Investigating Electrical Circuits Kit

96-1500

INSTRUCTIONAL GUIDE

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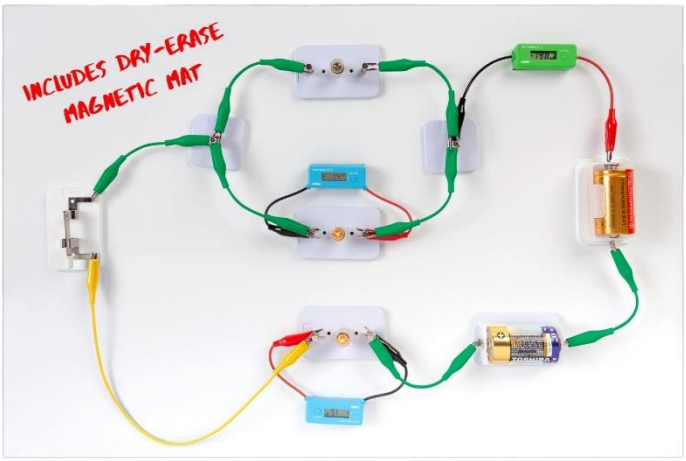
- Instructional Guide



Recommended for Activity:

- **Miniature Digital Ammeter (96-8080)**
- **Miniature Digital Voltmeter (96-8085)**
- **D Battery (2 pack) (04-2106)**

Introduction

This kit is designed for student inquiry and discovery. The pedagogy is consistent with the Modeling in Physics programs and emphasizes that concepts should precede calculations. The components in the kit are simple, but well-designed for dynamic flexibility. The first investigations are related to the basic concepts: open and closed circuits, series circuits, parallel circuits, and combination circuits.

The activities will engage students to meet challenges and compare the circuits to their existing knowledge of home circuits. Later activities will introduce the concepts of voltage, resistance, and electrical current. The newly designed, **Miniature Digital Ammeter (96-8080)** and **Miniature Digital Voltmeter (96-8085)** allow students to make easy and accurate measurements.

Here is a brief outline of the student activities:

Circuit Challenges is an introduction to electrical circuits. Students will build their intuition as they design and construct increasingly complex circuits. Students will observe changes in the brightness of the lamps as they construct series, parallel, and then combination circuits.

Home Circuits reinforces Students’ observations and supports their “conceptual model” as they place switches into their circuits to mimic their home circuits. Students will gain a solid understanding of series, parallel, and combination circuits.

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Electrical Measurements introduces the digital ammeters and the digital voltmeters. Students will discover the following patterns for series and parallel circuits:

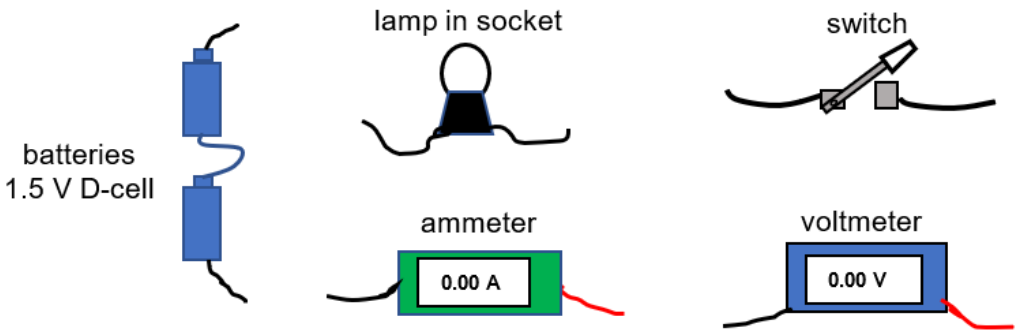
- All elements in a series circuit have the same current and the components will share the voltage.
- In parallel circuits, different branches have full voltage and can be operated independently.
- The currents in parallel branches add to achieve the current in the main branch.
- Finally, a circuit breaker will be explained. This safety device limits the current to keep wires from overheating, thus preventing electrical fires.

Background

Imagine if you woke up one day and there was no electricity. Power outages at your home make life suddenly difficult. Your electric powered garage door opener doesn't work. If you travel, all traffic signals are out and every intersection becomes a dangerous, stop-and-go experience. Food in the freezer and refrigerator begin to warm, etc. Thankfully, our electrical grids are quite reliable and we even take them for granted. Thomas Edison is credited for inventing the lightbulb, but his true genius was his vision. Edison imagined a lighting system that would enable folks to be safe to work or play any time of the day or night! His vision included a vast network that could supply electrical energy to homes, businesses, outdoor lights, etc.

Circuit Challenges

Diagram key:



Challenge 1:

Remove a lamp from its socket. Now use the power supply and wires to light the lamp. Can you light it up with only one connection to the lamp?

Sketch what works!

Challenge 2:

Return the lamp to its socket. Now make a simple circuit with the power supply and one lamp.

Make a sketch and label the lamp as “bright.”

Challenge 3:

Design a circuit with 2 lamps and when one lamp is removed, the other lamp goes out.

Draw your circuit. Label this as a **SERIES CIRCUIT**. Label the brightness of the lamps as “medium.”

Challenge 4:

Design a circuit with 2 lamps and when one lamp is loosened, the other lamp stays on.

Label this a **PARALLEL CIRCUIT**. Draw your circuit and label the brightness of the lamps.

Challenge 5:

Design a circuit with 3 lamps. Lamp **1** is medium and lamps **2** and **3** are equally dim. When lamp **1** is loosened, the other lamps go out.

This is a **COMBINATION CIRCUIT**. Draw your circuit and label the brightness of the lamps.

Challenge 6:

Design a circuit with 3 lamps. Lamp **1** is bright and lamps **2** and **3** are equally medium. When lamp **1** is removed, the other lamps stay on.

Label this as a **COMBINATION CIRCUIT**. Draw your circuit and label the brightness of the lamps.

Challenge 7:

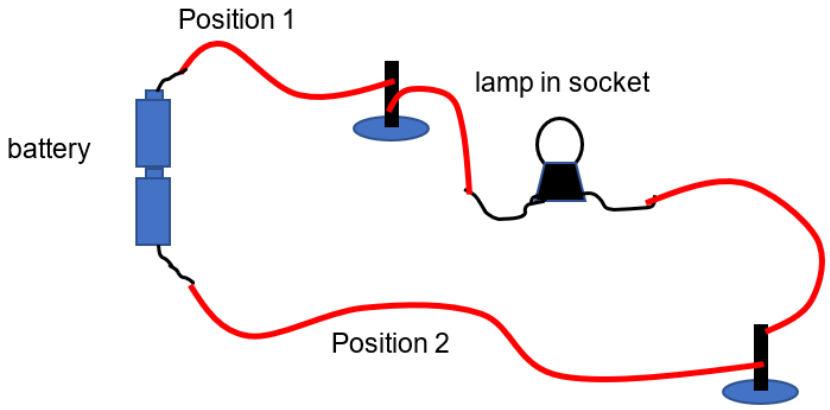
Design a circuit with 3 lamps all bright and **2** switches. Switch **1** turns on and off bulb **1**.

Switch **2** controls both lamps **2** and **3**. Make a drawing that shows your circuit. Label each switch and each bulb.

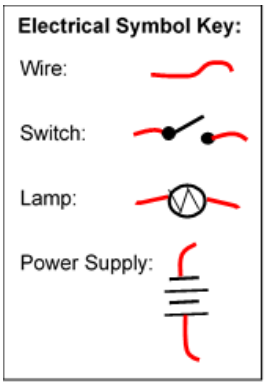
Home Circuits

The lighting system in you home consists of lamps and switches. This activity will allow you to “model” these circuits using the miniature lamps and switches in the circuits kit.

Suppose you have a room with one overhead lamp and one switch. Build the circuit below. Try putting the switch in position 1. Then try the switch in position 2. **Describe your results.**



Now “model” a different room in your house. This room has two ceiling lights. It also has **one switch to control both lights**. When one lamp is unscrewed, the other stays on. Design and construct this model. Test to see if it works. Use the symbols in the key and sketch your winning design here:



In a different room, you have two wall lamps each controlled by its own switch. Continue to use the symbols and draw your design below. Then use the equipment to test your design. Modify your design if needed!

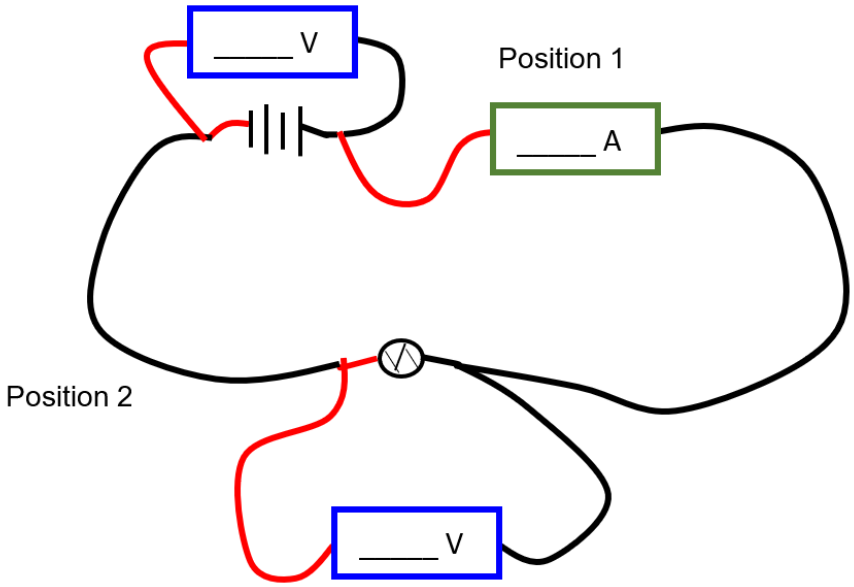
Your home also has a safety system called a **circuit breaker**. This device is a "**safety switch**" that will automatically open to cut off the electricity when the flow becomes too great. This will keep the wires from overheating and starting a fire! Draw one circuit that combines all of the cases above and add the circuit breaker to your design. Finally, compare your design to that of a different lab group. Note that the switches are always in series with the lamps that they are controlling. The circuit breaker in your home is always located where the electrical power comes into your home.

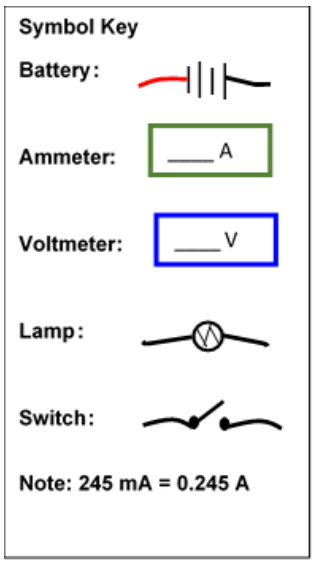
Electrical Measurements

This activity is designed to for you make measurements with the voltmeter and the ammeter. You will also discover the patterns for current (amps) and voltage for series and parallel circuits. Use the symbol key for all of your drawings. The electrical flow through any part of a circuit is measured by the ammeter.

Simple Circuit:

Use the components to build the circuit shown below. Record the values of the ammeter and voltmeters.





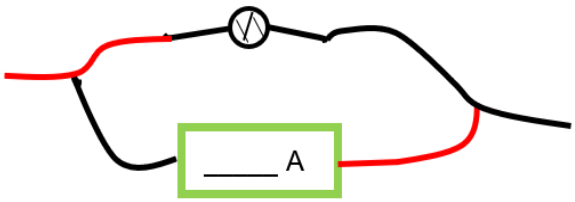
NOTE – The **voltmeter** is always added in **parallel** with a lamp or power supply.
NOTE – The **ammeter** must always be in **series**.

Understanding Electrical Meters:

Ammeter:

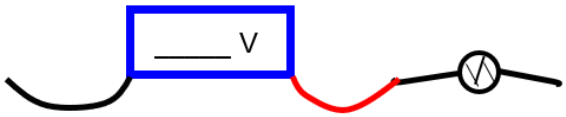
The ammeter is designed to have a very low resistance, so connecting it in series with the lamp as shown above will have little impact on the current measurement.

Suppose you mistakenly connect the ammeter in parallel with the lamp as shown here:



The ammeter is designed to have a very small resistance. When the ammeter is connected in parallel, almost all the current will pass through the ammeter. For example, if the resistance of the lamp is 50 times the resistance of the ammeter, the ammeter will have 50 times as much current through it compared to the lamp. **The lamp will not light!**

Voltmeter



The voltmeter is designed to have a very high resistance, so it will have a very small current through it. If the voltmeter is placed in series with a lamp, the effect is to block the current through both devices. The voltmeter will measure the battery voltage and the **lamp will not light!**

Now look closely at the simple circuit on the previous page. The electrical flow (or current) is measured by the ammeter. Predict the value of the current at position 2 in the circuit.

Predicted current = _____

Now remove the ammeter from position 1 and hook up the circuit with the ammeter in position 2. Record the value from the ammeter.

Measured current = _____

Write a statement that describes the value of the current in different parts of this simple circuit:

Series Circuit:

Next, build a series circuit with 2 lamps (Recall that if one lamp is removed, the other lamp goes out). Now use the voltmeter to measure the voltage across the battery and also the voltage across one of the lamps.

Battery = _____ One lamp = _____

Write a statement that describes the relation between the voltage of the battery and the lamps.

Now add the ammeter to the circuit to measure the current between the lamps.

Measured current = _____

Predict the current in the part of the circuit next to the power supply and then move the ammeter to that position to measure it.

Predicted current = _____ Measured current = _____

As more lamps are added in this series circuit, the lamps get dimmer. What happens to the current as more bulbs are added?

Draw and construct a **series circuit** with the power supply, and ammeter, and three lamps. Show the drawing here:

Now measure the voltage across the battery. Battery voltage = _____ V

Predict the voltage across each lamp, then **measure** the voltages.

	Predicted Voltage	Measured Voltage
Lamp 1		
Lamp 2		
Lamp 3		

Describe a rule that relates the power supply voltage to the individual voltages:

Now put the ammeter in series with the lamps. What is the measured current?

Measured current = _____

You should be able to accurately predict the current at any other point in the circuit. Make your prediction, then move the ammeter to check your prediction.

Predicted current = _____ Measured current = _____

Parallel Circuits

Draw and the construct a parallel circuit with the battery and 3 lamps. All lamps should be bright and when any lamp is removed from the socket the others remain bright! Include the ammeter in series with one of the lamps to measure the current through that lamp. Show your drawing here:
Use the voltmeter to measure the voltage across the battery and then across each lamp. Describe your results here:

What is the value of the ammeter? Current = _____

Make a prediction for the current through the other lamps. Explain you prediction.

Would you expect the current in the main branch (next to the power supply) to be the same for each other branch? Explain your guess.

Remove the ammeter from one of the parallel branches and use it to measure the current in the **main branch**.

Measured current = _____

As more branches are added in a parallel circuit, the current in the main branch increases. This extra current causes heating of the wires. To prevent the hot wires from starting fires, most circuits include a protection device called a **circuit breaker. All of the circuit breakers for your house are in a metal box. Ask mom or dad to show you this box. If you lose electricity in a particular part of your house, you should unplug some of the appliances, then visit the box to re-set the individual circuit breaker.**

Related Products

Building & Designing Batteries STEM Kit (96-7950) Students learn hands-on with the Building and Designing Batteries Kit. Students learn how to use a multimeter to measure voltage and amplitude, calculate electrical resistance and electrode potentials, evaluate battery performance, assemble electrical circuits, and construct batteries with the 8 investigative activities included.

Circuit Board 2 (P6-8014) This circuit board 2 is a simple preconfigured board that is a basic electricity lab on a board.

Investigating the Design & Output of Wet Cell Batteries Kit (P6-7940) This kit introduces students to the concept of energy conversion through the study of a simple electrochemical cell connected to an electric motor. Electrochemical cells are the basis for batteries and contain metals and other chemicals with stored chemical potential energy.

Acknowledgement

Special thanks to Mark Davids for developing these activities.