ALTERNATING CURRENT

IMPORTANT FORMULAE

1. **For an alternating current circuit**

$$V = V_0 \sin \omega t; \; I = I_0 \sin (\omega t + \phi)$$

2. **RMS value of an alternating current**

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

3. **Impedance of series LCR circuit**

$$Z = \frac{V_{rms}}{I_{rms}} = \sqrt{R^2 + (X_C - X_L)^2} = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$$

4. **Phase angle between I and V,**

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

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

5. **Resonance: (If $X_C = X_L$ and $Z = R$), then**

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

6. **Q-Factor:**

$$Q\text{ - Factor} = \frac{\omega_r}{\omega_2 - \omega_1} = \frac{\omega_r L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

7. **Average power dissipated in LCR-circuit,**

$$P_{av} = V_{rms} I_{rms} \cos \theta = \frac{1}{2} V_0 I_0 \cos \theta$$

8. **Peak emf in a rotating coil of generator**

$$E_0 = NBA\omega$$

9. **For LC oscillations**

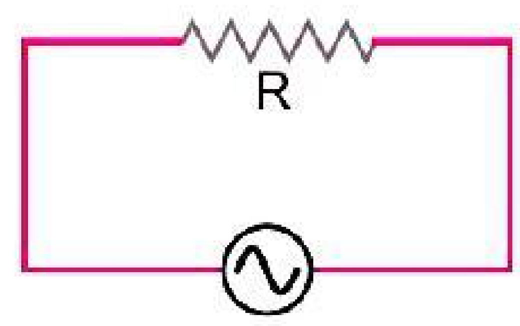
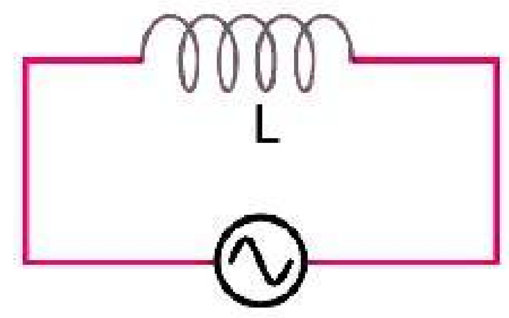
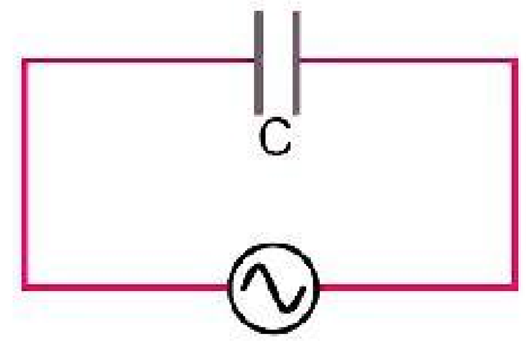
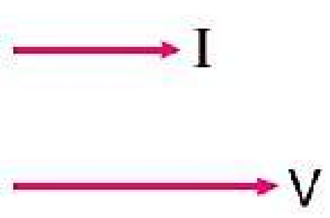
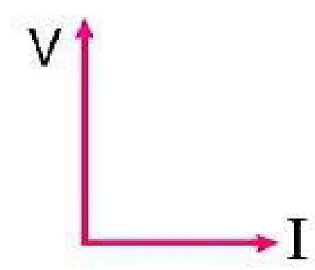
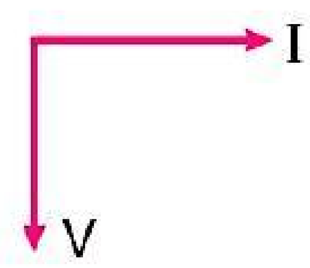
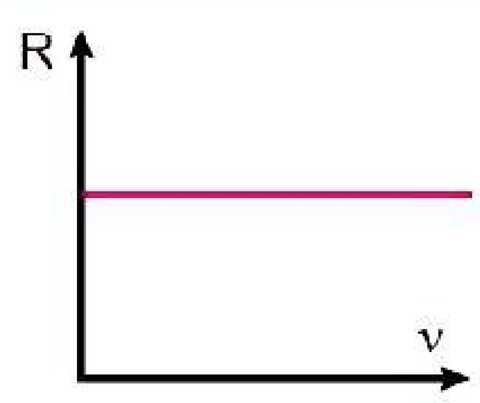
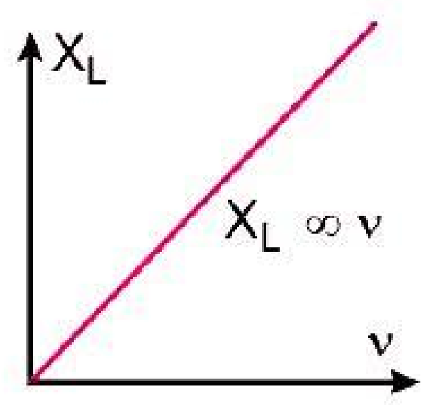
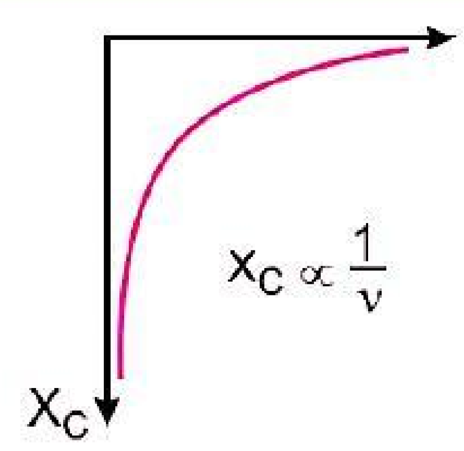
$$W_r = \frac{1}{\sqrt{LC}} \text{ and } f_r = \frac{1}{2\pi\sqrt{LC}}$$

10. **For a Transformer** $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s} = r$ (transformation ratio)

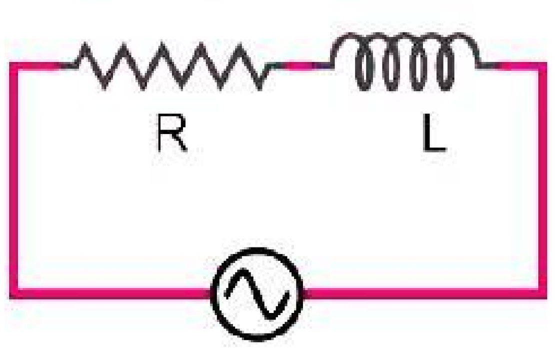
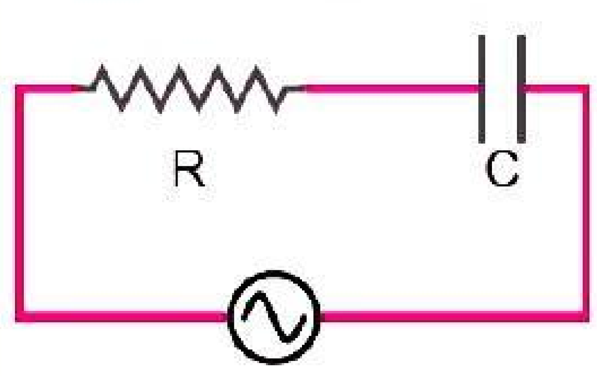
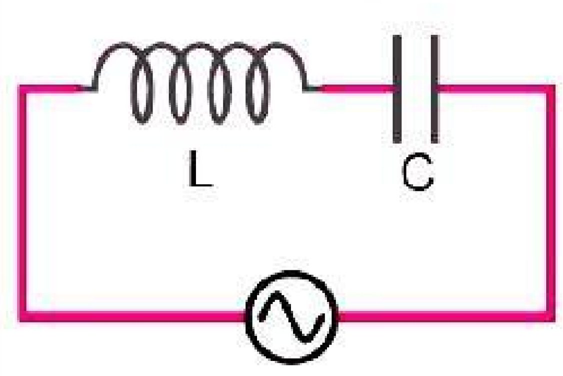
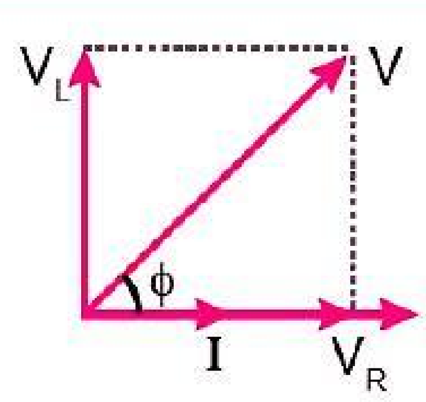
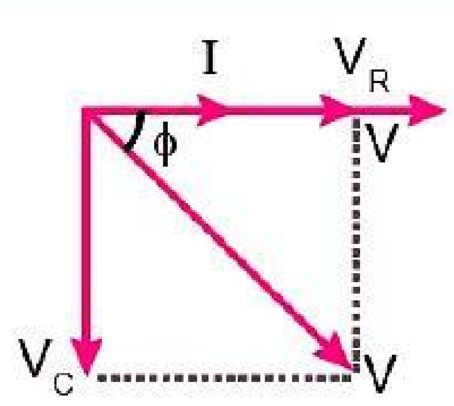
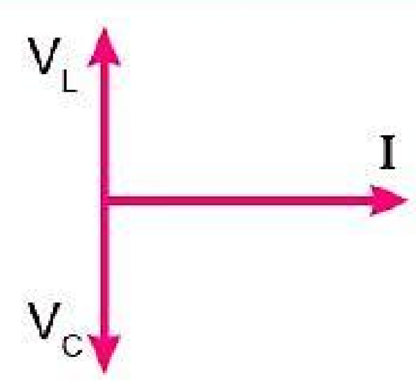
For a step up transformer $r = \frac{N_s}{N_p} > 1$

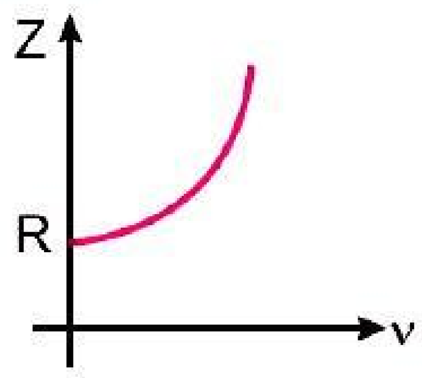
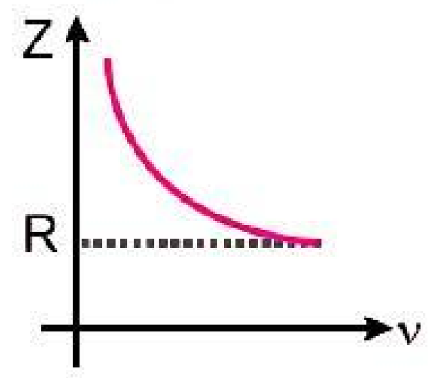
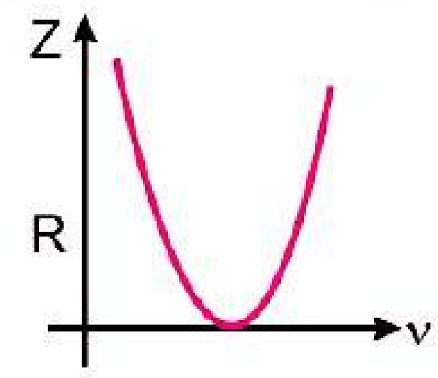
For a step down transformer, $r = \frac{N_s}{N_p} < 1$

Individual Components (R or L or C)

TERM	R	L	C
Circuit			
Supply Voltage	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$
Current	$I = I_0 \sin \omega t$	$I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$	$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$
Peak Current	$I_0 = \frac{V_0}{R}$	$I_0 = \frac{V_0}{\omega L}$	$I_0 = \frac{V_0}{1/\omega C} = V_0 \omega C$
Impedance (Ω) $Z = \frac{V_0}{I_0} = \frac{V_{rms}}{I_{rms}}$	$\frac{V_0}{I_0} = R$ R = Resistance	$\frac{V_0}{I_0} = \omega L = X_L$ X_L = Inductive reactance	$\frac{V_0}{I_0} = \frac{1}{\omega C} = X_c$ X_C = Capacitive reactance
Phase difference	zero (in same phase)	$+\frac{\pi}{2}$ (V leads I)	$-\frac{\pi}{2}$ (V leads I)
Phasor Diagram			
Variation of Z with ν	 R does not depend on ν		

Combination of Components (RL or RC or LC)

TERM	RL	RC	LC
Circuit	I is same in R & L 	I is same in R & C 	I is same in L & C 
Phasor diagram	 $V^2 = V_R^2 + V_L^2$	 $V^2 = V_R^2 + V_C^2$	 $V = V_L - V_C \ (V_L > V_C)$ $V = V_C - V_L \ (V_C > V_L)$
Supply Voltage	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$	$V = V_0 \sin \omega t$

Current	$I = I_0 \sin(\omega t - \phi)$	$I = I_0 \sin(\omega t + \phi)$	$I = I_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$
Phase difference in between V and I	V leads I $\left(\phi = 0 \text{ to } \frac{\pi}{2}\right)$	V lags I $\left(\phi = 0 \text{ to } \frac{\pi}{2}\right)$	V lags I $\left(\phi = -\frac{\pi}{2}, \text{ if } X_C > X_L\right)$ V leads I $\left(\phi = +\frac{\pi}{2}, \text{ if } X_L > X_C\right)$
Impedance	$Z = \sqrt{R^2 + X_L^2}$	$Z = \sqrt{R^2 + (X_C)^2}$	$Z = \lvert X_L - X_C \rvert$
Variation of Z with ν	As ν increases, Z increases 	As ν increases, Z decreases 	As ν increases, Z first decreases then increases 

MULTIPLE CHOICE QUESTIONS

Choose and write the correct option in the following questions.

1. **If the *rms* current in a 50 Hz *ac* circuit is 5 A, the value of the current 1/300 seconds after its value becomes zero is** *[NCERT Examplar]*

   (*a*) $5\sqrt{2}$ A (*b*) $5\sqrt{\frac{3}{2}}$ A (*c*) 5/6 A (*d*) $5/\sqrt{2}$ A

2. **An alternating current generator has an internal resistance R_g and an internal reactance X_g. It is used to supply power to a passive load consisting of a resistance R_g and a reactance X_L. For maximum power to be delivered from the generator to the load, the value of X_L is equal to** *[NCERT Examplar]*

   (*a*) zero (*b*) X_g (*c*) $-X_g$ (*d*) R_g

3. **In an ac circuit, the maximum value of voltage is 423 volts. Its effective voltage is**

   (*a*) 400 volt (*b*) 300 volt (*c*) 323 volt (*d*) 340 volt

4. **The peak voltage of 220 V *ac* mains is**

   (*a*) 155.6 V (*b*) 220.0 V (*c*) 311 V (*d*) 440 V

5. **An inductive circuit have zero resistance. When *ac* voltage is applied across this circuit, then the current lags behind the applied voltage by an angle**

   (*a*) 30° (*b*) 45° (*c*) 90° (*d*) 0°

6. **If an *LCR* circuit contains L = 8 henry; C = 0.5 μF, R = 100 Ω in series. Then the resonant angular frequency will be:**

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

7. **When a voltage measuring device is connected to *ac* mains, the meter shows the steady input voltage of 220 V. This means** *[NCERT Examplar]*

   (*a*) input voltage cannot be *ac* voltage, but a *dc* voltage.

   (*b*) maximum input voltage is 220 V.

   (*c*) the meter reads not V but $<V^2>$ and is calibrated to read $\sqrt{<V^2>}$.

   (*d*) the pointer of the meter is stuck by some mechanical defect.

8. To reduce the resonant frequency in an *LCR* series circuit with a generator [*NCERT Examplar*]

(*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.

9. In a pure capacitive circuit, the current

(*a*) lags behind the applied emf by angle $\pi/2$ (*b*) leads the applied emf by an angle π

(*c*) leads the applied emf by angle $\pi/2$ (*d*) and applied emf are in same phase

10. In an *ac* circuit, the emf (ε) and the current (i) at any instant are given by

$$\varepsilon = E_0 \sin \omega t, \; i = I_0 \sin(\omega t - \phi)$$

Then average power transferred to the circuit in one complete cycle of *ac* is

(*a*) $E_0 I_0$ (*b*) $\frac{1}{2}E_0 I_0$ (*c*) $\frac{1}{2}E_0 I_0 \sin\phi$ (*d*) $\frac{1}{2}E_0 I_0 \cos\phi$

11. The average power dissipation in pure inductance is

(*a*) $\frac{1}{2}LI^2$ (*b*) $\frac{1}{4}LI^2$ (*c*) $2LI^2$ (*d*) zero

12. Electrical energy is transmitted over large distances at high alternating voltages. Which of the following statements is (are) correct? [*NCERT Examplar*]

(*a*) For a given power level, there is a lower current.

(*b*) Lower current implies less power loss.

(*c*) It is easy to reduce the voltage at the receiving end using step-down transformers.

(*d*) All of these

13. The reactance of a capacitance at 50 Hz is 5 Ω. If the frequency is increased to 100 Hz, the new reactance is

(*a*) 5 Ω (*b*) 10 Ω (*c*) 2.5 Ω (*d*) 125 Ω

14. In a pure inductive circuit, the current

(*a*) lags behind the applied emf by an angle π (*b*) lags behind the applied emf by an angle $\pi/2$

(*c*) leads the applied emf by an angle $\pi/2$ (*d*) and applied emf are in same phase

15. When an *ac* voltage of 220 V is applied to the capacitor C [*NCERT Examplar*]

(*a*) the maximum voltage between plates is 220 V.

(*b*) power delivered to the capacitor is zero.

(*c*) the charge on the plates is in phase with the applied voltage.

(*d*) both (*b*) and (*c*)

16. Which of the following combinations should be selected for better tuning of an *LCR* circuit used for communication? [*NCERT Examplar*]

(*a*) $R = 20\ \Omega, L = 1.5\ \text{H}, C = 35\ \mu\text{F}$ (*b*) $R = 25\ \Omega, L = 2.5\ \text{H}, C = 45\ \mu\text{F}$

(*c*) $R = 15\ \Omega, L = 3.5\ \text{H}, C = 30\ \mu\text{F}$ (*d*) $R = 25\ \Omega, L = 1.5\ \text{H}, C = 45\ \mu\text{F}$

17. An inductor of reactance 1 Ω and a resistor of 2 Ω are connected in series to the terminals of a 6 V (rms) *ac* source. The power dissipated in the circuit is [*NCERT Examplar*]

(*a*) 8 W (*b*) 12 W (*c*) 14.4 W (*d*) 18 W

18. 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 [*NCERT Examplar*]

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

19. In a series LR-circuit, the inductive reactance is equal to the resistance *R* of the circuit. An emf $E = E_0 \cos(\omega t)$ is applied to the circuit. The power consumed in the circuit is

(*a*) $\frac{E_0^2}{4R}$ (*b*) $\frac{E_0^2}{8R}$ (*c*) $\frac{E_0^2}{R}$ (*d*) $\frac{E_0^2}{2R}$

20. One 60 V, 100 W bulb is to be connected to 100 V, 50 Hz *ac* source. The potential drop across the inductor is

(*a*) 10 V (*b*) 40 V (*c*) 20 V (*d*) 80 V

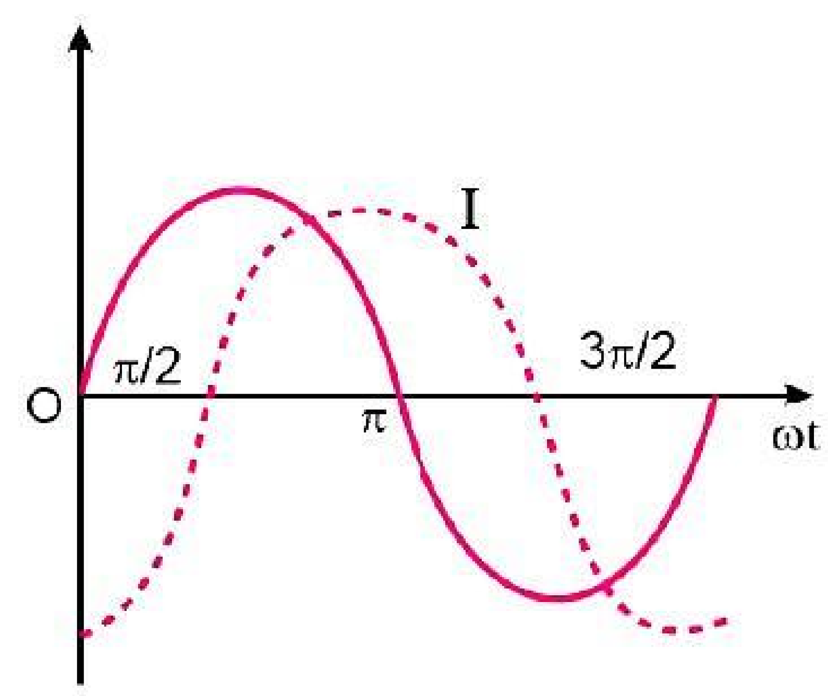
21. An *ac* voltage source of variable angular frequency ω and fixed amplitude *a* is connected in series with a capacitance *C* and an electric bulb of resistance *R* (inductance zero). When ω is increased

(*a*) the bulb glows dimmer (*b*) the bulb glows brighter
(*c*) net impedance of circuit is unchanged (*d*) total impedance of the circuit increases

22. An alternating emf of angular frequency ω is applied across an inductor. The instantaneous power developed across it has an angular frequency

(*a*) ω (*b*) ω/2 (*c*) ω/4 (*d*) 2 ω

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



(*a*) The voltage lags behind the current by $\pi/2$. (*b*) The voltage leads the current by $\pi/2$.
(*c*) The voltage and the current are in phase. (*d*) The voltage leads the current by π.

24. In electric arc furnace, Copper or iron is melted due to variation of

(*a*) current (*b*) magnetic field (*c*) voltage (*d*) electric field

25. When *ac* source is connected across series R-C combination, the *ac* current may lead *ac* voltage by

(*a*) 0° (*b*) 180° (*c*) 30° (*d*) 90°

26. High voltage transmission line is preferred as

(*a*) its appliances are less costly (*b*) thin power cables are required
(*c*) idle current very low (*d*) power loss is very less

27. In series R-L-C circuit, quality factor can be improved by

(*a*) decreasing *L* (*b*) increasing *C* (*c*) decreasing *R* (*d*) decreasing *R* & *L*

28. When *ac* source is connected across series R-L-C combination, maximum power loss will occur provided

(*a*) current and voltage are in phase (*b*) current from source is minimum
(*c*) inductance is minimum (*d*) capacitance is maximum

29. In R-L-C series *ac* circuit, impedance cannot be increased by

(*a*) increasing frequency of source (*b*) decreasing frequency of source
(*c*) increasing the resistance (*d*) increasing the voltage of the source

30. In highly inductive load circuit, it is more dangerous when

(*a*) we close the switch (*b*) we open the switch
(*c*) increasing the resistance (*d*) decreasing the resistance

31. In electric sub-station in township, large capacitor banks are used

(*a*) to reduce power factor (*b*) to improve power factor
(*c*) to decrease current (*d*) to increase current in the circuit

32. In a purely resistive *ac* circuit, the current

(*a*) is in phase with the emf
(*b*) leads the emf by a phase difference of π radians
(*c*) leads the emf by a phase difference of π /2 radians
(*d*) lags behind the emf by phase difference of π /4 radians

33. A capacitor of capacitance *C* has reactance X_C. If capacitance and frequency become double, then the capacitive reactance will be

(*a*) $2X_C$ (*b*) $4X_C$ (*c*) $\frac{X_C}{4}$ (*d*) $\frac{X_C}{2}$

34. The core of a transformer is laminated, so as to

(*a*) make it light weight (*b*) make it robust and strong
(*c*) increase the secondary voltage (*d*) reduce energy loss due to eddy current

35. The ratio of number of turns of primary coil to secondary coil in a transformer is 2:3. If a cell of 6 V is connected across the primary coil, then voltage across the secondary coil will be

(*a*) 3 V (*b*) 6 V (*c*) 9 V (*d*) 12 V

36. In a transformer, the number 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*) 5 : 9 (*b*) 5 : 4 (*c*) 9 : 5 (*d*) 4 : 5

37. An LC-circuit contains 10 mH inductor and 25 mF capacitor with given initial charge. The resistance of the circuit is negligible. At what time the energy stored in circuit is completely magnetic? (Time is measured from the instant when the circuit is close)

(*a*) $\frac{T}{4}, \frac{3T}{4}, \frac{5T}{4} \ldots$ (*b*) $0, \frac{T}{2}, \frac{2T}{2} \ldots$ (*c*) $\frac{T}{3}, \frac{2T}{3}, \frac{5T}{3} \ldots$ (*d*) $0, \frac{T}{8}, \frac{T}{4} \ldots$

38. In an *ac* circuit the voltage and current are given by the following expressions $V = V_0 \sin \omega t$ and $I = I_0 \cos \omega t$, where the symbols have their usual meaning. Which of the following statement is correct?

(*a*) Voltage lead the current by a phase angle of $\pi/2$.
(*b*) Voltage lags behind the current by phase angle of π.
(*c*) Voltage and current are in phase.
(*d*) Voltage lags behind the current by phase angle of $\pi/2$.

39. The peak value of an *ac* of 2 A in a circuit

(*a*) $\sqrt{2}$ A (*b*) 2 A (*c*) $2\sqrt{3}$ A (*d*) $2\sqrt{2}$ A

40. In an *ac* circuit, current is given by the relation $I = 100\sqrt{2} \cos 50t$ A. The rms value of the current is

(*a*) 50 A (*b*) 200 A (*c*) 100 A (*d*) $100\sqrt{2}$ A

41. In an *ac* circuit containing resistance only, *E* and *I* are given by $E = 200 \sin (200)t$ volt and $I = 100 \sin (200)t$ mA. The power dissipated in the circuit is

(*a*) 10 watt (*b*) 200 watt (*c*) 100 watt (*d*) 400 watt

42. In case of an *ac* circuit containing pure inductance, the phase difference between *E* and *I* is

(*a*) $\frac{\pi}{4}$ (*b*) zero (*c*) π (*d*) $\frac{\pi}{2}$

43. A transformer has 20 turns of primary and 100 turns of secondary. If the two ends of the primary are connected to a 220 V *dc* supply, the voltage across the secondary will be

(*a*) zero (*b*) 1100 V (*c*) 220 V (*d*) 11 V

44. An *ac* source is connected in series to an inductance L and a capacitance C, such that the frequency of the *ac* source is

(*a*) $L^{-1}C^{-1}$ (*b*) $L^{-1/2}C^{-1/2}$ (*c*) $\left(\frac{1}{2\pi}\right)L^{-1}C^{-1}$ (*d*) $\left(\frac{1}{2\pi}\right)L^{-1/2}C^{-1/2}$

45. An ac source is of $\frac{200}{\sqrt{2}}$ V, 50 Hz. The value of voltage after $\frac{1}{600}$ s from the start is

(*a*) 200 V (*b*) $\frac{200}{\sqrt{2}}$V (*c*) 100 V (*d*) 50 V

46. In an *ac* series circuit, the instantaneous current is maximum when the instantaneous voltage is maximum. The circuit element connected to the source will be

(*a*) pure inductor (*b*) pure capacitor
(*c*) pure resistor (*d*) combination of a capacitor and an inductor

47. R, L and C represent the physical quantities resistance, inductance and capacitance respectively. Which one of the following combinations has dimension of frequency?

(*a*) $\frac{1}{\sqrt{RC}}$ (*b*) $\frac{R}{L}$ (*c*) $\frac{1}{LC}$ (*d*) $\frac{C}{L}$

48. Which of the following effects is not possible by *ac*?

(*a*) Heating effect (*b*) Chemical effect
(*c*) Magnetic effect (*d*) None of the above

49. A pure capacitor in an *ac* circuit

(*a*) stores energy in its electrostatic field (*b*) stores energy in its magnetic field
(*c*) does not store energy (*d*) dissipates energy

50. In an *ac* circuit the phase difference between current and emf is 45°. The circuit contains

(*a*) a pure inductance
(*b*) a pure resistance
(*c*) a pure capacitance
(*d*) a resistance, an inductance and a capacitance in series.

51. The metal/alloy that is more suitable for making cores of transformers is

(*a*) steel (*b*) soft iron (*c*) copper (*d*) brass

52. An electric bulb 220 V, is connected to 220 V, 50 Hz *ac* source. Then the bulb

(*a*) does not glow (*b*) glows intermittently
(*c*) glows continuously (*d*) fuses

53. The average power dissipation in a pure capacitor is:

(*a*) $\frac{1}{2}CV^2$ (*b*) CV^2 (*c*) $\frac{1}{4}CV^2$ (*d*) zero

54. The frequency of *ac* is 50 Hz. How many times the current becomes zero in one second?

(*a*) 50 times (*b*) 100 times (*c*) 200 times (*d*) 25 times

55. In a circuit current I is given by $I = I_0 \sin(\omega t - \pi/2)$ when *ac* potential of $E = E_0 \sin \omega t$ has been applied. Then the power consumption P in the circuit would be:

(*a*) $\frac{E_0 I_0}{\sqrt{2}}$ (*b*) $\frac{E_0 I_0}{2}$ (*c*) $\frac{EI}{\sqrt{2}}$ (*d*) zero

56. The potential difference V and current i flowing through an inductor in an *ac* circuit are given by $V = 5 \cos \omega t$ volt, $i = 2 \sin \omega t$ ampere, the power dissipated in the inductor is:

(*a*) 0 W (*b*) 10 W (*c*) 5 W (*d*) 2.5 W

57. Electric power is transmitted over long distance through conducting wires of high voltages because

(*a*) it reduces the possibility of theft of wire
(*b*) this entails less power losses
(*c*) *ac* generators produce electric power at very high voltages
(*d*) *ac* signal of high voltage travels faster.

58. A choke coil is a coil having

(*a*) low inductance and high resistance

(*b*) low inductance and low resistance

(*c*) high inductance and high resistance

(*d*) high inductance and negligible or small resistance

59. The voltage measured across the *ac* mains terminals is 210 V. Then the peak to peak variation of voltage between the terminals will be:

(*a*) 420 V (*b*) $420/\sqrt{2}$ V (*c*) $420\sqrt{2}$ V (*d*) $210\sqrt{2}$ V

60. An *ac* voltage source $E = 200\sqrt{2}$ sin 100 *t* is connected across a circuit containing an *ac* ammeter and a capacitor of capacitance 1μF. The reading of ammeter is

(*a*) 10 mA (*b*) 20 mA (*c*) 40 mA (*d*) 80 mA

61. An alternating current circuit consists of an inductor and a resistor in series. In this circuit

(*a*) The potential difference across and current in resistor leads the potential difference across inductor.

(*b*) The potential difference across and current in resistor lags behind the potential difference across inductor by an angle $\pi/2$.

(*c*) The potential difference across and current in resistor lags behind the potential difference across inductor by an angle π

(*d*) The potential difference across resistor lags behind the potential difference across inductor by an angle $\pi/2$, while the current in resistor leads the potential difference across inductor by an angle $\pi/2$.

62. The core used in transformers and other electromagnetic devices are laminated

(*a*) to increase the magnetic field

(*b*) to increase the level of magnetic saturation of the core

(*c*) to reduce the magnetism in the core

(*d*) to reduce eddy current losses in the core

63. An alternating voltage of frequency ω is induced in electric circuit consisting of an inductance *L* and capacitance *C*, connected in series. Then across the inductance coil

(*a*) current is maximum when $\omega^2 = 1/LC$ (*b*) current is minimum when $\omega^2 = 1/LC$

(*c*) voltage is minimum when $\omega^2 = 1/LC$ (*d*) voltage is zero when $\omega^2 = 1/LC$

64. An alternating voltage is connected in series with a resistance *R* and an inductance *L*. If the potential drop across the resistance is 200 volts and across the inductance is 150 volt, the applied voltage is:

(*a*) 250 V (*b*) 300 V (*c*) 350 V (*d*) 500 V

65. An inductive circuit contains a resistance of 10 ohm and an inductance of 2·0 henry. If an *ac* voltage of 120 volt and frequency 60 Hz is applied to this circuit, the current in the circuit would be nearly

(*a*) 0·32 A (*b*) 0·16 A (*c*) 0·48 A (*d*) 0·80 A

66. When 100 volt *dc* is applied across a solenoid, a current of 1.0 A flows in it. When 100 volt *ac* is applied across the same coil, the current drops to 0.5 A If the frequency of *ac* source is 50 Hz, the impedance and inductance of solenoid are:

(*a*) 200 Ω and 0·55 henry (*b*) 100 Ω and 0·86 henry

(*c*) 200 Ω and 1·0 henry (*d*) 100 Ω and 0·93 henry

67. An electric fan is:

(*a*) electric motor (*b*) electric generator

(*c*) an accelerator (*d*) based on electromagnetic induction

68. A transformer is used to

(*a*) convert *ac* into *dc* (*b*) convert *dc* into *ac*

(*c*) to step up or down *dc* voltage (*d*) to step up or down *ac* voltage

69. **The power dissipated in an LCR series circuit connected to an ac source of emf ε is :**

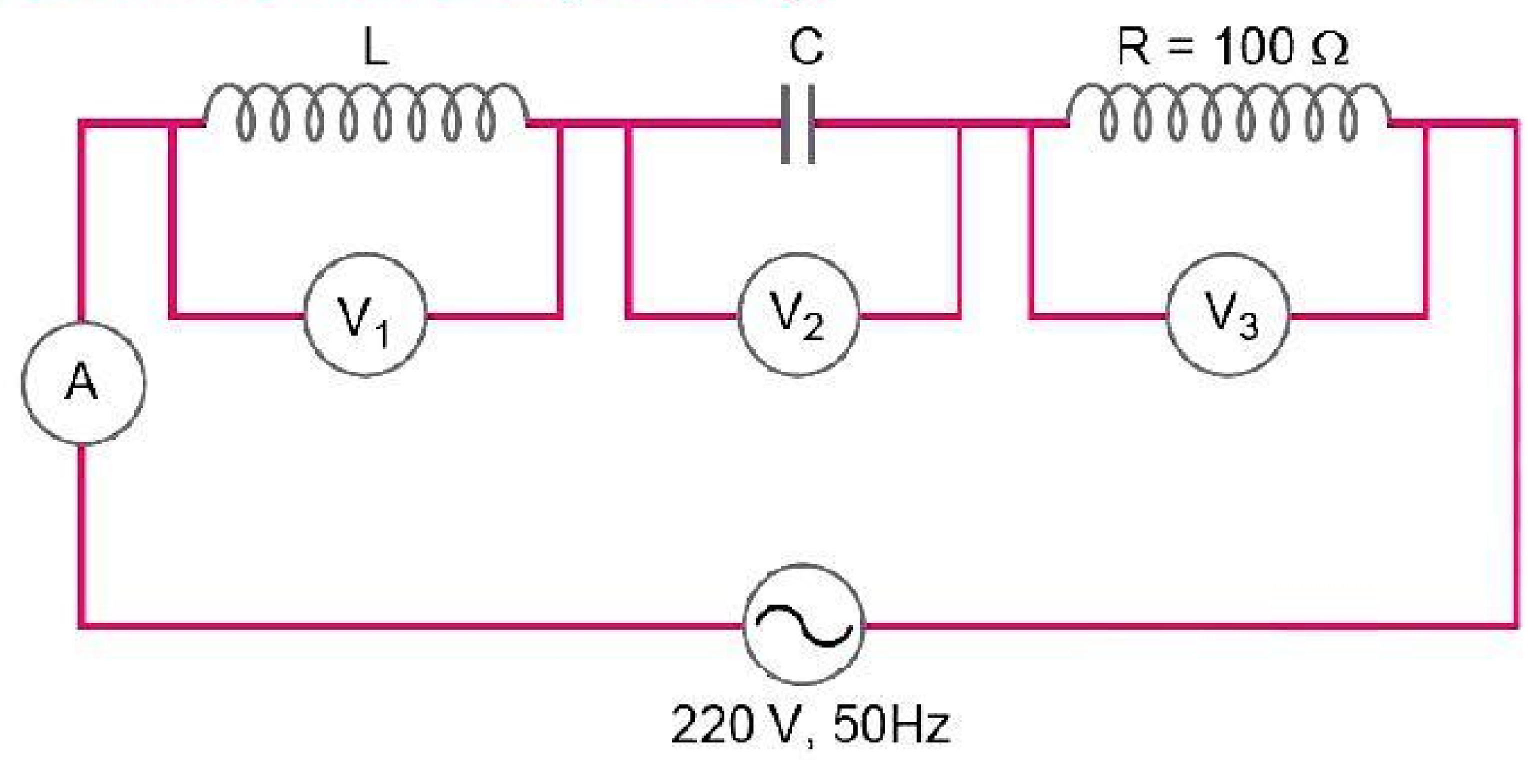
(a) $\dfrac{\varepsilon^2\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}{R}$

(b) $\dfrac{\varepsilon^2\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}{R}$

(c) $\dfrac{\varepsilon^2 R}{\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}$

(d) $\dfrac{\varepsilon^2 R}{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}$

70. **In the given circuit, the reading of voltmeter V_1 and V_2 are 300 volts each. The reading of voltmeter V_3 and ammeter A are respectively.**

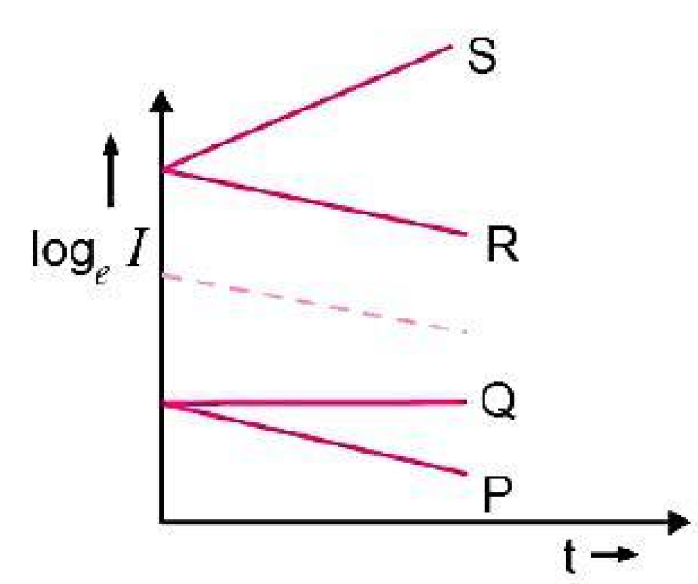


(a) 220 V, 2.2 A (b) 220 V, 2.0 A (c) 100 V, 2.0 A (d) 150 V, 2.2 A

71. **An emf of 15 V is applied in a circuit containing 5 H inductance and 10 Ω resistance. The ratio of the currents in time $t = \infty$ and at $t = 1$ second is:**

(a) $\dfrac{e^{1/2}}{e^{1/2-1}}$ (b) $\dfrac{e^2}{e^2-1}$ (c) $1-e^{-1}$ (d) e^{-1}

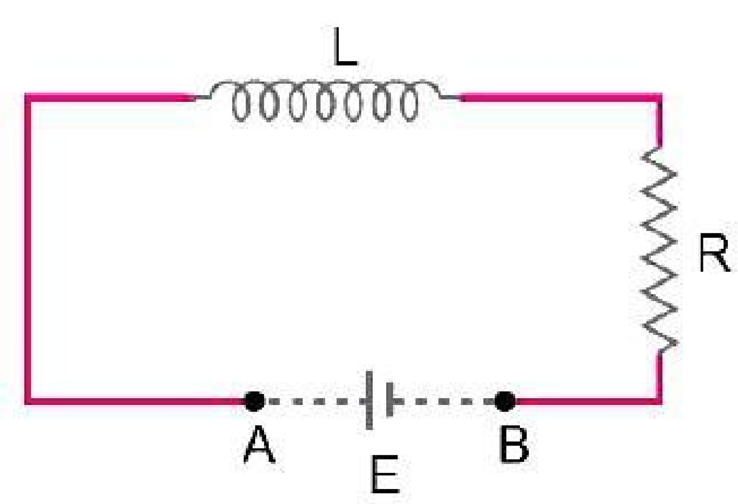
72. **In an RC circuit while charging, the graph of $\log_e I$ versus time (t) is shown by the dotted line in the diagram where I is the current. When the value of the resistance is doubled, which of the solid curves best represents the variation of $\log_e I$ versus time (t)?**



(a) P (b) Q

(c) R (d) S

73. **An inductor (L = 100 mH), a resistor (R = 100 Ω) and a battery (E = 100 V) are initially connected in series as shown in figure. After a long time the battery is disconnected after short circuiting the points A and B. The current in the circuit 1 ms after the short circuit is:**



(a) $\dfrac{1}{e}$ A (b) e A

(c) 0·1 A (d) 1 A

74. **In LCR circuit, capacitance is changed from C to $2C$. For resonant frequency to remain unchanged, the inductance should be changed from L to:**

(a) $4L$ (b) $2L$ (c) $L/2$ (d) L

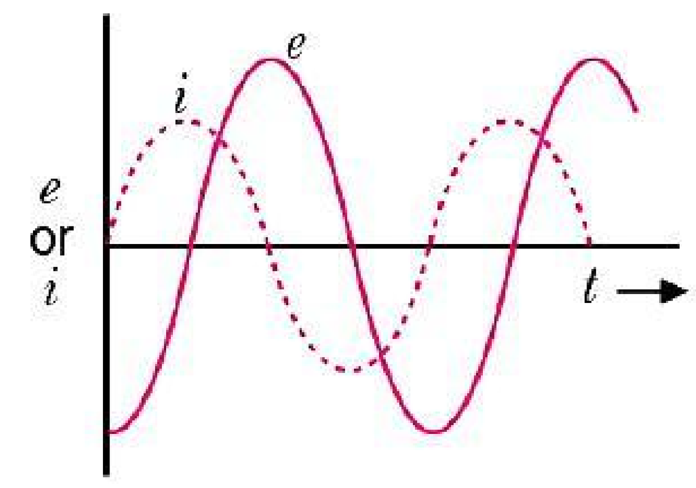
75. **An alternating current is given by $i = i_1 \cos \omega t + i_2 \sin \omega t$. The rms current is given by:**

(a) $\dfrac{i_1+i_2}{\sqrt{2}}$ (b) $\dfrac{i_1-i_2}{\sqrt{2}}$ (c) $\sqrt{\dfrac{i_1^2+i_2^2}{2}}$ (d) $\dfrac{i_1 i_2}{\sqrt{2}}$

76. **In a transformer, the number of turns in the primary are 140 and that in secondary are 280. If the current in the primary is 4 A; the current in secondary is:**

(a) 4 A (b) 2 A (c) 6 A (d) 10 A

77. **When an *ac* source of emf $e = E_0 \sin 100t$ is connected across a circuit, the phase difference between emf *e* and the current in the circuit is observed to be $\pi/4$ as shown in figure. If the circuit consists possibly *RC* or *RL* or *LC* in series, find the relationship between the two elements:**



(a) $R = 1\ \text{k}\Omega, C = 10\ \mu\text{F}$ (b) $R = 1\ \text{k}\Omega, C = 1\ \mu\text{F}$

(c) $R = 1\ \text{k}\Omega, L = 10\ \text{H}$ (d) $R = 1\ \text{k}\Omega, L = 1\ \text{H}$

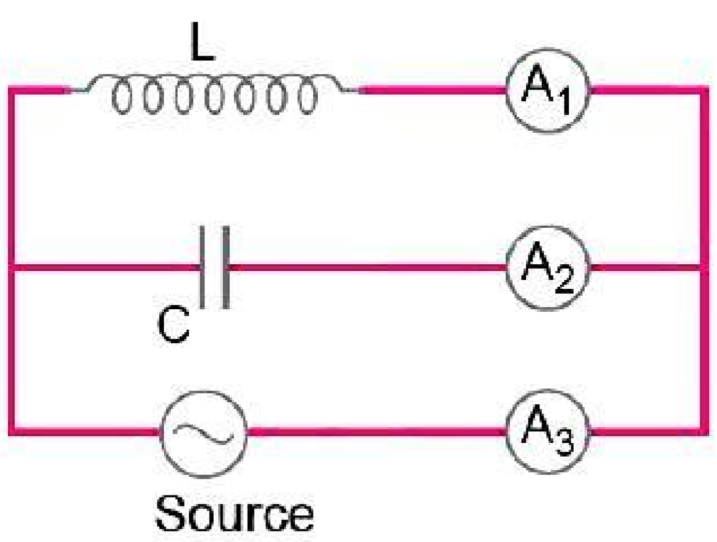
78. **The phase difference between the alternating current and emf is $\frac{\pi}{2}$. Which of the following can not be the constituent of the circuits?**

(a) *R, L* (b) *C* alone (c) *L* alone (d) *L, C*

79. **The voltage of an *ac* supply varies with time as $V = 120 \sin \pi t \cos 100\, \pi t$. The maximum voltage and frequency respectively are:**

(a) 120 V, 100 Hz (b) $60\sqrt{2}$ V, 100 Hz (c) 60 V, 200 Hz (d) 60 V, 100 Hz

80. **A circuit containing *L*, *C* and *ac* source with ammeters A_1, A_2, A_3 is shown in figure. At resonance which ammeter reads zero?**



(a) A_1 (b) A_2

(c) A_3 (d) all the three A_1, A_2 and A_3

81. **A capacitor of capacitance 2 μF is connected to a tank circuit of an oscillator with frequency of 1 kHz. If the current in the circuit is 2 mA, the voltage across the capacitor will be :**

(a) 0·16 V (b) 0·32 V (c) 79·5 V (d) 159 V

82. **A purely resistive circuit element *X* when connected to an *ac* supply of peak voltage 200 V gives a peak current of 5 A which is in phase with voltage. A second circuit element *Y*, when connected to same *ac* supply also gives the same value of peak current but the current lags behind by 90°. If the series combination of *X* and *Y* is connected to same supply; what will be the value of rms current?**

(a) 1·5 A (b) 2·5 A (c) 3·5 A (d) 0·5 A

83. **The voltage and current in *ac* circuit are given by**

$$V = 5\sin\left(100\pi t - \frac{\pi}{6}\right),\ i = 4\sin\left(100\pi t + \frac{\pi}{6}\right)$$

We can conclude

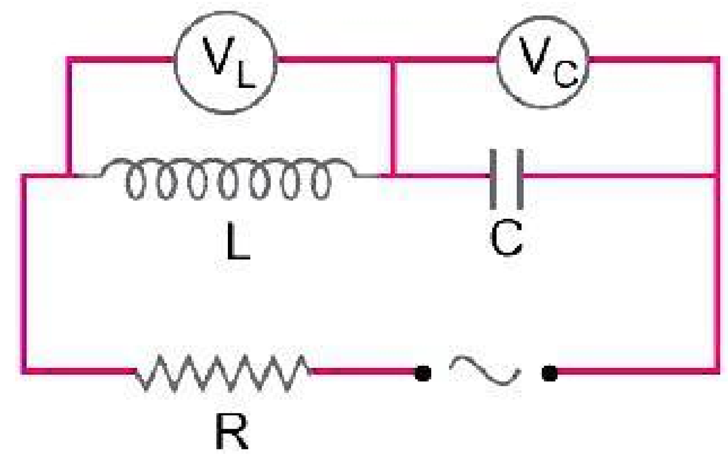
(a) voltage leads the current by 30° (b) current leads the voltage by 30°

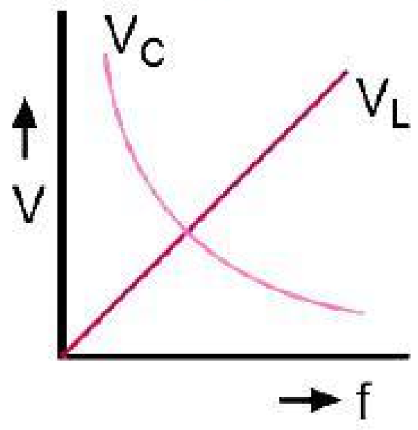
(c) current leads the voltage by 60° (d) current and voltage are in phase

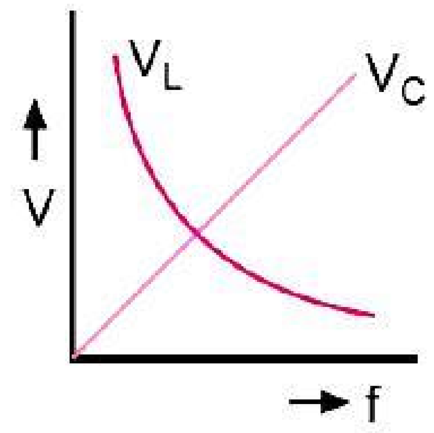
84. **The electric current in a circuit is given by $I = I_0\left(\frac{t}{T}\right)$ for some time. The rms value of current for the period $t = 0$ to $t = T$ is :**

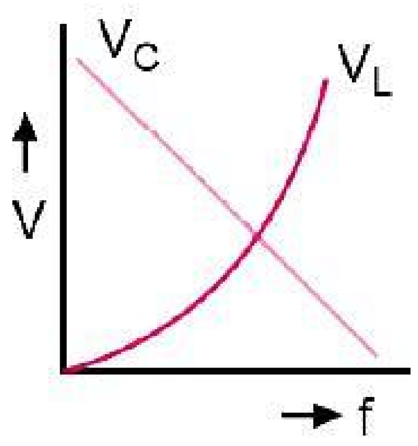
(a) $\frac{I_0}{\sqrt{2}}$ (b) $\sqrt{2}\,I_0$ (c) $\frac{I_0}{\sqrt{3}}$ (d) $\sqrt{3}\,I_0$

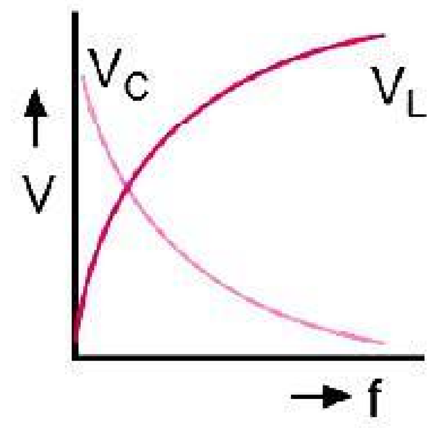
85. A series *LCR* circuit is shown in figure. The source frequency *f* is varied, but the current is kept unchanged. Which of the curves shows changes of V_C and V_L with frequency?



(*a*)


(*b*)


(*c*)


(*d*)


86. An alternating current of 1·5 mA rms and angular frequency ω = 100 rad/s flows through a 10 kΩ resistor and a 0·50 μF capacitor in series. The rms potential difference across the capacitor is:

(*a*) 4·8 V (*b*) 15 V (*c*) 30 V (*d*) 42 V

87. In a series *LCR* circuit, the voltage across *R* is 100 V and *R* = 1 kΩ with *C* = 2 μF. The resonant frequency ω is 200 rad/s. At resonance, the voltage across *L* is:

(*a*) 2.5×10^{-2} V (*b*) 40 V (*c*) 250 V (*d*) 4×10^{-3} V

88. In an *ac* generator, a coil with *N* turns, all of the same area *A* and total resistance *R*, rotates with frequency ω in a magnetic field *B*. The maximum value of emf generated in the coil is:

(*a*) *NABR*ω (*b*) *NAB* (*c*) *NABR* (*d*) *NAB*ω

89. An ideal coil of 10 H is connected in series with a resistance of 5 Ω and a battery of 5 V. 2 seconds after the connections are made, the current flowing, in ampere, in the circuit is:

(*a*) e (*b*) e^{-1} (*c*) $(1 - e^{-1})$ (*d*) $(1 - e)$

90. The selectivity of a series LCR ac circuit is large, when ***[CBSE 2020 (55/5/1)]***

(*a*) L is large and R is large (*b*) L is small and R is small
(*c*) L is large and R is small (*d*) L = R

91. The phase difference between the current and the voltage in series LCR circuit at resonance is ***[CBSE 2020 (55/5/2)]***

(*a*) π (*b*) π/2 (*c*) π/3 (*d*) zero

Answers

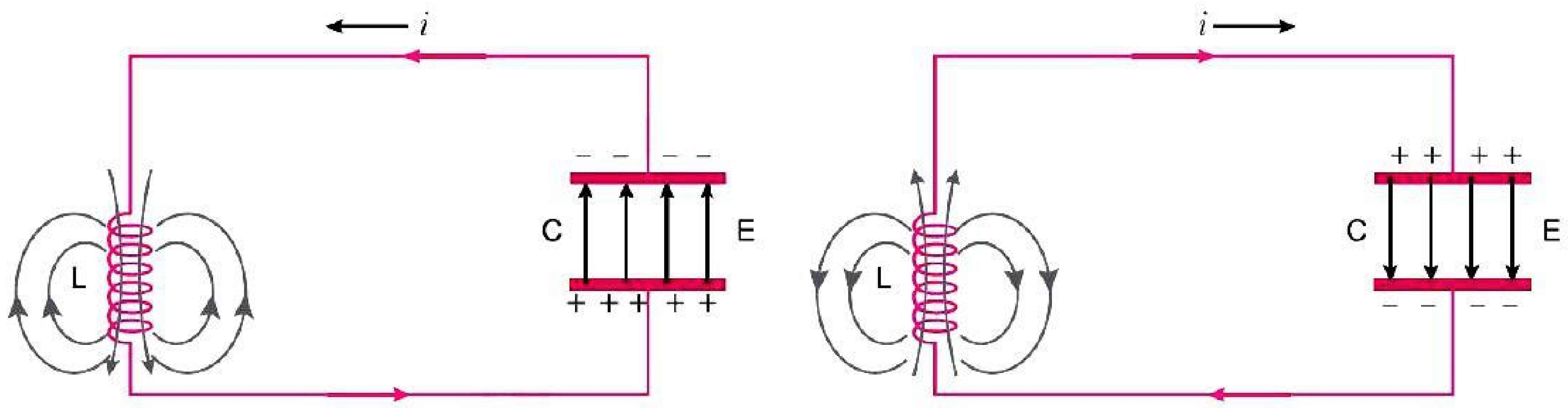
1. (*b*)	**2.** (*c*)	**3.** (*b*)	**4.** (*c*)	**5.** (*c*)	**6.** (*b*)	**7.** (*c*)	**8.** (*b*)
9. (*c*)	**10.** (*d*)	**11.** (*d*)	**12.** (*d*)	**13.** (*c*)	**14.** (*b*)	**15.** (*d*)	**16.** (*c*)
17. (*c*)	**18.** (*a*)	**19.** (*a*)	**20.** (*d*)	**21.** (*b*)	**22.** (*d*)	**23.** (*b*)	**24.** (*a*)
25. (*d*)	**26.** (*d*)	**27.** (*c*)	**28.** (*a*)	**29.** (*d*)	**30.** (*b*)	**31.** (*b*)	**32.** (*a*)
33. (*c*)	**34.** (*d*)	**35.** (*c*)	**36.** (*d*)	**37.** (*a*)	**38.** (*d*)	**39.** (*d*)	**40.** (*c*)
41. (*a*)	**42.** (*d*)	**43.** (*a*)	**44.** (*d*)	**45.** (*c*)	**46.** (*c*)	**47.** (*b*)	**48.** (*b*)
49. (*a*)	**50.** (*d*)	**51.** (*b*)	**52.** (*b*)	**53.** (*d*)	**54.** (*b*)	**55.** (*d*)	**56.** (*a*)
57. (*b*)	**58.** (*d*)	**59.** (*d*)	**60.** (*b*)	**61.** (*d*)	**62.** (*d*)	**63.** (*a*)	**64.** (*a*)
65. (*b*)	**66.** (*a*)	**67.** (*a*)	**68.** (*d*)	**69.** (*d*)	**70.** (*a*)	**71.** (*b*)	**72.** (*a*)
73. (*a*)	**74.** (*c*)	**75.** (*c*)	**76.** (*b*)	**77.** (*c*)	**78.** (*a*)	**79.** (*d*)	**80.** (*c*)
81. (*a*)	**82.** (*b*)	**83.** (*c*)	**84.** (*c*)	**85.** (*a*)	**86.** (*c*)	**87.** (*c*)	**88.** (*d*)
89. (*c*)	**90.** (*c*)	**91.** (*d*)					

CASE-BASED QUESTIONS

Attempt any 4 sub-parts from each question. Each question carries 1 mark.

1. LC OSCILLATORS:

An LC circuit oscillating at its natural resonant frequency can store electrical energy. A capacitor store electrical energy in the electric field (E) between its plates, depending on the voltage across it, and an inductor stores magnetic energy in its magnetic field (B), depending on the current through it. If an inductor is connected across a charged capacitor, the voltage across the capacitor will drive a current through inductor, building up a magnetic field around it. The voltage across the capacitor falls to zero as the charge is used up by the current flow. At this point, the energy stored in the coil's magnetic field induces a voltage across the coil, because inductor oppose changes in current. This induced voltage cause a current to begin to recharge the capacitor with a voltage of opposite polarity to its original charge. Due to Faraday's law, the emf which drives the current is caused by a decrease in magnetic field, thus the energy required to charge the capacitor is extracted from the magnetic field. When the magnetic field is completely dissipated the current will stop; and the charge will again be stored in the capacitor with the opposite polarity as before. Then the cycle will begin again, with the current flowing in the opposite direction through the inductor. The charge flows back and forth between the plates of the capacitor, through the inductor. The energy oscillates back and forth between the capacitor and the inductor until internal resistance makes the oscillations die out. The tuned circuit's action, known mathematically as harmonic oscillator, is similar to a pendulum swinging back and forth.



(i) In an LC oscillator, the frequency of oscillator is ____________ L or C.

(a) directly proportional to
(b) proportional to the square of
(c) independent of the value of
(d) inversely proportional to square root of

(ii) An LC oscillator cannot be used to produce

(a) high frequencies
(b) audio frequencies
(c) very low frequencies
(d) very high frequencies

(iii) In an LC oscillator, if the value of L is increased four times, the frequency of oscillations is

(a) increased by 2 times
(b) decreased 4 times
(c) increased by 4 times
(d) decreased by 2 times

(iv) In an ideal parallel LC circuit, the capacitor is charged by connecting it to a dc source, which is then disconnected. The current in the circuit

(a) becomes zero instantly
(b) grows monotonically
(c) decays monotonically
(d) oscillates instantly

(v) An LC circuit contains a 0.6 H inductor and 25 μF capacitor. What is the rate of change of the current (in A/s) when the charge on the capacitor is 3×10^{-5} C?

(a) 2
(b) 4
(c) 3
(d) 6

Answers

1. (*i*) (*d*); In *LC* oscillator, the frequency is given as

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

(*ii*) (*c*); An *LC* oscillator cannot be used to produce very low frequencies.

(*iii*) (*d*); The frequency of *LC* oscillator is given as $\omega = \frac{1}{\sqrt{LC}}$

If *L* is increased four times then,

$$\omega' = \frac{1}{\sqrt{4LC}} = \frac{1}{2\sqrt{LC}} = \frac{1}{2}\omega$$

(*iv*) (*d*); When capacitor is connected to a *dc* source and then disconnected it gets charged and then it starts discharging through the inductor. When circuit is closed, the capacitor begins to discharge through the inductor causing current to flow. The energy of electric field between the capacitor plates has transferred to magnetic field. By Lenz's law, this dying magnetic field induces on emf in the inductance in the same direction as current. Hence *LC* circuit sets up oscillations.

(*v*) (*a*); For *LC* circuit,

Electrostatic energy of capacitor = Magnetic energy of inductor

$$\frac{a^2}{2C} = \frac{1}{2}LI^2$$

Differentiate *w.r.t. t*

$$\frac{1}{2C}(2q)\frac{dq}{dt} = \frac{1}{2}L(2I)\frac{dI}{dt}$$

$$\frac{q}{C}I = LI\frac{dI}{dt}$$

$$\frac{dI}{dt} = \frac{q}{LC} = \frac{3\times10^{-5}}{0.6\times25\times10^{-6}}$$

$$\frac{dI}{dt} = 2 \text{ A/s}$$

2. RESONANCE:

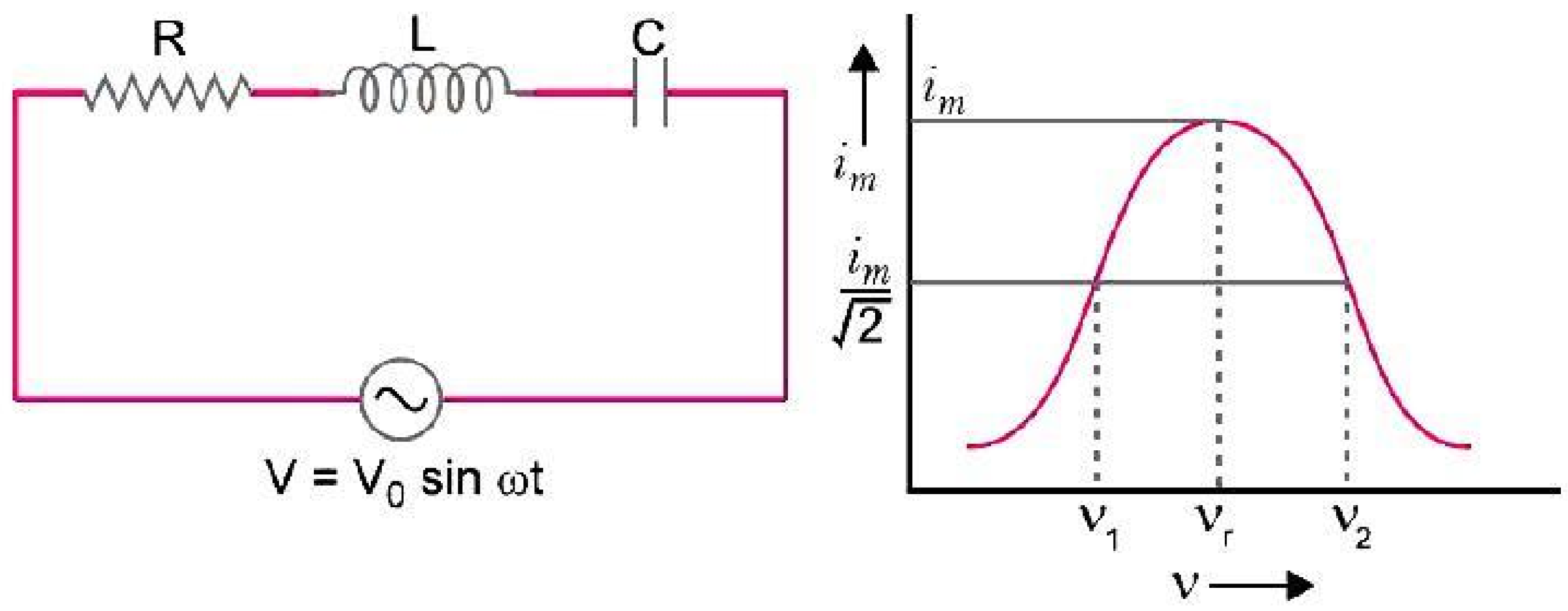
An interesting characteristic of the series *RLC* circuit is the phenomenon of resonance. The phenomenon of resonance is common among systems that have a tendency to oscillate at a particular frequency. This frequency is called the system's natural frequency. If such a system is driven by an energy source at a frequency that is near the natural frequency, the amplitude of oscillation is found to be large. A familiar example of this phenomenon is a child on a swing. The swing has a natural frequency for swinging back and forth like a pendulum. If the child pulls on the rope at regular intervals and the frequency of the pulls is almost the same as the frequency of swinging, the amplitude of the swinging will be large.

Suppose a resistance *R*, inductance *L* and capacitance *C* are connected in series and fed by an alternating source of voltage *V*, the frequency of alternating current source be *f*. This series *RLC* circuit is said to be in resonance only if the frequency *f* of applied alternating source be such that the current flowing in circuit and voltage applied are in the same phase. At resonance in *RLC* series circuit impedance is minimum (*i.e.*, $Z = R$). For an *RLC* circuit driven with voltage of amplitude V_m and angular frequency ω_0 is given by

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

At resonant frequency, the current amplitude is maximum

i.e., $$i_m = \frac{V_m}{R}$$



(*i*) **To reduce the resonant frequency in an LCR series circuit with a generator**

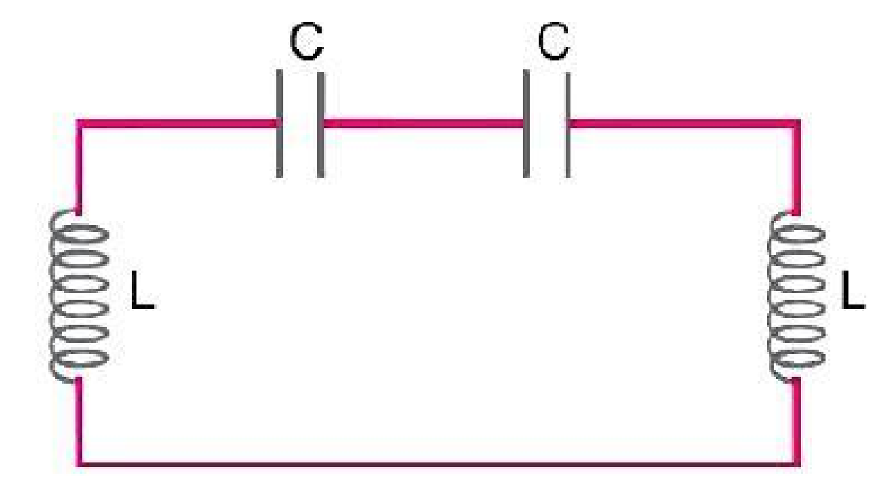
(*a*) the generator frequency should be reduced

(*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

(*ii*) **The natural frequency of the circuit shown in fig. is**



(*a*) $\frac{1}{2\pi\sqrt{LC}}$ (*b*) $\frac{1}{2\pi\sqrt{2LC}}$

(*c*) $\frac{2}{2\pi\sqrt{LC}}$ (*d*) none of these

(*iii*) **In an *ac* circuit the emf (*e*) and the current (*i*) at any instant are given respectively by**

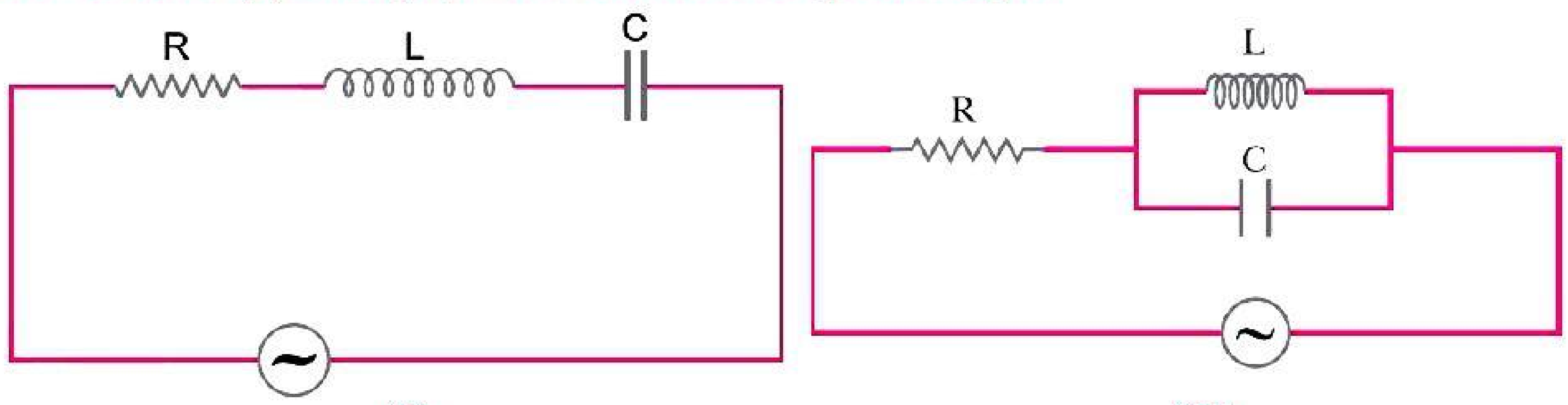
$$e = E_0 \sin \omega t$$
$$i = I_0 \sin (\omega t - \phi)$$

The average power in the circuit over one cycle of *ac* is

(*a*) $E_0 I_0$ (*b*) $\frac{E_0 I_0}{2}$

(*c*) $\frac{E_0 I_0}{2} \sin \phi$ (*d*) $\frac{E_0 I_0}{2} \cos \phi$

(*iv*) **An *ac* voltage is connected to two circuits as shown in fig., the current through resistance *R* in the circuit (I) and (II) at resonance respectively is**



(I) **(II)**

(*a*) 0 A, 0 A (*b*) $\frac{V}{R}$, 0 A

(*c*) 0 A, $\frac{V}{R}$ (*d*) $\frac{V}{R}, \frac{V}{R}$

(*v*) **The resonant frequency ω_r of a series LCR circuit with $L = 2$ H, $C = 32$ μF *and* $R = 10\ \Omega$ is**

(*a*) 125 rad s^{-1} (*b*) 130 rad s^{-1}

(*c*) 135 rad s^{-1} (*d*) 140 rad s^{-1}

Answers

2. (*i*) (*b*); The resonant frequency of *LCR* series circuit is

$$\nu_0 = \frac{1}{2\pi\sqrt{LC}}$$

So, to reduce resonant frequency ν_0, we either have to increase *L* or to *C*. To increase *C*, another capacitor must be connected in parallel with the first.

(*ii*) (*a*); The two capacitors are in series and two inductors are also in series.

So, $L_S = L + L = 2L$ and $\frac{1}{C_S} = \frac{1}{C} + \frac{1}{C} = \frac{2}{C}$

$\Rightarrow \quad C_S = \frac{C}{2}$

$\therefore$ Natural frequency of the circuit, $\nu_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{2L \times \frac{C}{2}}} = \frac{1}{2\pi\sqrt{LC}}$

(*iii*) (*d*); Power = Rate of work done in one cycle

$$P_{av} = \frac{W}{T}$$

$$P_{av} = \frac{(E_0 I_0 \cos\phi)\frac{T}{2}}{T} \qquad \left[\because \text{Work done in half cycle is } W = (E_0 I_0 \cos\phi).\frac{T}{2}\right]$$

$$P_{av} = \frac{E_0 I_0 \cos\phi}{2}$$

(*iv*) (*b*) In series LCR circuit, at resonance, $Z = R$

So, $i_{series} = \frac{V}{Z} = \frac{V}{R}$

In parallel LCR circuit, current in circuit

$$i_{parallel} = i_C - i_L = 0$$

(*v*) (*a*); Resonant frequency, $\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2 \times 32 \times 10^{-6}}} = \frac{1}{8} \times 10^3 = 125 \text{ rad/s}$

$$\omega_r = 125 \text{ rad/s}$$

ASSERTION-REASON QUESTIONS

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct answer out of the following choices.

(a) *Both A and R are true and R is the correct explanation of A.*

(b) *Both A and R are true but R is not the correct explanation of A.*

(c) *A is true but R is false.*

(d) *A is false and R is also false.*

1. Assertion (A) : An alternating current of frequency 50 Hz becomes zero, 100 times in one second.
Reason (R) : Alternating current changes direction and becomes zero twice in a cycle.

2. Assertion (A) : Capacitor serves as a block for DC and offers an easy path to AC.
Reason (R) : Capacitive reactance is inversely proportional to frequency.

3. Assertion (A) : A capacitor of suitable capacitance can be used in an AC circuit in place of the choke coil.
Reason (R) : A capacitor blocks DC and allows AC only.

4. Assertion (A) : An alternating current does not show any magnetic effect.
Reason (R) : Alternating current does not vary with time.

5. Assertion (A) : In series LCR-circuit, the resonance occurs at one frequency only. [*AIIMS 1998*]
Reason (R) : At resonance, the inductive reactance is equal and opposite to the capacitive reactance.

6. Assertion (A) : 220 V, 50 Hz appliance implies that emf across the appliance should be 220 V.
Reason (R) : Every appliance is specified with its peak Tolerable voltage.

7. Assertion (A) : The quantity L/R possesses the dimension of time. [*AIIMS 2002*]
Reason (R) : In order to reduce the rate of increase of current through a solenoid, we should increase the time constant.

8. **Assertion (A) :** Transformers are used only in alternating current source not in direct current. *[AIIMS 2009]*

Reason (R) : Only a.c. can be stepped up or down by means of transformers.

9. **Assertion (A) :** The possibility of an electric bulb fusing is higher at the time of switching ON and OFF. *[AIIMS 2003]*

Reason (R) : Inductive effects produce a surge at the time of switch-OFF and switch-ON.

10. **Assertion (A) :** It is advantageous to transmit electric power at high voltage. *[AIIMS 2010]*

Reason (R) : High voltage implies high current.

Answers

1. (*a*) **2.** (*a*) **3.** (*b*) **4.** (*d*) **5.** (*a*) **6.** (*c*) **7.** (*b*) **8.** (*a*)
9. (*a*) **10.** (*c*).

HINTS/SOLUTIONS OF SELECTED MCQs

1. (*b*) $I = I_0 \sin \omega t = I_0 \sin 2\pi\nu t = 5\sqrt{2} \sin 2\pi \times 50 \times \frac{1}{300} = 5\sqrt{2} \sin\frac{\pi}{3} = 5\sqrt{\frac{3}{2}}\text{A}$

2. (*c*) According to maximum power transfer theorem, $X_L = -X_g$

3. (*b*) $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{423}{\sqrt{2}} = 300\text{ V}$

4. (*c*) $V_0 = \sqrt{2}\, V_{rms} = \sqrt{2} \times 220 = 311\text{ V}$

6. (*b*) $W_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8 \times 0.5 \times 10^{-6}}} = 500\text{ rad/s}$

7. (*c*) The voltmeter connected to AC mains reads mean ($< V^2 >$) and is calibrated in such a way that it gives value of $< V^2 >$, which is multiplied by firm factor to give rms value.

8. (*b*) Resonant frequency, $\nu_r = \frac{1}{2\pi\sqrt{LC}}, \quad \nu_r \propto \frac{1}{\sqrt{LC}}$

Now, to reduce ν_r either we can increase L or C.

So, to increase C, we must connected another capacitor parallel to the first.

10. (*d*) $P_{av} = E_{rms}\, I_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} \cos\phi = \frac{1}{2} E_0 I_0 \cos\phi$

11. (*d*) For pure inductive circuit, $\phi = 90°$, $\cos\phi = 0$, so $P_{av} = 0$.

12. (*d*) We have to transmit power over large distance at high alternating voltage, so, current flowing through the wires will be low.

Here, $P = E_{rms}\, I_{rms}$. I_{rms} is low when E_{rms} is high also power loss $= I^2_{rms} R$ = Low

Now, at the receiving end high voltage is reduced by using step-down transformer.

13. (*c*) $X_C = \frac{1}{\omega c} \quad \Rightarrow \quad \frac{X_C}{(X_C)_{new}} = \frac{\omega_2}{\omega_1} = \frac{2\pi f_2}{2\pi f_1} = \frac{f_2}{f_1} = \frac{100}{50} = 2$

$\therefore \quad (X_c)_{new} = \frac{5}{2} = 2.5\Omega$

15. (*d*) The plate with positive charge will be at higher potential and the plate with negative charge will be at lower potential. So, we can say that the charge is in phase with applied voltage.

16. (*d*) Quality factor $(Q) = \frac{1}{R}\sqrt{\frac{L}{C}}$ for an L-C-R circuit,

To make, Q is high, R should be low, L should be high and C should be low.

17. (*d*) Average power dissipated in the circuit,

$$P_{av} = E_{rms} I_{rms} \cos\phi = \left(\frac{E_{rms}}{Z}\right)^2 \cos\phi$$

where, $Z = \sqrt{R^2 + x_L^2} = \sqrt{4+1} = \sqrt{5}\,\Omega$ and $\cos\phi = \frac{R}{Z} = \frac{2}{\sqrt{5}}$

then, $P_{av} = \frac{(6)^2}{\sqrt{5}} \times \frac{2}{\sqrt{5}} = \frac{72}{5} = 14.4$ W

18. (*a*) $P_s = V_S I_S \Rightarrow I_s = \frac{124}{24} = \frac{1}{2}$A

$I_0 = I_S\sqrt{2} = \frac{1}{2} \times \sqrt{2} = \frac{1}{\sqrt{2}}$A

19. (*a*) Power consumed: $P = E_{\text{rms}} i_{\text{rms}} \cos\phi$

$P = E_{rms}\left(\frac{E_{rms}}{Z}\right)\frac{R}{Z}$ $\qquad \left[\because\ i_{rms} = \frac{E_{rms}}{Z} \text{ and } \cos\phi = \frac{R}{Z}\right]$

$E_{rms} = \frac{E_0}{\sqrt{2}}$, then $P = \frac{E_0^2}{4R}$

20. (*d*) Voltage across the inductor is

$V_l = \sqrt{V^2 - V_R^2} = \sqrt{(100)^2 - (60)^2} = \sqrt{10000 - 3600} = \sqrt{6400} = 80$ V

21. (*b*) We know that

$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

Now, Power $= V_{rms}\, i_{rms} \cos\phi$

$$P = V_{rms}\, i_{rms}\, \frac{R}{Z}$$

Now, as ω increase, Z decreases

i.e., the bulb glows brighter (more power)

22. (*d*) $\text{Power}_{inst} = P_0 = E_0 \sin\omega t \times i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

$P = E_o i_0 \sin\omega t \,.\, \cos\omega t$

$P = \frac{1}{2} E_0 i_0 \sin(2\,\omega t)$ $\qquad$ [as $\sin 2\omega t = 2 \sin\omega t \cos\omega t$)]

Hence, angular frequency of instantaneous power is [2ω].

24. (*a*) In electric furnace Cu and Fe is melted due to variation of current because current generates heat and electricity.

25. (*d*) $\phi = \tan^{-1}\left|\frac{1}{\omega CR}\right|$

i.e., 90° for maximum

26. (*d*) Weak current flows through the transmission line, hence low power loss (I^2R).

27. (*c*) Q factor $= \frac{1}{R}\sqrt{\frac{L}{C}}$

Q factor can be improved by decreasing R.

30. (*b*) When just open the switch, more quickly current changes gives higher the voltage in the circuit.

33. (*c*) $X_C' = \frac{1}{2\pi(2f)(2C)} = \frac{X_C}{4}$

35. (*c*) Given $\frac{N_S}{N_P} = \frac{3}{2}$

Now, we know that $\frac{E_S}{E_P} = \frac{N_S}{N_P}$

$E_P = 6$ V

then $E_S = E_P \frac{N_S}{N_P} = 6 \times \frac{3}{2} = 9$ V

36. (*d*) $\frac{I_P}{I_S} = \frac{N_S}{N_P} = \frac{400}{500} = 4:5$

37. (*a*) At $t = 0, \frac{T}{2}, T, \frac{3T}{2}$... energy is electrostatic & at $t = \frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}$... energy is totally magnetic.

38. (*d*) $V = V_0 \sin \omega t, I = I_0 \cos \omega t = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

i.e., voltage lags behind the current by phase angle of $\frac{\pi}{2}$.

41. (*a*) $P_{av} = \frac{1}{2}V_0 i_0 = \frac{1}{2} \times 100 \times 200 \times 10^{-3} = 10 \text{ W}$

43. (*b*) In DC supply, magnetic flux does not change, so emf not induced, *i.e.*, $E_s = 0$.

45. (*c*) $V_{rms} = \frac{200}{\sqrt{2}} \text{V}$

$V_0 = \sqrt{2}\, V_{rms} = \sqrt{2} \times \frac{200}{\sqrt{2}} = 200 \text{ V}$

$V = V_0 \sin 2\pi \upsilon t = 200 \sin\left(2\pi \times 50 \times \frac{1}{600}\right) = 200 \sin \frac{\pi}{6} = 200 \times \frac{1}{2} = 100 \text{ V}$

47. (*b*) Time constant for RC circuit is given by $\tau = RC \Rightarrow \frac{1}{RC}$ will have the dimension of frequency. Similarly, time constant for a LR circuit is given by

$\tau = \frac{L}{R} \Rightarrow \frac{R}{L}$ will have dimension of frequency.

50. (*d*) Because ϕ between current and emf is 45° in case of LCR circuit.

51. (*b*) Soft iron because it reduces the hysteresis loss.

53. (*d*) For pure capacitor, $\phi = 90°$

$P_{av} = \frac{V_0 I_0}{2} \cos \phi = \frac{V_0 I_0}{2} \cos 90° = 0$

54. (*b*) 100 times as current is zero two times for one complete cycle.

55. (*d*) $P = E_{rms} I_{rms} \cos \phi = E_{rms} I_{rms} \cos\left(-\frac{\pi}{2}\right) = 0$

60. (*b*) $X_C = \frac{1}{\omega C} = \frac{1}{100 \times 10^{-6}} = 10^4 \ \Omega$

$I_{rms} = \frac{V_{rms}}{X_C} = \frac{200}{10^4} \text{A} = 20 \text{ mA}$

63. (*a*) i_{max} when $\omega = \frac{1}{\sqrt{LC}}$ or $\omega^2 = \frac{1}{LC}$

64. (*a*) $V = \sqrt{V_R^2 + V_L^2} = \sqrt{(200)^2 + (150)^2} = 250 \text{ V}$

65. (*b*) $Z = \sqrt{R^2 + (\omega L)^2} = \sqrt{10^2 + (120\pi \times 2)^2} = 753.6 \ \Omega$

$I = \frac{V}{Z} = \frac{120}{753.6} = 0.16 \text{ A}$

66. (*a*) $R = \frac{V_{dc}}{I_{dc}} = \frac{100}{1} = 100\,\Omega, \quad Z = \frac{V_{rms}}{I_{rms}} = \frac{100}{0.5} = 200\,\Omega$

$X_L = \sqrt{Z^2 - R^2} = \sqrt{200^2 - 100^2} = 100\sqrt{3}\ \Omega, \ L = \frac{X_L}{\omega} = \frac{100\sqrt{3}}{2\pi \times 50} = \frac{100\sqrt{3}}{314} = 0.55 \text{ H}$

70. (*a*) Now at resonance, $V_L = V_C = 300$ V, then, $V_R = 220$ V

$i = \frac{V}{R} = \frac{220}{100} = 2.2 \text{ A}$

71. (*b*) Time constant, $\tau = \frac{L}{R} = \frac{5}{10} = 0 \cdot 5 \text{ s}$

Equation of growth of current in RL-circuit is

$$I = I_0 [1 - e^{-Rt/L}]$$

At $t = \infty, I_1 = I_0$

At $t = 1, I_2 = I_0 [1 - e^{-1/0.5}] = I_0 (1 - e^{-2})$

$$\therefore \quad \frac{I_1}{I_2} = \frac{1}{1 - e^{-2}} = \frac{e^2}{e^2 - 1}$$

72. (*a*) Charging current $I = I_0 e^{-t/RC}$

$$\Rightarrow \quad \log_e I = \log_e I_0 - \frac{t}{RC} \qquad \text{where } I_0 = \frac{E}{R}$$

Clearly, the graph of $\log_e I$ versus t is a straight line of slope $-\frac{1}{RC}$ shown by dotted line. When R increases to $2R$, I_0 decreases so value of $\log_e I_0$ decreases and slope becomes half. This is shown in P.

73. (*a*) $I_0 = \frac{E}{R} = \frac{100}{100} = 1 \text{ A}$

Time constant

$$\tau = \frac{L}{R} = \frac{100 \times 10^{-3}}{100} = 1 \times 10^{-3} \text{ s} = 1 \text{ ms}$$

Current during discharging after time t is

$$I = I_0 e^{-t/T} = I_0 e^{-1/1} = I_0 \cdot \left(\frac{1}{e}\right) = \frac{1}{e} \text{ A}$$

74. (*c*) $\omega_r = \frac{1}{\sqrt{LC}}, \omega_r' = \frac{1}{\sqrt{L'C'}}$

$\therefore \quad \omega_r = \omega_r'$ implies $LC = L'C'$

$$\Rightarrow \quad L' = \frac{C}{C'} L = \frac{C}{2C} L = \frac{L}{2}$$

75. (*c*) $i_{rms}^2 = (i^2)_{mean} = \dfrac{\int_0^T (i_1 \cos \omega t + i_2 \sin \omega t)^2}{T}$

$$= \int_0^T i_1^2 \cos^2 \omega t + \int_0^T i_2^2 \sin^2 \omega t + \int_0^T 2 i_1 i_2 \sin \omega t \cos \omega t$$

$$= i_1^2 \times \frac{1}{2} + i_2^2 \times \frac{1}{2} + 0$$

$$i_{rms} = \sqrt{\frac{i_1^2 + i_2^2}{2}}$$

76. (*b*) $\frac{I_S}{I_P} = \frac{N_P}{N_S} = \frac{140}{280} = \frac{1}{2} \Rightarrow I_S = \frac{I_P}{2} = 2 \text{ A}$

77. (*c*) In given figure current is leading applied voltage by $\frac{\pi}{4}$, so circuit may be RL or RLC circuit. Out of given circuits the possible circuit is RL circuit.

Also $\tan \phi = \frac{\omega L}{R}$

$$\tan 45° = \frac{100 L}{R} \quad \Rightarrow \quad R = 100 L$$

78. (*a*) In RL circuit, the phase difference is $\tan^{-1}\left(\frac{\omega L}{R}\right)$ which is never $\frac{\pi}{2}$ for finite values of L and R.

79. (*d*) $V = 120 \sin 100 \pi t \cos 100 \pi t = 60 \sin (2 \times 100 \pi t)$

Maximum voltage $= V_0 = 60$ V

Frequency, $f_r = \frac{\omega_r}{2\pi} = \frac{200\pi}{2\pi} = 100 \text{ Hz}$

80. (*c*) At resonance $i_L = i_C$ with a phase difference of π. Current in main circuit $i_3 = i_C - i_L = 0$, so ammeter A_3 reads zero.

81. (*a*) $V_C = X_C I = \dfrac{1}{2\times 3\cdot 14\times 2\times 10^{-3}}\times 2\times 10^{-3}$ volt $= 0\cdot 16$ V

82. (*b*) $R = \dfrac{E_0}{I_0} = \dfrac{200}{5} = 40\,\Omega$

In purely inductive circuit current lags behind the applied voltage by $\dfrac{\pi}{2}$;

$\therefore\ X_L = \dfrac{E_0}{I_0} = \dfrac{200}{5} = 40\,\Omega$

Impedance $Z = \sqrt{R^2 + X_L^2} = 40\sqrt{2}\,\Omega$

$I_0 = \dfrac{E_0}{Z} = \dfrac{200}{40\sqrt{2}}\text{ A} = \dfrac{5}{\sqrt{2}}\text{A}$

$I_{rms} = \dfrac{I_0}{\sqrt{2}} = 2\cdot 5$ A

83. (*c*) Phase lead of current over voltage

$\phi = 100\,\pi t + \dfrac{\pi}{6} - \left(100\pi t - \dfrac{\pi}{6}\right) = \dfrac{\pi}{3} = 60°$

84. (*c*) $I_{rms}^2 = \dfrac{\int_0^T I^2 dt}{\int^T dt} = \dfrac{\int^T I_0^2 t^2 dt}{T^2 . T} = \dfrac{I_0^2\,[t^3]_0^T}{3T^3}$

$\therefore\ I_{rms} = \dfrac{I_0}{\sqrt{3}}$

85. (*a*) $V_C = \dfrac{1}{2\pi f C} \propto \dfrac{1}{f}$ and $V_L = (2\pi f L) \propto f$

86. (*c*) $X_C = \dfrac{1}{\omega C} = \dfrac{1}{100\times 0\cdot 50\times 10^{-6}}\,\Omega = 2\times 10^4\,\Omega$

$V_C = X_C I = 2\times 10^4 \times 1\cdot 5\times 10^{-3} = 30$ V

87. (*c*) Current in circuit at resonance frequency

$I - \dfrac{V}{R} - \dfrac{100}{1\times 10^3}\text{ A} - 0.1\text{ A}$

At resonance $X_L = X_C$

$\therefore$ Voltage across L, $V_L = X_L I = X_C I = \dfrac{1}{\omega C} I = \dfrac{1}{200\times 2\times 10^{-6}}\times 0.1 = 250$ V

89. (*c*) $i = i_0\,(1 - e^{-Rt/L})$

$L = 10$ H, $R = 5\,\Omega$, $t = 2$ s

$i_0 = \dfrac{E}{R} = \dfrac{5}{5} = 1$ A

$i = 1\,(1 - e^{-5\times 2/10}) = (1 - e^{-1})$

90. (*c*) $Q = \dfrac{1}{R}\sqrt{\dfrac{L}{C}}$

The selectivity of a series LCR circuit can be increased by increasing the quality factor, *i.e.*, when L is large and R is small.

91. (*d*) At resonance, the circuit behaves as purely resistive and the phase difference between current and voltage in purely resistive circuit is zero.