi/2 - \omega t)$

So, peak value of net AC,

$$I_0 = \sqrt{I_{0_1}^2 + I_{0_2}^2 + 2I_{0_1}I_{0_2}\cos(\Delta\phi)}$$

$$\Rightarrow I_0 = \sqrt{3^2 + 4^2 + 2(3)(4)\cos(\pi/2)}$$

$$\Rightarrow I_0 = 5 \text{ A}$$

$$\therefore I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{5}{\sqrt{2}}\text{A}$$

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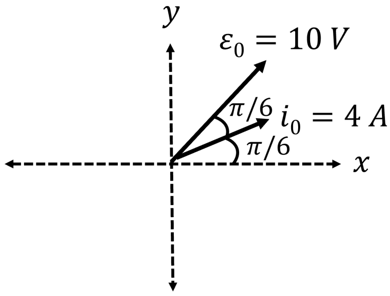
14. The phasor diagram for a component (other than a resistor) connected to an AC source, at an instant, is shown below. The value of voltage across the component and current flowing through the circuit, at this instant, respectively is -



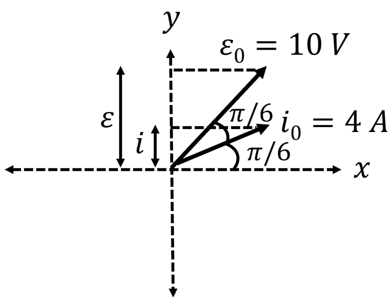
A. $5\sqrt{3}\ \mathrm{V}, 2\sqrt{3}\ \mathrm{A}$

B. $5\ \mathrm{V}, 2\sqrt{3}\ \mathrm{A}$

C. $2\sqrt{3}\ \mathrm{V}, 2\ \mathrm{A}$

D. $5\sqrt{3}\ \mathrm{V}, 2\ \mathrm{A}$

The value of voltage and current at any instant can be calculated from phasor diagram by calculating components of $\mathcal{E}_0$ and i_o along the $y-$axis respectively.



Therefore, the current flowing in the circuit at this instant is,

$$i = i_0 \sin\frac{\pi}{6} = 4 \times \frac{1}{2} = 2\ \mathrm{A}$$

The voltage across the element at this instant is,

$$\mathcal{E} = \mathcal{E}_0 \sin\left(\frac{\pi}{6} + \frac{\pi}{6}\right) = 10 \sin\frac{\pi}{3} = 5\sqrt{3}\ \mathrm{V}$$

Hence, option (D) is the correct answer.

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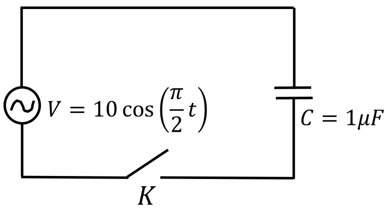
15. An AC voltage source described by $V = 10\cos\left(\frac{\pi}{2}t\right)$ is connected to a $1\ \mu\mathrm{F}$ capacitor as shown in the figure. The key K is closed at $t = 0$. The time $t > 0$ after which the magnitude of current reaches its maximum value for the first time is -



A. $1\ \mathrm{s}$

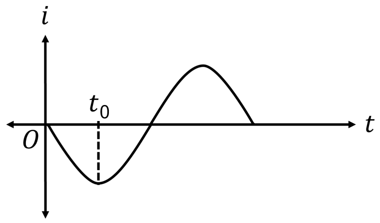
B. $2\ \mathrm{s}$

C. $3\ \mathrm{s}$

D. $4\ \mathrm{s}$

Current will lead the voltage function by $\pi/2$.

Voltage function is a cos function. Therefore, current function will be $-$sin function.



So,

$$t_0 = \frac{T}{4} = \frac{2\pi/\omega}{4} = \frac{\pi}{2\omega} = \frac{\pi}{2 \times \frac{\pi}{2}} = 1\ \mathrm{s}$$

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16. Applied AC voltage is given as, $V = V_0 \sin(\omega t)$. Corresponding to this voltage, match the following two columns.

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

A. $a \rightarrow p;\ b \rightarrow q;\ c \rightarrow r$

B. $a \rightarrow q;\ b \rightarrow p;\ c \rightarrow r$

C. $a \rightarrow p;\ b \rightarrow r;\ c \rightarrow q$

D. $a \rightarrow r;\ b \rightarrow q;\ c \rightarrow p$

Given:
$V = V_0 \sin(\omega t)$

In pure resistive circuit, current and voltage remains in the phase.

$\Rightarrow I = I_0 \sin(\omega t)$

$\therefore a \rightarrow p$

In pure inductive circuit, voltage leads ahead the current by $\pi/2$.

$\Rightarrow I = I_0 \sin(\omega t - \pi/2) = -I_0 \cos(\omega t)$

$\therefore b \rightarrow q$

In AC RC circuit, current lead the voltage by some phase.

$\Rightarrow I = I_0 \sin(\omega t + \phi)$

$\therefore c \rightarrow r$

Hence, option (A) is the correct answer.

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17. An AC source rated $100\ \mathrm{V}\ (rms)$ supplies a current of $10\ \mathrm{A}\ (rms)$ to a circuit. The average power delivered by the source is

- **A.** may be $1000\ \mathrm{W}$
- **B.** may be less than $1000\ \mathrm{W}$
- **C.** Both options (A) and (B)
- **D.** may be greater than $1000\ \mathrm{W}$

The average power delivered by the source is given by:

$P_{avg} = V_{rms} I_{rms} \cos\ \phi$

Where $\cos\phi$ is the power factor of the circuit.

Given, $V_{rms} = 100\ \mathrm{V}$ and $I_{rms} = 10\ \mathrm{A}$

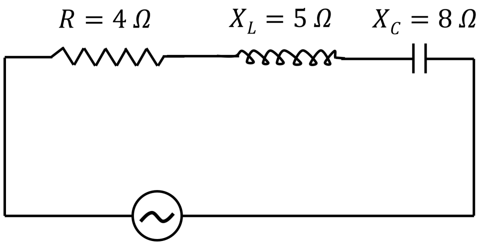
$\Rightarrow P_{avg} = 100 \times 10 \cos\phi = 1000 \cos\phi$

The value of $\cos\phi$ lies between $[-1,\ 1]$.

Therefore, power delivered by the source would be either equal to $1000\ \mathrm{W}$ or less than $1000\ \mathrm{W}$ depending on the elements connected in the circuit.

Hence, option (C) is the correct answer.

18. For the given AC RLC circuit, at a particular frequency of the AC source, the current -

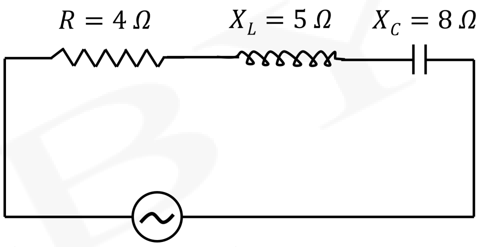


A. Lead the voltage by $\tan^{-1}(3/4)$

B. Lead the voltage by $\tan^{-1}(5/8)$

C. Lag the voltage by $\tan^{-1}(3/4)$

D. Lag the voltage by $\tan^{-1}(5/8)$



Suppose, the AC source voltage is given by,

$V = V_m \sin(\omega t)$

Then, the AC in the circuit is,

$I = I_m \sin(\omega t + \phi)$

So,

$$\tan\phi = \frac{X_C - X_L}{R} = \frac{8-5}{4} = \frac{3}{4}$$

$\Rightarrow \phi = \tan^{-1}(3/4)$

Hence, option (A) is the correct answer.

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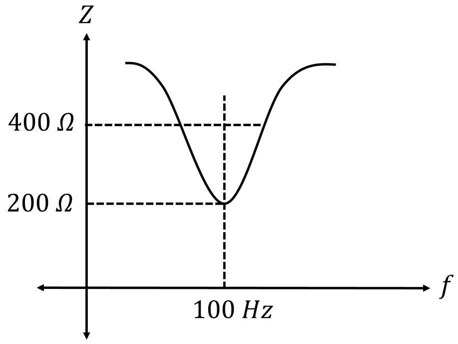
19. For the given curve between impedance (Z) and frequency (f) of a series LCR circuit, the value of resistance is -

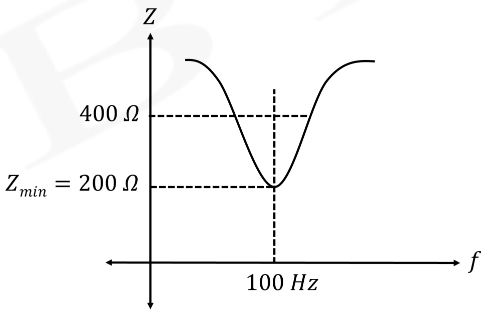


A. $100\ \Omega$

B. $200\ \Omega$

C. $300\ \Omega$

D. $400\ \Omega$



At resonance, $Z_{\min} = R$.

From figure, $Z_{\min} = R = 200\ \Omega$

Hence, option (B) is the correct answer.

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20. In an ideal transformer, number of turns in the primary coil are 140 and those in the secondary coil are 280. If current in the primary coil is $4\ \mathrm{A}$, then that in the secondary coil is -

A. $4\ \mathrm{A}$

B. $2\ \mathrm{A}$

C. $6\ \mathrm{A}$

D. $8\ \mathrm{A}$

For an ideal transformer,

$$\frac{N_P}{N_S} = \frac{\mathcal{E}_P}{\mathcal{E}_S} = \frac{I_S}{I_P}$$

$$\Rightarrow I_S = \frac{N_P I_P}{N_S} = \frac{140 \times 4}{280} = 2\ \mathrm{A}$$

Hence, option (B) is the correct answer.