🌟 ALTERNATING CURRENT (AC) – Class 12 Physics

Prepared in **simple language**, with **colorful analogies, diagrams, formulas, solved numericals, PYQs, revision notes, exam hacks**, and more.

⭐ 1. THEORY IN SIMPLE WORDS (WITH VISUALS)

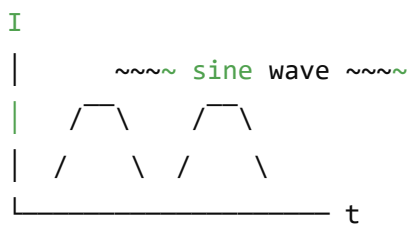
🌈 1.1 What is Alternating Current?

AC (Alternating Current) = current that **keeps changing direction** and **magnitude** with time.

Visual Analogy

Imagine water in a pipe **moving forward then backward** rhythmically.

Graph:



🌈 1.2 AC Voltage & Current

$$i = i_0 \sin(\omega t)$$

$$v = v_0 \sin(\omega t)$$

Where:

- i_0, v_0 = peak values
- ω = angular frequency
- T = time period
- f = frequency

$$\omega = 2\pi f = \frac{2\pi}{T}$$

🌈 1.3 RMS (Root Mean Square)

AC does not have constant value → we use "effective value".

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

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

Memory Trick:
“Divide peak by 1.414”

🌈 1.4 AC Circuit Elements

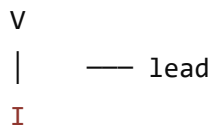
💡 Resistor (R)

No phase difference:

$$V \text{ in phase with } I$$

💡 Inductor (L)

Current **lags** voltage by 90°.



💡 Capacitor (C)

Current **leads** voltage by 90°.

Mnemonic:

"ICE" → In Capacitor, Current leads
"LIV" → In Inductor, Voltage leads

🌈 1.5 Reactance

Inductive Reactance

$$X_L = \omega L = 2\pi f L$$

Capacitive Reactance

$$X_C = \frac{1}{\omega C}$$

🌈 1.6 Impedance of LCR Series Circuit

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

Phase angle:

$$\tan \phi = \frac{X_L - X_C}{R}$$

🌈 1.7 Resonance in LCR Circuit

At resonance:

$$X_L = X_C$$

$$Z = R \ (minimum)$$

$$I = I_{max}$$

Resonant frequency:

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

Visual:

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Resonance = maximum glow of bulb in LCR circuit
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🌈 1.8 Power in AC Circuit

$$P = V I \cos \phi$$

cosϕ = **power factor**

Special cases:

- Pure R → cosϕ = 1 (maximum power)
- Pure L or C → cosϕ = 0 (no power consumed)

⭐ 2. KEY CONCEPTS & FORMULAS TABLE

Quantity	Formula	Notes
AC current	$i = i_0 \sin \omega t$	sinusoidal
RMS value	$I_0/\sqrt{2}$	effective
Inductive reactance	$X_L = \omega L$	increases with f
Capacitive reactance	$X_C = 1/\omega C$	decreases with f
Impedance	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	AC resistance
Power	$P = V I \cos \phi$	power factor
Resonance	$f_r = 1/(2\pi\sqrt{LC})$	max current

🌈 Mnemonics

💡 The famous one: ELI–ICE

- **E L I** → Voltage (E) leads current (I) in **L**
- **I C E** → Current (I) leads voltage (E) in **C**

💡 Power Factor

"Cosϕ tells the truth"
(Real power = VIcosϕ)

⭐ 3. SOLVED NUMERICAL PROBLEMS

⭐ Type 1: RMS Values

Q1: Peak current = 5 A. Find RMS.

$$I_{rms} = \frac{5}{\sqrt{2}} = 3.54A$$

⭐ Type 2: Reactance

Q2: L = 0.1 H, f = 50 Hz. Find XL.

$$X_L = 2\pi fL = 2\pi \cdot 50 \cdot 0.1$$

$$= 31.4\Omega$$

⭐ Type 3: Impedance

Q3: R = 20Ω, XL = 40Ω, XC = 10Ω. Find Z.

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

$$= \sqrt{20^2 + 30^2} = \sqrt{400 + 900} = \sqrt{1300}$$

$$Z = 36.05\Omega$$

⭐ Type 4: Resonance

Q4: L = 2 mH, C = 5 µF. Find resonance frequency.

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

$$= \frac{1}{2\pi\sqrt{2 \times 10^{-3} \cdot 5 \times 10^{-6}}}$$

$$= 1591\ Hz$$

⭐ Type 5: Power in AC

Q5: V = 220 V, I = 5 A, cosϕ = 0.8.

$$P = V I \cos\phi = 220 \times 5 \times 0.8 = 880W$$

⭐ 4. PAST YEARS' BOARD QUESTIONS (SOLVED)

(Based on CBSE trends 2014–2024)

✔ Q1

State RMS value.
(1 mark — very common)

✔ Q2

Define reactance and impedance.
(2 marks)

✔ Q3

Draw phasor diagram of R-L series circuit.
(3 marks)

✔ Q4

Explain resonance in LCR circuit.
(3 marks)

✔ Q5

Derive expression for impedance of LCR circuit.
(5 marks)

✔ Q6

A numerical on XL or XC.
(Almost every year)

✔ Q7

AC power expression derivation.
(4 marks)

⭐ 5. QUICK REVISION NOTES (1–2 PAGES)

🌈 AC Basics

- AC varies sinusoidally.
- RMS = peak/√2
- ω = 2πf

🌈 Circuit Elements

Element	Phase Relation	Reactance
R	I & V in phase	R
L	I lags	$X_L = \omega L$
C	I leads	$X_C = 1/\omega C$

🌈 LCR Circuit

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

🌈 Resonance

- Occurs when XL = XC
- Z minimum, I maximum
- Used in tuning radios

🌈 Power

- Instantaneous power fluctuates
- Average power = $V I \cos\phi$
- Power factor important for efficiency

⭐ 6. PREDICTED / LIKELY QUESTIONS (2025 Boards)

Short Answer

- Define RMS value
- What is reactance?
- Difference between AC & DC
- Write formula for impedance
- Explain resonance

Long Answer

- Derive RMS value
- Derive impedance of LCR circuit
- Derive power in AC circuit
- Explain phasor diagrams

Numerical

- XL, XC
- Impedance
- Power factor
- RL/RC/LCR circuit current

⭐ 7. EXAM TIPS & TRICKS

✔ Tip 1

Use **ELI–ICE** for phase:

- Voltage leads in **L**
- Current leads in **C**

✔ Tip 2

Always convert **mH → H**, **μF → F**.

✔ Tip 3

In resonance problems:

- Z = R
- I = maximum

✔ Tip 4

Phasor diagrams = easy scoring.
Draw clean arrows.

✔ Tip 5

Before solving AC problems, identify:

- R?
- L?
- C?
- Series or parallel?

⭐ 8. VISUAL & KID-FRIENDLY MEMORY TOOLS

🎨 Visual: AC Wave

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Positive – Zero – Negative – Zero – Repeat
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🎨 Visual: L vs C Phase

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L: heavy coil → current slow
C: storage tank → current fast
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🎨 Visual: Resonance

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L & C cancel each other → only R left → max current
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🎨 Visual: Impedance Triangle