Alternating Current

Class 12 · Physics · Quick Revision · **chapternotes.in**

NEET: 2-3 Qs (~8-12 marks) | Boards: 6-8 marks

Scan: practise free

Current that reverses every half cycle: rms values, how R/L/C oppose and phase-shift it, how they combine in a series LCR circuit, resonance, real power, and the transformer.

1. AC, Peak & RMS Values

A sine source averages to zero over a cycle, so we rate it by its rms (heating-equivalent) value.

$i = i_0 \sin(\omega t)$, $\omega = 2\pi f$
i_0 = peak, ω = angular freq

$I_{rms} = I_0/\sqrt{2} \approx 0.707\, I_0$
same I^2R heating as this DC

$V_{rms} = V_0/\sqrt{2}$
mains 220 V → $V_0 \approx 311$ V

$I_{avg}(\text{half cycle}) = 2I_0/\pi \approx 0.637\, I_0$
mean over half a cycle

MUST KNOW Full-cycle average of AC is ZERO; that is why rms (not mean) is used.

MUST KNOW AC ammeters/voltmeters already read rms - don't divide by √2 again.

- A stated value (e.g. '5 A') is rms unless 'peak' or 'maximum' is specified.

2. AC Through R, L and C Separately

Each element has its own opposition (in ohms) and phase relation between V and I.

Resistor: V, I in phase, opposition = R
$\varphi = 0$

$X_L = \omega L = 2\pi f L$
I lags V by 90°; rises with f

$X_C = 1/(\omega C) = 1/(2\pi f C)$
I leads V by 90°; falls with f

MUST KNOW Mnemonic CIVIL: in C, I leads V; in L, V leads I.

MUST KNOW At DC (f=0): X_L = 0 (coil = wire); X_C → ∞ (capacitor blocks DC).

- Pure L and pure C dissipate ZERO average power - reactance is not resistance.

3. Series LCR Circuit & Impedance

Same current, but V_R, V_L, V_C differ in phase, so add them as phasors - never arithmetically.

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

$V_{rms} = I_{rms} Z$
AC Ohm's law

$\tan\varphi = (X_L - X_C)/R$
phase angle V w.r.t I

$V = \sqrt{V_R^2 + (V_L - V_C)^2}$
V_L, V_C are 180° apart → subtract

MUST KNOW X_L > X_C → inductive (V leads I); X_C > X_L → capacitive (I leads V); X_L = X_C → resistive.

MUST KNOW V_L or V_C can exceed the source voltage - perfectly normal, they largely cancel.

- Never write Z = R + (X_L − X_C); the terms add in quadrature (Pythagoras).

4. Resonance & Quality Factor

At one frequency X_L = X_C cancel; impedance is minimum and current maximum (acceptor circuit).

$\omega_0 = 1/\sqrt{LC}$, $f_0 = 1/(2\pi\sqrt{LC})$
depends only on L, C - not R

At resonance: Z = R (min), I = V/R (max)
$\cos\varphi = 1$, purely resistive

$Q = (1/R)\sqrt{L/C} = \omega_0 L/R = 1/(\omega_0 C R)$
sharpness of resonance

$Q = f_0/\Delta f$
Δf = bandwidth

MUST KNOW Smaller R → larger Q → sharper, narrower peak → better selectivity (radio tuning).

MUST KNOW R does NOT shift f_0; it only sets the sharpness and the peak current.

- At resonance Z = R (a minimum), NOT zero - current stays finite at V/R.

5. Power & Power Factor (Wattless Current)

Real power depends on the phase: only the resistor consumes energy.

$P = V_{rms} I_{rms} \cos\varphi$
true power (watts)

$\cos\varphi = R/Z$
power factor

Apparent power $= V_{rms} I_{rms}$
volt-amperes (VA)

$P = I_{rms}^2 R$
reliable cross-check

MUST KNOW Pure L or C: $\varphi = 90°$, $\cos\varphi = 0$ → wattless current (flows but consumes nothing).

MUST KNOW At resonance $\cos\varphi = 1$, so power is maximum - not zero.

- Dropping $\cos\varphi$ gives apparent (not true) power - the classic blunder.

6. Transformer & LC Oscillations

Mutual induction reshapes AC voltage; an LC loop swaps energy between fields like an SHM.

$V_s/V_p = N_s/N_p = I_p/I_s$
ideal transformer

$V_p I_p = V_s I_s$
ideal: power conserved (η = 100%)

LC: $f = 1/(2\pi\sqrt{LC})$, $q = q_0\cos(\omega t)$
$\omega_0 = 1/\sqrt{LC}$

MUST KNOW Works ONLY on AC - steady DC gives constant flux, so no induced emf.

MUST KNOW Step-up: voltage up, current down (and vice versa) - power can't be created.

- Iron loss cut by laminated core (eddy) + soft iron (hysteresis); copper loss = I^2R.

R vs L vs C in AC

Element	Opposition	Phase (I vs V)	Power
R	R	in phase	$P = I^2R$
L	$X_L = \omega L$	I lags 90°	zero
C	$X_C = 1/\omega C$	I leads 90°	zero

Series LCR Behaviour

Condition	Nature	Phase
$X_L > X_C$	Inductive	V leads I
$X_C > X_L$	Capacitive	I leads V
$X_L = X_C$	Resonance (Z = R)	$\varphi = 0$, $\cos\varphi = 1$

Mnemonic - In C, I leads V; in L, V leads I - the phase relations for capacitor and inductor.
CIVIL

Common traps

- Full-cycle average of AC is zero; $2I_0/\pi$ is the HALF-cycle mean. Don't swap them.
- AC meters read rms already - never divide a meter reading by $\sqrt{2}$ again.
- Add V_R, V_L, V_C as phasors using $(V_L - V_C)$; arithmetic sum is wrong. V_L/V_C may exceed the source.
- Power factor $\cos\varphi$ must be kept: $P = V_{rms} I_{rms} \cos\varphi$ is true power; without $\cos\varphi$ it is only apparent power. At resonance $\cos\varphi = 1$, not 0.

Most asked in NEET » Peak ↔ rms ($i_0/\sqrt{2}$) | X_L, X_C and current in single elements | Impedance & power factor of series LCR | $V = \sqrt{V_R^2 + (V_L-V_C)^2}$ | Resonant ω_0 / f_0 & Q-factor | Transformer turns ratio & LC frequency