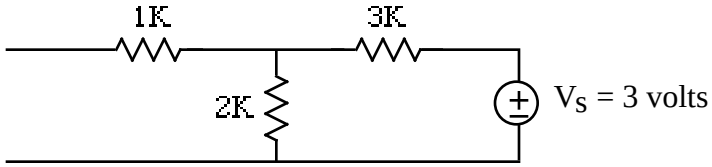
ECE 109 - EQUIVALENT CIRCUITS - INVESTIGATION 19
THEVENIN'S THEOREM - PART II

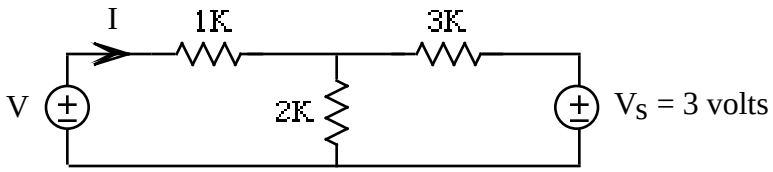
SUMMER 2007 **A.P. FELZER**

To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

We know from the last Investigation that if we take a circuit of resistors and sources as follows



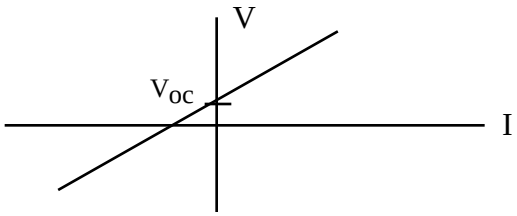
and connect a voltage source V as follows



then V and I will be related by an equation of the form

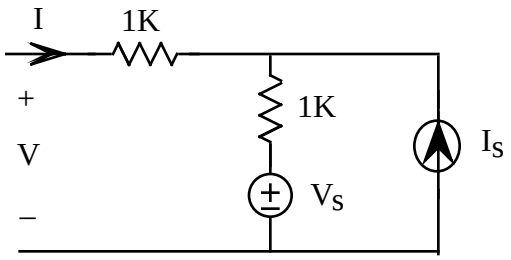
$$V = aI + b$$

with a graph like the following

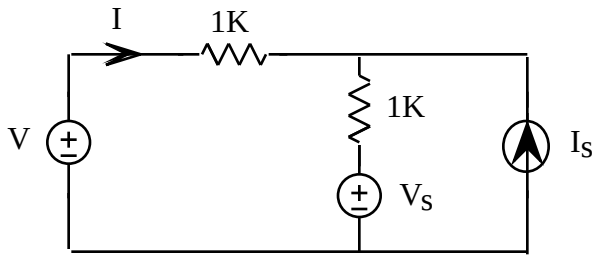


with $V = V_{OC}$ = Open Circuit Voltage = Voltage when I is equal to zero. The objective of this Investigation is to find the physical significance of the coefficient *a* and the constant *b*. Be sure to take a look at the **Computer Demos** on Thevenin's Equivalent

1. We begin with the following circuit



a. Make use of node equations to verify that when we connect a voltage source V as follows

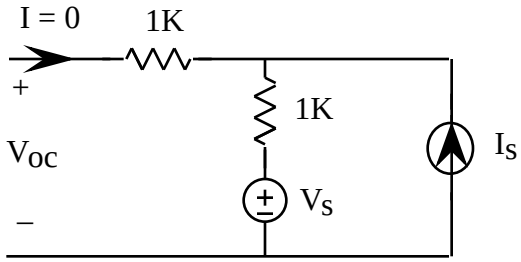


then

$$V = 2000I + V_s + 1000I_s = aI + b$$

with $a = 2000$ and $b = V_s + 1000I_s$

b. Now make use of your result in part (a) to find the open circuit voltage V_{OC} of the circuit - the value of V when $I = 0$ as follows



c. From part (b) we see that when $I = 0$ then

$$V = a(0) + b = b = V_s + 1000I_s$$

and so $b = V_S + 1000I_S$ *is the open circuit voltage* V_{OC} *of the circuit*. Now make use of the equation from part (a)

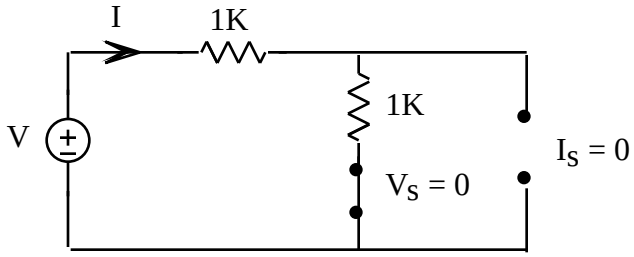
$$V = 2000I + V_s + 1000I_s = aI + b$$

to find V when $V_s = 0$ and $I_s = 0$

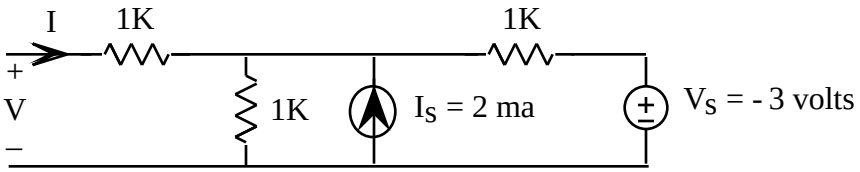
d. From part (c) we see that when $V_s = 0$ and $I_s = 0$ then

$$V = 2000I + 0 + 1000(0) = aI = 2000I$$

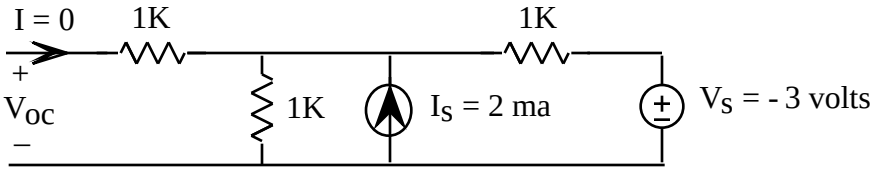
and so *a is equal to the equivalent resistance* R_{EQ} *of the circuit when all the sources* V_S *and* I_S *are set to zero*. Verify that a = 2000 is in fact equal to the equivalent resistance $R_{EQ} = V/I$ of our circuit with V_s and I_s set to zero as follows



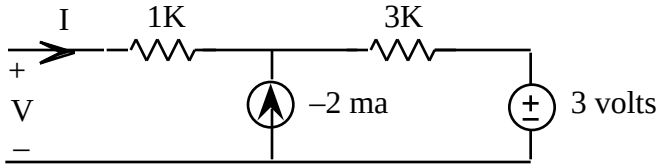
2. The objective of this problem is to repeat the analysis of Problem (1) for the following circuit



a. First connect a voltage source V and then make use of node equations to find V as a function of I in the form $V = aI + b$
b. Then make use of your equation in part (a) to find *a* and *b*
c. Verify that $a = R_{EQ}$ = Equivalent Resistance of the circuit with all its sources V_s and I_s set to zero
d. Verify that *b* is equal to the open circuit voltage V_{OC} of the circuit as follows



3. Generalizing on the results of the first two problems it can be shown that if N is any circuit of resistors and sources like the following



then

$$V = R_{EQ} I + V_{OC}$$

where

R_{EQ} = Equivalent Resistance of the circuit with all its *sources V_S and I_S set to zero*

V_{OC} = Open Circuit Voltage of the circuit with all its *sources V_S and I_S on*

Now *by tradition* we define R_{EQ} to be the *Thevenin Equivalent Resistance R_{TH}* of the circuit and V_{OC} to be the *Thevenin Equivalent Voltage V_{TH}* of the circuit. And so for circuits of resistors and sources we have

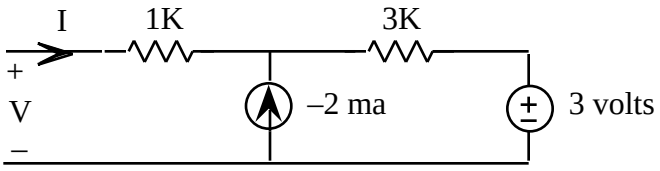
$$V = R_{EQ} I + V_{OC} = R_{TH} I + V_{TH}$$

with

R_{TH} = Equivalent Resistance of the circuit with all its sources *set to zero*

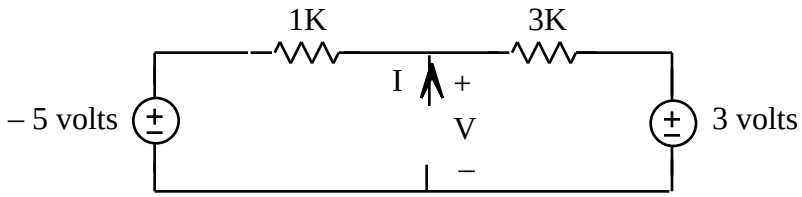
V_{TH} = Open Circuit Voltage of the circuit with all its sources *on*

Memorize this result forever. Then make use of it in the following circuit



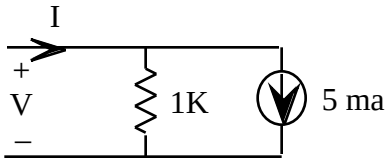
a. To find $V_{TH} = V_{OC}$ by calculating the open circuit voltage of the circuit
b. To find R_{TH} by finding the equivalent resistance of the circuit with all the sources set to zero. *Be sure to draw the circuit your analyzing*
c. Write the equation for V as a function of I
d. Draw the graph for V as a function of I

4. For the following circuit



a. Calculate $V_{TH} = V_{OC}$
b. Calculate R_{TH}. *Be sure to draw the circuit you're analyzing*
c. Write the equation for V as a function of I
d. Draw the graph for V as a function of I

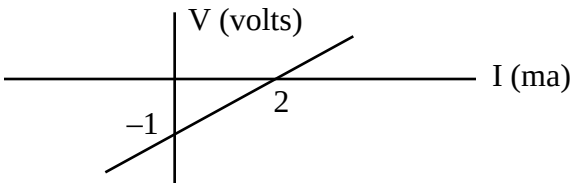
5. For the following circuit



a. Calculate $V_{TH} = V_{OC}$
b. Calculate R_{TH}. Be sure to draw the circuit you're analyzing
c. Write the equation for V as a function of I
d. Draw the corresponding graph for V as a function of I

6. Find V as a function of I for a circuit with $R_{TH} = 2K$ and $V_{TH} = -3$ volts.

7. Find R_{TH} and V_{TH} for a circuit with the following graph



8. Math Review: Sketch e^{-t} and e^{-2t} on the same graph for $t \geq 0$. Identify which is which