

Alternating Current — CBSE Pattern Test 2

Class 12 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

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General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.
 (2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.
 (3) For MCQ questions choose the single correct option; for VSA answers write a single line.
 (4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

1. The average value of an alternating current over a full cycle is
 - (A) zero
 - (B) $I_0/\sqrt{2}$
 - (C) $I_0/2$
 - (D) $2I_0/\pi$
2. The impedance of an LCR series circuit is
 - (A) $\sqrt{R^2 + (X_L - X_C)^2}$
 - (B) $R + X_L + X_C$
 - (C) $\sqrt{R^2 + X_L^2 + X_C^2}$
 - (D) $R - X_L + X_C$
3. In a purely inductive AC circuit, the current
 - (A) lags the voltage by $\pi/2$
 - (B) leads the voltage by $\pi/2$
 - (C) is in phase with the voltage
 - (D) leads the voltage by π
4. At resonance, the current in a series LCR circuit is
 - (A) maximum
 - (B) minimum
 - (C) zero
 - (D) infinite
5. The power factor of a purely resistive circuit is
 - (A) one
 - (B) zero
 - (C) 0.5
 - (D) 0.707
6. The term $\cos\phi$ in the power equation is called the
 - (A) power factor
 - (B) form factor
 - (C) quality factor
 - (D) peak factor
7. At the instant the capacitor is fully charged in an LC circuit, the current is
 - (A) zero

- (B) maximum
(C) half maximum
(D) infinite
8. The peak value and the RMS value of an AC are related by
(A) $I_0 = \sqrt{2} I_{\text{rms}}$
(B) $I_0 = I_{\text{rms}}/\sqrt{2}$
(C) $I_0 = 2 I_{\text{rms}}$
(D) $I_0 = I_{\text{rms}}$
9. Define inductive reactance.
10. Define the power factor.

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. Find the average value of an AC of peak value 10 A over a half cycle.
12. A 5 μF capacitor is connected to a source of $\omega = 1000$ rad/s. Find its reactance.
13. An LC circuit has $L = 2$ mH and $C = 8$ μF . Find its frequency of oscillation.
14. A series LCR circuit resonates at 1000 Hz with a bandwidth of 100 Hz. Find its quality factor.

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Derive the expression for the impedance of a series LCR circuit and discuss the cases of a pure inductor and a pure capacitor.
16. Define the quality factor of a series LCR circuit, derive its expression and explain its significance.
17. Derive the expression for the average power in a series LCR circuit and explain the power factor.
18. Describe the energy changes in an LC oscillator and show the analogy with a mechanical oscillator.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Define the RMS value of an AC. Derive $I_{\text{rms}} = I_0/\sqrt{2}$, and use it to explain why an AC of a given RMS value produces the same heating effect as a DC of the same value.
20. For an LC oscillator, describe how energy oscillates between the capacitor and the inductor, show that the total energy is constant, and derive the frequency of oscillation.

Answer Key (Marking Scheme)

- Q1 — (A) zero. Q2 — (A) $\sqrt{(R^2 + (X_L - X_C)^2)}$. Q3 — (A) lags the voltage by $\pi/2$. Q4 — (A) maximum.
Q5 — (A) one. Q6 — (A) power factor. Q7 — (A) zero. Q8 — (A) $I_0 = \sqrt{2} I_{\text{rms}}$.
Q9 — $X_L = \omega L$, the opposition offered by an inductor to AC.
Q10 — $\cos\phi$, the cosine of the phase angle between voltage and current.
Q11 — $I_{\text{avg}} = 2I_0/\pi \approx 6.37$ A.
Q12 — $X_C = 1/\omega C = 1/(1000 \times 5 \times 10^{-6}) = 200$ Ω .
Q13 — $\nu = 1/2\pi\sqrt{LC} \approx 1258$ Hz.
Q14 — $Q = f_0/\Delta f = 1000/100 = 10$.
Q15 — $Z = \sqrt{(R^2 + (X_L - X_C)^2)}$; pure L: $Z = X_L$, $\phi = +90^\circ$; pure C: $Z = X_C$, $\phi = -90^\circ$.
Q16 — $Q = \omega_0 L/R = 1/(\omega_0 CR)$; it measures the sharpness of resonance and the voltage magnification across L and C.

Q17 — $P = V_{\text{rms}} I_{\text{rms}} \cos\phi$ with $\cos\phi = R/Z$.

Q18 — Energy shuttles between the capacitor (electric) and inductor (magnetic); the LC circuit is the electrical analogue of a mass-spring system.

Q19 — I_{rms} is the equivalent DC that gives the same Joule heating; $I_{\text{rms}} = I_0/\sqrt{2}$ since the mean of $\sin^2$ is $1/2$.

Q20 — $\frac{1}{2}q^2/C$ and $\frac{1}{2}Li^2$ interchange; total $\frac{1}{2}q_0^2/C$ is constant; $\nu = 1/2\pi\sqrt{LC}$.