Alternating Current

JEE Main Exercise

1. (B)

$$i_{rms} = \sqrt{\frac{\int_2^4 (2\sqrt{t})^2 dt}{\int_2^4 dt}} = \sqrt{\frac{4\left[\frac{t^2}{2}\right]_2^4}{[t]_2^4}} = 2\sqrt{3}\text{ A}$$

2. (B)

$$i^2 = 9 + 16\sin^2\left(\omega t + \frac{\pi}{3}\right) + 24\sin\left(\omega t + \frac{\pi}{3}\right)$$

$$i_{rms} = \sqrt{< i^2 >} = \sqrt{9 + 16\left(\frac{1}{2}\right) + 24(0)} = \sqrt{17}\text{ A}$$

3. (D)

$$e^2 = e_1^2 \sin^2 \omega t + e_2^2 \cos^2 \omega t + 2e_1 e_2 \sin \omega t \cos \omega t$$

$$\Rightarrow \quad e^2 = e_1^2 \sin^2 \omega t + e_2^2 \cos^2 \omega t + e_1 e_2 \sin 2\omega t$$

$$\Rightarrow \quad < e^2 >= e_1^2\left(\frac{1}{2}\right) + e_2^2\left(\frac{1}{2}\right) + e_1 e_2(0)$$

$$\Rightarrow \quad e_{rms} = \sqrt{< e^2 >} = \sqrt{\frac{e_1^2 + e_2^2}{2}}$$

4. (C)

$$P_1 = i^2 R = (2)^2 R = 4R$$

$$P_2 = i_{rms}^2 R = \left(\frac{2}{\sqrt{2}}\right)^2 R = 2R$$

$$\Rightarrow \quad P_1 : P_2 = 2:1$$

5. (D)

$$i = 3 + 4\sqrt{2}\sin \omega t$$

$$\Rightarrow \quad i^2 = 9 + 32\sin^2 \omega t + 24\sqrt{2}\sin \omega t$$

$$\Rightarrow \quad < i^2 >= 9 + 32\left(\frac{1}{2}\right) + 0$$

$$i_{\text{rms}} = \sqrt{9+16} = 5\,\text{A}$$

6. (B)

AC ammeter measures rms current.

$$i_{\text{rms}} = \frac{V_{\text{rms}}}{X_C} = \frac{\frac{(300\sqrt{2})}{\sqrt{2}}}{\left(\frac{1}{100\times10^{-6}}\right)} = 30\text{ mA}$$

7. (C)

For DC source, $P = \frac{V^2}{R} \Rightarrow 20 = \frac{(10)^2}{R}$

$\Rightarrow \quad R = 5\Omega$

For AC source, $P = \frac{V^2 R}{Z^2} = \frac{V^2 R}{R^2 + X_L^2}$

$\Rightarrow \quad 10 = \frac{(10)^2 (5)}{(5)^2 + X_L^2} \Rightarrow X_L = 5\Omega$

Now, $X_L = 2\pi f L$

$\Rightarrow \quad 52\pi f\,(10\times10^{-3}) \Rightarrow f = 80\,\text{Hz}$

8. (D)

$Z = |X_C - X_L| = 75 - 25 = 50\Omega$

$$i = \frac{V}{Z} = \frac{250}{50} = 5\,\text{A}$$

$V_L = iX_L = 5\times25 = 125\text{ V}$

$V_C = iX_C = 5\times75 = 375\,\text{V}$

$V_C > V$

9. (B)

$$X_L = \omega L = 2\pi\left(\frac{500}{\pi}\right)\left(8\times10^{-3}\right) = 8\Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\left(\frac{500}{\pi}\right)\left(\frac{1000}{3}\right)\times10^{-6}} = 3\Omega$$

$$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2} = \sqrt{(10)^2 + (8-3)^2}$$

$$= 5\sqrt{5}\,\Omega$$

$$i_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{1000}{5\sqrt{5}} = \frac{20}{\sqrt{5}}\,\text{A}$$

$$P_{\text{avg}} = I_{\text{rms}}^2 R = \left(\frac{20}{\sqrt{5}}\right)^2 (10) = 800\,\text{W}$$

10. (C)

$X_L = \omega L = 100 \times 0.1 = 10\,\Omega$

$\cos\phi = \frac{1}{\sqrt{2}} \Rightarrow \phi = \frac{\pi}{4}$

$\tan\phi = \frac{|X_L - X_C|}{R} \Rightarrow 1 = \frac{|10 - X_C|}{10} \Rightarrow X_C = 20\,\Omega$

$X_C = \frac{1}{\omega C} \Rightarrow 20 = \frac{1}{100C} \Rightarrow C = 500\,\mu\text{F}$

11. (D)

$E_{\text{rms}} = \frac{500\sqrt{2}}{\sqrt{2}} = 500\text{ V}$

$E = \sqrt{V_R^2 + (V_L - V_C)^2}$

$\Rightarrow \quad 500 = \sqrt{(400)^2 + (700 - V_C)^2}$

$\Rightarrow \quad V_C = 400\text{ V}$

or $\quad V_C = 1000\text{ V}$

Peak voltage across capacitor $= \sqrt{2}\,V_C$

12. (A)

$V = |X_L - X_C| = 0,\ Z = \sqrt{R^2 + (X_L - X_C)^2} = 30\,\Omega$

$i = \frac{V_R}{R} = \frac{240}{30} = 8\text{ A}$

13. (B)

$V^2 = V_R^2 + (V_L - V_C)^2 \Rightarrow (200)^2 = V_R^2 + (120)^2$

$\Rightarrow \quad V_R = 160\text{ V}$

$i = \frac{V_R}{R} = \frac{160}{40} = 4\text{ A}$

14. (A)

At resonance, $X_L = X_C$ and $Z = R$

$i = \frac{V}{R} \Rightarrow 600 \times 10^{-3} = \frac{6}{R}$

$\Rightarrow \quad R = 10\,\Omega$

For DC source,

$i = \frac{V}{R + r} = \frac{6}{10 + 2} = 0.5\text{ A}$

15. (C)

Quality factor $= \frac{f_R}{\Delta f} = \frac{600}{(650 - 550)} = 6$

16. (C)

$X_L = \omega L = 1000 \times 0.5 \times 10^{-3} = 0.5\,\Omega$

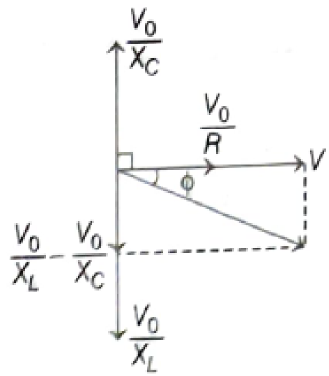
$X_C = \frac{1}{\omega C} = \frac{1}{1000 \times 10^{-3}} = 1\,\Omega$

$R = 1\,\Omega$

$$\tan\phi = \frac{\frac{V_0}{X_L} - \frac{V_0}{X_C}}{\frac{V_0}{R}} = \frac{\frac{1}{X_L} - \frac{1}{X_C}}{\frac{1}{R}}$$

$= 1$

$\Rightarrow \quad \phi = 45°$



17. (D)

$X_L = \omega L = 50 \times 0.1 = 5\,\Omega$

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

$= \frac{1}{50 \times 0.004} = 5\,\Omega$

For LR branch, $Z = \sqrt{R^2 + X_L^2} = 5\sqrt{2}\,\Omega$

$i_L = \frac{100}{5\sqrt{2}} = 10\sqrt{2}$ A and $\tan\phi = \frac{X_L}{R} = 1$

$i_L = 10\sqrt{2}\sin\left(50t - \frac{\pi}{4}\right)$

For RC branch, $Z = \sqrt{R^2 + X_C^2} = 5\sqrt{2}\,\Omega$

$i_C = \frac{100}{5\sqrt{2}} = 10\sqrt{2}$ A and $\tan\phi = \frac{X_C}{R} = 1$

$\Rightarrow \quad \phi = \frac{\pi}{4}$

$i_C = 10\sqrt{2}\sin\left(50t + \frac{\pi}{4}\right)$

$i = i_L + i_C = 10\sqrt{2}\sin\left(50t - \frac{\pi}{4}\right) + 10\sqrt{2}\sin\left(50t + \frac{\pi}{4}\right)$

$= 20\sin(50t)$ A

18. (4)

$i^2 = 4\sin^2\omega t + 16\cos^2\omega t + 6 + 4\sqrt{6}\sin\omega t + 8\sqrt{6}\cos\omega t + 8\sin 2\omega t$

$\langle i^2 \rangle = 4\left(\frac{1}{2}\right) + 16\left(\frac{1}{2}\right) + 6 + 0 + 0 + 0$

$i_{\text{rms}} = \sqrt{\langle i^2 \rangle} = 4$ A

19. (4)

$$\tan\phi = \frac{X_L}{R} \Rightarrow \tan 30° = \frac{\omega L}{R} \Rightarrow R = \sqrt{3}\omega L$$

$$i = \frac{V}{\sqrt{R^2 + (\omega L)^2}} = \frac{\sqrt{3}V}{2R}$$

With new source, $i' = \frac{V}{\sqrt{R^2 + (2\omega L)^2}} = \frac{\sqrt{3}V}{\sqrt{7}R}$

$$P = i^2 R \Rightarrow \frac{P_1}{P_2} = \left(\frac{i_1}{i_2}\right)^2 \Rightarrow \frac{7}{P_2} = \left(\frac{\sqrt{7}}{2}\right)^2$$

$\Rightarrow \quad P_2 = 4\,\text{W}$

20. (1)

$X_L = \omega L = (100\pi)(5) = 500\pi, R = 55\Omega$

$P = i^2 R$, for power to remain unchanged, current should be unchanged.
So, impedance should be constant.

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

$\Rightarrow \quad X_L = |X_L - X_C|$

$\Rightarrow \quad X_C = 2X_L$

$\Rightarrow \quad \frac{1}{(100\pi)C} = 2(500\pi)$

$\Rightarrow \quad C = 1\,\mu\text{F}$

21. (3)

Current at resonance, $i = \frac{V}{R} = 3\sqrt{2}\,\text{A}$

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

$\Rightarrow \quad \tan 45° = \frac{X_L - X_C}{R} \Rightarrow X_L - X_C = R$

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

New current, $i' = \frac{V}{Z'} = \frac{V}{\sqrt{2}R} = \frac{3\sqrt{2}}{\sqrt{2}} = 3\,\text{A}$

22. (2.5)

Since, current is lagging behind voltage, the box must have an inductor.

$V_C = iX_C \quad \Rightarrow \quad 2000 = 2X_C$

$\Rightarrow \quad X_C = 1000\,\Omega$

$\cos\phi = 0.8$

$\Rightarrow \quad \tan\phi = \frac{3}{4} = \frac{X_L - 1000}{800}$

$\Rightarrow \quad X_L = 1600\,\Omega$

$X_L = \omega L \Rightarrow 1600 = 2\pi(100)L \Rightarrow L = 2.5\,\text{H}$

23. (6)

Impedance of box A, $Z = \frac{V}{i} = \frac{200}{0.4} = 500\,\Omega$

For power factor to becomes 1, $X_L = X_C = 400\,\Omega$

$Z = \sqrt{R^2 + X_L^2} \Rightarrow 500 = \sqrt{R^2 + (400)^2}$

$\Rightarrow \quad R = 300\,\Omega$

Power factor of box A, $\cos\phi = \frac{R}{Z} = \frac{300}{500} = 0.6$

1. (B)

(b) Time constant of $R - C$ circuit, $\tau = R_{eq} C_{eq}$

(i) R_1 & R_2 in series and C_1 & C_2 in parallel.

$\tau_1 = (2+1)(2+4) = 18\ \mu s$.

(ii) R_1 & R_2 in parallel and C_1 & C_2 in series.

$$\tau_2 = \left(\frac{2\times1}{2+1}\right)\left(\frac{2\times4}{2+4}\right) = \frac{8}{9}\mu s$$

(iii) R_1 & R_2 in parallel and C_1 & C_2 in parallel.

$$\tau_3 = \left(\frac{2\times1}{2+1}\right)\times(4+2) = 4\mu s$$

2. (B)

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

As ω increases, I_{rms} through the bulb increases. Hence the bulb glows brighter.

3. (D)

(d) Power factor $_{(old)}$

$$= \frac{R}{\sqrt{R^2 + X_L^2}} = \frac{R}{\sqrt{R^2 + (2R)^2}} = \frac{R}{\sqrt{5}R}$$

Power factor$_{(new)}$

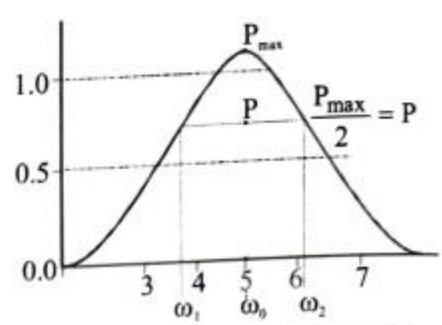
$$= \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}} = \frac{R}{\sqrt{R^2 + (2R - R)^2}} = \frac{R}{\sqrt{2}R}$$

$$\therefore \frac{\text{New power factor}}{\text{Old power factor}} = \frac{\frac{R}{\sqrt{2}R}}{\frac{R}{\sqrt{5}R}} = \sqrt{\frac{5}{2}}$$

4. (B)

Quality factor of the circuit

$$= \frac{\omega_0}{\omega_2 - \omega_1} = \frac{5}{2.5} = 2.0$$



5. (C)

Voltage E of the ac source, $E=\sqrt{(V_C-V_L)^2+V_R^2}$

$E = V_C - V_L = 400\,V - 300\,V = 100\,V$

6. (B)

(b) In a pure inductive circuit current always lags behind the emf by $\frac{\pi}{2}$.

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

then $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

Now, given v(t) = 100 sin (500 t)

and $I_0 = \frac{E_0}{\omega L} = \frac{100}{500 \times 0.02}$ $[\because L = 0.02H]$

$I_0 = 10\sin\left(500t - \frac{\pi}{2}\right) \Rightarrow I_0 = -10\cos(500t)$

7. (C)

(c) Given, $V_L : V_C : V_R = 1 : 2 : 3$

$V = 100$ V, let $V_L = x$. Then, $V_C = 2x$ and $V_R = 3x$

$V_R = ?$

As we know,

$V = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{9x^2 + x^2} = \sqrt{10}x$

So, $x = \frac{V}{\sqrt{10}} = \frac{100}{\sqrt{10}}$

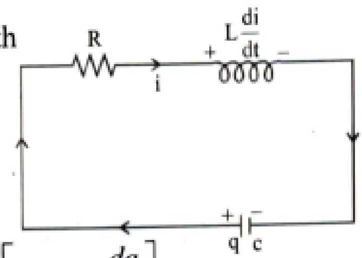
So $V_R = 300/\sqrt{10} = 90V$

8. (C)

(c) From KVL at any time t

As current is decreasing with time. So inductor will support the current.

By KVL,



$$\frac{q}{c} - iR - L\frac{di}{dt} = 0$$

$$\frac{q}{c} + \frac{dq}{dt}R + \frac{Ld^2q}{dt^2} = 0 \qquad \left[\because i = -\frac{dq}{dt}\right]$$

$$\frac{d^2q}{dt^2} + \frac{R}{L}\frac{dq}{dt} + \frac{q}{Lc} = 0$$

From damped harmonic oscillator, the amplitude is given by $A = A_o e^{-bt/2m}$ for $\frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x = 0$

So, $Q_{max} = Q_o e^{-\frac{Rt}{2L}} \Rightarrow Q_{max}^2 = Q_o^2 e^{-\frac{Rt}{L}}$

Hence damping will be faster for lesser self inductance.

9. (B)

(b) Here

$$i = \frac{e}{\sqrt{R^2 + X_L^2}} = \frac{e}{\sqrt{R^2 + \omega^2 L^2}} = \frac{e}{\sqrt{R^2 + 4\pi^2 \nu^2 L^2}}$$

$$\Rightarrow 10 = \frac{220}{\sqrt{64 + 4\pi^2 (50)^2 L}} \quad \left[\because R = \frac{V}{I} = \frac{80}{10} = 8\right]$$

On solving we get

$L = 0.065$ H

10. (A)

(a) For two concentric circular coil,

Mutual Inductance $M = \dfrac{\mu_0 \pi N_1 N_2 a^2}{2b}$

here, $N_1 = N_2 = 1$

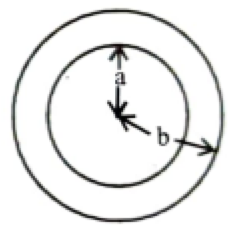
Hence, $M = \dfrac{\mu_0 \pi a^2}{2b}$ ..... (i)

and given $I = I_0 \cos \omega t$ ..... (ii)

Now according to Faraday's second law induced emf

$$e = -M\frac{dI}{dt}$$

From eq. (ii),



$$e = \frac{-\mu_0 \pi a^2}{2b}\frac{d}{dt}(I_0 \cos \omega t)$$

$$\Rightarrow e = \frac{\mu_0 \pi a^2}{2b} I_0 \sin \omega t\,(\omega)$$

$$e = \frac{\pi \mu_0 I_0}{2} . \frac{a^2}{b} \omega \sin \omega t$$

11. (B)

(b) Given,

$V_0 = 283$ volt, $\omega = 320$, $R = 5\ \Omega$, $L = 25$ mH, $C = 1000\ \mu F$

$x_L = \omega L = 320 \times 25 \times 10^{-3} = 8\ \Omega$

$$x_C = \frac{1}{\omega C} = \frac{1}{320 \times 1000 \times 10^{-6}} = 3.1\ \Omega$$

Total impedance of the circuit :

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{25 + (4.9)^2} = 7\ \Omega$$

Phase difference between the voltage and current

$$\tan \phi = \frac{X_L - X_C}{R} \Rightarrow \tan \phi = \frac{4.9}{5} \approx 1 \Rightarrow \phi = 45^\circ$$

12. (B)

(b) As we know, average power $P_{avg} = V_{rms} I_{rms} \cos\theta$

$$= \left(\frac{V_0}{\sqrt{2}}\right)\left(\frac{I_0}{\sqrt{2}}\right)\cos\theta = \left(\frac{100}{\sqrt{2}}\right)\left(\frac{20}{\sqrt{2}}\right)\cos 45^\circ \quad (\because \theta = 45^\circ)$$

$$P_{avg} = \frac{1000}{\sqrt{2}} \text{ watt}$$

Wattless current $I = I_{rms} \sin\theta$

$$= \frac{I_0}{\sqrt{2}}\sin\theta = \frac{20}{\sqrt{2}}\sin 45^\circ = 10A$$

13. (A)

Quality factor $Q = \frac{\omega_0}{2\Delta\omega} = \frac{\omega_0 L}{R}$

14. (D)

(d) As $V(t) = 220 \sin 100\pi t$ so, $I(t) = \frac{220}{50} \sin 100\pi t$

i.e., $I = I_m = \sin(100\pi t)$ For $I = I_m$

$t_1 = \frac{\pi}{2} \times \frac{1}{100\pi} = \frac{1}{200}$ sec. and for $I = \frac{I_m}{2}$

$\Rightarrow \frac{I_m}{2} = I_m \sin(100\pi t_2) \Rightarrow \frac{\pi}{6} = 100\pi t_2 \Rightarrow t_2 = \frac{1}{600} s$

$\therefore t_{req} = \frac{1}{200} - \frac{1}{600} = \frac{2}{600} = \frac{1}{300} s = 3.3$ ms

15. (B)

(b) We have, $i = i_0(1 - e^{-t/c}) = \frac{\varepsilon}{R}(1 - e^{-t/c})$

Charge, $q = \int_0^{\tau} i dt = \frac{\varepsilon}{R}\int_0^{\tau}(1 - e^{-t/\tau})dt$

$= \frac{E}{R}\frac{\tau}{e} = \frac{E}{R} \times \frac{(L/R)}{e} = \frac{EL}{2.7R^2}$

16. (D)

(d) $I = I_0\left(1 - e^{-\frac{Rt}{L}}\right)$ Here $R = R_L + r = 1\Omega$

$\Rightarrow 0.8I_0 = I_0\left(1 - e^{-\frac{t}{.01}}\right) \Rightarrow 0.8 = 1 - e^{-100t}$

$\Rightarrow e^{-100t} = 0.2 = \left(\frac{1}{5}\right)$

$\Rightarrow 100t = \ln 5 \Rightarrow t = \frac{1}{100}\ln 5 = 0.016$ s

17. (C)

(c) $i^2 R = Li\frac{di}{dt} \Rightarrow \frac{di}{dt} = \frac{i}{\tau}$

$\Rightarrow t = \tau\, ln2 = 2ln2 \left[\text{as}\ \tau = \frac{L}{R} = \frac{20}{10} = 2\right]$

18. (C)

(c) Given: $R = 60\Omega$, $f = 50$ Hz, $\omega = 2\pi f = 100\pi$ and $v = 24v$
$C = 120\ \mu f = 120 \times 10^{-6} f$

$$x_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 120 \times 10^{-6}} = 26.52\Omega$$

$x_L = \omega L = 100\pi \times 20 \times 10^{-3} = 2\pi\Omega$
$x_C - x_L = 20.24 \approx 20$

$$z = \sqrt{R^2 + (x_C - x_L)^2} \quad \Rightarrow \quad z = 20\sqrt{10}\Omega$$

$$\cos\phi = \frac{R}{z} = \frac{60}{20\sqrt{10}} = \frac{3}{\sqrt{10}}$$

$$P_{avg} = VI\cos\phi, I = \frac{v}{z} = \frac{v^2}{z}\cos\phi = 8.64 \text{ watt}$$

Energy dissipated (Q) in time t = 60s is

$Q = P.t = 8.64 \times 60 = 5.17 \times 10^2 J$

19. (A)

(a) Given, Inductance, $L = 40$ mH
Capacitance, $C = 100\ \mu F$
Impedance, $Z = X_C - X_L$

$$\Rightarrow Z = \frac{1}{\omega C} - \omega L \quad \left(\because X_c = \frac{1}{\omega C} \text{ and } X_L = \omega L\right)$$

$$= \frac{1}{314 \times 100 \times 10^{-6}} - 314 \times 40 \times 10^{-3} = 19.28\Omega$$

Here $X_C > X_L$. So current will lead.

$$\text{Current, } i = \frac{V_0}{Z}\sin(\omega t + \pi/2) \left[\because \tan\phi = \frac{X_C - X_C}{R} \text{ and } R = 0\right]$$

$$\Rightarrow i = \frac{10}{19.28}\cos\omega t = 0.52\cos(314\,t)$$

20. (A)

(a) The current (I) in LR series circuit is given by

$$I=\frac{V}{R}\left(1-e^{-\frac{tR}{L}}\right); \text{At } t=\infty,$$

$$I_{\infty}=\frac{20}{5}\left(I-e^{\frac{-\infty}{L/R}}\right)=4 \qquad \text{...(i)}$$

At $t = 40$s,

$$4\left(1-e\frac{-40\times 5}{10\times 10^{-3}}\right)=4(1-e^{-20,000}) \qquad \text{...(ii)}$$

Dividing (i) by (ii) we get

$$\Rightarrow \quad \frac{I_{\infty}}{I_{40}}=\frac{1}{1-e^{-20,000}}\simeq 1.06$$

21. (C)

(c) Power output $(V_2I_2) = 2.2$ kW

$$\therefore \ V_2=\frac{2.2\text{kW}}{(10\text{A})}=220 \text{ volts}$$

$\therefore$ Input voltage for step-down transformer

$$\frac{V_1}{V_2}=\frac{N_1}{N_2}=2$$

$$V_{input}=2\times V_{output}=2\times 220=440\text{ V}$$

Also $\frac{I_1}{I_2}=\frac{N_2}{N_1}$

$$\therefore \quad I_1=\frac{1}{2}\times 10=5\text{A}$$

22. (B)

(b) Efficiency, $\eta=\frac{P_{out}}{P_{in}}=\frac{V_sI_s}{V_pI_p}$

$$\Rightarrow 0.9=\frac{230\times I_s}{2300\times 5}\Rightarrow I_s=0.9\times 50=45\text{A}$$

Output current = 45A

23. (A)

(a) Quality factor,

$$Q=\frac{1}{R}\sqrt{\frac{L}{C}}=\frac{1}{100}\sqrt{\frac{80\times 10^{-3}}{2\times 10^{-6}}}=\frac{1}{100}\sqrt{40\times 10^{3}}=\frac{200}{100}=2$$

24. (C)

(c) Impedance in LCR circuit

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

25. (A)

(a) Power will be maximum at resonance

At resonance $X_L=X_C \Rightarrow L\omega=\frac{1}{C\omega}$

$\Rightarrow 250\pi=\frac{1}{2\pi(50)C} \Rightarrow C=4\times10^{-6}$

26. (C)

(c) $\cos 45°=\frac{R}{X_L}$ ....(i)

$\cos 45°=\frac{R}{X_C}$ ....(ii)

So, from (i) & (ii) we get $X_L=X_C$ i.e. circuit in resonance.
LCR circuit is in resonance, behaves as resistive circuit.

$\therefore I_{rms}=\frac{V_{rms}}{R}=\frac{220}{110}=2\text{ A}$

27. (C)

(c) Given, $E=440\sin 100\pi t$, $L=\frac{\sqrt{2}}{\pi}H$

As, $X_L=\omega L=100\pi\frac{\sqrt{2}}{\pi}=100\sqrt{2}\,\Omega$

So, peak current, $I_0=\frac{E_0}{X_L}=\frac{440}{100\sqrt{2}}=2.2\sqrt{2}\text{A}$

We know AC ammeter reads RMS value therefore reading will be I_{rms}, $I_{rms}=\frac{I_0}{\sqrt{2}}=2.2\text{A}$

28. (D)

(d) Voltage amplitude across the inductor

$v_0=i_0x_L=i_0(\omega L)=(5)(49\pi)(30\times10^{-3})=23.1\text{ v}$

Voltage will lead current by 90°.
Therefore the equation for the voltage across the inductor
$V=23.1\sin(49\pi t+60°)$

29. (B)

(b) As $H = i_{rms}^2 Rt$

$H \propto i_{rms}^2 R$

$$\frac{H_1}{H_2} = \left(\frac{i_{rms_1}}{i_{rms2}}\right)^2 \times \frac{R_1}{R_2} = \left(\frac{4}{\frac{4}{\sqrt{2}}}\right)^2 \times \frac{3}{2} = 2 \times \frac{3}{2} = \frac{3}{1}$$

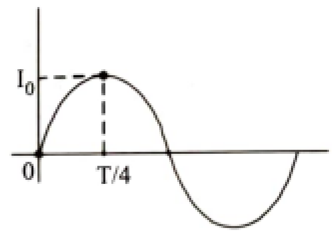
30. (D)

(d) We have

$\omega = 120\pi$

and, $T = \frac{2\pi}{\omega} = \frac{2\pi}{120\pi} = \frac{\pi}{60\pi} = \frac{1}{60}$

So, req. time $= \frac{T}{4} = \frac{1}{240}$ s



31. (A)

(a) When $I = I_0$

$I_0 \sin\ (\omega t_1 + \phi) = I_0 \Rightarrow \sin(\omega t_1 + \phi) = 1$

$\omega t_1 + \phi = \frac{\pi}{2}$ ...(i)

when $I = \frac{I_0}{\sqrt{2}} \Rightarrow I_0 \sin(\omega t_2 + \phi) = \frac{I_0}{\sqrt{2}}$

$\Rightarrow \sin(\omega t_2 + \phi) = \frac{1}{\sqrt{2}} \Rightarrow \omega t_2 + \phi = \frac{\pi}{4}$ ...(ii)

Substracting (ii) from (i), we get

$\omega(t_1 - t_2) = \frac{\pi}{4} \Rightarrow 2\pi f(t_1 - t_2) = \frac{\pi}{4}$

$\Rightarrow t_1 - t_2 = \frac{1}{8f} = \frac{1}{400}$ s = 2.5 ms.

32. (D)

(d) Element X should be resistance with R

$= \frac{E}{I} = \frac{100}{5} = 20\,\Omega$

Element Y should be inductive with $X_L = 20\,\Omega$

When X and Y are connected in series

$$I_0 = \frac{E_0}{Z} = \frac{E_0}{\sqrt{X_L^2 + R^2}} = \frac{100}{20\sqrt{2}} = \frac{5}{\sqrt{2}} A$$

The rms value of the current will be,

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

33. (C)

(c) In LCR circuit,
At resonance $X_L = X_C$

$$\Rightarrow \omega_0 L = \frac{1}{\omega_0 C} \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$$

$$\Rightarrow \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(0.01)(1\times10^{-6})}} = 10^4 \text{ rad/sec}$$

At frequency 60% lower than resonant frequency,

$$\omega' = \frac{40}{100}\times10^4 = 4000 \text{ rad/sec}$$

$$\text{Current, } I = \frac{V_0}{\sqrt{R^2+(X_C'-X_L')^2}}$$

$$= \frac{50}{\sqrt{(10)^2+\left(\frac{1}{4000\times1\times10^{-6}}-4000\times0.01\right)^2}}$$

$$= \frac{50}{\sqrt{100+\left(\frac{1000}{4}-40\right)^2}} = 238 \text{ mA}$$

34. (B)

(b) Given that power factor of the circuit is P_1,
when $X_L = R$

$$P_1 = \frac{R}{\sqrt{R^2+(X_L-X_C)^2}} = \frac{1}{\sqrt{2}} \quad (\because X_C = 0)$$

Power factor of the circuit is P_2, when $X_L = X_C$

$$P_2 = \frac{R}{\sqrt{R^2+(X_L-X_C)^2}} = 1$$

So, we have $\frac{P_1}{P_2} = \frac{1}{\sqrt{2}}$

35. (C)

(c) Resonant frequency, $f_r = \frac{1}{2\pi\sqrt{LC}} \Rightarrow f_r \times \frac{1}{\sqrt{C}}$

When another capacitor is added in series, C_{eq} decreases.
So, f_r increases.

36. (B)
Metal detector works on the principle of transmitting an electromagnetic signal and analyses a return signal from the target. So it works on the principle of resonance in AC circuit.

37. (A)

(a) We know that

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

$$f_{r2} = f_{r1}\sqrt{\frac{L_1C_1}{L_2C_2}} = f_1\sqrt{\frac{1}{2} - \frac{1}{2}} = \frac{f_1}{2}$$

And, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ as, $\left(\frac{L}{C}\right)_i = \left(\frac{L}{C}\right)_f$

so, Q remains same

i.e $Q_1 = Q_2$

38. (B)

Wattless current flow in a circuit only when circuit is resistance less i.e. circuit is purely capacitive or inductive.

39. (A)

(a) $X_L = \omega L = 3000 \times 10^{-2}\,\Omega = 30\,\Omega$

$$X_C = \frac{1}{\omega c} = \frac{1}{3000 \times 25 \times 10^{-6}} = \frac{1000}{75} = \frac{40}{3}\Omega$$

So, $X_L - X_C = \left(30 - \frac{40}{3}\right)\Omega = \frac{50}{3}\Omega$

Given, $R = 100\,\Omega$

As, $\tan\phi = \frac{|X_L - X_C|}{R} = \frac{50}{3 \times 100} = \frac{1}{6}$

$$\phi = \tan^{-1}\left(\frac{1}{6}\right) = \tan^{-1}(0.17)$$

40. (C)

(c) When a circuit is purely inductive or capacitive then

$\phi = \pm\frac{\pi}{2}$, then $P_{avg} = V_{rms}\, I_{rms}\, \cos\left(\pm\frac{\pi}{2}\right) = 0$

Also when circuit has only capacitor and inductor, then $P_{avg} = 0$ because their is no resistance to waste the energy.

41. (C)

(c) $\frac{(8 \times 10^3)^2}{R_P} = 80 \times 10^3 \left[\because\ P = \frac{V^2}{R}\right]$

$\Rightarrow R_P = 800\,\Omega$

Similarly, $\frac{(160)^2}{R_S} = 80 \times 10^3 \Rightarrow R_S = 0.32\,\Omega$

42. (A)

(a) AC Generator:- It converts mechanical energy into electrical energy.
Galvanometer:- It shows deflection when current passes through it, so it is used to show presence of current in the wire.
Transformer:- It is used to step up or step down the voltage.
Metal detector:- It contain inductor coil and use principle of induction and resonance in AC circuit.

43. (440)

(440) As we know,

$$\frac{N_P}{N_S} = \frac{V_P}{V_S}$$

Since, $N_S = 24$, $V_P = 220$ V and $V_S = 12$ V

$$\frac{N_P}{24} = \frac{220}{12} \Rightarrow N_P = \frac{220 \times 24}{12} = 440$$

44. (400)

(400) $P = V_{\text{rms}} I_{\text{rms}} \cos\phi \Rightarrow 400 = \frac{V_{\text{rms}}^2}{Z} \times 0.8$

$$\Rightarrow Z = \frac{250^2}{400} \times 0.8 = 125\,\Omega$$

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

$R = Z\cos\phi = 125 \times 0.8 = 100\,\Omega$

Now, $Z^2 = X_L^2 + R^2 \Rightarrow 125^2 = X_L^2 + 100^2$

$\Rightarrow X_L = 75\,\Omega$

At resonance

$X_L = X_C$

$$\Rightarrow 75 = \frac{1}{\omega C} \Rightarrow 75 = \frac{1}{2\pi} \times 50 \times C \Rightarrow C = \frac{400}{3\pi}\mu F$$

45. (11)

(11) $i_{rms} = \sqrt{i_{1rms}^2 + i_{2rms}^2} = \sqrt{\left(\frac{\sqrt{42}}{\sqrt{2}}\right)^2 + 10^2}$

$= \sqrt{121} \Rightarrow i_{rms} = 11A$.

46. (1)

(1) Power factor for RL circuit

$$\cos\phi = \frac{R}{\sqrt{R^2 + X_L^2}} = \frac{R}{\sqrt{R^2 + 3R^2}} = \frac{1}{\sqrt{10}}$$

Power factor for LCR circuit

$$\cos\phi' = \frac{R}{\sqrt{R^2 + \left(X_L^2 - X_C^2\right)}} = \frac{R}{\sqrt{R^2 + R^2}} = \frac{1}{\sqrt{2}}$$

$$\frac{\cos\phi'}{\cos\phi} = \frac{\sqrt{10}}{\sqrt{2}} = \frac{\sqrt{5}}{1} \quad \therefore x = 1$$

47. (3)

(3) For current leads the voltage by 45°

$$\tan 45° = \frac{x_C - x_L}{R}$$

$$\Rightarrow \quad x_C - x_L = R \Rightarrow \frac{1}{\omega C} - \omega L = R \Rightarrow \frac{1}{\omega C} - 300 \times 0.03 = 1$$

$$\frac{1}{\omega C} = 10 \Rightarrow C = \frac{1}{10\omega} = \frac{1}{10 \times 300} \Rightarrow C = \frac{1}{3} \times 10^{-3}$$

Hence, value of x = 3.

48. (242)

(242) When voltage is minimum, current is maximum.
So, circuit is purely inductive i.e. $R = 0$

So, $Z = X_L$ Then, $i_0 = \frac{V_0}{X_L}$

$$\Rightarrow i_0 = \frac{V_0}{2\pi f L} \Rightarrow i_0 = \frac{\sqrt{2} V_{rms}}{2\pi f L}$$

$$\Rightarrow i_0 = \frac{\sqrt{2} \times 220}{2\pi \times 50 \times 0.2} = \frac{220\sqrt{2}}{20\pi} = \frac{11\sqrt{2}}{\pi} = \frac{\sqrt{242}}{\pi}$$

$\therefore \quad a = 242$

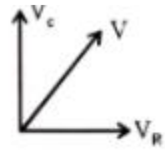
49. (250)

(250) Band width, $\Delta\omega = \omega_2 - \omega_1 = \frac{R}{L} = 232 - 212 = \frac{R}{L}$

$$\Rightarrow \quad 20 = \frac{R}{L} \Rightarrow L = \frac{R}{20} = \frac{5}{20} = 250 \text{ mH}$$

50. (3)

(3) Power $P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P}$

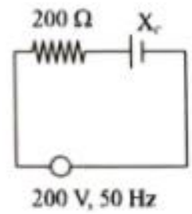


$\Rightarrow \quad R = \frac{100 \times 100}{100} \Rightarrow R = 200\,\Omega$

By phasor Diagram

$V_R^2 + V_C^2 = V^2$

$\Rightarrow \quad (100)^2 + V_C^2 = (200)^2$



$\Rightarrow \quad V_C = 100\sqrt{3}$

Now, $I = \frac{100}{200} = \frac{1}{2} A$

As, $V_C = I \times X_C$; $V_C = 100\sqrt{3}$ and $I = \frac{1}{2} A$

So, $X_C = 200\sqrt{3}$

$\Rightarrow \quad 200\sqrt{3} = \frac{1}{\omega C}$

$\Rightarrow C = \frac{1}{200\sqrt{3} \times 2\pi \times 50} = \frac{50}{\pi\sqrt{3}} \mu F$

So, $x = 3$

51. (500)

(500) For maximum power

power factor = $\cos\theta = 1 \; \therefore \frac{R}{Z} = 1$

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

$X_L = X_C$

$\frac{70}{11} = \frac{1}{100\pi \times C} \Rightarrow C = \frac{11}{7000\pi} = 500 \times 10^{-6} F = 500 \mu F$

52. (100)

(100) For minimum impedance, we have

$X_l - X_c \Rightarrow \omega L = \frac{1}{\omega c}$

$L = \frac{1}{\omega^2 c} = \frac{1}{(2\pi \times 500)^2} \times 0.01 = 101 \times 10^{-3} H \simeq 100\,mH$

53. (0)

(0) This is a case of parallel RLC circuit

So, $\frac{1}{Z} = \sqrt{\left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}$

At resonance, $X_L = X_C$. So $Z \to \infty$

$I = \frac{V}{Z} \to 0$

1.	(D)	2.	(B)	3.	(C)	4.	(A)	5.	(C)
6.	(A)	7.	(D)	8.	(A)	9.	(B)	10.	(D)
11.	(B)	12.	(C)	13.	(B)	14.	(C)	15.	(A)
16.	(C)	17.	(B)	18.	(B)				

19. (A)

$$i = \frac{V_{rms}}{\sqrt{R^2 + (L\omega)^2}} = 5.9\,\text{amp}$$

$$V_L = I\omega L = 148.2\,\text{volt}$$

20. (C)

Resultant voltage = 200 volt

Since v_1 and v_3 out of phase, the resultant voltage is equal to v_2

$\therefore$ v_2 = 200 volt

21. (C)

$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\times\sqrt{\frac{1}{\pi}\times\frac{1}{4\pi}\times 10^{-6}}} = 1000\text{Hz}$$

22. (A)

$$Z = \sqrt{R^2 + \omega^2 L^2}$$

$$\cos\phi = \frac{R}{2} \Rightarrow \frac{1}{2} = \frac{100}{2} \Rightarrow z = 200\,\Omega$$

$$\therefore R^2 + \omega^2 L^2 = Z^2 \Rightarrow \omega^2 L^2 = Z^2 - R^2$$

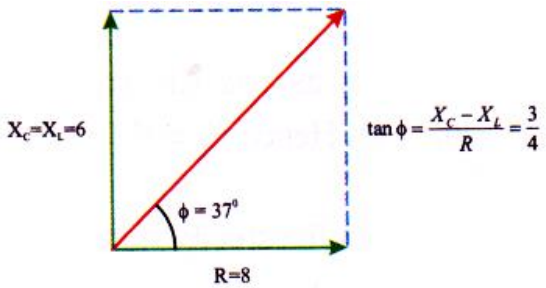
$$\Rightarrow \omega^2 L^2 = 4\times 10^{-4} - (100)^2 = 3\times 10^4 \Rightarrow \omega L = 100\sqrt{3}$$

$$\Rightarrow 2\times\pi\times 50\times L = 100\sqrt{3} \Rightarrow L = \frac{100\sqrt{3}}{2\pi\times 50} = \frac{\sqrt{3}}{\pi}$$

23. (B)

The current leads in phase by $(\because X_C > X_L)$ $\phi = 37^0$

$$\therefore i = \frac{10\cos(100\pi t + 37^0)}{Z} = \cos(100\pi + 37^0)$$



The instantaneous potential difference across AB is

$$= I_m = (X_C - X_L)\cos(100\pi t + 37^0 - 90^0)$$

The instantaneous potential difference across AB is half of source voltage.

$\therefore 6\cos\left(100\pi t-53^0\right)=5\cos 100\pi t$

Solving, $\cos\left(100\pi t\right)=\dfrac{1}{\sqrt{1+\left(7/24\right)^2}}=\dfrac{24}{25}$

$\therefore$ Instantaneous potential difference $=5\times\dfrac{24}{25}=\dfrac{24}{5}$ volts

EXERCISE - 2

More than one option correct

1. (BC) **2.** (ABD) **3.** (ABC) **4.** (ABCD) **5.** (AB)

6. (BD)

EXERCISE - 3

Comprehension Type

1. (C)

Current drawn in maximum at resonant angular frequency.

$L_{eq}=4\,mH \quad C_{eq}=10mF$

$\omega=\dfrac{1}{\sqrt{LC}}=5000\,rad/s$

2. (D)

c_{eq} decreases thereby increasing resonant frequency.

3. (B)

At resonance $i_{rms}=\dfrac{100}{100}=1A$

Power supplied $=V_{rms}I_{rms}\cos\phi$

(ϕ = 0 *at resonance*); P = 100 W

4. (B)

Average energy stored = $\dfrac{1}{2}Li_{rms}^2$

$=\dfrac{1}{2}\left(2.4\times10^{-3}H\right).\left(1A\right)^2=1.2mJ$

5. (D)

As 1ms time duration is very less time period T at resonance, thermal energy produced is not possible to calculate without information about start of the given time duration.

6. (B)

$V_{out}=\dfrac{V_s}{\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}\times\sqrt{R^2+\omega^2L^2}$;

$\dfrac{V_{out}}{V_s}=\dfrac{\sqrt{R^2+\omega^2L^2}}{\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}=\sqrt{\dfrac{R^2+\omega^2L^2}{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}}$

7. (A)

As $\omega \to 0, \frac{V_{out}}{V_s} = \omega CR$

8. (A)

As $\omega \to \infty, \frac{V_{out}}{V_s} = 1$

Matrix Match

1. A – Does not match; B – q, r; C – q, r, s; D – p

EXERCISE - 4

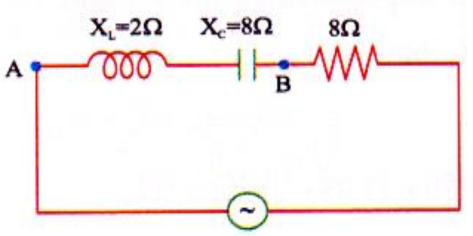
Subjective Questions

1. rms Voltage = 7 V, rms current = 0.5 amp **2.** 20 A **3.** 200V, 50Hz

4. 0.08H, 17.28W **5.** 2A, 400W **6.** 0.2 mH, (1/32) μF, 8×10^5 rad/sec

7. (4)

8. (AB)

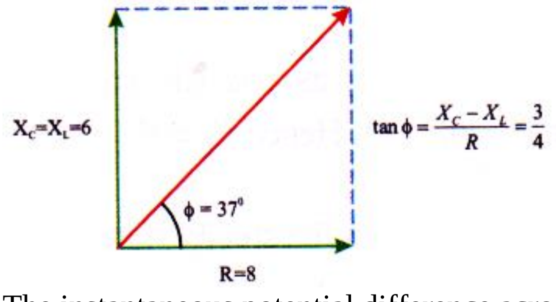


(a) Impedance of circuit $=\sqrt{R^2+(X_C+X_L)^2}$

$Z=\sqrt{8^2+(8-2)}=10\Omega$

(b) The current leads in phase by $(\because X_C > X_L)$ $\phi = 37^0$

$\therefore i = \frac{10\cos(100\pi t+37^0)}{Z} = \cos(100\pi+37^0)$



The instantaneous potential difference across AB is

$= I_m = (X_C - X_L)\cos(100\pi t + 37^0 - 90^0)$

$= 6\cos(100\pi t - 53^0)$

The instantaneous potential difference across AB is half of source voltage.

$= 6\cos(100\pi t - 53^0) = 5\cos 100\pi t$

Solving, $\tan(100\pi t) = \frac{17}{24}$ $\quad\therefore t = \frac{1}{100\pi}\tan^{-1}\left(\frac{17}{24}\right)$

9. (ABCD)

Let I_r be the rms current through the circuit then $I_r = 2A, \frac{I_r}{\omega C} = 20V, I_r\omega C = 20V$ and $I_rR = 10V$

Solving we get

$R = 5\Omega, C = \frac{1}{\pi}\times10^{-3}F$ and $L = \frac{1}{10\pi}H$

$\therefore V_s =$ source voltage =

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

$= \sqrt{(I_rR)^2 + \left(I_r\omega L - \frac{I}{\omega C}\right)^2}$

$= \sqrt{10^2 + (20-20)^2} = 10$ volts

10.

Given, $V_{rms} = 220$ V, $\nu = 50$ Hz, $L = 35$ mH, $R = 11\Omega$

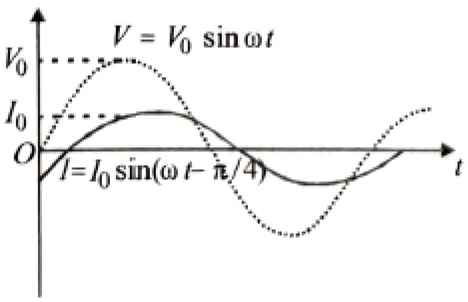
Impedance $Z = \sqrt{(\omega L)^2 + R^2} = 11\sqrt{2}\,\Omega$

Also, current amplitude, $I_0 = \frac{V_0}{Z}$

$V_0 = V_{rms}\sqrt{2}$ $\quad\therefore I_0 = \frac{V_{rms}\sqrt{2}}{Z} = 20A$

$\cos\phi = \frac{R}{Z} = \frac{11}{11\sqrt{2}} = \frac{1}{\sqrt{2}}$ $\quad\therefore \phi = \frac{\pi}{4}$ phase

In L-R circuit, voltage leads the current. $I_{instantaneous} = 20 \sin\left(\omega t - \pi/4\right)$, the current time graph as shown below.



One or More than One Option Correct

1. (AC)

(a,c) In RC - circuit impedance, $Z = \sqrt{R^2 + \left(\frac{1}{WC}\right)^2}$

The capacitance in case B is four times the capacitance in case A

$\therefore$ Impedance in case B is less then that of case A ($Z_B < Z_A$)

Now $I = \frac{V}{Z}$ $\therefore I_R^A < I_R^B$.

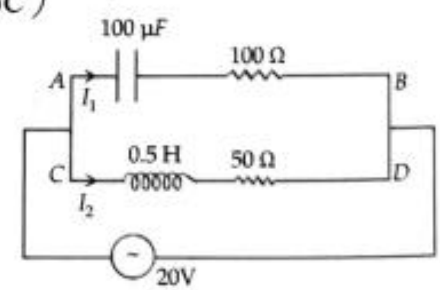
and $V_R^A < V_R^B$. $\Rightarrow$ $V_C^A > V_C^B$

[$\because$ If V is the applied potential difference access series R-C circuit then $V = \sqrt{V_R^2 + V_C^2}$]

2. (AC)

(a,c) Impedance across AB, RC part of the circuit

$$Z_1 = \sqrt{X_c^2 + R_1^2} = \sqrt{\left(\frac{1}{\omega C}\right)^2 + R_1^2}$$



$$= \sqrt{(100)^2 + (100)^2}$$

$$= 100\sqrt{2}$$

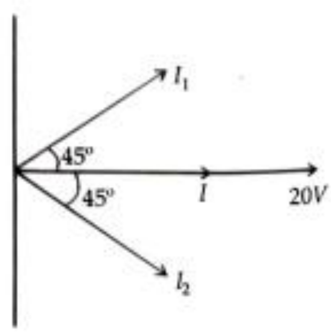
$$\therefore \quad I_1 = \frac{V}{Z_1} = \frac{20}{100\sqrt{2}}$$

[leads emf by ϕ_1]

where $\cos\phi_1 = \frac{R}{Z_1} = \frac{100}{100\sqrt{2}} = \frac{1}{\sqrt{2}} \Rightarrow \theta = 45^\circ$

Impedance across CD, LR part of the circuit.

$$Z_2 = \sqrt{X_L^2 + R_2^2} = \sqrt{(\omega L)^2 + R_2^2}$$



$$= \sqrt{(0.5 \times 100)^2 + (50)^2} = 50\sqrt{2}\ \Omega$$

$$\therefore \quad I_2 = \frac{V}{Z_2} = \frac{20}{50\sqrt{2}}$$

[leads emf by ϕ_2]

where $\cos\phi_2 = \frac{R}{Z_2} = \frac{50}{50\sqrt{2}} = \frac{1}{\sqrt{2}} \Rightarrow \phi_2 = 45^\circ$

$\therefore$ Current I from the circuit

$$I = \frac{20}{100\sqrt{2}} + \frac{20}{50\sqrt{2}} = I_1 + I_2 = 0.3\ A$$

3. (BC)

(b, c) The frequency at which the current is in phase with the voltage is resonance frequency,

$$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{(10^{-6} \times 10^{-6})^{1/2}} = 10^6\ \text{rad s}^{-1}$$

This frequency is independent of 'R'

At $\omega \approx 0$, the current $i = \frac{V}{\sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}}$

i.e, current through the circuit nearly becomes zero.
If $\omega >> \omega$, $X_L > X_C$ so circuit behaves like an inductor.

Comprehensions Type

1. (A)

(a) Step up transformer $\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{10}{1} = \frac{V_s}{4000}$

$\therefore$ $V_s = 40{,}000\ V$

Step down transformer $\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{40000}{200} = \frac{200}{1}$

2. (B)

(b) Power $P = V \times I$

$\Rightarrow$ $I = \frac{P}{V} = \frac{600 \times 1000}{4000} = 150\ A$

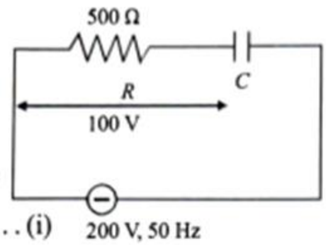
Total resistance $= 0.4 \times 20 = 8\ \Omega$

$\therefore$ Power dissipated as heat $= I^2R = (150)^2 \times 8$
$= 180{,}000W = 180\ kW$

$\therefore$ % loss $= \frac{180}{600} \times 100 = 30\%$

Stem Type Questions

1. (100.00)



From $V_{RMS} = \sqrt{V_C^2 + V_R^2}$

$\Rightarrow \quad V_C^2 + 100^2 = 200^2$

or, $\quad V_C^2 + 10000 = 40000$

$\therefore \quad V_C = 100\sqrt{3}V \qquad \ldots \text{(i)}$

$$\tan\phi = \frac{V_C}{V_R} = \frac{100\sqrt{3}}{100}$$

$\therefore \quad \phi = \mathbf{60^\circ} \qquad \ldots \text{(ii)}$

Power consumed, $P = I_{rms} V_{rms} \cos\phi = \frac{1}{2}\frac{V_{rms}^2}{z}$

$\Rightarrow \quad 500 = \frac{200}{z}\frac{1}{2}$

$\therefore \quad z = 40\,\Omega \qquad \ldots \text{(iii)}$

$$\cos\phi = \frac{R}{Z} \Rightarrow \frac{1}{2} = \frac{R}{40}$$

$\therefore \quad R = 20$

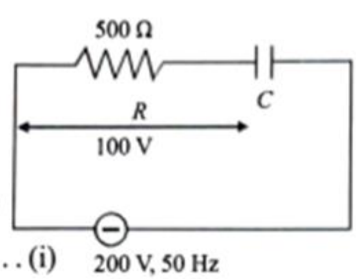
And $X_C = \sqrt{z^2 - R^2} = \sqrt{40^2 - 20^2} = 20\sqrt{3}\ \Omega$

$$X_C = \frac{1}{C\omega} \Rightarrow 20\sqrt{3} = \frac{1}{C2\pi f}$$

$$\therefore \quad C = \frac{1}{2\pi f(20\sqrt{3})} = \frac{1}{20\pi\sqrt{3} \times 100}$$

$$= 10^{-4}\,F = \mathbf{100}\,\mu\text{F}$$

2. (60.00)



From $V_{RMS} = \sqrt{V_C^2 + V_R^2}$

$\Rightarrow \quad V_C^2 + 100^2 = 200^2$

or, $\quad V_C^2 + 10000 = 40000$

$\therefore \quad V_C = 100\sqrt{3}V \qquad \ldots \text{(i)}$

$$\tan\phi = \frac{V_C}{V_R} = \frac{100\sqrt{3}}{100}$$

$\therefore \quad \phi = \mathbf{60^\circ} \qquad \ldots \text{(ii)}$

Power consumed, $P = I_{rms} V_{rms} \cos\phi = \frac{1}{2}\frac{V_{rms}^2}{z}$

$\Rightarrow \quad 500 = \frac{200}{z}\frac{1}{2}$

$\therefore \quad z = 40\,\Omega \qquad \ldots \text{(iii)}$

$$\cos\phi = \frac{R}{Z} \Rightarrow \frac{1}{2} = \frac{R}{40}$$

$\therefore \quad R = 20$

And $X_C = \sqrt{z^2 - R^2} = \sqrt{40^2 - 20^2} = 20\sqrt{3}\ \Omega$

$$X_C = \frac{1}{C\omega} \Rightarrow 20\sqrt{3} = \frac{1}{C2\pi f}$$

$$\therefore \quad C = \frac{1}{2\pi f(20\sqrt{3})} = \frac{1}{20\pi\sqrt{3}\times 100}$$

$$= 10^{-4}\,F = \mathbf{100}\ \mu\text{F}$$

Matrix-Match Type

1. (A-r,s,t; B-q,r,s,t; C-p,q; D-q,r,s,t)

For DC circuit, in steady state, the current I through the capacitor (c) is zero. In case of L-C circuit, the potential difference (v) across the inductor (L) is zero and that across the capacitor = applied potential difference. In case of L-R circuit, = (V) across inductor (L) = across (R) = applied voltage.

For AC circuit in steady state, I_{rms} current flows through the capacitor (c), inductor (R) and (L) and resistor (R). The potential difference across resistor, inductor and capacitor I. And for changing current, the potential difference across (V) inductor (L), capacitor (c) or resistor (R) $\propto$ Current (I).