

# Digital Relay

## Home Connection

Dear Family,

During the last few weeks, the students used mathematical patterns to develop codes, and then used their codes to send messages to other students. They acted just like telecommunication engineers! They . . .

- identified and learned about a problem
- planned ways to solve the problem
- developed a digital code
- tested their code by sending it over two kinds of equipment
- revised their code to send information faster and more accurately

In this challenge, students developed an understanding of how digital codes allow electronic devices to communicate. Students learned how messages can be sent as electrical pulses that travel through wires, as pulses of light that travel through optical fibers, or radio waves that travel through the air. They also learned about the engineering design process and practiced skills such as developing and using prototypes, analyzing data, making claims based on evidence, and communicating technical information.

Encourage your child tell you what his or her team did in this engineering challenge. Prompt your child if he or she needs help.

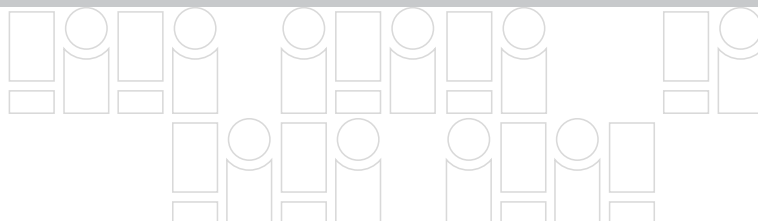
- What was the problem you were solving?
- What were the criteria (goals) that your prototype had to meet?
- What equipment did you use to send your message?
- How did you measure the success of your prototype?
- How did you improve your prototype? What did you learn that lead you to make improvements?
- What did you think about communicating in this way?

On the back of this sheet, work with your child to extend his or her work in the challenge.



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## Home Connection

### About Digital Codes

Computers, cell phones, and other electronic devices transmit information in the form of digital code. A digital code is made up of bits of information which can be sent as electrical impulses, radio waves, or pulses of light. Morse code is an example of a digital code; it was the way that people communicated over the first telecommunication system—the telegraph.

Ask your child to describe Morse code.

- How is information sent in Morse code?
- What do the dots and dashes mean?

Have your child describe the digital code that his or her team developed.

- What was your code?
- How was it different from Morse code?
- What mathematical rule did you use to make your code?
- How did you keep your message secure?

### Try It!

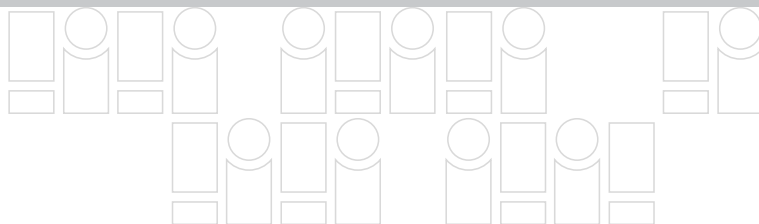
You do not need a telegraph to use Morse code. Find objects and tools in your home that allow you to send messages in Morse code. You might use a small flashlight, a buzzer, or an instrument that makes two notes. You might even write it out on paper. Practice sending and receiving messages in Morse code.

#### Morse Code

A • —	N — •	1 • — — — —
B — • • •	O — — —	2 • • — — —
C — • — •	P • — — •	3 • • • — —
D — • •	Q — — • —	4 • • • • —
E •	R • — •	5 • • • • •
F • • — •	S • • •	6 — • • • •
G — — •	T —	7 — — • • •
H • • • •	U • • —	8 — — — • •
I • •	V • • • —	9 — — — — •
J • — — —	W • — —	0 — — — — —
K — • —	X — • • —	
L • — • •	Y — • — —	
M — —	Z — — • •	

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# Flashlight Messages

Name \_\_\_\_\_

**Follow these steps. Use the Morse Code Card.**

1. Write your color and number message on a scrap of paper. Then code it using the Morse Code Card.
2. Practice making dots and dashes. To make a dot, blink the flashlight. To make a dash, leave the flashlight on three times as long. Show your team. Ask if they can tell the difference. Practice until they can.
3. Take turns practicing. Then send your message. Receive and write your teammates' codes in the chart.

Team member	Color in Morse code	Number in Morse code	Decoded color	Decoded number

4. After everyone has sent a message, decode your teammates' messages. Check to see whether your teammates received and decoded your message correctly.
5. Use the back of this sheet to write and receive more messages. Try other colors and numbers of tiles.
6. **Compare** How is communicating by code different from speaking?

\_\_\_\_\_

7. **Evaluate** What was the hardest part of transmitting the message?

\_\_\_\_\_

8. **Solving Problems** Suppose you wanted to transmit your birth date in Morse code. How could you make it as short as possible for coding?

\_\_\_\_\_

\_\_\_\_\_

# Explore Codes: Reverse Numerical Order

Name \_\_\_\_\_

## Follow these steps.

- Look at the **Reverse Numerical Order Code**. Study the table.
  - Numerical order was used. A number was assigned to A, B, C, D, E and the numbers 1 to 5.
  - An algorithm was used (reverse numerical order). This created a code number.
  - Code numbers were written using tally marks. *###* and */* represent the two signals of the equipment.
  - Tally marks were converted to symbols (dots and dashes).  
Fill in the empty spaces in the table to show what you know.

Letter or number to be coded	Numerical order	Algorithm (reverse numerical order) = code number	Code number written using tally marks	Code symbol • = / - = ###
A	1	10	### ###	--
B	2	9	### IIII	-....
C	3	8	### III	-...
D	4	7	### II	-..
E	5	6	### I	-.
1	6	5		-
2	7	4	IIII	
3	8		III	...
4	9	2	II	..
5	10			

- Practice** Use the code to solve the math problem. Write your answer on the line. Then decode the answer to check yourself.

....	..	...	+	-	...	..	+	.	..

Your answer: \_\_\_\_\_

Answer in code: \_\_\_\_\_

..	...	-

# Explore Codes: Add 4

Name \_\_\_\_\_

## Follow these steps.

- Look at the **Add 4 Code**. Study the table.
  - Numerical order was used. A number was assigned to A, B, C, D, E and the numbers 1 to 5.
  - An algorithm was used. The number 4 was added to create a code number.
  - Code numbers were written using tally marks. *###* and */* represent the two signals of the equipment.
  - Tally marks were converted to symbols (dots and dashes).
- Fill in the empty spaces in the table to show what you know.

Letter or number to be coded	Numerical order	Algorithm (+ 4) = code number	Code number written using tally marks	Code symbol • = / - = ###
A	1	5	<i>###</i>	-
B	2	6	<i>### /</i>	-•
C	3	7	<i>### //</i>	-••
D	4	8	<i>### ///</i>	
E	5	9	<i>### ////</i>	-••••
1	6	10	<i>### ###</i>	--
2	7	11	<i>### ### /</i>	--•
3	8		<i>### ### //</i>	--••
4		13		
5				

- Use the code to solve a riddle. Write your answer. Then decode the answer to check yourself. Figure out where words end and draw a line between them.

Riddle: Where does a flower sleep?

Your answer: \_\_\_\_\_

Answer in code:

-	-•	-••••	-•••

# Equipment Practice

Name \_\_\_\_\_

**Follow these steps. Transmit messages as you practice using the equipment. Use your Explore Codes pages to remember the code.**

1. **Practice** Send messages that all teammates know. Use the Reverse Numerical Order Code or the Add 4 Code. Tell your teammates which code you are using.

Letter and number	D	3	B	4	C	2
Symbol						

2. **Practice** Send a secret message. Code and transmit a few words, such as “bed,” “bad,” “dab,” or “cab.”

Letter			
Symbol			

Letter			
Symbol			

3. **Think** How could your team identify the end of each word or set of digits? For example, you might pause for a count of three or transmit code letters, such as BR for “break for the next letter.”
4. **Analyze** What features of a code help you send information quickly?  
\_\_\_\_\_
5. **Analyze** What features of a code help you send information accurately?  
\_\_\_\_\_

# Transmission System Design Plan

Name \_\_\_\_\_

**Think about the codes you investigated. Think about how well everyone used the equipment.**

1. What features should you use to invent a code for transmitting a secure message? Why?
  - a.
  - b.
  - c.
2. Which team member will carry out each task? Write the names in the chart.

Task	Who will do the task?
Read map and write locations	
Code the locations with Team Code	
Send message on (circle one): Telegraph Key Optical Fiber Cable	
Receive message	
Send message on (circle one): Telegraph Key Optical Fiber Cable	
Receive message	
Decode locations with Team Code	
Draw locations on the map	
Deliver map to Millennium Mines' office	

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3. On the back of this page, draw the path of your transmission. Show where each teammate will be. Label all of the equipment. Use arrows to show where the message will travel.

# Team Code

Name \_\_\_\_\_

**Follow these steps to complete the table.**

1. Assign a number to each letter and number on the map. The numbers you assign might be in numerical, reverse numerical, or random order.
2. Write an algorithm to make your code more secure. By what number will you add, subtract, multiply, or divide? Apply the algorithm to the assigned number.
3. The transmission equipment can transmit two signals:  
**short** or **on** (/) and **long** or **off** (###). Write the code number using tally marks.
4. Use the tally marks to create the code symbols: **short** or **on** (•) and **long** or **off** (-).

Map letter or number	Assigned number	Algorithm ( ) = code number	Code number written using tally marks	Code symbols • = / - = ###
A				
B				
C				
D				
E				
1				
2				
3				
4				
5				



# Map of Beryllium Locations

Name \_\_\_\_\_

**Darken four squares in each map. Cut them apart. Give one map to each team.**

	A	B	C	D	E	
1						1
2						2
3						3
4						4
5						5
	A	B	C	D	E	

	A	B	C	D	E	
1						1
2						2
3						3
4						4
5						5
	A	B	C	D	E	

	A	B	C	D	E	
1						1
2						2
3						3
4						4
5						5
	A	B	C	D	E	

	A	B	C	D	E	
1						1
2						2
3						3
4						4
5						5
	A	B	C	D	E	

	A	B	C	D	E	
1						1
2						2
3						3
4						4
5						5
	A	B	C	D	E	

	A	B	C	D	E	
1						1
2						2
3						3
4						4
5						5
	A	B	C	D	E	

# Record Transmissions

Name \_\_\_\_\_

## The original map locations

	Location 1		Location 2		Location 3		Location 4	
	Letter	Number	Letter	Number	Letter	Number	Letter	Number
Code to send								

----- CUT HERE -----

## Message received from first transmission

	Location 1		Location 2		Location 3		Location 4	
	Letter	Number	Letter	Number	Letter	Number	Letter	Number
Transmission 1								
Transmission 2								
Code to send								

----- CUT HERE -----

## Message received from second transmission

	Location 1		Location 2		Location 3		Location 4	
	Letter	Number	Letter	Number	Letter	Number	Letter	Number
Transmission 1								
Transmission 2								
Decode								

# Decode the Message

Name \_\_\_\_\_

**Follow these steps.**

1. **Decode** Use your **Team Code** page to decode the message.





1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

4. \_\_\_\_\_

**Darken squares that show the location of the four deposits on this map:**

	1	2	3	4	5	
A						A
B						B
C						C
D						D
E						E
	1	2	3	4	5	

2. Deliver this page to Millennium Mines (your teacher) to stop the timer.

3. **Record** the time to code, send, and decode the message: \_\_\_\_\_ minutes

4. Attach the original map to this page.

5. **Compare** your final map with the original map. Circle the squares on your map that are in the correct location.

6. **Count** the number of squares in the correct location: \_\_\_\_\_ squares

# Reflect On It

Name \_\_\_\_\_

**Use your plan, prototype transmission system, and test results to reflect.**

## Transmission System

1. To make our code secure, we \_\_\_\_\_  
because \_\_\_\_\_
2. We chose our team roles based on \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

## Test Results

3. Our prototype met these criteria:
  - ☐ Included a code that was based on an algorithm for security.
  - ☐ Accurately communicated the location of four beryllium deposits.
  - ☐ Allowed the team to code, transmit, decode, and map the message in 5 minutes or less.
4. One part of our system that worked well was \_\_\_\_\_  
because \_\_\_\_\_
5. One part of our system that did not work well was \_\_\_\_\_  
because \_\_\_\_\_

## Compare Transmission Systems

6. We compared our system to Team \_\_\_\_\_. I observed that \_\_\_\_\_  
\_\_\_\_\_
7. The most successful system was made by Team \_\_\_\_\_. It was  
most successful because \_\_\_\_\_  
\_\_\_\_\_