Solution

CET25P7 ALTERNATING CURRENT

Class 12 - Physics

1.

(c) Pure resistive circuit0

Explanation: Since in pure resistive circuit the current and voltage are in phase, the power dissipation is maximum.

2.

(d) L/2

Explanation: The resonance frequency is given by

$f_0 = \frac{1}{2\pi\sqrt{L\,C}}$

When C is changed to 2C, f_0 will remain unchanged, if L is changed to L/2.

3.

(d) 300 volt

Explanation: 300 volt

4.

(c) 161 V

Explanation: R = 300.0 Ω, X_C = 300.0 Ω and X_L = 500.0 Ω, $P_{av} = 60W$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{300^2 + (500 - 300)^2} = 100\sqrt{13}\Omega$

$P_{av} = V_{rms} \times I_{rms} \times \cos\phi$

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

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

Thus, $P_{av} = \frac{(V_{rms})^2}{Z} \times \frac{R}{Z} = \frac{(V_{rms})^2 R}{Z^2}$

$60 = \frac{(V_{rms})^2 \times 300}{100\sqrt{13} \times 100\sqrt{13}}$

$V_{rms} = \sqrt{\frac{60 \times 100 \times 13}{3}} = 161V$

5.

(d) 0 V

Explanation: Average value of AC voltage for a half cycle is positive and similarly, the mean value of AC voltage for other half cycle is negative.

Average potential difference between the two terminals for complete full cycle,

$V_{av} = (0.637V_0) + (-0.637V_0) = 0$ V

6.

(c) 120 V

Explanation: Flux linked with the primary coil,

$\phi = \phi_0 + 4t$

Voltage across primary,

$V_p = \frac{d\phi}{dt} = 0 + 4 \times 1$ = 4 V

Voltage across secondary,

$V_s = \frac{N_s}{N_p} \cdot V_p = \frac{1500}{50} \times$ 4 = 120 V

7.

(d) zero

Explanation: Since reactive impedance at resonance is zero and we know that,

tan ϕ = X_L - $\frac{X_C}{Z}$

but X_L - X_C = 0

therefore ϕ = 0

8.

(d) 22×10^3 cal

Explanation: $H = \frac{\varepsilon_{rms}^2 t}{RJ} = \frac{\varepsilon_0^2 t}{2RJ} = \frac{(220)^2 \times 7 \times 60}{2 \times 110 \times 4.2}$

= 22×10^3 cal

9. **(a)** 0.239 H

Explanation: $X_L = 120\Omega$, f = 80Hz

Now,

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

$L = \frac{X_L}{2\pi f} = \frac{120}{2 \times 3.14 \times 80} = 0.239H$

10.

(d) 198 V

Explanation: $V_{av} = \frac{2}{\pi} V_0 = \frac{2}{\pi} \times \left(V_{rms} \times \sqrt{2}\right) = \frac{2\sqrt{2}}{\pi} \cdot V_{rms}$

$= \frac{2\sqrt{2}}{\pi} \times 220 = 198V$

11.

(b) 3.2×10^{-3} A, 0.16 A

Explanation: $\frac{I_1}{I_2} = \frac{3.2 \times 10^{-3}}{0.16} = \frac{1}{50} = \frac{10}{500} = \frac{N_2}{N_1}$

12.

(c) 10 W

Explanation: Let P = actual power used

W = power specified = 40 W

V_A = Applied voltage = 100 V

V_S = Specified voltage = 200 V

Now,

$P = \left(\frac{V_A}{V_S}\right)^2 W$

$P = \left(\frac{100}{200}\right)^2 \times 40 = 10W$

13. **(a)** 4800 W, 0.6

Explanation: $R = 3\Omega$

L = 25.48mH

$C = 796\mu F$

V_{rms} = 283V

f = 50Hz

Impedance

$X_L = 2\pi f L = 2 \times 3.14 \times 50 \times 25.48 \times 10^{-3} = 8\Omega$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2 \times 3.14 \times 50 \times 796 \times 10^{-6}} = 4\Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{3^2 + (8-4)^2} = 5\Omega$

Power dissipated in the circuit,

P = i^2R

$i = \frac{i_m}{\sqrt{2}} = \frac{1}{\sqrt{2}} \frac{V_{rms}}{Z} = \frac{1}{\sqrt{2}} \times \frac{283}{5} = 40A$

$P = i^2 R = 40 \times 40 \times 3 = 4800W$

power factor,

$\cos\phi = \frac{R}{Z} = \frac{3}{5} = 0.6$

14. **(a)** soft iron

Explanation: Soft iron provides the best material for the core of a transformer as its permeability (μ) is very high. Its hysteresis curve is of small area and its coercivity is very low.

15. **(a)** 3 V

Explanation: $\varepsilon_2 = \frac{N_2}{N_1} \cdot \varepsilon_1 = \frac{2}{1} \times 1.5 = 3$ V

16. **(a)** $\frac{15}{\sqrt{2}}$ A

Explanation: I = I_0 sinωt

I = $I_{rms} \times \sqrt{2} \times \sin(2\pi ft)$

or, I = $15 \times \sqrt{2} \times \sin\frac{2\times\pi\times50}{600}$

or, I = $15 \times \sqrt{2} \times \sin\left(\frac{\pi}{6}\right)$

I = $\frac{15}{\sqrt{2}}$ A

17. **(a)** 66 V, 210 V

Explanation: $R = 100\Omega$

$C = 10\mu F$

V = 220 volt

f = 50Hz

$Z = \sqrt{R^2 + {X_C}^2}$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi fC} = \frac{1}{2\times3.14\times50\times10\times10^{-6}} = 318.5\Omega$

$Z = \sqrt{(100)^2 + (318.5)^2} = 333.8\Omega$

Current in circuit,

$i = \frac{V}{Z} = \frac{220}{333.8} = 0.66A$

Voltage across the resistor, $V_R = iR = 0.66 \times 100 = 66V$

Voltage across the capacitor, $V_C = iX_C = 0.66 \times 318.5 = 210V$

18.

(c) $\frac{1}{400}$ s

Explanation: $I = I_0 \sin 2\pi ft = 100 \sin 200\pi t$

$\therefore 2f = 200$ or $f = 100$ Hz

$T = \frac{1}{f} = \frac{1}{100}$ s

Time taken by current to rise from zero to peak value

$= \frac{T}{4} = \frac{1}{4\times100}$ s $= \frac{1}{400}$ s

19.

(c) 1.06 A

Explanation: Maximum value of current, $i_0 = 1.5A$

Thus, root-mean-square current,

$i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{1.50}{\sqrt{2}} = 1.06A$

20. **(a)** $0 \cdot 8$

Explanation: Power factor $cos\phi = \frac{R}{Z}$

Here, R = 12 ohm and Z = 15 ohm

$\therefore$ power factor = $\frac{12}{15}$ = $0 \cdot 8$

21.

(b) 7.54×10^2 m

Explanation: Resonant frequency,

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

$= \frac{1}{2\pi\sqrt{8\times10^{-6}\times0.02\times10^{-6}}}$ Hz

= 3.98×10^5 Hz

Resonant wavelength,

$\lambda = \frac{c}{f_r} = \frac{3\times10^8}{3.9\times10^5}$

= 7.54×10^2 m

22. **(a)** 600 Ω, 200 Ω and 500Ω

Explanation: Given that

$R = 300\Omega$

$L = 60mH = 60 \times 10^{-3}H$

$C = 0.5\mu F = 0.5 \times 10^{-6} F$

V = 50 volt

$\omega = 10000 rad/s$

Inductive reactance, $X_L = \omega L = 10000 \times 60 \times 10^{-3} = 600\Omega$

Capacitive reactance, $X_C = \frac{1}{\omega C} = \frac{1}{10000 \times 0.5 \times 10^{-6}} = 200\Omega$

Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{300^2 + (600 - 200)^2} = \sqrt{300^2 + 400^2} = 500\Omega$

23. **(a)** 3.07×10^{-8} H

Explanation: Frequency,

$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{360} = \frac{1}{12} \times 10^7$ Hz

Required inductance,

$L = \frac{1}{4\pi^2 f^2 C} = \frac{1}{4\pi^2 \left(\frac{1}{12} \times 10^7\right)^2 \times 1.2 \times 10^{-6}}$

= 3.07×10^{-8} H

24.

(c) decreases the current

Explanation: The coil of choke in a circuit decreases the current.

25. **(a)** 1508 Ω

Explanation: L = 3 H, f = 80 Hz

Inductive reactance, $X_L = \omega L = 2\pi f L = 2 \times 3.14 \times 80 \times 3 = 1508\Omega$

26.

(b) 5.0 ampere

Explanation: $\eta = \frac{V_s I_s}{V_p I_p}$

$\therefore I_p = \frac{V_s I_s}{\eta V_p} = \frac{440 \times 2}{0.80 \times 220}$ = 5 A

27.

(d) X is a capacitor and X_C = R

Explanation: X is a capacitor and X_C = R

28.

(c) 193 Hz

Explanation: V = 45 volt

L = 9.5 mH

i = 3.9 A

f = ?

$V = iX_L = i \times \omega L = i \times 2\pi f L$

Frequency of the source,

$f = \frac{V}{i \times 2\pi L} = \frac{45}{3.9 \times 2 \times 3.14 \times 9.5 \times 10^{-3}} = 0.193 \times 10^3$ = 193Hz

29.

(b) 40 Ω, 5.75 A

Explanation: $R = 40\Omega$

L = 5H

$C = 80\mu F$

Impedence in series LCR circuit, $Z = \sqrt{R^2 + (wL - 1/wC)^2}$

At resonance, $\omega L = \frac{1}{\omega C}$

Hence, $Z = \sqrt{R^2 + 0} = R = 40\Omega$

V = 230 Volt

Hence current,

$i = \frac{V}{Z} = \frac{230}{40} = 5.75A$

30.

(c) inductor decreases and the capacitor increases.

Explanation: inductor decreases and the capacitor increases.

31.

(b) 0.831

Explanation: R = 300.0 Ω, X_C = 300.0 Ω and X_L = 500.0 Ω

$Z=\sqrt{R^2+(X_L-X_C)^2}=\sqrt{300^2+(500-300)^2}=100\sqrt{13}$ ohm

Now, power factor, $\cos\phi=\frac{R}{Z}$

$\cos\phi=\frac{300}{100\sqrt{13}}=0.831$

32. **(a)** 200 V - 50 Hz

Explanation: $\varepsilon_2=\frac{N_2}{N_1}\cdot\varepsilon_1=\frac{500}{50}\times 20=200$ V

The frequency remains unchanged.

33. **(a)** 200 V - 50 Hz

Explanation: $\varepsilon_s=\frac{N_s}{N}\cdot\varepsilon_p$

$=\frac{5000}{500}\times 20=200$ V

frequency remains the same.

34.

(c) Over a full cycle the capacitor C does not consume any energy from the voltage source.

Explanation: The current in a capacitor is ahead of voltage in phase by 90^{o}.

$P_{av}=\varepsilon_{ms}I_{rms}\,cos\left(-\frac{\pi}{2}\right)=0$

35.

(d) R, L

Explanation: The phase difference between the alternating current and emf in R-L circuit varies between zero to $\frac{\pi}{2}$, but never equal to $\frac{\pi}{2}$.

36.

(c) $[M^0L^0TA^0]$

Explanation: CR is the time constant of CR-circuit.

$\therefore[CR]=\left[M^0L^0TA^0\right]$

37.

(c) 0.79 W

Explanation: $X_L=\omega L=314\times 20\times 10^{-3}=6.28\Omega$

$X_C=\frac{1}{\omega C}=\frac{1}{314\times 100\times 10^{-6}}=31.84\Omega$

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

$=\sqrt{50^2+(31.84-628)^2}\Omega$

$=\sqrt{2500+(25.56)^2}\Omega$

$=\sqrt{2500+635.3}\Omega$

$=\sqrt{3153.3}\Omega$

$P_{av}=\left(\frac{V_{rms}}{Z}\right)^2R$

$=\left(\frac{10}{\sqrt{2}}\right)^2\times\frac{50}{3153.3}$ W

= 0.79 W

38.

(c) Zero

Explanation: In pure AC capacitor Circuit, the current leads the voltage by an angle of 90 degrees.

Power in Pure Capacitor Circuit Instantaneous power is given by P = VI

$P=(V_m\,sin\,\omega t)[I_m\,sin(\omega t+\frac{\pi}{2})]$

$\Rightarrow P=I_mV_m\,sin\,\omega t\,cos\omega t$

$\Rightarrow P=\frac{I_m}{\sqrt{2}}\frac{V_m}{\sqrt{2}}\,sin\,2\omega t$

$So,\ P_{avg}=0$

Hence, from the above equation, it is clear that the average power in the Capacitor circuit is zero.

39.

(c) Power

Explanation: Energy losses be zero in transformers hence power remains constant in step down and step up transformer also.

40.

(b) 127 μF

Explanation: Voltage and current will be in phase when $X_C = X_L$

Or, $\frac{1}{\omega C} = \omega L$

Or, $\frac{1}{2\pi fC} = 2\pi fL$

Or, C = $\frac{1}{4\pi^2 f^2 L}$

Or, C = $\frac{1}{4\times(3.14)^2\times(50)^2\times80\times10^{-3}}$

$\therefore$ C = 127 μF

41.

(d) 400

Explanation: N_p = no. of turns in primary coil = 4000

N_s = no. of turns in secondary coil

V_p = input voltage = 2300 V

V_s = output voltage = 230 V

Now, $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$\frac{230}{2300} = \frac{N_s}{4000}$

Thus, N_s = 400

42.

(d) 0.064 H

Explanation: $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

L = $(QR)^2C$

= $(0.4 \times 2 \times 10^3)^2 \times 0.1 \times 10^{-6}$ H

= 0.064 H

43.

(c) $ML^2T^{-3}I^{-2}$

Explanation: Impedance has the same dimensions as the resistance.

$[Z] = [R] = \frac{V}{I} = \frac{\mathrm{ML^2\ T^{-3} I^{-1}}}{\mathrm{I^{-1}}} = \left[\mathrm{ML^2\ T^{-3} I^{-2}}\right]$

44. **(a)** $\frac{10}{\sqrt{2}}$ V

Explanation: $V_R = V_L = V_C$ = 10V

$\Rightarrow$ R = X_L = X_C and Z = R

V = IR = 10 V

When the capacitance is short-circuited,

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

New current, $I' = \frac{V}{Z'} = \frac{V}{\sqrt{2}R} = \frac{10}{\sqrt{2}R}$

$V_L' = I'X_L = \frac{10}{\sqrt{2}R} \times R = \frac{10}{\sqrt{2}}V$

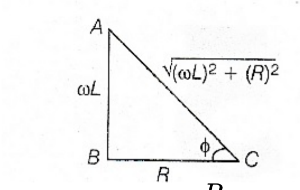
45. **(a)** $R/(R^2 + \omega^2L^2)^{1/2}$

Explanation:

In an LR-circuit, e.m.f leads the current by phase angle ϕ, which is given by

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

Therefore, power factor, $\cos\phi = \frac{1}{\sqrt{1+\tan^2\phi}}$



$\Rightarrow \cos\phi = \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{1}{\sqrt{1+(\omega L/R)^2}}$

$= \frac{1}{\sqrt{1+\tan^2\phi}} = \frac{1}{\sqrt{1+(\omega L/R)^2}} = \frac{R}{\sqrt{R^2+\omega^2L^2}}$

46.

(d) equal to natural frequency of LCR system

Explanation: For maximum current in LCR series circuit, impedance Z will be minimum. Now,

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

Impedance Z will be minimum when $X_L = X_C$

Hence,

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

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

This is equal to natural frequency of LCR system.

47.

(b) 220 V, 50 Hz

Explanation: In India, we use electricity at 220 volt and 50 hertz.

48.

(d) mutual induction

Explanation: A transformer works on the principle of mutual induction.

49. **(a)** soft iron

Explanation: Soft iron is used for the core of a transformer because of its high permeability and low hysteresis loss.

50.

(c) frequency

Explanation: Input and output voltages have same frequency in a transformer.

51.

(c) 90 %

Explanation: The efficiency of a transformer

$\eta = \frac{\text{Output power}}{\text{Input power}} = \frac{V_sI_s}{V_pI_p}$

Here V_SI_S = 100 W, V_P = 220 V, I_P = 0.5 A

$\therefore \eta = \frac{100}{220\times0.5}$ = 0.90 = 90 %

52. **(a)** 7.61mA

Explanation: $R = 200\Omega$, L = 0.4H, $C = 5\mu F = 5\times10^{-6}F$, $\omega = 400rad/s$, E = 3volt

Now, $X_L = \omega L = 400\times0.4 = 160\Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{400\times5\times10^{-6}} = 500\Omega$

$Z = \sqrt{R^2+(X_C-X_L)^2} = \sqrt{200^2+(500-160)^2} = 394.46\Omega$

$i = \frac{E}{Z} = \frac{3}{394.46} = 0.00761A = 7.61mA$

53.

(c) eddy current

Explanation: Lamination increases the resistance and hence reduced the eddy current.

54.

(b) 80 Ω

Explanation: V_R = 1.20 cos(2500t)

Thus, $\omega = 2500 rad/s$

$C = 5\mu F = 5 \times 10^{-6} F$

Capacitive reactance,

$X_C = \frac{1}{\omega C} = \frac{1}{2500 \times 5 \times 10^{-6}} = 80\Omega$

55.

(c) 5.5 V

Explanation: $V_s = \frac{N_s}{N_p} \times V_p = \frac{100}{2000} \times 110$ = 5.5 V

56.

(b) 0 W, 0 W

Explanation: $P = VI\cos\phi$

Average power consumed by inductor is zero as actual voltage leads the current by $\frac{\pi}{2}$ and $\left(\cos\frac{\pi}{2} = 0\right)$.

Average power consumed by capacitor is zero as actual voltage lags the current by $\frac{\pi}{2}$ and $\left(\cos\frac{\pi}{2} = 0\right)$.

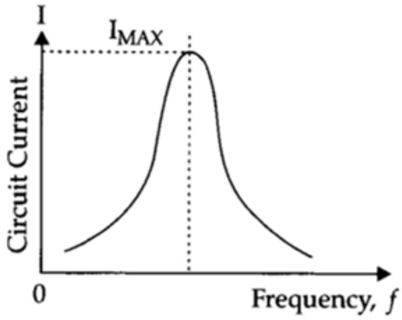
57. **(a)** 10 Ω

Explanation: 10 Ω

58.

(b) L, C and R

Explanation: The frequency vs. circuit current graph in a series LCR circuit is as follows, where current initially increases, reaches a maximum and then decreases with increase in frequency.



Hence, the circuit contains a combination of L,R and C.

59.

(b) 115.0 Ω

Explanation: $R = 115\Omega$

$C = 1.25\mu F = 1.25 \times 10^{-6} F$

$L = 4.5 mH = 4.5 \times 10^{-3} H$

Resonant angular frequency,

$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{4.5 \times 10^{-3} \times 1.25 \times 10^{-6}}} = \frac{1}{7.5 \times 10^{-5}}$

Given that the angular frequency of the ac source $\omega = \omega_0$. It means that $X_L = X_C$

Hence, Impedance,

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{115^2 + 0}$

$Z = 115\Omega$

60. **(a)** Current

Explanation: Current increases in a step-down transformer.

61. **(a)** $\frac{\pi}{2}$

Explanation: $E = E_0 \sin\omega t$

$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

62.

(b) 13.3 μF

Explanation: V = 170 volt, f = 60 Hz, i = 0.85 A

$V = iX_C = i\frac{1}{\omega C} = \frac{i}{2\pi fC}$

Thus, Capacitance required,

$C = \frac{i}{2\pi fV} = \frac{0.85}{2 \times 3.14 \times 60 \times 170} = 13.3 \times 10^{-6} F = 13.3\mu F$

63. **(a)** 8×10^5 Hz

Explanation: $f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$

$= \frac{1}{2\times3.14}\sqrt{\frac{1}{250\times10^{-6}\times0.16\times10^{-3}} - \frac{20\times20}{(0.16\times10^{-3})^2}}$

= 8×10^5 Hz

64.

(d) 0.05 J

Explanation: U = $\frac{1}{2}LI^2$

= $\frac{1}{2}\times 100 \times 10^{-3} \times (1)^2$ = 0.05 J

65.

(c) $\omega = \frac{1}{LC}$

Explanation: At resonance,

$X_L = X_C$

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

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

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

66. **(a)** 90^o

Explanation: 90^o

67.

(b) 25 V

Explanation: The resultant voltage in the LCR series circuit is calculated as,

V = $\sqrt{V_R^2 + (V_c \sim V_L)^2}$

Here, all alphabets are in their usual meanings.

V_R = 20 V, V_C = 30 V and V_L = 15 V

So, V = $\sqrt{(20)^2 + (30 \sim 15)^2}$

V = $\sqrt{400 + 225}$ = $\sqrt{625}$

V = 25 V

68. **(a)** 90%

Explanation: $\eta = \frac{output\ power}{input\ power} = \frac{V_s I_s}{V_p I_p} \times 100 = \frac{100}{220\times0.5} \times 100 = 90\%$

69.

(d) zero

Explanation: Here, the phase difference between current and e.m.f.,

$\phi = \pi/2$

$\therefore P_{av} = E_v I_v\, cos\phi = E_v I_v \cos\pi/2 = 0$

70.

(d) 50 amp

Explanation: $\frac{N_s}{N_p} = \frac{i_p}{i_s} = \frac{V_s}{V_p} = r$

Given that $\frac{N_p}{N_s} = \frac{1}{25}$

i_s = 2 amp

Thus, $\frac{25}{1} = \frac{i_p}{2}$

i_p = 50 amp

71.

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

Explanation: $\sqrt{R^2 + (X_L - X_C)^2}$

72. **(a)** 84.8 V

Explanation: V_{rms} = 0.707 V_0 = 0.707 × 120 V = 84.8 V

73.

(d) $\frac{1}{4}$

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

For, ω = constant $\rightarrow \sqrt{LC}$ = constant

Therefore, C is inversely proportional to L

So, if C is made 4C then L should be reduced to $\frac{L}{4}$ to keep ω constant.

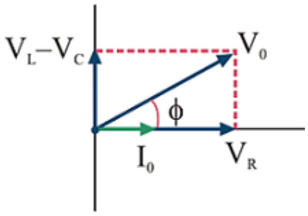
74. **(a)** A.C. voltage

Explanation: A transformer changes the magnitude of a.c.

75.

(b) 76.7 V

Explanation: Consider RLC circuit phasor diagram:



Hence,

$\cos\phi = \frac{V_R}{V_o}$

$\cos 31.5^\circ = \frac{V_R}{90}$

Thus, $V_R = 90 \times \cos 31.5^\circ = 90 \times 0.852 = 76.7V$