Chapter.7
Alternating Current
Class – XII
Subject – Physics

7.1. A 100 Ω resistor is connected to a 220 V, 50 Hz ac supply.

a) What is the rms value of current in the circuit?

b) What is the net power consumed over a full cycle?

Sol.

Given:
R = 100 ohms
V = 220 V
f = 50 Hz

a) We know
Irms = Vrms / R
Substituting the values
Irms = 220 / 100 = 2.2 A

b) Power = V.I
Or Power = 220 x 2.2
Or Power = 484 W

7.2.

a) The peak voltage of an ac supply is 300 V. What is the rms voltage?

b) The rms value of current in an ac circuit is 10 A. What is the peak current?

Sol.

a) We know
Vrms = Vpeak / 1.414
Vrms = 300 / 1.414
Or Vrms = 212.13 V

b) Using above identity for current
Ipeak = 1.414 x Irms
Or Ipeak = 1.414 x 10 = 14.14 A

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

Sol.

Given:
L = 44 mH
V = 220 V
f = 50 Hz

I_{rms} is given by = V / X_L
Determining inductive reactance
$X_L = 2 \times 3.14 \times 50 \times 44 \times 10^{-3}$
X_L = 13.82 ohms
Therefore
I_{rms} = 220 / 13.82
Or I_{rms} = 15.92 A

7.4. A 60 µF capacitor is connected to a 110 V, 60 Hz ac supply. Determine the rms value of the current in the circuit.

Sol.

Given:

C = 60 microfarads
V = 110 volts
f = 60 hertzs

Irms = V / Xc
Now
Xc = 1 / (2 x 3.14 x 60 x 60 x 10^{-6})
Xc = 44.248 ohms
Hence
Irms = 110 / 44.248 = 2.488 A

7.5. In Exercises 7.3 and 7.4, what is the net power absorbed by eachcircuit over a complete cycle. Explain your answer.

Sol.

Zero. Power is absorbed only by resistance in the circuit.

7.6. Obtain the resonant frequency $\omega_r$of a series LCR circuit withL = 2.0H, C = 32 µF and R = 10 Ω. What is the Q-value of this circuit?

Sol.

Given:
L = 2 H
C = 32 microF
R = 10 ohms

Resonant frequency $\omega_r = \frac{1}{\sqrt{LC}}$
Substitution yields
ω_r = 125 /s

Now Q-value = $\omega_r L / R$
Putting the desired values gives us
Q-value = 25

7.7. A charged 30 µF capacitor is connected to a 27 mH inductor. What isthe angular frequency of free oscillations of the circuit?

Sol.

Given:
C = 30 microF
L = 27 mH

Angular frequency of free oscillations = $\frac{1}{\sqrt{LC}}$
Substitution results
Angular frequency = 1111.11 /s

7.8. Suppose the initial charge on the capacitor in Exercise 7.7 is 6 mC. What is the total energy stored in the circuit initially? What is the total energy at later time?

Sol.

Initial energy, Ui = $q_m^2 / 2C$
Solving
Ui = 0.6 J
The energy will remain constant at all times.

7.9. **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?**

Sol.

Given:
R = 20 ohms
L = 1.5 henries
C = 35 micro farads
V = 200 volts

Natural frequency

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

= 138 /s

At natural frequency,
Z = R
So I = V / R = 200 / 20 = 10 A
Thus
$P = I^2R$
Or P = 10 x 10 x 20 = 2000 W

7.10. **A radio can tune over the frequency range of a portion of MWbroadcast band: (800 kHz to 1200 kHz). If its LC circuit has an effective inductance of 200 μH, what must be the range of its variable capacitor? [Hint: For tuning, the natural frequency i.e., the frequency of free oscillations of the LC circuit should be equal to the frequency of the radio wave.]**

Sol.

By the relation

$$\frac{1}{\sqrt{LC}} = 2\pi f$$

Solving for C

$$C = \frac{1}{4\pi^2 f^2 L}$$

For f = 800 kHz,

C' = 197.8 pF

For f = 1200 kHz,

C''= 87.9 pF

Range: 88 pF to 198 pF

7.11. **Figure 7.21 shows a series LCR circuit connected to a variable frequency 230 V source. L = 5.0 H, C = 80μF, R = 40 Ω.**

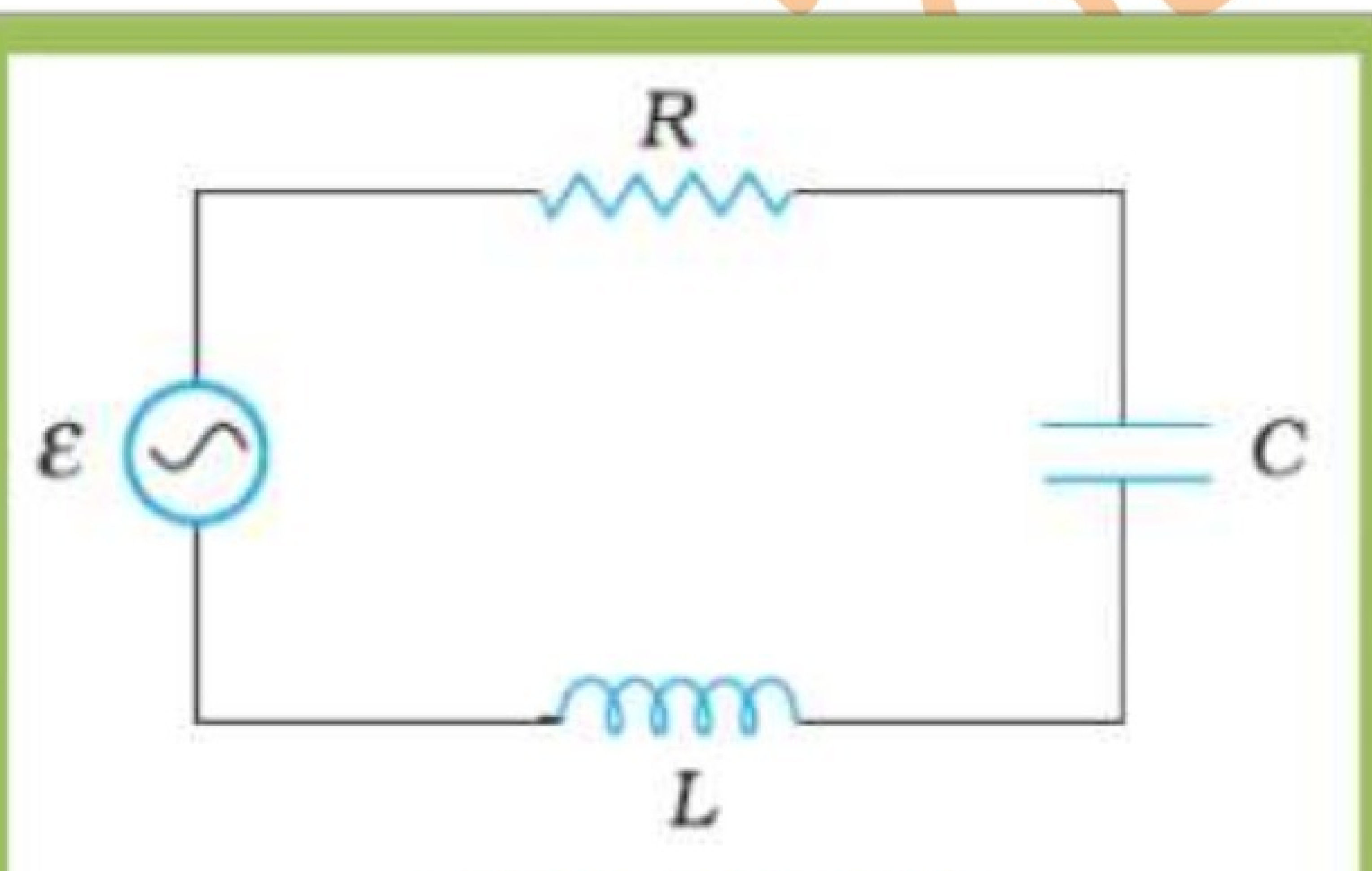

FIGURE 7.21

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.**

Sol.

Given:
V = 230 V
L = 5 H
C = 80 μF
R = 40 ohms

a) Source frequency at resonance $= \frac{1}{\sqrt{LC}}$
Solving by putting respective values
= 50 rad / s

b) At resonance,
Impedance, Z = Resistance, R
So Z = R = 40 ohms
Now rms value of current,
I = V / R
Or I = 230 / 40
Hence I = 5.75 A
Amplitude of this value of current = 1.414 x I
= 1.414 x 5.75
= 8.13 A

c) Now taking into consideration the rms potential drops
Across Resistance
$V_R = IR$
= 5.75 x 40
= 230 V

Across Capacitance
$V_C = IX_C$
= 1437.5 V

Across Inductance
$V_L = IX_L$
= 5.75 x 50 x 5
= 1437.5 V

Across LC combination

$$V_{LC} = I(X_L - X_C)$$

$$= 0 \text{(at resonating frequency)}$$

Hence shown!