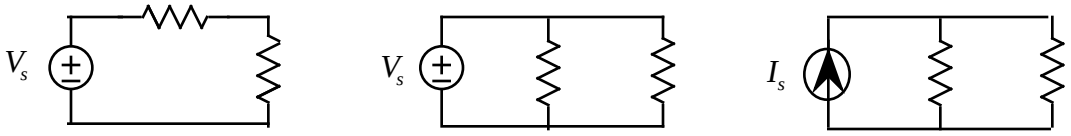
ECE 109 - SERIES AND PARALLEL - INVESTIGATION 11
EQUIVALENT RESISTANCE

FALL 2006 **A.P. FELZER**

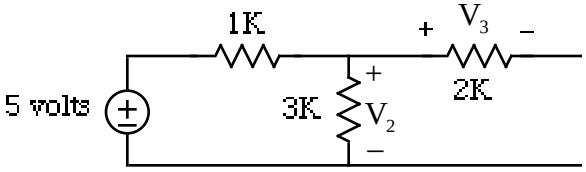
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs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

In the last two Investigations we saw how to calculate the voltages and currents in series and parallel circuits like the following

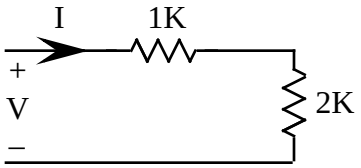


The objective of this Investigation is to find the equivalent resistances of series and parallel circuits. Be sure to take a look at the **Computer Demos** on Series and Parallel Resistor Circuits.

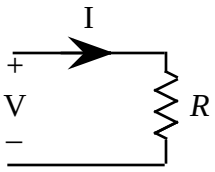
1. We begin with a review problem. Find V_2 and V_3 in the following circuit



2. Now suppose we have a nice simple series resistor circuit as follows

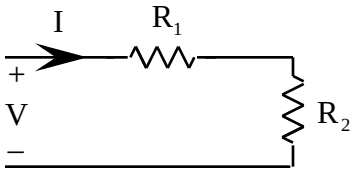


   a. Find V as a function of I. Hint - connect a voltage source of value V at the input and then analyze the circuit
   b. Make use of your result in part (a) to sketch V as a function of I
   c. Describe your graph in part (b)
   d. What single resistor R as follows

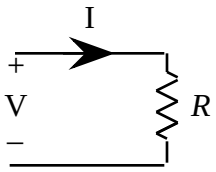


   has the same graph for V as a function of I

3. Generalizing on the circuit of Problem (2) as follows

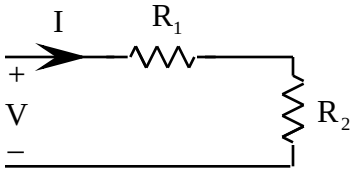


a. Find V as a function of I
b. Sketch V as a function of I
c. Describe your graph in part (b)
d. What single resistor R as follows



has the same graph of V as a function of I

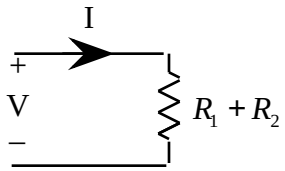
4. From Problem (3) we know that if R_1 and R_2 are in series as follows



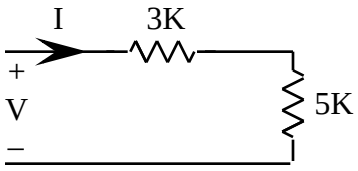
then V and I are related by the equation

$$V = (R_1 + R_2)I$$

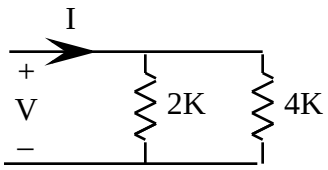
just like they are for a single resistor of value $R_1 + R_2$ as follows



We call $R_{EQ} = R_1 + R_2$ the **equivalent resistance** of the series R_1 and R_2. Find and draw the equivalent resistance R_{EQ} of the following circuit

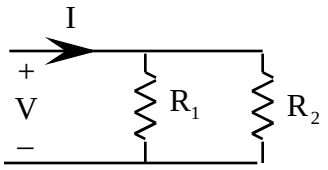


5. We now find the equivalent resistance of the following simple parallel circuit



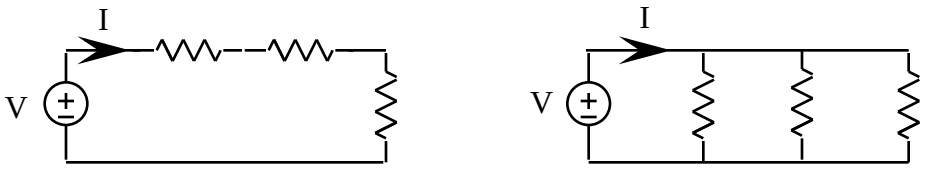
a. Find and sketch V as a function of I. Hint - connect a voltage source of value V across the input and then analyze the circuit
b. Make use of your result in part (a) to find and draw the equivalent resistance R_{EQ} of this circuit

6. Generalizing on the circuit of Problem (5) as follows

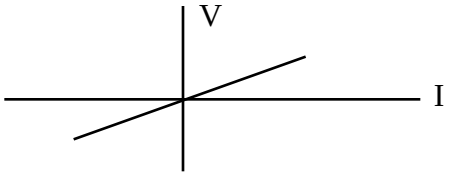


a. Find and sketch V as a function of I
b. Make use of your result in part (a) to find and draw the equivalent resistance R_{EQ} of this circuit

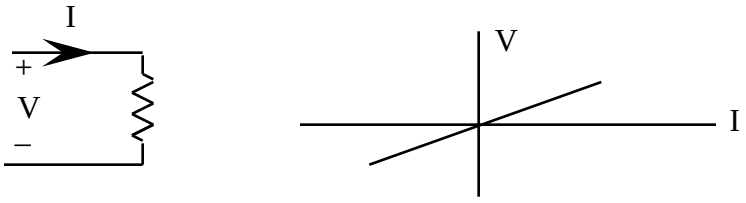
7. Generalizing on the results from the last five problems we see that if connect voltage sources across series and parallel circuits as follows



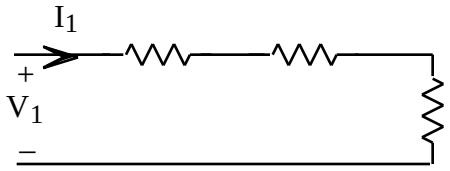
then V will be proportional to I with graphs as follows



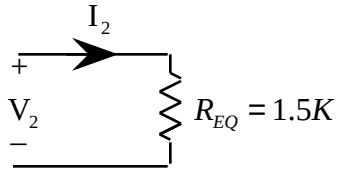
just like for single resistors as follows



Suppose in particular that for the following series circuit



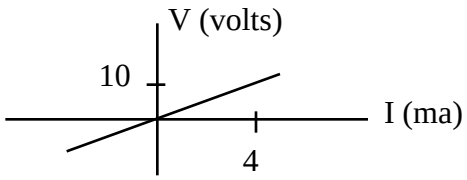
V_1 and I_1 are related by $V_1 = 1500 I_1$. We then say that this series circuit is **equivalent** to a single resistor of value $R_{EQ} = 1.5K$ with $V_2 = 1500 I_2$ as follows



because whenever these two circuits have the same voltages across them then their currents will be the same. In particular

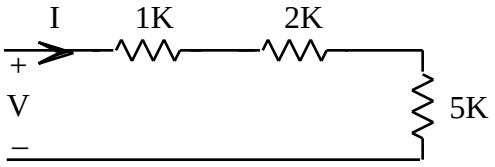
whenever $V_1 = V_2$ **then** $I_1 = I_2$

Memorize this definition of **equivalent circuit**. And then find and draw the **equivalent resistance** R_{EQ} of a circuit with the following graph for V as a function of I

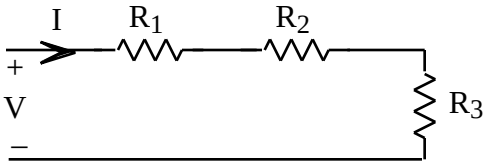


8. Find the equivalent resistances R_{EQ} of each of the following series resistor circuits by connecting a voltage source and then finding V as a function of I

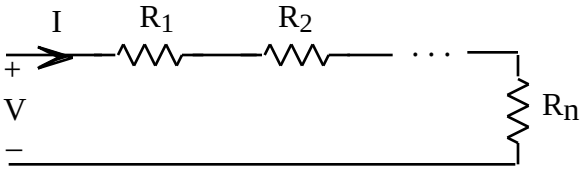
a.



b.



c.

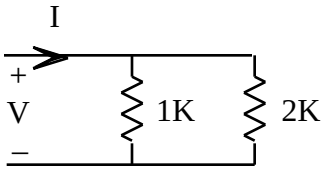


9. How will adding another resistor in a series circuit affect its equivalent resistance R_{EQ}. How do you know. Hint - make use of the fact that adding another series resistor will decrease the

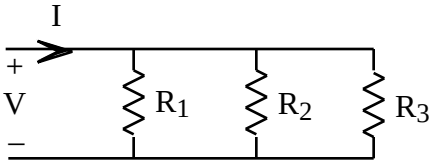
current I. **Memorize** this result.

10. Find and then draw the equivalent resistance R_{EQ} of each of the following parallel resistor circuits by connecting a voltage source and then finding V as a function of I

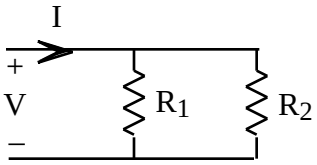
a.



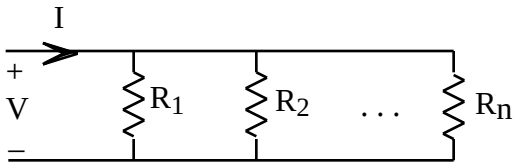
c.



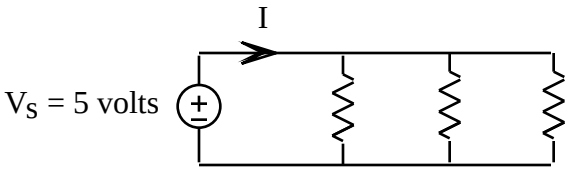
b.



d.



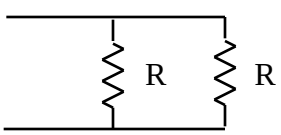
11. How will adding another resistor to a parallel circuit as follows



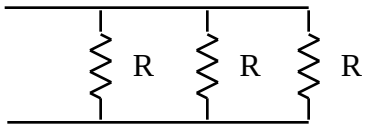
affect the value of its equivalent resistance R_{EQ}. How do you know. Hint - make use of the fact that adding another parallel resistor will increase the value of I. **Memorize** this result.

12. Find and draw the equivalent resistances of each of the following parallel circuits with equal resistors

a.

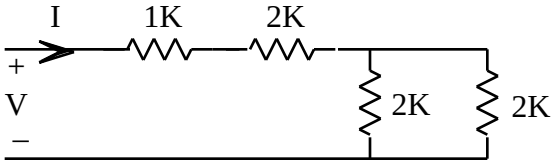


b.

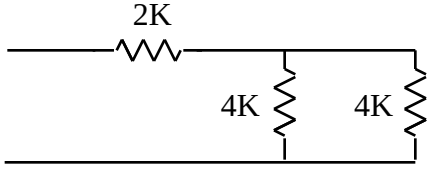


Memorize these results for the equivalent resistances of equal resistors in parallel

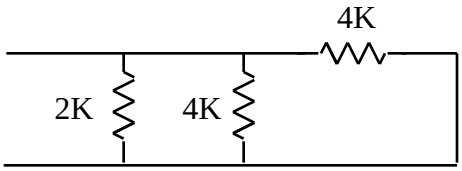
13. Find and draw the equivalent resistance R_{EQ} of the following circuit



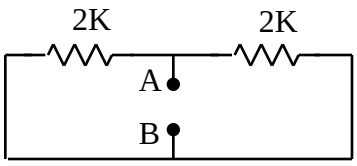
14. Find the equivalent resistance of the following circuit



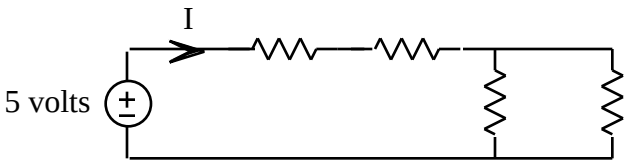
15. Find the equivalent resistance of the following circuit



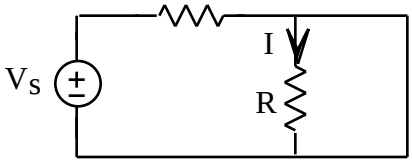
16. What will an ohmmeter read for R_{EQ} when connected to terminals A-B in the following circuit



17. Find and draw the equivalent resistance R_{EQ} of the following circuit with I = 2ma.

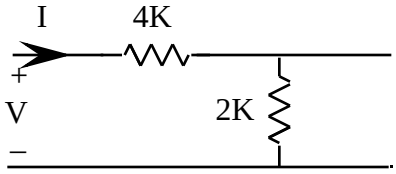


18. What is the current I in the following circuit. Explain why it has the value it does

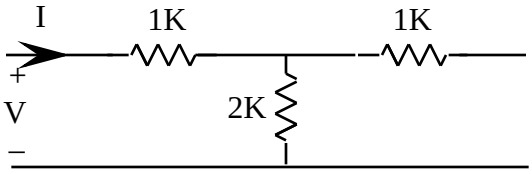


Note that we refer to the wire across R as a **short** and say R is **shorted out**

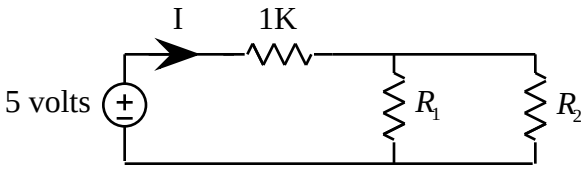
19. Find the equivalent resistance of the following circuit



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



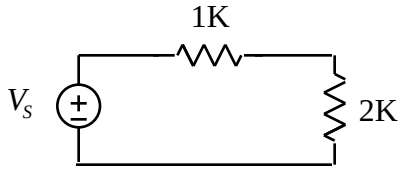
21. The importance of equivalent circuits like the ones we've been calculating is that they can simplify the analysis of complicated circuits. Find I in the following circuit



if the equivalent resistance of R_1 and R_2 is $R_{EQ} = 1K$

22. How would you make use of a power supply, voltmeter and ammeter to determine the equivalent resistance of a series or parallel circuit in the lab

23. What is V_S in the following circuit



if the total power being delivered to the resistors is $P = 10$ mw

24. Math Review - Sketch the product $y_1(t) = x_1(t)\ x_2(t)$ of $x_1(t)$ and $x_2(t)$ as follows