Technology Investigation 12-A

Designing a Staircase Circuit

Many AC circuits are similar to DC circuits. In this investigation, you will design and build a circuit with two switches that control a single light. Your circuit will be similar to a circuit for a staircase light that can be turned on or off by operating either of two switches placed at the top and bottom of the staircase.

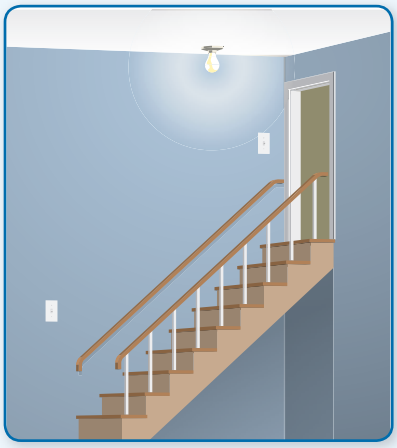
Skill Check

- ✓ Initiating and Planning
- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communicating

Safety Precautions

Materials

- battery (6 V)
- connecting wires
- flashlight bulb in holder
- 2 three-connection switches



A staircase circuit allows you to turn a light on or off at two different locations.

Challenge

Design a circuit that can be used to switch a light bulb on or off using two switches. Construct and test your circuit.

Design Criteria

a. Use a minimum number of connecting wires to construct your circuit.

b. You must be able to turn the light on or off using either of the two switches.

Plan and Construct

1. Draw diagrams of possible circuits. Decide which circuit will work best.

2. Have your teacher approve your design. Then connect and test your circuit.

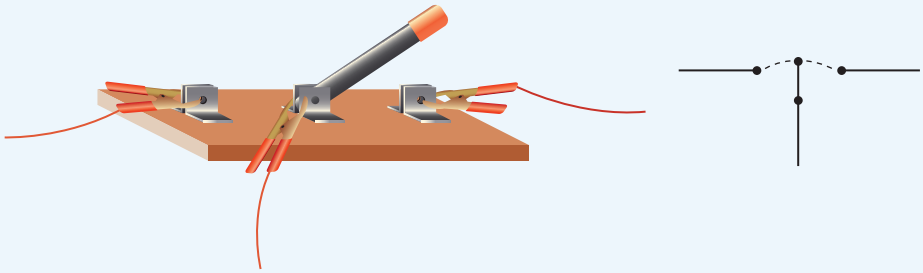
3. If your circuit does not operate properly, check the connections and your circuit diagram. If necessary, modify your circuit and try again.

4. Demonstrate your circuit to your teacher and then to your classmates.

Evaluate

1. Did your first circuit work properly? If not, explain why not.

2. What precaution would you expect an electrician to take before wiring switches in your home?



In this investigation, you will use switches with three connections, as shown.

Real World Investigation 12-B

Skill Check

Initiating and Planning

✓ **Performing and Recording**

✓ **Analyzing and Interpreting**

✓ **Communicating**

Science Skills

Go to **Science Skills Toolkit 7** to learn more about Creating Data Tables.

An Electrical Energy Audit

You can calculate the energy that your family uses in one week by adding up the energy consumed by all the appliances and devices used. If you cannot find the power rating of an appliance or device in your home, use typical data from **Table 12.2**.

Question

Which appliances in your home consume the most energy?

Organize the Data

Make a table to record your family's use of electrical appliances and lighting. Give your table a title. Some appliances are never turned off. For these appliances, enter 24 h multiplied by the number of days you monitor your energy use.

Appliance or Device	Power		Time on	Time off	Time Used	Energy Used
	(W)	(kW)			(h)	(kW·h)

Analyze and Interpret

1. Record the date and the meter reading for your home.
2. One week later, record the date and the final meter reading. Calculate the energy used. Then calculate your family's daily consumption of electricity.
3. Calculate and record the total energy used in the chart. Treat all the lighting as one device. **Note:** This gives only an approximate estimate. A power rating refers to usage at full power.
4. Compare the value you calculated for energy use in step 2, based on the meter readings, with the value you calculated in step 3 by adding the energy used by all the appliances and devices. Explain the likely causes of any difference between the two values.

Conclude and Communicate

5. List the six appliances or devices in your home that consume the most electrical energy.
6. List the appliances or devices in your home that could be replaced with energy-saving models.

Extend Your Inquiry and Research Skills

7. **Research** Use the Internet to find out the time of use prices in effect during your audit. Then use your time and energy data to calculate the cost of using each appliance.

Data Analysis Investigation 12-C

Skill Check

- ✓ Initiating and Planning
- Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communicating

A "Dry" Investigation

When you are in a public restroom and need to dry your hands, should you use paper towels or an electric hot-air hand dryer? In this investigation, you will compare the use of paper towels with the use of hot-air hand dryers at two high schools.

Question

Which is the least expensive and most environmentally friendly way to dry your hands during a school year (about 200 days)?

Organize the Data

Make a table to summarize the data on the left.

Analyze and Interpret

1. a. How many paper towels are used during the school year at AHS?

b. How many cases of paper towels are used?

c. What is the annual mass of paper towels that go to a landfill?

d. What is the annual cost of paper towels?

e. What was the cost of the paper towel dispensers?

2. a. At EHS, how many hours do the dryers operate per year?

b. How much energy (in kW·h) is used to operate the dryers?

c. What is the cost of the electricity used to operate the dryers?

d. What was the cost of installing the hand dryers?

3. a. The hot-air hand dryers remain connected all year, which is 8760 h. What is the total number of hours that all the dryers at EHS are connected?

b. For how many hours are the dryers in stand-by mode?

c. How much energy is consumed in stand-by mode?

d. What is the cost of the electricity used in stand-by mode?

Conclude and Communicate

4. Compare the total annual cost of using power towels and electric hot-air hand dryers.

Extend Your Inquiry and Research Skills

5. Inquiry Although the amount of CO_2 emitted by generating electricity varies with the type of station, an overall estimate is 0.5 kg CO_2 per kW·h. Calculate the mass of CO_2 emitted by generating the electricity for the hand dryers. Compare this with the mass of the paper towels sent to a landfill.

Anywhere High School (AHS)

- AHS has 1500 students and staff who wash their hands four times each school day, using two paper towels each time.
- The washrooms at AHS have a total of 16 paper-towel dispensers, which cost $25 each.
- A case of brown paper towels costs $30 and contains 4000 towels.
- Brown paper towels are made from recycled paper products but are sent to a landfill after being used. A case has a mass of 10 kg.

Erehwon High School (EHS)

- EHS is identical to AHS but has electric hot-air hand dryers.
- Each of the 16 dryers cost $80.
- The dryers are rated at 1.5 kW and provide hot air for 30 s.
- Each dryer uses 2 W in stand-by mode throughout the school year.
- The school pays an average of $0.08/kW·h for electrical energy.

Plan Your Own Investigation 12-D

Skill Check

- ✓ Initiating and Planning
- ✓ Performing and Recording
- ✓ Analyzing and Interpreting
- ✓ Communicating

Suggested Materials

- copy of a recent electricity bill
- computer and spreadsheet program

Every Kilowatt Counts

The electricity bill is a very important part of many families' budget. Electricity costs can be reduced by using appliances during off-peak times and by using less electricity.

Question

What steps can you take to reduce your family electricity costs?

Plan and Conduct

1. Refer to your work on Real World Investigation 12-B, An Electrical Energy Audit.
2. Identify which major appliances in your home, if any, could be replaced. Predict the annual savings if you replaced one.
3. Examine your electrical energy audit for your family. Outline ways your family could save by changing your use of major appliances to off-peak times. Estimate the annual savings if you did this.
4. Gather information about ways to conserve electrical energy from your local utility company and the Internet.
5. Divide your family use of electricity into various categories, such as lighting, heating, entertainment, and food preparation. For each category, identify ways to reduce energy use or switch to off-peak use. Include phantom loads in your investigation.

Analyze and Interpret

1. Make three recommendations for reducing the family's electricity bill. Estimate total annual savings (in kW·h and dollars) if your family follows each recommendation. Show your calculations.
2. There are about 4.6 million households in Ontario. Estimate the annual energy savings if each household reduced its electrical energy use by the same amount you estimated for your family.

Conclude and Communicate

3. Evaluate the processes you used to gather information and make decisions. Explain any improvements you could make.

Extend Your Inquiry and Research Skills

4. **Inquiry** Compare the output from a medium-sized generating station (500 MW) with the reduction in electrical generation that would be possible if all the households in Ontario followed your conservation recommendations.