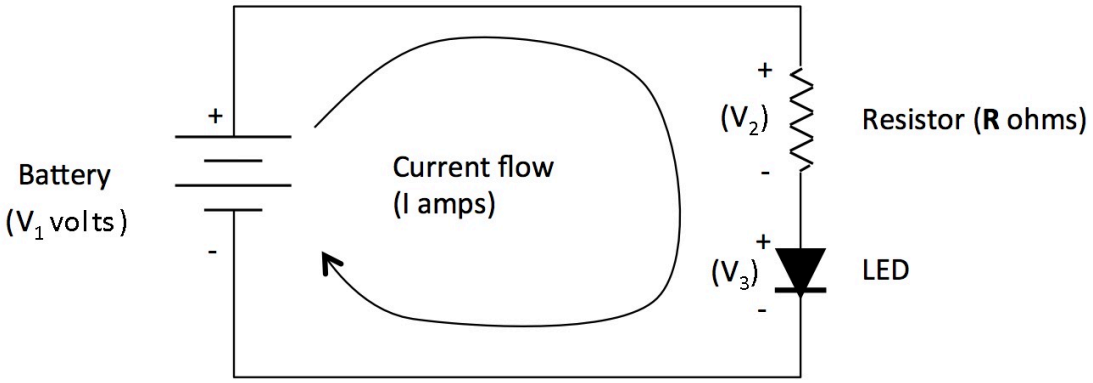
Circuit Design Worksheet

You are an electrical engineer. Your job is to design a circuit to use a battery to light a small lamp (a light-emitting diode, or LED). Your design skills and calculations will ensure that you choose just the right parts so that you can light up the LED, but not let it get too hot or burn up.

You'll need:
1 9-volt battery
A few LEDs (at least 2-3 different colors - red, orange, yellow, yellow-green, white, or blue)
A few resistors of different values in the range of 350 – 600 ohms
A breadboard
Some wires
Some electrical tape

Introduction
You will recall this simple circuit from your earlier reading:



In this diagram, V_1 is the voltage supplied by the battery, V_2 is the voltage drop across the resistor, and V_3 is the voltage drop across the LED. Remember, all of the voltage supplied by the battery must be dropped across the components in the circuit, in this case the resistor and the LED. In other words, part of the voltage will be dropped across the resistor, and the rest across the LED. You will also recall that Ohm's Law states that the current through is equal to the voltage across the resistor and resistance provided by the resistor. Or, rearranging, Voltage across the resistor (V_2) equals current (I) times resistance (R).

$$V_2 = IR$$

Now, it turns out that LEDs like to have 15 mA (or 0.015 amps) of current flowing through them to light up nicely. If you give an LED more current than that, it might burn up. If you don't give it enough current, it won't light up. Your challenge is to make sure your circuit is designed to give the LED the 15 mA of current it wants.

How much "voltage drop" across the LED is determined by the color of the LED. This chart will be helpful to you in your design:

LED Color	Voltage Drop
Red	1.7 V
Orange	1.9 V
Yellow	1.9 V
Yellow-Green	2.1 V
Bright White	3.4 V
Blue	3.4 V

So, to design your circuit, you have to make sure you pick the correct resistor to put in the circuit to ensure that the correct current (15 mA) flows through the LED.

Design hint: All 9 volts provided by the battery must be dropped across the resistor and the LED, so whatever is dropped across the LED, the rest must be dropped across the resistor. Once you know what color LED you will use, you know how much voltage will be dropped across it, and you can figure out how much voltage must be dropped across the resistor. Once you know the voltage drop across the resistor, you can use Ohm's Law to calculate the size of the resistor you need to provide the desired 15 mA current flow in the circuit.

Use this table to help you design your circuit:

Voltage provided by battery (in volts) _____
Voltage drop across LED (in volts) _____
Voltage drop across resistor (in volts) _____
Desired current flow in circuit (in amps) _____
Value of resistor needed (in ohms) _____

Building and Testing your Design

Once you have your design complete, you're ready to build it. Find the parts you need in your kit. Use what you know about resistor markings to find the correct resistor.

Egads! What do you do if you cannot find a resistor with the precise amount of resistance you calculated you need! Find two (or three) resistors whose sum is the desired resistance! If you still cannot get to the precise resistance you need, you can use any resistor whose resistance is within 10% of your desired value (or combination of resistors whose sum is within 10% of the desired value) So if you calculated that you need a 370-ohm resistor, using any resistor or combination of resistors totaling between 340-ohms and 400-ohms should work.

Now using the breadboard, the 9-volt battery, jumper wires, and the LED of your chosen color, select a resistor of the value from your design, and build your circuit. Decide how you will connect them using the breadboard. (Your teacher will show you how to connect things together on the breadboard.) Make sure the polarity of the leads on the LED match the circuit diagram; ie. the positive lead (the longer lead) should be oriented in the direction of the resistor and the positive terminal of the battery.

Did it work? If so, congratulations!

If not, try to figure out why not. Are the wires connecting everything correctly? Is the polarity of the LED correct? Is the polarity of the battery correct? Is the battery working? As you try different solutions,