

CHAPTER 07

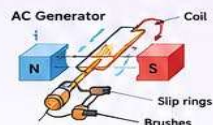


ALTERNATING CURRENT



1. ALTERNATING CURRENT & VOLTAGE

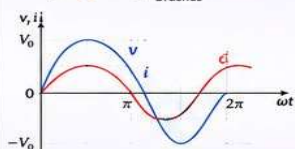
AC is a current whose magnitude and direction change with time periodically.



Instantaneous values:

$$v = V_0 \sin(\omega t)$$

$$i = I_0 \sin(\omega t - \phi)$$



V_0, I_0 = Peak values
 ω = Angular frequency
 $= 2\pi f \text{ rad s}^{-1}$
 f = Frequency (Hz)
 T = Time period
 $= 1/f$

RMS (Effective) Values:

$$V_{rms} = \frac{V_0}{\sqrt{2}} \quad I_{rms} = \frac{I_0}{\sqrt{2}}$$



Quick Recall

In one time period, current reverses direction twice.

In India: $f = 50 \text{ Hz}$, $T = 20 \text{ ms}$

2. AC THROUGH DIFFERENT CIRCUITS

Circuit	Waveform	Phasor Diagram	Phase Relation	Key Point
(A) Pure Resistor (R)			$\phi = 0^\circ$ V and I in phase	All power consumed as heat.
(B) Pure Inductor (L)			$\phi = 90^\circ$ I lags V by 90°	Energy stored in magnetic field.
(C) Pure Capacitor (C)			$\phi = -90^\circ$ I leads V by 90°	Energy stored in electric field.

★ **MEMORY TRICK:** "ELI the ICE man"

E leads I in Capacitor (ICE) | I lags E in Inductor (ELI)

3. REACTANCE & IMPEDANCE

Opposition in AC Circuits

- R** Resistor opposes the flow of current. (Resistance R)
- L** Inductor opposes change in current. (Inductive Reactance X_L)
- C** Capacitor opposes change in voltage. (Capacitive Reactance X_C)

Reactance

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

(Inductive Reactance)

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC}$$

(Capacitive Reactance)

Impedance in LCR Series Circuit

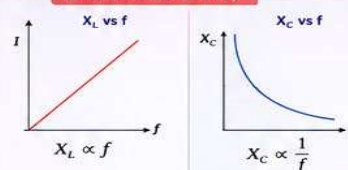
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Net opposition offered to AC by the circuit.

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

ϕ = Phase angle

5. RESONANCE CURVE



Resonant Frequency

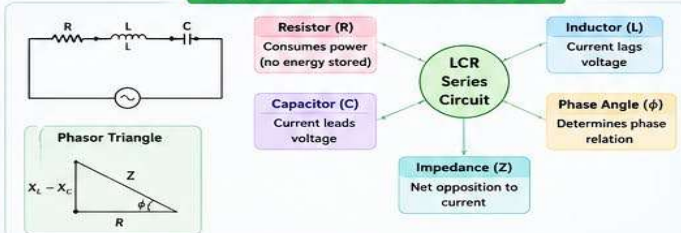
$$\omega_0 = \frac{1}{\sqrt{LC}} \quad \text{or} \quad f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Tuning:

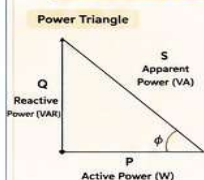
In radio receivers, f_0 is changed to select a particular station.

MOST IMPORTANT
PYQ FAVOURITE

4. LCR SERIES CIRCUIT – CONCEPT MAP



6. POWER IN AC CIRCUIT



Active Power (P)
 Actually consumed.
 $P = V_{rms} I_{rms} \cos \phi$

Reactive Power (Q)
 Oscillates between source and circuit.
 $Q = V_{rms} I_{rms} \sin \phi$

Apparent Power (S)
 Product of rms values.
 $S = V_{rms} I_{rms}$

Power Factor
 $\cos \phi = \frac{P}{S} = \frac{R}{Z}$
 (Closer to 1 is better)

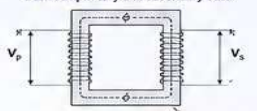
Why Power Factor Matters?

- Low power factor $\rightarrow$ More current for same power
- More current $\rightarrow$ More I^2R losses
- High power factor $\rightarrow$ Efficient & economical



7. TRANSFORMER

Working: Based on mutual induction between primary and secondary coils.



Step-Up Transformer ($N_s > N_p$)
 $V_s > V_p$, $I_s < I_p$

Step-Down Transformer ($N_s < N_p$)
 $V_s < V_p$, $I_s > I_p$

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad \text{and} \quad \frac{I_p}{I_s} = \frac{N_s}{N_p}$$

$$\eta = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

8. LC OSCILLATIONS



Energy oscillates between inductor (magnetic field) and capacitor (electric field).

Capacitor Fully Charged	Current Maximum	Capacitor Fully Discharged	Current in Opposite Direction
Energy stored in Electric Field	Energy stored in Magnetic Field	Energy stored in Electric Field	Energy stored in Magnetic Field

Time Period of Oscillation

$$T = 2\pi\sqrt{LC}$$

Angular Frequency

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

9. MEMORY TRICKS

- ELI the ICE man
 E leads I in Capacitor (ICE)
 I lags E in Inductor (ELI)
- At Resonance:
 $X_L = X_C$, $Z = R$ (min), $I = \text{max}$, $\cos \phi = 1$



10. COMMON MISTAKES

- ✗ Ignoring phase angle while solving power
- ✗ Considering X_L and X_C independent of f
- ✗ Using peak values instead of rms values
- ✗ Forgetting resonance condition ($X_L = X_C$)

11. EXAM BOOSTER (CBSE)

- ★ Resonance, Power Factor, Transformers are high weightage topics.
- ★ Diagrams + Concept-based questions are frequently asked.
- ★ Assertion-Reason questions are common.

12. PYQ FOCUS AREAS

- ✓ Resonance condition & curve
- ✓ Phase relationships in circuits
- ✓ Power factor & power triangle
- ✓ Transformer ratio and efficiency
- ✓ LC oscillations and energy exchange

PYQ

MULTIPLE CHOICE QUESTIONS

1. A series LCR circuit with $R=3\ \Omega$, $X_C=4\ \Omega$, $X_L=8\ \Omega$ is connected to a 220 V, 50 Hz ac source. The power factor for the circuit is (CBSE 2026)

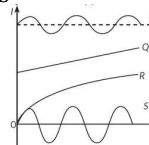
- (a) 0.30 (b) 0.45 (c) 0.50 (d) 0.60

2. The figure shows the variation of capacitive reactance (X_C) of two ideal capacitors of capacitances C_1 & C_2 with the reciprocal of angular frequency ($1/\omega$) of ac source. The value of C_1/C_2 is (CBSE 2026)

- (a) $1/2$ (b) 2 (c) $\sqrt{3}$ (d) $\frac{1}{\sqrt{3}}$

3. The figure shows variation of current (I) with time (t) in four devices P, Q, R and S. The device in which an alternating current flow is

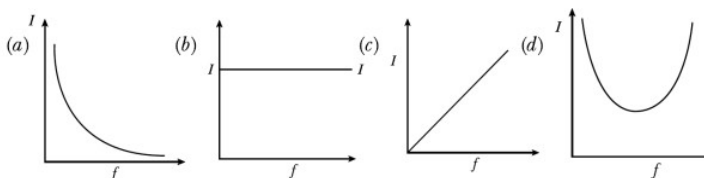
- (a) P (b) Q (c) R (d) S



4. An ac voltage $V = V_0 \sin \omega t$ is applied to a series combination of a resistor R and an element X . The instantaneous current in the circuit is $I = I_0 \sin(\omega t + \pi/4)$. Then which of the following is correct?

- (a) X is a capacitor and $X_C = \sqrt{2} R$ (b) X is an inductor and $X_L = R$
(c) X is an inductor and $X_L = \sqrt{2} R$ (d) X is a capacitor and $X_C = R$

5. Which of the following graphs on the right side represent the variation of current (I) with frequency (f) in an AC circuit containing a pure capacitor?



6. The rms and the average value of an ac voltage $V = V_0 \sin \omega t$ volt over a cycle respectively will be: (CBSE 2026)

- (a) $\frac{V_0}{2}, \frac{V_0}{\sqrt{2}}$ (b) $\frac{V_0}{\pi}, \frac{V_0}{2}$ (c) $\frac{V_0}{\sqrt{2}}, 0$ (d) $V_0, \frac{V_0}{\sqrt{2}}$

7. In a laboratory, an inductor (L), a capacitor (C), and a resistor (R) were happily connected in series with an AC source. One day, the frequency of the AC supply was gradually decreased. As the frequency dropped, the reactance of:

- (a) both L and C decreased (b) L decreased but C increased
(c) both L and C increased (d) L increased but C decreased

8. An ac circuit has a resistance of 12 ohm and an impedance of 15 ohm. The power factor of the circuit will be

- (a) 0.8 (b) 0.4 (c) 0.125 (d) 1.25

9. In an AC circuit, an inductor was connected to an alternating voltage source. Initially, it had a certain inductive reactance X_L . Suddenly, the frequency of the AC source was made 4 times its initial value. What will happen to the inductive reactance?

- (a) It becomes 2 times (b) It becomes 3 times
(c) It becomes 4 times (d) It remains unchanged

10. An alternating current in a circuit is given by $I = 20 \sin(100\pi t + 10.05\pi)$ A. The r.m.s value of current & its frequency respectively are

- (A) 10A & 100 Hz (B) 10 A & 50 Hz (C) $10\sqrt{2}$ A & 50Hz (D) $20\sqrt{2}$ A & 100Hz

11. An ac voltage is given as $v = 14 \sin (314t)$ V. The average and the effective value of the voltage (in V) over a cycle are respectively: (CBSE 2026)

- (a) 14 and 7 (b) 10 and 14 (c) 0 and 10 (d) 10 and 0

12. An LCR series circuit with a resistance of 100Ω is connected to an ac source of 200 V (r.m.s.) and angular frequency 300 rad/s. When only the capacitor is removed, the current lags behind the voltage by 60° . When only the inductor is removed the current leads the voltage by 60° . The average power dissipated is

- (a) 50 W (b) 100 W (c) 200 W (d) 400 W

13. A power transformer is used to step up an alternating e.m.f. of 220 V to 11 kV to transmit 4.4 kW of power. If the primary coil has 1000 turns, what is the current rating of the secondary? Assume 100% efficiency for the transformer

- (a) 4 A (b) 0.4 A (c) 0.04 A (d) 0.2 A

14. In an ideal transformer, the no. of turns of primary and secondary coil are 500 and 400 respectively. If 220 V is supplied to the primary coil, then ratio of currents in primary and secondary coils is

- (a) 4: 5 (b) 5: 4 (c) 5: 9 (d) 9: 5

15. To reduce the resonant frequency in an L-C-R series circuit with a generator

- (a) the generator frequency should be reduced
(b) another capacitor should be added in parallel to the first
(c) the iron core of the inductor should be removed
(d) dielectric in the capacitor should be removed

ANSWERS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
d	d	d	d	c	c	b	a	c	c	c	d	b	a	b

TAKE THE CHALLENGE

1. If an LCR circuit contains $L = 8H$, $C = 0.5 \mu F$, $R = 100 \Omega$ in series. Then the resonant angular frequency will be:

- (a) 600 rad/s (b) 500 rad/s (c) 600 Hz (d) 500 Hz

2. To reduce the resonant frequency in an LCR series circuit with a generator

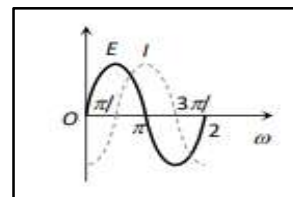
- (a) the generator frequency should be reduced.
(b) another capacitor should be added in parallel to the first.
(c) the iron core of the inductor should be removed.
(d) dielectric in the capacitor should be removed.

3. The output of a step-down transformer is measured to be 24 V when connected to a 12 watt light bulb. The value of the peak current is

- (a) $1/\sqrt{2}$ A (b) $\sqrt{2}$ A (c) 2A (d) $2\sqrt{2}$ A

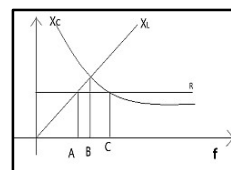
4. The variation of the instantaneous current (I) and the instantaneous emf (E) in a circuit is as shown in fig. Which of the following statements is correct?

- (a) The voltage lags behind the current by $\frac{\pi}{2}$
(b) The voltage leads the current by $\frac{\pi}{2}$
(c) The voltage and the current are in phase
(d) The voltage leads the current by π



5. The figure shows variation of R , X_L and X_C with frequency f in a series L, C, R circuit. Then for what frequency point, the circuit is inductive

- (a) A (b) B (c) C (d) All points



1-(b), 2-(b), 3-(a), 4-(b), 5-(c)

ASSERTION-REASON

In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

- (a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).
 (b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
 (c) Assertion (A) is true but reason (R) is false.
 (d) Assertion (A) is false but reason (R) is true.
 (e) Both Assertion (A) and Reason(R) are false.

1. **Assertion (A):** In a pure resistive circuit, voltage and current are in the same phase

Reason (R): In resistors, energy is alternately stored and released.

2. **Assertion (A):** In an ideal LC circuit, the current oscillates indefinitely.

Reason (R): There is no energy loss in an ideal LC circuit.

3. **Assertion (A):** In an LCR circuit at resonance, the impedance is minimum.

Reason (R): At resonance, the inductive and capacitive reactance cancel each other.

4. **Assertion (A):** The average power consumed in a pure inductive circuit is zero.

Reason (R): In a pure inductive circuit, the current leads the voltage by 90°

5. **Assertion (A):** The power factor in a purely capacitive circuit is zero.

Reason (R): In a capacitive circuit, the current leads the voltage by 90°

6. **Assertion (A):** In an AC circuit containing only a capacitor, current lags the voltage by 90°

Reason (R): Capacitors offer no resistance to AC current.

7. **Assertion (A):** The power consumed in an AC circuit is given by $P = V_{RMS} I_{RMS} \cos \phi$

Reason (R): The product $V_{RMS} I_{RMS}$ gives the apparent power.

8. **Assertion (A):** The voltage across the inductor leads the current by 90° .

Reason (R): The induced emf in the inductor opposes the change in current.

9. **Assertion (A):** The quality factor of an LCR series circuit increases with increase in resistance.

Reason (R): Higher resistance causes sharper resonance

10. **Assertion (A):** In a transformer, higher value of alternating voltage can be converted into lower voltage and vice versa

Reason (R): A transformer works on the principle of electromagnetic induction.

11. **Assertion (A):** The alternating current lags behind the emf by a phase angle of $\pi/2$, when AC flows through an inductor.

Reason (R): The inductive reactance increase as the frequency of AC source decrease.

12. **Assertion (A):** In series LCR resonance circuit, the impedance is equal to the ohmic resistance.

Reason (R): At resonance, the inductive reactance exceeds the capacitive reactance

13. **Assertion (A):** When capacitive reactance is smaller than the inductive reactance in LCR

series circuit, emf leads the current

Reason (R): The phase angle is the angle between alternating emf and alternating current of the circuit

14. **Assertion (A):** When alternating current flows through a pure inductor, the current lags behind the voltage by a phase angle of 90° ($\pi/2$).

Reason (R): The inductive reactance increases as the frequency of the AC source decreases.

15. **Assertion (A):** A transformer cannot work on DC supply.

Reason (R): Transformers work on the principle of mutual induction, which requires a changing magnetic flux.

ANSWERS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
c	a	a	c	a	e	b	b	e	b	c	c	b	c	a

TAKE THE CHALLENGE

1. **Assertion (A):** At an airport, a person is made to walk through the doorway of a metal detector.

Reason (R): Metal detector works on the principle of resonance in AC circuits.

2. **Assertion (A):** Smaller the band width, sharper the resonance and easier it is to tune an LCR circuit.

Reason (R): Resonant frequency is arithmetic mean of half power frequencies.

3. **Assertion (A):** An electric lamp is connected in series with a long solenoid of copper with air core and then connected to ac source. If an iron rod is inserted in solenoid, the lamp will become dim.

Reason (R): If an iron rod is inserted in solenoid, the inductance of solenoid increases.

4. **Assertion (A):** At frequency greater than resonant frequency, circuit is inductive in nature.

Reason (R): Reciprocal of reactance is called susceptance.

5. **Assertion (A):** Average power consumed in an ac circuit is equal to average power consumed by resistors in the circuit.

Reason (R): Average power consumed by capacitor and inductor is zero

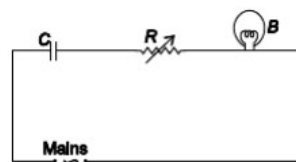
1-(b), 2-(c), 3-(a), 4-(b), 5-(a)

2 MARKS QUESTIONS

1. An inductor of $5/\pi$ H and, a capacitor of $50/\pi$ μ F and a resistor of 400Ω are connected in series across an ac voltage $v = 140 \sin(100\pi t)$ V. Calculate: (i) impedance of the circuit, and (ii) rms value of current that flows in the circuit.

2. A capacitor C, a variable resistor R and a bulb B are connected in series to the ac mains in circuit

as shown. The bulb glows with some brightness. How will the glow of the bulb change if (i) a dielectric slab is introduced between the plates of the capacitor, keeping resistance R to be the same; (ii) the resistance R is increased keeping the same capacitance?



3. An alternating voltage of frequency f is applied across a series LCR circuit. Let f_r be the resonance frequency for the circuit. Will the current in the circuit lag, lead or remain in phase with the applied voltage when (i) $f > f_r$, (ii) $f < f_r$? Explain your answer in each case.

4. Draw the graphs showing the variations of (i) inductive reactance, and (ii) capacitive reactance, with frequency of applied voltages in ac circuit. How do the values of (i) inductive, and (ii) capacitive reactance change, when the frequency of applied voltage is tripled?
5. The coil of an ac generator consists of 100 turns of wire, each of area 0.5m^2 . The resistance of the wire is $100\ \Omega$. The coil is rotating in a magnetic field of 0.8 T perpendicular to its axis of rotation, at a constant angular speed of $60\text{ radian per second}$. Calculate the maximum emf generated and power dissipated in the coil.
6. Prove that an ideal capacitor in an ac circuit does not dissipate any average power.
7. Define 'quality factor' of resonance in series LCR circuit. What is its SI unit.
8. A bulb B and an inductor are connected in series to the ac mains. The bulb glows with some brightness. How will the glow of the bulb change when a paramagnetic slab is introduced in side the inductor.
9. Mention any two characteristics properties of the material suitable of making the core of transformer.
10. Calculate the quality factor of a series LCR circuit with $L=2.0\text{ H}$, $C=2\ \mu\text{F}$ and $R=10\ \Omega$.

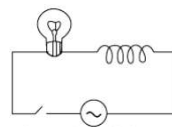
SOLUTIONS- 2 MARKS QUESTIONS

1. Using $Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$ and $I_{rms} = \frac{V_o}{Z\sqrt{2}}$, we get. $Z=500\text{ ohm}$ and $I_{rms}=0.2\text{A}$
2. If slab is inserted between the plates, capacitance will increase and X_c decrease so Z will decrease making the current in bulb more and hence, the bulb will shine brighter.
(ii) If R is increased, Z will increase making the current less and again the bulb will glow dimly.
3. As the frequency of the AC source increases, X_c decreases while X_L increases. (i) Hence for $f > f_r$ circuit turns inductive in nature and current lags behind the voltage by certain phase angle.
(ii) For $f < f_r$ circuit is capacitive in nature as $X_c > X_L$ and current leads the voltage by certain phase angle.
4. Suitable graphs as per NCERT. (i) Inductive reactance also gets tripled and ii) Capacitive reactance reduces to one third.
5. Using formula $e_o = NBA\omega$, we get $e_o = 2400\text{ V}$ and $P = \frac{e_o^2}{R} = 28.8\text{ kW}$
6. P_{avg} is proportional to $\cos\phi$ and ϕ is 90° so average power dissipated is zero.
7. Write definition, no unit and dimensions.
8. X_L increases so brightness decreases.
9. Mention any two.
10. $Q = \frac{1}{R} \sqrt{\frac{L}{C}}$ so $Q = 100$

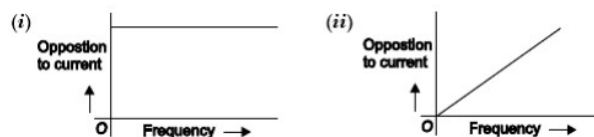
3 MARKS QUESTIONS

1. Define the terms (i) resonant frequency, and (ii) power factor of a series LCR circuit. For what value of the power factor will the power dissipated in the circuit be maximum? (CBSE 2026)
2. The number of turns in the primary and the secondary coil of an ideal transformer are 100 and 5000 respectively. If 3.3 kW power is supplied to the transformer at 220 V , find
(i) Current in the primary coil, and (ii) output voltage. (CBSE 2026)
3. (a) Can a transformer step up or step down dc power supply ?
(b) Can a step up transformer work as a step down transformer?
(c) Does a step up transformer contradict the principle of conservation of energy? Justify your answer. (CBSE 2026)

4. A light bulb and an open coil inductor are connected to an ac source through a key as shown in the figure. The switch is closed and after sometime, an iron rod is inserted into the interior of the inductor. The glow of the light bulb (a) increases; (b) decreases; (c) is unchanged, as the iron rod is inserted. Give your answer with reason. What will be your answer if ac source is replaced by a dc source?



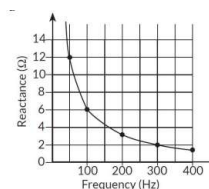
5. (a) The graphs (i) and (ii) represent the variation of the opposition offered by the circuit element to the flow of alternating current with frequency of the applied emf. Identify the circuit element corresponding to each graph.



(b) Write the expression for the impedance offered by the series combinations of the above two elements connected across the ac. Which will be ahead in phase in this circuit, voltage or current?

6. Show that the current leads the voltage in phase by $\pi/2$ in an ac circuit containing an ideal capacitor.

7. The figure shows the graphical variation of the reactance of a capacitor with frequency of ac source. (a) Find the capacitance of the capacitor. (b) An ideal inductor has the same reactance at 100 Hz frequency as the capacitor has at the same frequency. Find the value of inductance of the inductor. (c) Draw the graph showing the variation of the reactance of this inductor with frequency.



8. A resistor of $30\ \Omega$ and a capacitor of $250/\pi\ \mu\text{F}$ are connected in series to a 200 V, 50 Hz ac source. Calculate (i) the current in the circuit, and (ii) voltage drops across the resistor and the capacitor (iii) Is the algebraic sum of these voltages more than the source voltage? If yes, solve the paradox.

9. A series LCR circuit with $R = 20\ \Omega$, $L = 2\ \text{H}$ and $C = 50\ \text{F}$ is connected to a 200 volts ac source of variable frequency. What is (i) the amplitude of the current, and (ii) the average power transferred to the circuit in one complete cycle, at resonance? (iii) Calculate the potential drop across the capacitor.

10. A step-up transformer has 200 and 3000 turns in its primary and secondary coils respectively. The input voltage given to the primary coil is 90 V.

Calculate:

- (1) The output voltage across the secondary coil
- (2) The current in the primary coil if the current in the secondary coil is 2.0 A.

. SOLUTIONS- 3 MARKS QUESTIONS

1. (i) Frequency at which $X_L = X_C$, (ii) $\cos\phi = Z/R$, (iii) P is maximum when $\cos\phi = 1$.
2. Using $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$ and $P = V_p I_p$, we get $I_p = 15\ \text{A}$ and $V_s = 11000\ \text{V}$
3. (a) No, Transformers work on the principle of mutual induction because D.C. provides a constant current, there will be no change in magnetic flux.
(b) Yes, By reversing the connections, the secondary winding can be used as the primary.
(c) No, A step-up transformer changes low voltage into high voltage, and the current is reduced by the same proportion.
4. When an iron core is inserted, it gets magnetized and the magnetic field inside the coil increases. The L of the coil increases. Consequently, the X_L of the coil increases. A large fraction

of the applied ac voltage appears across the inductor and the voltage across the bulb decreases. Thus, the glow of the bulb decreases. In case of a dc source, the glow of the bulb does not change.

5. (a) In graph (i), the opposition to the flow of current does not depend upon frequency, the circuit element is a resistor. In graph (ii), the opposition increases with frequency, the current element is an inductor. (b) When the resistor R and the inductance L are connected in series across an ac source, then impedance Z of the circuit is given by $Z = \sqrt{R^2 + X_L^2}$ where X_L is an inductive reactance. In an L-R circuit, the voltage is ahead of the current.

6. Derive to obtain $I = I_o \sin(\omega t + \frac{\pi}{2})$

7. (a) $C = 265 \mu F$ (b) $L = 9.6 mH$ (c) suitable graph

8. (i) Using formula for X_c and Z, we get $I_{rms} = 4A$ (ii) $V_R = 120V$ and $V_C = 160V$ (iii) $V_R + V_C = 280V$ While V_{rms} of the source is 200 V. Yes, the voltages across the combination is more than the voltage of the source. The voltage across the resistor and capacitor are not in phase. This paradox can be resolved as when the current passes through the capacitor, it leads the voltage VC by phase $\pi/2$. So voltage of the source can be given as $V_{rms} = 200V$.

9. (i) At resonance $Z=R$ so $I=V/R$ $I_{rms}=10A$ and $I_o=I_{rms}\sqrt{2}=14.14A$

Average power transferred to the circuit in one complete cycle at resonance: $P = I_{rms}^2 R = 2000W$

$\omega_o = \frac{1}{\sqrt{LC}} = 100 \text{ rad/s}$, $X_c = 1/\omega C$, $V_c = I_{rms} X_c = 2000V$

10. (i) secondary voltage = 1350V

(ii) current in the primary coil = 30A

5 MARKS QUESTIONS

1. (a) Draw a labelled diagram of a step-up transformer. State the principle on which it works and obtain the ratio of secondary voltage to primary voltage in terms of number of turns and currents in the two coils. (CBSE 2026)

(b) The ratio of the number of turns in the primary to the secondary of an ideal transformer is 1:5. If 5 kW power at 200 V is supplied to the primary, find

(i) current in the primary, and

(ii) output voltage.

2. (a) A series combination of L, C and R is connected to an a.c. source. Using a phasor diagram, derive an expression for the impedance of the circuit and phase difference between V and I. (CBSE 2026)

(b) Under what conditions the

(i) Impedance of the circuit is minimum?

(ii) Wattless current flows in the circuit?

OR

(i) With the help of a labelled diagram, explain the principle, construction and working of an a.c. generator.

(ii) Deduce an expression for the induced emf in the coil of the generator.

(iii) If T is the time period of the rotation of the coil, at what values of T in a cycle, the emf generator is maximum?

3. (i) you are given three circuit elements X, Y and Z. They are connected one by one across a given ac source. It is found that V and I are in phase of element X. V leads I by $\frac{\pi}{2}$ for element Y where I leads V by $\frac{\pi}{2}$ for element Z. Identify elements X, Y and Z.

(ii) Establish the expression for total opposition offered to circuit when elements X, Y and Z are connected in series to an ac source. Show the variation of current in circuit with the frequency of the applied source when only Y & Z are connected in circuit.

(iii) In a series LCR circuit obtain, the conditions under which impedance is minimum, justify why circuit becomes purely resistive at resonance?

SOLUTIONS- 5 MARKS QUESTIONS

1. (a) Drawing labelled diagram of step-up transformer. Stating the principle. Obtaining the ratio of voltages in terms of number of turns and current.

(b) Using $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$ and $P = V_p I_p$, we get $I_p = 25\text{ A}$ and $V_s = 1000\text{ V}$

2. (a) Deriving expression for Impedance of series LCR circuit and Phase difference between V & I.

(b) (i) Minimum when $X_L = X_C$

(ii) When average power consumer is zero.

OR

(i) For ac generator, labelled diagram / construction. It is based on the principle of Electromagnetic Induction. Working: When coil is rotated in magnetic field, magnetic flux linked with it changes and emf is induced in the coil.

(ii) Deducing expression for induced emf $\varepsilon = NBA\omega \sin \omega t$

(iii) Emf generated is maximum at $T/4$ and $3T/4$

3. (i) X-resistor Y-inductor Z-Capacitor

(ii) Deduce expression for Z. Graph for LC combination circuit.

(iii) Condition of resonance, $X_C = X_L$ so $Z = R$

CASE BASED QUESTIONS

1. Capacitor used in old radio sets is gang capacitor. It consists of two sets of parallel circular plates one of which can rotate manually by means of a knob. The rotation causes overlapping areas of plates to change, thus changing its capacitance. Air gap between plates acts as dielectric. The capacitor has to be tuned in to the corresponding frequency of a station so that the LC combination of the radio set resonates at the frequency of the desired station. When capacitive reactance (X_C) is equal to the inductive reactance (X_L), then the resonance occurs and the

resonant frequency is given by $\omega_0 = \sqrt{\frac{1}{LC}}$. Current amplitude becomes maximum at the resonant frequency. It is important to note that resonance phenomena is exhibited by a circuit only if, both L and C are present in the circuit. Only then, the voltage across L and C cancel each other (both being out of phase) and the current amplitude is max., where $I_m = V_m / R$. This means that we cannot have resonance in a RL or RC circuit.

(i) Name the phenomena involved in tuning a radio set to a particular station

(a) Stabilization (b) Resonance (c) Rectification (d) Reflection

(ii) Capacitor used in radio set for tuning is a

(a) Parallel plate capacitor (b) Spherical capacitor (c) gang capacitor (d) electrolytic capacitor.

(iii) Resonance occurs only when:

(a) $X_C = R$ (b) $X_L = R$ (c) $X_C > X_L$ (d) $X_L = X_C$

(iv) Resonance may occur in

(a) LC circuit (b) RC circuit (c) LR circuit (d) resistor only circuit

2. A transformer is an electrical device which is used for changing a.c. voltages. It is based on the phenomenon of mutual induction. It can be shown that $\frac{E_s}{E_p} = \frac{I_p}{I_s} = \frac{n_s}{n_p} = K$, where symbols have their standard meaning. For a step up transformer, $K > 1$ and for a step down transformer, $K < 1$. The numbers of turns in the primary and secondary coils of a transformer are 2000 and 50 respectively. The primary coil is connected to main of 120 V and secondary to a night bulb of 0.6 ohm. The efficiency of transformer is 80 %.

(i) A transformer is used:

- (a) to transform electric energy into mechanical energy. (b) to obtain suitable DC voltage
(c) to transform AC into DC (d) to obtain suitable AC voltage.

(ii) Which quantity is increased in step-down transformer?

- (a) Resistance (b) power (c) current (d) charge

(iii) In step-up transformer, relation between number of turns in primary (N_p) and number of turns in secondary (N_s) is

- (a) $N_s > N_p$ (b) $N_p > N_s$ (c) $N_s = N_p$ (d) $N_p = 2 N_s$

(iv) Voltage across the secondary of transformer is

- (a) 120 V (b) 360 V (c) 40 V (d) 3 V

3. Series LCR circuits at resonance admit maximum current at particular frequencies. Therefore, it is called acceptor circuit because at resonance, impedance of LCR circuit is minimum and it easily accepts that current out of the many currents whose frequency is equal to the resonant frequency. This circuit is used in radio and TV receivers to tune the desired frequency or filtered unwanted frequencies. The amplitude of the current with the frequency of the signal from the desired station becomes maximum and hence it is received by the radio or TV receiver. The maximum current flows through for that a.c. voltage which has frequency equal to $f_r = \frac{1}{2\pi\sqrt{LC}}$. If Q-value of circuit is large the signals of the other stations will be very weak. Quality factor determines the clarity of reception.

(i) The current admitted by series LCR circuit corresponding to resonant frequency is

- (a) maximum (b) minimum (c) zero (d) 10A

(ii) In a series LCR circuit $L=8H$, $C=0.5\mu F$ and $R=100\Omega$. The resonant frequency of the circuit is:

- (a) $1000 / \pi$ Hz (b) $500 / \pi$ Hz (c) $250 / \pi$ Hz (d) $125 / \pi$ Hz

(iii) At resonance, in a series LCR circuit, which relation does not hold?

- (a) $\omega = \frac{1}{LC}$ (b) $\omega = \frac{1}{\sqrt{LC}}$ (c) $L\omega = \frac{1}{\omega_c}$ (d) $C\omega = \frac{1}{L\omega}$

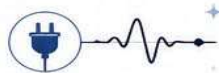
(iv) Nita switched on the radio set to listen to her favourite music but found the reception was not clear. Also there was overlapping of signals. So she adjusted the tuner. Name the phenomenon involved here

- (a) reception (b) bandwidth (c) resonance (d) filtration

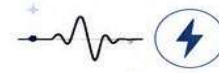
1 i-b, ii-c, iii-d, iv-a

2 i-d ii-d iii-d iv-a

3 i-d ii-a iii-b iv-c



ALTERNATING CURRENT



CLASS 12 PHYSICS – FORMULA SHEET

CBSE SYLLABUS

NEP 2020 ALIGNED

QUICK REVISION

EXAM READY

1 ALTERNATING CURRENT & VOLTAGE ★ MOST IMPORTANT

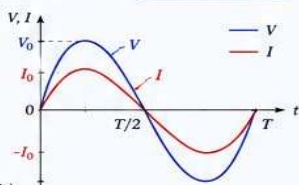
Instantaneous Values

$$v = V_0 \sin(\omega t)$$

$$i = I_0 \sin(\omega t)$$

V_0, I_0 = Peak (maximum) values

$\omega = 2\pi f$ (rad s⁻¹), f = frequency (Hz)



QUICK RECALL

- AC reverses direction periodically.
- Average value of sinusoidal AC over a complete cycle = 0
- RMS value is the equivalent DC value producing same power in a resistor.

2 RMS VALUE & PEAK VALUE

RMS (Effective) Values

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

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



TRICK

$$RMS = \frac{Peak}{\sqrt{2}}$$

$$Peak = RMS \times \sqrt{2}$$

Key Point

In AC circuits, V_{rms}, I_{rms} are used for power calculations.

3 REACTANCE

Inductive Reactance



$$X_L = \omega L$$

$$= 2\pi fL$$

Unit: ohm (Ω)

Capacitive Reactance



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

$$= \frac{1}{2\pi fC}$$

Unit: ohm (Ω)

Note: X_L increases with f . X_C decreases with f

4 IMPEDANCE & PHASE RELATION

Impedance (Z)

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

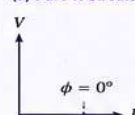
Phase Angle (ϕ)

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

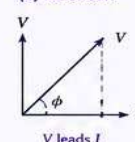
Z is always positive. Unit: ohm (Ω)

5 PHASOR DIAGRAMS (KEY CASES)

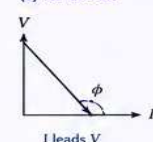
(a) Pure R Circuit



(b) RL Circuit

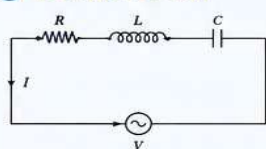


(c) RC Circuit



Note: For LCR circuit, phase angle ϕ can be leading or lagging depending on X_L and X_C .

6 LCR SERIES CIRCUIT



$$I_0 = \frac{V_0}{Z}$$

$$I_{rms} = \frac{V_{rms}}{Z}$$

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

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

Phase: Current lags voltage by ϕ if $X_L > X_C$ (inductive)
Current leads voltage by ϕ if $X_C > X_L$ (capacitive)

7 RESONANCE (LCR CIRCUIT)

At Resonance:

- $X_L = X_C$
- $\phi = 0$ (I and V in phase)
- $Z = R$ (minimum)
- Current is maximum
- Power factor = 1

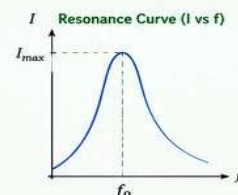
Resonant Angular Frequency

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

Resonant Frequency

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Helpful to select a particular frequency.



8 POWER IN AC CIRCUIT

Average Power (Real Power)

$$P_{avg} = V_{rms} I_{rms} \cos \phi$$

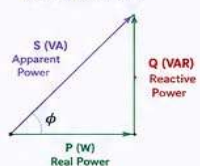
or

$$P_{avg} = \frac{V_0 I_0}{2} \cos \phi$$

Power Factor

$$\cos \phi = \frac{R}{Z}$$

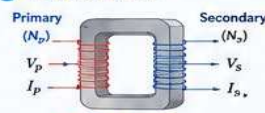
POWER TRIANGLE



$$S^2 = P^2 + Q^2$$

$$\tan \phi = \frac{Q}{P}$$

9 TRANSFORMER



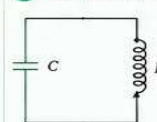
Ideal Transformer

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad \frac{I_p}{I_s} = \frac{N_s}{N_p}$$

Efficiency

$$\eta = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

10 LC OSCILLATIONS



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

$$T = 2\pi\sqrt{LC}$$

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

Key Point

Energy oscillates between electric field of C and magnetic field of L. Total energy remains constant.

11 X_L vs X_C vs Z

Quantity	Formula	Depends on	Nature
X_L	$2\pi fL$	f, L	Inductive (increases with f)
X_C	$\frac{1}{2\pi fC}$	f, C	Capacitive (decreases with f)
Z	$\sqrt{R^2 + (X_L - X_C)^2}$	R, X_L, X_C	Combination (always +ve)

12 IMPORTANT CONDITIONS

- ✓ Resonance: $X_L = X_C$ or $\omega_0 = \frac{1}{\sqrt{LC}}$
- ✓ Power factor unity: $\phi = 0$ (at resonance)
- ✓ Net inductive: $X_L > X_C$ (current lags)
- ✓ Net capacitive: $X_C > X_L$ (current leads)

13 DIFFERENCE

Feature	Resistance (R)	Reactance (X)	Impedance (Z)
Definition	Opposition in pure resistor	Opposition due to L or C	Total opposition in AC circuit
Depends on	Does not depend on f	Depends on f	Depends on R, L, C and f
Power	Consumes power	Does not consume power	Consumes power
Unit	Ohm (Ω)	Ohm (Ω)	Ohm (Ω)

14 MEMORY TRICKS



"ELI the ICE man"

ELI $\rightarrow X_L$ (Inductor)
ICE $\rightarrow X_C$ (Capacitor)
 X_L increases,
 X_C decreases with f



"The Z Rule"

Impedance Z is the resultant of R and $(X_L - X_C)$



"Power Formula"

Use $P = V_{rms} I_{rms} \cos \phi$
Remember:
 $\cos \phi$ = Power Factor

15 COMMON MISTAKES

- ✗ Using peak values in power formula.
- ✗ Forgetting unit of reactance (ohm).
- ✗ Using X_L instead of X_C or vice versa.
- ✗ Ignoring phase angle ϕ in calculations.
- ✗ Incorrect transformer turn ratio.

16 PYQ TIPS

Questions often come from:

- Resonance condition & ω_0
- Power factor & power formula
- Transformer ratios
- Phasor diagrams (RL, RC, LCR)



Practice NCERT & PYQs!

KEEP CALM
STAY FOCUSED
CRACK THE EXAM!

17 SYMBOLS, UNITS & CONSTANTS

V, I : Voltage (V), Current (A)
 V_{rms}, I_{rms} : Peak values
 f : RMS values

R : Resistance (Ω)
 X_L : Inductive Reactance (Ω)
 X_C : Capacitive Reactance (Ω)
 Z : Impedance (Ω)

L : Inductance (H)
 C : Capacitance (F)
 N : Number of turns
 ϕ : Phase angle (rad or $^\circ$)

$\pi = 3.1416$
 $\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$

$1 \text{ H} = 1 \text{ Wb A}^{-1}$
 $1 \text{ F} = 1 \text{ C V}^{-1}$