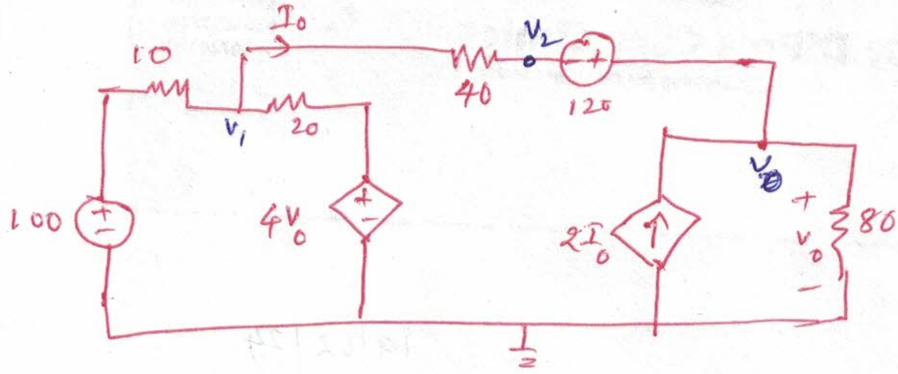
LNT- Key.

Q1



Let v_1, v_2 be the non-reference voltages.

Applying KCL at Node 1:

$$\frac{v_1 - 100}{10} + \frac{v_1 - 4v_0}{20} + \frac{v_1 - v_2}{40} = 0$$

But $v_2 = v_0 - 120$

$$\therefore \quad 7v_1 - 9v_0 = 280 \quad - (1) \rightarrow 0.5M$$

At node 2:

$$-i_0 - 2i_0 + \frac{v_0}{80} = 0 \quad \Rightarrow \quad 3i_0 = \frac{v_0}{80}$$

but $i_0 = \dfrac{v_1 + 120 - v_0}{40}$

$$\Rightarrow 3\left(\frac{v_1 + 120 - v_0}{40}\right) = \frac{v_0}{80}$$

$$6v_1 - 7v_0 = -720 \quad - (2) - 0.5M$$

From (1) & (2)

$$\begin{bmatrix} 7 & -9 \\ 6 & -7 \end{bmatrix} \begin{bmatrix} v_1 \\ v_0 \end{bmatrix} = \begin{bmatrix} 280 \\ -720 \end{bmatrix}$$

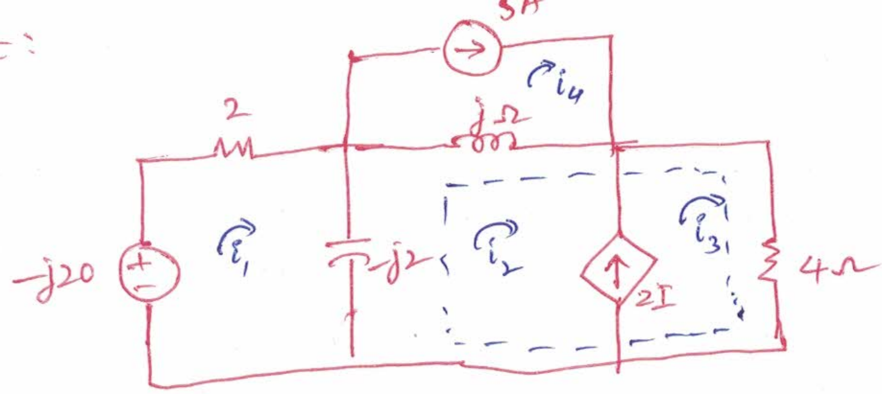
$$\left.\begin{aligned} \Delta &= 5 \\ \Delta_1 &= -8440 \\ \Delta_2 &= -6720 \end{aligned}\right\} 1M$$

$v_1 = \dfrac{\Delta_1}{\Delta} = -1688\text{ V}. \quad - 1$

$v_0 = \dfrac{\Delta_2}{\Delta} = -1344\text{ V}. \quad - 1$

$I_0 = -5.6\text{ A}. \quad - 1$

Q2:



For Mesh 1: $-j20 - 2i_1 + j2(i_1 - i_2) = 0$

$(-1+1j)\,i_1 - (1j)\,i_2 = j10$ — ① — 1M

For Super mesh: $-(-j2)(i_2 - i_1) - 1j(i_2 - i_4) - 4i_3 = 0$

$i_4 = 5A$, $\quad i_3 - i_2 = 2I = 2(i_1 - i_2) \Rightarrow i_3 = 2i_1 - i_2$

$\therefore \quad (-8-j2)\,i_1 + (4+j)\,i_2 = -5j$ — ② → 1M

$$\begin{bmatrix} -1+1j & -1j \\ -8-j2 & 4+j \end{bmatrix}\begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} j10 \\ -j5 \end{bmatrix},$$

$\Delta = -3-5j$
$\Delta_1 = -5+40j$
$\Delta_2 = -15+85j$
1.5M

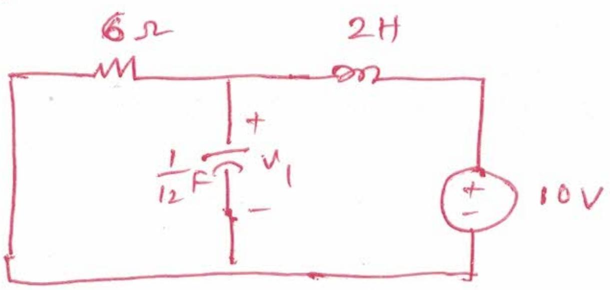
$I = I_1 - I_2 = \dfrac{\Delta_1 - \Delta_2}{\Delta} = 5.7 + j5.4$ or $7.9\angle 43.4^\circ$ A.

→ 1.5M

Q3: By using Super position theorem, v_o can be expressed as

$$v_o = v_1 + v_2 + v_3$$

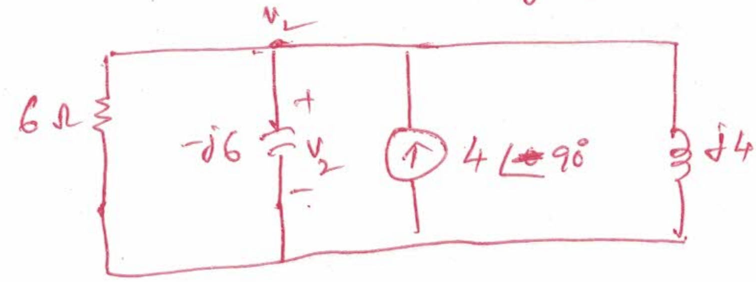
With 10V:



$v_1 = 10V$. — 1M

with 4A: $\omega = 2$, $j\omega L = j4\ \Omega$

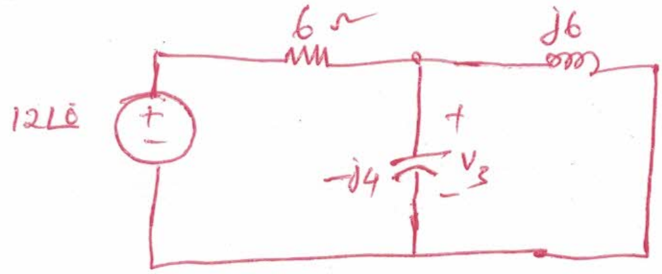
$\frac{1}{j\omega C} = -j6\ \Omega$



Apply in KCL, $\frac{V_2}{6} + \frac{V_2}{-j6} + \frac{V_2}{j4} = -4j$

$(0.16 - 0.083j)\,V_2 = -4j \Rightarrow V_2 = 9.6 - 19.2j$ or $= 21.4\angle -63^\circ$ → 2M

12V Source:



$\omega = 3$,
$j\omega L = j6$
$\frac{1}{j\omega C} = -j4$

$\frac{V_3 - 12}{6} + \frac{V_3}{-j4} + \frac{V_3}{j6} = 0 \Rightarrow V_3\left(\frac{1}{6} + \frac{1}{-j4} + \frac{1}{j6}\right) = 2.$

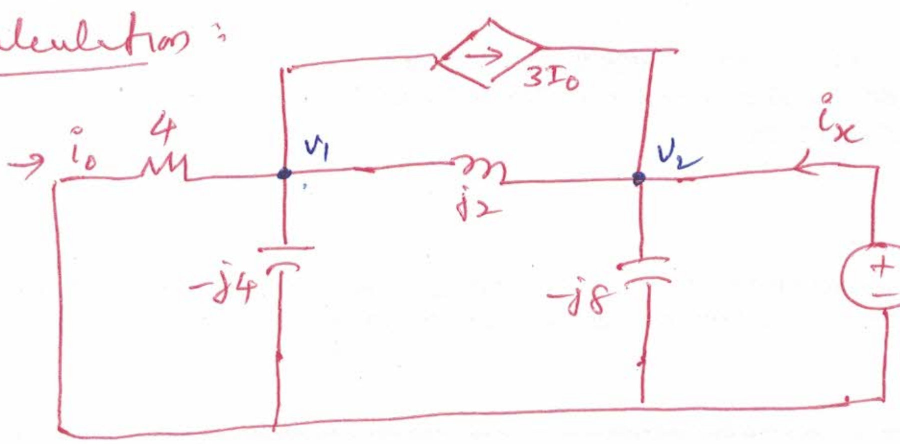
$V_3 = 9.6 - 4.8j$ or $10.73\angle -26.56$. – 2M

$V_0 = 10 + 21.45\cos(2t - 63^\circ) + 10.73\cos(3t - 26.56)$ V.

Q4:

– Transform all elements to frequency domain.

Zth. calculation:



Apply KCL at node 1 (4)

$$\frac{V_1}{4} + \frac{V_1}{-j4} + 3i_0 + \frac{V_1 - 1}{j2} = 0 \quad \rightarrow \text{ when } i_0 = \frac{-V_x}{4}$$

$$\therefore \frac{V_1}{-j4} - \frac{2V_1}{4} = \frac{1 - V_x}{j2} \Rightarrow V_1\left(\frac{1}{-j4} - \frac{1}{2} + \frac{1}{j2}\right) = \frac{1}{j2}$$

$$\boxed{V_1 = 0.4 + 0.8j}$$

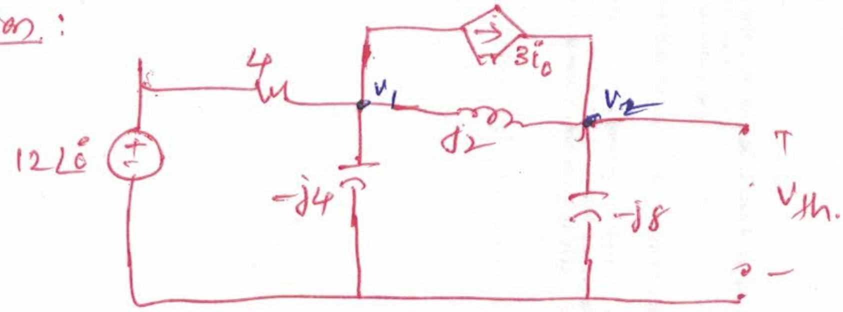
At node 2:

$$I_x + 3I_0 = \frac{1}{-j8} + \frac{1 - V_1}{j2}$$

$$I_x = (0.75 + j0.5)V_1 - j\frac{3}{8} = -0.1 + j0.425$$

$$\therefore Z_{th} = \frac{1}{I_x} = -0.52 - j2.2 = \text{or } 2.29\angle -103.2^\circ \Omega. \quad - 2M$$

Vth Calculation:



At node 1:

$$\frac{12 - V_1}{4} = 3i_0 + \frac{V_1}{-4j} + \frac{V_1 - V_2}{2j}, \quad \text{where } i_0 = \frac{12 - V_1}{4}.$$

$$(2+j)V_1 - j2V_2 = 24 \quad - (1)$$

At node 2:

$$\frac{V_1 - V_2}{j2} + 3i_0 = \frac{V_2}{-j8} \Rightarrow (6 + j4)V_1 - j3V_2 = 72 \quad - (2)$$

$$\begin{bmatrix} 2+j & -j2 \\ 6+j4 & -j3 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 24 \\ 72 \end{bmatrix}$$

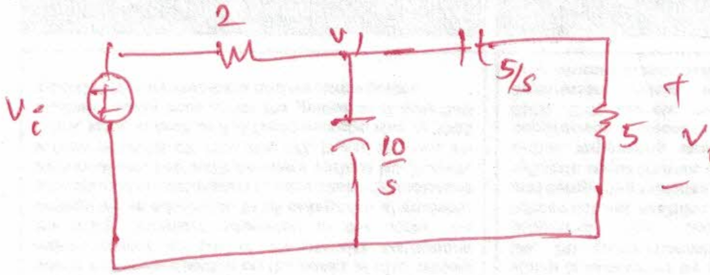
$\Delta = -5 + j6$; $\Delta_2 = -j24$. ; $V_{th} = V_2 = 3.\angle -219.8$ $\hookrightarrow$ 2M

$$V_0 = \frac{2}{2 + Z_{th}} \cdot V_{th} = 2.3\angle -163.3^\circ \text{ V}. \quad - 1M.$$

Q5: Transform all elements to freq. domain.

$$0.2F \rightarrow \frac{1}{j\omega C} = \frac{1}{s(0.2)} = \frac{5}{s}$$

$$0.1F = \frac{1}{s(0.1)} = \frac{10}{s}$$



Let $Z = \frac{10}{s} \parallel \left(5+\frac{5}{s}\right) = \frac{10(s+1)}{s(s+3)}$ — 1M

$V_1 = \frac{Z}{Z+2} V_i$; $V_0 = \frac{5}{5+\frac{5}{s}} V_1 = \frac{s}{s+1} \cdot \frac{Z}{Z+2} \cdot V_i$

↳ 1M ↳ 1M

$H(s) = \frac{V_0}{V_i} = \frac{5s}{s^2+8s+5}$ → 2M.