Alternating Current

Voltage and Power

2011

1. **In an AC circuit, V and I are given by** $V = 150\sin(150t)$ volt**, and** $I = 150\sin\left(150t + \frac{\pi}{3}\right)$ amp**. The power dissipated in the circuit is**

a) 106 W b) 150 W c) 5625 W d) Zero

2010

2. **An AC ammeter is used to measure current in a circuit. When a given direct current passes through the circuit, the AC ammeter reads 3A. When another alternating current passes through the circuit, the AC ammeter reads 4A. Then the reading of this ammeter, if DC and AC flow through the circuit simultaneously, is**

a) 3 A b) 4 A c) 7 A d) 5 A

3. **An AC source is 120V – 60Hz. The value of voltage after** $\frac{1}{720}s$ **from start will be**

a) 20.2 V b) 42.4 V c) 84.8 V d) 106.8 V

2009

4. **The oscillating electric and magnetic vectors of an electromagnetic wave are oriented along**

a) The same direction but has a phase difference of $90°$

b) The same direction and are in same phase

c) Mutually perpendicular directions and are in same phase

d) Mutually perpendicular directions but has a phase difference of $90°$

5. **Alternating current is transmitted to take places**

a) At high voltage and low current b) At high voltage and high current

c) At low voltage and low current d) At low voltage and high current

2008

6. In an AC circuit the emf (e) and the current (i) at any instant are given respectively by

$$e = E_o \sin \omega t$$

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

The average power in the circuit over one cycle of AC is

a) $\frac{E_o I_o}{2}$ b) $\frac{E_o I_o}{2}\sin\phi$ c) $\frac{E_o I_o}{2}\cos\phi$ d) $E_o I_o$

7. Alternating current cannot be measured by DC ammeter because

a) AC cannot pass through DC ammeter

b) AC changes direction

c) Average value of current for complete cycle is zero

d) DC ammeter will get damaged

2007

8. If the power factor changes from $\frac{1}{2}$ to $\frac{1}{4}$ then what is the increase in impedance in AC?

a) 20% b) 50% c) 25% d) 100%

9. The instantaneous voltage through a device of impedance 20Ω is $e = 80\sin 100\pi t$. The effective value of the current is

a) 3 A b) 2.828 A c) 1.732 A d) 4 A

e) $\sqrt{2}A$

10. For high frequency, capacitor offers

a) More resistance b) Less resistance c) Zero resistance d) None of the above

2006

11. If reading of an ammeter is 10A, the peak value of current is

a) $\frac{10}{\sqrt{2}}A$ b) $\frac{5}{\sqrt{2}}A$ c) $20\sqrt{2}\ A$ d) $10\sqrt{2}\ A$

12. **If impedance is $\sqrt{3}$ times of resistance, find phase difference**

a) Zero b) 30° c) 60° d) Data is incomplete

13. **An alternating voltage $V = V_o \sin \omega t$ is applied across a circuit. As a result the current $I = I_o \sin(\omega t - \pi/2)$ flows in it. The power consumed in the circuit per cycle is**

a) $0.5 V_o I_o W$ b) $0.707 V_o I_o W$ c) $1.919 V_o I_o W$ d) Zero

14. **An AC is represented by $e = 220 \sin(100\pi) t$ volt and is applied over a resistance of $110\,\Omega$. The heat produced in 7 min is**

a) $11 \times 10^3 cal$ b) $22 \times 10^3 cal$ c) $33 \times 10^3 cal$ d) $25 \times 10^3 cal$

15. **If an AC produces same heat as that produced by a steady current of 4A, then peak value of current is**

a) 4 A b) 1.56 A c) 5.6 A d) 1.41 A

16. **The potential difference across an instrument in an AC circuit of frequencies f is V and the current through it is I such that $V = 5 \cos 2\pi ft$ and $I = 2 \sin 2\pi ft$ amp. The power dissipated in the instrument is**

a) Zero b) 10 W c) 5 W d) 2.5 W

2005

17. **An alternating current is given by $I = I_1 \cos \omega t + I_2 \sin \omega t$. The root mean square current is**

a) $\frac{(I_1 + I_2)}{\sqrt{2}}$ b) $\frac{(I_1 + I_2)^2}{2}$ c) $\sqrt{\frac{I_1^2 + I_2^2}{2}}$ d) $\frac{\sqrt{I_1^2 - I_2^2}}{2}$

18. **The peak value of AC voltage on 220V mains is**

a) $240\sqrt{2} V$ b) $230\sqrt{2} V$ c) $220\sqrt{2} V$ d) $200\sqrt{2} V$

19. **The time taken by an alternating current of 50Hz in reaching from zero to its maximum value will be**

a) 0.5 s b) 0.005 s c) 0.05 s d) 5

Alternating Current

Voltage and Power

Key

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

11) **d** 12) **c** 13) **d** 14) **b** 15) **c** 16) **a** 17) **c** 18) **c** 19) **b**

Solutions

1. V = 150 sin (150t) volt

   And $I = 150\sin(150t + \pi/3) amp$

   $I_0 = 150 amp$ and $V_0 = 150 volt$

   $P = \frac{1}{2} V_o I_0 \cos\phi$

   $P = 0.5 \times 150 \times 150 \times \cos 60^0$

2. Quantity of heat liberated in the ammeter of resistance R

   i) Due to direct current of 3 A, $Q = \left[(3)^2 R/J)\right]$

   ii) Due to alternating current of 4 A, $Q = \left[(4)^2 R/J)\right]$

   Total heat produced per second $= \frac{(3)^2 R}{J} + \frac{(4)^2 R}{J} = \frac{25R}{J}$

   But, $\frac{I^2 R}{J} = \frac{25R}{J}$

   I = 5 A

3. $V = V_0 \sin\omega t$

   $V = V_{rms}\sqrt{2}\sin\omega t$

$t = \frac{1}{720} s$

$V = 120\sqrt{2} \sin 2\pi \nu t \; = 120\sqrt{2} \sin 2\pi \times 60 \times \frac{1}{720} \; = 60\sqrt{2} = 84.8V$

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

$P_{av} = \frac{(E_0 I_0 \cos\phi) T/2}{T}$

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

8. $\cos\phi \; \alpha \frac{1}{Z}$

$\therefore \quad \frac{Z_1}{Z_2} = \frac{\cos\phi_1}{\cos\phi_2} = \frac{1/4}{1/2} = \frac{1}{2}$

$\Rightarrow \quad Z_2 = 2Z_1$

Percentage change $= \frac{2Z_1 - Z_1}{Z_1} \times 100$ =100%

9. e = 80 sin $100\pi t$

Here, $e_0 = 80V$

Where e_0 is the peak value of voltage

Impedance (Z) = 20 Ω

$I_0 = \frac{e_0}{Z} \; I_0 = \frac{e_0}{Z}$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{4}{\sqrt{2}} = 2\sqrt{2} = 2.828\,A$

11. $i_{rms} = \frac{i_0}{\sqrt{2}}$

$\Rightarrow i_0 = \sqrt{2} \times i_{rms} = \sqrt{2} \times 10\,A = 10\sqrt{2}\,A$

2011

13. $V = V_0 \sin\omega t$ and $I = I_0 \sin(\omega t - \pi/2)$

$\therefore\ P = \frac{1}{2}V_0 I_0 \cos\phi$

But $\phi = \pi/2 = 90^0$

$P = \frac{1}{2}V_0 I_0 \cos 90^0$

$= 0\ \left(\therefore \cos 90^0 = 0\right)$

14. $H = \frac{I_v^2 RT}{J} cal = \frac{\left(\sqrt{2}\right)^2 \times 100 \times 7 \times 60}{42} = 22 \times 10^3$ Cal

$\left(\because I_{ms} = \frac{I_0}{\sqrt{2}} = \frac{220/100}{\sqrt{2}} = \sqrt{2}\right)$

15. $I_0 = \sqrt{2}\, I_{rms}$

$I_{rms} = 4A$

$I_0 = \sqrt{2} \times 4 = 5.6\,A$

16. $P = VI\cos\phi$

V= 5cos $P = VI\cos 2\pi ft$

$V = 5\sin\left(2\pi ft + \frac{\pi}{2}\right) and\ I = 2\sin 2\pi ft$

Here, $\phi = \frac{\pi}{2}$

$P = VI\cos\phi = VI\cos\frac{\pi}{2} = 0$

17. $I = I_1\cos\omega t + I_2\sin\omega t$

$I_0 = \sqrt{I_1^2 + I_2^2}$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{\sqrt{I_1^2 + I_2^2}}{\sqrt{2}} = \sqrt{\frac{I_1^2 + I_2^2}{2}}$

18. $V_{rms} = 220V$

But $V_{rms} = \frac{peak\ voltage}{\sqrt{2}} = \frac{V_P}{\sqrt{2}}$

$V_P = 220\sqrt{2}\,V$

19. $T = \frac{1}{f} = \frac{1}{50} = 0.0.2s$

$\therefore \frac{T}{4} = \frac{0.02}{4} = 0.005s$

AC Circuits

2011

1. In an AC circuit an alternating voltage $e = 200\sqrt{2}\sin 100t$ volt is connected to a capacitor of capacity $1\mu F$. The rms value of the current in the circuit is

a) 100 mA b) 200 mA c) 20 mA d) 10 mA

2. An AC voltage is applied to a resistance R and an inductor L in series. If R and the inductive reactance are both equal to 3Ω, the phase difference between the applied voltage and the current in the circuit is

a) $\pi/4$ b) $\pi/2$

c) Zero d) $\pi/6$

3. The peak value of an alternating current is 5A and its frequency is 60Hz. Find its rms value and time taken to reach the peak value of current starting from zero

a) 3.536 A, 4.167 ms b) 3.536 A, 15 ms

c) 6.07 A, 10 ms d) 2.536 A, 4.167 m

4. An L – C – R series current is under resonance. If I_m is current amplitude, V_m is voltage amplitude, R is the resistance, z is impedance, X_L is the inductive reactance and X_C is the capacitive reactance then

a) $I_m = \frac{V_m}{Z}$ b) $I_m = \frac{V_m}{X_L}$ c) $I_m = \frac{V_m}{X_C}$ d) $I_m = \frac{V_m}{R}$

5. In the case of an inductor

a) Voltage lags the current by $\frac{\pi}{2}$ b) Voltage leads the current by $\frac{\pi}{2}$

c) Voltage leads the current by $\frac{\pi}{3}$ d) Voltage leads the current by $\frac{\pi}{4}$

2010

6. **The power factor of an R – L circuit is $\frac{1}{\sqrt{2}}$. If the frequency of AC is doubled, what will be the power factor?**

a) $\frac{1}{\sqrt{3}}$ b) $\frac{1}{\sqrt{5}}$ c) $\frac{1}{\sqrt{7}}$ d) $\frac{1}{\sqrt{11}}$

7. **An ideal choke draws a current of 8A when connected to an AC supply of 100V, 50Hz. A pure resistor draws a current of 10A when connected to the same source. The ideal choke and the resistor are connected in series and then connected to the AC source of 150V, 40Hz. The current in the circuit becomes**

a) $\frac{15}{\sqrt{2}}A$ b) 8A c) 18A d) 10A

8. **In an AC circuit the potential difference V and current i are given respectively by** $V = 100\sin(100t)$ volt **and** $i = 100\sin\left(100t + \frac{\pi}{3}\right)mA$**. The power dissipated in the circuit will be**

a) $10^4 W$ b) 10 W c) 2.5 W d) 5 W

9. **An inductor L, a capacitor of** $20\mu F$ **and a resistor of** 10Ω **are connected in series with an AC source of frequency 50Hz. If the current in the phase with the voltage, then the inductance of the inductor is**

a) 2.00 H b) 0.51 H c) 1.5 H d) 0.99 H

10. **The impedance of a circuit, when a resistance R and an inductor of inductance L are connected in series in an AC circuit of frequency f, is**

a) $\sqrt{R + 2\pi^2 f^2 L^2}$ b) $\sqrt{R + 4\pi^2 f^2 L^2}$

c) $\sqrt{R^2 + 4\pi^2 f^2 L^2}$ d) $\sqrt{R^2 + 2\pi^2 f^2 L^2}$

11. **In a series L – C – R circuit, resistance** $R = 10\Omega$ **and the impedance** $Z = 10\Omega$**. The phase difference between the current and the voltage is**

a) 0° b) 30° c) 45° d) 60°

12. The inductive time constant in an electrical circuit is

a) LR b) $\frac{L}{R}$ c) $\sqrt{\frac{L}{R}}$ d) $\frac{R}{L}$

13. In a L – C – R circuit $R = 10\Omega$. When capacitance C is removed, the current lags behind the voltage by $\frac{\pi}{3}$, when inductance L is removed, the current leads the voltage by $\frac{\pi}{3}$. The impedance of the circuit is

a) 50Ω b) 100Ω c) 200Ω d) 400Ω

14. In an L – C – R series Ac circuit at resonance

a) The capacitive reactance is more than the inductive reactance

b) The capacitive reactance equals the inductive reactance

c) The capacitive reactance is less than the inductive reactance

d) The power dissipated is minimum

15. An L – C – R series circuit consists of a resistance of 10Ω a capacitor of reactance 6.0Ω and an inductor coil. The circuit is found to resonate when put across a 300V, 100Hz supply. The inductance of coil is (taking $\pi = 3$)

a) 0.1 H b) 0.01 H c) 0.2 H d) 0.02 H

16. A capacitor or capacitance $1\mu F$ is charged to a potential of 1V. It is connected in parallel to an inductor of inductance $10^{-3} H$. The maximum current that will flow in the circuit has the value

a) $\sqrt{1000}\, mA$ b) 1 A c) 1 mA d) 1000 mA

17. Assertion: For an electric lamp connected in series with a variable capacitor and AC source, its brightness increases with increase in capacitance

Reason: Capacitive reactance decreases with increase in

1) Both assertion and reason are true and reason is the correct explanation of assertion

2) Both assertion and reason are true but reason is not the correct explanation of assertion

3) Assertion is true but reason is false

4) Assertion is false but reason is true

18. In an L – R circuit, the value of L is $\left(\frac{0.4}{\pi}\right)H$ and the value of R is 30Ω. If in the circuit, an alternating emf of 200V at $50\,\text{cycle/s}$ is connected, the impedances of the circuit and current will be

a) $11.4\Omega, 17.5A$ b) $30.7\Omega, 6.5A$ c) $40.4\Omega, 5A$ d) $50\Omega, 4A$

2009

19. Power dissipated in an L – C – R series circuit connected to an AC source of emf ε is

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

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

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

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

20. An AC voltage is applied to a pure inductor L, drives a current in the inductor. The current in the inductor would be

a) Ahead of the voltage by $\pi/2$ b) Lagging the voltage by $\pi/2$

c) Ahead of the voltage by $\pi/4$ d) Lagging the voltage by $3\pi/4$

21. The average power dissipated in a pure capacitance AC circuit is

a) CV b) Zero c) $\frac{1}{CV^2}$ d) $\frac{1}{4}CV^2$

22. In a pure inductive circuit, current

a) Lags behind emf by $\frac{\pi}{2}$ b) Leads the emf by $\frac{\pi}{2}$

c) Lags behind by π d) Leads the emf by π

23. An alternating current of rms value 10A is passed through a 12Ω resistor. The maximum potential difference across the resistor is

a) 20 V b) 90 V c) 169.68 V d) None of these

24. Same current is flowing in to alternating circuits. The first circuit contains only inductance and the other contains only a capacitor. If the frequency of the emf of AC is increased, the effect on the value of the current will be

a) Increases in the first circuit and decreases in the other

b) Increases in both the circuits

c) Decreases in both the circuits

d) Decreases in the first circuit and increases

2008

25. An AC source of angular frequency ω is fed across a resistor R and a capacitor C in series. The current registered is I. If now the frequency of source is changed to $\omega/3$ (but maintaining the same voltage), the current in the circuit is found to be halved. Calculate the ratio of reactance to resistance at the original frequency ω

a) $\sqrt{\frac{3}{5}}$ b) $\sqrt{\frac{2}{5}}$ c) $\sqrt{\frac{1}{5}}$ d) $\sqrt{\frac{4}{5}}$

26. What is the value of inductance L for which the current is a maximum in a series L – C – R circuit with $C = 10\mu F$ and $\omega = 1000\, s^{-1}$?

a) 100 mH b) 1 mH

c) Cannot be calculated unless R is known d) 10 mH

27. In non – resonant circuit, what will be the nature of the circuit for frequencies higher than the resonant frequency?

a) Resistive b) Capacitive c) Inductive d) None of the above

28. A coil has an inductance of 0.7H and is joined in series with a resistance of 20Ω. When an alternating emf of 220V at 50 cps is applied to it, then the wattles component of the current in the circuit is

a) 5 A b) 0.5 A c) 0.7 A d) 7 A

29. In L – C – R circuit what is the phase angle ϕ ?

a) $90°$ b) $180°$ c) $0°$ d) $60°$

30. In R – C circuit $\omega = 100\, rad\, s^{-1}$, $R = 100\Omega$, $C = 20\mu F$. What is impedance?

a) 510Ω b) 200Ω c) 250Ω d) 300Ω

31. The power factor in a circuit connected to an AC power supply has a value which is

a) Unity when the circuit contains only inductance

b) Unity when the circuit contains only resistance

c) Zero when the circuit contains an ideal resistance only

d) Unity when the circuit contains an ideal capacitance only

32. In an AC circuit, a resistance of R ohm is connected in series with an inductor of self inductance L. If phase angle between voltage and current be $45°$, the value of inductive reactance (X_L) will be equal to

a) R b) $\frac{R}{8}$ c) $\frac{R}{4}$ d) $\frac{R}{2}$

33. A transistor – oscillator using a resonant circuit with an inductor L (or negligible resistance) and a capacitor C in series produce oscillations of frequency f. If L is doubled and C is changed to 4C, the frequency will be

a) $f/4$ b) 8f c) $f/2\sqrt{2}$ d) $f/2$

34. The natural frequency (ω_o) of oscillations in L – C circuit is given by

a) $\frac{1}{2\pi}\frac{1}{\sqrt{LC}}$ b) $\frac{1}{2\pi}\sqrt{LC}$ c) $\frac{1}{\sqrt{LC}}$ d) $\sqrt{LC}$

35. In L – C- R circuit the resonance condition in terms of capacitive reactance (X_C) and inductive reactance (X_L) is

a) $X_C + X_L = 0$ b) $X_C = 0$ c) $X_L = 0$ d) $X_C - X_L = 0$

2007

36. An inductor of inductance L and resistor of resistance R are joined in series and connected by a source of frequency ω. Power dissipated in the circuit is

a) $\left(\frac{R^2+\omega^2L^2}{V}\right)$ b) $\frac{V^2R}{\left(R^2+\omega^2L^2\right)}$ c) $\left(\frac{V}{R^2+\omega^2L^2}\right)$ d) $\frac{\sqrt{R^2+\omega^2L^2}}{V^2}$

37. An inductive coil has a resistance of $100\,\Omega$. When an AC signal of frequency 1000 Hz is applied to the coil, the voltage leads the current by $45°$. The inductance of the coil is

a) $\frac{1}{10\pi}$ 2) $\frac{1}{20\pi}$ c) $\frac{1}{40\pi}$ d) $\frac{1}{60\pi}$

38. The reactance of a coil when used in the AC power supply $\left(220V, 50\,\text{cycles}^{-1}\right)$ is $50\,\Omega$. The inductance of the coil is nearly

a) 0.16 H b) 0.22 H c) 2.2 H d) 1.6 H

39. An inductance of $\left(\frac{200}{\pi}\right)mH$, a capacitance of $\left(\frac{10^{-3}}{\pi}\right)F$ and a resistance of $10\,\Omega$ are connected in series with an AC source 220V, 50Hz. The phase angle of the circuit is

a) $\frac{\pi}{6}$ b) $\frac{\pi}{4}$ c) $\frac{\pi}{2}$ d) $\frac{\pi}{3}$

40. In a circuit, the current lags behind the voltage by a phase difference of $\pi/2$, the circuit will contain which of the following?

a) Only R b) Only C c) R and C d) Only L

41. A coil of inductive reactance 31Ω has a resistance of $8\,\Omega$. It is placed in series with a condenser of capacitive reactance $25\,\Omega$. The combination is connected to an AC source of 110V. The power factor of the circuit is

a) 0.56 b) 0.64 c) 0.80 d) 0.33

42. In a choke coil, the reactance X_L and resistance R are such that

a) $X_L = R$ b) $X_L >> R$ c) $X_L << R$ d) $X_L = \infty$

43. The power factor of a series L – C – R circuit when at resonance is

a) Zero b) 0.5 c) 1.0 d) Depends on values of L, C and R

2006

44. **In a series L – C – R circuit the frequency of a 10V, AC voltage source is adjusted in such a fashion that the reactance of the inductor measures 15Ω and that of the capacitor 11Ω. If $R = 3\Omega$, the potential difference across the series combination of L and C will be**

a) 8 V b) 10 V c) 22 V d) 52 V

45. **An L – C circuit is in the state of resonance. If $C = 0.1\mu F$ and L = 0.25H, neglecting ohmic resistance of circuit, what is the frequency of oscillations?**

a) 1007 Hz b) 100 Hz c) 109 Hz d) 500 Hz

46. **In an AC circuit, the current lags behind the voltage by $\pi/3$. The components of the circuit are**

1) R and L 2) L and C 3) R and C 4) Only R

47. **What is the ratio of inductive and capacitive reactance in AC circuit?**

a) $\omega^2 LC$ b) 1 c) zero d) $\omega^2 L$

48. **If a circuit made up of a resistance 1Ω and inductance 0.01H, and alternating emf 200V at 50Hz is connected, then the phase difference between the current and the emf in the circuit is**

a) $\tan^{-1}(\pi)$ b) $\tan^{-1}\left(\frac{\pi}{2}\right)$ c) $\tan^{-1}\left(\frac{\pi}{4}\right)$ d) $\tan^{-1}\left(\frac{\pi}{3}\right)$

49. **A circuit draws 330W from a 110V, 60Hz AC line. The power factor is 0.6 and the current lags the voltage. The capacitance of a series capacitor that will result in a power factor of unity is equal to**

a) $31\mu F$ b) $54\mu F$ c) $151\mu F$ d) $201\mu F$

2005

50. **In a circuit, L, C and R are connected in series with an alternating voltage source of frequency f. The current leads the voltage by $45°$. The value of C is**

a) $\frac{1}{2\pi f(2\pi fL + R)}$ b) $\frac{1}{\pi f(2\pi fL + R)}$

c) $\frac{1}{2\pi f(2\pi fL - R)}$ d) $\frac{1}{\pi f(2\pi fL - R)}$

AC Circuits

Key

1) c	2) a	3) a	4) a	5) b	6) b	7) a	8) c	9) b	10) c
11) a	12) b	13) b	14) b	15) a	16) a	17) a	18) d	19) a	20) a
21) b	22) a	23) c	24) d	25) a	26) a	27) c	28) b	29) c	30) a
31) b	32) a	33) c	34) a	35) d	36) b	37) b	38) a	39) b	40) d
41) c	42) b	43) c	44) a	45) a	6) a	47) a	48) a	49) b	50) c

Solutions

1. $e = 200\sqrt{2}\sin 100t$ and $C = 1\mu F$

$$E_{rms} = 200V$$

$$X_C = \frac{1}{\omega C} = \frac{1}{1\times10^{-6}\times100} = 10^4\Omega$$

$$i_{rms} = \frac{E_{rms}}{X_c}$$

$$i_{rms} = \frac{200}{10^4} = 2\times10^{-2}A = 20\,mA$$

2. $\tan\phi = \frac{X_L}{R} = \frac{L\omega}{R}$

$$\tan\phi = \frac{3\Omega}{3\Omega} \quad \text{Or} \quad \phi = \frac{\pi}{4}rad$$

3. $i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{5}{\sqrt{2}} = 2.536A$

$$T = \frac{1}{4\times60} = 4.167\,ms$$

6. $\cos\phi = \frac{R}{\sqrt{R^2+4\omega^2L^2}} = \frac{R}{\sqrt{R^2+4R^2}} = \frac{1}{\sqrt{5}}$

7. $R = \frac{100}{10} = 10\Omega$

$X_L = 2\pi fL$

$\frac{100}{8} = 2\pi \times 50 \times L$

$\Rightarrow L = \frac{1}{8\pi} H$

$X_i = 2\pi fL = 2\pi \times 40 \times \frac{1}{8\pi}$

$X_i = 2\pi fL = 2\pi \times 40 \times \frac{1}{8\pi} = \sqrt{(10)^2 + (10)^2} = 10\sqrt{2}\Omega$

$i = \frac{V}{Z} = \frac{150}{10\sqrt{2}} = \frac{15}{\sqrt{2}} A$

8. $V_0 = 100V$, $i_0 = 100\,mA = 100 \times 10^{-3} A$ and $\phi = \frac{\pi}{3} = 60^0$

$P = \frac{V_0 i_0}{2} \cos\phi = \frac{100 \times 100 \times 10^{-3}}{2} \times \cos 60^0 = 2.5$ W

9. $\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R} = 0$

$\omega L - \frac{1}{\omega C}$

$L = \frac{1}{\omega^2 C}$

Here $\omega = 2\pi f = 2 \times 3.14 \times 50 s^{-1} = 314 s^{-1}$

And $C = 20\mu F = 20 \times 10^{-6} F$

$\therefore L = \frac{1}{(314 s^{-1})^2 \times (20 \times 10^{-6} F)} = 0.51 H$

11. $Z = \sqrt{R^2 + X_L^2}$

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

$Z = \sqrt{R^2 + 4\pi^2 f^2 L^2}$

$$\therefore\ 10=\sqrt{(10)^2+(X_L-X_C)^2}$$

$$\Rightarrow\ 100=100+(X_L-X_C)^2$$

$$\Rightarrow\ X_L-X_C=0$$

13. $\tan\frac{\pi}{3}=\frac{X_L}{R}$

When L is removed, $\tan\frac{\pi}{3}=\frac{X_L}{R}$

Z= R = 100Ω

$$\Rightarrow i_0=\frac{220\times\sqrt{2}}{100\pi}=\frac{220\times\sqrt{2}}{100\times 3.14}$$

$I_0=1A$

15. $\omega_0=2\pi n-2\pi\times 100$

$\omega_0=2\times 3\times 100=600 rad/s$

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

$$X_C=\frac{1}{C\omega_0}=60\omega$$

$$\Rightarrow\ C=\frac{1}{\omega_0\times 60}=\frac{1}{600\times 60}$$

$$600-\frac{1}{\sqrt{L\left(\frac{1}{36\times 10^3}\right)}}$$

$$36\times 10^4=\frac{36\times 10^3}{L}$$

$$L=\frac{36\times 10^3}{36\times 10^4}=\frac{1}{10}=0.1H$$

16. $q=q_0\sin\omega t$

Or $I_0=\omega q_0=$ maximum current

$$\omega=\frac{1}{\sqrt{LC}}=\frac{1}{\sqrt{10^{-9}}}=\left(10^9\right)^{1/2}$$

$$I_0 = \left(10^9\right)^{1/2} \times \left(1 \times (10^{-6}\right) = \sqrt{1000}\, mA$$

18. $$X_L = \omega L = 2\pi fL = 2\pi \times 50 \times \frac{0.4}{\pi} = -40\Omega$$

$$R = 30\Omega$$

$$Z = rR^2 + X_L^2 = \sqrt{(30)^2 + (40)^2} = 50\Omega$$

$$i_{rms} = \frac{v_{rms}}{X} = \frac{200}{50} = 4A$$

25. $$I_{rms} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$$

Also, $$\frac{I_{rms}}{2} = \frac{V_{rms}}{\sqrt{R^2 + \left[\frac{\frac{1}{\omega c}}{3}\right]^2}} = \frac{V_{rms}}{\sqrt{R^2 + \frac{9}{\omega^2 C^2}}}$$

$$\therefore 3R^2 = \frac{5}{\omega^2 C^2}$$

$$\Rightarrow \frac{\frac{1}{\omega C}}{R} = \sqrt{\frac{3}{5}}$$

26. $$i = \frac{V}{\sqrt{R^2 + (X_L = X_C)^2}}$$

But, $X_L = X_C$

Or $\omega L = \frac{1}{\omega C}$ Or $L = \frac{1}{\omega^2 C}$

$$\omega = 1000\, s^{-1}, C = 10\mu F = 10 \times 10^{-6}$$

$$\therefore L = \frac{1}{(1000)^2 \times 10 \times 10^{-6}} = 0.1 \text{ H}$$

28. Wattless component of current $= I_v \sin\theta = \frac{E_V}{Z} \sin\theta$

$$= \frac{220}{\sqrt{R^2 + \omega^2 L^2}} \times \frac{\omega L}{\sqrt{R^2 + \omega^2 L^2}} = \frac{220 \times \omega L}{\left(R^2 + \omega^2 L^2\right)}$$

$$= \frac{220 \times (2\pi \times 50 \times 0.7)}{(220)^2 + (2\pi \times 50 \times 0.7)^2} = \frac{1}{2} = 0.5A$$

34. $X_L = X_C \Rightarrow \quad \omega_o L = \frac{1}{\omega_0 C}$

$$\omega_0^2 = \frac{1}{LC}$$

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

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

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

35. Resonance condition is $X_L = X_C$ or $X_C - X_L = 0$

37. $\tan\phi = \frac{X_L}{R}$

$$\Rightarrow \tan 45^0 = \frac{L\omega}{R}$$

$$\Rightarrow L = \frac{R}{\omega} = \frac{100}{2\pi(1000)}$$

$$\Rightarrow L = \frac{1}{20\pi}$$

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

$X_L = 50\Omega,\ f = 50cps$

$$L = \frac{X_L}{\omega} = \frac{X_L}{2\pi f} = \frac{50}{2\pi \times 50} = \frac{1}{2 \times 3.14} = 0.16H$$

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

$$X_L = 2\pi fL = 2\pi \times 50 \times \left[\frac{200}{\pi} \times 10^{-3}\right] = 20\Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1 \times \pi}{2\pi \times 50 \times 10^{-3}} = 10\Omega$$

And $R = 10\Omega$

$$\tan\theta = \frac{20-10}{10} = 1$$

$$\tan\theta = \tan\frac{\pi}{4}$$

$$\theta = \frac{\pi}{4}$$

45. $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.25\times0.1\times10^{-6}}} \approx 1007\,Hz$

47. $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$

$$\frac{X_L}{X_C} = \frac{\omega L}{1/\omega C} = \omega^2 LC$$

48. $\tan\phi = \frac{X_L}{R}$ and $X_L = \omega L = 2\pi fL = 2\pi\times50\times0.01 = \pi\Omega$

Also $R = 1\Omega$ $\therefore \phi = \tan^{-1}(\pi)$

49. $R = \frac{V_2}{P} = \frac{110\times110}{330} = \frac{110}{3}\Omega$

Cos $R = \frac{V_2}{P} = \frac{110\times110}{330} = \frac{110}{3}\Omega$ = 0.6.

$$\frac{R}{\sqrt{R^2 + X_L^2}} = 0.6$$

$$R^2 + X_L^2 = \left(\frac{R}{0.6}\right)^2$$

$$X_L^2 = \frac{R^2}{(0.6)^2} - R^2 \qquad \Rightarrow X_L^2 = \frac{R^2\times0.64}{0.36}$$

$$X_L = \frac{0.8R}{0.6} = \frac{4R}{3}$$

And

$$X_L = K_C$$

$$X_C = \frac{4R}{3} = \frac{4}{3}\times\frac{100}{3} = \frac{440}{9}\Omega$$

$$\frac{1}{2\pi f} = \frac{440}{9}\Omega$$

$$C = \frac{9}{2 \times 3.14 \times 60 \times 440}$$

$$-0.000054\,F = 54\,\mu F$$

50. $$\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R}$$

$$\phi = 45°$$

$$\therefore \quad \tan 45° = \frac{\omega L - \frac{1}{\omega C}}{R}$$

$$\Rightarrow \; 1 = \frac{\omega L - \frac{1}{\omega C}}{R}$$

$$\Rightarrow \quad R = \omega L - \frac{1}{\omega C}$$

$$\Rightarrow \quad \omega C = \frac{1}{(\omega L - R)}$$

$$\Rightarrow \quad C = \frac{1}{2(\omega L - R)} = \frac{1}{2\pi f\,(2\pi f L - R)}$$

Growth and Decay of Current

2010

1. A coil of resistance R and inductance L is connected to a battery of emf E volt. The final current in the coil is

a) $\frac{E}{R}$ b) $\frac{E}{L}$ c) $\sqrt{\frac{E}{R^2+L^2}}$ d) $\sqrt{\frac{EL}{R^2+L^2}}$

2008

3. A coil of inductance 300mH and resistance 2Ω is connected to a source of voltage 2V. The current reaches half of its steady state value in

a) 0.05 s b) 0.1 s c) 0.15 s d) 0.3 s

2007

4. A coil of 40H inductance is connected in series with a resistance of 8Ω and this combination is connected to the terminals of 2V battery. The inductive time constant of the circuit is (in second)

a) 40 b) 20 c) 5 d) 0.2

5. In an L – R circuit, time constant is that time in which current grows from zero to the value

a) $0.63 I_o$ b) $0.50 I_o$

c) $0.37 I_o$ d) I_o

2004

6. In a series resonant L – C – R circuit, the voltage across R is 100V and $R = 1k\Omega$ with $C = 2\mu F$. The resonant frequency ω is $200\, rad\, s^{-1}$. At resonance the voltage across L is

a) $2.5\times10^{-2} V$ b) 40 V c) 250 V d) $4\times10^{-3} V$

Growth and Decay of Current

Key

1) **a** 2) **c** 3) **b** 4) **c** 5) **a** 6) **c**

Hints

2. At time t = 0, i.e., when capacitor is charging, current $I = \frac{2}{1000} = 2mA$

$$I = \frac{2}{2000} = 1mA$$

3. $$I = I_o\left(1 - e^{-Rt/L}\right)$$

$$\frac{I_o}{2} = I_o\left(1 - e^{-Rt/L}\right)$$

$$\frac{1}{2} = \left(1 - e^{-Rt/L}\right)$$

$$e^{-Rt/L} = 1/2$$

$$\frac{Rt}{L} = \ln 2$$

$$\therefore \quad \frac{L}{R}\ln 2 = \frac{300 \times 10^{-3}}{2} \times 0.693$$

$= 150 \times 0.693 \times 10^{-3}$

= 0.10395 s = 0.1 s

4. $t = \frac{L}{R} = \frac{40}{8} = 5s$

5. $I = I_o\left(1 - e^{-1/\tau}\right)$

$\tau\left(= \frac{L}{R}\right)$ Is called time constant.

At $t = \tau$

$$I = I_o\left(1 - e^{-1}\right)$$

Or $I = I_o\left(1-\frac{1}{e}\right)$

Or $I = 0.63 I_o$

6. $\omega L = \frac{1}{\omega C}$

$I = \frac{V_R}{R} = \frac{100}{1000} = 0.1A$

$V_L = IX_L = I\omega L$

But $\omega L = \frac{1}{\omega C}$

$\therefore V_L = \frac{1}{\omega C} = \frac{0.1}{200\times 2\times 10^{-6}} = 250V$