HEADS IN, HEARTS IN

18 USC 707

Engineering Activities

The Heads In, Hearts In family enrichment program encourages families to use their minds (putting their "heads in") as a tool to expand their knowledge around a variety of topic areas. By creating a shared educational experience, the family unit will work, grow and learn together, putting their "hearts in" to the process.

This unit contains the following:

- What Does an Engineer Do?
- Engineering Process Handout (used at the end of every lesson)
- Building Like a Beaver
- Egg Drop: Will It Stop?
- Filter Fun
- Hello! Who Is Calling?
- Humming Harmonica
- Index Apex
- Marble Maze
- Marshmallow High-Rise
- Marshmallow Launcher
- Paper Airplane Race
- Peanut Hut
- Pingpong Catapults
- Pulley Power
- Rockin' Roller Coaster
- The Strongest Column
- A Tube Rube

Produced by the MSU Extension Educational Materials Team (*http://msue.anr.msu.edu/*).1P–06:2022-WEB–PA/RR WCAG 2.0

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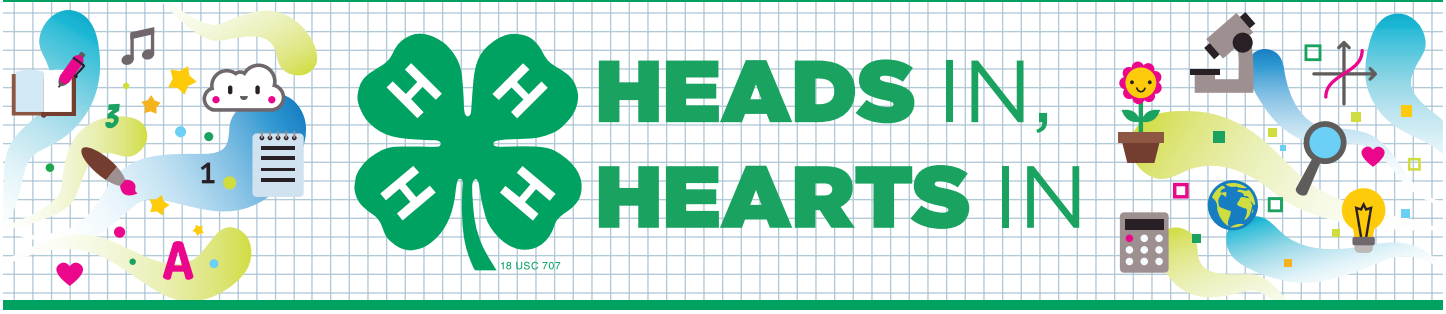

What Does an Engineer Do?

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better. Many different types of engineers work in many different jobs.

- **Aerospace engineer:** Designs, tests and creates aircrafts or space vehicles
- **Agricultural engineer:** Helps farmers and other food producers have higher crop yields and use sustainable practices (designing farm equipment, developing seeds and working in other areas)
- **Architect:** Designs buildings such as houses, office buildings, and factories or manufacturing plants
- **Biomedical engineer:** Works with designing, testing and improving medical equipment
- **Chemical engineer:** Works with chemicals to make things such as medicines and fertilizer
- **Civil engineer:** Works on designing and building community projects such as bridges, buildings and other public structures
- **Computer hardware or software engineer:** Designs and creates systems and programs for computers, tablets, smartphones and gaming systems
- **Electrical engineer**: Works with designing, testing and improving electrical equipment ranging from computers to larger projects such as electricity grids
- **Environmental engineer:** Helps to find solutions to problems that affect everyone including climate change, environmental and public health, sanitation, air quality and pollution
- **Health and safety engineer:** Designs systems to protect people from becoming sick, getting hurt or having their property damaged
- **Industrial engineer:** Designs systems that help materials, machines and people work together to make a product or accomplish a task
- **Mechanical engineer:** Designs and creates products and machines that create or use power, such as generators, engines, refrigerators, turbines, escalators and elevators
- **Mining and geological engineer:** Works with mines to develop safety equipment and procedures to efficiently and safely remove minerals from the earth
- **Nuclear engineer:** Researches and develops systems, tools and processes to use nuclear energy
- **Petroleum engineer:** Designs and creates ways to extract gas and oil from the earth
- **Surveyors:** Advises about the construction of buildings, bridges or other structures for construction, repair or maintenance

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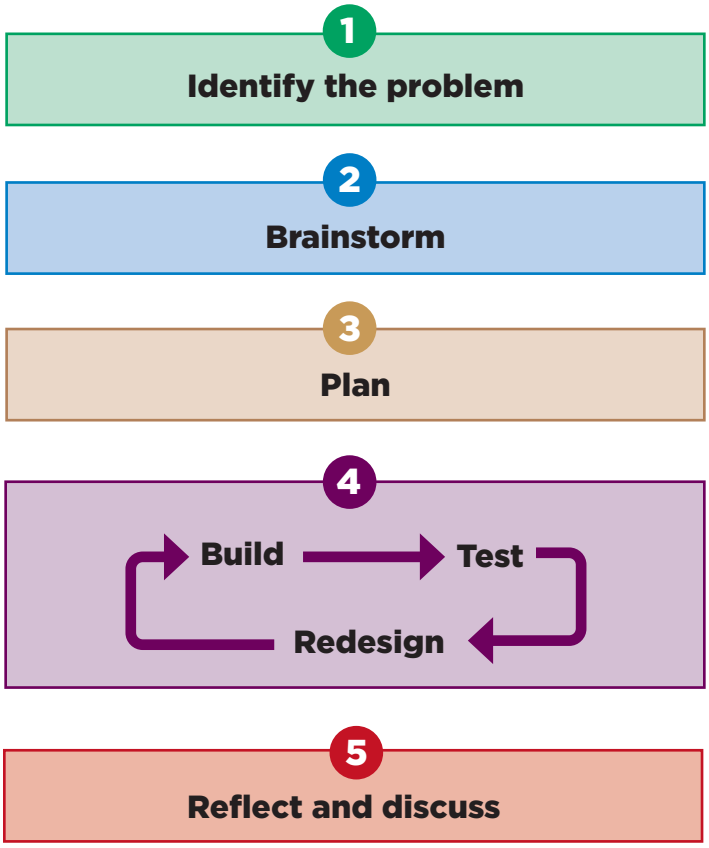
Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Building Like a Beaver

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ large disposable baking foil pans (suggested size: 17 inches long by 12 inches wide by 3 inches deep)
- ❑ Various materials for building a dam, such as sand, potting soil, several small rocks, several pebbles or aquarium gravel, mud, modeling clay, sticks, or leaves
- ❑ Craft sticks
- ❑ Water
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Building Like a Beaver

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Beavers build **dams** using materials such as rocks, branches, grass and mud that are natural to their habitat (where they live). Have you ever wondered why beavers build dams? They build them so that they can stop water from flowing freely to create a pool or pond of water where they can live. This water protects them from **predators** (animals that will kill and eat them). It also allows the beaver to get more food.

Humans build **dams** too using materials such as earth, rock and concrete. Our dams are built to stop water from flowing freely too. With the water that is pooled or ponded we are able to create energy (**hydroelectric power**), use the water to grow crops (**irrigation**), fish, boat, swim and even prevent flooding.

What you will do and learn:

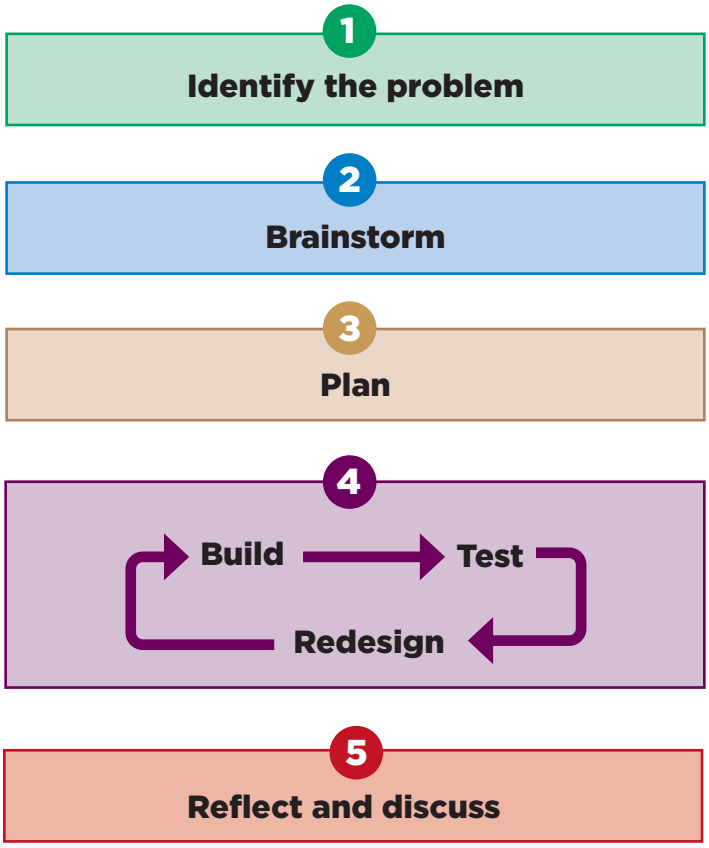
In this activity, you will practice using the engineering process to build a model of a dam. The goal of this activity is to build a dam that prevents water from flowing freely and creates a pool or pond.

Instructions

1. Using the "Engineering Process" handout, start to work through building your dam.
2. Identify the problem: How can you build a dam that prevents water from flowing freely through a pan?
3. Brainstorm: What materials allow water through and what do not? What does it take to make a watertight seal? What do you need to know to build a dam that will prevent water from flowing freely? How can you use your design to create a pool or pond of water? How can you build your dam? What might happen if you pick a different solution?
4. Plan: Make a drawing or sketch of your design. Gather your materials.
5. Build: Build your dam inside the disposable baking pan.
6. Test: Add water to one side of the baking pan. Angle the pan so water might flow to one side. Does the dam hold the water? Does water leak through the dam? Does the dam collapse?
7. Redesign: Make some changes to your design to improve your dam. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: How did you find the solution to this problem? What materials could you use instead of the materials provided today? How would it have been different with different materials?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Egg Drop: Will It Stop?

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Heavy-duty trash bag
- ❑ Eggs (uncooked, still in shell)
- ❑ Various household materials, such as coffee filters, newspaper, yarn or string, plastic cups, tissue paper, chenille stems, straws, plastic baggies, toothpicks and others
- ❑ Tape
- ❑ Scissors
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Place the heavy-duty trash bag on the floor. You may want to use tape to secure it to the floor.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Egg Drop: Will It Stop?

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

A **device** is an object or machine that is made for a specific purpose.

What you will do and learn:

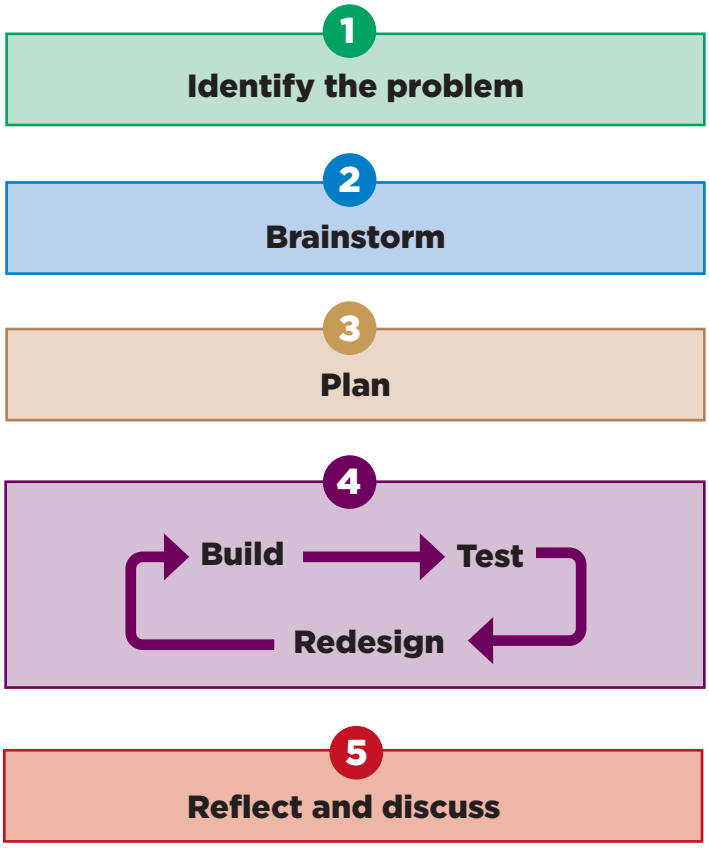
In this activity, you will practice using the engineering process to build a **device** from household items that will protect an egg from breaking when it is dropped. The goal of this activity is to develop a **device** that protects an egg so that when it is dropped, it does not break, but instead, it safely lands on the ground.

Instructions

1. Using the "Engineering Process" handout, start to work through building your device.
2. Identify the problem: How can you build a device to support an egg while it is dropped to keep it from breaking?
3. Brainstorm: Think about other items that keep things safe. How are they constructed? How can you build your device? What materials should you use? How can you keep the egg protected?
4. Plan: Make a drawing or sketch of your design. Gather your materials.
5. Build: Build your device. When you are done building, include your egg into the structure.
6. Test:
   - Hold your egg-protecting device in one hand. Extend your arm out directly in front of you. Open your hand and allow the egg-protecting structure to fall to the ground.
   - Examine your egg-protecting device and egg. Is the egg broken or cracked? Did the structure keep the egg protected?
7. Redesign: Make some changes to the design of your structure to improve its ability to protect the egg. Try some of the other ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: What materials could you use instead of the materials provided today? How would it have been different with different materials? Were you able to achieve the goal?

Engineering Process Handout

Engineering Process



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2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Filter Fun

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ 3–5 clear 2-liter plastic bottles, empty and clean, bottle caps removed
- ❑ Utility knife
- ❑ Large bucket of dirty water (create your own using leaves, dirt, cooking oil or other things or get dirty water from a ditch, puddle, pond, brightly colored flavored drink mix or other sources)
- ❑ Pitcher or measuring cup with a spout
- ❑ 3–5 different filtering materials, such as sand, gravel, potting soil, wood chips, shredded paper, kitty litter, paper towel, and other materials
- ❑ Coffee filters (1 per filtering bottle)
- ❑ 5-gallon bucket
- ❑ Paper
- ❑ Pencils
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Using a utility knife, prepare the 2-liter bottles by cutting 1/3 of the bottle off of the top. Flip the cut top over and place it inside of the bottom of the bottle. This "filter bottle" should look like a funnel.
- Set up the display table and arrange needed supplies. (Participants will use the pitcher or measuring cup with a spout to pour the dirty water. The 5-gallon bucket will be used for discarded water and filtering materials.)

HEADS IN, HEARTS IN

Filter Fun

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

If water is clear, it doesn't mean it's safe to drink. Many **pollutants** (something that makes it unclean) in water are dissolved and are invisible, such as harmful bacteria or certain poisons. When water looks dirty, it is usually because **particulates**, or tiny bits of soil or other material, are **suspended** (hanging, not sinking) in the water. Filters can remove these particulates, even though removing them does not make the water safe to drink.

What you will do and learn:

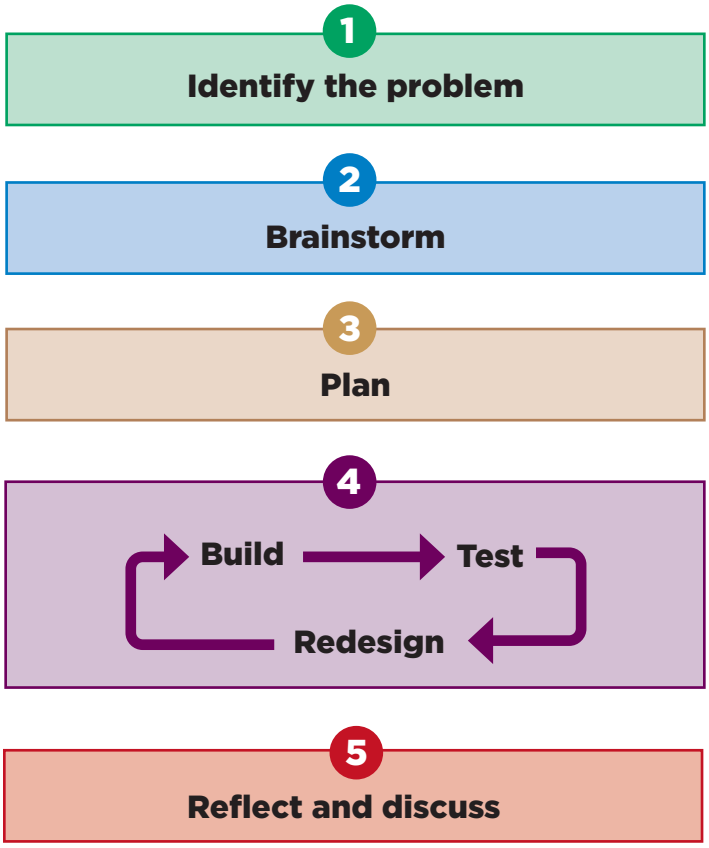
In this activity, you will practice using the engineering process to discover which filtering materials help make water clear. The goal of this activity is to build a filter, which will make the water clear.

Instructions

1. Using the "Engineering Process" handout, start to consider which materials will work best to filter the dirty water.
2. Identify the problem: How do you create a filter that will make the water clear?
3. Brainstorm: How can you use common materials to filter water? What kind of materials will allow water through but not the particulates that make the water look dirty? Should you use one filtering material at a time? Should you combine filtering materials? What happens if you layer the filtering materials?
4. Plan: Make a drawing or sketch of your design. Gather your filter bottle, coffee filters (one for each filter bottle) and filtering materials. Place your chosen filtering materials inside the top of each filter bottle.
5. Test: Using the pitcher or measuring cup with a spout, pour the dirty water over the filtering material of the first filtering bottle. Did the filter make the water clear?
6. Redesign: Build another filter bottle, making some changes to your design to improve your ability to filter water. Try some of the ideas you came up with during your brainstorming.
7. Repeat steps 5 and 6 as many times as needed.
8. Use the 5-gallon bucket for gathering water and filtering materials for disposal. *Do not discard water and materials in a sink.*
9. Reflect and Discuss: What might happen if you pick a different material or use a different way to filter water? Were you able to make the water clearer? What filtering materials worked best? Although this doesn't make water safe to drink, what do you think might be used to make water safe for drinking? What filtering materials could you use instead of the materials provided today? How would it have been different with different materials? How does this process happen in nature?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Hello! Who Is Calling?

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Cups of varying sizes and materials
- ❑ String, yarn or twine
- ❑ Scissors
- ❑ Metal paper clips
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Using the scissors, carefully poke holes in the bottom of each cup.
- Using the scissors, pre-cut the yarn, string or twine into lengths of approximately 4 feet long.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Hello! Who Is Calling?

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

In this activity, you'll explore the transmission of **sound waves**, which are simply vibrations that can travel through any material. Your voice will vibrate the air inside a cup and those vibrations will go through the bottom of the cup and be transferred to the string, yarn or twine to the cup on the other end.

What you will do and learn:

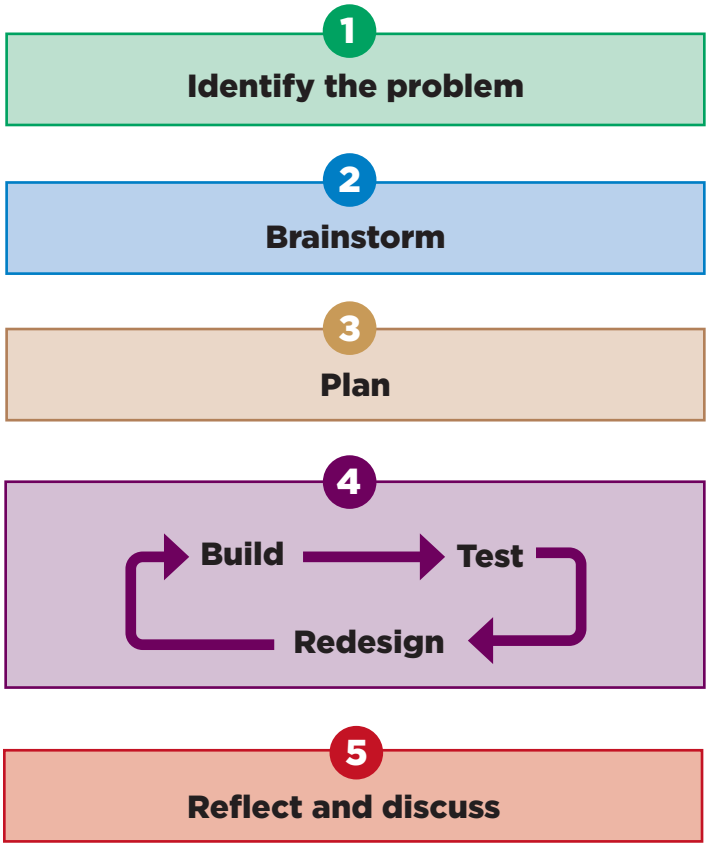
In this activity, you will practice using the engineering process to build a model of a telephone. Engineers often try a variety of building materials to see what works best and you will too. The goal of this activity is to build a model of a telephone to see which materials allow sound waves to travel best.

Instructions

1. Using the "Engineering Process" handout, start to work through building your telephone.
2. Identify the problem: Using cups and string, yarn or twine, design and build a telephone that will allow you to communicate with another person from across the room.
3. Brainstorm: What are your options for your telephone "wire"? What material will transfer sound the best between two cups? Does the length of the string, yarn or twine matter? Does the type of cup matter? Does the size of the cup matter? How will you connect your wire to your cup? How can I build my telephone so that the person on the other end hears me well?
4. Plan: Make a drawing or sketch of your design. Based on your brainstorming, how will you design your phone with the materials you are given? Gather your materials.
5. Build: Build your telephone, using your design.
6. Test:
   - Find a partner. Each of you will take a cup and slowly walk away from each other until the string, yarn or twine is straight and tight, but won't break.
   - One partner will place the cup over their ear while the other partner will talk into their cup. Reverse roles.
   - Can you hear each other talking? What happens when there is slack in the string and it's not held tight? What happens if something is touching the string such as a finger, hand or wall?
7. Redesign: Make some changes to your design to improve the ability for sound waves to travel and your partner to hear. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 5 and 6 as many times as needed.
9. Reflect and Discuss: What type of string, yarn or twine allowed you to hear the best? Do you think the size of the cup was important? Did it matter if it is a paper cup or a plastic cup? Did the length of string, yarn or twine matter? What materials could you use instead of the materials provided today? How would it have been different with different materials? How might this apply to the real world?

Engineering Process Handout

Engineering Process



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2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN Humming Harmonica

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Wide wooden craft sticks (4 per participant or family)
- ❑ Rubber bands (2 per participant or family)
- ❑ Toothpicks (3-4 per participant or family)
- ❑ Plastic straws (3-4 per participants or family)
- ❑ Paper (3-4 per participant or family)
- ❑ Scissors
- ❑ 3 medium-sized bowls to hold supplies (optional)
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Using the scissors, cut the paper into approximately 1-inch by 5 inch-strips. Cut both the toothpicks and the plastic straws into 1-inch pieces.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN Humming Harmonica

Guide for Families

Learning Objectives

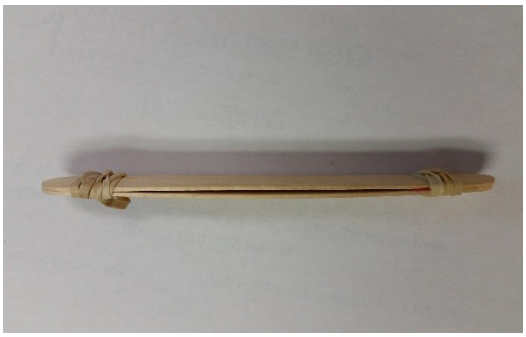
What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Engineers use their skills to design, build and tune musical instruments. The design of an instrument changes the sounds the instrument makes. **Sound** is the noise that you make by creating vibrations (such as singing, humming, whistling or music). The sound can be described in many ways such as warm, ringing or shrill.

What you will do and learn:

In this activity, you will build two harmonicas and practice using the engineering process to create harmonicas that make different sounds.

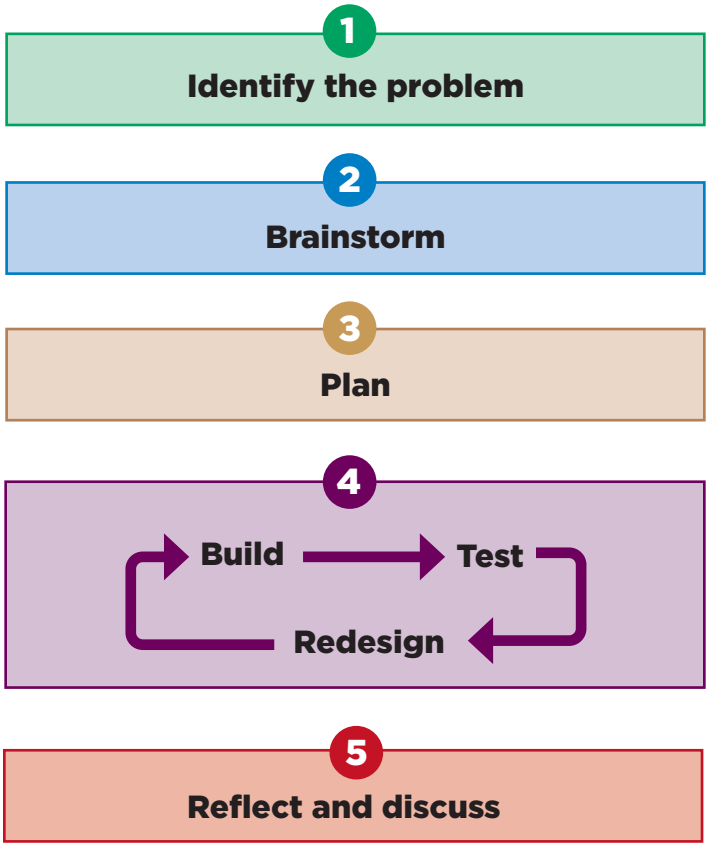


Instructions

1. Build your first harmonica.
   - Sandwich a strip of paper in between two craft sticks.
   - Wrap a rubber band tightly around one end of the craft stick.
   - Slide a toothpick to the inside of the rubber band on one side.
   - While holding the toothpick in place, wrap the other end of the craft sticks with a rubber band until it's tight.
   - You should have two crafts sticks rubber banded together with a toothpick at each end holding the crafts sticks a little bit apart.
2. Using the "Engineering Process" handout, start to work through building your second harmonica.
3. Identify the problem: Can you make two harmonicas with each producing a different sound? Practice using your first harmonica.
4. Brainstorm: How does a harmonica make sound? What features of a harmonica help it make sound or change the sounds it makes?
5. Plan: Discuss how you will alter your design to make a second harmonica that makes a different sound. Gather your materials.
6. Build: Build your second harmonica.
7. Test: Hold your second harmonica up to your lips and blow. Is the sound it makes different from your first harmonica? Does it sound the same or different?
8. Redesign: Modify your harmonicas so they make different sounds. Use the initial directions to help determine how to modify your harmonicas. Try some of the ideas you came up with during your brainstorming.
9. Repeat steps 7 and 8 as many times as needed.
10. Reflect and Discuss: Were the sounds made by your first harmonica different from the second harmonica? What features of musical instruments help to make the sounds they produce? What materials could you use to create different sounds rather than the materials provided today? Could you make one

Engineering Process Handout

Engineering Process



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4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Index Apex

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ 3-inch by 5-inch index cards (25–30 per participant or family)
- ❑ Several yard sticks or measuring tape
- ❑ Ruler(s)
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Index Apex

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Some engineers work to build structures or buildings. A **structure** is the result of building or constructing something by arranging materials or parts. How a structure or building is designed can affect how safe and durable it is. An **apex** is the highest point of something. In this activity, the apex is the tallest point on a tower.

What you will do and learn:

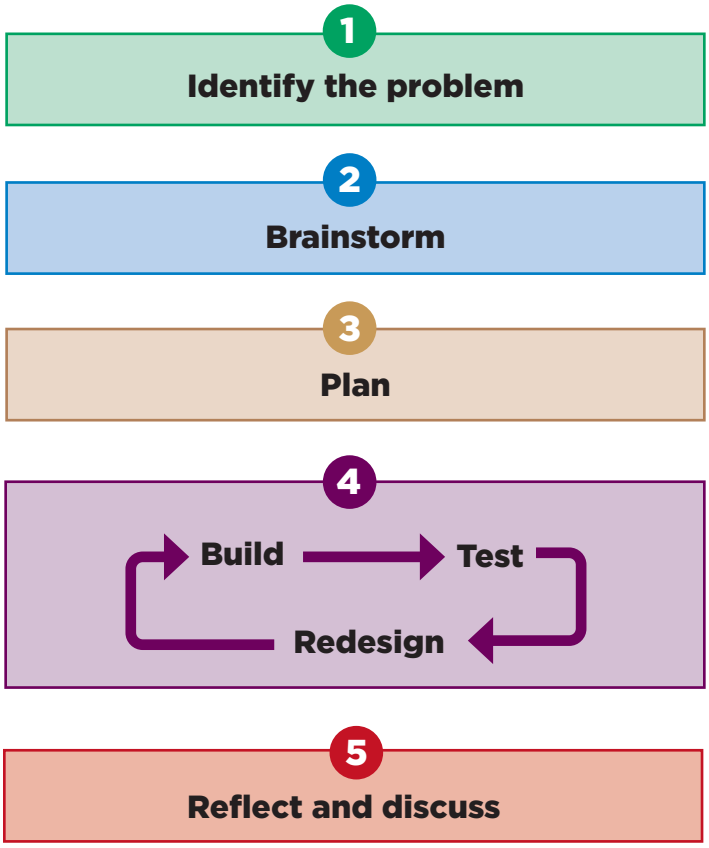
In this activity, you will practice using the engineering process to build a tower structure. The goal of this activity is to build a tower with the highest apex using index cards.

Instructions

1. Using the "Engineering Process" handout, start to work through building your tower.
2. Identify the problem: How can you build the tallest tower possible out of index cards that will stay standing on its own?
3. Brainstorm: How can you build your tower? How many different ways can you stack the cards? Why might one design be better than another? Is one way sturdier? Do you think the angle that you lean the cards against each other will affect the stability of the design?
4. Plan: Make a drawing or sketch of your design. Gather your materials.
5. Build: Build your tower.
6. Test: Use the yardstick or sewing tape measure to measure the height of your tower.
7. Redesign: Make some changes to your design to improve your tower. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: How did you find the solution to this problem? Did your changes lead you to build a taller tower? What materials could you use instead of the materials provided today? How would it have been different with other materials? How might you change your tower design if it had to support weight? How does the design of your tower compare to towers in the real world?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Marble Maze

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Large paper plates
- ❑ Small marble
- ❑ Straws
- ❑ Chenille stems
- ❑ Marker
- ❑ Tape
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Marble Maze

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Engineers design many things for entertainment, such as toys. When designing a toy, engineers consider how to create a toy challenging enough to be fun but not so difficult that the person playing with the toy becomes frustrated and gives up.

What you will do and learn:

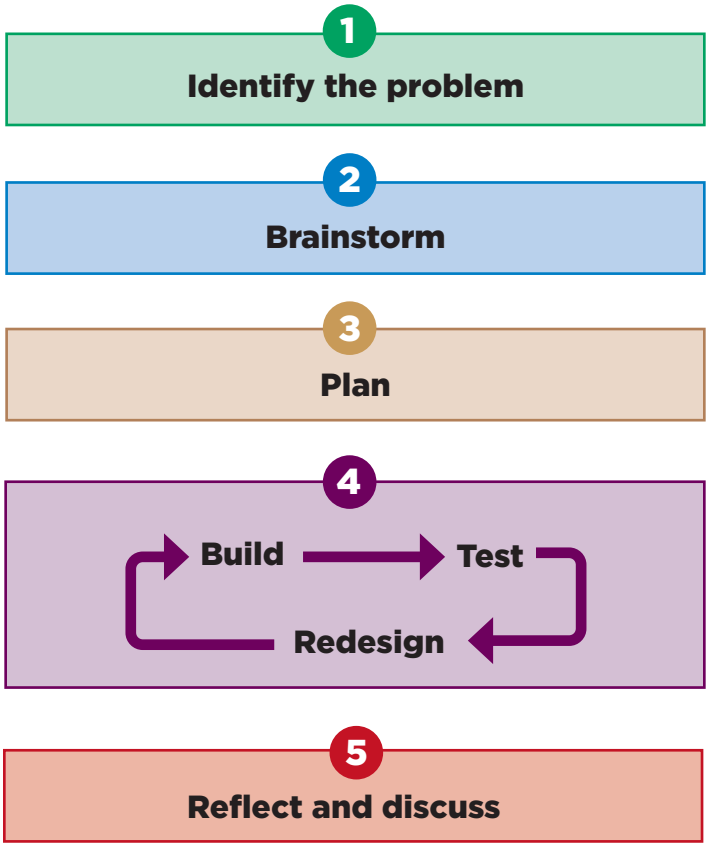
In this activity, you will practice using the engineering process to build a maze. The goal of this activity is to build a maze that a marble can go through from beginning to end while navigating a variety of obstacles.

Instructions

1. Using the "Engineering Process" handout, start to work through building your maze. The paper plate will be the foundation on which your maze is built.
2. Identify the problem: How can I make an entertaining toy that moves a marble using a paper plate as its foundation?
3. Brainstorm: How can you build your maze? What is the purpose of a maze game? Why might it be created? What makes a maze fun? What makes it too easy or too difficult? What skills might you gain playing a maze game?
4. Plan: Make a drawing or sketch of your design. Gather your materials.
5. Build: Build your maze using the paper plate as the foundation. Use straws for the walls of your maze, attaching them to the plate with the tape. Use the marker to label where the marble should "begin" the maze and "end" the maze.
6. Test: Place a marble on the paper plate where it is labeled "begin." Tilt, turn or twist the paper plate to move the marble in the direction it needs to go to navigate through the obstacles. Could you get the marble to the end of the maze? Was there an obstacle where the marble got stuck? Was the maze too easy? Does the maze need additional obstacles?
7. Redesign: Make some changes to your design to improve your maze using the available materials. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: How did you build your maze? What materials would you consider using when making another maze? Can you share your maze with a friend to see if they can move the marble from the beginning to the end? How might this apply to the real world?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN Marshmallow High-Rise

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Jumbo marshmallows (12 per participant or family, plus some extra)
- ❑ Bowl for marshmallows (optional)
- ❑ Wooden 12-inch skewers (8–10 per participant or family)
- ❑ Ruler(s)
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN Marshmallow High-Rise

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

A **structure** is the result of building or constructing something by arranging materials or parts. In engineering, structures are specially designed to be safe and durable. How a structure or building is designed can impact how sturdy and safe it is.

What you will do and learn:

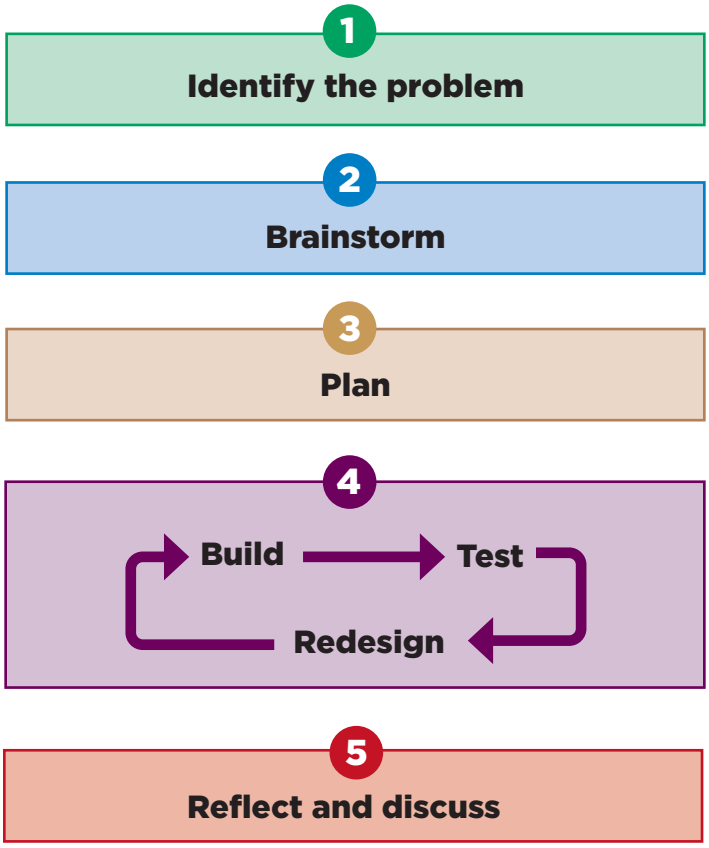
In this activity, you will practice using the engineering process to build a model of a high-rise building out of marshmallows. The goal of this activity is to build the tallest tower you can build that will stay standing on its own.

Instructions

1. Using the "Engineering Process" handout, start to work through building your high-rise.
2. Identify the problem: How can you build the tallest tower that will stay standing on its own?
3. Brainstorm: Have you seen any towers before? (Some examples might be a cellphone tower, high voltage power line tower or the Eiffel Tower.) What do they look like? What features make these towers sturdy and allow them to stand up without falling over? How can you build your tower? Think about other towers you have seen (cellphone towers, the Eiffel Tower, high voltage power lines). How can you make sure that your tower is able to stand on its own?
4. Plan: Make a drawing or sketch of your tower design. Gather your materials.
5. Build: Build your tower using the marshmallows and wooden skewers.
6. Test: Use the ruler to measure the height of your tower. How tall is it? Does it stand up on its own with the marshmallow on top?
7. Redesign: Make some changes to your design to improve your high-rise (make it taller, sturdier, shorter). Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: What materials could you use instead of the materials provided today? How would it have been different with different materials? How is the tower you built different or similar from other towers you have seen? What about your design is similar or different from real towers? How does that affect the ability to be tall?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN Marshmallow Launcher

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Regular-sized marshmallows
- ❑ Bowl for marshmallows (optional)
- ❑ Empty cardboard toilet paper rolls or paper towel rolls
- ❑ Scissors
- ❑ Masking tape
- ❑ Scotch tape
- ❑ Plastic cups (3–5 per participant)
- ❑ Eight 12-inch balloons (3–5 per participant)
- ❑ Ruler, measuring tape or yard stick
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Using masking tape, mark a "starting line" on the floor.
- Set up the display table and arrange needed supplies.
-

HEADS IN, HEARTS IN Marshmallow Launcher

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

In engineering, machines can be used to move objects from one place to another. A **launcher** is a machine that throws an object forward.

What you will do and learn:

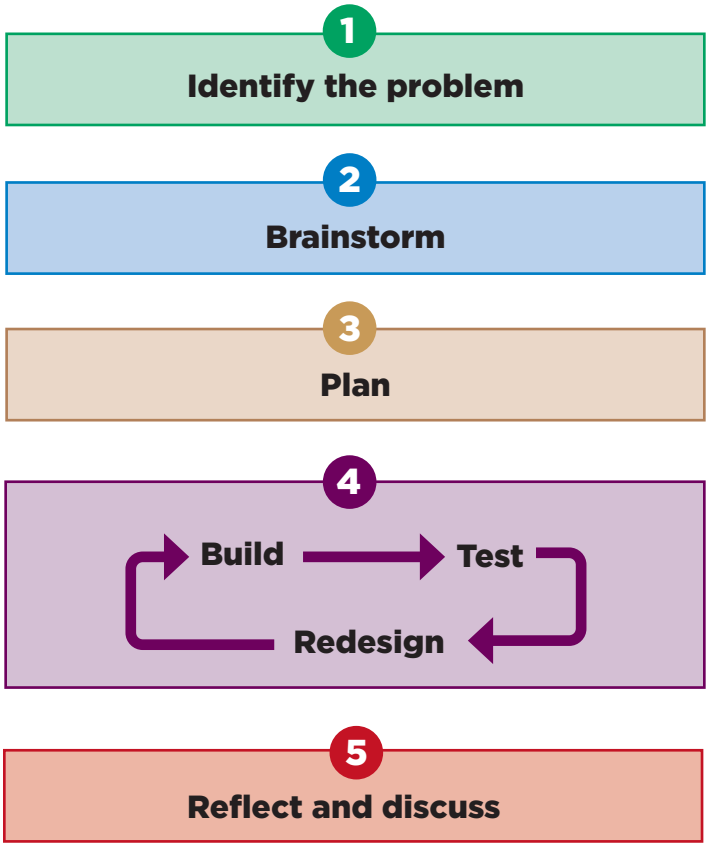
In this activity, you will practice using the engineering process to build a marshmallow launcher. The goal of this activity is to build a launcher that hurls a marshmallow as far away from you as possible.

Instructions

1. Using the "Engineering Process" handout, start to work through building your marshmallow launcher.
2. Identify the problem: How can you build a launcher that throws a marshmallow forward as far away from you as possible?
3. Brainstorm: Where have you seen other launchers? What features of those launchers help them move objects? How can you build your launcher? How can you put materials together to build a device that will launch a marshmallow?
4. Plan: Make a drawing or sketch of your design. Choose the materials that you wish to use to make your launcher.
5. Build: Build your launcher.
6. Test: Stand with your marshmallow launcher at the starting line. Place a marshmallow in your launcher. Launch the marshmallow. Use the ruler, measuring tape or yardstick to see how far your marshmallow went. Did it launch far? Could it launch farther? Are there changes you would make to your launcher to help the marshmallow move farther away from you?
7. Redesign: Make some changes to your design to improve your marshmallow launcher. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: What materials could be safely moved this way in the real world? How important might accuracy be if you were using this to move things in the real world? Is your launcher accurate? What materials could you use instead of the materials provided today? How would it have been different with different materials? How do you think engineers might use launchers in their work?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Paper Airplane Race

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper, 8.5 inch by 11 inch (6–7 sheets per participant or family)
- ❑ Masking tape or painter's tape
- ❑ Ruler, yardstick or measuring tape
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Designate a testing area approximately 25 feet long. Mark a starting line on the floor with masking tape or painter's tape. Using the ruler, yardstick or measuring tape, measure a few distances from the starting line and mark with the tape (1 foot, 3 feet, 5 feet and so on). Safety suggestion: Have a wall as a backdrop to the testing area to stop planes from flying.

HEADS IN, HEARTS IN

Paper Airplane Race

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Aerodynamics is the way air moves around things. When an airplane is flying, aerodynamics is an important factor in keeping a plane in the air. When an airplane is flying, several forces act on a plane including gravity and thrust. **Gravity** is the force that pushes things down toward the earth, as when you throw a ball up into the air and it falls back to the ground. **Thrust** is force that pushes forward. Examples of thrust include the force of an engine on an airplane or the act of throwing a paper airplane forward.

Engineers design airplanes, cars and other machines to move quickly and efficiently taking into consideration aerodynamics, gravity and thrust.

What you will do and learn:

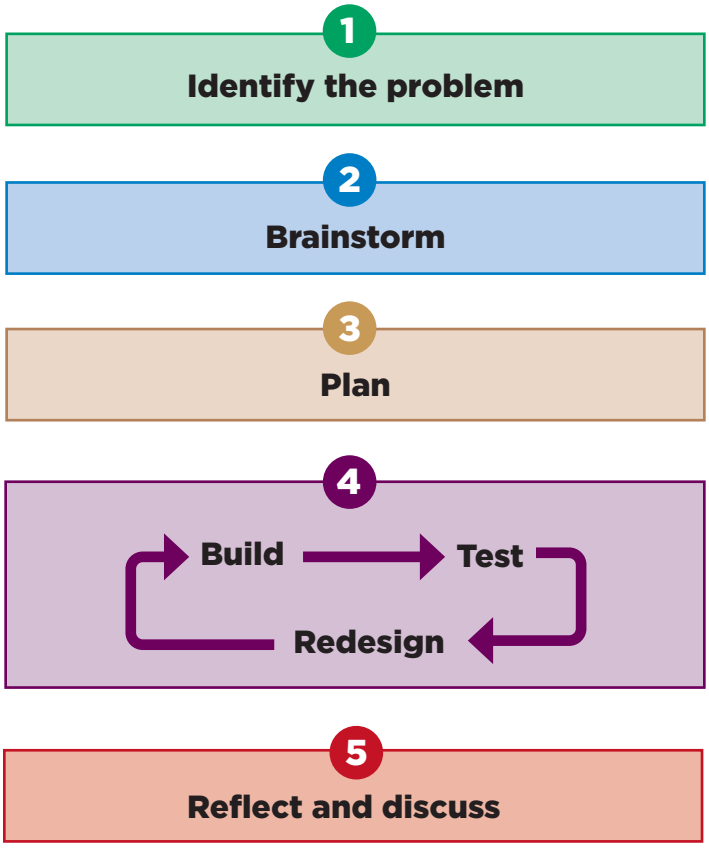
In this activity, you will make a paper airplane. The goal of this activity is to design your airplane to see if you can make one that goes the farthest. You will also explore the role that aerodynamics, thrust and gravity can play in how far it will fly.

Instructions

1. Using the "Engineering Process" handout, start to work through building your paper airplane.
2. Identify the problem: How can you design and build a paper airplane that flies the farthest?
3. Brainstorm: What do you need to know to build a paper airplane? What makes a paper airplane move forward? What makes it fall to the ground? Does how hard you throw a paper airplane influence how far it goes?
4. Think: How can you build your airplane? Think of several different designs for paper airplanes. Do you think a long skinny one will fly further than a wide-winged one?
5. Plan: Gather your materials. Choose which design(s) you think will allow a plane to fly the farthest.
6. Build: Build your airplane.
7. Test: Stand at the starting tape line and throw your airplane. Measure how far it flew using the ruler, yardstick or measuring tape. Throw your airplane a few more times and measure how far it flies. Try to use the same amount of force (thrust) every time you throw the airplane to test. Consider the plane's aerodynamics, or the way that the air moves around it.
8. Redesign: Make some changes to your design to try to increase the distance your airplane will fly. Try some of the ideas you came up with during your brainstorming.
9. Repeat steps 7 and 8 as many times as needed.
10. Reflect and Discuss: How did you find the solution to this problem? What materials could you use instead of the materials provided today? How would it have been different with different materials? What kind of designs do real airplanes have? How are real airplanes similar or different from paper airplanes? Have you ever seen an airplane that looks like your paper airplane?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Peanut Hut

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Toothpicks
- ❑ Cornstarch packing peanuts
- ❑ Water
- ❑ Container to pour water such as measuring cup with spout or plastic water bottle
- ❑ Small toy
- ❑ Heavy book
- ❑ One 1-gallon plastic bag that seals closed
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Place the heavy book in the gallon bag and seal it to ensure the book does not get wet.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Peanut Hut

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Some engineers work to build structures or buildings. A **structure** is the result of building or constructing something by arranging materials or parts. In engineering, structures are specially designed to make buildings safe and durable. How a structure or building is designed can affect how sturdy and safe it is.

What you will do and learn:

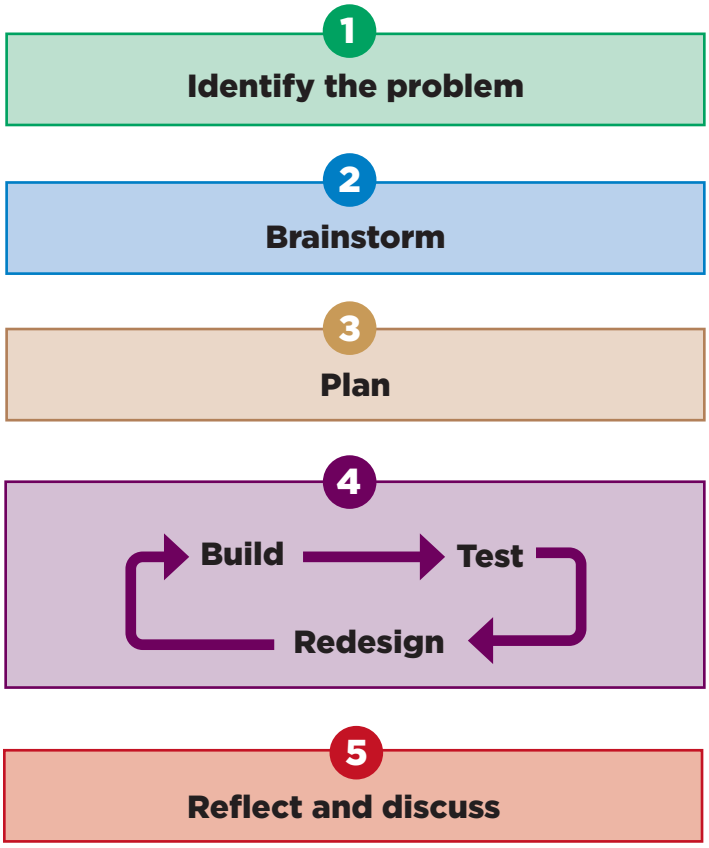
In this activity, you will practice using the engineering process to build the model of a hut. A hut is a simple structure or dwelling that can be compared to a tent, igloo or small shelter. The goal of this activity is to build a hut that can fit a small toy inside and is strong enough to support a heavy book without collapsing.

Instructions

1. Using the "Engineering Process" handout, start to work through building your hut.
2. Identify the problem: How can you build a structure strong enough to support a heavy book, as well as house a small toy?
3. Brainstorm: How can you build your hut? What might the structure look like? Think about other structures you have seen that can support a heavy weight. What shapes were the structures? Getting the packing peanuts wet will help them stick together; how can you stick them together to build a structure? How could you use the toothpicks to make your structure?
4. Plan: Gather your toothpicks, packing peanuts and water. Make a drawing or sketch of your design.
5. Build: Build your hut. Adding a little water to the packing peanuts makes them sticky so they will stick together.
6. Test: Put the small toy inside your hut to make sure it fits. Then, place the heavy book on top of your hut. Does the hut support the book?
7. Redesign: Make some changes to your design to improve your hut. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: How sturdy was the structure that you built? How does the amount of water used affect the strength of the hut? Did the toothpicks help make your design sturdier? Are buildings in the real world designed similar to your hut? Why or why not? What materials could you use instead of the materials provided today? How might this apply to the real world?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Pingpong Catapults

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Pieces of cardboard cut into 6-inch by 6-inch squares
- ❑ Scissors
- ❑ Plastic spoons (2 per participant)
- ❑ Rubber bands (4 per participant)
- ❑ Masking tape
- ❑ Plastic straws (4 per participant)
- ❑ Popsicle sticks (8 per participant)
- ❑ Pingpong balls
- ❑ Measuring tape, yardstick or ruler
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Cut cardboard pieces into 6-inch by 6-inch squares. (Scrap pieces from shipping boxes work great.)
- Set up the display table and arrange needed supplies

HEADS IN, HEARTS IN Pingpong Catapults

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

A **catapult** is a type of launcher. One type of catapult can be made using a rubber band. The launching process involves a transfer of energy. The energy transfer happens when you pull the rubber band back and then you release it. Rubber bands are elastic. The elasticity allows you to stretch the band and then enables the band to return to its original shape.

What you will do and learn:

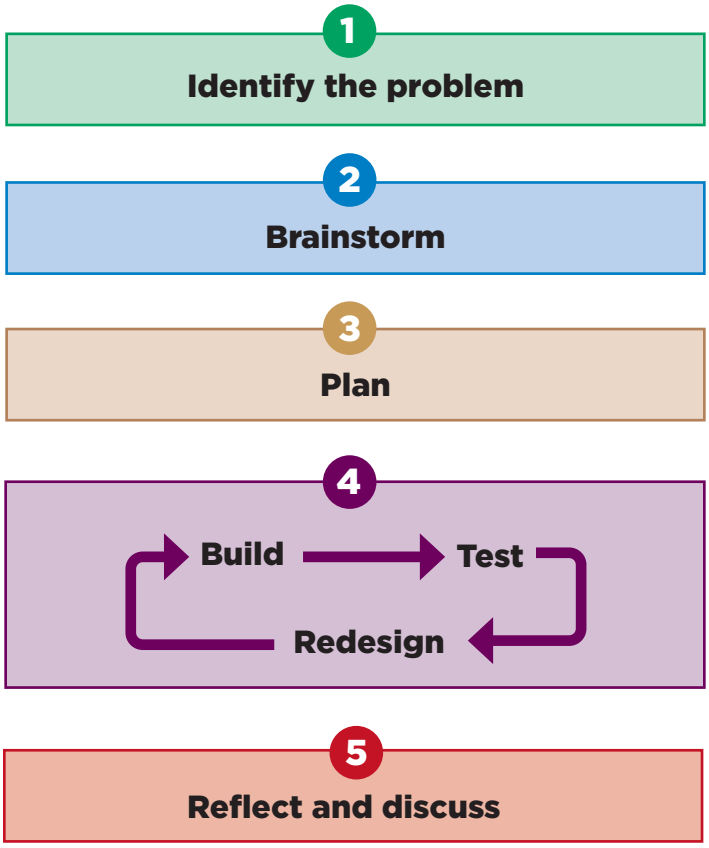
In this activity, you will practice using the engineering process to build a catapult. The goal of this activity is to see how far you can launch a pingpong ball using your catapult.

Instructions

1. Using the "Engineering Process" handout, start to work through building your catapult.
2. Identify the problem: How can you build a catapult that will launch a pingpong ball as far as you can?
3. Brainstorm: Have you ever seen a catapult? How does it work? What about the catapult makes things fly further? Where does the energy come from to launch a catapult? How will you keep the pingpong ball in your catapult?
4. Plan: Make a drawing or sketch of your catapult design. Gather your materials.
5. Build: Build your catapult using the supplied materials.
6. Test: Load a pingpong ball into your catapult, pull it back and let your pingpong ball fly. Using the measuring tape, yardstick or ruler, measure the distance the pingpong ball traveled.
7. Redesign: Make some changes to your design to improve your catapult. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: What are some real-world uses for catapults? What materials might you use if you wanted to make a catapult on a larger scale? What else could you use besides a rubber band?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Pulley Power

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Jumbo craft sticks
- ❑ Small 3-ounce or 5-ounce paper cups (3–4 per participant or family)
- ❑ One-hole punch (optional)
- ❑ Scissors
- ❑ Small wooden or plastic spool, such as an empty spool of thread or spool purchased from a craft store (1 per participant or family)
- ❑ Unsharpened pencils (1 per participant or family)
- ❑ String
- ❑ Tape
- ❑ Small toy
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print
- Using the one-hole punch or scissors, make a hole at the top of the cup (the part you drink from) approximately half an inch from the top. Next, make another hole directly across from the first hole.
- Using the scissors, cut the string into approximately 6-inch to 8-inch strips.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Pulley Power

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Pulleys are simple machines that use a rope or string wrapped around a wheel to move an object from one place to another. One end of the rope is attached to an object that needs to move and then the rope goes through a pulley. The other end is attached to a person or motor that works to help the object move.

In engineering, pulleys are used to move objects. An elevator uses pulleys to move people and objects to different floors in a building. Pulleys are also used in exercise equipment, window blinds and garage doors. Multiple pulleys can also be used in systems to reduce the force needed to move an object.

What you will do and learn:

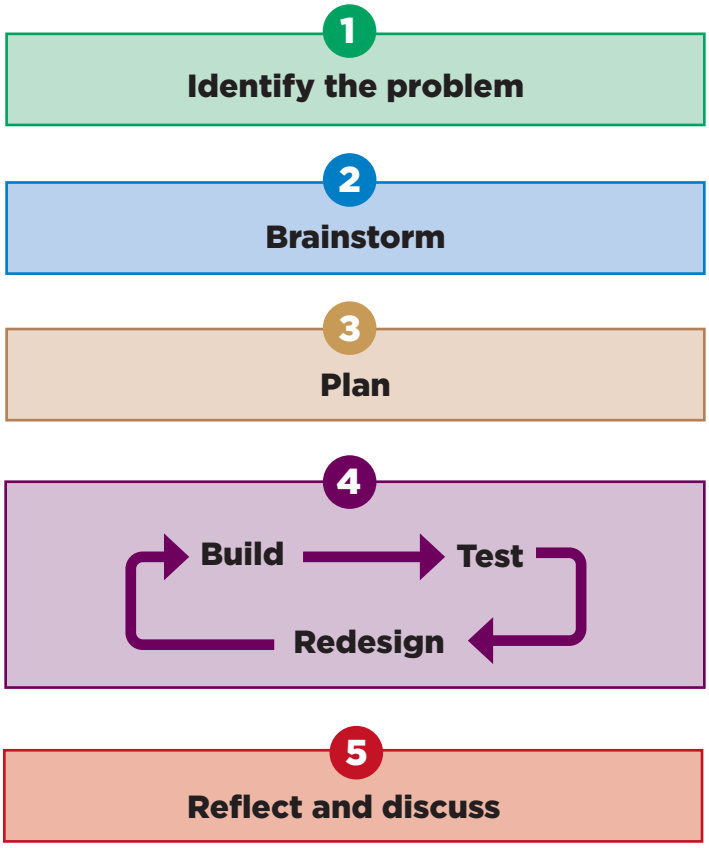
In this activity, you will practice building different pulley systems. The goal of this activity is to build your own pulley to lift a small toy.

Instructions

1. Using the "Engineering Process" handout, start to work through building your first pulley.
2. Identify the problem: Build your own pulley to lift a small toy.
3. Brainstorm: Why do we use pulleys? Is it easier to pull down or push up? How can you build your pulley? What might happen if you pick a different solution?
4. Plan: Make a drawing or sketch of your tower design. Gather your materials.
5. Build: Build your first pulley using any of the materials provided.
6. Test: Place several washers in the cup and test your pulley. How well does it work? Does it support the weight in the cup? What happens when you add more weight or take weight away from the pulley?
7. Redesign: Make some changes to your design to improve your pulley. Try using different materials. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: Where else do you see pulleys used in the real world? Why would you want to change the direction you are pulling something? What do you think might happen if you used multiple pulleys?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

Rockin' Roller Coaster

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Foam pipe insulation at least 1.5 inches in diameter
- ❑ Sharp scissors or utility knife (for use by an adult only)
- ❑ Painter's tape
- ❑ Marbles or metal ball bearings, small wooden balls or rubber balls
- ❑ Cups
- ❑ Chair, desk, wall or other stationary item
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Using the sharp scissors or utility knife, cut the foam pipe insulation in half, lengthwise, to form two U-shaped trenches. Next, cut the U-shaped trenches in lengths of at least 6 feet long.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

Rockin' Roller Coaster

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

For the marble to stay on the track, it must have the correct speed and be moving in the correct direction. **Speed** is the distance you go in a particular amount of time (such as miles per hour). Engineers use their understanding of speed to design and build machines such as roller coasters to make sure that people are safe.

What you will do and learn:

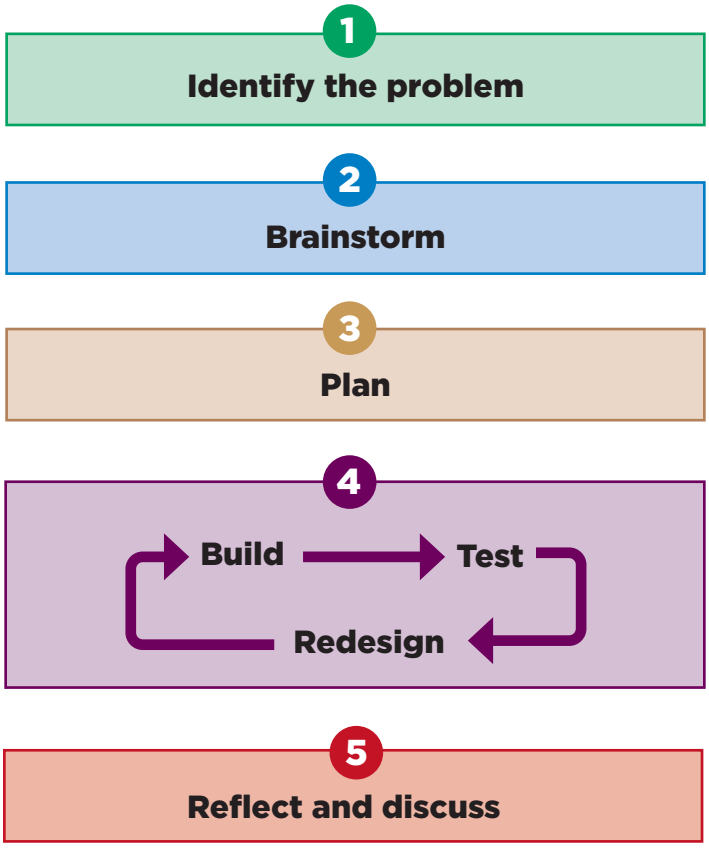
In this activity, you will practice using the engineering process to build a roller coaster that contains at least one upside-down loop, and holds a marble in its track from beginning to end without falling out. For the marble to stay on the track, you must pay attention to its speed.

Instructions

1. Using the "Engineering Process" handout, start to work through building your roller coaster.
2. Identify the problem: Build a roller coaster that will hold a marble that will go through an upside-down loop without it falling out.
3. Brainstorm: What keeps a roller coaster on a track when it goes upside down? Is that the same or different from what would keep a marble in the track? Would a marble be more likely to stay in the track if it was faster or slower? How might you help the marble go faster or slower? Does the weight or size of the marble make a difference?
4. Plan: Make a drawing or sketch of your design. Gather your materials.
5. Build: Build your roller coaster. Remember that it needs to have at least one upside-down loop. Use the cup at the end of your roller coaster to catch your marble.
6. Test: Place a marble at the beginning of the roller coaster. Let it go. Did the marble follow the curves and twists of the roller coaster? Did the marble get to the end of the roller coaster? Was it able to stay inside the track when it went upside down? Did your marble need more speed?
7. Redesign: Make some changes to your design to improve your roller coaster. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: Did your marble stay in the track when it was fast and slow? Why or why not? How is a roller coaster the same and different from a marble on a track? How do you think the speed on a real roller coaster is altered to keep both the coasters on the track and the riders in their seats?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN
The Strongest Column
Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper (for drawing design)
- ❑ Pencils
- ❑ Tape
- ❑ 8.5-inch by 11-inch copy paper (5–7 per participant or family)
- ❑ Several lightweight books
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print one "Engineering Process" handout per participant or family. Optionally, print and laminate a few to leave on the table.
- Set up the display table and arrange needed supplies.

HEADS IN, HEARTS IN

The Strongest Column

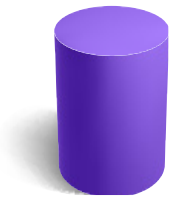
Guide for Families

Learning Objectives

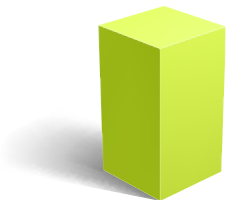
What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

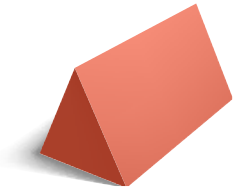
Some engineers work to build structures or buildings. A **structure** is the result of building or constructing something by arranging materials or parts. How a structure or building is designed can affect how safe and durable it is. A **column** is part of a structure designed to support a larger structure above it. For example, four poles, or columns, can hold up the roof of a pavilion. Columns come in various shapes such as a **cylinder**, a **triangular prism** or a **rectangular prism**.



cylinder



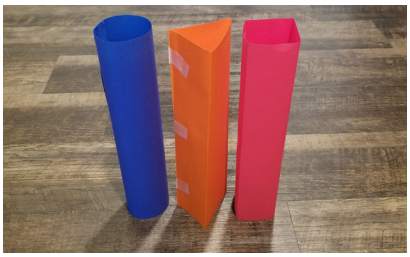
rectangular prism

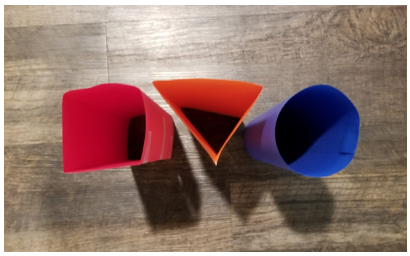


triangular prism

Instructions

1. Using the "Engineering Process" handout, start to work through building your column.
2. Identify the problem: Build a table that can support six books using tape and paper.
3. Brainstorm: Why might different column shapes support more weight than others? Which column shape do you think will build the strongest support? How many legs do you need for your table?
4. Plan: Make a drawing or sketch of your design. Gather your materials.
5. Build: Build tables. If you are having trouble coming up with a design on your own, you can use the following column shapes in your design, or come up with one of your own:
   - Cylinder: Roll a piece of paper, and tape it together to make a cylinder.
   - Triangular Prism: Take a piece of paper and fold it into thirds lengthwise. Tape the two edges together so the ends make a triangle shape.
   - Rectangular Prism: Take a piece of paper and fold it into fourths lengthwise. Tape the two edges together so the ends make a square shape.

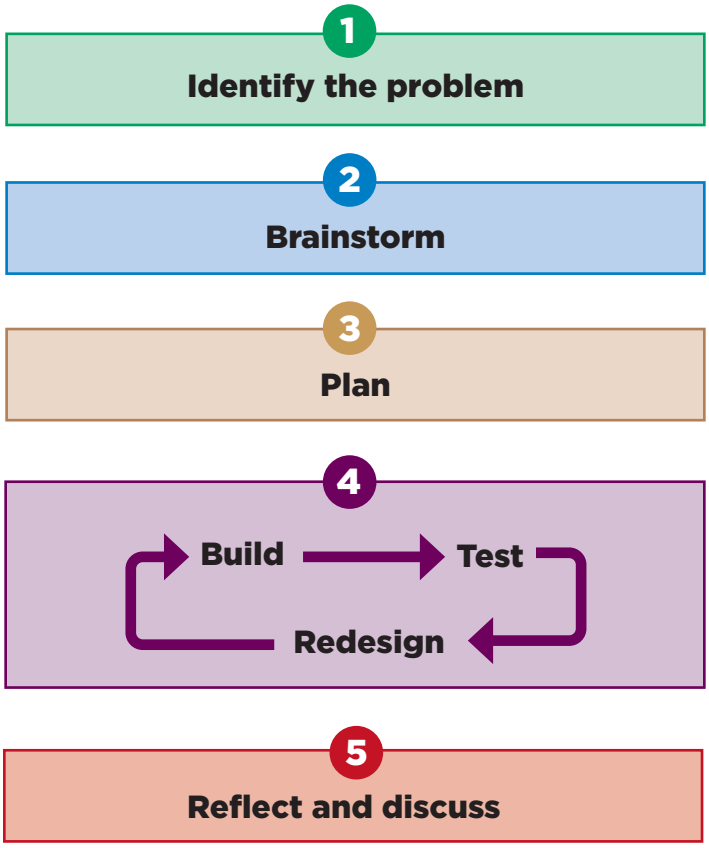




6. Test:
   - Will your table hold six books? Test your design and find out.
7. Redesign: Make some changes to your design or create a new table with a different design to see if your table can hold more weight.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: How did your table hold up when supporting six books? What other materials could support the weight of six books? How would a solid design compare to a hollow design?

Engineering Process Handout

Engineering Process



1. **Identify the problem:** Engineering is about identifying problems and designing solutions. As you go through these activities, think of the goal you are trying to achieve.
2. **Brainstorm:** What are the many different ways I could solve this problem? What are the potential advantages and disadvantages of different ideas? What things do I need to think about to make that solution successful?
3. **Plan:** What are the different ways I can solve this problem or make the build? What steps can I take to try out my solution? What do I need to do to prepare my build? What might happen if I choose that solution? During your design phase, you might discover new problems that you need to brainstorm.
4. **Build:** Construct and carry out the design. As you build your design, you might come up with more problems that you need to brainstorm and design new ideas for.

   Test: How does my solution work? Does it solve the problem? Is it effective? Are there additional problems?

   Redesign: How can I improve my design? What can I try to make my solution work better?
5. **Reflect and Discuss:** How did the solution turn out? What could I do differently next time? How would my design be different if I had different materials?

HEADS IN, HEARTS IN

A Tube Rube

Instructions for Set-Up

Supplies

- ❑ "Guide for Families" handout
- ❑ Clear plastic standup display (optional)
- ❑ "Engineering Process" handout (1 per participant or family)
- ❑ Paper
- ❑ Pencils
- ❑ Marbles (1 per participant or family)
- ❑ Paper towel tubes
- ❑ Toilet paper tubes
- ❑ Various household materials, such as dominoes, blocks, toy cards, books, balls, fans, plastic tubing, cardboard, cereal boxes, popsicle sticks, string, balloons, tape, rubber bands, cups, bowls, and others
- ❑ Display table

Activity Preparation

- Purchase or locate items on supply list.
- Print one copy of the "Guide for Families" handout. Laminate or place in a clear plastic standup display to allow participants to see it more readily.
- Print the "Engineering Process" handout, one per participant or family. Optionally, print and laminate a few to leave on the table.
- Set up the display table and arrange needed supplies.
-

HEADS IN, HEARTS IN

A Tube Rube

Guide for Families

Learning Objectives

What you need to know:

Engineering is a process used to solve problems by designing, building and testing things. An engineer is a person who uses math and science to create new things, solve problems or make things better.

Engineers are in charge of building machines to accomplish many different tasks such as moving materials from one place to another or putting a product together. A **Rube Goldberg machine** is built to accomplish a simple task in an interesting way. (Rube Goldberg was an American cartoonist and inventor known for his cartoons showing complicated gadgets performing simple tasks.)

What you will do and learn:

In this activity, you will use engineering skills to design and build a Rube Goldberg machine to get a marble through a cardboard tube and into a cup. You can use any materials to build your machine and build it any way you want as long as it results in the marble moving through a tube and into a cup as the last step. Try using multiple materials to find an interesting way to end up with the marble in a cup.

Instructions

1. Using the "Engineering Process" handout, start to work through building your Rube Goldberg machine.
2. Identify the problem: How can you move a marble through a tube into a cup with the most steps?
3. Brainstorm: How can you build the machine? What might happen if you pick a different solution?
4. Plan: Make a drawing or sketch of your design. Try to include at least three different steps in your plan. Gather your materials.
5. Build: Build your machine.
6. Test: Test your machine to see if, through multiple steps, you can make a marble move through a cardboard tube and into a cup as your last step. Watch what happens and where the marble lands. Does your machine work and move your marble through the tube and into the cup?
7. Redesign: Make some changes to your design to improve your machine or make it more complicated. Try some of the ideas you came up with during your brainstorming.
8. Repeat steps 6 and 7 as many times as needed.
9. Reflect and Discuss: How did you find the solution to this problem? What materials could you use instead of the materials provided today? How would it have been different with different materials?