GRIFFIN MUSEUM
OF SCIENCE+INDUSTRY

007™ SCIENCE

INVENTING THE WORLD OF JAMES BOND

EDUCATOR GUIDE

msichicago.org

Kenneth C. Griffin MUSEUM OF SCIENCE+INDUSTRY

To inspire the inventive genius in everyone

Dear Guests,

The *007 Science: Inventing the World of James Bond* exhibit at the Griffin Museum of Science and Industry offers a unique glimpse into the intersection of science and cinema. It showcases the innovative technologies and engineering feats that bring the James Bond franchise to life. From the iconic gadgets to the thrilling action sequences, each exhibit aspect invites us to marvel at the ingenuity behind the scenes.

At Griffin MSI, our goal is to inspire the inventive genius in every child, sparking their curiosity and nurturing their potential to innovate. Through engaging exhibits like this one, we aim to ignite a passion for discovery and empower future generations to pursue careers in science, technology, engineering, and mathematics.

I'm particularly excited about the exhibit's interactive elements, which allow visitors to delve deeper into the science behind the spy world. There are endless hands-on opportunities to engage with STEAM concepts, from designing vehicles for spy activities to testing out stunt-like challenges.

As you explore the exhibit, I encourage you to embrace the spirit of discovery and consider the countless career paths within the film industry. Whether you're drawn to the technical intricacies of special effects or the creative vision of directing, there is a place for everyone in this dynamic field.

I hope this guide inspires you. Enjoy your visit, and may it spark new dreams and aspirations for the future.

Warm regards,

Dr. Chevy Humphrey
President and CEO
Griffin Museum of Science and Industry

A note from Chris Corbould
Director, Writer
007 Special Effects Supervisor

When I was at school, I had no idea what career I wanted to pursue. I had just finished my chemistry, physics, and math exams when I was asked if I wanted some work experience during my summer holidays. That work was on the film *Tommy*, a musical released in 1975 and based on The Who's 1969 album of the same name. There were cameos from Eric Clapton, Elton John, Tina Turner, but I loved The Who, so I accepted the offer. My role was to open 1,000 tins of baked beans (before electric can openers were invented) to be used in one of the scenes! I was instantly captivated by the filmmaking process and proceeded to make it my career.

Forty to fifty years ago, special effects was all about smoke, wind, and explosions, but over the years it has become more about engineering, and we now control huge mechanisms via computers. Classic examples are the Venice sinking house in *Casino Royale* and the London Underground tube train crash in *Skyfall*. I pitched the London Underground moment to the director Sam Mendes, and he loved it, but the next task was to work how we actually achieved it. A tube carriage is about 60 tons in weight and over sixty feet in length, but together with my brilliant team of engineers, we developed an overhead monorail system and made much lighter carriages, though they were still five tonnes each. One crucial decision was how to stop the moving carriages in a short space of time. There were three of four mechanisms that rapidly slowed down the carriage, and the final mechanism was a wall of 40 tons of sand. We only had one take to capture the stunt, so we had 12 cameras strategically positioned throughout the set. We had to think about every single eventuality that could go wrong before we did it. We filmed the sequence, and it worked perfectly. If you look very, very closely, you will see my image digitally inserted as the train driver.

So good luck with this guide. Enjoy visiting the exhibition, and I hope it encourages some of you to think about a career in the film industry.

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007 Science: Inventing The World of James Bond

ABOUT THE EXHIBITION

The Museum's new limited-time exhibit, *007 Science: Inventing the World of James Bond* reveals how moviemakers harness scientific thinking to craft iconic gadgets and vehicles that employ physics, chemistry, engineering, and mathematics to create thrilling stunts and action sequences.

Educators and youth will learn how real-world science has driven many James Bond story ideas and how these movies have prefigured many real-world inventions. The exhibition features 13 vehicles and more than 90 additional artifacts. Included are earpieces and Bombardier lipstick that allowed for secret communication, a retina scanner that enabled entry into a secret room, a skidoo, and a safe-cracking device. Step into Q's lab — the source of secret field technologies in James Bond movies — to test your skills in designing the perfect vehicle for spy activities and stunts and your strength in the hang-time interactive.

The exhibition is in partnership with EON Productions and the Ian Fleming® Foundation. It makes its world premiere at Griffin MSI as the first exhibit in history to explore the science and technology behind the franchise and to display artifacts and reproductions from every EON-produced James Bond film (25 total) as well as the International Spy Museum in Washington, D.C.

The Central Ideas of the Exhibition:

- Explore scientific thinking in the movie-making process.
- Explore the creative process through hands-on exhibit interactives.
- Learn how moviemakers employ Science, Technology, Engineering, Art, and Mathematics (STEAM) to create action-packed stunt sequences.

Next Generation Science Standards (NGSS)

The Exhibition aligns with the following Next Generation Science Standards (NGSS).

Science and Engineering Practices:

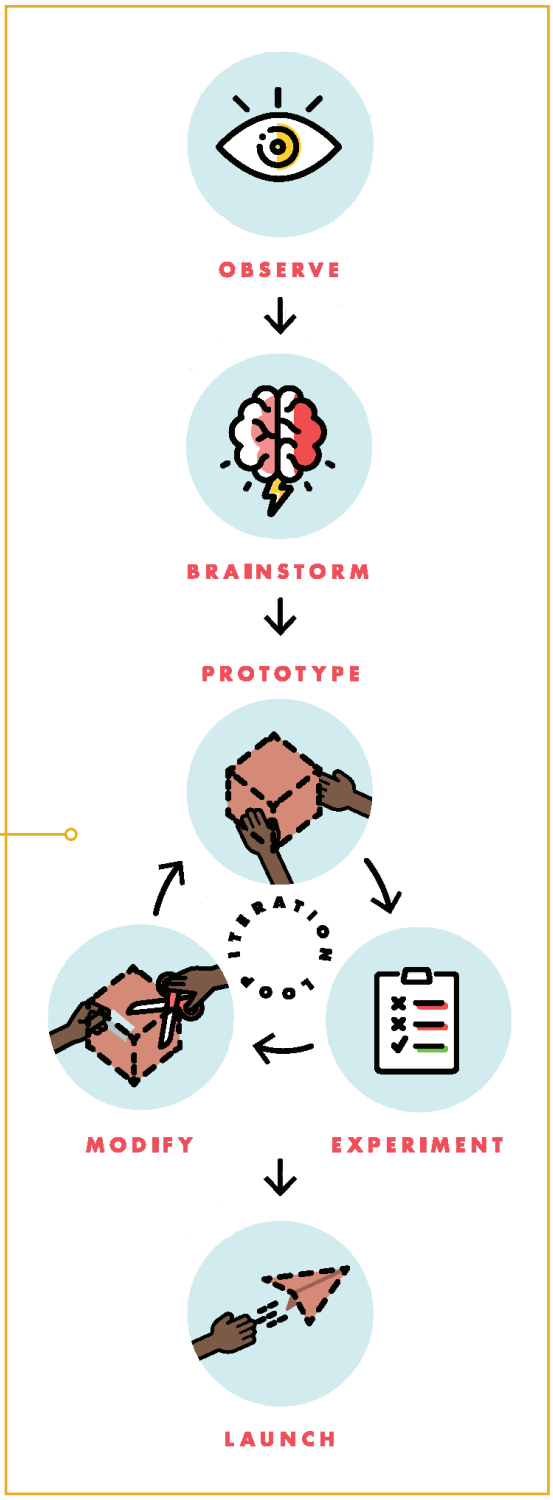
- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Constructing Explanations and Designing Solutions
- Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts:

- Patterns
- Cause and Effect: Mechanisms and Prediction
- Scale, Proportion, and Quantity
- Systems and Systems Models
- Structure and Function

Design Thinking and the Griffin MSI Innovation Process

An iterative process helps us to understand a problem, find solutions to a problem, understand the user, and find creative solutions to problems through prototyping and testing.



Plan Your Field Trip

To schedule a field trip, please use the QR code below to access the Griffin Museum of Science and Industry's webpage.

Bring your young people to the Griffin Museum of Science and Industry to explore hands-on, real-world examples of science. Visit *007 Science: Inventing The World of James Bond* and use the Educator Guide to access hands-on activities and challenges that reinforce Science, Technology, Engineering, Art, and Mathematics (STEAM) and encourage creativity and imagination.

Museum entry is free for Illinois PreK-12 schools.

CLASSROOM AND PROGRAM SPACE ACTIVITIES AND CHALLENGES

During the Exhibition:

The activity sheets highlight and capture the themes of Galleries 1 and 2 and help guide young people's experiences within the exhibit. The highlighted areas are:

Gallery 1: Q's Lab

1. The Creative Process
2. Gadget Interactive & V8
3. Wall of Gadgets
4. Movie Magic

Gallery 2: Secret Entry, Escape, and Gadgets

1. Secret Entry
2. Escape

Pre- and Post Exhibition:

Engage young people in hands-on experiences that encourage creativity and reinforce exhibition ideas and experiences by exploring the science behind code-breaking, movie stunts, imagining inventive solutions, and more. Activities and challenges are printable.

1. What's Your Secret?
2. Messages: Cipher Wheel
3. Electronic Resistor Codes
4. Rubber Band Car
5. Winding Stunt Car Track
6. Pencil Holder Secret Compartments: Candy Stash
7. Dead Drop: Concealment Container
8. Geocaching

Additional Resources

Bond Theme Songs

https://www.bing.com/videos/riverview/relatedvideo?&q=james+bond+theme+song&&mid=FDA6367ACD58300B492BFDA6367ACD58300B492B&&FORM=VRDGAR

How Strong is Plastic Wrap

IP013, How strong are plastic wraps?
(scienceproject.com)

Eggshell Strength Experiment

Eggshell Strength Experiment: How strong is an eggshell?
(littlebinsforlittlehands.com)

Marble Roller Coaster

Marble Roller Coaster: Converting Potential Energy to Kinetic Energy | Science Project
(sciencebuddies.org)

Books

Read Like a Spy | Chicago Public Library | BiblioCommons
https://chipublib.bibliocommons.com/list/share/200049033_chipublib_kids/2363263039_read_like_a_spy

Booklist provided by the Chicago Public Library

Quiz Game

1. In what James Bond film did the Aston Martin DB5 spin in a circle?
   What actor portrayed James Bond in this movie?

2. What year was the James Bond film *Skyfall* released?

3. Who composed the movie theme song for *Diamonds Are Forever*?
   What artist sang the theme song?

4. What actor portrayed the first James Bond? What was the name of the movie?

Quiz Game Answer Key:

1. *"No Time To Die"* and Daniel Craig
2. 2012
3. John Berry (music), Don Black (lyrics), and Shirley Bassey (sang the theme song)
4. Sean Connery and Dr. No

Activities During The Exhibition Gallery I

In the wondrous world of films, spies operate under pressure in unique situations and have equipment designed to meet their mission. To work effectively in the field to obtain secret information, spies use everyday items like toothpaste, lipstick, shoes, or even an alarm clock to conceal weapons or detonators that aid in their escape or evasion. Explore exhibit panels to reveal the real science behind gadgets, interactive missions, and more.

1 Aston Martin vehicle

2 Deep Star Underwater Helmet

3 Q's analyzer with Bionic Eyeball

4 Q's bag of tricks including an exploding alarm clock and detonating toothpaste

5 Q's Leg Cast Missle Launcher

Exhibition photo

Exhibition photo

Exhibition photo

1

2

Exhibition photo

3

Hangtime exhibit interactive

1 Poison-Tipped Dagger Shoes

2 Q-Boat

3 Nuclear Material Container (movie prop)

ACTIVITY SHEET

Gallery 1: Q's Lab

Name: _____

The creative process begins in Q's Lab. This is the zone where you will learn about and apply steps in the creative process. Designers use the creative process to move from an idea (concept) to a final product, which they test and refine.

1. Using the space below, sketch your favorite gadget in Gallery 1.

2. Using the first step in the creative process, let's observe.

   A. What do you see?

   B. Identify the characteristics of the gadget.

   C. State the gadget's intended use.

   D. Would you add elements to enhance the gadget? Why or why not? If yes, sketch your ideas.

ACTIVITY SHEET

Gallery 1: Identifying the Challenge, Build a Car Interactive

Name: _____

There are two parts to the creative process.

The steps in part one of the creative process are:
(1) Explore (2) Experiment (3) Develop (4) Create (5) Reflect

The steps in part two of the creative process are:
(1) Assess and Revise (2) Share (3) Imagine (4) Examine (5) Perceive

Reflect:

1. Think about part one and part two of the creative process.
   What questions do you have about the process? Write it below.

_____

_____

2. You are an agent assigned to a clandestine operation. How will you use your knowledge of the creative process to learn about the operation's mission? Write your answer below.

_____

_____

3. What is the purpose of this clandestine operation?
   What is the location of this clandestine operation?

_____

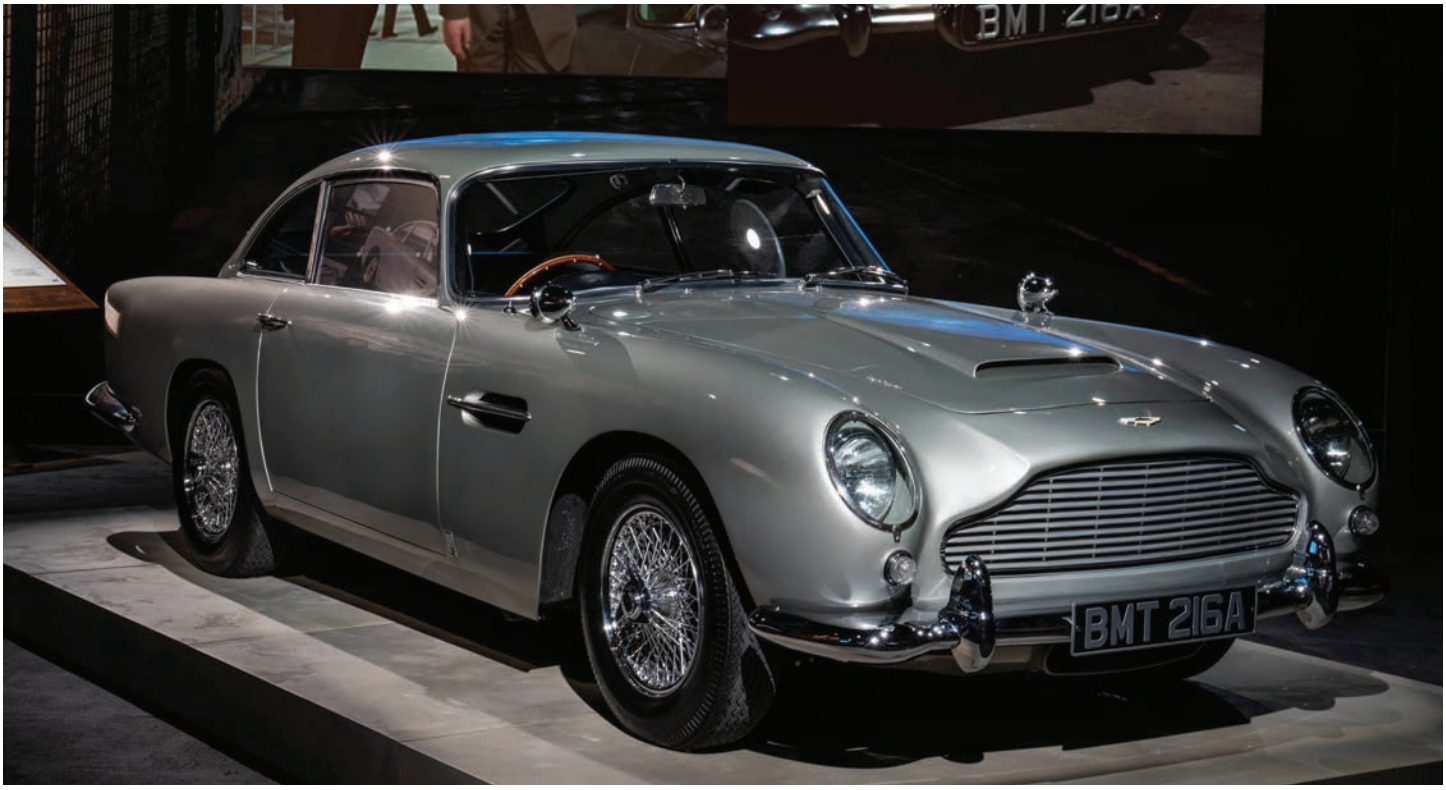
_____

4. Using what you know about the operation's mission and your knowledge of the creative process, in the space below, sketch the type of vehicle you need for this operation in the "Build A Car" interactive.

1. List two elements you added to your car to have a safe and successful mission. State why the mission might not be safe without these two elements.

2. Share the sketch of your car with other young people. What feedback did they give you? Write your answer below.

3. Will you use the feedback to assess and revise your sketch? If yes, what will you do? If no, why not?



Aston Martin exhibition photo

ACTIVITY SHEET

Gallery 1: Movie Magic, Build A Stunt Interactive

Name: _____

1. Stunts in James Bond movies require creative thinking and careful planning. Think about purpose, risk, audience, message, and visual impact. What else can you think of that is necessary to plan and execute a safe, successful, jaw-dropping stunt?

2. Remember a stunt in your favorite action movie. Think about how Science, Technology, Engineering, Art, and Mathematics (STEAM) could be used to create the stunt in your movie. Explore the science behind action scenes and write one or more STEAM areas you would use to create the stunt in your favorite movie.

3. Safety wires are often used in movies to make actors/actresses fly like birds in the air, walk on walls, or get smashed into things without being hurt. Explore the science behind safety wires and give one or more examples of how they were used in your favorite action movie.

4. Identify an element in your favorite action scene that uses safety wires.

5. Name the area of STEAM you are most interested in. Why? Describe how you would use it in an action scene.

Exhibition photo

1

1 Primo's Pretzl Harness and Magnetic Puck Bomb

2 Spectre Bionic Eyeball

3 Jaws' Metal Teeth

4 BMW R1200C

2

3

4

Activities Gallery 2

Secret Entry and Escape

Using codebreaking to enter secret chambers to plant a listening device and escape in the Aston Matin DB5—mission complete. Explore Gallery 2 to view James Bond's memorable chase scenes, gadgets, and much more.

1. Cello Case Sled
2. Fake Fabergé Egg fitted with a transmitter
3. Underwater Re-Breather Device
4. Parahawk

Exhibition photo

ACTIVITY SHEET

Gallery 2: Secret Entry

Name: _____

You are a **Cryptanalyst**. Your skill is to decipher and analyze secret codes and messages to help operatives in the field who are in sticky situations and need entry into the bad guy's bureau or need to keep our information safe.

Agent G is leading Operation Blue Sheep and needs you to decode a secret message now!

1. Explore Secret Entry in the exhibition and decipher a code in the interactive. Describe the method you used to crack the code.

_____

_____

2. What patterns formed in the code? Patterns that use math codes are ciphers. In a cipher, every letter of the alphabet is replaced by a different letter or symbol you choose, which makes the message a secret. Write the code used below.

_____

_____

3. Write a secret message below. Send it to a friend via text message or share your Secret Entry activity sheet. Do you think your friend can decode your message without a key? Why or why not?

_____

_____

Secret message: _____

Decoded message: _____

ACTIVITY SHEET

Gallery 2: Escape

Name: _____

Agents are responsible for protecting the mission. The last thing they must do for the mission to be successful is to evade capture while escaping the bad guy's territory.

Think about action movies you've seen. Agents take those jaw-dropping, breath-taking actions using gadgets to hang off the edge of buildings, the bumper of a car, or the skid of a helicopter to complete their mission safely and successfully.

Explore the many James Bond escape scenes. Based on what you observed, what is your favorite mission? _____ You are an agent. Using the space below, list the steps you will take to achieve a safe and successful mission.

Step 1: Set the scene. Describe the mission. (Who, What, When, and Where)

_____

_____

Step 2: The mission is at risk. The bad guys are gaining on you. Describe the chase. What vehicle is the bad guy driving? Describe your vehicle. Name the gadgets you're using and draw a sketch below.

_____

_____

_____

_____

Step 3: Think about the outcome of your chase. List one action you are proud of. List one action you would do differently. List one piece of advice you will give a fellow agent about escaping the bad guys. Write one question you want to ask fellow agents about your chase. List one thing from your chase that needs to be included in a spy movie that will make our jaws drop.

Step 4: Discuss your chase with other students. Ask for their feedback. Record the most important thing you learned from your peers.

Exhibition photo

Pre and Post-Exhibition Activities and Challenges

Exhibition photo

1

2

1 Zao's Jaguar XKR

2 Gustave Graves' Exoskeleton

3 Omega Seamaster Watch

3

What's Your Secret?

Grade Range: Elementary

Lesson Goals:

- Explore encoding and decoding messages.
- Use creativity to develop symbols.

Suggested Time: 20 minutes

NGSS Crosscutting Concepts:

- Patterns
- System and System Models

What the Facilitator Needs to Know:
In this activity, youth explore codes. "What's Your Secret" challenges young people to encode and decode a message using a block code sheet.

Essential Question:
What comes to your mind when you hear "code" and "spies?"

- Use young people's responses, which might include spies, breaking a code to enter a vault or room, secret societies, symbols etc. to present the definition below.
- A code is words, letters, figures, or other symbols substituted for other words, letters, etc. A code is used to keep a secret.
- A code is created by using a symbol to replace a word or phrase. The person who receives the code must follow the rules of the person who sent the code. This is called the "Key." A code cannot be broken without the correct key.
- Example: Can you unlock the door to your house if you don't have the correct key?

You have received a text message to embark upon a mission to open a secret door in a Dundee, Illinois factory to extract a package with a top-secret recipe. Practice your encoding and decoding skills to help you complete your mission. You need to create and use a key in the activity.

What's Your Secret?

Activity

Materials:

- A copy of the Secret Code Activity Sheet.
- Pencil
- Colored Pencils (optional)

Activity Plan: Writing Your Secret Code

1. Write your **secret code**. Using the secret code activity sheet, draw a symbol for each number and letter in the boxes.
2. After step one is complete, you have a key.
3. Write a top-secret message using your key.
4. Share your key with a friend and have them decode your top-secret message.

Example Key:

A	B	C	D	E	F
☺	☆	☼	❖	⌘	✱

Activity Sheet: What's Your Secret?

Name: _____

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	?	,	.	!

1	2	3	4	5	6	7	8	9	10

Secret Message: Cipher Wheel Activity

Grade Range: Middle School

Lesson Goals:

- Practice critical thinking, problem solving, and teamwork.
- Experiment with encoding and decoding messages.

Suggested Time: 20 minutes

NGSS Crosscutting Concepts:

- Patterns
- System and System Models

Materials:

Challenge Snapshot:

What the Facilitator Needs to Know:

In this activity, young people will explore the use of codes. The activity challenges youth's understanding of how codes are used to keep their information safe, secure, and private.

Essential Question:
What comes to your mind when you hear the word "code"?

Use young people's responses, which might include comments such as messages, agents, secret societies, and symbols to generate discussion about what a code is and how it is created.

- A code contains words, letters, figures, and other symbols substituted for other words, letters, etc.
- A code is used to protect a secret.
- A code is created by using a symbol.

Discussion Question:
You know what a code is and how to create a code. What do you think encoding and decoding is?

- Encoding is sending a secret message using words and symbols. Decoding is using the right words and symbols to read the secret message. The code must be broken to decipher the secret message.
- Name some action movies in which you have seen a spy break a code.

Question:
What do you think a spy uses to break a code? Use students' comments to introduce the words ***cryptanalysis* (process) and *cryptanalysts* (person).**

Those spies were able to break their codes because they knew the rules. They followed the rules exactly. What is the rule? "Use the right words, letters or symbols in the right place." This is called the key. Every code has a key.

Cryptanalysis is the science of codes and codebreaking. A ***Cryptanalysis*** is used to keep our information safe, secure, and private.

- People of all ages are excellent ***cryptanalysts***. What evidence do you have to show you are an excellent cryptanalyst?
- Encourage students to give examples such as my passcode, e-mail address, password, user ID, etc. used for laptops, tablets, watches, home security cameras, etc.

Keeping our information safe and secure is called cybersecurity. Use questions such as, how does cybersecurity help you keep your information private? Secure? Safe? What changes do you, as a young ***cryptanalyst,*** want cybersecurity to make to keep your information private, safe, and secure? *(Ask about specific websites young people use.)*

Youth Learning Challenge:
Young people pair up to complete the challenge. Each pair decides who will be person A and who will be person B. Person "A" writes person "B" a 7-word encrypted message. Person "A's" message uses a set of rules called algorithms to encode the message. Encoding information is called encryption. Once encrypted, "A's" message cannot be understood until the code is decrypted or turned back into its plaintext by the person "B." Have young people switch roles.

Discussion Questions:

- Were you able to decrypt the message? Why or why not?
- Was the encryption recognizable?
- What steps were used to decrypt the message?

Example of an Algorithm/Cipher Key: "W = A," then

E HEGA ZKCO = I like dogs

W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
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

Materials:

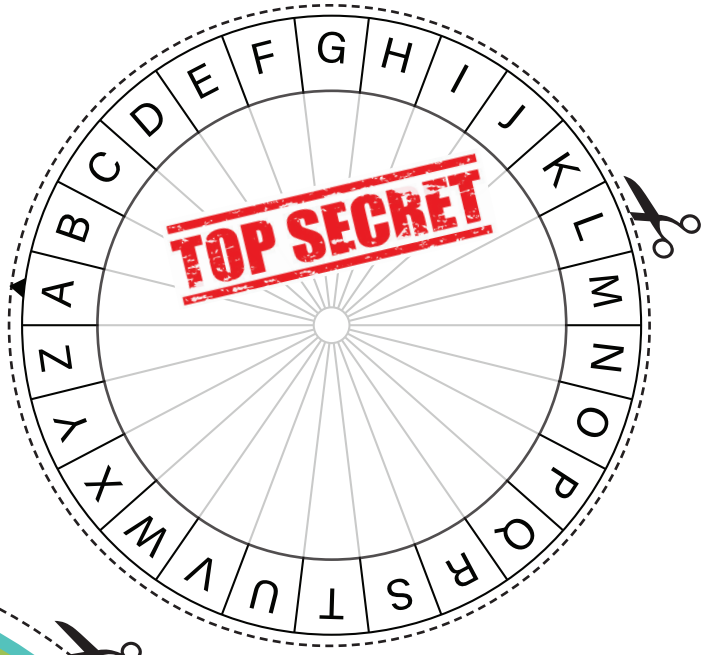
- A Copy of Cipher Wheels Activity Sheet 1
- A Copy of Activity Sheet 2
- Brass Fastener
- Pencil

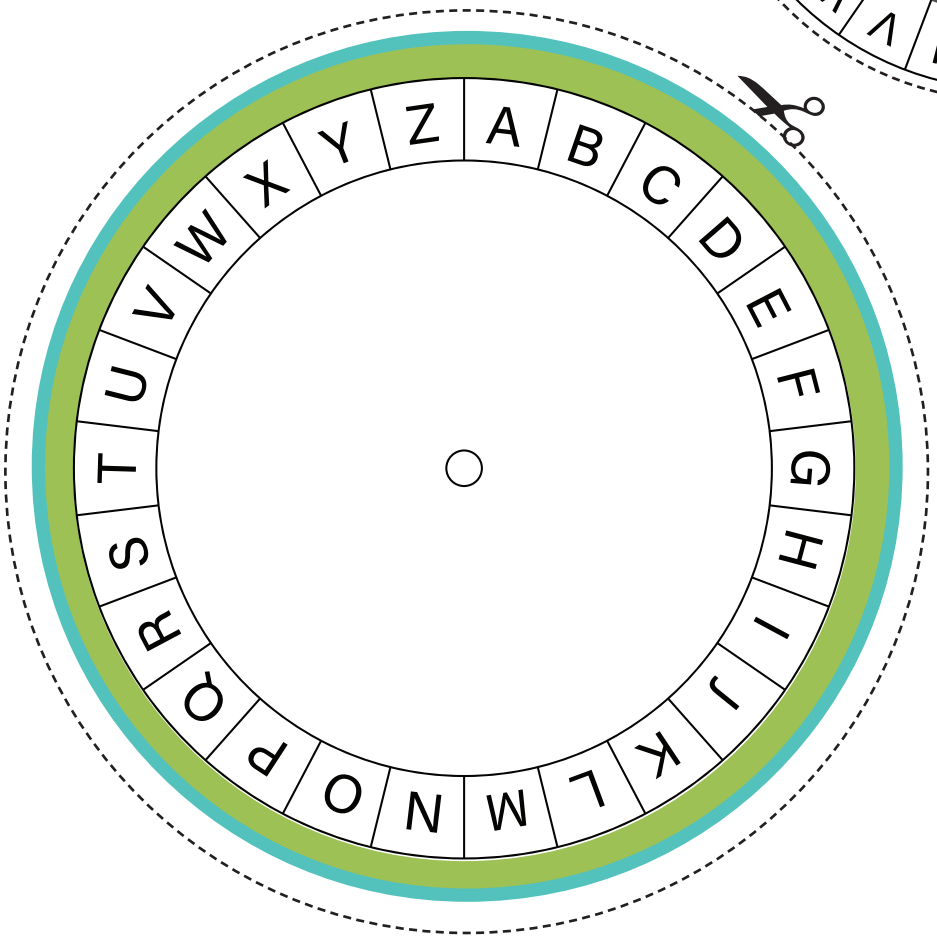
Activity Plan: Building the Cipher Wheel

1. Cut out both circle wheels found on the activity sheet.
2. Use a pencil to poke a hole through the small circles in the middle of both wheels.
3. Put the small wheel on top of the big wheel. Match up the holes.

Activity Sheet I: Cipher Wheel

Name: _____





Activity Sheet 2: Cipher Wheel

Name: _____

Use your Cipher Wheel:

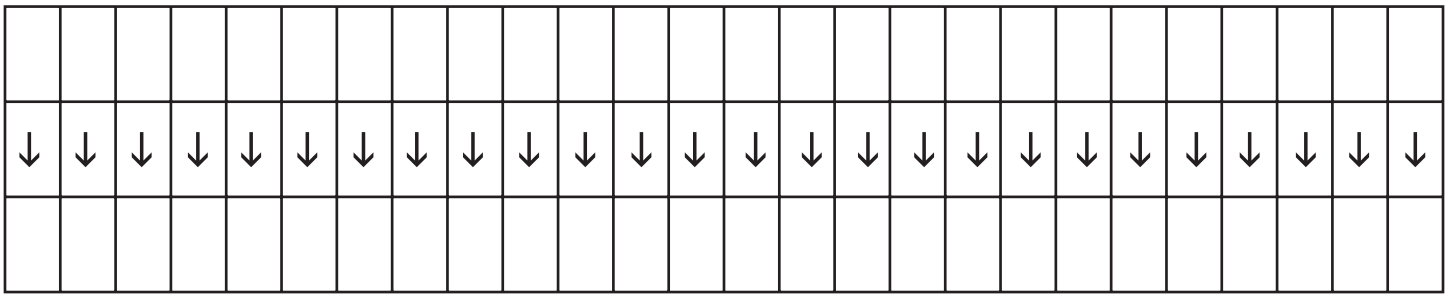
1. Turn the small wheel to set your cipher key. In our example, the letter "A" on the small wheel would be "W" on the big wheel.
2. Find the letter "A "on the small wheel. What letter matches up with it on the big wheel?
3. This is your "cipher key."
   Now that letter A =____, it means that B = ____ and so on.
4. Write a short message or phrase that you want to encode. Match every letter in your message with the "encoded" letter on the big wheel.
5. Write your encoded message and show it to a friend. Tell or give your friend your cipher key (____= A). To make deciphering challenging, give your friend your encoded message without your **key**.
6. Can your friend decipher your encoded message using their cipher wheel?

Write your original "decrypted" message below.

_____

_____

Now, write your new "encrypted "message on the bottom line.



Resistor Codes:
Electronic Resistor Code Challenge

Grade Range: High School

Lesson Goals:

- To learn the basics of electronic resistor codes.
- To decode the values of electronic resistors.
- For youth to make decisions that are unique to their level of knowledge, coordination, and aesthetics.
- By encountering simple obstacles and making decisions, students exercise their capacity for perseverance.
- To develop manual dexterity by assembling a delicate, but not precious, device using basic paper engineering skills.
- Youth explore game theory while encoding messages through scavenger hunts, clandestine communication, and spy team activities.

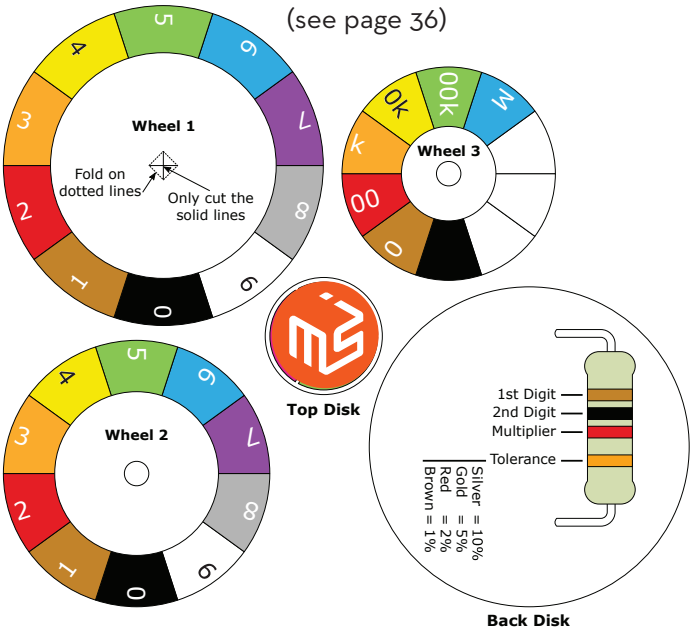
Suggested Time: 30 minutes

NGSS Crosscutting Concepts:

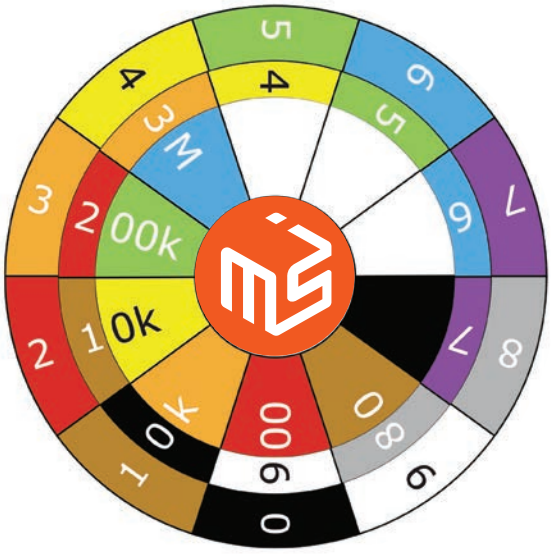
- Cause and Effect: Mechanism and Prediction
- Scale, Proportion, and Quantity
- Systems and Systems Model
- Structure and Function

Materials:

Wheels printed on cardstock
(see page 36)



Challenge Snapshot:



Assembled Resistor Code Wheel

Electronic Resistors

What the Facilitator Needs to Know:

In this challenge, young people will explore decoding the values of electronic resistors.

Essential Question:

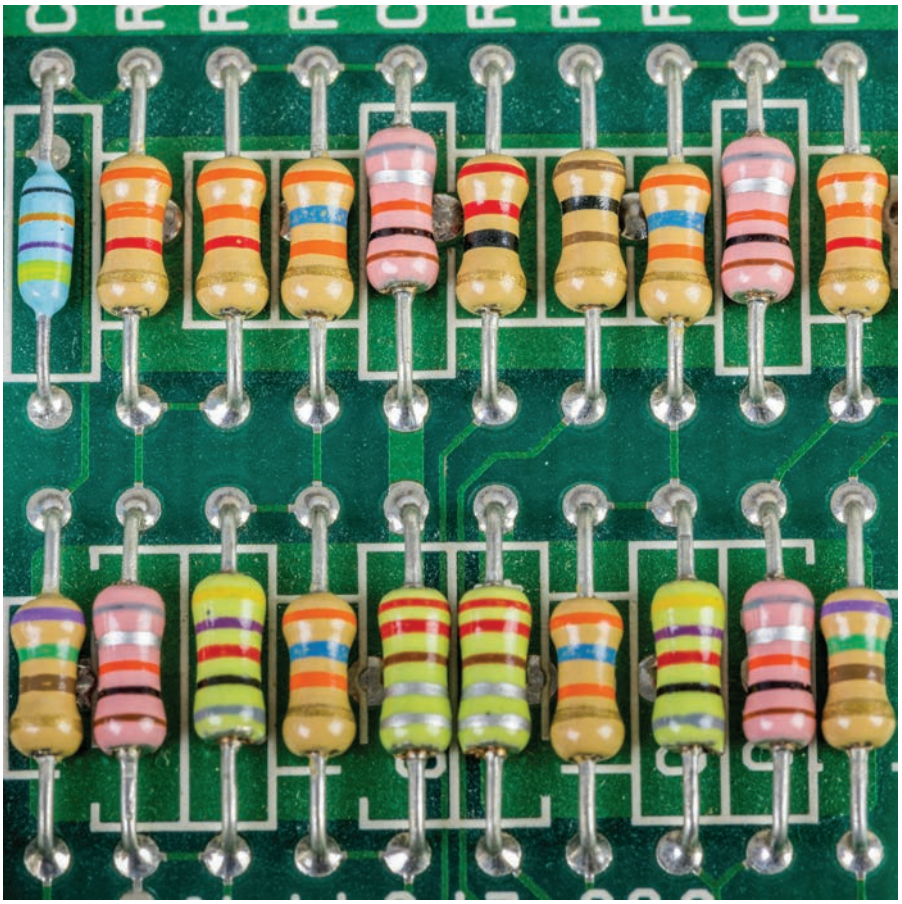
What comes to mind when you hear the words ***electronic resistor codes***?

Use young people's responses to generate discussions about what electronic resistor codes are and their use.

- Electronic resistor codes are a standardized method used in the electronics industry to denote the resistance value of resistors.

Discussion Questions:
You know what an electronic resistor code is and its use. These codes contain color bands or digits printed on the resistor's surface. How do you identify an electronic resistor? What is the color band sequence of a resistor? Why are resistors color-coded?

- Each color or digit represents a numerical value, typically 0 to 9, corresponding to the resistance value in ohms.
- By interpreting the colors or digits according to a specific code, engineers and technicians can quickly determine the resistance value of a resistor without the need for additional measurement tools. This system facilitates easy identification and selection of resistors for electronic circuit design and repair.



Materials:

- The Resistor Code Wheel Activity Sheet
- White Glue
- A Pair of Scissors

Challenge Plan: Building the Resistor Code Wheel

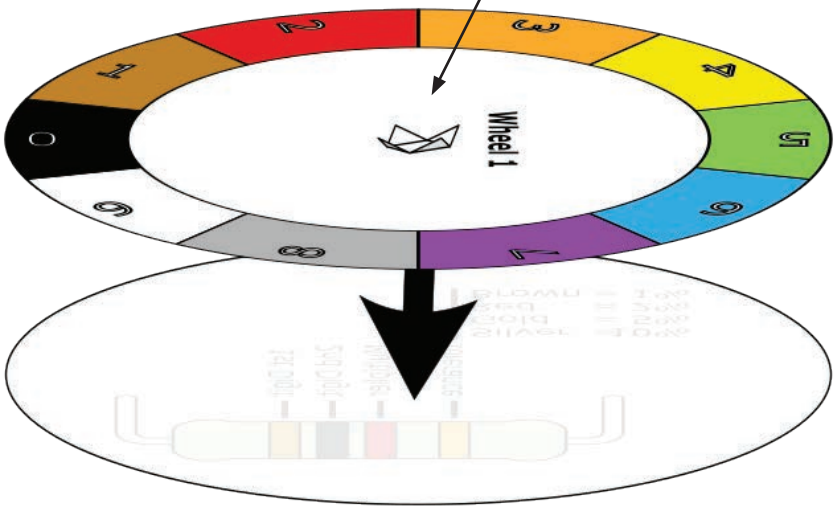
1. With a pair of scissors, cut out all five disks on page 36.
2. With a pair of scissors, cut out the two center holes in **Wheels 2 and 3**, and the four tabs in **Wheel 1.**

   NOTE: Only cut the diagonal lines in the square hole in Wheel 1.
3. Fold up the four tabs on Wheel 1.

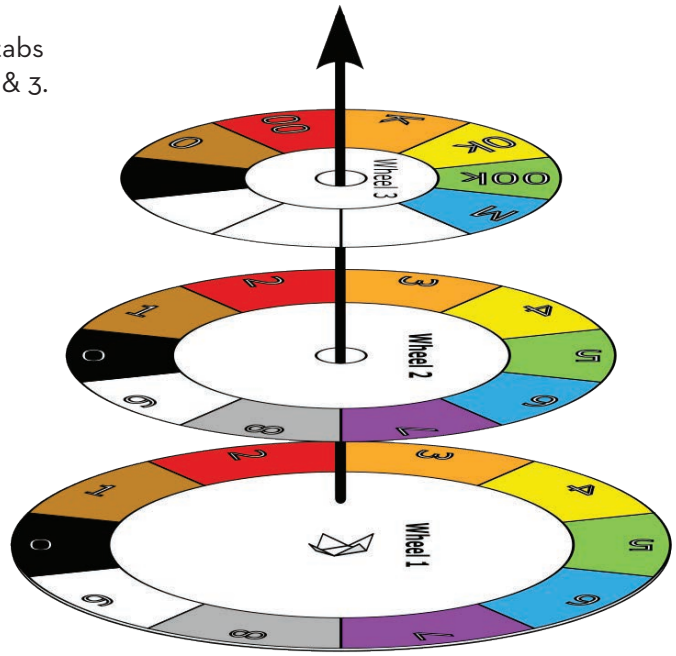
Enlarged Diagram

4. Glue Wheel 1 to the face down Back Disk.

   NOTE: The Back Disk should be face down.

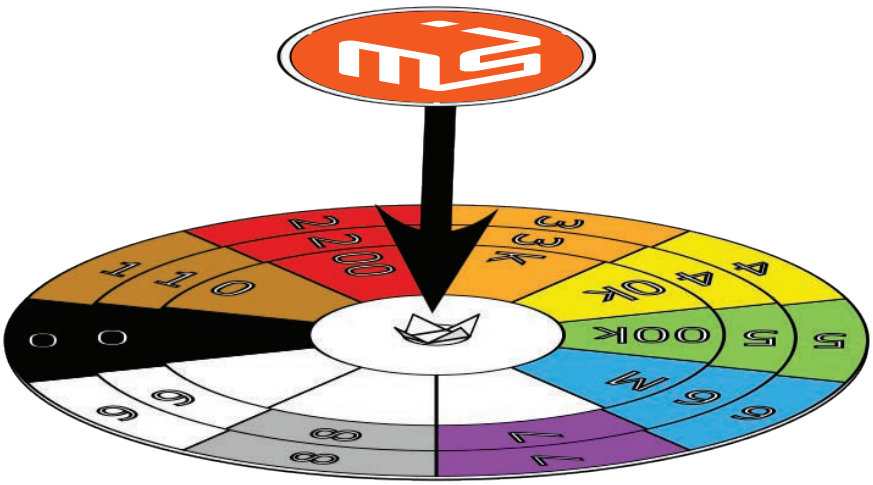


5. Thread Wheel 1's tabs through Wheels 2 & 3.



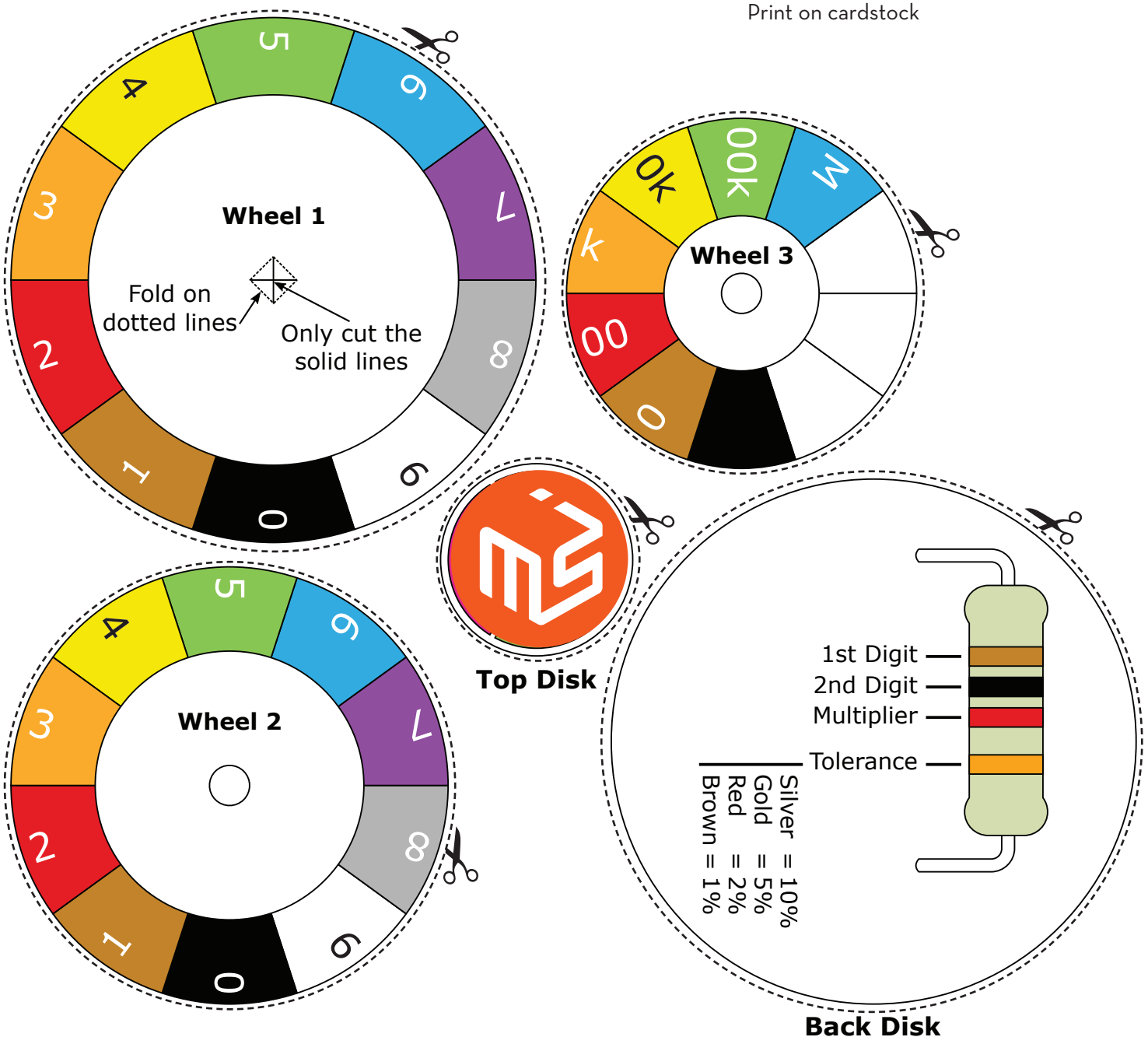
6. Flatten Wheel 1's tabs and carefully glue the Top Wheel to the tabs only.

NOTE: Wheels 2 & 3 should spin freely!



Activity Sheet I: Resistor Code Wheel

Print on cardstock



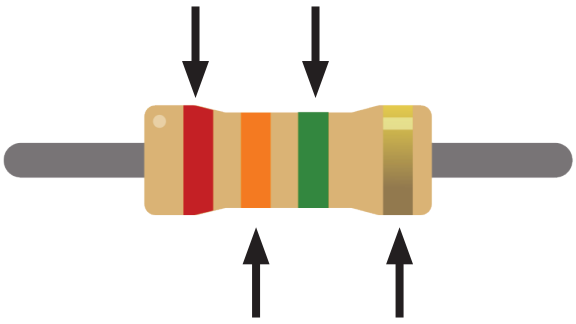
How to Use Your Resistor Codes Wheel:

What is a resistor? Resistors are a common electronic component used to slow down (resist) the electric flow of a circuit.

A unique measurement indicates the amount of resistance in a resistor. The electrical resistance of a resistor is measured in **"ohms."** The symbol for ohms is the Greek letter **Omega**. It's a horseshoe-shaped symbol that looks like this **Ω.**

The manufacturer paints little stripes around the component to indicate the ohm value of a resistor. These colors are a code! Each color represents a particular number.

When reading from left to right, there will usually be three colorful stripes, then a gold or silver stripe. Let's look at the stripes. The first two stripes refer to numbers. So, looking at our wheel, we can see the first two stripes are red and orange, and then we know the first two numbers are two and three. The third colored stripe is called the ***"multiplier,"*** which means "the number of zeros to add to the end." For example, if the third stripe is green, that would indicate two zeros.



Let's put it all together. Red, orange, brown = 2300·, or 2.3k· (pronounced "two-point three-kilo ohms"). The **k** stands for ***"kilo,"*** which means "thousands." The gold/silver stripe indicates the "tolerance" of the resistor. That refers to how accurate the resistor is. Gold represents the resistor's value, which may be five percent more or less than the code indicates.

Now that you understand ohms, what the colorful stripe on a resistor means, and resistor tolerance, find the value of the resistors below.

1.  =_____

2.  =_____

3.  =_____

Answers to decoded resistors:

1.  23 Ω =_____

2.  220 Ω =_____

3.  5400 Ω =_____

After decoding the resistors, what is another way to write the value of 5.4k Ω?

_____

You have received a text message from your controller to decipher several pictures using an electronic resistor code wheel. The pictures are below. What steps will you use to crack the secret messages?

1. The picture represents the spy's birthday in resistor code. Try to figure out the spy's age.

Birthdate is:

_____

1/10/1963

2. What is the spy's age?

_____

2024-1963=61

3. Let's convert the spy's age to resistor code. Our spy is blue-brown years old!

2024
−1963
61 =

Inquiry Questions:

1. How would you use your resistor codes to encode a phone number?

2. How could you use resistor codes to play a game?

3. Do you need the entire code wheel to encode numbers?

Rubber Band Car Challenge

Grade Range: Elementary through High School

Lesson Goals:

- Explore mechanical and elastic potential energy.
- Use the *Design Thinking and Griffin MSI Innovation Process* on the following page to build a rubber band car.
- Explore how to increase the downward force of the rubber band car.
- Explore how to get your car to move quickly and as far as possible with one charge (elastic rubber band).

Suggested Time: 30 Minutes

NGSS Crosscutting Concepts:

- Cause and Effect: Mechanism and Prediction
- Scale, Proportion, and Quantity
- Systems and Systems Model
- Structure and Function

Materials:

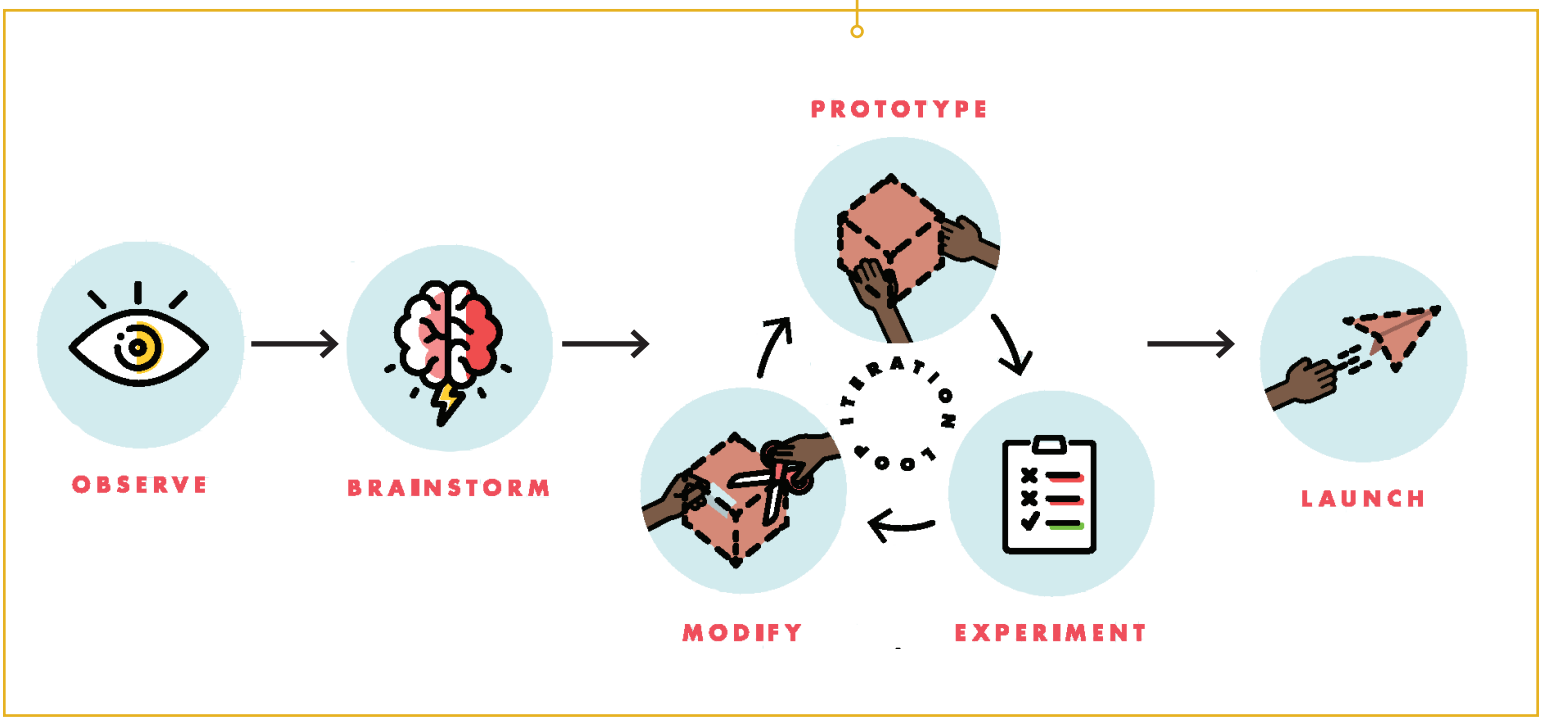
Challenge Snapshot:

What the Facilitator Needs to Know:

In this Real-World learning activity, young people design a rubber band car using *Design Thinking and the Griffin MSI Innovation Process*. (see diagram) What does the term design thinking mean to you? Do you think design thinking is used in science and technology laboratories to make gym shoes, iPhones, and clothing? *Design thinking* is an iterative process teams use to understand users, challenge assumptions, redefine problems, and create innovative solutions to prototype and test. How does this process fit with designing things like gym shoes, iPhones, and clothing?

You are an automotive designer or engineer. You work in Q's Lab and have been asked to build a Rubber Band Car using design thinking. Why would a designer or engineer be asked to build a rubber band car? A rubber band car is a simple machine using a rubber band as the source of energy. The rubber band is an easy way to power the car. When you stretch a rubber band, the **mechanical energy** turns into **elastic potential energy**. The rubber band comprises molecules called polymers that store potential energy. When the car is released, the elastic potential energy returns to mechanical energy as the wheels spin and power the car forward.

Design Thinking and the Griffin MSI Innovation Process



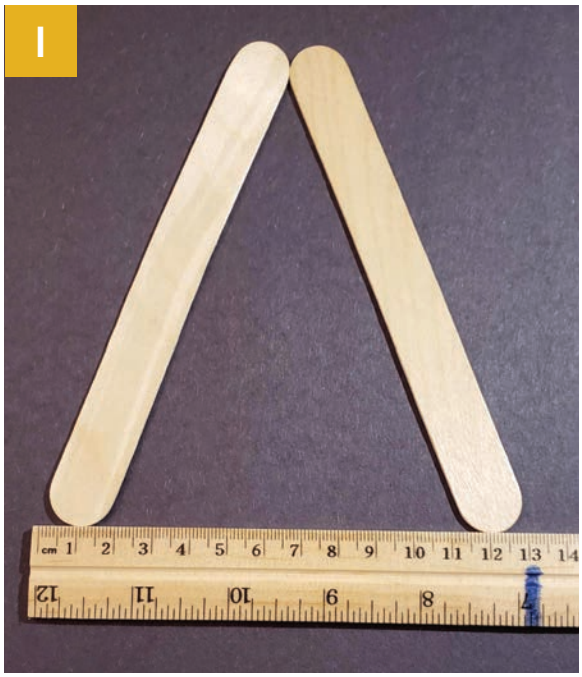
Rubber Band Car Challenge:

Materials:

- 5.9 in x .07 in (15 cm x 1.8 cm) Craft Sticks (2) or smaller
- AA Batteries (2) any brand
- Plastic Soda Bottle Caps (4)
- 2 inch Rubber Bands (2)
- 3½ inch Rubber Band (1)
- Mini Phillips Screwdriver
- Plastic Drinking Straw (1)
- 12 inch Wood Skewers (2)
- Mini Hot Glue Gun (1)
- Mini Hot Glue Sticks
- Push Pin (1)
- Scissors or Cutting Pliers
- Ruler (inch/centimeter)
- Markers or Colored Pencils (optional)

Challenge Plan: Building the Rubber Band Car

1. Place two craft sticks in a V shape with the open ends measuring 13.5 centimeters (5⅜") (see picture 1).
   Optional: Use markers or colored pencils to decorate craft sticks.



2. Using the mini glue gun, glue the closed end of the craft sticks.
3. Using the 12-inch-long wood skewer, measure 2 centimeters and draw a line.
4. Repeat step three, measuring from the first 2-centimeter line.
5. Using scissors or pliers, cut the skewer at each 2-centimeter line.
   You created the tabs for the car.

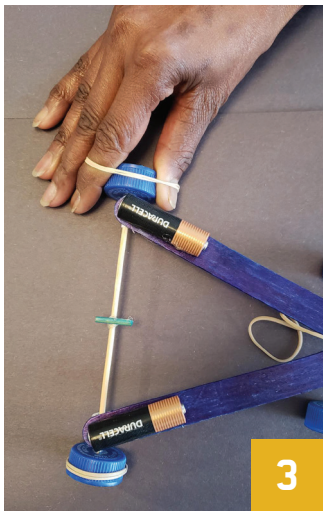
6. Using the mini glue gun, attach one 2-centimeter piece of a skewer (tab) in the middle of the closed V (base of the car). Ensure half of the wood skewer extends past the car base's end (see picture 2).

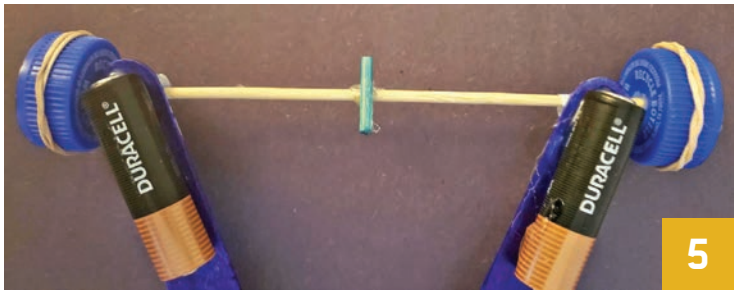
7. Measure two 1.7-centimeter pieces and one 6.35-centimeter piece of the straw.
8. Cut each measured piece of straw with scissors.
9. Hot glue the 6.35-centimeter piece of straw to the closed end of the car base. You have created the car's front axle.
10. Place a drop of hot glue on each open end of the car's base. Affix a 1.7-centimeter piece of straw horizontally on each end.
11. Measure and mark 8.1 centimeters and 14.5 centimeters on a skewer. Cut each piece with scissors or pliers.
12. Slide the 8-centimeter piece of skewer into the front axle to check its length.
13. Repeat step 12 for the 14.5-centimeter skewer for the rear axle.

Note: Adjust the skewer length based on the width of the craft stick.

14. Gather four soda bottle caps.
15. Using a pushpin, poke a hole in the center of each soda cap. You have created a starter hole.
16. Push the end of the mini-Phillips screwdriver through the starter hole to fit the diameter of the skewer.
17. Repeat step 16 three more times.
18. Place a bottle cap on one end of the 14.5-centimeter piece of skewer. Slide the skewer into the straw and affix a cap onto the other end — the rear axle.
19. Repeat step 18 for the front axle.

20. Secure caps (wheels) to the axle on the outside using hot glue.
21. Affix the second 2-centimeter skewer (tab) in the middle of the rear axle.
22. Hot glue an AA battery (weight) to the car's left and right rear sides.
23. Twist one 2-inch rubber band around each rear wheel of the car. There is no slack in the rubber bands, which are placed in the middle of the wheel (see pictures 3, 4, and 5).





24. Loop the 3½-inch rubber band around the front tab. Hot glue the rubber band to the tab.
25. Stretch the 3½-inch rubber band to reach the rear tab. Loop the rubber band under the back tab.
26. While holding the car, use the rear tab to wind the rubber band. Wind the rubber band until taut.
27. Release the car, and it will move forward.

Inquiry Questions:

1. What happens if you don't steer the car before release?
2. Will the car move forward at a greater distance if the rubber band is longer? Shorter? Why or why not?
3. How will different-sized wheels affect the speed of the car? The forward movement of the car?
4. How is the forward motion affected without adding batteries to the car base if the wheel sizes differ? If the wheel sizes are the same?
5. The wheels of the car spin without the car moving. How can you increase the friction between the wheels and the floor?

Transformation:
Youth will collaborate to create templates as a guide to add design elements to their rubber band car (see picture 6).

6

Inquiry Questions:

1. Does adding materials or elements to the car change how it moves forward? Why or why not?
2. Does the choice of material appear to shift the weight or speed of the car? Why or why not?

Winding Stunt Car Track Challenge

Grade Range: Middle School- High School

Lesson Goals:

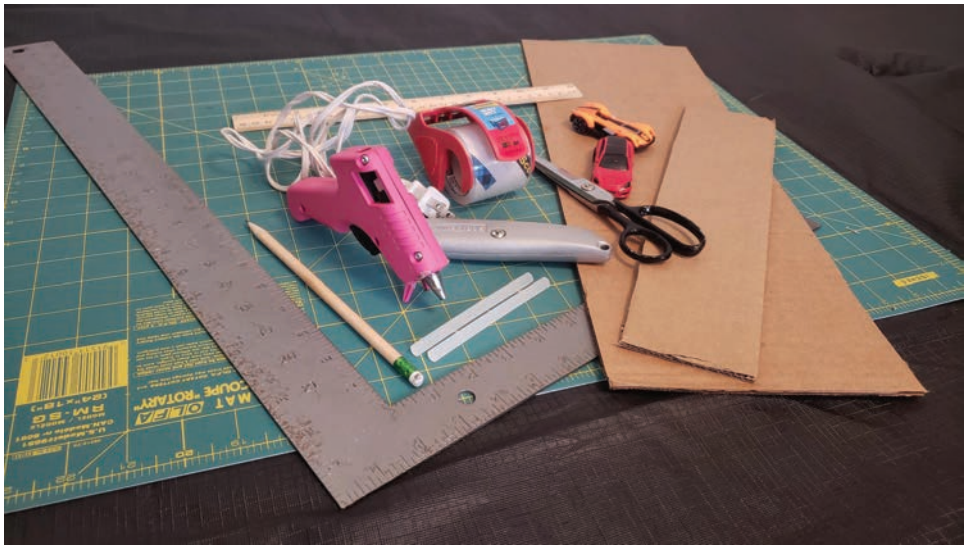
- Use the creative process to build a stunt car track.
- Discover how math and physics are connected to movie stunts.
- Use math conversions to create 2D track templates.

Suggested Time: 180 Minutes: 2 Sessions

NGSS Crosscutting Concepts:

- Patterns
- Cause and Effect: Mechanism and Prediction
- Scale, Proportion, and Quantity
- Structure and Function

Materials:



Challenge Snapshot:

You are a Stunt Coordinator hired to create movie magic in a film. Your assignment is to create a stunt track for a getaway scene after an agent extracted a secret mental box from a factory in Dundee, Illinois. The agent must deliver the metal box to Agent X in just 4 hours. The escape route is a steep landscape surrounding the factory, winding and banking roads, bumpy areas, and a few small but deep utility holes. Use the **creative process** to plan and build stunt sequences for an action-packed, safe, and successful "agent" getaway.

The steps in part one of the creative process are:
(1) Explore (2) Experiment (3) Develop (4) Create (5) Reflect.

The steps in part two of the creative process are:
(1) Assess and Revise (2) Share (3) Imagine (4) Examine (5) Perceive.

In spy movies, agents complete daring jumps and spins in their cars or on motorbikes during a high-impact getaway. Imagine the agent's getaway. What are the features of the agent's car?

Will the features of the car have an impact on navigating challenging terrain?

1. List the features that make it easy for the agent to navigate the terrain.
2. Identify the features that makes it challenging for the agent to navigate the terrain? Explain why.

Car stunts in movies are designed and can be described using math and physics. Kinematics is the study of how objects move. If a car jumps from a ramp over water, you can break down its motion into two parts: forward motion and vertical, or up-and-down motion. You can determine how far it will go before it lands based on (1) how high the ramp is, (2) how fast the car is moving, and (3) the steepness of the ramp.

Think of a time you rode your bike down a hill; what happened? Did you accelerate? Why? Did you slow down? Why? As a Stunt Coordinator, use your experience riding your bike to assist in designing and building an epic track.

Inquiry Questions:
Youth work in small groups to discuss the following questions.

1. What forces are acting on the car as it is going down the ramp?
2. In what other direction is the car moving?
3. How does a ramp affect force?
4. Will the car land moving forward?
5. Will the car land at the same speed it started?

As you design your track, experiment with the angle of each slope as it relates to speed.

Materials:

- Cardboard ⅛ inch thick (corrugated works best)
- Mini Hot Glue Gun
- Mini Glue Sticks
- Scissors
- Cutting Board (optional)
- Utility or X-ACTO Knife
- Hot Wheels or miniature cars
- Tape (Packing, Grey or Black) (optional)
- Straight Edge for Cutting
- Ruler or architectural scale

Challenge Plan: Building the Track
Using the creative process, design and build a stunt track using a scale of ¼ inch = 1 foot with the following criteria. Test stability with Hot Wheels or similar miniature cars.

1. Steep landscape
2. Breaks in road (1)
3. Winding road
4. Banking track
5. Straight away track
6. Bumpy areas in the road

Designing the Track:

1. Create templates (patterns) for your track using ¼" = 1 foot scale.
2. Using a pencil, trace your template on cardboard and cut out each piece using a X-ACTO or utility knife. The knife is sharp. Make sure there is supervision to ensure safety.
3. Ready, set, design!

Inquiry Questions:
Youth work in small groups to discuss the following questions.

1. What is the initial **slope** of your track leading up to the loop the loop? **Slope** = rise/run.
2. How much drop (**rise**) is optimal to ensure your car can loop the loop?
3. What happens if you change the (**run**) of your track but keep the rise constant? Do you think the car will continue to loop the loop?

Pencil Holder Secret Compartment: Candy Stash

Grade Range: Elementary

Lesson Goals:

- To explore the DIY (Do It Yourself) world of being a secret agent.
- For youth to make decisions that are unique to their level of knowledge, coordination, and aesthetics.
- To explore how a slight change in a system can affect a design outcome and help to build capacity for adapting.

Suggested Time: 35 Minutes

NGSS Crosscutting Concepts:

- Cause and Effect: Mechanism and Prediction
- Scale, Proportion, and Quantity
- Structure and Function

Materials:

Challenge Snapshot:

What the Facilitator Needs to Know:

The History of Spies Using Secret Compartments
Long ago, spies used special hiding places called ***secret compartments***. These were secret treasure spots to keep important things safe! Imagine a hidden drawer in a table or a secret pocket in clothes.

Even in modern times, spies use secret compartments or secret rooms to conceal special items. Spies hide messages, maps, or tiny gadgets in these hidden places to help keep their secret items safe and secure.

Spies used secret compartments throughout history; the list below provides content for specific eras.

Questions:
- What era would you like to place yourself in?
- What items will you store in your designed secret compartment?

Ancient Rome 625 BCE-CE 476 and Ancient Greece: 700-480 BCE
Spies hid scrolls, messages, or valuables in secret compartments in furniture such as tables and chests.

Medieval Europe: 500-1500 CE
Secret compartments were often integrated into furniture, clothing, and architecture to hide important documents, jewels, or escape routes.

Renaissance Period: 14th to the 17th century
Spies and diplomats utilized secret compartments in books, hollowed-out items, and hidden pockets in garments to discreetly transport messages, maps, and small objects.

World War 2: 1935-1945
Secret compartments were employed in various espionage operations, including hiding microfilm, radio equipment, and forged documents within everyday items like suitcases, clothing, and personal effects.

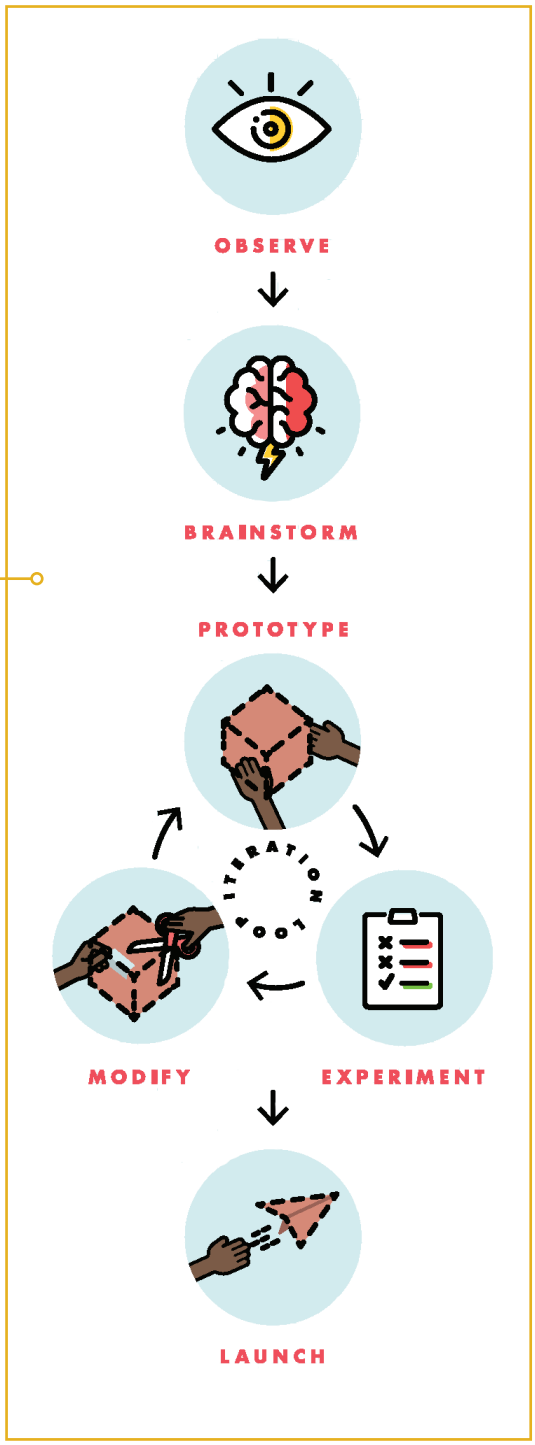
Cold War Era: 1947-1991
Spies from the East and West used sophisticated concealment methods, including secret compartments in briefcases, vehicles, and buildings, to hide surveillance equipment, documents, and even people during covert operations.

Contemporary Era: 1950-Present
With technological advancements, secret compartments have evolved to include digital encryption, hidden compartments in electronic devices, and sophisticated concealment techniques in vehicles, luggage, and buildings used by intelligence agencies and espionage operatives.

You are a design engineer. You work in Q's lab and have been asked to create secret compartments in ordinary items for other spies. Why would a design engineer be asked to create items with secret compartments? Will your compartment be in a cabinet, a bag, a car, or a floor? What will your compartment hold?

To build a secret compartment, you will use the *Design Thinking and the Griffin MSI Innovation Process*.

Design Thinking and the Griffin MSI Innovation Process
An iterative process that helps us to understand a problem, find solutions to a problem, understand the user, and find creative solutions to problems through prototyping and testing.



Secret Compartment Pencil Holder Activity: Candy Stash

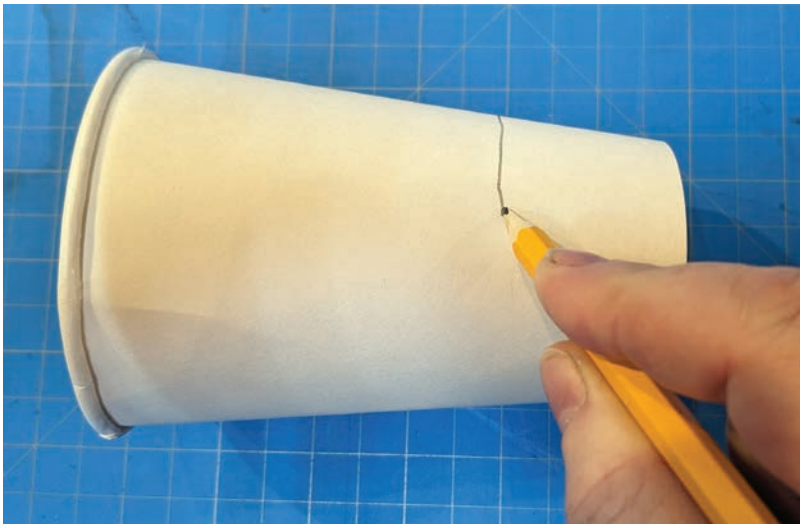
Materials:

- Pencil or Pen
- Scissors
- Small Candies
- Two 10- or 12-ounce Paper Cups
- Paints, Markers, or Crayons
- Paint Brushes or Sponges

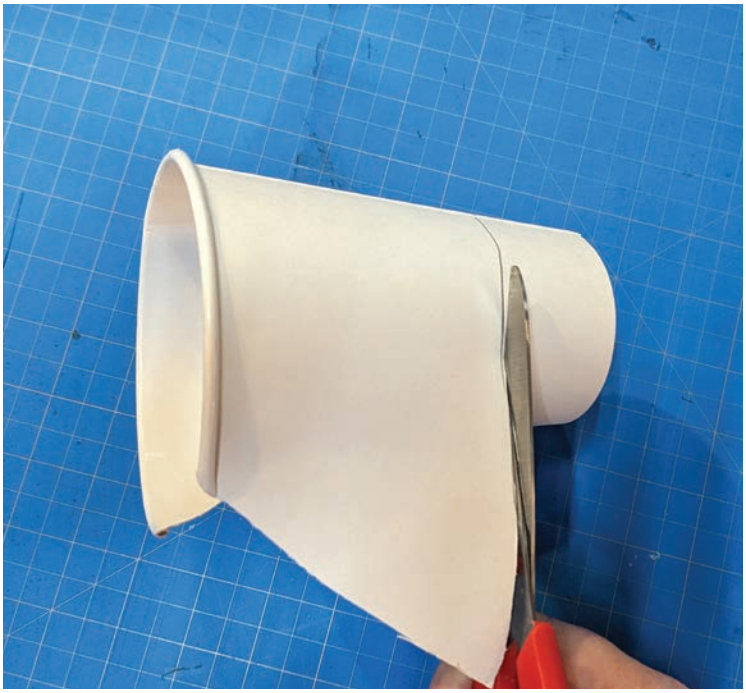
Activity Plan: Building the Pencil Holder

1 Using paint, markers, or crayons (or all three!), decorate one paper cup with any design you like.

2 Using a pen or pencil, draw a ring around the bottom of the second paper cup, approximately 1-1½ inches based on your cup size.



3 While your art on the first cup is drying, carefully cut off the bottom of the second cup using a pair of scissors.



4 Drop something small, like candy or a secret message into the painted cup.

5 Drop your false bottom into the painted cup to complete your secret compartment.

6 Your cup should look like this.

How to Use Your Secret Pencil Holder Candy Stash:
Add pencils, pens, paintbrushes, scissors, or anything you like to finish your secret compartment pencil holder.

NOTE: Please do not drink out of your new spy device!

Inquiry Questions:

1. You might notice that your secret compartment isn't very big. How could you increase the size of the secret compartment?
2. What other objects around your house, classroom, or program space could you use to make a secret compartment?

Extension:
Use the Secret Pencil Holder Candy Stash to Solve a Challenge.

Have the young people create a spy name. Create a mission and start a treasure hunt where different secret compartments have clues to locate other hidden compartments. At the end of the mission, provide prizes for young people based on the number of secret compartments found.

Dead Drop: Concealment Container Challenge

Grade Range: Middle School

Lesson Goals:

- To explore "dead drops."
- To explore game theory.
- For youth to make decisions that are unique to their level of knowledge, coordination, and aesthetics.
- To explore how a slight change in a system can affect a design outcome and help to build capacity adapting.

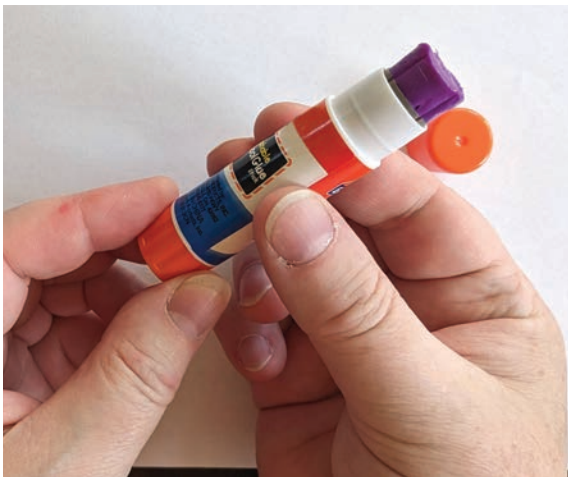
Suggested Time: 35 Minutes

NGSS Crosscutting Concepts:

- Cause and Effect: Mechanism and Prediction
- Scale, Proportion, and Quantity
- Structure and Function

Materials:

Challenge Snapshot:



What the Facilitator Needs to Know:

In this challenge, young people explore "dead drops" and use design thinking and innovation to engage in a hands-on process of designing, developing, and constructing solutions to a problem. Have you stumbled over an object while walking in a park in your neighborhood and wondered how it got there? Have you met a friend or family member at a specific location to give them a package, a letter, or a card?

Use young people's responses to explain the meaning of a ***dead drop***. Dead drops refer to clandestine locations where individuals can secretly exchange information or items without direct contact. Often used in espionage, covert communication, or as part of underground networks, dead drops typically involve a hidden physical container, such as a small tube or container, concealed in a public location like a park or urban setting.

Discussion Questions:

You know what a dead drop is and how spies use them. In small groups, have young people discuss the following questions:

- What type of mission will require a dead drop?
- What does a dead drop look like?
- What information is needed to retrieve the item or message?
- What location would be accessible to find a dead drop and why?

Making a dead drop requires the agent and the ***controller*** to develop signals to ensure the bad guys are not watching or discovering the hidden items or messages.

Dead drops offer a discreet means of communication or exchange, allowing individuals to share sensitive information or goods without direct interaction, thus maintaining anonymity and security.

While historically associated with espionage and covert operations, you will find dead drops in various contexts, including urban exploration, art projects, gaming, and underground communities.

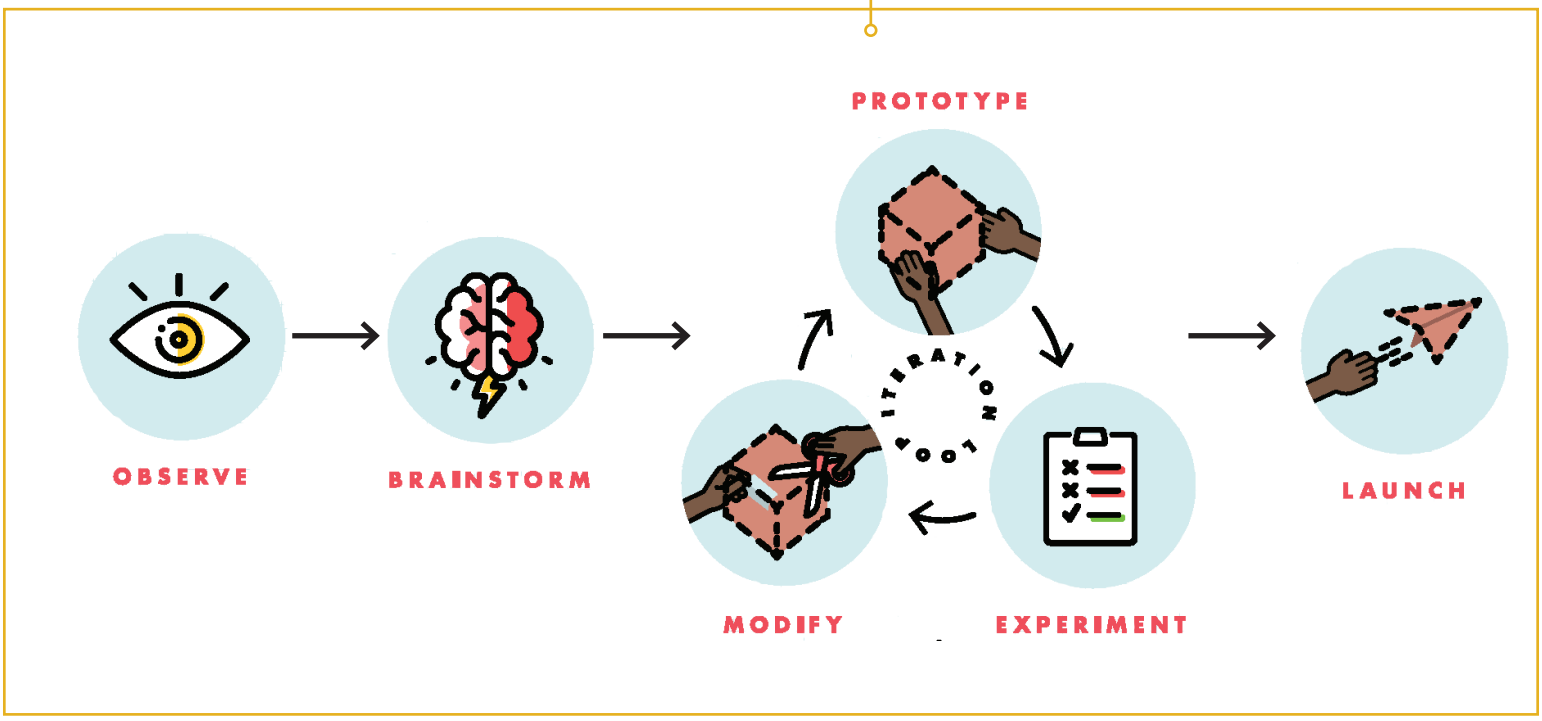
Inquiry Questions:

1. What other objects around your house, program space, or classroom could you use to make a secret compartment?
2. If you were to peel back the label of a container and write a secret message on it, why would a jar of peanut butter work better than a water bottle?
3. What are some things that could go wrong during a dead drop?
4. If you wanted your secret message to be in spy code, what code would you use?

Materials:

- Thin, Thread-like String (dental floss)
- Glue Stick (any brand)
- A Secret Message for the Dead Drop

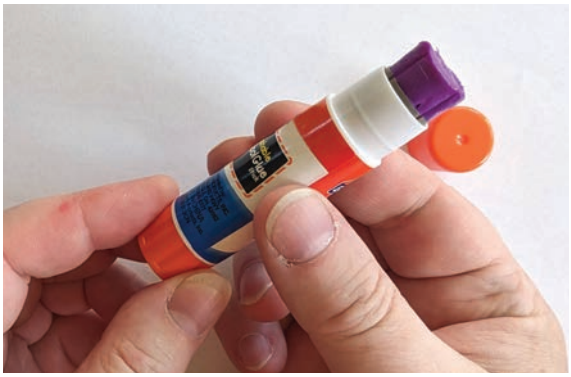
Design Thinking and the Griffin MSI Innovation Process



Challenge Plan:

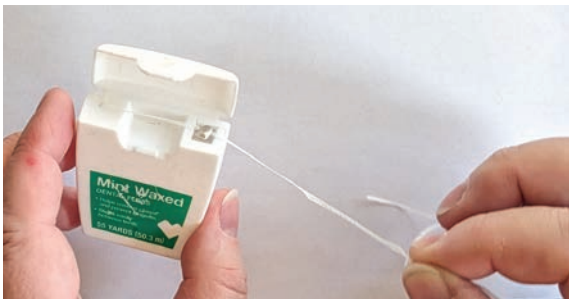
Building the Concealment Container

1 Open the glue stick and screw the glue stick out of the container.



2 Remove the glue stick and its base. Keep the base connected to the glue stick.

3 Use a small amount of string, about 4 inches. Dental floss is used for this project.



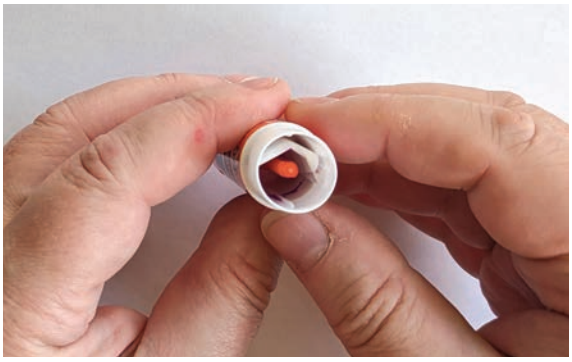
4 Wrap the string around the glue stick, leaving about a half-inch of glue above the base.

5 Gently pull the string through the glue stick to cut it. Save the top part! You can add it to another stick with less glue.

6 Write a secret message!

7 Fold the secret message to fit in the empty glue stick container.

8 Do not push the stick out of position in the middle of the container.



9 Insert the glue stick base with glue still attached back into the glue stick base.

10 Screw the glue stick into its original container and have the top sticking out, and put the cap on.

11 Your dead drop spy container will look and operate like a normal glue stick.

It's best to hide your dead drop container in plain sight. That way, no one will suspect it's a spy gadget. Dead drops work best if used in an area where people can come and go.

You can use your dead drop to play all sorts of games! You could have a large container that leads different spy teams from one location to another in a spy race! Or how about a treasure hunt?

You can make dead drop containers from almost anything. You can peel back the label on a bottle or a jar and write your secret message right on the inside of the label.

Geocaching

Grade Range: High School

Lesson Goals:

- To develop navigation skills through geocaching.
- Practice critical thinking, problem-solving, and teamwork.
- Use GPS devices, mobile apps, and online platforms to build digital literacy skills.
- Explore cultural and historical landmarks through geocaching.
- Experiment with encoding and decoding messages.

Suggested Time: 50 Minutes

NGSS Crosscutting Concepts:

- Cause and Effect: Mechanism and Prediction
- Systems and Systems Models

Materials:

Challenge Snapshot:

What the Facilitator Needs to Know:

Spies are responsible for protecting the mission and often receive coordinates from a controller to retrieve items in undisclosed locations; these secure locations are called ***dead drops***. You are a spy and will participate in a modern-day treasure hunt utilizing a ***Global Positioning System*** (GPS), a satellite-based navigation system that provides location and time information to users anywhere to navigate to specific coordinates and find hidden containers called ***"geocaches"*** or "caches" placed by other agents. ***Remember, your location is a "dead drop."*** The caches come in various sizes and shapes, from small containers holding only a logbook for signing to larger containers containing trinkets for trading. The thrill of the hunt lies in finding the cache and the journey to reach it. Your handler provided ***encrypted*** coordinates to a dead drop that you must **decrypt**. Great! What does ***encryption*** and ***decryption*** mean? Encryption converts a message into a super-secret code to hide the information's true meaning, which helps agents protect top-secret intel. Decryption is the process of changing encrypted information into plaintext. Have young people work in small groups for the challenge below.

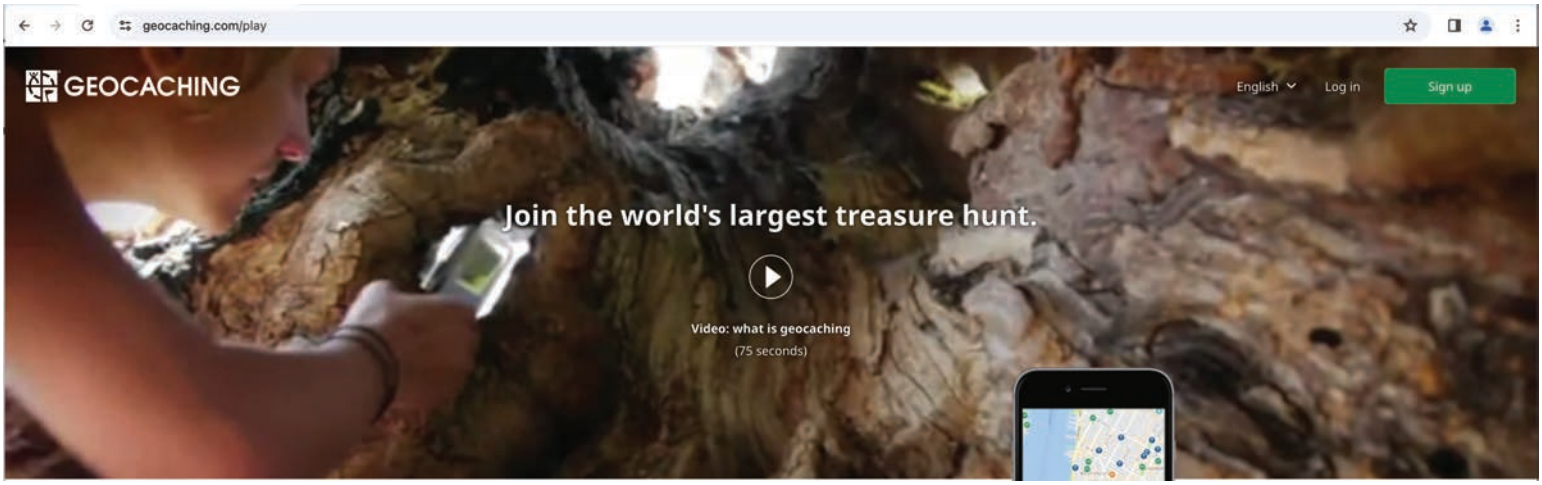
Youth Learning Challenge:

In a small group of four, create two teams. Team 1 makes a message and a "key" using the alphabet. Example, "Z = A," "Y = B," "X = C," etc. Team 1 sends Team 2 the encrypted message via their cell phone. Using team 1's key, team 2 decrypts or turns the message back into its plaintext. Teams switch roles.

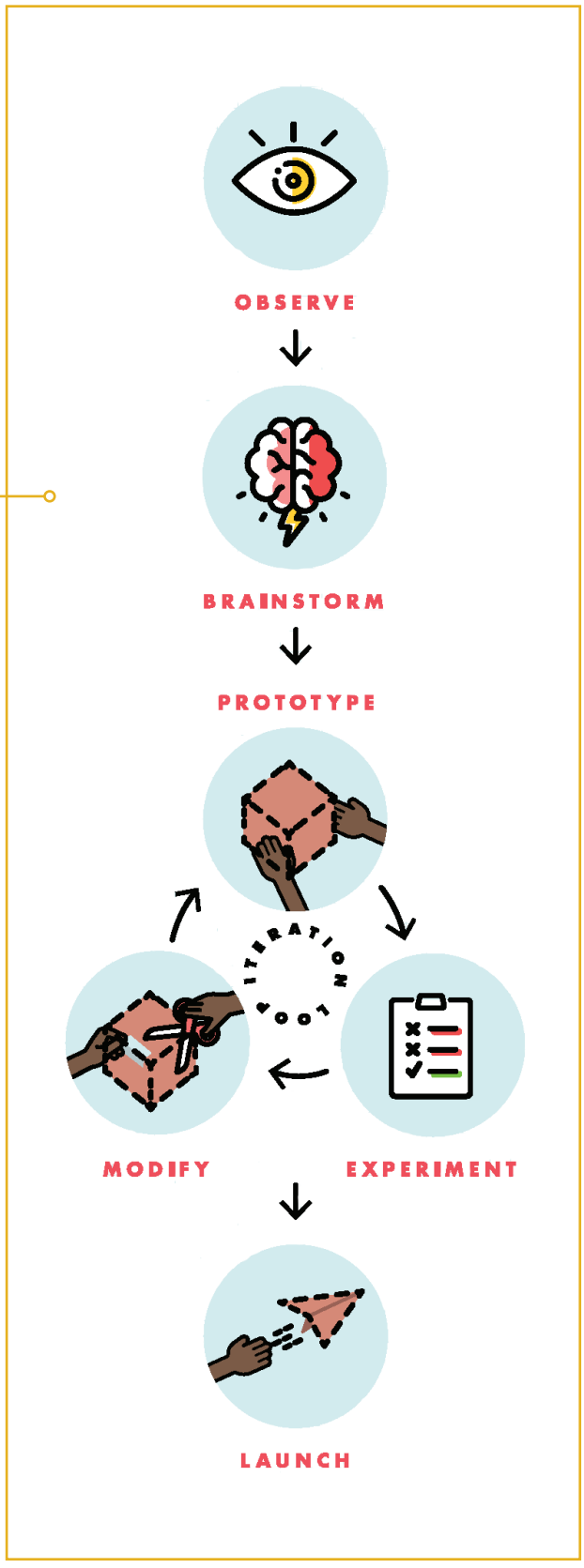
Discussion Questions:

- Were you able to decrypt the message? Why or why not?
- Was the encryption recognizable?
- What steps were used to decrypt the message?

Now that you know about encryption and decryption, let's use coordinates to determine a geocache location.



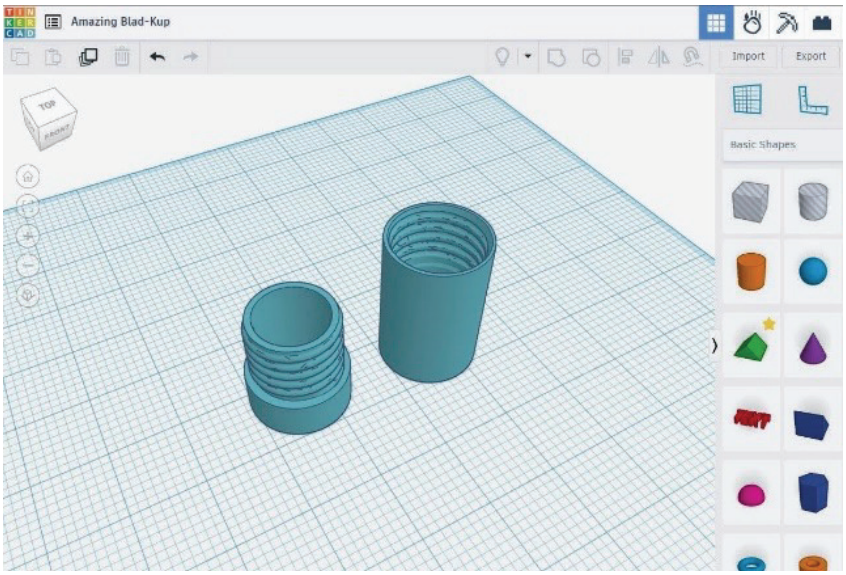
Design Thinking and the Griffin MSI Innovation Process



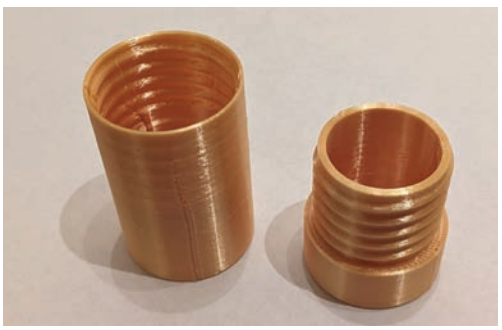
Activity Plan: Encryption and Decryption of a Geocache

1 Find a small weatherproof container that is not a breakable material like glass.

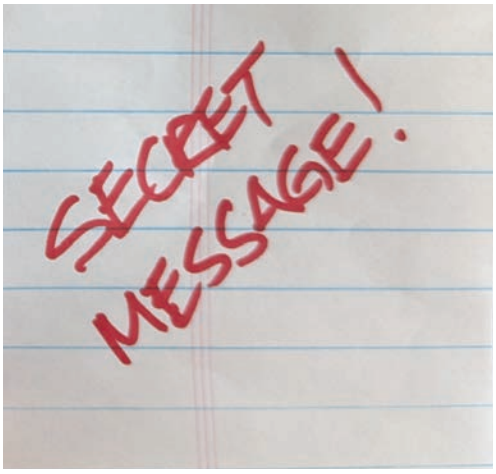
2 If you have access to a 3D printer, you can model a custom container in your preferred design software, such as TinkerCAD.com



3 Keep your container small. You want to hide it, and a larger container is recognizable, and it takes longer to 3D print. Designing your own container gives you creative freedom.

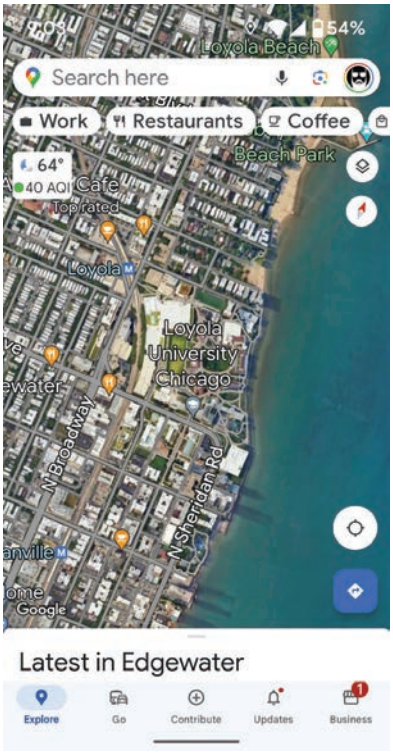


4 Create your secret spy message or add another item and place it in your container.

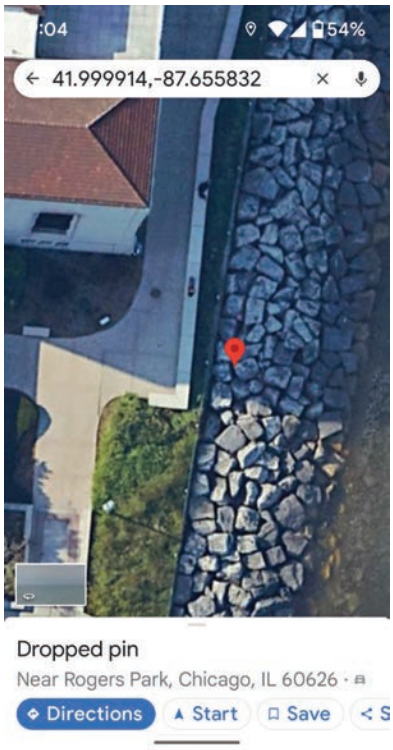


5 Find a location.
The picture is Lake Michigan by Loyola University.

6 Open Google Maps on your cellphone. Set it to Satellite view and find your current location. It's the blue dot.



7 Zoom in on your location until you have found exactly where you are. Press and hold your finger on your exact geocache location and the GPS coordinates will appear in the location bar at the top of your screen.



8 Copy the coordinates so others can find your geocache! To find a geocache, open Google Maps and enter the GPS coordinates. Google Maps will show you that exact spot.

9

Google Maps

Original Number

Encryption

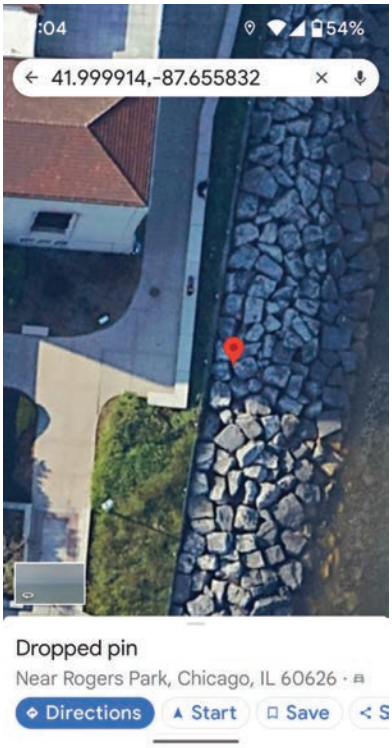
X Key Number =

Encrypted Number

Decryption

Encrypted Number X Key Number = **Original Number**

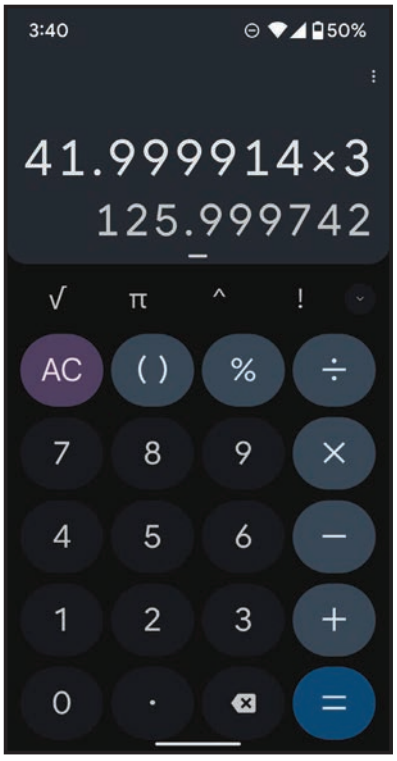
10 Use GPS software to obtain the two numbers for your geocache. We're using Google Maps. The two numbers you're looking for are at the top of your device's screen.

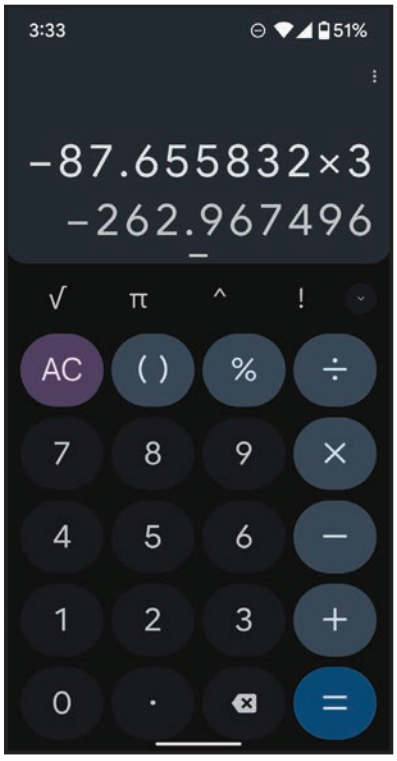


11 Multiply your two GPS numbers by an agreed "encryption key." We are going to use the number 3.

41.999914 x 3 = 125.999742

-87.655832 x 3 = -262.967496

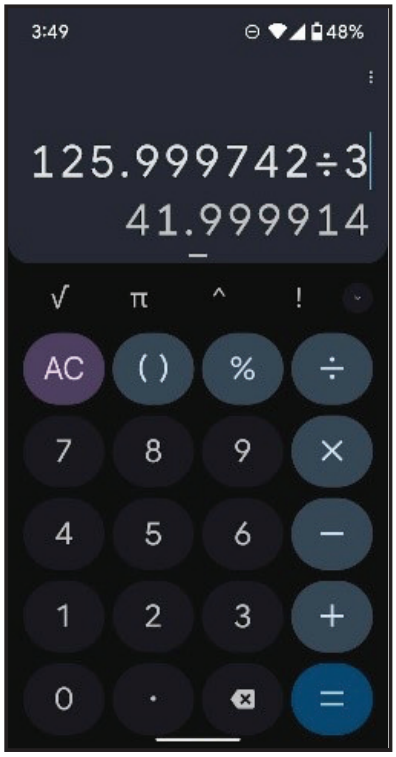


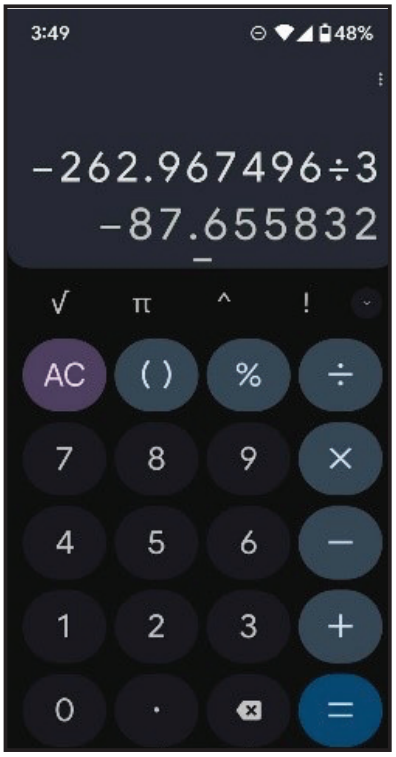


12 Divide your two encrypted numbers by the agreed "encryption key." We are going to use the number 3.

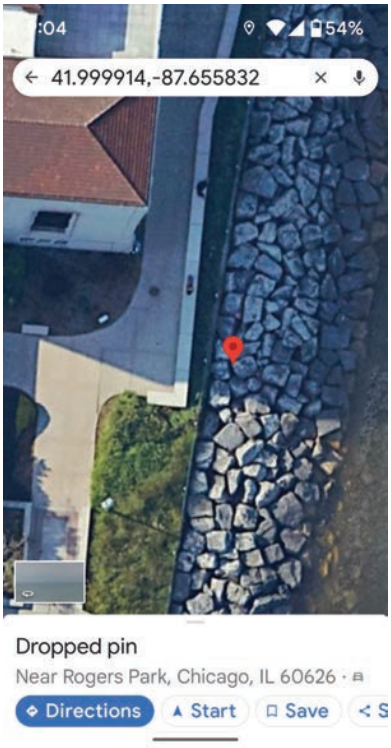
125.999742 · 3 = 41.999914

-262.967496 · 3 = -87.655832





13 Plug the two decrypted numbers into GPS software to obtain the two numbers for your geocache. We're using Google Maps.



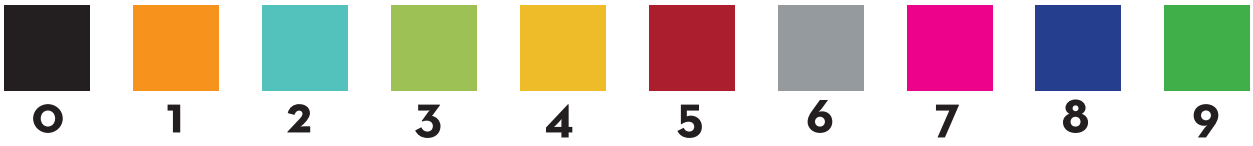
Inquiry Questions:

1. What other ways can you encrypt the ten digits of 0 - 9?
2. How could you use geocaching to play a game?
3. Can you geocache inside buildings?
4. How do satellites determine a GPS location?
5. How many GPS satellites does it take to get coordinates?

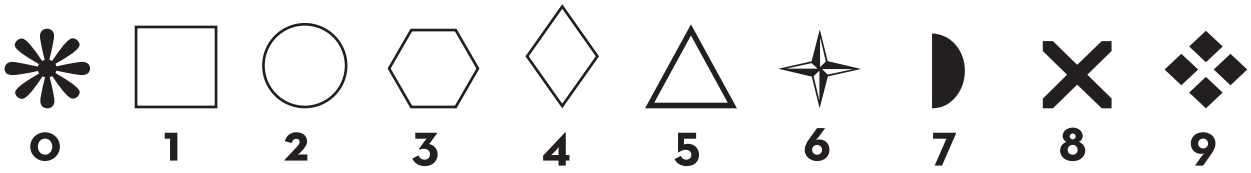
Other Encryption Techniques

Numbers. There are only ten. 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. You can reassign those ten digits to almost anything. Here are a few ideas:

1. Assign the ten digits to colors. For example:



2. Assign the ten digits to shapes. For example:



3. Can you guess how the numbers are encrypted below?

) ! @ # $ % ^ & * (

If you'd like to learn more about geocaching all around the world, check out **geocaching.com**.

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