Question 1

Solving using the mesh-current method:

mesh $\bar{I}_1$: $-30\angle 20^\circ + (3+j4)\bar{I}_1 + (2+j)(\bar{I}_1 - \bar{I}_2) = 0$

$-30\angle 20^\circ + 3\bar{I}_1 + j4\bar{I}_1 + 2\bar{I}_1 + j\bar{I}_1 - 2\bar{I}_2 - j\bar{I}_2 = 0$

$$(5+j5)\bar{I}_1 + (-2-j)\bar{I}_2 = 30\angle 20^\circ \qquad (1)$$

mesh $\bar{I}_2$: $(2+j)(\bar{I}_2 - \bar{I}_1) + (3+j2-j6)\bar{I}_2 = 0$

$2\bar{I}_2 - 2\bar{I}_1 + j\bar{I}_2 - j\bar{I}_1 + 3\bar{I}_2 - j4\bar{I}_2 = 0$

$$(5-j3)\bar{I}_2 + (-2-j)\bar{I}_1 = 0 \qquad (2)$$

From equation (2), $\bar{I}_2 = \dfrac{(2+j)}{5-j3}\bar{I}_1$

so $\bar{I}_2 = \dfrac{(2+j)}{(5-j3)} \cdot \dfrac{(5+j3)}{(5+j3)} \times \bar{I}_1$

$$= \frac{7+j11}{34} \times \bar{I}_1 = (0.2059 + j0.3235)\bar{I}_1 \qquad (3)$$

Substitute into equation (1),

$(5+j5)\bar{I}_1 + (-2-j)(0.2056 + j0.3235)\bar{I}_1 = 30\angle 20^\circ$

$(5+j5)\bar{I}_1 + (-0.08824 - j0.8529)\bar{I}_1 = 30\angle 20^\circ$

$(4.9118 + j4.1471)\bar{I}_1 = 30\angle 20^\circ$

$\bar{I}_1 = \dfrac{28.191 + j10.261}{4.9118 + j4.1471} = \dfrac{30\angle 20^\circ}{6.4284\angle 40.175^\circ}$

$$\boxed{\bar{I}_1 = 4.667\angle -20.174^\circ}$$

From equation (3),

$\bar{I}_2 = (0.2056 + j0.3235)\bar{I}_1 = (0.3835\angle 57.529^\circ)\bar{I}_1$

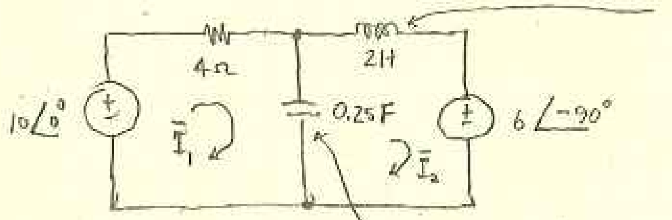
$\bar{I}_2 = (4.667\angle -20.174^\circ)(0.3835\angle 57.529^\circ)$

$$\boxed{\bar{I}_2 = 1.790\angle 37.355^\circ}$$

Question 2

In phasor form using complex impedances

$j\omega L = j \times 2 \times 2$
$= j4\Omega$



$$\frac{1}{j\omega C} = \frac{1}{j(2)(0.25)} = -j2\Omega$$

Mesh $\bar{I}_1$: $-10\angle 0^\circ + 4\bar{I}_1 + (-2j)(\bar{I}_1 - \bar{I}_2) = 0$

$$-10 + 4\bar{I}_1 - j2\bar{I}_1 + j2\bar{I}_2 = 0$$

$$(4 - j6)\bar{I}_1 + j2\bar{I}_2 = 10 \qquad (1)$$

Mesh $\bar{I}_2$: $(-j2)(\bar{I}_2 - \bar{I}_1) + (j4)\bar{I}_2 + 6\angle -90^\circ = 0$

$$-j2\bar{I}_2 + j2\bar{I}_1 + j4\bar{I}_2 - j6 = 0$$

$$j2\bar{I}_2 + j2\bar{I}_1 = j6$$

Divide by j: $2\bar{I}_2 + 2\bar{I}_1 = 6 \qquad (2)$

From equation (2), $\bar{I}_2 + \bar{I}_1 = 3$, so $\bar{I}_2 = 3 - \bar{I}_1 \qquad (3)$

Substitute into (1)

$$(4 - j2)\bar{I}_1 + j2(3 - \bar{I}_1) = 10$$

$$4\bar{I}_1 - j2\bar{I}_1 + j6 - j2\bar{I}_1 = 10$$

$$(4 - j4)\bar{I}_1 = 10 - j6$$

$$\bar{I}_1 = \frac{10 - j6}{4 - j4} = \frac{10 - j6}{4 - j4} \times \frac{4 + j4}{4 + j4} = \frac{40 + j40 - j24 + 24}{16 - j16 + j16 + 16} = \frac{64 + j16}{32}$$

$$\bar{I}_1 = 2 + j0.5$$

From (3), $\bar{I}_2 = 3 - \bar{I}_1 = 3 - 2 - j0.5 = 1 - j0.5$

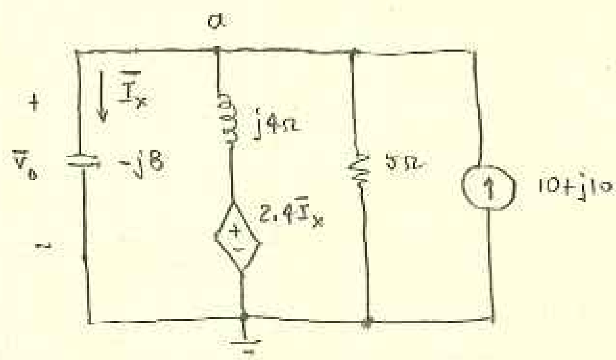
And $\bar{I}_0 = \bar{I}_1 - \bar{I}_2 = 2 + j0.5 - (1 - j0.5) = 1 + j$

$$\bar{I}_0 = 1 + j = 1.414\angle 45^\circ$$

Question 3

From above, $\theta = 14.036^\circ$

Question 4



Note that $\bar{V}_0 = \bar{V}_a$

Using the node-voltage method,

$$\frac{\bar{V}_0}{-j8} + \frac{\bar{V}_0 - 2.4\bar{I}_x}{j4} + \frac{\bar{V}_0}{5} - (10+j10) = 0$$

$$(\times j40) \qquad -5\bar{V}_0 + 10\bar{V}_0 - 24\bar{I}_x + j8\bar{V}_0 = -400 + j400$$

$$\bar{V}_0(5+j8) - 24\bar{I}_x = -400 + j400 \qquad (1)$$

The controlling current $\bar{I}_x = \dfrac{\bar{V}_0}{-j8}$, so equation (1) becomes

$$(5+j8)\bar{V}_0 - j3\bar{V}_0 = -400 + j400$$

$$(5+j5)\bar{V}_0 = -400 + j400$$

$$\text{so} \quad \bar{V}_0 = \frac{-400+j400}{5+j5} = \frac{-80+j80}{1+j1}$$

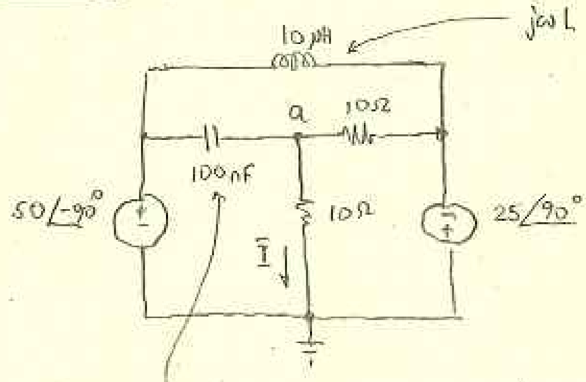
$$\text{and} \quad \bar{V}_0 = \frac{-80+j80}{1+j} \cdot \frac{1-j}{1-j} = \frac{-80+j80+j80+80}{1+j-j+1}$$

$$= \frac{j160}{2} = \boxed{j80}$$

Question 5

From above, $\bar{V}_o = j80$ V, so $\boxed{\theta = 90^\circ}$

Question 6



$$j\omega L = j10^6 \times 10 \times 10^{-6} = j10\Omega$$

$$\frac{1}{j\omega C} = \frac{1}{j(10^6 \times 100 \times 10^{-9})} = -j10\Omega$$

Node a : $$\frac{\bar{V}_a - 50\angle -90^\circ}{-j10} + \frac{\bar{V}_a}{10} + \frac{\bar{V}_a - (-25\angle 90^\circ)}{10} = 0$$

or $$\frac{\bar{V}_a + j50}{-j10} + \frac{\bar{V}_a}{10} + \frac{\bar{V}_a + j25}{10} = 0$$

$(\times 10)$ $$j(\bar{V}_a + j50) + \bar{V}_a + \bar{V}_a + j25 = 0$$
$$j\bar{V}_a - 50 + 2\bar{V}_a + j25 = 0$$

$$\bar{V}_a(2+j) = 50 - j25$$

$$\bar{V}_a = \frac{50-j25}{2+j} \times \frac{2-j}{2-j} = \frac{50 - j50 - j50 + 25}{4 + 2j - 2j + 1}$$

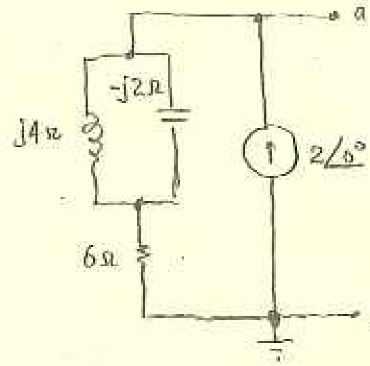
$$= \frac{75 - j100}{5} = 15 - j20$$

The phasor current $\bar{I}$ is simply $\bar{I} = \frac{\bar{V}_a}{10}$

so $\bar{I} = 1.5 - j2$

$$\boxed{\bar{I} = 2.5\angle -53.13^\circ}$$

Question 7

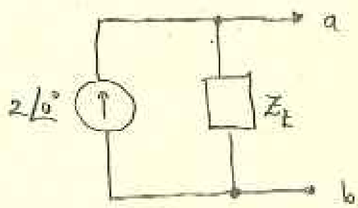


We may solve for the Thevenin impedance first. Zeroing the current source, we get

$$Z_T = (j4 // -j2) + 6 \ \Omega$$

$$= \frac{j4 \times -j2}{j4 + -j2} + 6 = \frac{8}{j2} + 6 = 6 - j4 \ \Omega$$

This will give us Norton equivalent circuit



so $\bar{V}_T = 2\angle 0° \times Z_t$

$$= 2 \times (6 - j4)$$

$$= 12 - j8 \ \text{V}$$

$$= 14.422 \angle -33.69°$$

Question 8

From above, the Thevenin impedance is $Z_T = 6 - j4$

$$= 7.211 \angle -33.69°$$