ELEC2004 Homework 1

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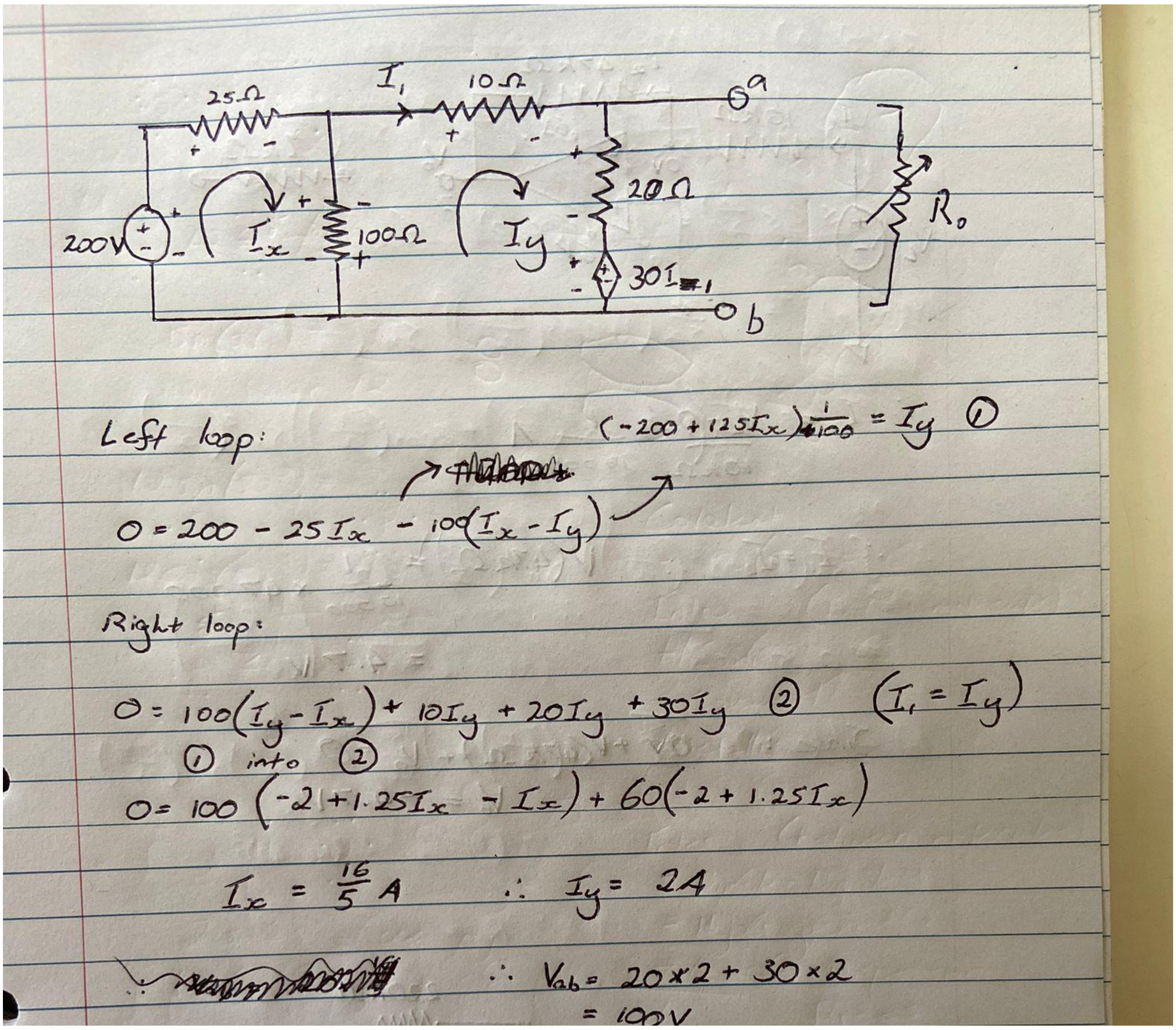
Q1)

In order to solve for a resistor (R_0) whose power dissipated is 250W, we must find a Thevenin equivalent circuit whose load is the R_0. To do this, we must first find the voltage over the terminal a-b depicted below. (please note that in this working, I_x is the loop current not equivalent to the I_x current in the original question).



Left loop:

$0 = 200 - 25I_x - 100(I_x - I_y)$

$(-200 + 125I_x)\frac{1}{100} = I_y$ ①

Right loop:

$0 = 100(I_y - I_x) + 10I_y + 20I_y + 30I_y$ ② $(I_1 = I_y)$

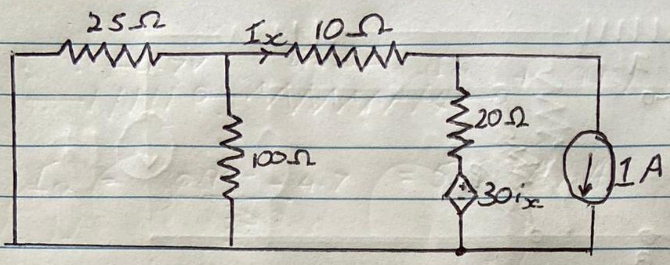
① into ②

$0 = 100(-2 + 1.25I_x - I_x) + 60(-2 + 1.25I_x)$

$I_x = \frac{16}{5}A$ $\therefore I_y = 2A$

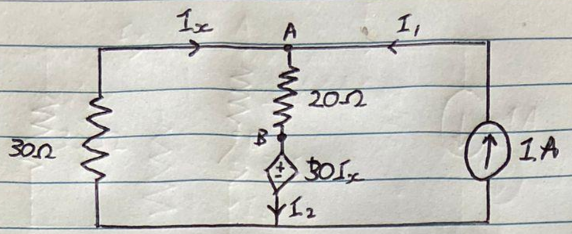
$\therefore V_{ab} = 20 \times 2 + 30 \times 2$
$= 100V$

Now that the Thevenin voltage has been acquired, we must now find the Thevenin resistance. We achieve this by creating a short circuit over the 200V source and then placing a temporary 1amp source over the a-b terminal. We can further simplify such a circuit as seen below.



$$R = 10 + \left(\frac{1}{25} + \frac{1}{100}\right)^{-1}$$
$$= 30\,\Omega$$

Now solving we find.



Nodal analysis at A:

$$I_x + I_1 = I_2 \quad \Rightarrow \quad I_x + 1 = \frac{V_A - V_B}{20}$$

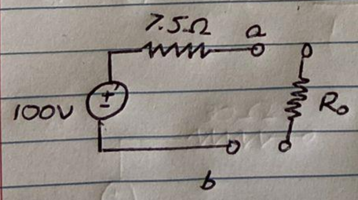
$$I_x + 1 = \frac{V_A - 30I_x}{20}$$

Since $V_A = -30I_x$:

$$I_x + 1 = \frac{-60I_x}{20} \quad \Rightarrow \quad I_x = -0.25\,A$$

Thus $V_A = -30 \times -0.25$
$= 7.5\,V$

Thus $R_{TH} = \frac{7.5}{1} = 7.5\,\Omega$



Voltage divider:

$$V_{ab} = 100\left(\frac{R_o}{R_o + 7.5}\right)$$

Given $P = \frac{V^2}{R}$:

$$250 = \frac{100^2\left(\frac{R_o^2}{(R_o+7.5)^2}\right)}{R_o} = \frac{100^2 R_o}{(R_o + 7.5)^2}$$

Thus $R_o = 2.5\,\Omega$ or $22.5\,\Omega$

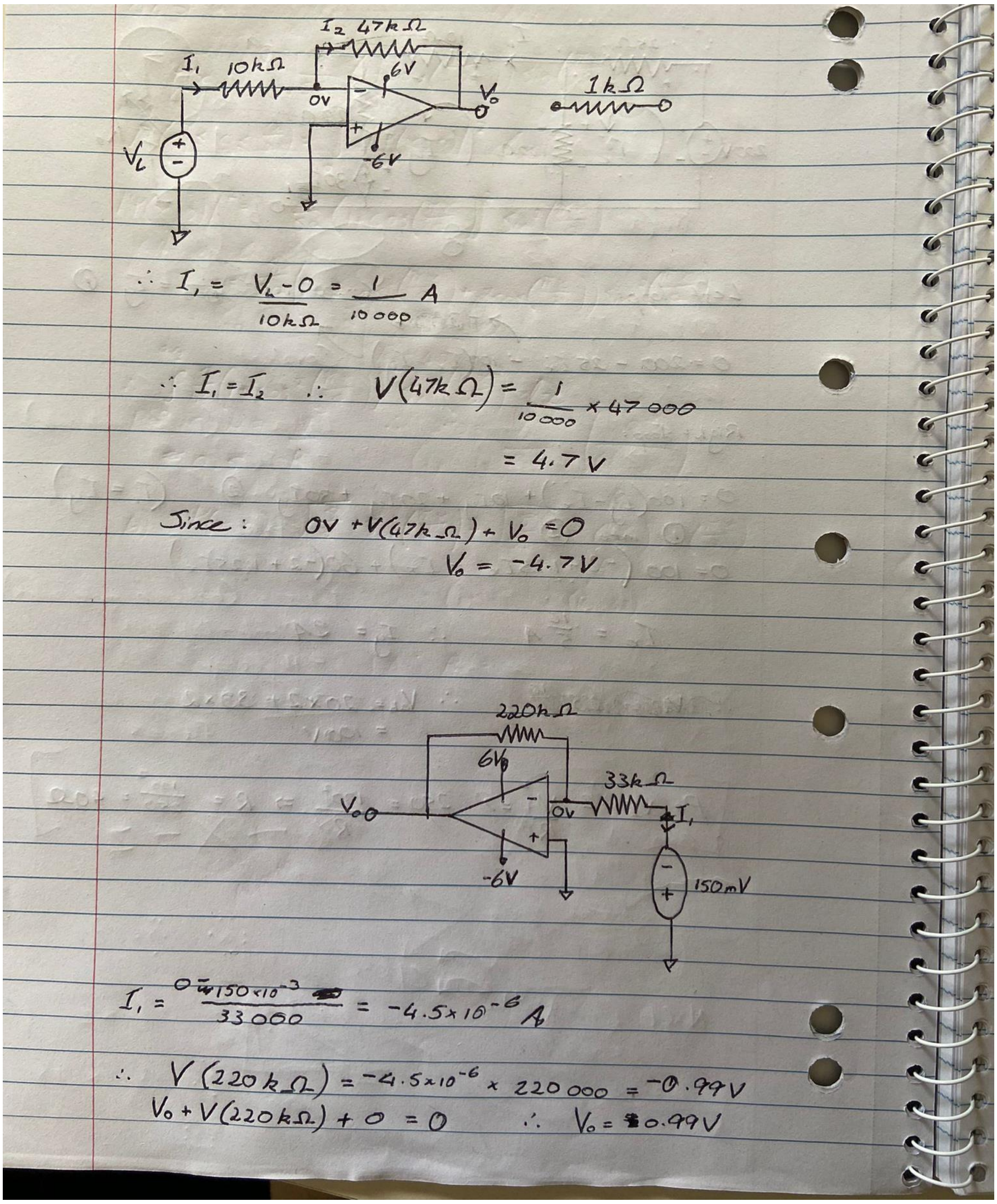
This demonstrates that in order for our power dissipated over R_0 to be 250W, R_0 will either need to be 2.5ohms or 22.5ohms.

Q2) a)

In order to evaluate the current i_a given the source V_L is 1V, we can use superposition to solve each inverting op amp individually. Given that the op amps are ideal, it is important to remember that this leaves two laws:

1) The current through the op amp is 0.
2) There is no voltage difference between the negative and positive terminals.

In both cases this indicates that the terminals are both 0 volts and that the current through the feedback loop must equal the current through the input wire. Solving we find:



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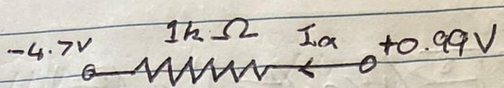

$$I_a = \frac{0.99 - -4.7}{1000} = 5.69\,mA$$

Thus, given V_L is 1V, the current i_a must be 5.69mA.

b)

In the case where i_a = 0, we know that the voltage at either end of the middle resistor must be equal. In other words, the two op amps must have the same output. In this case, we know that the left op amp must result in a voltage of 0.99V. We can therefore work backwards in order to solve for V_L. This was conducted as follows:

b) $I_a = 0$ Thus V_o for left op amp must be 0.99 V.

Thus: $V(47k\Omega) = -V_o = -0.99\,V$

Thus $I_2 = \frac{-0.99}{47000} = I_1$

Thus $V(10k\Omega) = \frac{-0.99}{47000} \times 10\,000$

$= -0.21\,V$

Thus V_L must be $-0.21V$ in order for i_a to be 0A.

Therefore, we have shown that in order for i_a to be 0A, V_L must be -0.21V.