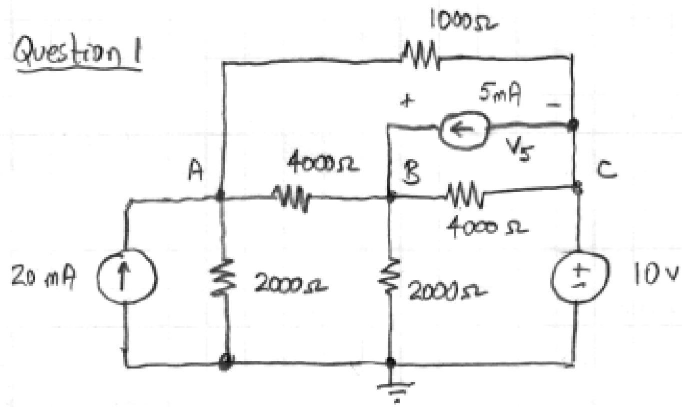
Question 1



Can use any method, but node-voltage looks easiest. Mesh-current could also be used, but it looks like there are 5 meshes (of which two are fixed by current sources). For node-voltage, there will be just two node equations for the reference node as shown.

Node C fixed at $V_c = 10V$.

Node A : $$-0.02 + \frac{V_A}{2000} + \frac{V_A - V_B}{4000} + \frac{V_A - V_C}{1000} = 0$$

or $$-80 + 2V_A + V_A - V_B + 4V_A - 4V_C = 0$$
$$7V_A - V_B - 4V_C = 80$$

$$7V_A - V_B = 120 \qquad (1)$$

Node B : $$\frac{V_B - V_A}{4000} + \frac{V_B}{2000} + \frac{V_B - V_C}{4000} - 0.005 = 0$$

or $$V_B - V_A + 2V_B + V_B - V_C - 20 = 0$$
$$-V_A + 4V_B - V_C = 20$$

$$-V_A + 4V_B = 30 \qquad (2)$$

Add 4 times equation (1) to (2)

$$28V_A - 4V_B = 480$$
$$-V_A + 4V_B = 30$$

$$27V_A = 510$$

so $V_A = 18.\overline{8}$ V

and therefore, $V_B = 12.\overline{2}$ v. As indicated in the above diagram, V_5 is the voltage across the 5 mA current source.

$$V_5 = V_B - V_C$$
$$= 12.\bar{2} - 10 \quad = \quad 2.\bar{2}\ \text{V}$$

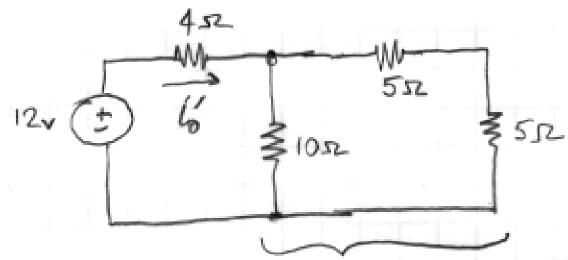
Finally, using the passive reference convention

$$P_5 = -V_5 i = -2.\bar{2} \times 0.005$$
$$= -11.\bar{1}\ \text{mW}$$ (and negative, means generating power)

Question 2

Let's tackle the sources one at a time from left to right.

Left-most 12v source alone

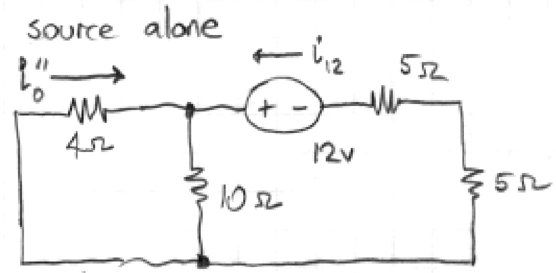


equivalent resistance $R_{eq} = (5+5) \parallel 10$

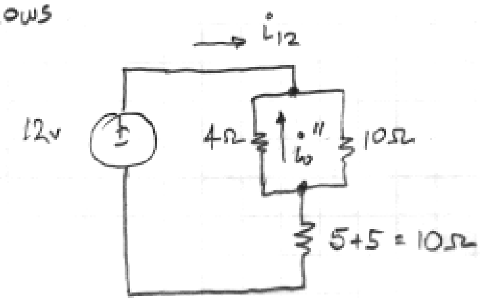
$$= \frac{10 \cdot 10}{10+10} = 5\Omega$$

Hence, $i_0' = \dfrac{12}{4 + R_{eq}} = 4/3\ \text{A}$

Middle 12v source alone



We have a current divider. We may redraw the circuit as follows



We have $i_{12} = \dfrac{12}{(4 \parallel 10) + 10}$

$$i_{12} = \frac{12}{2.857 + 10}$$

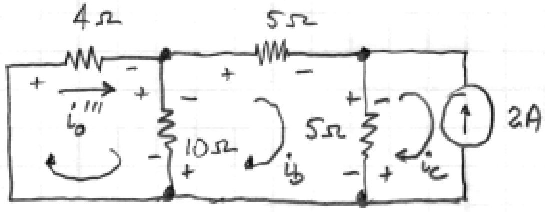
so $i_{12} = 0.9\overline{3}$ A

Current divider, with i_o'' pointing in the opposite direction

$$i_o'' = -\frac{10}{4+10} \times i_{12}$$

$$= -2/3 \text{ A}$$

Finally, the current source acting alone



A little more work this time. Since we need a current, lets give the mesh-current method a try.

Mesh i_o''' : $\quad 4i_o''' + 10(i_o''' - i_b) = 0$

$$14i_o''' - 10i_b = 0 \qquad (1)$$

Mesh i_b : $\quad 10(i_b - i_o''') + 5i_b + 5(i_b - i_c) = 0$

$$-10i_o''' + 20i_b - 5i_c = 0 \qquad (2)$$

Mesh i_c : $\quad i_c = -2$A

Hence, equation (2) becomes $\quad -10i_o''' + 20i_b = -10 \qquad (3)$

Take 2 times equation (1) and add to (3)

$$\begin{array}{r} 28i_o''' - 20i_b = 0 \\ -10i_o''' + 20i_b = -10 \\ \hline 18i_o''' = -10 \end{array}$$

so $i_o''' = -5/9$

Combining all three results, $\quad i_o = i_o' + i_o'' + i_o'''$

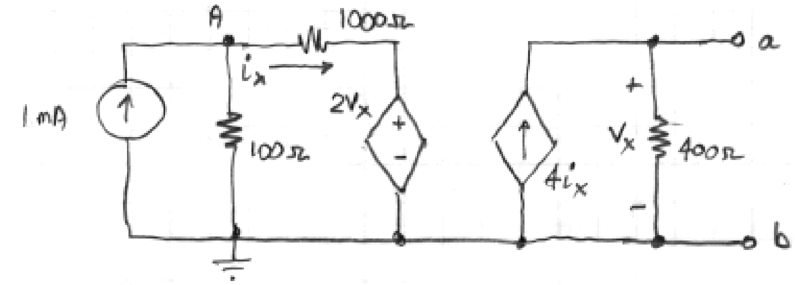
$$= 4/3 - 2/3 - 5/9$$

$$= 6/9 - 5/9$$

$$i_o = 1/9 \text{ A}$$

Question 3

First, let's find the open-circuit voltage, which is V_t



First, we may observe that $V_{oc} = V_t = V_x = V_{ab}$.

In the left portion of the circuit, we can write a single node equation.

Node A:
$$-0.001 + \frac{V_A}{100} + \frac{V_A - 2V_x}{1000} = 0$$

or
$$-1 + 10V_A + V_A - 2V_x = 0$$
$$11V_A - 2V_x = 1 \qquad (1)$$

We also see that
$$i_x = \frac{V_A - 2V_x}{1000} \qquad (2)$$

In the right portion of the circuit, we may immediately say
$$V_t = V_x = 400 \times 4i_x$$

Combining this with equation (2) gives
$$V_x = 400 \times 4\left(\frac{V_A - 2V_x}{1000}\right)$$
$$= 1.6V_A - 3.2V_x$$

so
$$4.2V_x = 1.6V_A$$
and
$$V_x = \frac{8}{21}V_A \qquad (3)$$

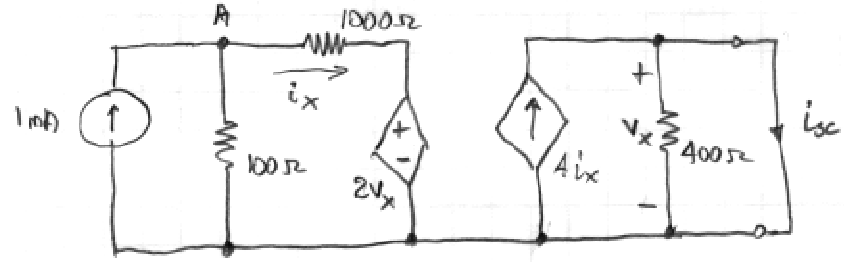
Substituting (3) into (1) gives
$$11V_A - 2\left(\frac{8}{21}\right)V_A = 1$$

hence $V_A = 0.09767$ V

Back to equation (3): $V_x = V_t = V_{oc} = v_{ab} = 0.09767\left(\frac{8}{21}\right)$

$$\boxed{V_t = 0.03721\ \text{v}}$$

Now, need Thevenin resistance. Unfortunately, we have dependent sources, so no short-cuts. Find i_{sc}



This isn't so bad because we may observe $V_x = 0$ due to the short circuit. Also, all the current passes through the short circuit

$$i_{sc} = 4i_x$$

This also causes the dependent voltage source to appear as a short circuit, so that at node A

$$-0.001 + \frac{V_A}{100} + \frac{V_A}{1000} = 0$$

$$-1 + 10V_A + V_A = 0$$

$$\therefore\ V_A = 0.0909091 = 1/11\ \text{v.}$$

Equation (2) still applies, but with $V_x = 0$:

$$i_x = \frac{V_A}{1000} = 1/11000\ \text{A}$$

And so $\quad i_{sc} = 4i_x = 4/11000\ \text{A}$

Finally, $\quad R_t = \frac{V_t}{i_{sc}} = \frac{0.03721}{(4/11000)}$

$$\boxed{R_t = 102.33\Omega}$$

We may also compute i_x simply using a current divider.

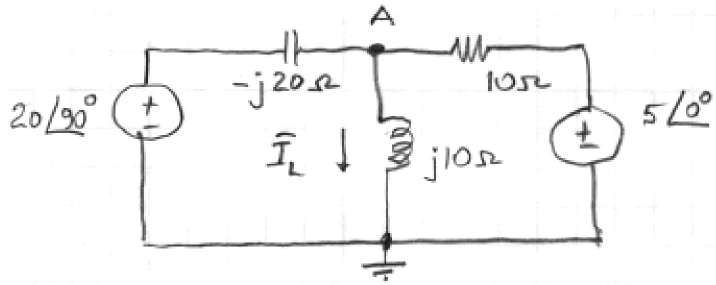
Question 4

Need impedances of the inductor and capacitor for $\omega = 10$ rad/sec

$$Z_L = j\omega L = j \times 10 \times 1 = j10\,\Omega$$

$$Z_C = \frac{1}{j\omega C} = \frac{1}{j \times 10 \times 0.005} = -j20\,\Omega$$

Hence, in terms of phasors and complex impedances, the circuit is



Choose any method. How about node-voltage:

Node A: $$\frac{\bar{V}_A - 20\angle 90^\circ}{-j20} + \frac{\bar{V}_A}{j10} + \frac{\bar{V}_A - 5\angle 0^\circ}{10} = 0$$

or $$\frac{\bar{V}_A - j20}{-j20} + \frac{\bar{V}_A}{j10} + \frac{\bar{V}_A - 5}{10} = 0$$

Multiply through by $-j20$

$$\bar{V}_A - j20 - 2\bar{V}_A - 2j(\bar{V}_A - 5) = 0$$

$$-\bar{V}_A - 2j\bar{V}_A - j20 + j10 = 0$$

$$-\bar{V}_A(1 + 2j) = j10$$

so $$\bar{V}_A = \frac{-j10}{1+2j}$$

And therefore, the phasor current $\bar{I}_L$ is

$$\bar{I}_L = \frac{\bar{V}_A}{j10} = \frac{-1}{1+2j}$$

$$= \frac{-1}{1+2j} \times \frac{1-2j}{1-2j} = \frac{-1+2j}{5}$$

$$\bar{I}_L = -0.2 + j0.4 \qquad \text{(second-quadrant)}$$

$$= 0.4472 \angle \underline{116.565^\circ}$$

Finally, $\quad i_L(t) = 0.4472 \cos(10t + 116.565^\circ)$