ECT150
Homework #6 Problem Set
Sr. Professor Wheeler

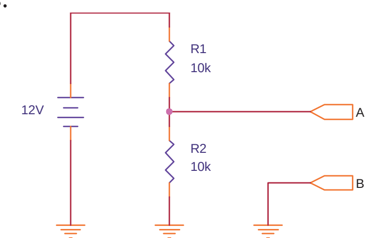
Handout Problems on Network Theorems
Total Points:

All work must be shown, and final answers boxed or underlined. No credit if work is not shown.

1. Explain in your own words the purpose of Thevenin's theorem. How is it used in circuit analysis?

   Thevenin's theorem is used to reduce a circuit containing one or more voltage sources and resistances to one voltage source with one series resistance. It is used for (a) simplifying complex circuits and (b) understanding circuit actions (especially when loading of circuits is concerned.)

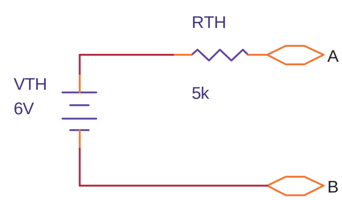
2. Draw the Thevenin equivalent circuit of the network below, giving the value of R_{TH} and V_{TH}. Show all calculations.



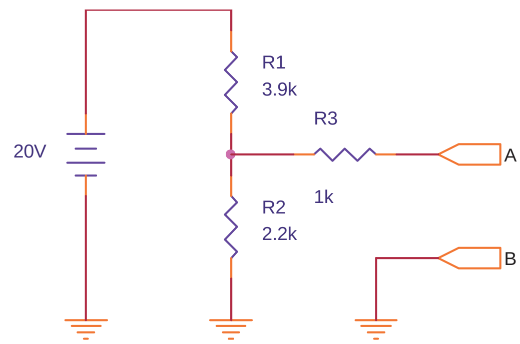
$$V_{TH} = V_{OC} = V_1\left(\frac{R2}{R1+R2}\right) = 12V\left(\frac{10k}{10k+10k}\right) = \underline{\underline{6V}}$$

$$I_{SC} = \frac{V1}{R1} = \frac{12V}{10k} = 1.2mA$$

$$R_{TH} = \frac{V_{OC}}{I_{SC}} = \frac{6V}{1.2mA} = \underline{\underline{5k\Omega}}$$



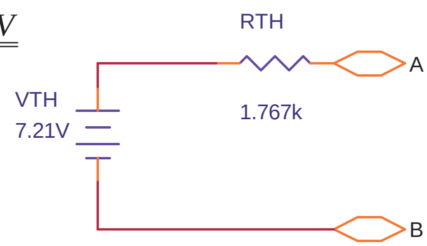
3. Draw the Thevenin equivalent circuit of the network below, giving the value of R_{TH} and V_{TH}. Show all calculations.



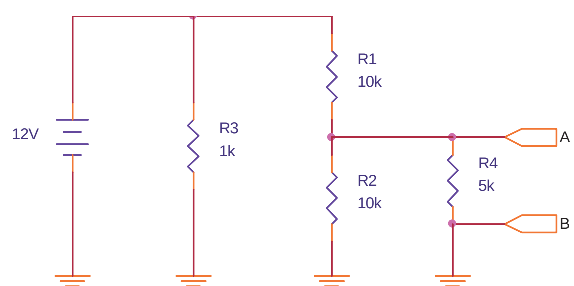
$$V_{TH} = V_{OC} = V_1\left(\frac{R2}{R1+R2}\right) = 20V\left(\frac{2.2k}{3.9k+2.2k}\right) = \underline{\underline{7.21V}}$$

$$I_{SC} = \frac{V1}{R1+R3} = \frac{20V}{3.9k+1k} = 4.08mA$$

$$R_{TH} = \frac{V_{OC}}{I_{SC}} = \frac{7.21V}{4.08mA} = \underline{\underline{1.767k\Omega}}$$



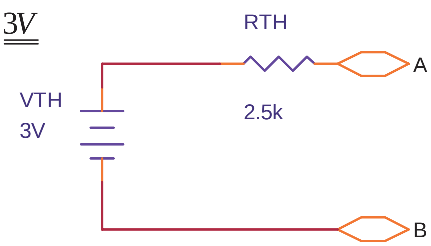
4. Draw the Thevenin equivalent circuit of the network below, giving the value of R_{TH} and V_{TH}. Show all calculations.



$$V_{TH} = V_{OC} = V_1\left(\frac{R2 \| R4}{R1+(R2 \| R4)}\right) = 12V\left(\frac{3.3\bar{3}k}{10k+3.3\bar{3}k}\right) = \underline{\underline{3V}}$$

$$I_{SC} = \frac{V1}{R1} = \frac{12V}{10k} = 1.2mA$$

$$R_{TH} = \frac{V_{OC}}{I_{SC}} = \frac{3V}{1.2mA} = \underline{\underline{2.5k\Omega}}$$



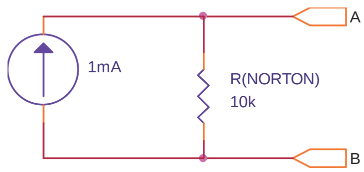
5. What is a constant current source? What controls its terminal voltage? What is its internal resistance?

A constant current source is an energy source that provides a constant terminal current regardless of the load resistance applied.

The terminal voltage of a constant current source is controlled by the load resistance.

The internal resistance of an ideal current source is infinity (∞).

6. Find the terminal voltage V_{AB} of the constant current source circuit below.

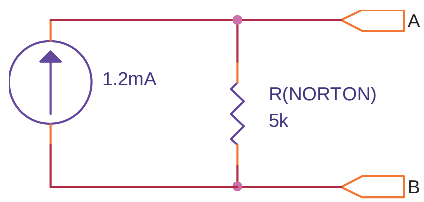


$$V_{AB} = I_N R_N = (1mA)(10k) = \underline{\underline{10V}}$$

7. Draw the Norton equivalent for the circuit of problem #2. Show all calculations.

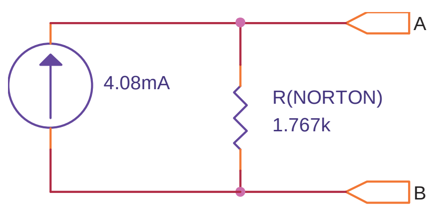
To find the Norton equivalent circuit, simply insert a current source equal to I_{SC} and a resistor equal to R_{TH}. If you've already Thevenized the circuit, there are no additional calculations.

$$I_N = I_{SC} = \underline{\underline{1.2mA}}$$
$$R_N = R_{TH} = \underline{\underline{5k}}$$



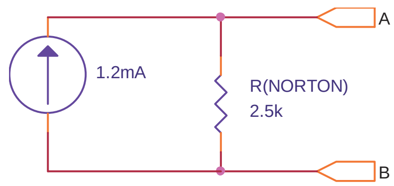
8. Draw the Norton equivalent for the circuit of problem #3. Show all calculations.

$$I_N = I_{SC} = \underline{\underline{4.08mA}}$$
$$R_N = R_{TH} = \underline{\underline{1.767k}}$$

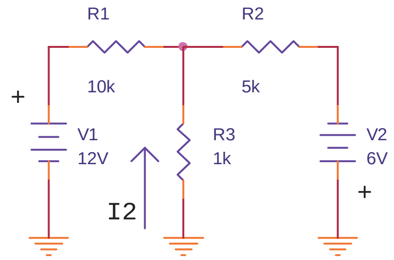


9. Draw the Norton equivalent for the circuit of problem #4. Show all calculations.

$$I_N = I_{SC} = \underline{\underline{1.2mA}}$$
$$R_N = R_{TH} = \underline{\underline{2.5k}}$$



10. Solve for the current I2 in the circuit below using the Superposition theorem.



To solve using Superposition requires multiple iterations through the circuit. For each pass, reduce all sources except one to zero, and find the current of interest (I2 in this case). Repeat the process for the next source (there are two in this circuit). The resulting current is the sum of the currents contributed by each voltage source.

Pass 1: (Source V2 reduced to zero, Source V1 exciting the circuit:)

$$R_{[T,1]} = R1 + R3 \,||\, R2 = 10k + 1k \,||\, 5k = 10.833k$$
$$I_{[T,1]} = V1 / R_T = 12V / 10.833k = 1.108mA$$
$$I_{[2,1]} = I_{[T,1]} R2 / (R2 + R3) = 1.108mA(5k)/(5k + 1k) = +0.923mA$$

Pass 2: (Source V1 reduced to zero, Source V2 exciting the circuit:)

$$R_{[T,2]} = R2 + R3 \,||\, R1 = 5k + 1k \,||\, 10k = 5.909k$$
$$I_{[T,2]} = V2 / R_{[T,2]} = -6V / 5.909k = -1.01mA$$
$$I_{[2,2]} = I_{[T,2]} R1 / (R1 + R3) = (-1.01mA)(10k)/(10k + 1k) = -0.923mA$$

The total current is the sum of all currents from all sources:

$$I_2 = I_{[2,1]} + I_{[2,2]} = 0.923mA + (-0.923mA) = \underline{\underline{0mA}}$$

In this case, *no* current flows through resistor R3.The effects of the two voltage sources are to exactly cancel each other, producing zero voltage across R3. (If you work out the voltage at the junction of R1 and R2 using Ohm's law, you'll see that this is true.)

11. What load resistance can draw the maximum power from the Thevenin source of:

a) Problem 2: $R_L = R_{TH}$ = 5k
b) Problem 3: $R_L = R_{TH}$ = 1.767k
c) Problem 4: $R_L = R_{TH}$ = 2.5k

For any Thevenin or Norton source, the load that can draw maximum power from the source is always equal to the internal resistance of the source. This is an important principle; it is often used in power electronics. (For example, if an amplifier has an output impedance of 500 Ohms, then the best load impedance for maximum power transfer is also 500 Ohms.)