NCERT Solutions for Class-XII Physics

Chapter-7

NCERT Physics Class 12

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?

1. Resistance of the resistor, R = 100 Ω,   Supply voltage, V = 220 V, Frequency, v = 50 Hz
(a) The rms value of a current in the circuit is given as

$$I = \frac{V}{R} = \frac{220}{100} = 2.20\text{ A}$$

(b) The net power consumed over a full cycle is given as: P = VI = 200 × 2.2 = 484 W

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?

2. (a) Given: Peak voltage of an A.C. supply, $V_{peak} = V_0 = 300$ V
The root mean square voltage can be calculated as follows:

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$V_{rms} = \frac{(300V)}{\sqrt{2}}$$

$\Rightarrow V_{rms} = 212.1$ V
(b) Given: the root mean square value in an A.C. circuit, $I_{rms} = 10$A
The peak current can be calculated as follows:

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$\Rightarrow I_0 = I\sqrt{2} = (10A)\sqrt{2}$$

$\Rightarrow I_0 = 14.1$ A

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

3. Inductance of inductor, L = 44 mH = 44 × 10^{-3} H
Supply voltage, V = 220 V, Frequency, v = 50 Hz, Angular frequency, ω = 2πv
Inductive reactance, X_L = ωL = 2πvL = 2π × 50 × 44 × 10^{-3} Ω
rms value of current is given as:

$$I = \frac{V}{X_L} = \frac{220}{2\pi \times 50 \times 44 \times 10^{-3}} = 15.92 \text{ A}$$

Hence, the rms value of current in the circuit is 15.92 A.

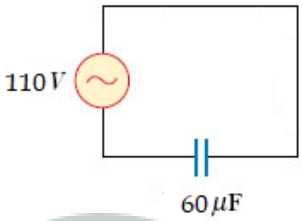
4. A 60 μF capacitor is connected to a 110 V, 60 Hz ac supply. Determine the rms value of the current in the circuit.

4. Given: capacitance = 60 μF = 60×10^{-6} F

Voltage V =110 V

Frequency f = 60 Hz

The diagram is:



Capacitive reactance is given by the following relation:

$X_c = 1/\omega C$

Substituting $\omega = 2\pi v$ in the above formula, we get

$X_c = 1/2\pi v C$

Substituting the values, we get

$$X_C = \frac{1}{\left(2 \times 3.14 \times 60\text{Hz} \times 60 \times 10^{-6}\text{F}\right)}$$

$$\Rightarrow X_C = \frac{1}{\left(2 \times 3.14 \times 60 \times 60 \times 10^{-6}\right)}\Omega$$

Now, the root mean square value of the current can be calculated as follows:

$$I_{rms} = \frac{V}{X_C}$$

$I_{rms} = 110\text{V} \times 2 \times 3.14 \times (60 \text{ Hz}) \times 60 \times 10^{-6} \text{ (F)}$

On calculating, we get

$I_{rms} = 2.49$ A

5. In Exercise 7.3 and 7.4, what is the net power absorbed by each circuit over a complete cycle. Explain your answer.

5. In the inductive circuit,

rms value of current, I = 15.92 A

rms value of voltage, V = 220 V

Hence, the net power absorbed can be obtained by the relation,

$P = VI \cos \Phi$

Where, Φ = Phase difference between V and I.

For a pure inductive circuit, the phase difference between alternating voltage and current is 90° i.e., $\Phi = 90°$

Hence, $P = 0$ i.e., the net power is zero.

In the capacitive circuit, rms value of current, $I = 2.49$ A, rms value of voltage, $V = 110$ V

Hence, the net power absorbed can be obtained as:

$P = VI \cos \Phi$

Where, Φ = Phase difference between V and I.

For a pure inductive circuit, the phase difference between alternating voltage and current is 90° i.e., $\Phi = 90°$.

Hence, $P = 0$ i.e., the net power is zero.

In the capacitive circuit, rms value of current, $I = 2.49$ A, rms value of voltage, $V = 110$ V

Hence, the net power absorbed can be obtained as:

$P = VI \cos \Phi$

For a pure capacitive circuit, the phase difference between alternating voltage and current is 90° i.e., $\Phi = 90°$.

Hence, $p = 0$ i.e., the net power is zero.

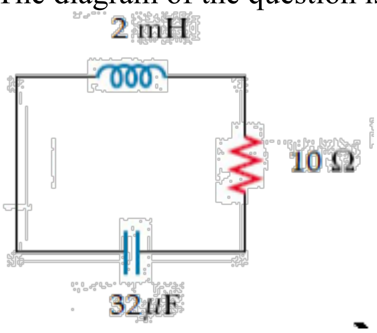
6. Obtain the resonant frequency ω_r of a series LCR circuit with $L = 2.0$ H, $C = 32\ \mu F$ and $R = 10\ \Omega$. What is the Q-value of this circuit?

6. Given: $L = 2.0$ H

$C = 32\ mF = 32 \times 10^{-6}$ F

$R = 10\ \Omega$

The diagram of the question is:



Resonant frequency ω_r is calculated as follows:

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

$$\omega_r = \frac{1}{\sqrt{2H \times 32 \times 10^{-6} F}}$$

$$\omega_r = 125\, s^{-1}$$

Q- value of the LCR circuit can be calculated as follows:

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

$$Q = \frac{1}{10}\sqrt{\frac{2H}{32 \times 10^{-6} F}}$$

On calculating, we get

Q = 25

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

7. Capacitance, C = 30 μF = 30 × 10^{-6} F

Inductance, L = 27 mH = 27 × 10^{-3} H

Angular frequency is given as:

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{27 \times 10^{-3} \times 30 \times 10^{-6}}} = \frac{1}{9 \times 10^{-4}} = 1.11 \times 10^{3} \text{ rad/s}$$

Hence, the angular frequency of free oscillations of the circuit is 1.11 × 10^3 rad/s.

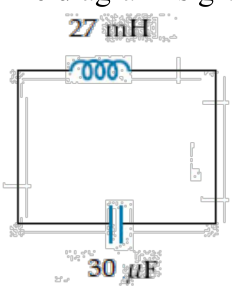
8. Suppose the initial charge on the capacitor in Exercise 7.7 is 6 mC. What is the total energy stored in the circuit initially? What is the total energy at later time?

8. Given: Capacitance C = 30 uF = 30 × 10^{-6} F

Inductance L = 27 mH = 20 × 10^{-6} H

The charge on capacitor, Q = 6 mC = 6 × 10^{-3} C

The diagram is given:



The total energy stored in the circuit can be calculated as followed:

E = 1/2 Q^2C

E = 1/2 × (6 × 10^{-3} C)^2 × 30 × 10^{-6} F

On calculating, we get

⇒ E = 0.6 J

At later time, total energy will be same i.e., E = 0.6 J as energy is shared between inductor and capacitor.

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?

9. At resonance, the frequency of the supply power equals the natural frequency of the given LCR circuit.

Resistance, R = 20 Ω

Inductance, L = 1.5 H

Capacitance, C = 35 μF = 30×10^{-6} F

AC supply voltage to the LCR circuit, V = 200 V

Impendence of the circuit is given by the relation,

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

$\therefore Z = R = 20\ \Omega$

Current in the circuit can be calculated as:

$$I = \frac{V}{Z} = \frac{200}{20} = 10\ \text{A}$$

Hence, the average power transferred to the circuit in one complete cycle:

VI = 200 × 10 = 2000 W

10. A radio can tune over the frequency range of a portion of MW broadcast 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.]

10. Given: frequency range of radio waves = 800 kHz to 1200 kHz

Therefore, low tuning frequency of radio wave v_1 = 800 kHz, or 800×10^{-3} Hz

Upper tuning frequency v_2 = 1200 kHz or 1200×10^{-3} Hz

Inductance L = 200 μH or 200×10^{-6} H

Capacitance of the variable capacitor for low tuning frequency v_1 is given by the following relation:

$C_1 = 1/\omega_1^2 L$ … (i)

Where ω is equal to $2\pi v_1$

Substituting in equation (i), we get

$C_1 = 1/\{(2\pi \times 800 \times 10^{-3}\ \text{Hz})^2 \times 200 \times 10^{-6}\ \text{H}\}$

On calculating we get

$C_1 = 1.9809 \times 10^{-10}$ F

Or C_1 = 198.1 pF

Capacitance of the variable capacitor for upper tuning frequency v_2 is given by the following relation:

$C_2 = 1/\omega_2^2 L$ ... (ii)

Where ω is equal to $2\pi v_2$

Substituting in equation (i), we get

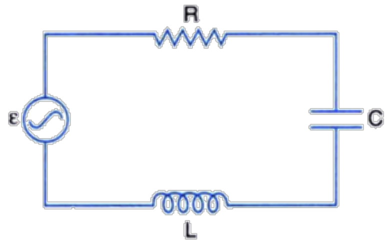
$C_2 = 1/\{(2\pi \times 1200 \times 10^{-3}\,\text{Hz})^2 \times 200 \times 10^{-6}\,\text{H}\}$

On calculating we get

$\Rightarrow C_2 = 88.04$ pF

Therefore, the range of its variable capacitor is from 88.04 pF to 198.1 pF.

11. 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.

11. Inductance of the inductor, L = 5.0 H, Capacitance of the capacitor, C = 80 μH = 80 × 10^{-6} F

Resistance of the resistor, R = 40 Ω

Potential of the variable voltage source, V = 230 V

(a) Resonance angular frequency is given as:

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5 \times 80 \times 10^{-6}}} = \frac{10^3}{20} = 50\ \text{rad/s}$$

Hence, the circuit will come in resonance for a source frequency of 50 rad/s.

(b) Impedance of the circuit is given by the relation:

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

At resonance, $X_L = X_C \Rightarrow Z = R = 40\ \Omega$

Amplitude of the current at the resonating frequency is given as: $I_o = \frac{V_o}{Z}$

Where, V_o = Peak voltage = $\sqrt{2}V$

$$\therefore I_o = \frac{\sqrt{2}V}{Z} = \frac{\sqrt{2} \times 230}{40} = 8.13\ \text{A}$$

Hence, at resonance, the impedance of the circuit is 40 Ω and the amplitude of the current is 8.13 A.

(c) rms potential drop across the inductor,

$(V_L)_{rms} = I \times \omega r L$

Where,

$$I_{rms} = \frac{I_o}{\sqrt{2}} = \frac{\sqrt{2}V}{\sqrt{2}Z} = \frac{230}{40} = \frac{23}{4} A$$

$$\therefore (V_L)_{rms} = \frac{23}{4} \times 50 \times 5 = 1437.5 \text{ V}$$

Potential drop across the capacitor:

$$\therefore (V_C)_{rms} = I \times \frac{1}{\omega_r C} = \frac{23}{4} \times \frac{1}{50 \times 80 \times 10^{-6}} = 1437.5 \text{ V}$$

Potential drop across the resistor:

$$(V_R)_{rms} = IR = \frac{23}{4} \times 40 = 230 \text{ V}$$

Potential drop across the LC combination:

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

At resonance, $X_L = X_C \Rightarrow V_{LC} = 0$

Hence, it is proved that the potential drop across the LC combination is zero at resonating frequency.