INTERNATIONAL SPY MUSEUM

LESSON PLAN
DEVELOPED SEPTEMBER 2023

TOP SECRET TELEGRAPH

GRADES | 4th - 6th

TIME | 45-60 minutes

SCIENCE BRANCH | Physics

KEY CONCEPTS
Simple Circuits, Switches, Telegraph, Energy Transfer, Constructing Explanations, Designing Solutions, Inquiry-Based Learning

Overview

In this inquiry-based lesson, students will use various materials to design and build a simple circuit with a switch. Then, they will use their circuits to send and receive secret telegrams (and intercept them, too.)

Learning Goals / Objectives

Students Will Be Able To:

- Build a working telegraph (simple circuit) using a source of electricity (battery), a path or conductor on which the electricity flows (wire), an electrical resistor (light or buzzer), and a device to interrupt the flow of electrons in the circuit (switch).
- Use Morse Code to send a secret message via telegraph from a transmitter to a receiver.
- Use teamwork and problem solving to construct, test, evaluate, and revise a telegraph.

NGSS Performance Expectations

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Make observations to produce data to serve as the basis for evidence for an explanation or test a design solution. **Constructing Explanations and Designing Solutions** Use evidence to construct explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.	**PS3.A: Definitions of Energy** Energy can be moved from place to place by moving objects or through sound, light, or electric currents. **PS3.B: Conservation of Energy and Energy Transfer** Energy can be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. **ETS1.A: Defining and Delimiting Engineering Problems** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions.	**Energy and Matter:** Energy can be transferred in various ways and between objects. The transfer of energy can be tracked as energy flows through a designed or natural system. **Science is a Human Endeavor:** Most scientists and engineers work in teams.

Background Information for Teachers

This lesson should serve as an introduction to the concept of energy and energy transfer. No previous knowledge of circuits is necessary. The concept is to encourage exploration and use knowledge gained through trial and error to understand how circuits can/cannot transfer energy.

In **Part 2**, students will use their circuits to transmit messages. This may be challenging for some students. Encourage students to explore how to send a message so that it can be easily understood, such as keeping a slow and steady pace when transmitting, keep dots as short as possible to distinguish them more easily from dashes, etc.

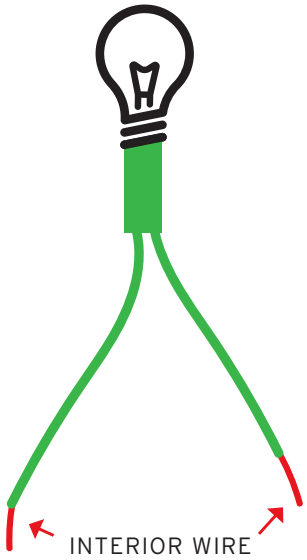
Materials

Each pair of students needs:

- O Brown paper lunch bag
- O 6" x 6" piece of cardboard
- O Tape
- O 1.5-volt battery
- O One light from strand of holiday lights (see preparation below for more details) OR 1 DC 6-15V Alarm Buzzer Sounder
- O Micro Switch with Snap Action Lever Arm (1NO + 1NC)
- O Two 6' pieces of insulated wire
- O One 1' piece of insulated wire
- O *Mission: Top Secret Telegraph* worksheet
- O *Mission HQ Team* worksheet (one for every other pair)
- O *Field Agent Team* worksheet (one for every other pair)
- O A file folder

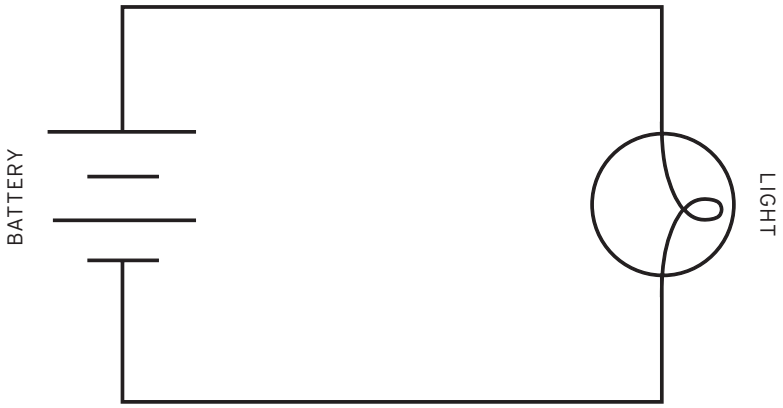
Preparation

- If you are using the lights, each pair of students will need one light from the strand of holiday lights. Locate the two wires extending from the base of a light. Cut each wire so there are about 2" of wire extending from the base of the bulb. Then, using scissors or a wire stripper, remove the bottom half inch of wire coating from each wire so the interior wire is exposed. Repeat these steps until you have enough lights for each pair of students.
- Each pair of students will need two 6' pieces of insulated wire and one 1' piece of insulated wire. Use scissors or a wire stripper to remove .5" of wire coating from each end of each wire.
- Place a light or alarm buzzer, 6" x 6" piece of cardboard, tape, micro switch, battery, wire pieces (3 total) in a brown paper lunch bag. Repeat until there is one bag of materials for each pair of students.
- Print one copy of *Mission: Top Secret Telegraph* for each pair of students.
- Print off *Mission HQ Team* worksheets (for half of the pairs) and the *Field Agent Team* worksheet for the other half of pairs.

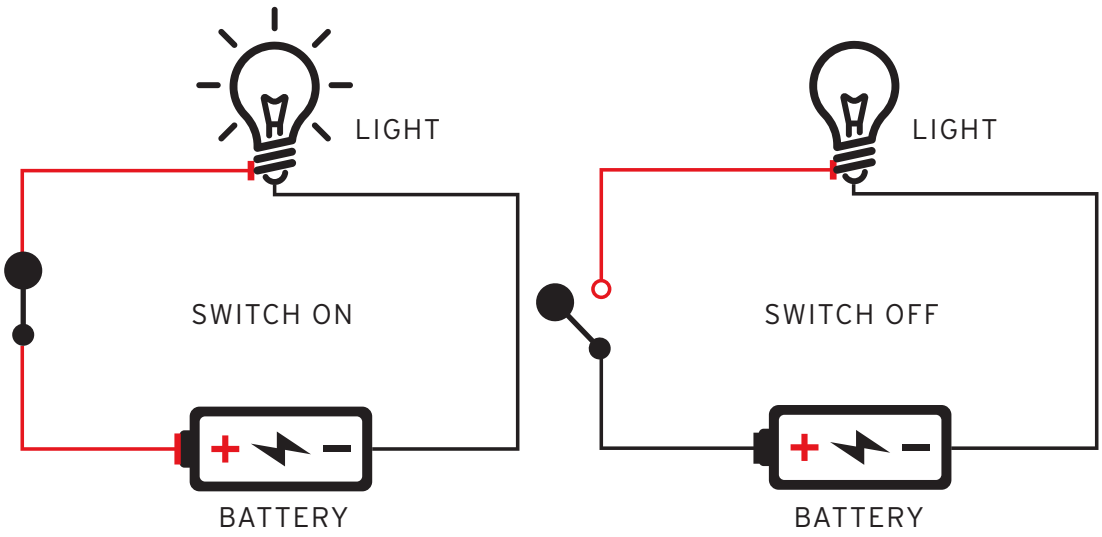


Part 1

1 Teach/review the three parts of a **simple circuit**: (1) an energy source (i.e., battery), (2) a path or conductor on which the electricity flows (i.e., wire), and (3) an energy receiver (i.e., light bulb, buzzer). Explain that for a circuit to be complete, the three components must form a *closed loop* so the electrical current can run continuously in one direction.



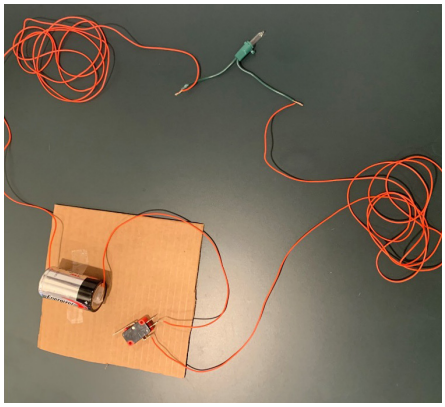
2 Explain that the function of a **switch** is to turn electric circuits on and off. A **closed circuit (switch on)** allows the electric current to continuously flow through the circuit. An **open circuit (switch off)** stops the flow of current. It may be helpful to have a diagram (like the one below) for students to refer to throughout the lesson.



3 Set up the scenario (read script below):

Our nation is at war and needs the best and brightest agents to go behind enemy lines and collect information. Your mission is to enter enemy territory and transmit secret messages back to HQ. Before you leave for your mission, retrieve a brown paper bag from the front of the room. While this bag may seem nondescript, inside are everyday items that can be used to build a telegraph. Once you have built a telegraph, you will be able to communicate using Morse Code with HQ. Until then, you are on your own. Do not open the bag until you are in enemy territory.

4 Have one member of each pair come and pick up a brown paper bag and the *Mission: Top Secret Telegraph* worksheet from the front of the room.



Remind students of Mission #1:

Using the supplies inside the brown bag, create a circuit in which the energy receiver (light) is at least 5 feet away from the energy source (battery) and switch.

Note: Students can choose to use either the light bulb or the buzzer as the receiver.

Allow time for students to explore the materials in the bag and experiment with how to create a closed circuit. If students are struggling, refer them to the simple circuit diagram.

TROUBLESHOOTING TIPS:

- Ensure that the wires are directly touching the ends of the battery, the nodes of the switch, and the wires on the receiver. Use tape to secure them.
- The battery and/or the receiver may need to face in the opposite direction to keep the flow of electrons moving in one direction.
- NC/NO switches have one input and two outputs. Therefore, it has two possible actions. The two outputs should be labeled NC and NO. NC stands for "normally closed" so when this output is chosen the circuit will naturally be closed and electrons will be flowing through the circuit until the lever arm of the switch is pressed. NO stands for "normally open" so when this output is chosen the circuit will naturally be open. No electric current will pass through the circuit until the lever arm of the switch is pressed. Students should decide which option is most suitable for a telegraph (We recommend using the NO output.)
- Use a fully charged battery.
- Check the wires and lightbulb (if that is the chosen receiver) for signs of damage.

5 Once completed, students should demonstrate for you how their telegraph works by sending a message (**dot – dash – dot – dash – dot – dash**).

6 While pairs are "awaiting further instructions" (a.k.a. waiting for all pairs of students in the class to finish constructing their telegraph), they can practice sending and receiving messages via morse code.

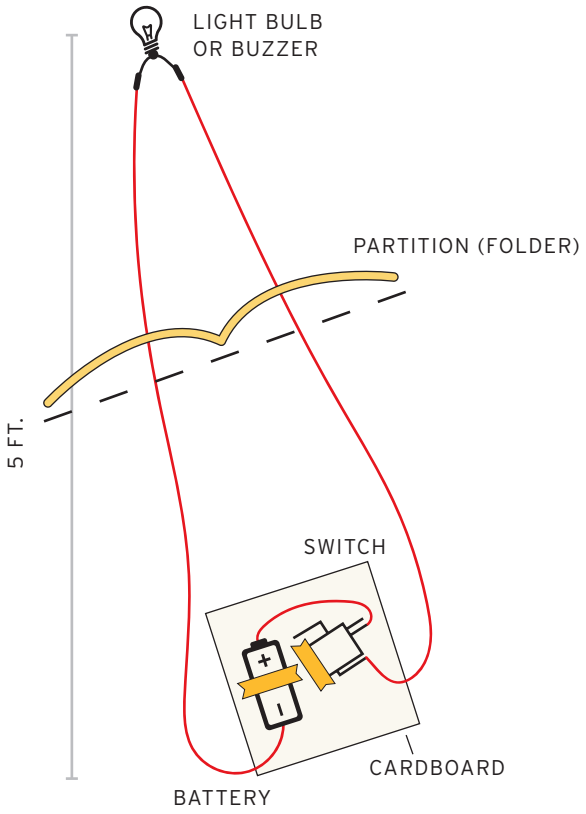
7 Once all pairs of students have constructed a working telegraph, explain their next assignment (Part 2).

Part 2

For part two, each student pair will need to partner up with another student pair (total of 4 students). One pair should be assigned the "FIELD AGENT Team" and the other pair should be assigned the "MISSION HQ Team".

SET UP

The two pairs will sit five to six feet apart. Each pair will set up their telegraph machine so that the battery and switch are in front of them, and the light bulb/buzzer is in front of the pair of students they have partnered with. Each pair should open up their file folder/"partition" and position it on their table so that it hides their device from other teams. That way no one can see their outgoing and incoming messages.



1. Explain that Mission HQ Team has returned back to headquarters since they have been compromised; however, the Field Agent Team is still on their mission. Pass out the *Field Agent Team* worksheet and *Mission HQ Team* worksheet to the corresponding pairs, along with one file folder per team.

2. Explain to students that they will be sending a secret message to the pair they've partnered with. They should follow the instructions on their assigned worksheet. If the message sent by Field Agent Team is received and correctly recorded by Mission HQ Team, both teams will receive 10 points. If, however, Mission HQ Team is unable to successfully decode and record the secret message, neither team will receive points. Field Agent Team will have 3 chances to send their secret message. The process will then be repeated with Mission HQ Team sending the message to Field Agent Team this time.

3. *OPTIONAL ADDED EXTENSION: While sending and receiving messages, pairs can also attempt to intercept secret messages from other pairs outside their group. If a pair can overhear or oversee another pair's secret message, they should record it on the back of their worksheet along with the names of the four students in group they intercepted the message from. Pairs will receive 5 points for each correct message they intercept.*

4. Collect the completed worksheets and score each pair. *Note: The messages sent by Field Agent Team should match the message received by Mission HQ Team, and vice versa.*

5. If there is extra time, allow students to repeat the process of sending/receiving secret messages (and record their messages on the back of their worksheet). Award points accordingly.

Adaptations to Increase Accessibility and/or Extend the Learning:

1. Print out the Troubleshooting Tips (on page 5) for students to refer to if they are struggling to create a working circuit.

2. Build the telegraphs together, step-by-step.

3. Use alligator clips instead of twisting the stripped wires together.

4. Before starting Part 2, have students practice sending/receiving simple one-word messages to help them become more familiar with Morse Code and using a telegraph.

5. Include more items in the brown bag for students to experiment with (i.e., batteries with varying voltages, various gauges of wire.

6. Explain how wired telegraphs evolved into wireless telegraphs and how that scientific advancement affected communication.

Building Real World Connections

Historical Connection:

During World War II, Britain established a clandestine organization known as Special Operations Executive (SOE) to help coordinate and manage resistance efforts in occupied countries. SOE agents were recruited, trained, and sent behind enemy lines to carry out covert operations. Among the most important yet dangerous jobs during this movement was that of the wireless radio operators. Their assignment was to transmit and receive encoded messages to SOE headquarters in London.

Most radio operators during that time were women as it was believed they would appear less suspicious while moving about with their concealed equipment. One of the most famous of these women was Virginia Hall. SOE radio operators were always on the move. Each transmission needed to be sent from a new location and because of the Germans' ability to quickly track down transmitters, operators needed to set up their equipment, send/receive messages, dismantle their equipment, and get away within 20 minutes or else they were likely to be captured, tortured, and killed. It was an incredibly dangerous job. In fact, in occupied France the life expectancy of an operator was a mere six weeks.

INTERNATIONAL SPY MUSEUM

TOP SECRET TELEGRAPH

ACCOMPANYING WORKSHEETS

MISSION: TOP SECRET TELEGRAPH

Our nation is at war, and we need YOUR help!

Your mission is to enter enemy territory and transmit secret messages back to our nation's headquarters (HQ). Once you cross enemy lines you will receive a nondescript brown paper bag. It will contain everyday items which can be used to build a telegraph. Once you have built a successful telegraph, send out the following code:

• _ • _ • _

You will receive the next set of instructions after the commander at HQ (a.k.a. your teacher) has received your message.

A telegraph is a way to send a message from one place to another along a wire. The message is usually sent by making and breaking an electrical circuit in a series of dots (very short electrical connections) and dashes (slightly longer electrical connections). The dots and dashes are received by a person at the other end of the wire who then translates the dots and dashes.

Morse Code is a system used to send messages via telegraph. Keep the **Morse Code alphabet** (below) with you. You will need this to send and receive messages.

A | •_	N | _•	0 | _____
B | _•••	O | ___	1 | •____
C | _•_•	P | •__•	2 | ••___
D | _••	Q | __•_	3 | •••__
E | •	R | •_•	4 | ••••_
F | ••_•	S | •••	5 | •••••
G | __•	T | _	6 | _••••
H | ••••	U | ••_	7 | __•••
I | ••	V | •••_	8 | ___••
J | •___	W | •__	9 | ____•
K | _•_	X | _••_	. | •_•_•_
L | •_••	Y | _•__	, | __••__
M | __	Z | __••	? | ••__••

CODEBOOK

NUMBER

Code	Meaning
1	Agent Smith
2	Agent Hari
3	Agent Sterling
4	Agent Mattis
5	Agent Barry

COLOR

Code	Meaning
Red	Sunrise
Orange	10:00 AM
Yellow	Noon
Green	2:00 PM
Blue	Sunset
Purple	Midnight

SIZE

Code	Meaning
Tiny	Ally Spy
Small	Ally Military
Average	Ally Leader
Large	Enemy Spy
Huge	Enemy Military
Gigantic	Enemy Leader

NATURAL DISASTERS

Code	Meaning
Blizzard	Supplies
Fire	Financial Support
Flood	Information / Intel
Hurricane	Orders / Instructions
Tornado	Transportation

ANIMAL

Code	Meaning
Eagle	Library Front Steps
Falcon	Riverside Park Bench
Hawk	Safe House
Owl	Maple Tree on Main St.
Vulture	Corner Market

CARDINAL DIRECTION

Code	Meaning
Northern	Need
Southern	Do Not Need
Eastern	Received/Acquired
Western	Was Captured/Lost

FIELD AGENT Partners:

_____

MISSION HQ Partners:

_____

MISSION HQ TEAM

While you await your field agent's transmission, look over the codebook to become familiar with terms and meanings. Are there codes that you do not want to receive? If so, how would you respond? Discuss with your partner.

When your telegraph from the field agents starts to light up, record the morse code message below. ***You ONLY have 3 chances to record the correct message before the message can be intercepted by the enemy!***

INCOMING MORSE CODE MESSAGE FROM FIELD AGENT:

TRANSLATED MESSAGE FROM MORSE CODE:

Now, write a secret encoded reply using your codebook. The message must include a **number**, **color**, and **animal**. *Example: 4 Green Eagles*

SECRET MESSAGE TO FIELD AGENT:

SECRET MESSAGE ENCODED TO MORSE CODE:

Once the message is encoded, send the message via telegraph **ONLY 3 times**.

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Code	Meaning
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FIELD AGENT Partners:

_____

MISSION HQ Partners:

_____

FIELD AGENT TEAM

Write a secret encoded message using your codebook – think about what intel HQ might be interested in. The message must include a **size**, **natural disaster**, and **cardinal direction**. *Example: Huge Blizzard West*

SECRET MESSAGE TO MISSION HQ:

SECRET MESSAGE ENCODED TO MORSE CODE:

Once the message is encoded, send the message via telegraph **ONLY 3 times**.

While you await word back from Mission HQ, look over the codebook to become familiar with terms and meanings. Are there codes that you do not want to receive? Discuss with your partner.

When your telegraph from Mission HQ lights up, record the morse code message below. **You ONLY have 3 chances to record the correct message before the message can be intercepted by the enemy!**

SECRET MESSAGE TO FIELD AGENT:

SECRET MESSAGE ENCODED TO MORSE CODE: