ANS(4)

T-3

Ans ①

ⓐ $P.f. = \dfrac{\text{average power}}{\text{apperant power}} = \dfrac{P}{S} = \dfrac{P}{(V_{rms} \cdot I_{rms})} = \cos\phi$

$P = V_{rms} I_{rms} \cos\phi = 20 \times 220 \times 0.75$

$\boxed{P = 3.3\ KW}$ Ans

ⓑ Now by connecting a capacitor in parallel with load, so that $pf = 1$

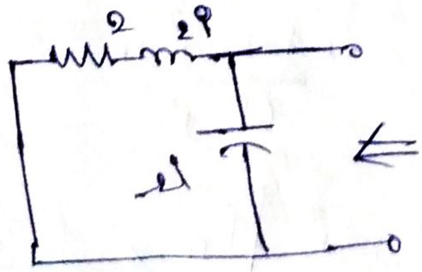
$$C = \frac{P(\tan\phi_{old} - \tan\phi_{new})}{\omega V_{rms}^2}$$

$\phi_{new} = 0°$, $\phi_{old} = \cos^{-1}(0.75)$

$$C = \frac{3300[(0.8819) - 0]}{2\pi \times 60 \times 220^2} = 1.59 \times 10^{-4} f$$

$\boxed{C = 0.159 mf}$ Ans

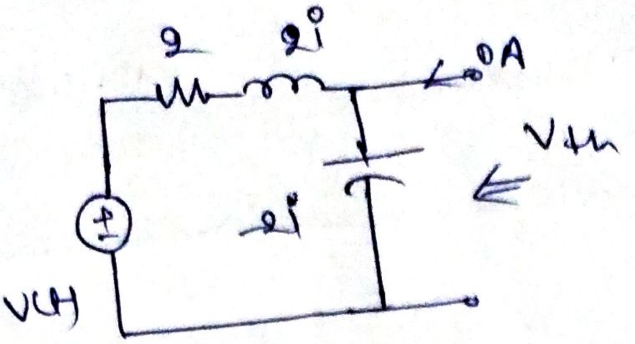
Ans ② for MPT across Z_L, 1st find Thevenin equivalent N/w across Z_L



$\leftarrow Z_{th}$

$Z_{th} = (2+2i) \| (-2i)$

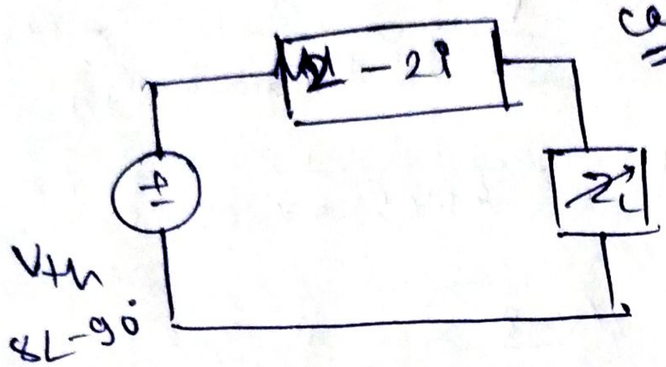
$= 2 - 2i$



$V_{th} = \dfrac{8\angle 0^\circ \times (-2i)}{(2+\cancel{2i}-\cancel{2i})}$

$= +8\angle 0^\circ \, i \angle -90^\circ$

$= 8\angle -90^\circ$



case ① for MPT

$Z_L = Z_s^*$

$= 2+2i$

and $P_{max} = \dfrac{(V_{th}^2)_{rms}}{4R_s}$

$= \dfrac{8^2\angle -180^\circ}{4\times 2\times(\sqrt{2})^2}$

$= (8\angle -180^\circ)/2$

$\boxed{P_{max} = 4W}$

case ② for Resistive load

$R_L = \sqrt{R_s^2+X_L^2} = 2\sqrt{2} = \sqrt{8}\,\Omega$

$I_{max} = \cancel{(V_{th})}.\ \dfrac{V_{th}}{2-2i+\sqrt{8}} = \dfrac{8^2\angle -180^\circ}{5.226\angle 202.5}$

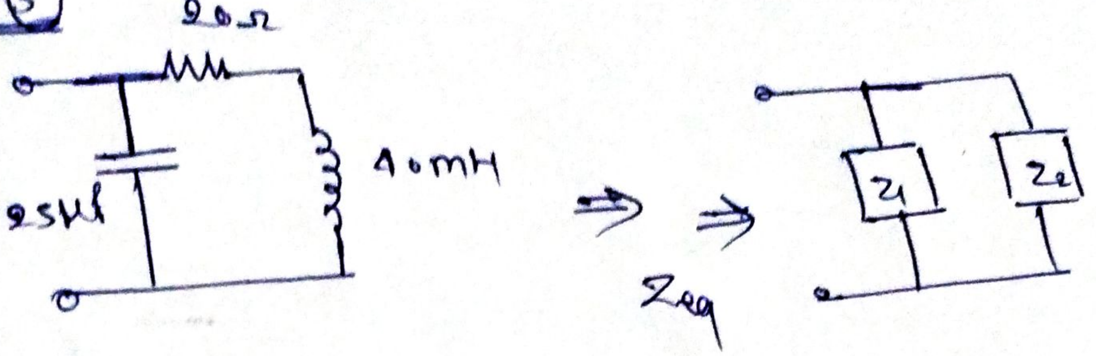
$= 1.53\angle -22.5$

~~Pmax = 1.53~~

$P_{max} = |I_{rms}|^2 R_L = \dfrac{(1.53)^2}{(\sqrt{2})^2}\times\sqrt{8} = \dfrac{6.62}{2}W$ Ans

$\boxed{P_{max} = \dfrac{6.62}{2}W} \Rightarrow \boxed{P_{max} = 3.31 \text{ watt}}$ Ans

AN③



$Z_1 = -jX_c = -106.157\,\Omega$

$Z_2 = 20 + jX_L = 20 + 15.0729\,\Omega$

then $Z_{eq} = Z_1 \| Z_2$

$Z_{eq} = 25.92 + j\,11.875$

(a) $\phi = \tan^{-1}\left(\frac{Z_{eq}|_{Im}}{Z_{eq}|_R}\right) = \tan^{-1}\left(\frac{11.875}{25.92}\right)$

$\phi = 24.61 \Rightarrow \boxed{\cos\phi = 0.909}$

(b) $\because$ $\angle Z_{eq}$ = +ve and overall behavior of Zeq is inductive hence it is lagging pf.

(c) value of 'c' to get pf = 1

$Z_{eq} = \frac{(20 + j15.072)(-jX_c)}{20 + j15.072 + (-jX_c)}$

$= \frac{(20 + j15.072)(-jX_c)(20 - j(15.072 - X_c))}{(20)^2 + (15.072 - X_c)^2}$

for unity pf img part = 0

$$\frac{j\left[400X_c + 15.072X_c(15.072 - X_c)\right]}{(20)^2 + (15.072 - X_c)^2} = 0$$

$$400 + 15.072(15.072 - X_c) = 0$$

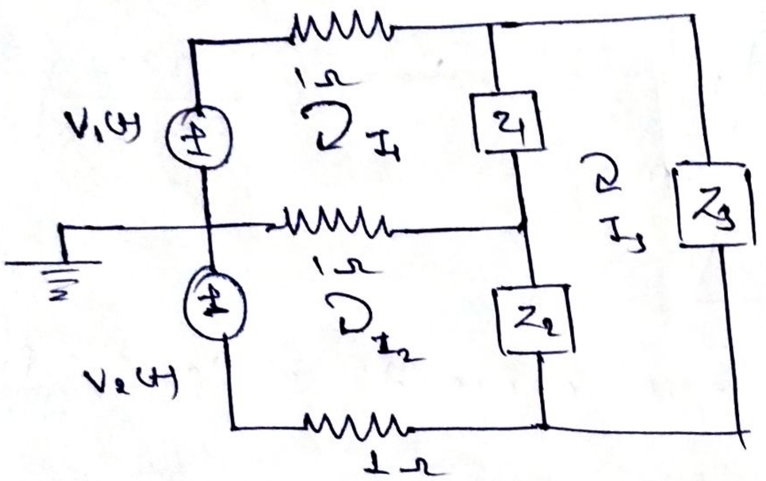
$$X_c = 41.61$$

$$\frac{1}{\omega c} = 41.61$$

$$\Rightarrow c = \frac{1}{2\pi \times 60 \times 41.61} = 63.73\mu f$$

$$\boxed{c = 63.73\mu f}$$ Ans

Ans(4) given ckt



$V_1(t) = 120\sqrt{2}\sin \omega t$

$= 120\sqrt{2}\angle 0°$

$V_2(t) = 120\sqrt{2}\cos \omega t$

$= 120\sqrt{2}\sin(90° + \omega t)$

$= 120\sqrt{2}\angle 90°$

apply KVL in Loop (1), (2) and (3)

$$-V_1 + I_1 + Z_1(I_1 - I_3) + (I_1 - I_2) = 0$$

$$\Rightarrow I_1(4 + 5i) - I_2 - (2 + 5i)I_3 = 120\sqrt{2} \quad \text{---(1)}$$

$$-V_2 + (I_2 - I_1) + Z_2(I_2 - I_3) + I_2 = 0$$

$$-I_1 + (5 + 4i)I_2 - (3 + 4i)I_3 = 120\sqrt{2}i \quad \text{---(2)}$$

$Z_3 I_3 + Z_2(I_3 - I_2) + Z_1(I_3 - I_1) = 0$

$\Rightarrow -(2+5i)I_1 - (3+4i)I_2 + (10-6i)I_3 = 0$ —— (3)

By solving (1), (2), (3)

$I_1 = 24.51 - i37.17 = 44.52\angle -56.6^\circ$

$I_2 = 13.92 + i30.34 = 33.38\angle 65.36^\circ$

$I_3 = 2.82 + i21.18 = 21.37\angle 82.42^\circ$

Hence, power supplied by V_1:

$$P_{avg} = \frac{1}{2} \cdot V_1 I_1 \cos(\theta_V - \theta_I)$$

$$= \frac{1}{2} \times 120\sqrt{2} \times 44.52\,(0-(-56.6^\circ)))$$

$$\boxed{P_{avg} = 2.079\ \text{KW}}$$

& Power supply by V_2:

$$P_{avg} = \frac{1}{2} \times V_2 \times I_2 \cos(\theta_V - \theta_I)$$

$$= \frac{1}{2} \times 120\sqrt{2} \times 33.38(90' - 65.36)$$

$$= 2.57\ \text{KW}$$ Ans

Ans (5)

(a)

Time		Phasor domain
$v(t)$	$\rightarrow$	V
$\int v(t)$	$\rightarrow$	$V/j\omega$
$10\cos t$	$\rightarrow$	$10\angle 0^\circ$

Hence equation will become $\Rightarrow$

$$V + \frac{V}{j\omega} = 10\angle 0^\circ \Rightarrow V(1-j) = 10\angle 0^\circ$$

($\omega = 1$ rad/sec)

$\Rightarrow V(1-j) = 10\angle 0^\circ \Rightarrow V\sqrt{2}\angle -45^\circ = 10\angle 0^\circ$

$\Rightarrow \quad V = \frac{10}{\sqrt{2}}\angle 45^\circ = 7.07\angle 45^\circ \ V$

$V(t) = 7.07\cos(\omega t + 45^\circ)$

$\boxed{V(t) = 7.07\cos(t + 45^\circ)}$ Ans

(b) $\frac{d}{dt}v(t) \rightarrow j\omega V, \ v(t) \rightarrow V, \ \int v(t) \rightarrow \frac{V}{j\omega}$

Then $j\omega V + 5V + 4 \times \frac{V}{j\omega} = 20\angle 10^\circ$

$\omega = 4$ rad/sec

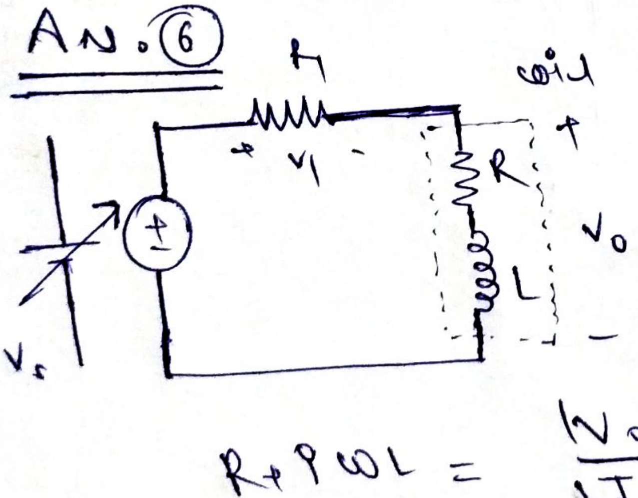
$4j \times V + 5V + (-jV) = 20\angle 10^\circ$

$\Rightarrow (3j + 5)V = 20\angle 10^\circ$

$\Rightarrow V = \frac{20\angle 10^\circ}{5.83\angle 30.96} = 3.43\angle -20.96^\circ \ V$

$\boxed{V(t) = 3.43\sin(4t - 20.96^\circ)} \ V$

An. 6



$|V_s| = 145V$

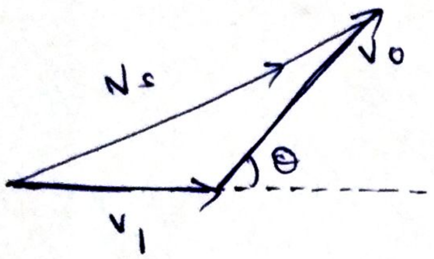
$|V_1| = 50V$

$|V_o| = 110V$

freq. $= 60Hz$

$R + j\omega L = \frac{|V_o|}{|I_o|}\angle \theta_v - \theta_i$ —— (1)

For finding θ_v and θ_i,
Since load is partly inductive, current I_o lags the voltage V_o.
Since V_1 is across a ~~regi~~ resistor, hence I_o and V_o have same phase.



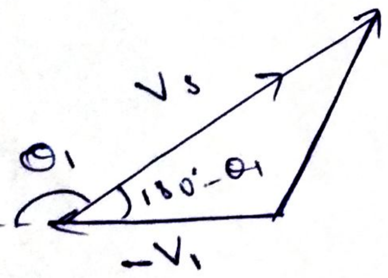
$$|V_s|^2 = |V_1|^2 + |V_o|^2 + 2|V_1||V_2|\cos\theta$$

put all the values

&

$$\cos\theta = \frac{(145)^2 - (50)^2 - (110)^2}{2 \times 50 \times 110}$$

$$\theta = 54.26^\circ = \theta_v - \theta_i$$



$$V_o \quad |V_o|^2 = |V_1|^2 + |V_s|^2 + 2|V_1||V_s|\cos\theta_1$$

put all the values

and

$$\theta_1 = 141.99^\circ$$

Then angle b/w V_s and V_1

$$180^\circ - \theta_1 = 38.01^\circ$$

$$\therefore |i_o| = \frac{|V_1|}{R_1} = \left(\frac{50}{R_1}\right)$$

$$R + i\omega L = \frac{|V_o|}{|I_o|} \angle\theta = \frac{110 \times R_1}{50} \angle 54.26^\circ$$

$$R + i\omega L = 2.2 R_1 (0.584 + i\,0.812)$$

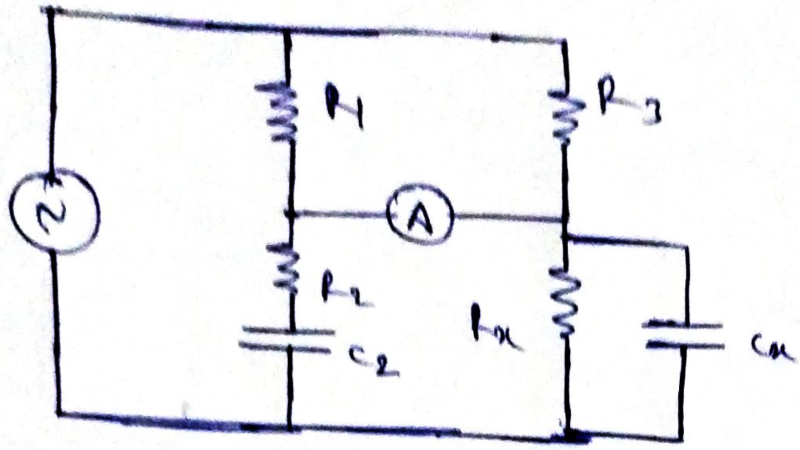
$$= 1.285 R_1 + i\,1.785 R_1$$

Hence $\boxed{R = 1.285 R_1}$

$$\omega L = 1.785 R_1 \Rightarrow \quad L = \frac{1.785 R_1}{2\pi \times 60}$$

$\boxed{L = 4.735 R_1 \text{ mH}}$ Ans

Ans (7)



Given
$R_1 = 400\,\Omega$
$R_2 = 600\,\Omega$
$R_3 = 1.2\,K\Omega$
$C_2 = 0.3\,\mu F$
freq. = 50 Hz
$\omega = 100\pi$ rad/sec

$\because$ bridge is balanced here

$$\frac{R_1}{\left(R_2 - j/\omega C_2\right)} = \frac{R_3}{R_x \,||\, \left(\frac{-j}{\omega C_x}\right)}$$

$$\Rightarrow \frac{R_1}{R_2 - j/\omega C_2} = \frac{R_3}{\left(\frac{R_x \times (-j/\omega C_x)}{R_x - j/\omega C_x}\right)}$$

$\Rightarrow$ put all the values and arrange it

$$R_2 R_3 - \frac{j R_3}{\omega C_2} = \frac{R_1 R_x (1 - j\omega R_x C_x)}{1 + \omega^2 R_x^2 C_x^2}$$

$$R_2 R_3 = \frac{R_1 R_x}{1 + (\omega R_x C_x)^2} \quad \text{—— (1)}$$

$$\frac{R_3}{\omega C_2} = \frac{\omega R_1 R_x^2 C_x}{1 + (\omega R_x C_x)^2} \quad \text{—— (2)}$$

(1) $\div$ (2)

$$\omega R_2 C_2 = \frac{1}{\omega R_x C_x} \Rightarrow R_2 C_2 = \frac{1}{\omega^2 R_x C_x} \quad \text{—— (3)}$$

$$R_x C_x = \frac{1}{(100\pi)^2 * 600 \times 0.3 \times 10^{-6}} = 0.056 \text{ sec}$$

from eq ①

$$R_2 R_3 = \frac{R_1 R_x}{1 + \omega^2 (R_x C_x)^2}$$

$$\Rightarrow \boxed{R_x = 559 \, k\Omega}$$

then

$$C_x = \frac{0.56}{556} \times 10^{-3}$$

$$\boxed{C_x = 0.1 \mu f}$$ Ans