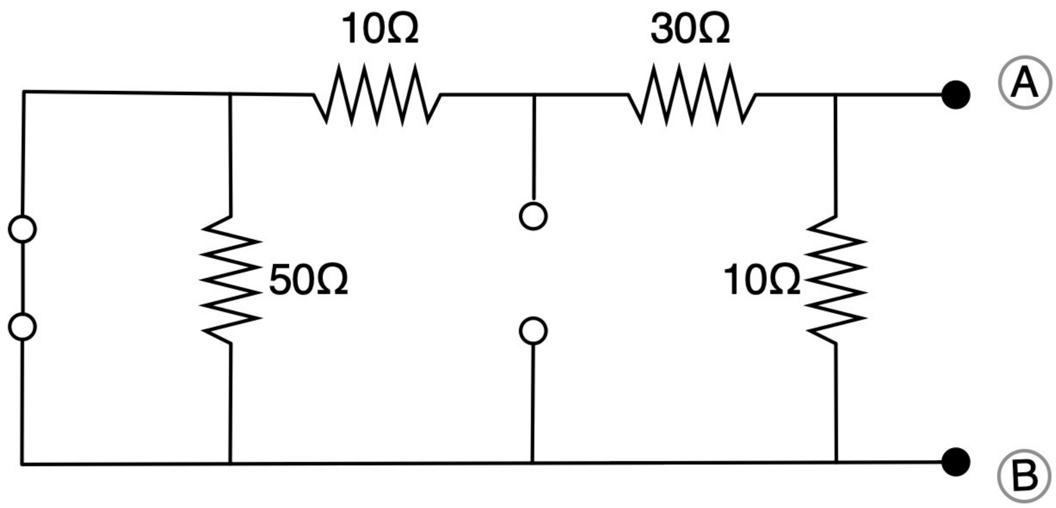
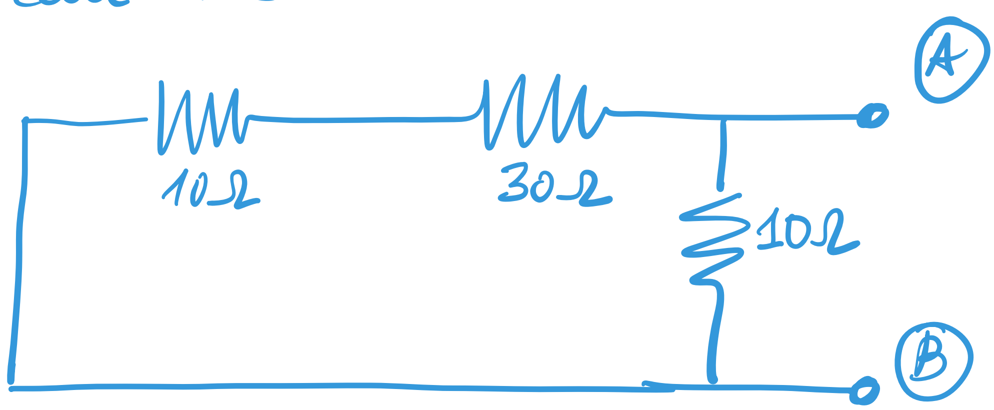
1.- Part I

We turn off the source in the circuit and obtain the circuit below



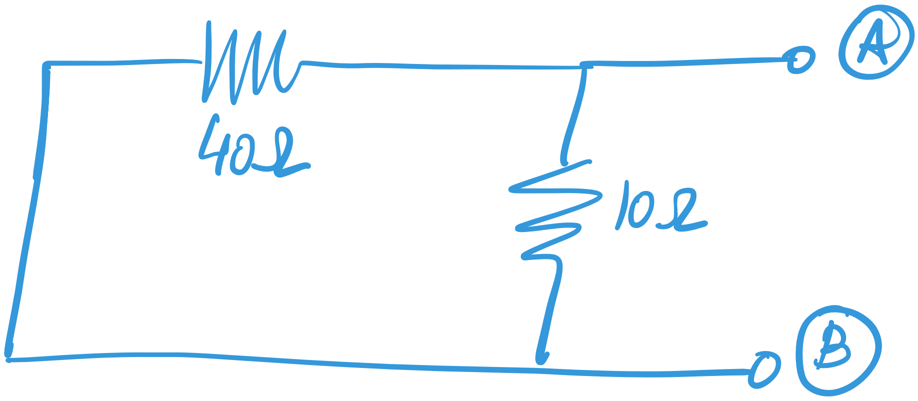
where the current source gets replaced by an open circuit and the voltage source by a closed circuit. [+1 point]

Next, we use association of resistors to find the equivalent resistance. Note that the 50Ω resistor is in parallel with a 0Ω resistor, so we can instead draw



[+1 point]

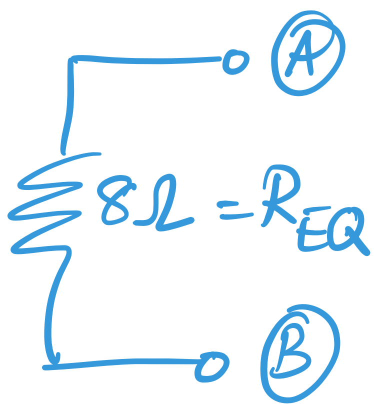
We combine the two resistors in series to get the plot



Finally, the two resistors are in parallel,

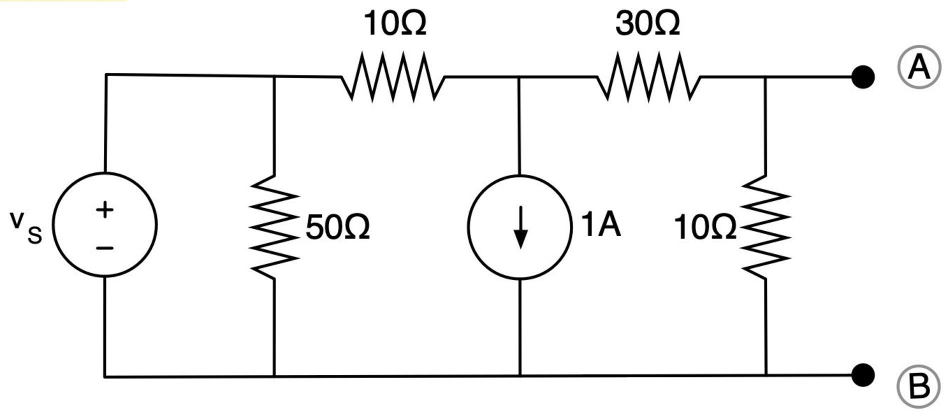
$$40 \| 10 = \frac{40 \cdot 10}{40+10} = \frac{40\cancel{0}}{5\cancel{0}} = 8\,\Omega$$

so this results in the equivalent resistance

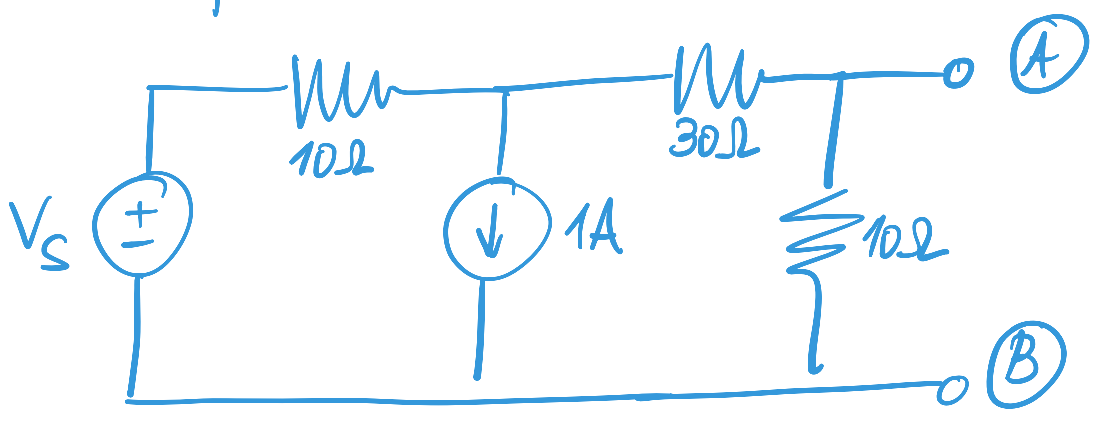


[+1 point]

Part II

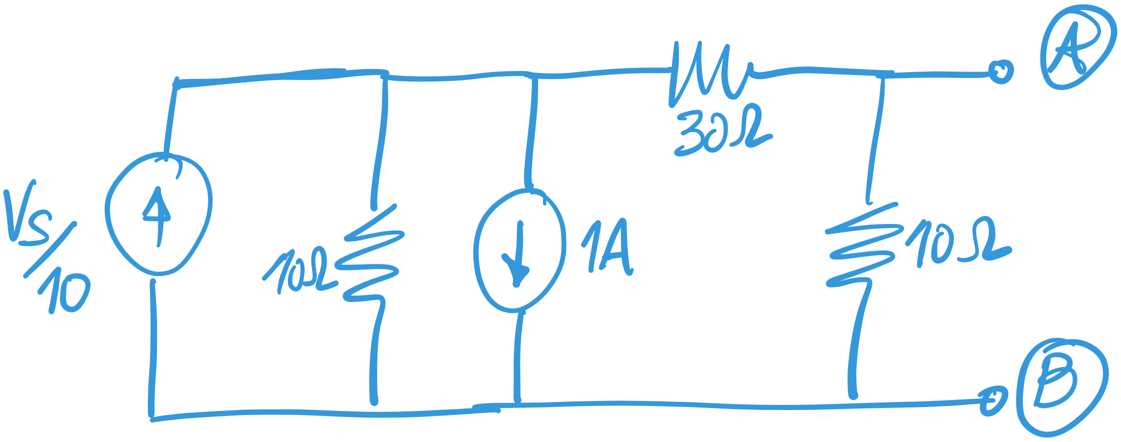


We are told to compute the open-circuit voltage as seen from terminals A B. We first note that the voltage source is in parallel w/ a 50Ω resistor, and from what we have discussed in class re: source transformations, we know this is equivalent to

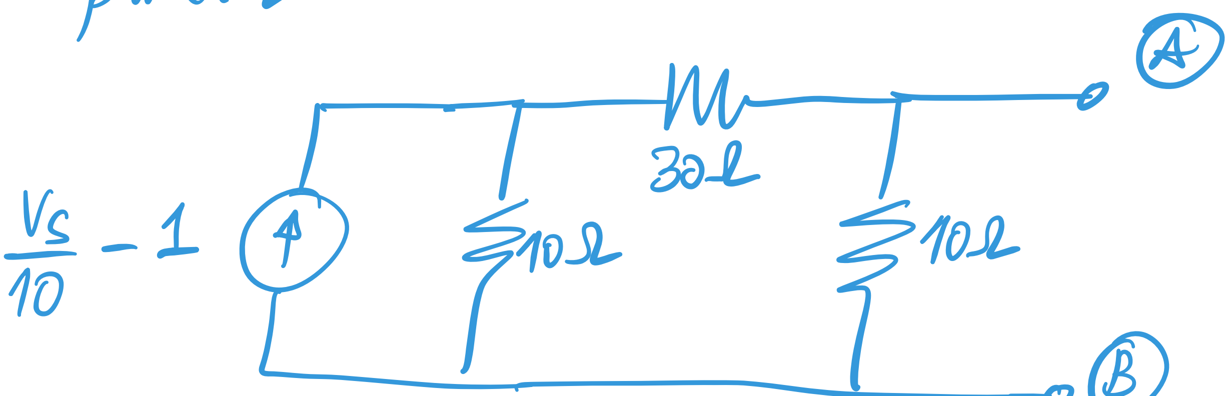


[+1 point]

Since the voltage source is in series w/ a resistor, we can equivalently draw

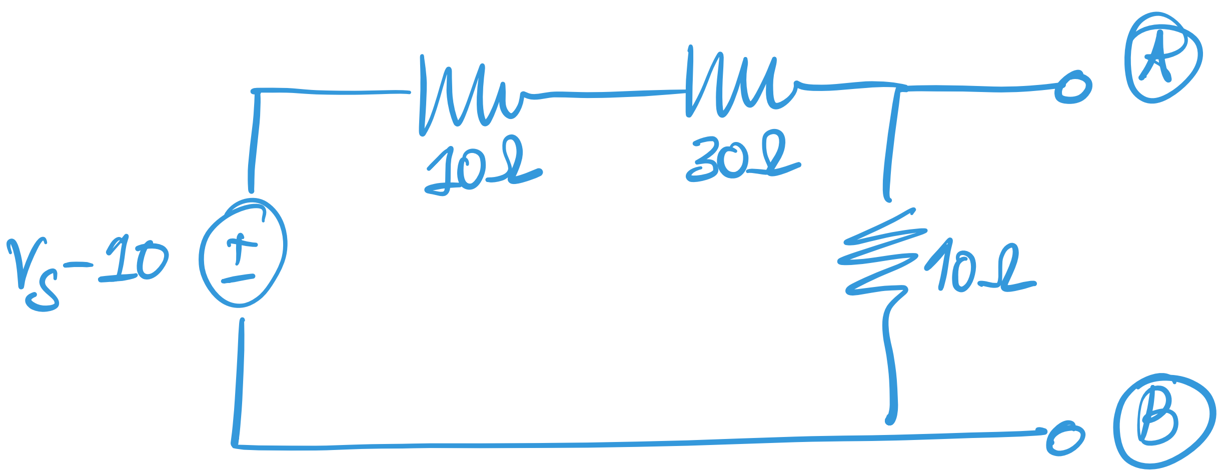


We combine the two current sources in parallel to obtain



[+1 point]

One more source transformation yields



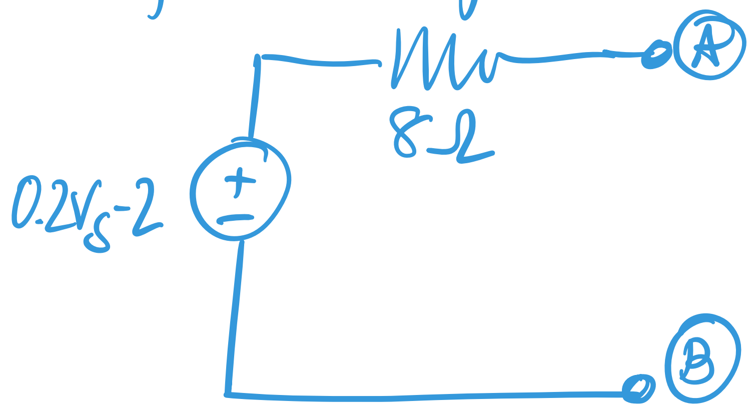
Using now voltage division, we obtain

$$V_{AB} = \frac{10}{10+30+10}(V_s-10) = 0.2V_s - 2$$

[+1 point]

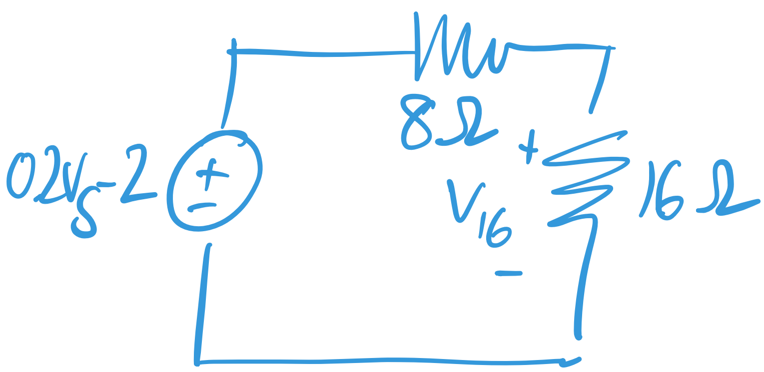
Part III

From Parts I & II, we know the Thevenin equivalent of our circuit



[+1 point]

Therefore, if we connect a $R = 16\Omega$ resistor to terminals A, B, we get



By voltage division,

$$V_{16} = \frac{16}{16+8} \cdot (0.2V_S - 2) =$$

$$= \frac{2}{3}(0.2V_S - 2) = \frac{4}{3}(0.1V_S - 1)$$ [+1 point]

Hence,

$$P_{16} = \frac{1}{R} \cdot V_{16}^2 = \frac{1}{16} \cdot \frac{16}{9}(0.1V_S - 1)^2 = \frac{1}{9}$$ [+1 point]

So $(0.1V_S - 1)^2 = 1 \iff 0.1V_S - 1 = 1 \iff \boxed{V_S = 20V}$

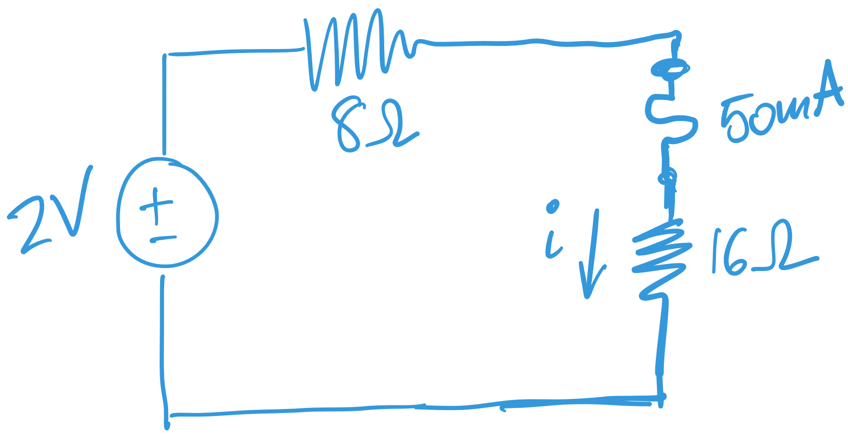
or

$-0.1V_S + 1 = 1 \iff V_S = 0V$ [+1 point]

this one ruled out because of statement

Part IV

Connecting a fuse and a resistor in series results in



We know $V_{16} = \frac{2}{3} 2 = \frac{4}{3}$

Therefore $i = \frac{1}{16} \cdot \frac{4}{3} = \frac{1}{12} A = 0.083 = 83\, mA$ [+1 extra point]

Since $83mA > 50mA$, the fuse will blow, creating an open circuit and stopping any current through the $R = 16\Omega$ resistor.

[+1 extra point]

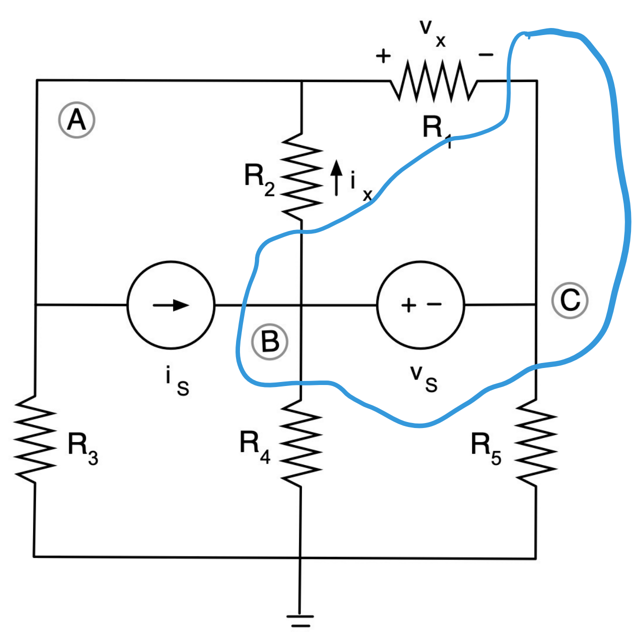
2.– Part I

To use node-voltage analysis, we must take care of the presence of the voltage source using one of the three methods discussed in class:

1) source transformation
2) grounding a node conveniently
3) supernode

We cannot use 1) because the voltage source is not in series with a resistor (even if it was, the statement of the question explicitly rules out modifying the circuit, which also discards source transformation). 2) cannot be used either, because the ground node (which has already been chosen) is not placed conveniently. So we are left with method 3), where we combine nodes B and C into a supernode.

[+2 points]



The equation for the supernode is

$$V_B - V_C = V_S$$ [+1 point]

Next, we write KCL for the supernode,

$$G_1(V_C - V_A) + G_2(V_B - V_A) + G_4 V_B + G_5 V_C = i_S$$ [+1 point]

(Here, we have used the shorthand notation $G_i = \frac{1}{R_i}$).

Next, we write KCL for node A,

$$G_1(V_A - V_C) + G_2(V_A - V_B) + G_3 V_A = -i_S$$ [+1 point]

In matrix form, we have

$$\begin{pmatrix} 0 & 1 & -1 \\ -G_1 - G_2 & G_2 + G_4 & G_1 + G_5 \\ G_1 + G_2 + G_3 & -G_2 & -G_1 \end{pmatrix} \begin{pmatrix} V_A \\ V_B \\ V_C \end{pmatrix} = \begin{pmatrix} V_S \\ i_S \\ -i_S \end{pmatrix}$$ [+1 point]

This gives 3 equations in 3 unknowns.

Part II

In terms of the node voltages, we have

$$v_x = V_A - V_C \qquad \text{[+1 point]}$$

$$i_x = G_2 (V_B - V_A) \qquad \text{[+1 point]}$$

Part III

Yes, choosing node B or node C as ground is a better choice than choosing it at A. This is because the presence of the voltage source V_S is a "problem" to set up node-voltage equations. In part I, we dealt with it using a supernode (b/c the problem statement rules out modifying the labels). But if we could choose ground at node C, instead, then $V_C = 0$ and $V_B = V_S$, and we would only need to write 2 KCL equations, one for node A and another for the bottom node. A similar argument can be made if ground is chosen at node B. However, choosing ground at node A does not help with the "problem" at all.

[+2 points]