# How to Use a Multimeter and Build a Simple Circuit

Components: 3 assorted resistors, 4 assorted batteries, 3 assorted LEDs, 1 SPST toggle switch, 1 DPDT knife switch, fuse, motor
Equipment and tools: Safety Glasses, 4AA battery pack, alligator clips, multimeter

All exercises require safety glasses over your eyes, all the time!

A multimeter is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter includes basic features such as the ability to measure voltage, current, and resistance.

1. Use a multimeter to test the voltage on an assortment of batteries. [Expected voltage is the voltage stamped on the battery.]

Set multimeter to  The black lead goes in the COM port; the red lead is in the V port.

| Battery Size | Expected Voltage | Measured Voltage | Good or Bad? |
|---|---|---|---|
| C size | 1.5 V | 1.3 V | Bad |
| | | | |
| | | | |
| | | | |

2. Use your multimeter to measure the voltage of your 4-AA battery pack. What is the voltage:_____. These batteries are in *series* and their voltage is cumulative.

3. Use a multimeter to measure the resistance of the 3 resistors. After measuring the value, verify that the resistor is within +- tolerance.

Set multimeter to  The black lead goes in the COM port; the red lead is in the V port.

| Resistor Band Colors | Expected Resistance (read code) | Percentage | Measured Resistance | OK? |
|---|---|---|---|---|
| orange, orange, brown | 330Ω | | 328Ω | |
| | | | | |
| | | | | |
| | | | | |

4. Create a circuit to light up your LED. Using a 4-AA battery pack, alligator clips, your red LED and resistors, create a circuit like the one shown below.

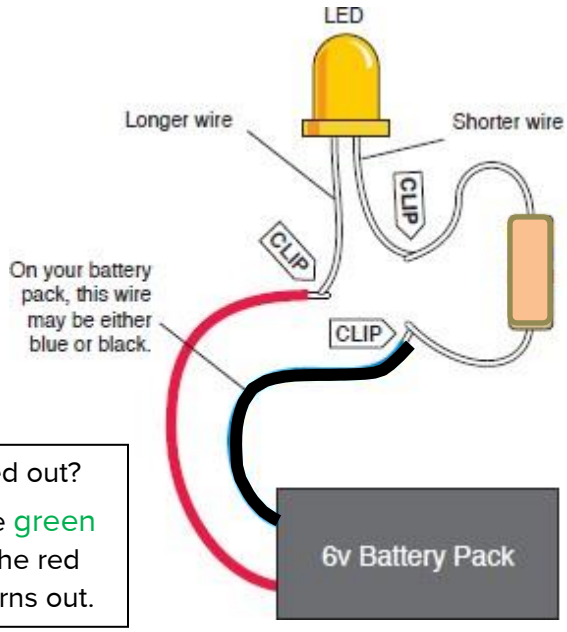



*Figure courtesy of MAKE Electronics Book*

Burned out?

Use the green LED if the red LED burns out.

Directions: Start with the 2K (2000) resistor in the circuit. Attached the resistor to battery negative (black wire) using the alligator clips. Attach the shorter wire of the LED (negative) to the resistor. Observe the intensity of the LED (cup your hands over it to make it dark.) Now remove the 2K resistor and insert the 1K (1000) resistor, observe the intensity of the LED. Repeat with the 470 resistor. What happens to the LED as resistance decreases?

Answer:_____

How does this relate to Ohm's Law?

$V = I \times R$

[V = Volts, I = Current, R = Resistance}

This circuit is in series, meaning the components are connected along a single path. In a series circuit, the current through each of the components is the same. However, we can change the current by changing the resistance. This is a very helpful way to protect electronic components from "frying" from too much current. If you were to connect the LED to the battery without a resistor, it will blow up. THAT IS WHY YOU ARE WEARING SAFETY GLASSES.

5. Voltage drop describes how the supplied energy of a voltage source is reduced as electric current moves through the passive elements (elements that do not supply voltage) of an electrical circuit.

Set multimeter to 

Use your meter to measure the voltage drop across the LED and the voltage drop across the 1000K resistor.

Battery Voltage_____=_____LED Voltage drop +_____Resistor Voltage drop

6. Using Ohm's Law, calculate the current in the circuit using each of the 3 resistor values.

$$V = I \times R \quad \text{or} \quad I = V/R$$

[V = Volts, I = Current, R = Resistance] (i.e. you know V and R, so solve for I.)

| Voltage (V) | Resistor value ( ) | Calculate the current using Ohm's Law Show answer in mA |
|---|---|---|
| | | |
| | | |
| | | |

7. Now measure the current in the circuit using the multimeter (remove the LED).

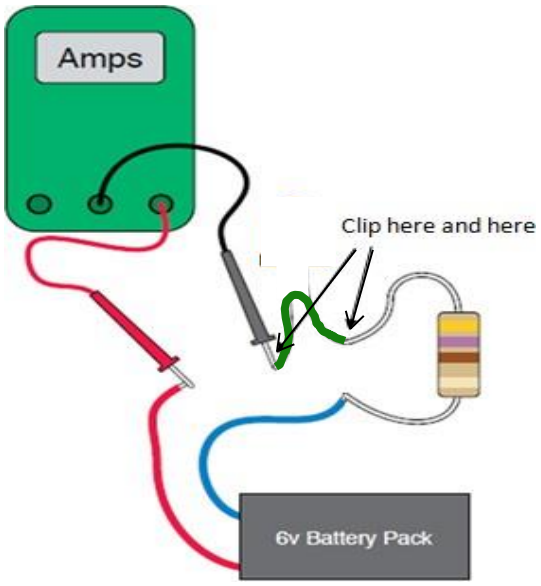



*Figure modified - courtesy of MAKE Electronics Book*

Hook up the circuit as shown. You will need 4 alligator clips.

Set the multimeter to milliamps 

You will need to change the leads. The black leads stays in the COM port, the red moves to the mA (milliamp) port.

Don't worry, it will beep at you until you get it right!

Make 3 measurements, one with each resistor.

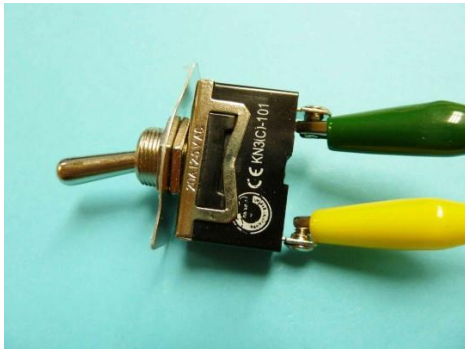
Remember to list the units.

Then compare your calculations above with the measurements below.

| Resistor value | Current measured in the circuit |
|---|---|
| | |
| | |
| | |

Are the values in #5 and #6 the same? If not, can you explain the differences?

8. Insert a single pole single throw (SPST) toggle switch into your circuit anywhere. This is a simple on-off switch. Use the switch to open (off) and close (on) your circuit. Does the LED turn on and off with the switch? Remove the LED and resistor and place a motor in your circuit (the motor can handle up to 18 volts, so a resistor is not needed or wanted.) Can you turn the motor on and off?

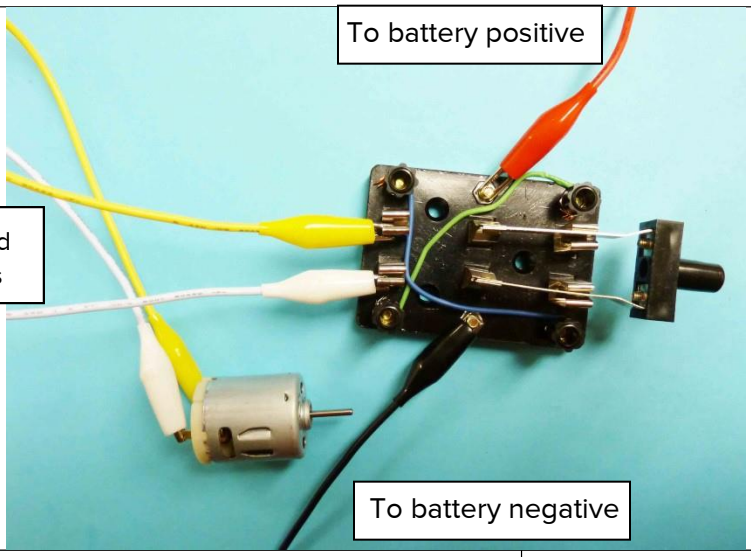



Does it spin in one direction or two directions? _____

9. Using electronic symbols (see component chart), draw a circuit that includes: a battery, a SPST switch, a resistor, and a LED. Use straight lines to connect the components. Straight lines represent wires in electrical schematics.

10. Remove the SPST toggle switch and replace it with the double pole double throw (DPDT) knife switch. Look at the picture carefully below to clip everything together. Use this type of switch to not only open and close your circuit but to reverse the direction of the electrons (i.e. reverse the polarity). Can you use the switch to make the motor turn in both directions? Look carefully at the wiring on the DPDT knife switch (top and bottom), every piece of metal on the switch is a *conductor.*

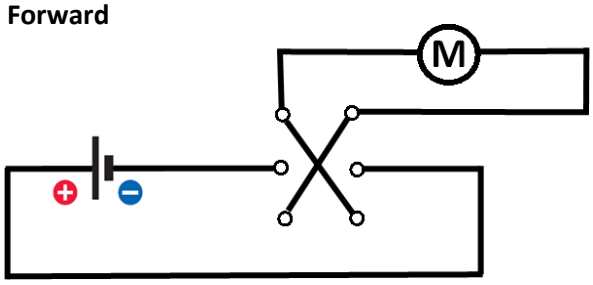
Motor is connected to switch terminals



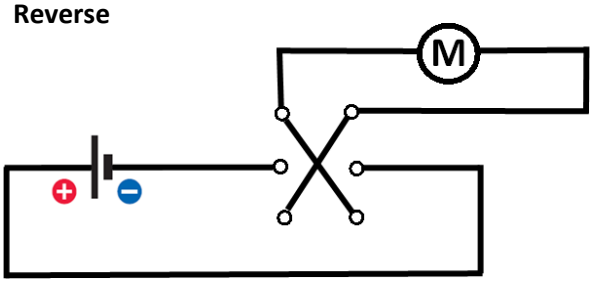

Note:
If your motor is not working, check all electrical

Exercise:
In the diagrams below, draw the contacts when the switch in thrown in the forward and reverse position and trace the flow of electrons.

**Forward**




**Reverse**




11. You will use a DPDT toggle switch in your Pufferfish control box, it will be a rocker switch rather than a knife switch. Write down the difference between a SPST and a DPDT switch?

12. MAKE SURE YOUR SAFETY GLASSES ARE ON. Look carefully at your 3-amp fuse, now let's burn it up.

Figure 1-36. A 3-amp fuse before its element was melted by a single 1.5-volt battery.

Figure 1-37. The same fuse after being melted by electric current.

Directions: Inspect the S-shape metal wire in the center of the fuse. Using your alligator clips, connect one metal blade to the positive wire of the battery pack and the other to the negative (direction does not matter.) Watch carefully and look at the S-shape metal wire in the center of the fuse again. Do you see a break in the wire?

*Note: If your battery pack is weak it might not blow the fuse, try the 6-volt lantern battery instead.

Why do we require fuses on all the ROVs that participate in the ROV competition?

## Review of important concepts:

- Voltage: difference in charge between two points, measured in volts (V).
- Current: the rate at which a charge is "flowing" in a circuit, measured in amps or milliamps (I).
    - 1 amp = 1000 milliamps or 1 A or 1000 mA
- Resistance: resistance to electron "flow", measured in ohms (R).
    - 1,000 Ohms = 1 kilohm = 1 K Ohm or 1K

To build a simple circuit you need (at a minimum):
1) Voltage (battery), 2) Conductive Path (wire), & 3) Load (light bulb, motor, etc.)