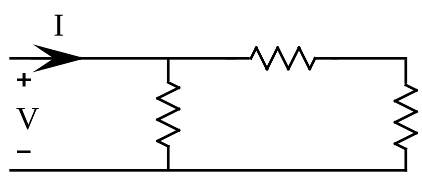
ECE 207 - REVIEW OF RESISTOR CIRCUITS - INV 3
EQUIVALENT CIRCUITS

FALL 2000 **A.P. FELZER**

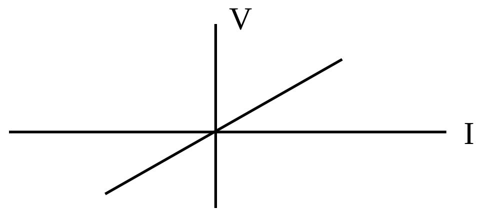
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs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

The objective of this investigation is to review Equivalent Resistance and Thevenin Equivalent.

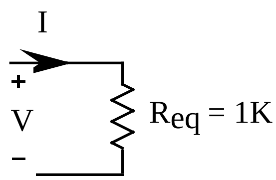
1. The objective of this first problem is to review Equivalent Resistance. From ECE 109 we know that the voltages V across and the currents I into resistor circuits like the following



are proportional as indicated in the following graph

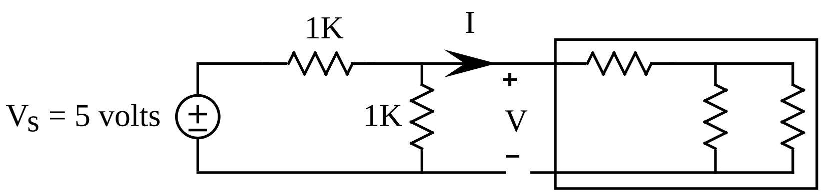


Suppose that for this circuit V = 1000I. Then we say that this circuit is **equivalent** to a single resistor of value R_{eq} = 1K as follows

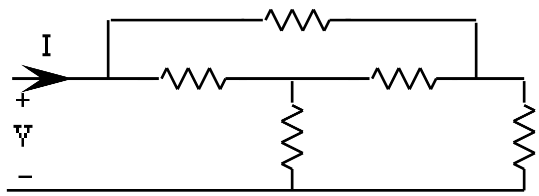


because **whenever** the voltages V across the two circuits are equal **then** so are their currents I. What this means, of course, is that the equations for V as a function of I are the same for both circuits.

   a. Find and draw the Equivalent resistance of a resistor circuit with V = 1500I
   b. Redraw the following circuit with the resistors in the box replaced by their equivalent circuit if V = 2000I

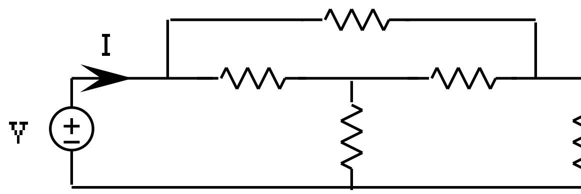


2. To find the Equivalent Resistance R_{eq} of a general resistor circuit as follows



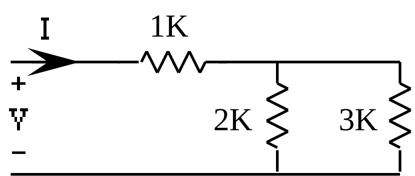
we need to connect a source and then solve for $R_{eq} = V/I$. A good procedure for doing this is as follows:

(1) Connect a voltage source V as follows

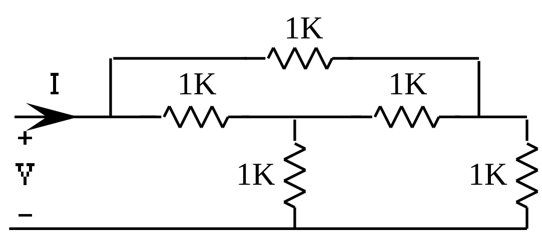


(2) Make use of the node analysis to find the circuit's node voltages in terms of V
(3) Make use of the node voltages from part (2) to express I in terms of V
(4) Make use of the result from part (3) to find the Equivalent Resistance $R_{eq} = V/I$

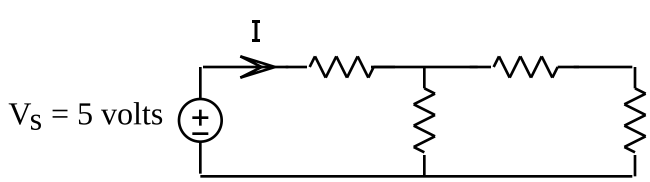
a. Find and draw the Equivalent Resistance R_{eq} of



b. Find and draw the Equivalent Resistance R_{eq} of

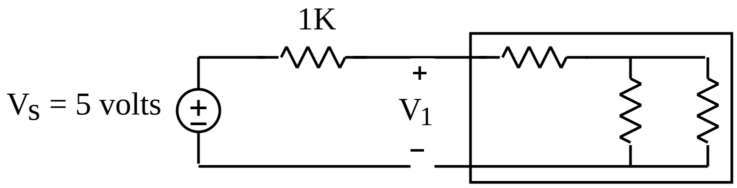


3. Find I in the following circuit

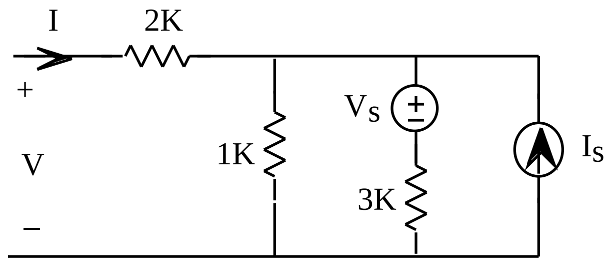


if the equivalent resistance of the resistors is $R_{eq} = 2K$. Be sure to first **redraw** the circuit with the resistors replaced by their equivalent resistance before doing any analysis.

4. Sketch V_1 as a function of the Equivalent Resistance R_{eq} of the resistors in the box in the following circuit

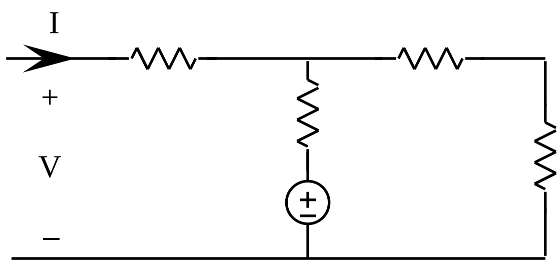


5. Find the equivalent resistance $R_{eq} = V/I$ of the following circuit

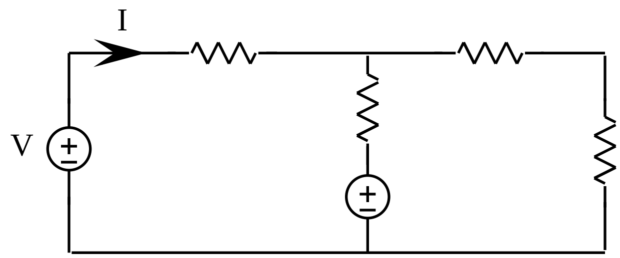


when all its sources are set to zero. Remember that a voltage source of value zero is equivalent to a short and a current source of value zero is equivalent to an open

6. So far we've only been finding equivalent circuits of purely resistor circuits. The objective of this problem is to review what happens when we add sources to our circuits as follows



From ECE 109 we know that we can find how V is related to I by connecting a voltage source V as follows



and then finding V as a function of I just like we did in Problem (2) for purely resistor circuits.

What we find when we do the analysis of such circuits is that

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

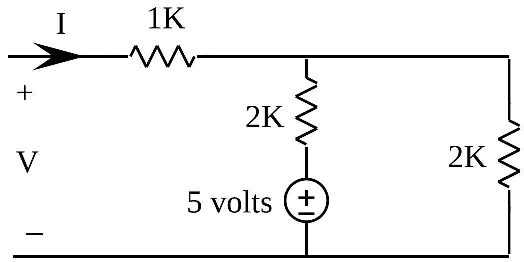
where

R_{TH} = R_{EQ} = Equivalent Resistance of the circuit with all its sources SET TO ZERO
= Thevenin Equivalent Resistance of the circuit

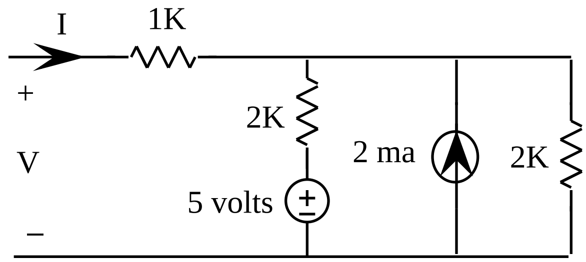
V_{TH} = V_{OC} = Open Circuit Voltage of the circuit with all its sources ON
= Thevenin Equivalent Voltage of the circuit

Memorize this result. Then

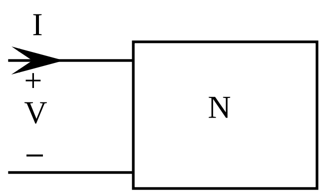
a. Find R_{TH} and V_{TH} for



b. Find R_{TH} and V_{TH} for



7. Now suppose we have a circuit N as follows



of resistors and sources like in Problem (6) with

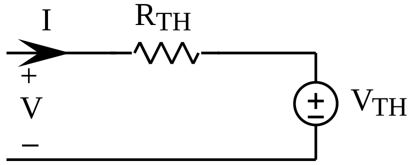
$$V = R_{TH} I + V_{TH} = 2500I + 3$$

Find a circuit of one resistor in series with one voltage source that has the same equation and is therefore equivalent to N.

8. Generalizing on the result of Problem (7) we have that any circuit of resistors and sources with

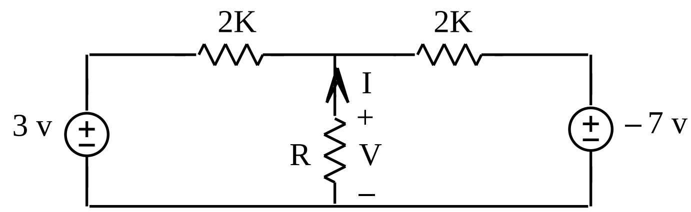
$$V = R_{TH} I + V_{TH}$$

has an equivalent circuit of the form

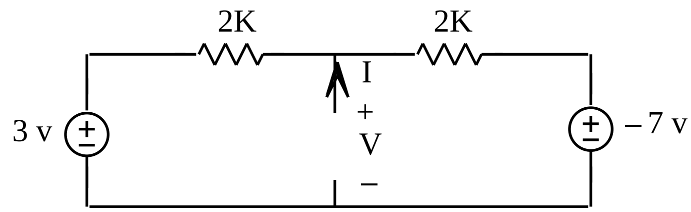


which we refer to as the **Thevenin Equivalent Circuit**.

a. Draw the Thevenin Equivalent of a circuit with R_{TH} = 2K and V_{TH} = 5 volts
b. Draw the Thevenin Equivalent of a circuit with R_{TH} = 2K and V_{TH} = -5 volts
c. Find and draw the Thevenin Equivalent circuit as seen by R in the following circuit

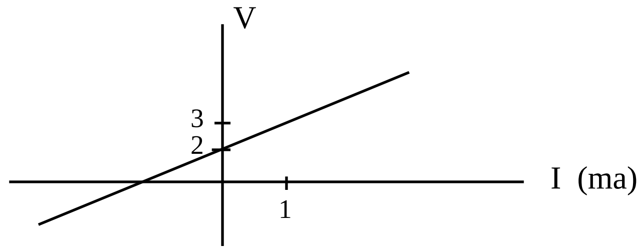


by which we mean the Thevenin Equivalent of

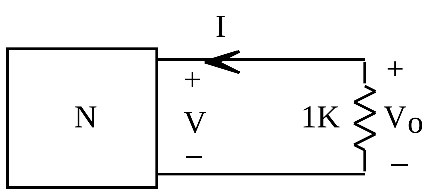


Then make use of your Thevenin Equivalent circuit to find V when R = 1K

9. Find the Thevenin Equivalent of a circuit characterized by the following graph. Note that the current is in ma

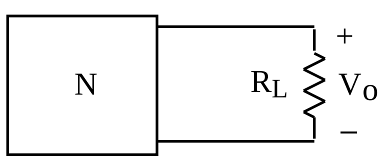


10. Find V_O in



if N is characterized by V = 1000I – 2. **Be sure to draw an equivalent circuit before you write any equations**

11. Given the following circuit



with N containing resistors and sources such that $V_{TH} > 0$. Draw the corresponding equivalent circuit and then

a. Sketch V_O as a function of R_L. Describe your graph.
b. Sketch V_O as a function of R_{TH}. Describe your graph.

12. The objective of this and the following problems is to review some basic math. Is the voltage v(t) satisfying the differential equation v' + 3v = -5 increasing or decreasing at t = 1 if

$v(1) = -2$. How can you tell.

13. Draw two different curves that have the same derivative.

14. Sketch each of the following voltages on separate graphs for time $t \geq 0$. Draw your curves so the differences are obvious. Note that $\exp(x) = e^x$
    a. $v_1(t) = -\exp(-t)$
    b. $v_2(t) = -1 + \exp(-t)$
    c. $v_2(t) = -2 - \exp(-t)$