

JEE Main Exercise

1. (B)

$$i_{\text{rms}} = \sqrt{\frac{\int_0^4 (2\sqrt{t})^2 dt}{\int_0^4 dt}} = \sqrt{\frac{4 \left[\frac{t^2}{2} \right]_0^4}{[t]_0^4}} = 2\sqrt{3} \text{ A}$$

2. (B)

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

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

3. (D)

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

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

$$\Rightarrow \langle e^2 \rangle = e_1^2 \left(\frac{1}{2} \right) + e_2^2 \left(\frac{1}{2} \right) + e_1 e_2 (0)$$

$$\Rightarrow e_{\text{rms}} = \sqrt{\langle e^2 \rangle} = \sqrt{\frac{e_1^2 + e_2^2}{2}}$$

4. (C)

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

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

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

5. (D)

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

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

$$\Rightarrow \langle i^2 \rangle = 9 + 32 \left(\frac{1}{2} \right) + 0$$

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

6. (B)
AC ammeter measures rms current.

$$i_{\text{rms}} = \frac{V_{\text{rms}}}{X_C} = \frac{(300\sqrt{2})}{\left(\frac{\sqrt{2}}{100 \times 10^{-6}}\right)} = 30 \text{ mA}$$

7. (C)

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

$$\Rightarrow R = 5 \Omega$$

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

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

$$\text{Now, } X_L = 2\pi fL$$

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

8. (D)

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

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

$$V_L = iX_L = 5 \times 25 = 125 \text{ V}$$

$$V_C = iX_C = 5 \times 75 = 375 \text{ V}$$

$$V_C > V$$

9. (B)

$$X_L = \omega L = 2\pi \left(\frac{500}{\pi}\right) (8 \times 10^{-3}) = 8 \Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi \left(\frac{500}{\pi}\right) \left(\frac{1000}{3}\right) \times 10^{-6}} = 3 \Omega$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(10)^2 + (8-3)^2} \\ = 5\sqrt{5} \Omega$$

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

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

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)

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

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

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

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

or $V_C = 1000 \text{ V}$

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)

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

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

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

14. (A)

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

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

$$\Rightarrow R = 10 \Omega$$

For DC source,

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

15. (C)

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

16. (C)

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

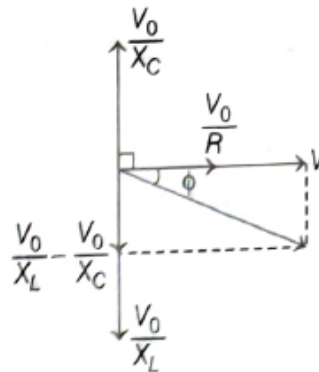
$$X_C = \frac{1}{\omega C} = \frac{1}{1000 \times 10^{-3}} = 1 \Omega$$

$$R = 1 \Omega$$

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

$$= 1$$

$$\Rightarrow \phi = 45^\circ$$



17. (D)

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

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

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

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

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

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

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

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

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

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

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

$$= 20 \sin(50t) \text{ A}$$

18. (4)

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

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

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

19. (4)

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

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

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

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

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

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.

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

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

$$\Rightarrow X_C = 2X_L$$

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

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

21. (3)

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

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

$$\Rightarrow \tan 45^\circ = \frac{X_L - X_C}{R} \Rightarrow X_L - X_C = R$$

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

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

22. (2.5)

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

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

$$\Rightarrow X_C = 1000\Omega$$

$$\cos \phi = 0.8$$

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

$$\Rightarrow X_L = 1600 \Omega$$

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

23. (6)

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

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

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

$$\Rightarrow R = 300 \Omega$$

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

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.
 $\tau_1 = (2 + 1)(2 + 4) = 18 \mu\text{s}$.
 (ii) R_1 & R_2 in parallel and C_1 & C_2 in series.
 $\tau_2 = \left(\frac{2 \times 1}{2 + 1}\right) \left(\frac{2 \times 4}{2 + 4}\right) = \frac{8}{9} \mu\text{s}$
 (iii) R_1 & R_2 in parallel and C_1 & C_2 in parallel.
 $\tau_3 = \left(\frac{2 \times 1}{2 + 1}\right) \times (4 + 2) = 4 \mu\text{s}$

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)

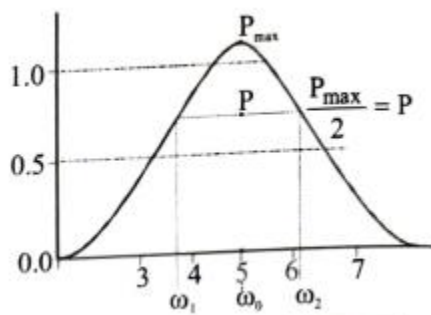
$$= \frac{R}{\sqrt{R^2 + X_L^2}} = \frac{R}{\sqrt{R^2 + (2R)^2}} = \frac{R}{\sqrt{5R}}$$
 Power factor _(new)

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

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

4. (B)
 Quality factor of the circuit

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



5. (C)

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

$$E = V_C - V_L = 400 \text{ V} - 300 \text{ V} = 100 \text{ V}$$

6. (B)

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

$$\text{If } v(t) = v_0 \sin \omega t$$

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

$$\text{Now, given } v(t) = 100 \sin(500t)$$

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

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

7. (C)

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

$V = 100 \text{ V}$, let $V_L = x$. Then, $V_C = 2x$ and $V_R = 3x$

$V_R = ?$

As we know,

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

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

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

8. (C)

(c) From KVL at any time t
As current is decreasing with time. So inductor will support the current.

By KVL,

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

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

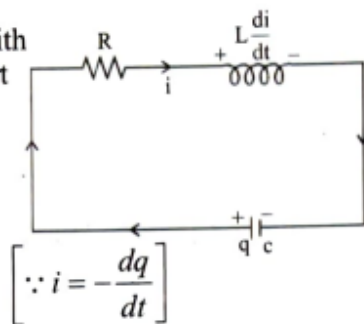
$$\frac{d^2 q}{dt^2} + \frac{R}{L} \frac{dq}{dt} + \frac{q}{Lc} = 0$$

From damped harmonic oscillator, the amplitude is given

by $A = A_0 e^{-bt/2m}$ for $\frac{d^2 x}{dt^2} + \frac{b}{m} \frac{dx}{dt} + \frac{k}{m} x = 0$

$$\text{So, } Q_{\max} = Q_0 e^{-\frac{Rt}{2L}} \Rightarrow Q_{\max}^2 = Q_0^2 e^{-\frac{Rt}{L}}$$

Hence damping will be faster for lesser self inductance.



9. (B)

(b) Here

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

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

On solving we get

$$L = 0.065 \text{ H}$$

10. (A)

(a) For two concentric circular coil,

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

here, $N_1 = N_2 = 1$

$$\text{Hence, } M = \frac{\mu_0 \pi a^2}{2b} \quad \dots (i)$$

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

Now according to Faraday's second law induced emf

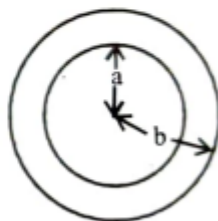
$$e = -M \frac{dI}{dt}$$

From eq. (ii),

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

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

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



11. (B)

(b) Given,

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

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

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

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 $P_{\text{avg}} = V_{\text{rms}} I_{\text{rms}} \cos \theta$

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

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

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

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

13. (A)

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

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 $I = I_m$

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

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

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

15. (B)

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

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

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

16. (D)

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

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

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

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

17. (C)

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

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

18. (C)

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

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

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

$$x_C - x_L = 20.24 \approx 20$$

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

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

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

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

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

19. (A)

(a) Given, Inductance, $L = 40$ mH

Capacitance, $C = 100\mu\text{F}$

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.

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

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

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

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

$$I_{\infty} = \frac{20}{5} \left(1 - e^{-\frac{-\infty}{L/R}} \right) = 4 \quad \dots(i)$$

At $t = 40\text{s}$,

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

Dividing (i) by (ii) we get

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

21. (C)
(c) Power output ($V_2 I_2$) = 2.2 kW

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

\therefore Input voltage for step-down transformer

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

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

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

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

22. (B)

$$\text{(b) Efficiency, } \eta = \frac{P_{\text{out}}}{P_{\text{in}}} = \frac{V_s I_s}{V_p I_p}$$

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

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

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

25. (A)

(a) Power will be maximum at resonance

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

$$\Rightarrow 250\pi = \frac{1}{2\pi(50)C} \Rightarrow C = 4 \times 10^{-6}$$

26. (C)

$$(c) \cos 45^\circ = \frac{R}{X_L} \quad \dots(i)$$

$$\cos 45^\circ = \frac{R}{X_C} \quad \dots(ii)$$

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

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

27. (C)

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

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

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

We know AC ammeter reads RMS value therefore reading

$$\text{will be } I_{\text{rms}}, \quad I_{\text{rms}} = \frac{I_0}{\sqrt{2}} = 2.2 \text{ A}$$

28. (D)

(d) Voltage amplitude across the inductor

$$v_0 = i_0 X_L = i_0 (\omega L) = (5)(49\pi)(30 \times 10^{-3}) = 23.1 \text{ v}$$

Voltage will lead current by 90° .

Therefore the equation for the voltage across the inductor

$$V = 23.1 \sin(49\pi t + 60^\circ)$$

29. (B)

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

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

$$\frac{H_1}{H_2} = \left(\frac{i_{rms1}}{i_{rms2}} \right)^2 \times \frac{R_1}{R_2} = \left(\frac{4}{\frac{4}{\sqrt{2}}} \right)^2 \times \frac{3}{2} = 2 \times \frac{3}{2} = \frac{3}{1}$$

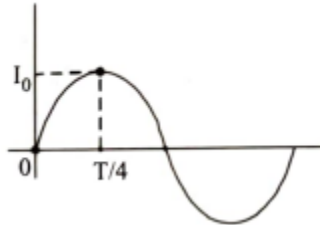
30. (D)

(d) We have

$$\omega = 120\pi$$

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

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



31. (A)

(a) When $I = I_0$

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

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

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

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

Subtracting (ii) from (i), we get

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

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

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

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

The rms value of the current will be,

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

33. (C)

(c) In LCR circuit,

At resonance $X_L = X_C$

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

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

At frequency 60% lower than resonant frequency,

$$\omega' = \frac{40}{100} \times 10^4 = 4000 \text{ rad/sec}$$

$$\begin{aligned} \text{Current, } I &= \frac{V_0}{\sqrt{R^2 + (X'_C - X'_L)^2}} \\ &= \frac{50}{\sqrt{(10)^2 + \left(\frac{1}{4000 \times 1 \times 10^{-6}} - 4000 \times 0.01\right)^2}} \\ &= \frac{50}{\sqrt{100 + \left(\frac{1000}{4} - 40\right)^2}} = 238 \text{ mA} \end{aligned}$$

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 $X_L = X_C$

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

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

35. (C)

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

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

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

$$f_{r2} = f_{r1} \sqrt{\frac{L_1 C_1}{L_2 C_2}} = f_1 \sqrt{\frac{1}{2} - \frac{1}{2}} = \frac{f_1}{2}$$

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

so, Q remains same

$$\text{i.e } Q_1 = Q_2$$

38. (B)

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

39. (A)

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

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

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

$$\text{Given, } R = 100 \Omega$$

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

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

40. (C)

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

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

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

41. (C)

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

$$\Rightarrow R_p = 800 \Omega$$

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

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)

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

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

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

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

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

$$\Rightarrow X_L = 75 \Omega$$

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)

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

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

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

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

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

47. (3)

(3) For current leads the voltage by 45°

$$\tan 45^\circ = \frac{x_C - x_L}{R}$$

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

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

Hence, value of $x = 3$.

48. (242)

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

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

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

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

$$\therefore a = 242$$

49. (250)

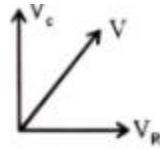
(250) Band width, $\Delta\omega = \omega_2 - \omega_1 = \frac{R}{L} = 232 - 212 = \frac{R}{L}$

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

50. (3)

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

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



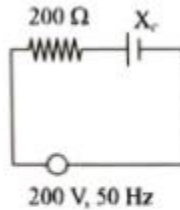
By phasor Diagram

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

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

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

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



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

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

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

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

$$\text{So, } x = 3$$

51. (500)

(500) For maximum power

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

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

$$X_L = X_C$$

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

52. (100)

(100) For minimum impedance, we have

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

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

53. (0)

(0) This is a case of parallel RLC circuit

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

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

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