OPEN STUDENT FOUNDATION
Physics (Class 12)
PRACTICE SHEET DAY 7

Section A

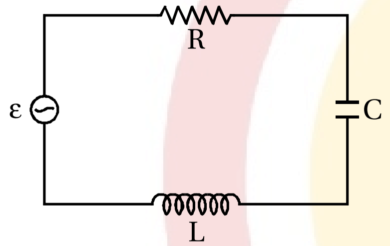
- **Write the answer of the following questions. [Each carries 1 Mark]** **[10]**

1. A 44 mH inductor is connected to 220 V, 50 Hz ac supply. Determine the rms value of the current in the circuit.

2. Derive an expression for current i passing through an AC circuit containing only inductor L. Draw a Phasor diagram and graph of v and i versus ωt. Explain instantaneous power and the average power.

3. Discuss AC voltage applied to a capacitor in details. Also obtain an equation of instantaneous power supplied to the capacitor.

4. Figure shows a series LCR circuit connected to a variable frequency 230 V source. L = 5.0 H, C = 80 μF, R = 40 Ω



(a) Determine the source frequency which drives the circuit in resonance.

(b) Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.

(c) Determine the rms potential drops across the three elements of the circuit. Show that the potential drop across the LC combination is zero at the resonating frequency.

5. A series LCR circuit with R = 20 Ω, L = 1.5 H and C = 35 μF is connected to a variable-frequency 200 V ac supply. When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle ?

6. What is transformer ? Write its principle and write its construction.

7. A sinusoidal voltage of peak value 283 V and frequency 50 Hz is applied to a series LCR circuit in which R = 3 Ω, L = 25.48 mH and C = 796 μF. Find

(a) What is the frequency of the source at which resonance occurs ?

(b) Calculate the impedance, the current and the power dissipated at the resonant condition.

8. A light bulb is rated at 100W for a 220 V supply. Find

(a) the resistance of the bulb;

(b) the peak voltage of the source; and

(c) the rms current through the bulb.

(d) A pure inductor of 25.0 mH is connected to a source of 220 V. Find the inductive reactance and rms current in the circuit if the frequency of the source is 50 Hz.

9. Write an equation of average power for L-C-R series AC circuit and discuss its various cases.

10. Obtain the relation of phase between instantaneous current and voltage with the help of phase diagram for series LCR circuit.

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Date : 22/02/24

Section [A] : 1 Marks Questions					
No	Ans	Chap	Sec	Que	Universal_QueId
1.	-	Chap 7	S8	3	QP23P11B1211_P1C7S8Q3
2.	-	Chap 7	S8	6	QP23P11B1211_P1C7S8Q6
3.	-	Chap 7	S8	8	QP23P11B1211_P1C7S8Q8
4.	-	Chap 7	S9	20	QP23P11B1211_P1C7S9Q20
5.	-	Chap 7	S9	19	QP23P11B1211_P1C7S9Q19
6.	-	Chap 7	S9	17	QP23P11B1211_P1C7S9Q17
7.	-	Chap 7	S9	18	QP23P11B1211_P1C7S9Q18
8.	-	Chap 7	S10	20	QP23P11B1211_P1C7S10Q20
9.	-	Chap 7	S1	18	QP23P11B1211_P1C7S1Q18
10.	-	Chap 7	S1	11	QP23P11B1211_P1C7S1Q11

Section A

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➠ Try Yourself

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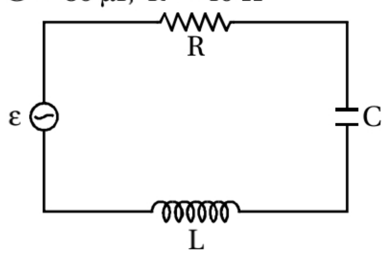
4. Figure shows a series LCR circuit connected to a variable frequency 230 V source. L = 5.0 H, C = 80 μF, R = 40 Ω



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(d) A pure inductor of 25.0 mH is connected to a source of 220 V. Find the inductive reactance and rms current in the circuit if the frequency of the source is 50 Hz.

➠ Try Yourself

9. Write an equation of average power for L-C-R series AC circuit and discuss its various cases.

➠ Average power for a given circuit,

$P = VI\cos\phi$

where $V = \frac{v_m}{\sqrt{2}}$, $I = \frac{i_m}{\sqrt{2}}$

➠ **Special cases :**

➠ **(1) Resistive circuit (Circuit containing only pure resistor) :**

➠ If the circuit contains only pure R, it is called resistive.

➠ In such circuit current and voltage are in same phase. So phase difference $\phi = 0°$

$\therefore$ Average power $P = VI\cos 0°$

$\therefore$ $P = VI$

There is maximum power dissipation.

(2) Purely inductive or capacitive circuit OR Circuit contains only an inductor OR Capacitor C :

➠ If the circuit contains only an inductor or only capacitor, such a circuit is called inductive and capacitive respectively.

➠ In purely inductive circuit, current is $\frac{\pi}{2}$ behind of voltage and in purely capacitive circuit, current is $\frac{\pi}{2}$ ahead of voltage. Means in both this type of circuit phase difference between current and voltage is $\frac{\pi}{2}$.

➠ Average power $P = Vi\cos\phi$

$$= Vi\cos\frac{\pi}{2}$$

$$= 0 \qquad \left[\because \cos\frac{\pi}{2} = 0\right]$$

➠ Even when current flows in circuit calculation of power is zero. This current called wattless current.

(3) L-C-R series circuit :

➠ In an L-C-R series circuit power dissipated is $P = VI\cos\phi$ where $\phi = \tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

➠ So, sometime ϕ may be non-zero in a RL or RC, or L-C-R circuits. Even in such case, power is dissipated only in the resistor.

(4) Power dissipated at resonance in L-C-R circuit :

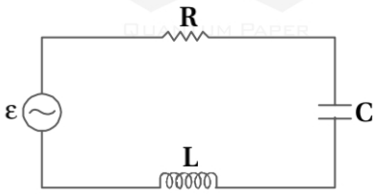
➠ At resonance $X_C - X_L = 0$, and $\phi = 0°$. Therefore, $\cos\phi = I$ and $P = i^2Z = i^2R$

$(\because P = VI\cos\phi,\ Z = R)$

Hence, maximum power is dissipated in a circuit at resonance.

10. Obtain the relation of phase between instantaneous current and voltage with the help of phase diagram for series LCR circuit.

➠ In circuit L-C-R are in series. Therefore, the ac current in each element is the same at any time having the same amplitude and phase.



➠ Let it be $I = I_m \sin(\omega t + \phi)$ ... (1)

where ϕ is the phase difference between the voltage across the source and the current in the circuit.

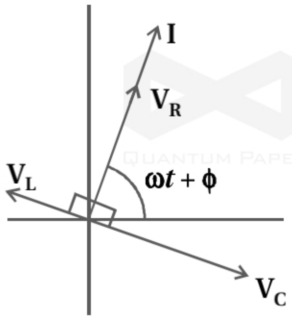
➠ Let $\vec{I}$ be the phasor representing the current in the circuit and $\vec{V}_L$, $\vec{V}_C$, $\vec{V}_R$ and $\vec{V}$ represent the voltage across the inductor, resistor, capacitor and the source respectively.

➠ $\vec{V}_R$ is parallel to $\vec{I}$.

$\vec{V}_C$ is $\frac{\pi}{2}$ behind $\vec{I}$ and

$\vec{V}_L$ is $\frac{\pi}{2}$ ahead of $\vec{I}$.

➠ $\vec{V}_L$, $\vec{V}_C$, $\vec{V}_R$ and $\vec{I}$ are shown in figure with appropriate phase relation.



(a)

➠ The amplitude of phasor are as follow,

$V_{Rm} = I_m R$, $V_{Cm} = I_m X_C$, $V_{Lm} = I_m X_L$

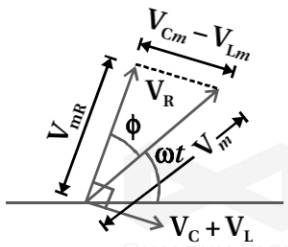
➠ The voltage equation for the circuit can be written as,

$L\frac{dI}{dt} + IR + \frac{q}{C} = V$ can be written as below

$\vec{V}_L + \vec{V}_R + \vec{V}_C = \vec{V}$ where $V_L = L\frac{dI}{dt}$, $V_R = IR$ and $V_C = \frac{q}{C}$

$\therefore$ The phasor relation $\vec{V}_L + \vec{V}_R + \vec{V}_C = \vec{V}$

➠ This relation is represented in below figure.



(b)

- Since $\vec{V}_C$ and $\vec{V}_L$ are in opposite directions, so the resultant value of phasor,

$$\vec{V}_C - \vec{V}_L = V_{Cm} - V_{Lm}$$

- Since $\vec{V}$ is represented as the hypotenuse of a right triangle whose sides are $\vec{V}_R$ and $\vec{V}_C + \vec{V}_L$ the Pythagorean theorem gives,

$$v_m^2 = v_{Rm}^2 + (v_{Cm} - v_{Lm})^2$$

$$\therefore\ v_m^2 = (i_m R)^2 + [(i_m X_C) - (i_m X_L)]^2$$

$$\therefore\ v_m^2 = i_m^2 \left[R^2 + (X_C - X_L)^2\right]$$

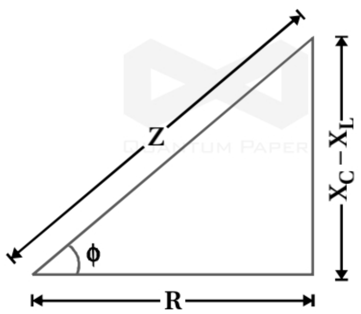
$$\therefore\ i_m^2 = \frac{v_m^2}{R^2 + (X_C - X_L)^2}$$

$$\therefore\ i_m = \frac{v_m}{\left[R^2 + (X_C - X_L)^2\right]^{1/2}}$$

but $\sqrt{R^2 + (X_C - X_L)^2} = Z$ where Z is called impedance.

$\therefore\ i_m = \dfrac{v_m}{Z}$ is the amplitude of current.

- Since phasor $\vec{I}$ is always parallel to phasor $\vec{V}_R$ the phase angle ϕ is the angle between $\vec{V}_R$ and $\vec{V}$ can be determined from figure,



- $$\tan\phi = \frac{v_{Cm} - v_{Lm}}{V_{Rm}}$$

$$= \frac{i_m X_C - i_m X_L}{I_m R}$$

$\therefore\ \tan\phi = \dfrac{X_C - X_L}{R}$ gives phase angle.

- Impedance Z of circuit can be determined by figure. This is called impedance diagram which is a right triangle with Z as its hypotenuse.

- Impedance from impedance diagram,

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