TECH for Tomorrow

CLASSROOM ACTIVITY

Cryptobabel: Coded Communication

Objectives

Students will be able to:

- **Explore** and **manipulate** a variety of ciphers.
- Apply ciphers to **decode** and **encode** messages.
- **Analyze** a code in order to determine its cipher and craft an encoded reply.

Overarching Question

How can information be communicated in code?

Activity Summary

Students are presented with a scenario in which they must investigate a secret message. After learning what it means to encode and decode, students will explore different examples of ciphers in stations and create their own secret decoder ring. Students will ultimately apply what they have learned to crack the message's code and craft a reply.

Grades

4–6

Timing

75–90 minutes

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Materials

- Station Materials, to be placed in stations around the classroom:
    - Morse Code Station:
        - Morse Code handout, one per student
    - Pig Pen Cipher Station:
        - Pig Pen Cipher handout, one per student
    - Caesar Shift Station
        - Caesar Shift handout, one per student
        - Create a Cipher Wheel handout, one per student
        - Scissors, enough for one quarter of the class
        - Paper fasteners, one per student
    - Birthday Cipher Station: Optional
        - Birthday Cipher Handout, one per student
- Mystery Message handout, one per student

Handout Answer Key

- Morse Code handout: *Create a code name!*
- Pig Pen Cipher handout: *Pick a meeting spot.*
- Cipher Interception handout: *This is a test. Waiting for your response.*

Activity Directions

Premise | 5 minutes

- Instruct students to pretend that they are now cryptanalyst interns at a cryptology agency. Explain that the field of cryptology studies the science of writing and solving codes. As cryptanalyst interns, the class is about to investigate this field!
- Begin with a think-pair-share, and ask: What do you already know about codes?
  Note: In a think-pair-share, students think about the question independently, discuss their answers with a partner, and then share their thoughts with the larger class.
- Ensure students understand that a code is a system of letters, words, figures, or symbols that are used to represent a message. The overall goal of a code is to make communication incomprehensible to everyone except those for whom the message is intended! Today's technology uses complex codes to keep our personal information safe, and people throughout history have relied (and continue to rely) on codes to send important and secret messages.

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- Go on to say that a coded message was just sent to the director of their cryptology agency, and its source is unknown. The director thinks a spy may be behind the message, but no one is sure. She would like the interns to decode the message, so the agency can decide what to do next!

Investigate | 55–70 minutes

- Write the following two words on the board: *Encode* and *Decode*.
- Explain that when you *encode* a message, you are creating the message's code. You begin with the information that you want to transfer to the receiver, and you translate it into symbols. Go on to explain that when you *decode* a message, you transform the symbols back into their original form so you can read and understand the message.

  Teacher note: Many people use the words cipher and code interchangeably. But there is actually a distinct difference! A cipher changes a message letter-by-letter, while a code changes entire words or phrases into other words or numbers.
- Write the following on the board: *3-1-14 25-15-21 3-18-1-3-11 20-8-9-19 3-15-4-5?* Without providing any additional hints, give students a couple minutes to work with a partner to try to decode this message.
- Once a couple minutes have passed, write the following on the board: *Cipher: A1 Z26*
- Explain that a cipher is a type of letter-substitution code with a specific key that tells you how to encode and decode a message. Point to A1 Z26 and reiterate that this cipher explains how the code can be figured out.
- After giving students a couple more minutes to work on the code, ask if anyone has cracked it! Explain that because this cipher states that A=1 and Z=26, all of the other letters of the alphabet also correspond to numbers. For instance, B=2, C=3, etc. When decoded, this message says: *Can you crack this code?*
- Next, divide students into pairs. Explain:
  - For the next 45–60 minutes, each pair will rotate through three or four cryptology stations as they learn about different ciphers. This training should give them the background they need to decode the mystery message!
  - At each station, partners will be responsible for picking up the station's code sheet and completing it together. They should follow the sheet's directions until time is called and they rotate to the next station.
- Tell each pair where to begin, and try to distribute groups evenly among the stations. Every 15 minutes, instruct groups to rotate clockwise to the next station even if they are not finished.
- When 45 minutes have passed (or 60 minutes if students are completing four stations), bring the class back together. Explain that now that they have received their training, they should be prepared to decode the mystery message and craft a reply.

Solve | 15 minutes

- Pass out the Mystery Message handout and review the email on the top half of the page.
- Ask students: Based on your training, does it appear this message was encoded using Morse Code,

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Pig Pen Cipher, Birthday Cipher (if included) or Caesar's Shift? What clues lead you to believe this?

- After a few students have shared their hypotheses, share that a couple agency members have verified that Caesar's Shift was used to craft this message, but the exact cipher has not yet been determined. Probe students for strategies on how the class could work together to efficiently crack the cipher.

  If needed, guide students toward the idea that the class could divide the 25 possible shifts among themselves and try to decode the first word only—moving on to try the next shift as soon as the first decoded word doesn't make sense.

Additional Student Challenge

Shifts are normally written as addition, but how could this shift also be written as subtraction?

Answer: A–10

- Give students a few minutes to strategically use their Caesar Shift wheels to test different shifts. The class should come to the realization that the most logical shift is A + 16. With this shift, the first word can be decoded to "this."
- Then instruct student pairs to decode the rest of the message and craft an encoded response using the same shift. Their message should seek to obtain more information from the sender in order to help the agency figure out who is behind this message!
- Conclude with a quick discussion that summarizes the activity. Ask:
  - What are some advantages and disadvantages of communicating in code?
  - When we use devices connected to the internet, cybersecurity keeps our information safe from others. How may codes and ciphers be related to cybersecurity?
- Wrap up by summarizing that cybersecurity relies on complex codes and ciphers to keep our personal information safe online. Because they now understand how fundamental codes and ciphers work, students have a better understanding of the problem-solving that is needed to protect and defend computer networks.

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Standards

Common Core Mathematics Standards

- CCSS.MATH.PRACTICE.MP1: Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP5: Use appropriate tools strategically.
- CCSS.MATH.PRACTICE.MP7: Look for and make use of structure.

Standards for Technological Literacy (ITEAA) Standards

- Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies. In order to select, use, and understand information and communication technologies, students should learn that:
    - F. Communication technology is the transfer of messages among people and/or machines over distances through the use of technology.
    - G. Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations
    - J. The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.

Station: Morse Code

Step 1: Background
In the 1830s before the invention of telephones, Morse Code was developed for electrical telegraphs. The electrical telegraph sent messages through pulses of electricity. These pulses made marks (dots and dashes) on a piece of paper, which the receiver would then decode. Today, Morse Code can also be transmitted using flashes of light or sound.

Step 2: Take a look at the Morse Code below. Each letter is represented by at least one dash (–) or one dot (.)

International 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	––••				••––•–		

Step 3: Decode the following message. “/” represents a space between words.

-.-. .-. . .- - . / .- / -.-. --- -.. . / -. .- -- . / -.--

_____ __ _____ _____ __

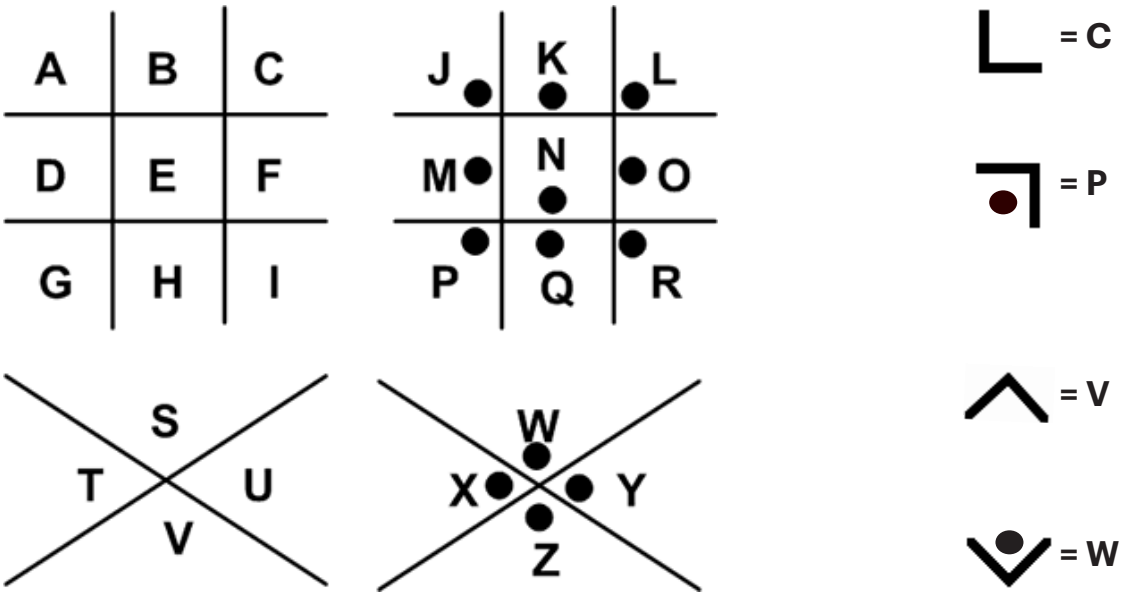
Step 4: Once you have decoded the message, follow its instructions and answer in Morse Code below:

Extra time? Exchange papers with a peer and decode what they have written!

Station: Pig Pen Cipher

Step 1: Background
Pigpen cipher is called a substitution cipher because it substitutes, or replaces, letters with symbols. While we don't know too much about where or how it began, it was used by a group called the Freemasons to keep their records private in the 1700s. Freemasons are part of a secret society that was started by stone workers and cathedral builders and continues to exist today.

Step 2: Take a look at the Pig Pen Cipher below. The symbols on the right show what C, P, V, and W look like using this code.



Step 3: Decode the message below. There is no symbol for spaces, so you'll have to figure out where spaces between words belong once you decode the message!

Step 4: Once you have decoded the message, you'll see that you are being instructed to do something. Follow these directions and respond in Pig Pen Cipher below:

Extra time? Exchange papers with a peer and decode what they have written!

Station: Caesar Shift Cipher

Step 1: Background
Julius Caesar, a famous leader of the Roman Empire, is said to have used this code to communicate with his generals. It is called a shift cipher because every letter in the message is shifted the same number of spaces forward.

Step 2: Practice the Shift
The key for a Caesar Shift can be written as: **A + #**

When you are encoding a message using the Caesar Shift, you must decide how many "shifts" you will give the letters. For instance, if you have a shift of one, then A +1 = B. Or, if you have a shift of 6, then A + 6 = G.

Can you figure out these shifts?

X + ___ = Z A + ___ = J ___ + 2 = P

C + 5 = ___ Y + __ = B (Tip: Start over at the beginning of the alphabet)

Step 3: Create a Cipher Wheel
A cipher wheel can make it much easier to understand messages written with shift ciphers. Follow the directions on the Create a Cipher Wheel handout and then return to Step 4 when your Cipher Wheel is complete.

Step 4: Ciphering Made Easy!
This cipher wheel will help you quickly encode and decode Caesar's Shift!

First, choose a code name for yourself and write it here: _____

Then, decide on a shift: **A +** ___

Now make sure the letters on both wheels are lined up. Once they are, shift your **outer** wheel clockwise the number of shifts that you decided.

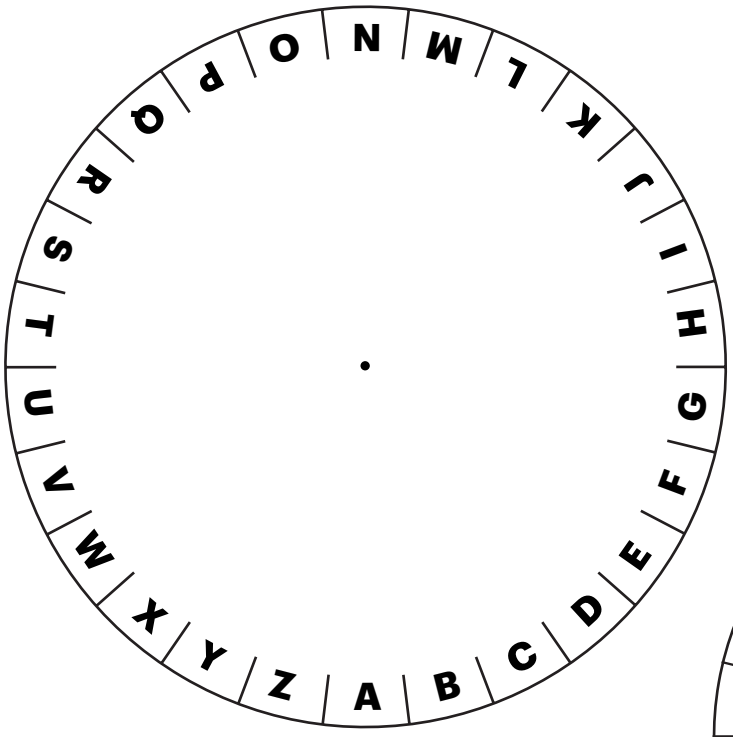
Then find each letter in your code name on the outer wheel, and see which letter is below it on the inner wheel. This is your secret code name! Write it below:

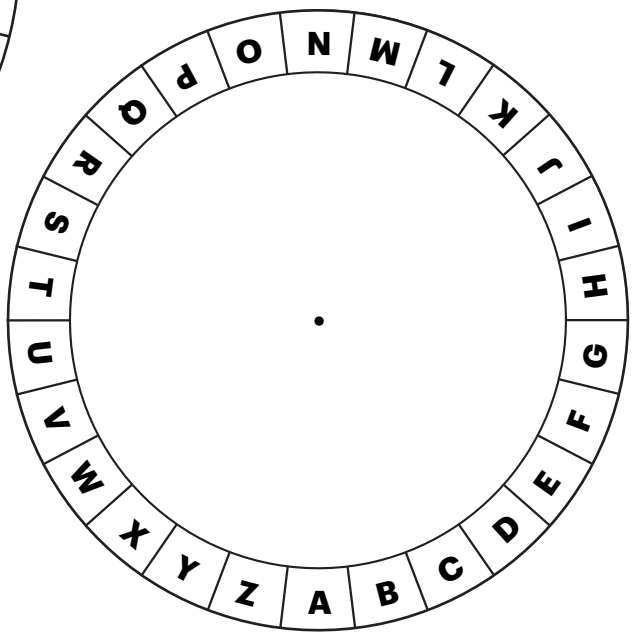
_____

Extra time? Choose another shift (**A +** ___) and use your cipher wheel to create a new message below.

Station: Caesar Shift Cipher

Create a Cipher Wheel handout





Directions:

1. Cut out each wheel.
2. Place the small wheel on top of the larger wheel.
3. Insert a paper fastener through the center dots, and attach the wheels together.
4. Line up the wheel's letters, so A is under A, B is under B. Now you can use the wheels to decode your Caesar's shift.

Station: Birthday Cipher

Step 1: Background
The birthday cipher is a numerical cipher. It can also be called a date cipher. This is a tricky cipher because the decoder will need to know your birthday!

Step 2: Follow these steps to see how a birthday cipher works:

1. First, write your message. For example: MEET ME AT NOON?
2. Pick a birthday. For this, we'll use Abraham Lincoln's birthday: 02 - 12 - 1809
3. Write the birthdate under your message. Leave out all spaces or dashes, and repeat the birthdate as many times as you need to, like this:

   MEET ME AT NOON ?

   0212 18 09 0212 ?

4. Then shift each letter forward as many times as the number below it says. Use the alphabet to help you!

   a b c d e f g h i j k l m n o p q r s t u v w x y z

M + 0 = **M**	e + 2 = **g**	e + 1 = **f**	t + 2 = **v**
m + 1 = ___	e + 8 = ___	a + 0 = ___	t + 9 = ___
n = 0 = ___	o + 2 = ___	o + 1 = ___	n + 2 = ___

5. Put it all together! Using Abraham Lincoln's birthday cipher, Meet me at noon ? becomes:

   Mgfv _____ _____ _____?

Step 3: Respond with your own birthday cipher!

1. First write a short response: _____
2. Write out your birthdate (month - day - year): __ - ___ - _____
3. Return to #1 and write your birthdate under the letters of your response.

4. Then shift each letter forward and write your encoded response below:

   _____

Extra time? Decode a peer's response!

Mystery Message

FW: Cipher Needed

From: Cryptanalysis Agency – Office of the Director

The message below was received yesterday by a well-known person whose name I cannot reveal. The message came from an unknown email account. Can you decode this message and write a response?

---------- Forwarded message ---------

From: unknown

Subject: - - -

Drsc sc k docd. Gksdsxq pyb iyeb boczyxco.

Step 1: Determine the cipher: _____

Step 2: Decode the message: _____

Step 3: Use the same cipher to write a response. Your response must try to find out more about the person behind the message. Write your response in plain text (regular words) *and* encoded text below:

Plain Text:

_____

_____

Encoded Text:

_____

_____