$$I_1 = 4\,mA \quad \text{—— (1)} \quad -(3)$$

$$I_2 = \frac{V_x}{2K} = \frac{2K(I_3 - I_1)}{2K}$$

$$I_2 + I_1 - I_3 = 0 \quad \text{—— (2)} \quad -(3)$$

$$1K\,I_x - 2K(I_3 - I_1) - 1K(I_3 - I_4) = 0$$

$I_x = I_4 - I_2$

$$1k(I_4 - I_2) - 2K(I_3 - I_1) - 1K(I_3 - I_4) = 0$$

$$2I_4 - I_2 - 3I_3 + 2I_1 = 0 \quad \text{—— (3)} \quad -(3)$$

$$12 + 1k(I_4 - I_3) + 1K(I_4 - I_2) = 0$$

$$\frac{12}{1K} + 2I_4 - I_2 - I_3 = 0 \quad \text{—— (4)} \quad -(3)$$

By (3) & (4)

$$-2I_3 + 2I_1 - 12m = 0$$

$$2I_3 = 2I_1 - 12m$$

$$2I_3 = 8 - 12 = -4m$$

$$\boxed{I_3 = -2\,mA} \quad -(3)$$

$$\cancel{I_1 = I_3 + I_2}$$

from (eqn 2) $\Rightarrow$ $$I_2 = I_3 - I_1 = -2m - 4m$$

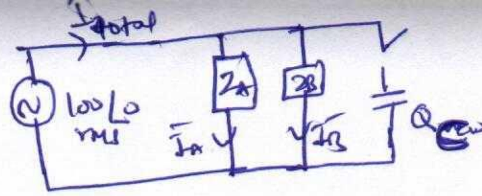
$$\boxed{I_2 = -6\,mA} \quad -(3)$$

from eqn 4: $$I_4 = -6m + \frac{(I_2 + I_3)}{2}$$

$$= -6m - 4m = -10\,mA \quad -(3)$$

Power $= 12 \times (-)(-10) = 120\,mW$ —— (4)

$V = 100\angle 0$



$I_A = 12\angle -25.84^\circ = 10.8 - j5.23\,A$

$I_{Total} = 20\angle -36.87^\circ$ (as $\cos^{-1} 0.8 = 36.87^\circ$)
$= (16 - j12)\ A$

$Z_{total} = \dfrac{V = 100\angle 0}{20\angle -36.87} = 5\angle 36.87^\circ$

$= 4 + j3 \Rightarrow R = 4\ \&\ X = 3\,\Omega$ — (6)

Impedance of ckt A $= \dfrac{V}{I_A}$

$Z_A = \dfrac{100\angle 0}{12\angle -25.84} = 8.33\angle 25.84^\circ$

$= 7.5 + j\,3.63$

$R_A = 7.5\ \&\ X_A = 3.63\,\Omega$. — (6)

Now $\bar{I}_{total} - \bar{I}_A = \bar{I}_B$ (using KCL)

$\bar{I}_B = 20\angle -36.87 - 12\angle -25.84^\circ$

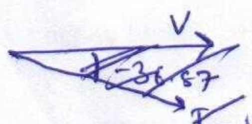
$I_B = 16 - j12 - (10.8 - j5.23)$ — (3)

$I_B = 5.2 - j6.77 = 8.54\angle -52.47^\circ$.

$\Rightarrow Z_B = \dfrac{V}{I_B} = \dfrac{100\angle 0}{8.54\angle -52.47^\circ}$

$= 11.71\angle 52.47^\circ$

$\Rightarrow R_B = 7.133\ \&\ X_B = 9.286\,\Omega$ — (6)



Assume that Q_{new} is given by Capacitance

$P_{Total} = I_{Total}^2 \times R_{total} = 20^2 \times 4 = 1600\,W$

$Q_{total} = I^2 \times X_{total} = 20^2 \times 3 = 1200\ VAR$

Reqd $\cos\theta = 0.95 \Rightarrow \theta = 18.19^\circ$

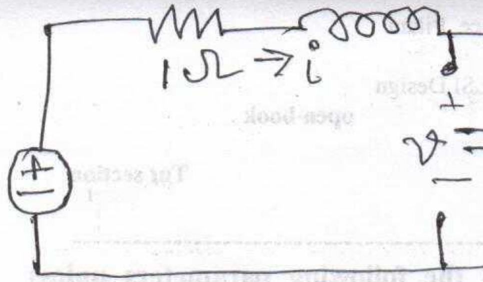
$\tan\theta = \dfrac{Q_{total} - Q_{new}}{P_{total}}$

$0.33 = \dfrac{1200 - Q_{new}}{1600} \Rightarrow Q_{new} = 674\ VAR$ — (5)

$Q_C = 674 = \dfrac{V^2}{X_C} = V^2 \cdot \omega C = (100)^2 \cdot 2\pi \times 50 \times C$

$\Rightarrow \boxed{C = 215\ \mu F}$ — (4)

Q3.



S/w open

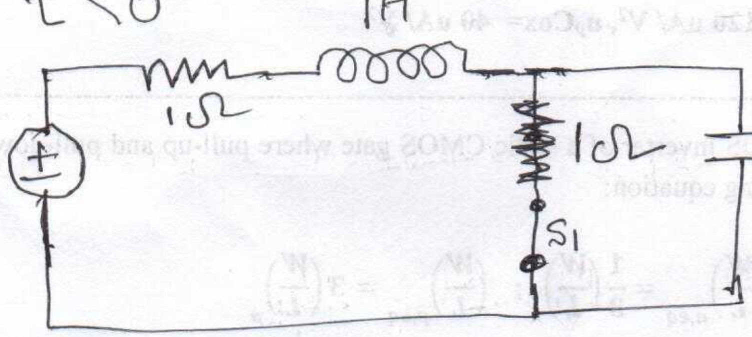
$$\alpha = \frac{R}{2L} = \frac{1}{2\times 1} = 0.5$$

$$\omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{1\times 0.25}} = 2$$

$\boxed{\alpha < \omega_0}$ underdamped case (3)

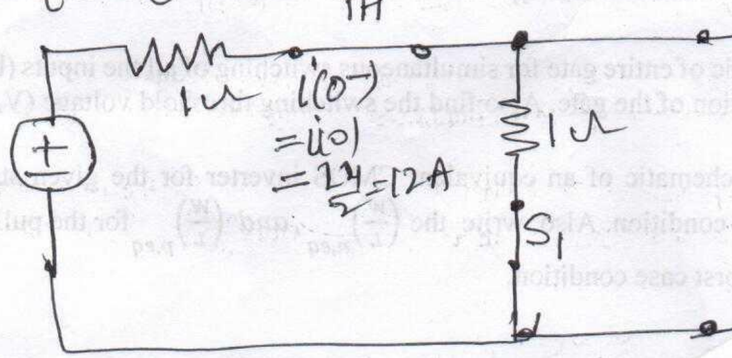
for $0 < t < \infty$

for $t < 0$



(when switch close).

at $t = 0^-$



$v(0) = 12V = v(0^-)$

$I_0 = 12A$ (3+3 = 6)

for $0 < t < \infty$

$$S = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2} = -0.5 \pm j1.936$$

$$v(t) = 24 + (A_1 \cos 1.936t + A_2 \sin 1.936t)e^{-0.5t}$$

$v(0) = 12 \Rightarrow 12 = 24 + A_1 \Rightarrow$ ~~A1 = 12~~ $\boxed{A_1 = -12V}$ (2)

$i(0) = C\frac{dv(0)}{dt} \Rightarrow \boxed{\frac{dv(0)}{dt} = \frac{i(0)}{C} = 12/0.25 = 48}$

$$\frac{dv}{dt} = e^{-0.5t}(-1.936A_1 \sin 1.936t + 1.936A_2 \cos 1.936t) - 0.5e^{-0.5t}(A_1 \cos 1.936t + A_2 \sin 1.936t)$$

$$\frac{dv(0)}{dt} = (-0 + 1.936A_2) - 0.5(A_1 + 0)$$

$$48 = 1.936A_2 - 0.5\times(-12)$$

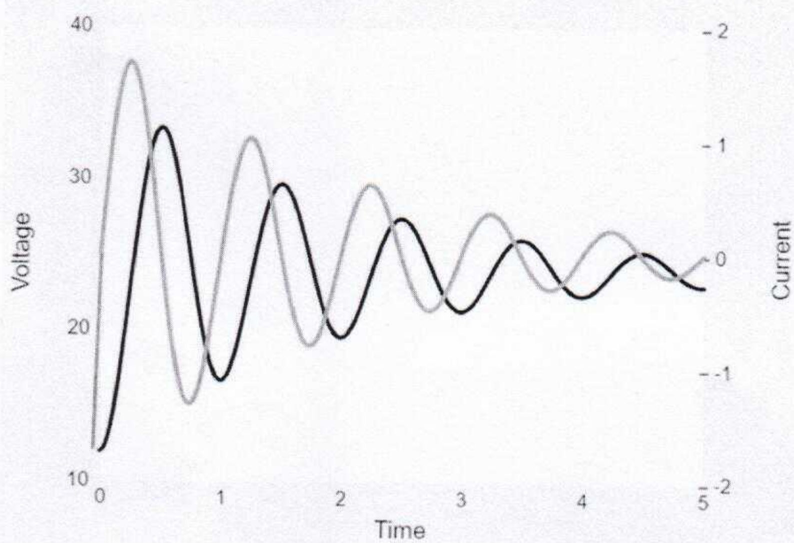
$$\Rightarrow A_2 = 21.694 \quad (2)$$

$$\Rightarrow v(t) = 24 + (21.694 \sin 1.936t - 12 \cos 1.936t)\, e^{-0.5t}$$ 4

$$i(t) = C\frac{dv(t)}{dt} = 0.25 \frac{d}{dt}\left[24 + \{(21.694 \sin 1.936t - 12 \cos 1.936t\} \right] e^{-0.5t}$$

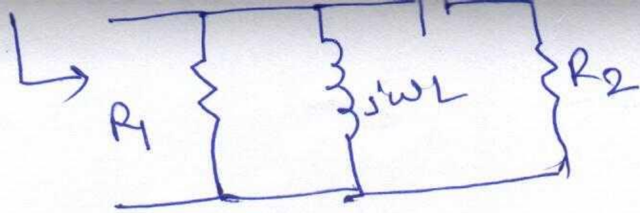
$$\boxed{i(t) = [3.1 \sin 1.936t + 12 \cos 1.936t]\, e^{-0.5t} \text{ A}}$$ 4

Plot of v(t) and i(t) with respect to time is shown in figure appended below:



4

1



$$Z_{in} = (R_1 \| j\omega L) \| \left(R_2 + \frac{1}{j\omega C}\right) \quad - \quad 2M$$

$$= \frac{\left(\frac{jR_1\omega L}{R_1 + j\omega L}\right) \times R_2 + 1/j\omega C}{\left(\frac{jR_1\omega L}{R_1 + j\omega L}\right) + \left(R_2 + \frac{1}{j\omega C}\right)}$$

$$= \frac{(-\omega^2 R_1 R_2 LC + j\omega R_1 L)[R_1 - \omega^2 LC R_1 - \omega^2 LCR_2 - j\omega(L + R_2 R_1 C)]}{(R_1 - \omega^2 LCR_1 - \omega^2 LCR_2)^2 + \omega^2 (L + R_1 R_2 C)^2}$$

at resonance, $Im(Z) = 0$.

$$\omega^3 R_1 R_2 LC (L + R_1 R_2 C) + \omega R_1^2 L - \omega^3 R_1^2 L^2 C - \omega^3 L^2 R_1 R_2 C = 0.$$

$$\downarrow$$

$$\omega^3 R_1^2 R_2^2 LC^2 + \omega R_1^2 L - \omega^3 R_1^2 L^2 C = 0.$$

taking common $\omega R_1^2 L$

$$\omega_1 R_1^2 L(\omega^2 R_2^2 C^2 + 1 - \omega^2 LC) = 0.$$

$\because \omega_1 R_1^2 L \neq 0$.

$$\Rightarrow \omega^2 LC - \omega^2 R_2^2 C^2 = 1$$

$$\therefore \omega^2 = \frac{1}{LC - R_2^2 C^2}$$

$$\text{or, } \boxed{\omega = \frac{1}{\sqrt{LC - R_2^2 C^2}}} \quad - \quad 4M$$

$\omega_0 = 2.603$ Krad/s

Or, $f_0 = 414.3$ Hz $\left[f_0 = \frac{\omega_0}{2\pi}\right]$, — (6M)

(iii) $Z_{in}(\omega_0) = (R_1 \parallel j\omega L) \parallel \left(R_2 + \frac{1}{j\omega C}\right)$

$\omega L = 26.03\big|_{\omega_0}$, $\frac{1}{\omega C} = 21.34\big|_{\omega_0}$.

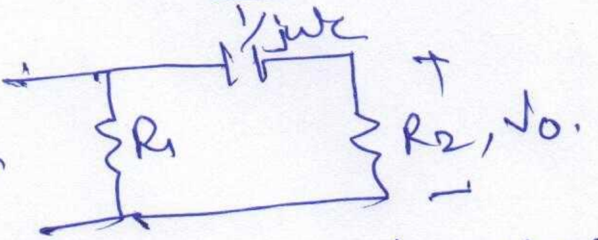
$= \left(\frac{1 \times j26.03}{1 + j26.03}\right) \parallel (10 - j21.34)$

$= (0.998 + j0.0384) \parallel (10 - j21.34)$

$= \frac{10.8 - j20.116}{0.998 - j21.3016} = \frac{23.54\angle -62.7^\circ}{23.97\angle -62.7^\circ}$

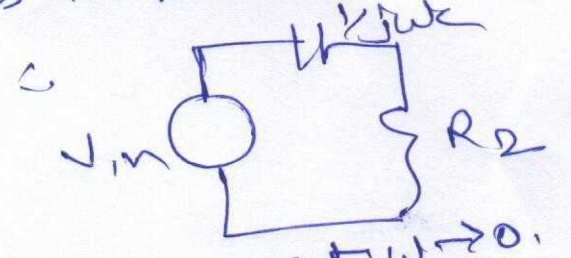
$\boxed{= 0.98\angle 0^\circ \approx 1\Omega}$ (6M)

(b)



Since, v_{in} is applied across R_1 which is in parallel to inductor & resistor R_2.

∴



$\rightarrow \boxed{\frac{v_o}{v_{in}} = \frac{j\omega C R_2}{1 + j\omega C R_2} = TF}$ (4M)

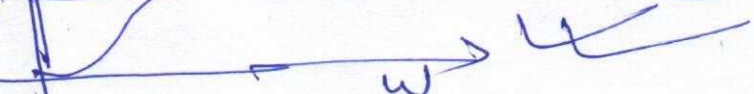
at $\omega \to 0$, $TF = 0$.

$\omega \to \infty$ $\frac{v_o}{v_{in}} = TF = 1$

∴ The response is of $\boxed{\text{high pass filter}}$ — (2M)

$\boxed{\omega = \frac{1}{R_2 C} \rightarrow \text{is the half power freq.}}$ (1M)

(i)



→ 4