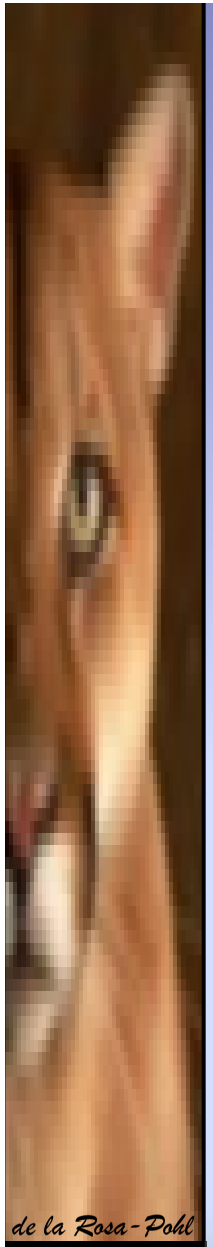

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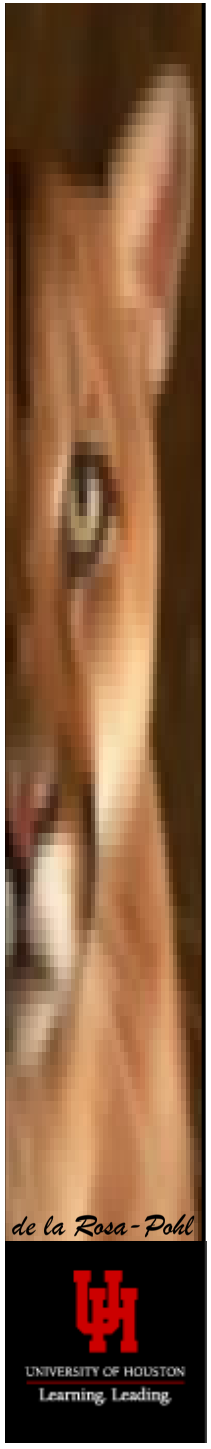
ECE 1100H
Introduction to Engineering

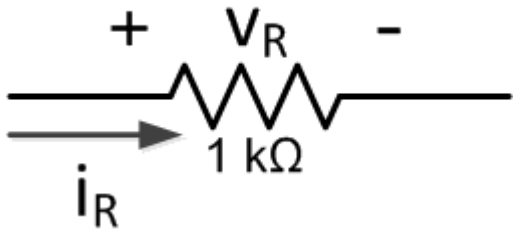
Circuit analysis made easy!
Part II: Kirchhoff's Voltage Law

University of Houston
Len Trombetta

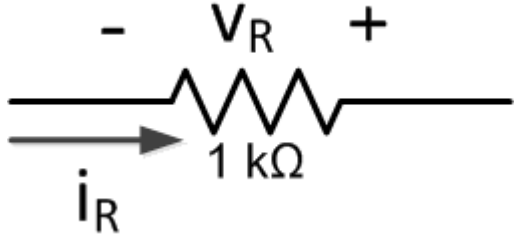


Review: Ohm's Law

Ohm's Law depends on how we label current and voltage:

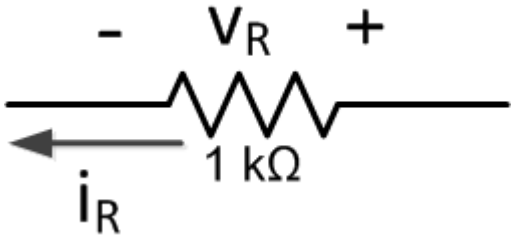


$$v_R = i_R R$$

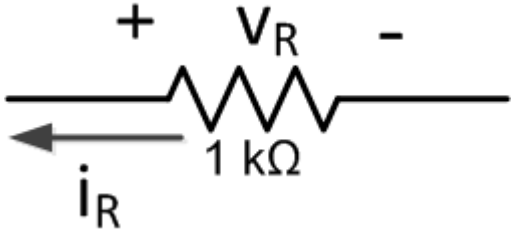


$$v_R = -i_R R$$

These are of course the same things



$$v_R = i_R R$$



$$v_R = -i_R R$$

KIRCHHOFF'S VOLTAGE LAW

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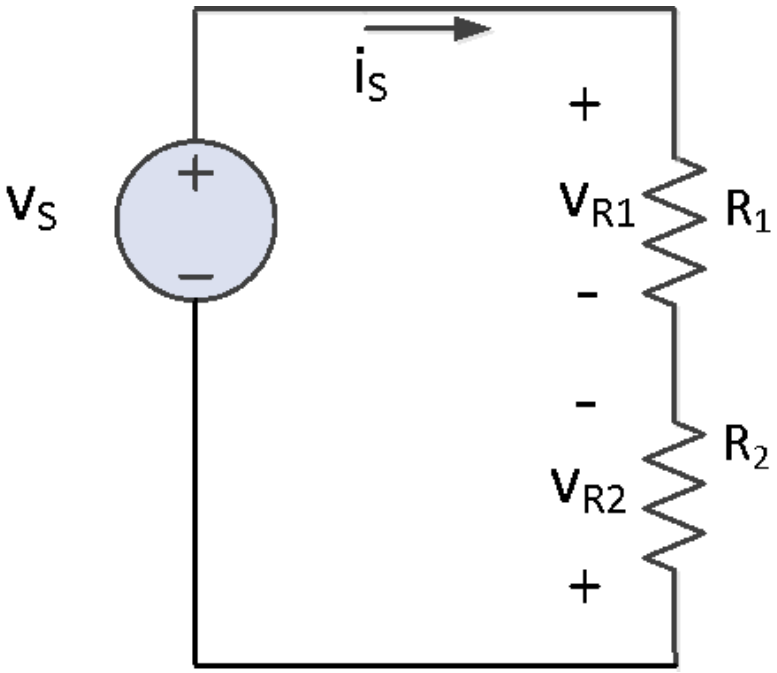
A Simple Circuit

- We want to "solve" this circuit



Solve??

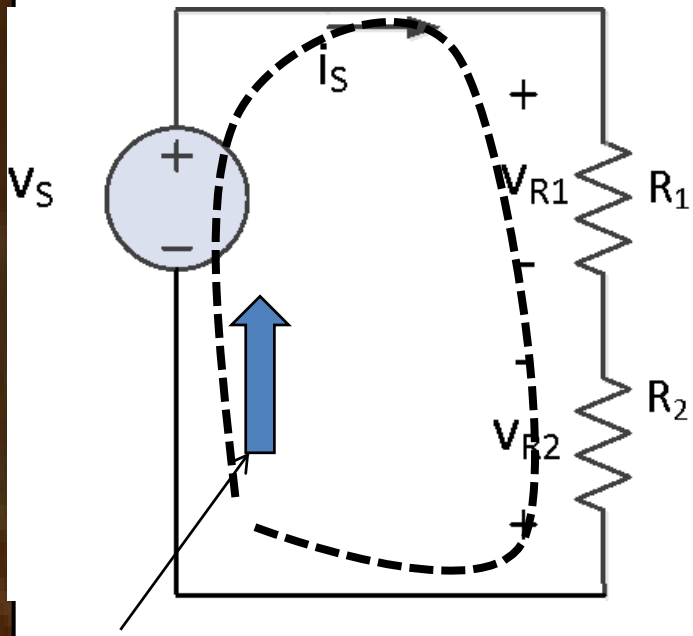
- We want to know all of the voltages (v_{R1}, v_{R2}) and currents (i_S).
- We will assume the source (v_S) and resistances are known.

Why did I label the voltages that way?

Because I can. And anyway, it's my class.

Kirchhoff's Voltage Law

KVL: The algebraic sum of the voltages around a closed loop is 0.



Direction of KVL path (either way is fine).

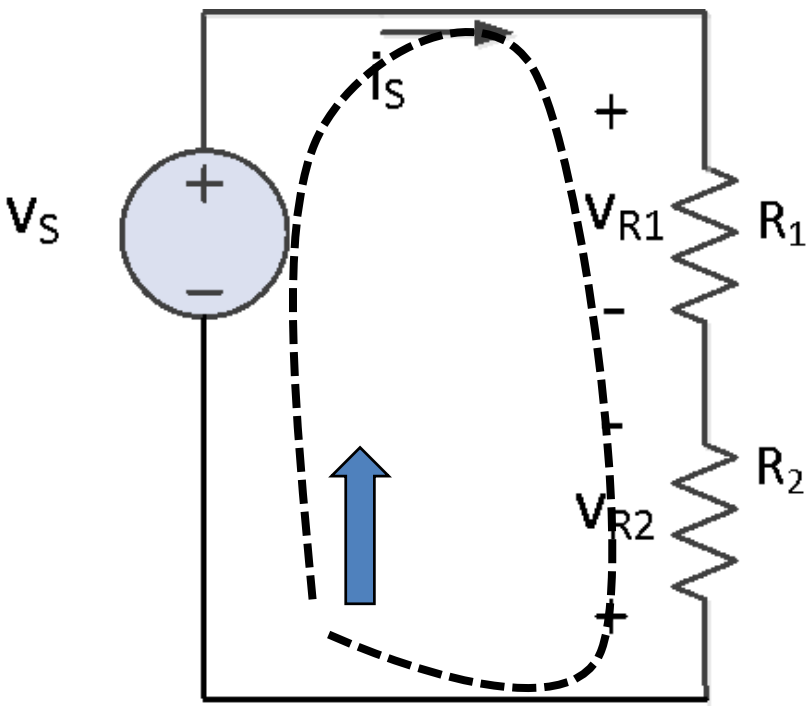
Closed Loop: We will trace a path around the circuit, accounting for all the voltages as we go. It doesn't matter which way the path goes.

Algebraic: we need to be aware of the sign of the voltage.

$$-v_S + v_{R1} - v_{R2} = 0$$

$$v_S = v_{R1} - v_{R2}$$

Substitute Ohm's Law for v_R's



KVL

$$v_S = v_{R1} - v_{R2}$$

Ohm's Law

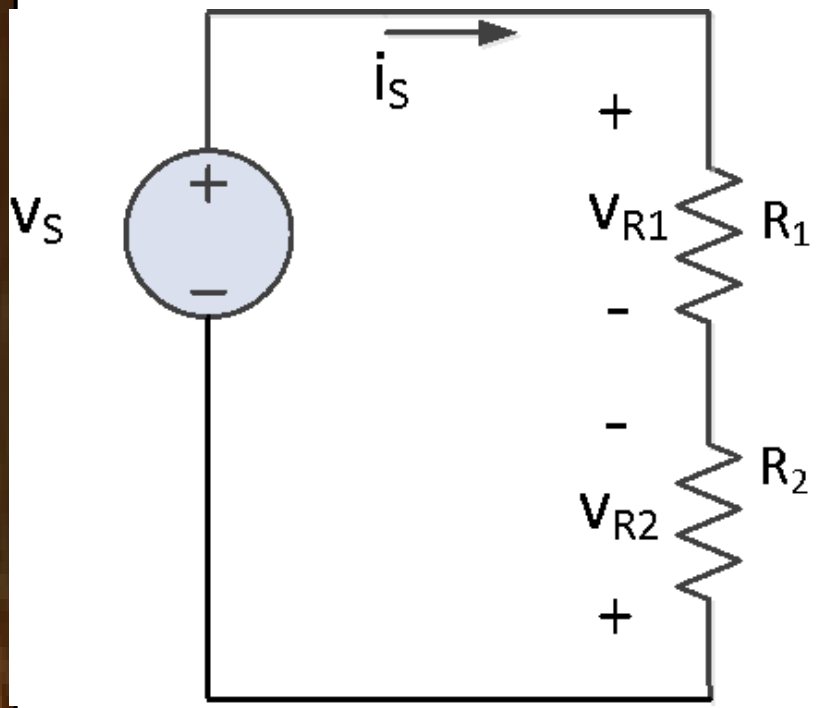
$$v_{R1} = i_S R_1 \qquad v_{R2} = -i_S R_2$$

Algebra

$$v_S = i_S R_1 + i_S R_2$$

$$i_S = \frac{v_S}{R_1 + R_2}$$

Now You Do It!



KVL

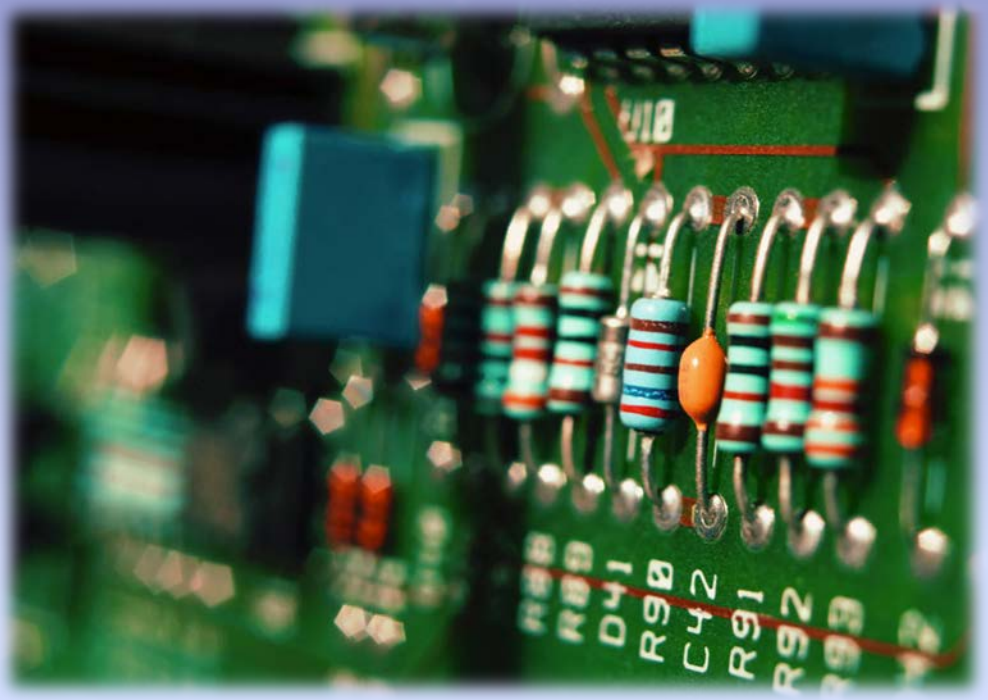
$$v_S = v_{R1} - v_{R2}$$

Ohm's Law

$$v_{R1} = i_S R_1 \qquad v_{R2} = -i_S R_2$$

Algebra

$$i_S = \frac{v_S}{R_1 + R_2}$$



A BIT OF CIRCUIT DESIGN

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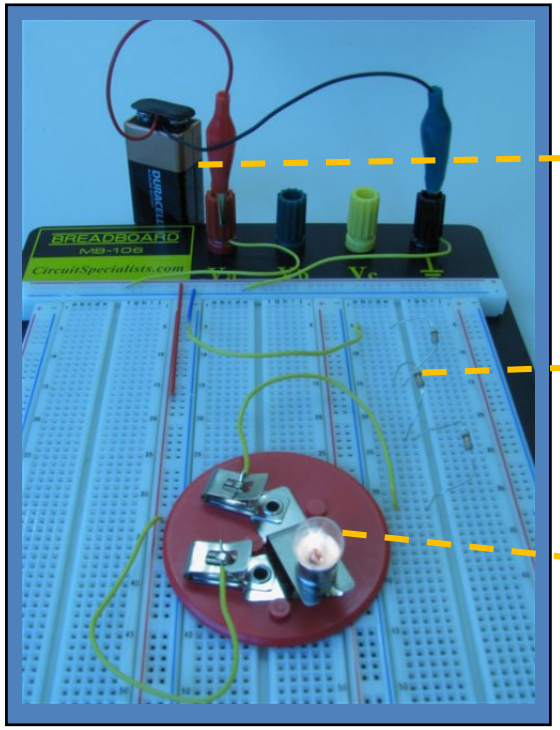
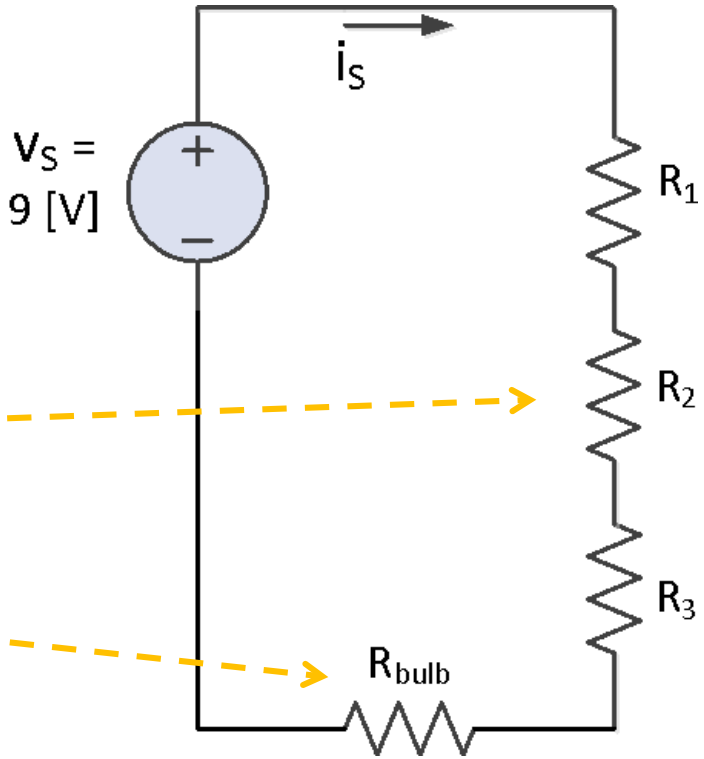
A Bit of Circuit Design





We will use a 9 [V] battery and a few resistors (to be determined shortly) to light a bulb. The bulb is “modeled’ by a resistor.

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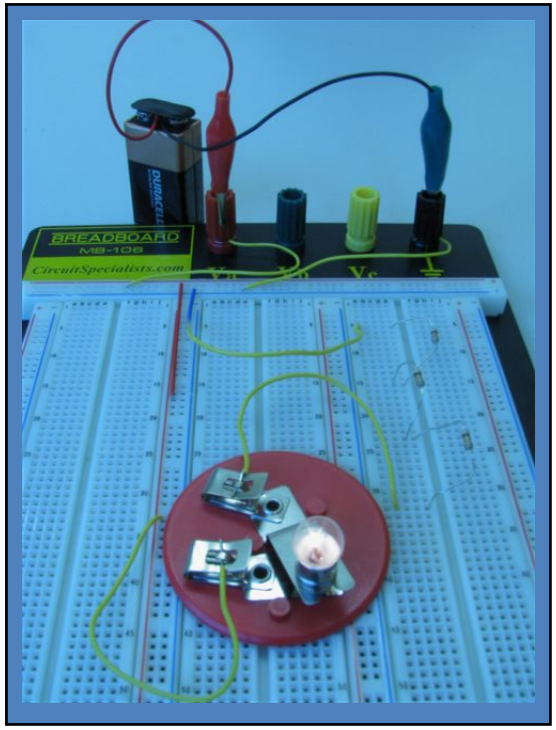
Why Resistors?



The bulbs are rated for voltage and current, which are the voltage and current values when it is working as intended.

2.0 V 0.150 A

These numbers are just an example. Yours may be different.

If you connect the 9 V battery to the light bulb directly boom!!

If we want to model the bulb as a resistor, we can use this information to find the resistance.

$$R_{bulb} = \frac{v_{bulb}}{i_{bulb}}$$

$$= \frac{2.0V}{0.150A} = 13.3\Omega$$

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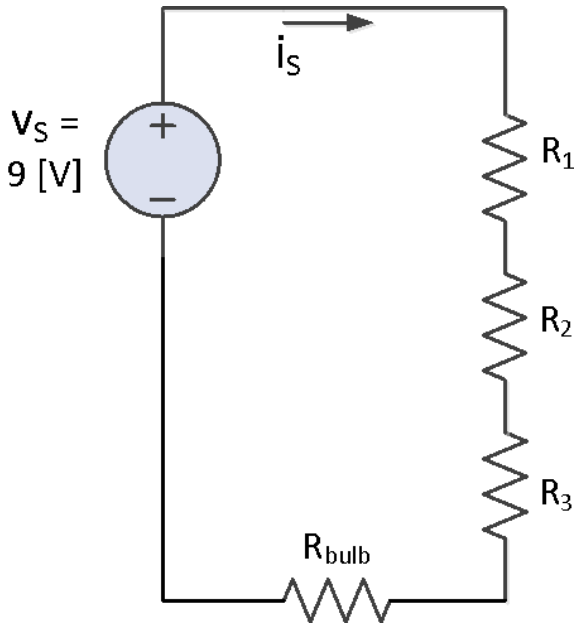
Which Resistors?



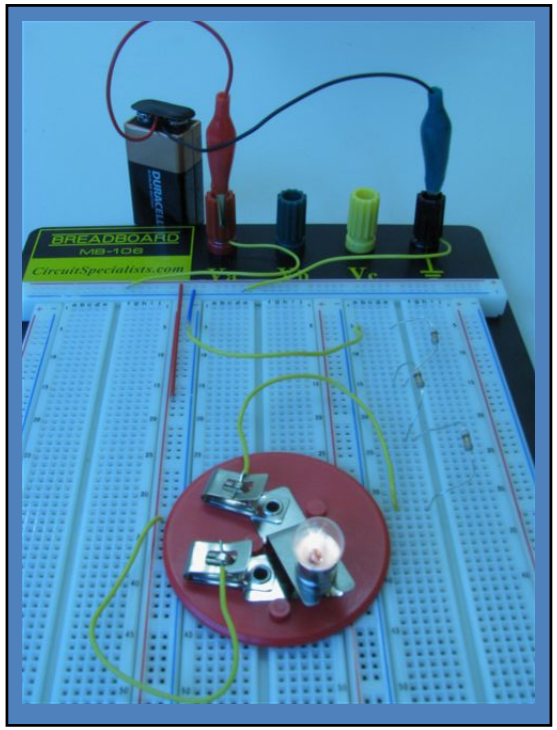
We can find the total resistance necessary to limit the current to about 0.150 A This looks like a job for

KVL and Ohm's Law!! We've done this!

It should be clear from our previous analysis with only two resistors that

$$i_S = \frac{v_S}{R_1 + R_2 + R_3 + R_{bulb}}$$

Which Resistors?



So we can find the total resistance necessary to limit the current to about 0.150 A

$$R_{total} = \frac{v_S}{i_S}$$

$$= \frac{9V}{0.150A} = 60\Omega$$

So we need a total of 60 Ω, and the bulb accounts for about 13 Ω of that. You do the math (it doesn't have to be "exact").

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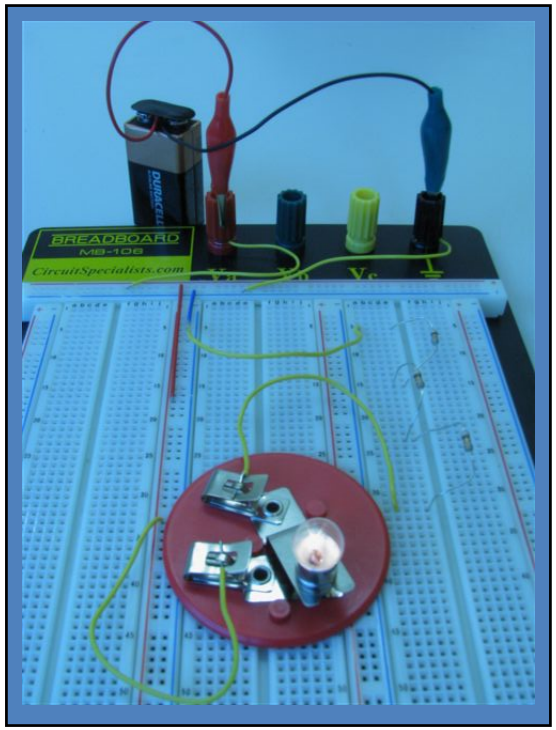
In-Class Activity



1. Using the information on your bulb, find the resistance that models the bulb (R_{bulb}).

2. Divide the battery voltage by the current rating on your bulb to get the total resistance in the circuit that is needed to limit the current.

3. Put resistors in series (one after the other) to get the total resistance needed after accounting for the bulb resistance.

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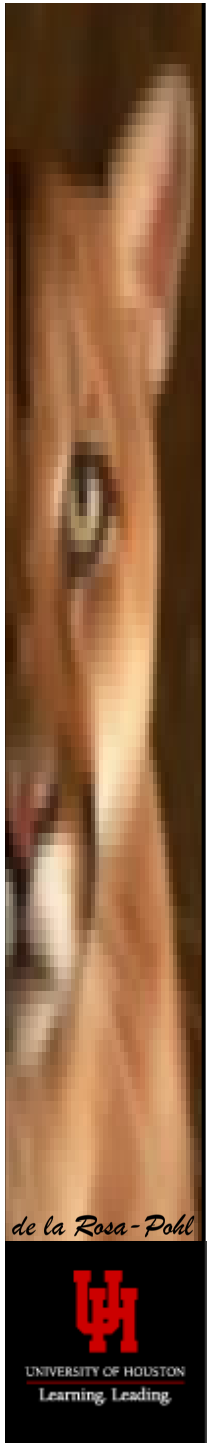
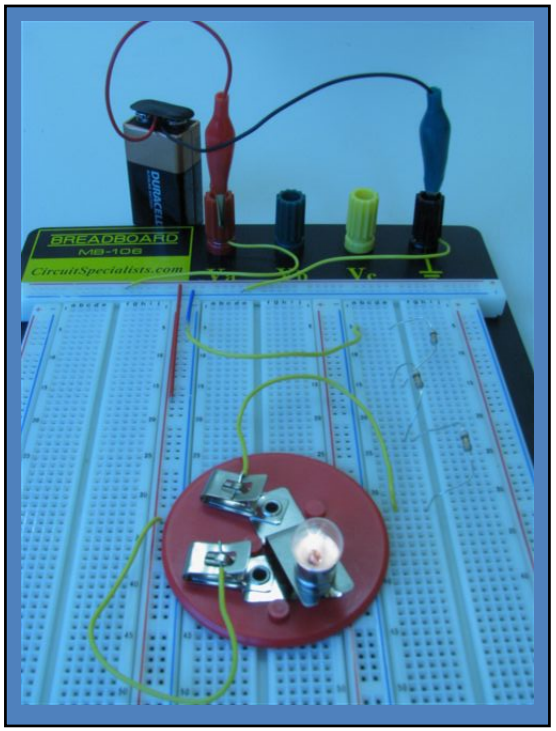
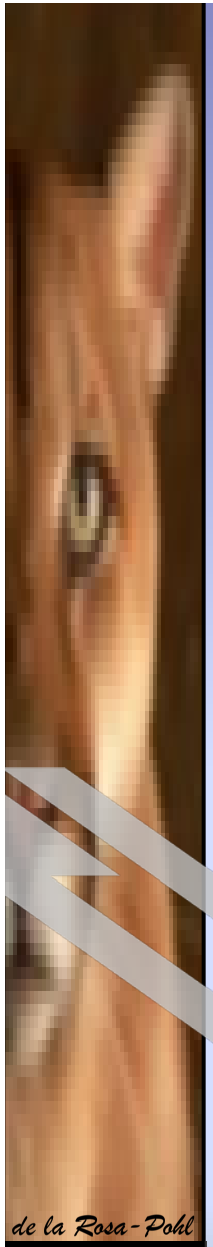


Design

This is a simple example of design:



1. ***Goal***: Light the bulb.
2. ***Specifications***: The bulb has a given voltage and current rating.
3. ***Constraint***: You have only a 9 [V] battery, which will exceed the bulb rating.
4. ***Analysis***: KVL and Ohm's Law tell us the resistance necessary to light the bulb "safely".
5. ***Constraint***: Your collection of resistors is limited.
6. ***Engineering Approximation***: The resistor values and the current you end up with don't have to be "exact".



The End

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