



Experiment Module 3 ***Electric Circuits***

Objective/Introduction

This experiment explores building simple circuits and testing Ohm's Law. Students will start lighting a simple light bulb. Then they will explore the differences between series and parallel circuits with light bulbs. After students have explored this thoroughly they will add switches and buttons to their circuits to turn the lights on and off. This will then lead them to building circuits with their motors and trying to change the direction of the spin of the motor and the speed.

Science Content Standards

Benchmarks 2061 Project (see References section to link to the online standards):

- At the end of 8th grade, students should know that
 - Energy can be transferred from one system to another (or from a system to its environment) in different ways: 1) thermally, when a warmer object is in contact with a cooler one; 2) mechanically, when two objects push or pull on each other over a distance; 3) electrically, when an electrical source such as a battery or generator is connected in a complete circuit to an electrical device; or 4) by electromagnetic waves.
 - Energy appears in different forms and can be transformed within a system. Motion energy is associated with the speed of an object. Thermal energy is associated with the temperature of an object. Gravitational energy is associated with the height of an object above a reference point. Elastic energy is associated with the stretching or compressing of an elastic object. Chemical energy is associated with the composition of a substance. Electrical energy is associated with an electric current in a circuit. Light energy is associated with the frequency of electromagnetic waves.
 - Electric currents and magnets can exert a force on each other.
 - Electrical circuits require a complete loop through which an electrical current can pass.
 - A charged object can be charged in one of two ways, which we call either positively charged or negatively charged. Two objects that are charged in the same manner exert a force of repulsion on each other, while oppositely charged objects exert a force of attraction on each other.

- At the end of 12th grade, students should know that
 - Thermal energy in a system is associated with the disordered motions of its atoms or molecules. Gravitational energy is associated with the separation of mutually attracting masses. Electrical potential energy is associated with the separation of mutually attracting or repelling charges.
 - Many forms of energy can be considered to be either kinetic energy, which is the energy of motion, or potential energy, which depends on the separation between mutually attracting or repelling objects.
 - The interplay of electric and magnetic forces is the basis for many modern technologies, including electric motors, generators, and devices that produce

- or receive electromagnetic waves
- The motion of electrons is far more affected by electrical forces than protons are because electrons are much less massive and are outside of the nucleus.

Materials Needed

- 1 D-Cell battery
- 6 6-inch pieces of wire
- 3 flashlight light bulbs
- 3 light bulb holders (optional)

Materials Needed From Sea Perch kit

- Buttons
- Switches
- Motors
- Multi-meter (optional)

Procedure – *How do light bulbs work?*

Light bulbs work when current runs through the small wire inside the glass (filament). The current heats the filament and it glows. The light bulb is set up so each end of the filament is connected to a different part of the screw-end of the light bulb. Specifically, one end is connected to the bottom of the screw and the other is connected to the side.

Activity: The goal of this exercise is to make the light bulb turn on by completing the wire-battery-bulb-wire circuit. There are four possible configurations you should be able to find. Draw each configuration in the space below.

Circuit 1

Circuit 2

Circuit 3

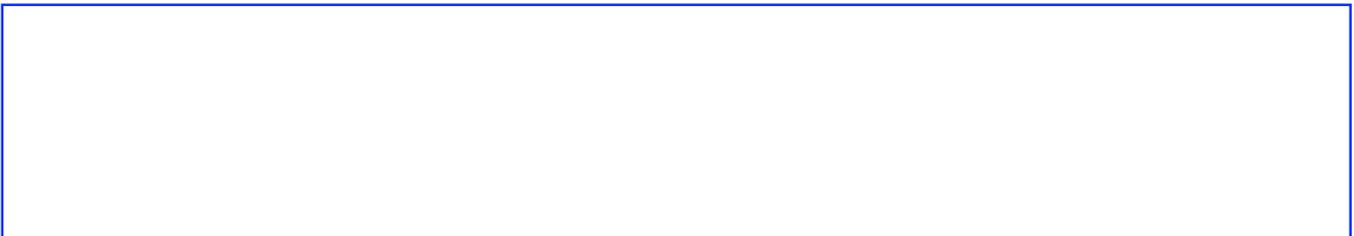
Circuit 4

Now build a circuit that places three light bulbs in series with the battery. Draw a representation of the circuit in the space below.



Unscrew one bulb. Observe what happens

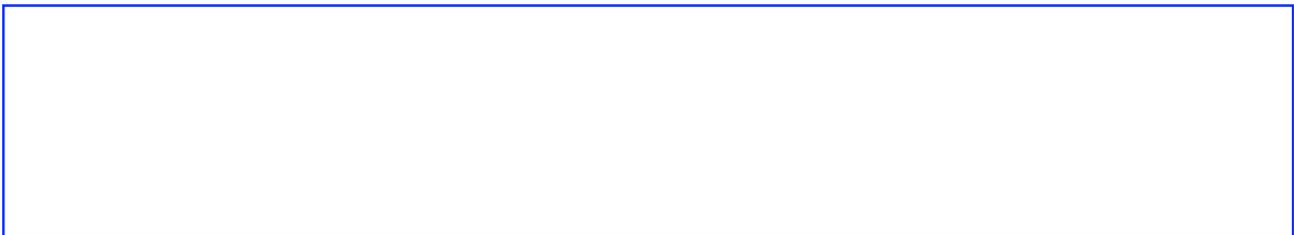
Now build a circuit with the three bulbs in parallel with each other and then connected to the battery. Draw the circuit in the space below.



Are the bulbs more or less bright compared to the series circuit?

Unscrew one bulb. Observe what happens

Now build a circuit with one bulb in series with the other two in parallel. Draw the circuit in the space below.



Are the bulbs more or less bright compared to the series and parallel circuits?

Unscrew one bulb at a time. Observe what happens and explain why this happens.

Try to design and build a circuit that incorporates a button to turn the light on and off. Draw the design in the space below.



Making a motor switch directions

This experiment can be done entirely with objects from the Sea Perch kit. It is desirable to operate the motors both backwards and forwards. Design a circuit that will allow this to be accomplished by just pressing one or more buttons or flipping one or more switches. Draw the design in the space below.



Note: There are a number of different circuit designs that will accomplish this goal. Try different configurations and discuss with your group the pros and cons of each set up.

Changing the motor speed

This experiment can be done almost entirely using objects from the Sea Perch kit. The only added objects will be a variable resistor (potentiometer, rheostat) and a multi-meter. The potentiometer is wired in series with the motor. This allows the motor's resistance (and therefore the current) to be varied.

Draw the circuit you have built in the previous step.



Using the Multi-Meter (optional)

You will now use the multi-meter to measure how the voltage and current applied to the motor change as the resistance is varied. Remember when using a multi-meter to measure current it must be placed in series in the circuit. When measuring voltage you must place the multi-meter in parallel with the motor.

Resistance (Ohms)	Current (Amps)	Voltage (Volts)	Motor Speed

Thinking Challenge:

Does your data match Ohm's Law? Explain your answer thoroughly.

Extending the Discussion to Sea Perch:

Based on the experiments in this lab, how will you build circuits to change the direction of your motors?

How will you build circuits to change the speed of your motor?

Additional Resources

- Please visit the following URLs, which links to simulations are from the University of Colorado at Boulder website.
 - Have students look inside a resistor to see how it works. Increase the battery voltage to make more electrons flow through the resistor. Increase the resistance to block the flow of electrons. Watch the current and resistor temperature change - <http://phet.colorado.edu/en/simulation/battery-resistor-circuit>
 - Look inside a battery to see how it works. Select the battery voltage and little stick figures move charges from one end of the battery to the other - <http://phet.colorado.edu/en/simulation/battery-voltage>
 - This simulation is an electronics kit in your computer. Build circuits with resistors, light bulbs, batteries, and switches. Take measurements with the realistic ammeter and voltmeter - <http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc>