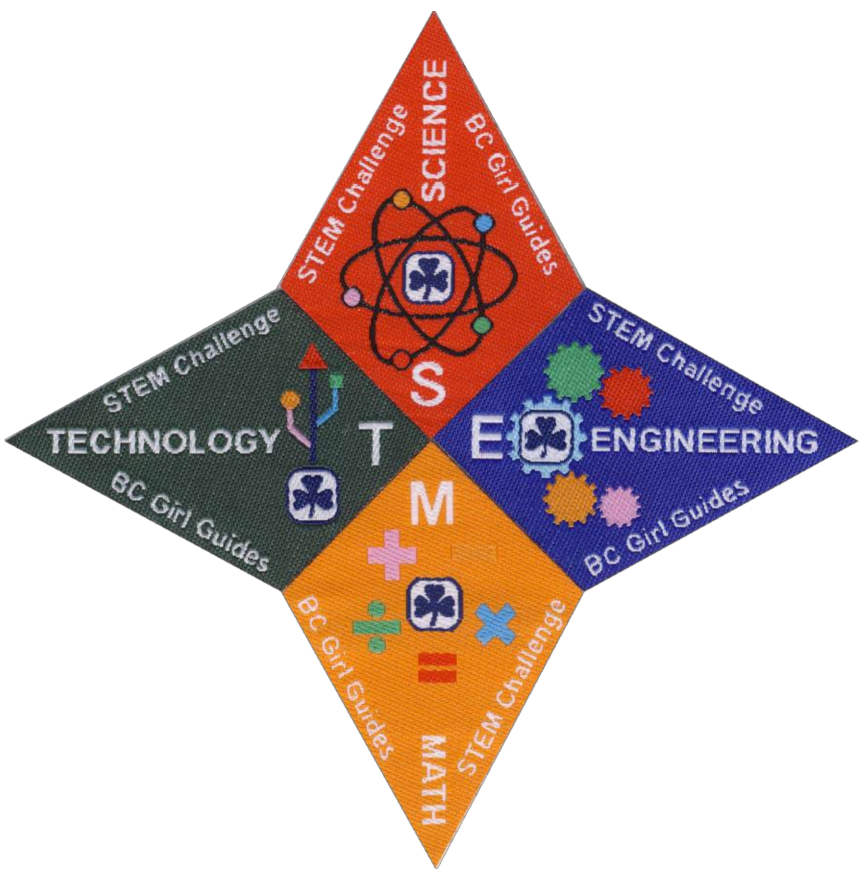
# STEM CHALLENGE: ENGINEERING

A FOUR-PART STEM CHALLENGE
FROM THE EC PROGRAM COMMITTEE



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# INTRODUCTION TO THE STEM CHALLENGE

Welcome to the new, updated Science, Technology, Engineering and Math Challenge from the BC Program Committee. This is a four-part challenge: one booklet and ribbon crest for each Science, Technology, Engineering and Math. Do just the parts that interest you, or tackle all four and proudly display the complete crest on your camp blanket.

The STEM Challenge is an update of the Science in a Box and Youth Exploring Technology (GET) challenges launched by the BC Program Committee several years ago.

As you work on the challenge, please remember: We'd love to hear from you! Please let us know what activities you've done and what you thought of the STEM Challenge.

Sincerely,

The BC Program Committee

## Objectives

To engage youth in engineering.

To have fun while exploring the fields of engineering and applied science.

## Outcomes

After this challenge, youth will demonstrate an improved awareness of and interest in:

1. the concepts of civil engineering.
2. the concepts of mechanical engineering.
3. the concepts of electrical engineering.
4. the concepts of chemical engineering.
5. the engineering process.

## What is Engineering, Exactly?

*Scientists study the world as it is; engineers create the world that has never been. —Theodore von Kármán, aeronautical engineer*

Merriam-Webster defines engineering as "the application of science and mathematics by which the properties of matter and energy sources in nature are useful to people." In other words, engineering is the process of making science useful. Scientists observe the natural world, develop theories about what they see, and then experiment to prove (or disprove) their theories. Once the theories have been put through the wringer and survived, engineers take the science and apply it to real-world problems—they make it useful to people. Consequently, engineering is also often referred to as *applied science*.

There is plenty of overlap between pure science and engineering, and it isn't always easy (or possible, or even desirable) to tell where one leaves off and the other begins. As a rule of thumb, you can look at it this way: If you are asking questions about why something is the way it is ("Why are cylinders so strong?" "Why do the planets appear to move through the sky?" "Why do baking soda and vinegar fizz when you mix them?"), you're doing science. If you already know that something is the way it is and you're trying to use that information to accomplish a goal ("Can I use a cylinder shape to support a bridge or building?" "What do I have to do to land a spaceship on Mars?" "Can I use a baking-soda-and-vinegar-reaction to drive a model boat?"), it's engineering.

In this part of the STEM Challenge, you'll notice that many activities don't have precise step-by-step instructions telling you exactly how to do something. That's because this part of the challenge is all about problem-solving: you have a problem you need to solve or a goal you want to accomplish; figuring out how is up to you. Also, in some of these activities, you will have limited resources—as in any real engineering job, there is only so much material, money, and time; sometimes, getting the job done within those constraints means making trade-offs and compromises. Be creative, be resourceful, be practical: be an engineer!

## Challenge Requirements

To earn the ribbon crest for this part of the STEM Challenge, you must complete activities to earn "challenge credits," depending on your branch of Guiding. You can select these activities from this booklet or choose activities from the Internet, books or magazines, other Guiders or people in your community, or any other resources. As long as the activities are challenging for your group and fit the objectives of this part of the STEM Challenge, go ahead and use them. (If you come across something cool, please let us know so we can add it to any future STEM-related challenges!)

The "challenge credit" system is new – activities that require more time to complete will earn more credits than quick activities. The challenge tracking sheet lists the number of challenge credits per activity. Suppose you would like to complete an alternate activity requiring more time and in-depth study. In that case, you can use your judgment to determine how many credits the activity should be worth.

The Program Committee has produced a variety of program resources that include STEM activities. Look for these resources on the *BC Girl Guides website*:

- Science in a Box – Program tab > Program Resources > STEM
- Eco-Pak Challenge – Program tab > Challenges & Activities > Provincial Challenges
- CSI Challenge – Program tab > Challenges & Activities > Provincial Challenges
- Branch-specific Instant Meeting booklets – Program tab > Instant Meetings
- FunFinder Program Resource – Program tab > FunFinder

| | Sparks | Embers | Guides | Pathfinders | Rangers/ Adults |
|---|---|---|---|---|---|
| **Total number of credits required.** | 3 | 4 | 5 | 5 | 5 |

## Crest Information

When you have completed the activities, complete the BC Challenge Crest, Pin, and Camp To Go Order Form, which can also be found on the BC Girl Guides website (click on Youth Engagement > Program > Program Challenges). Before filling out the Order form, please read the BC Challenge Crest, Pin, and Camp To Go Information document in order to understand the pricing and payment for the various crests, pins and merchandise.

# STEM CHALLENGE: ENGINEERING TRACKING SHEET

| Sparks | Embers | Guides | Pathfinders | Rangers/ Adults |
|---|---|---|---|---|
| 3 | 4 | 5 | 5 | 5 |

Except where indicated, activities in this challenge are worth 1 credit each.

- ❑ Discover Engineering (first activity)
- ❑ Discover Engineering (second activity)
- ❑ Build a Shelter (S, E)
- ❑ Build a Solar Still
- ❑ Egg Protectors (2 credits)
- ❑ Bridge Building – with glue or tape
- ❑ Rockets – Balloon or Paper
- ❑ Coin Sorter (2 credits)
- ❑ Build a Robot: Imagination Robot (S,E)
- ❑ Build a Robot: NanoRover (2 credits)
- ❑ Build a Robot: Robotic Arm (2 credits)
- ❑ Build a Light Bulb
- ❑ Wind Energy Pinwheels
- ❑ Solar Cooking (2 credits)
- ❑ Go Fly a Kite
- ❑ Paper Airplanes
- ❑ Hoop Gliders
- ❑ Reverse Engineering
- ❑ Rubber Band Power (2 credits)
- ❑ Build a Sail Car
- ❑ Build a Mousetrap Car (2 credits) (P,R)
- ❑ Build an Aluminum Boat (1 credit) *OR*
- ❑ Build a Raft (2 credits)
- ❑ Build a Rollercoaster (2 credits)
- ❑ Marshmallow Structures
- ❑ Marshmallow Catapult
- ❑ Kitchen Cookie Engineering (2 credits)

**Eco Pak Challenge Activities**

The following activities from the Eco Pak challenge are related to Environmental Engineering and may be applied to both challenges.

- ❑ The Great Cookie Extraction
- ❑ Dilution: A Pollution Solution
- ❑ Making Recycled Paper
- ❑ Oil Spill
- ❑ Plastic Bits' N Pieces
- ❑ Make an Air Pollution Collector

**CSI Challenge Activities**

The following activities from the CSI challenge are related to Genetic Engineering and may be applied to both challenges.

- ❑ How Alike Are We?
- ❑ DNA Extraction
- ❑ Bar Code DNA

**Other Engineering Activities**

Alternate activities that meet the objective of this challenge.

- ❑ ______________________________
- ❑ ______________________________
- ❑ ______________________________
- ❑ ______________________________

# ACTIVITIES

## Discover Engineering

Engineering is a huge field. Engineers build bridges, airplanes and computers. They work in space programs and in medical technology. Spend some time getting to know engineers and what they do.

### Directions

Choose one of the following activities (or come up with your own) to learn about different kinds of engineers, where they work and what they do. If several of these activities interest you, please do more than one! You can count up to two of them towards the Engineering challenge.

6. Find out about different types of engineering. A basic list can be found at http://www.aboriginalaccess.ca/adults/types-of-engineering.

   Complete the included crossword puzzle.

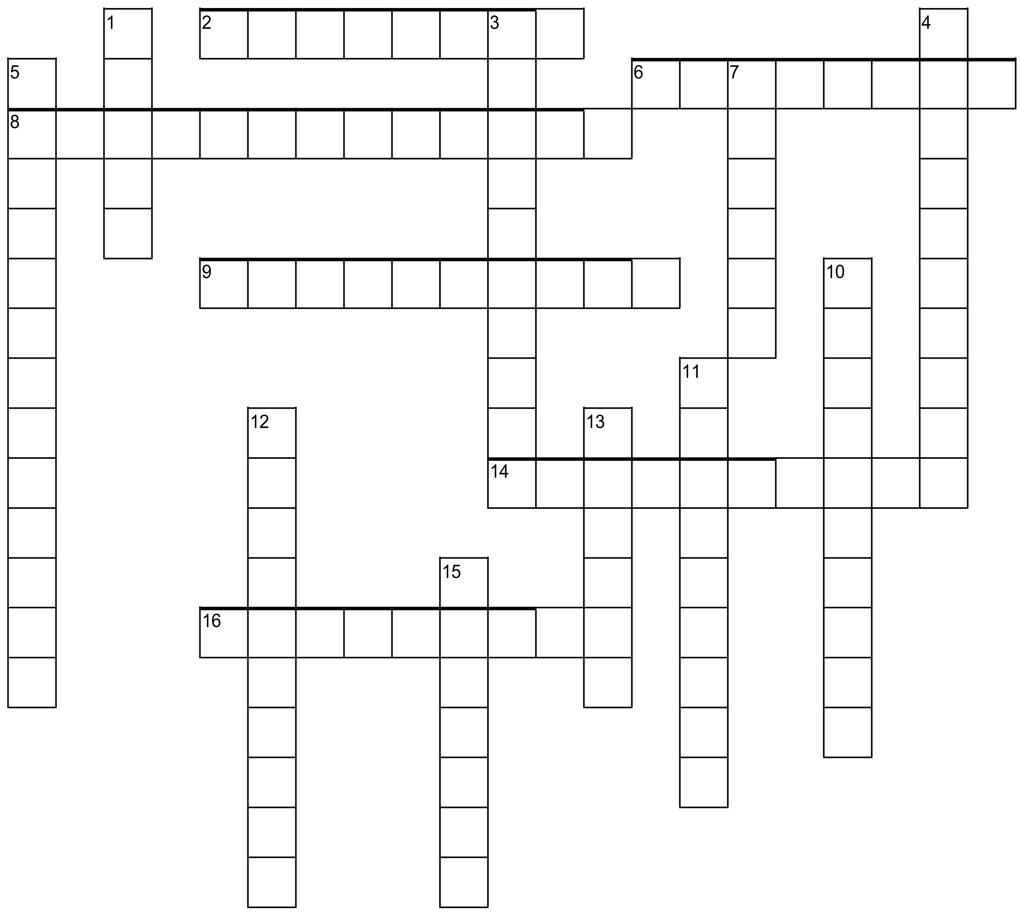
Visit an engineer at work. Tour her workplace and discover what they do and how they do it. If you're not sure where to find engineers at work, try these ideas:

- Construction sites/companies
- Universities
- Industrial sites include factories, mines, sawmills, hydroelectric dams, etc.
- Forestry companies
- Municipal engineering departments
- Large companies that might have a computer engineer as part of their IT staff
- Technology companies

7. Create a work of art that illustrates an engineering principle or shows what engineers do. For example:
   - Make a collage of photos from magazines showing engineers at work.
   - Build a sculpture that uses simple machines, electronics, construction materials or other engineering materials.
   - Design a poster illustrating the work of a famous engineer (past or present). Check out the National Engineering Month website at *www.nem-mng.ca*.
8. Find a current news or magazine article about engineers and their work and share it with your group. What makes the article interesting to you?
9. Watch a video or play a game about engineers and their work. For some good online resources, check out the following link:
   - Discover Engineering (*www.discoverE.org*): Website developed by the US National Engineers Week Foundation. It has videos with good kid appeal and ideas for follow-on activities.
10. Take part in a National Engineering Month activity in your community. National Engineering Month is in March, and you can find information on events on the National Engineering Month website (*www.nem-mng.ca*, and click Events on the menu).

# Discover Engineering Crossword Puzzle

There are over 200 types of engineering.
Discover some types of engineering with this puzzle.




**Word Bank**

aerospace
applied
automotive
biomedical
chemical
civil
computer
degree
electrical
electronic
environmental
mechanical

mining
petroleum
structural

**Across**

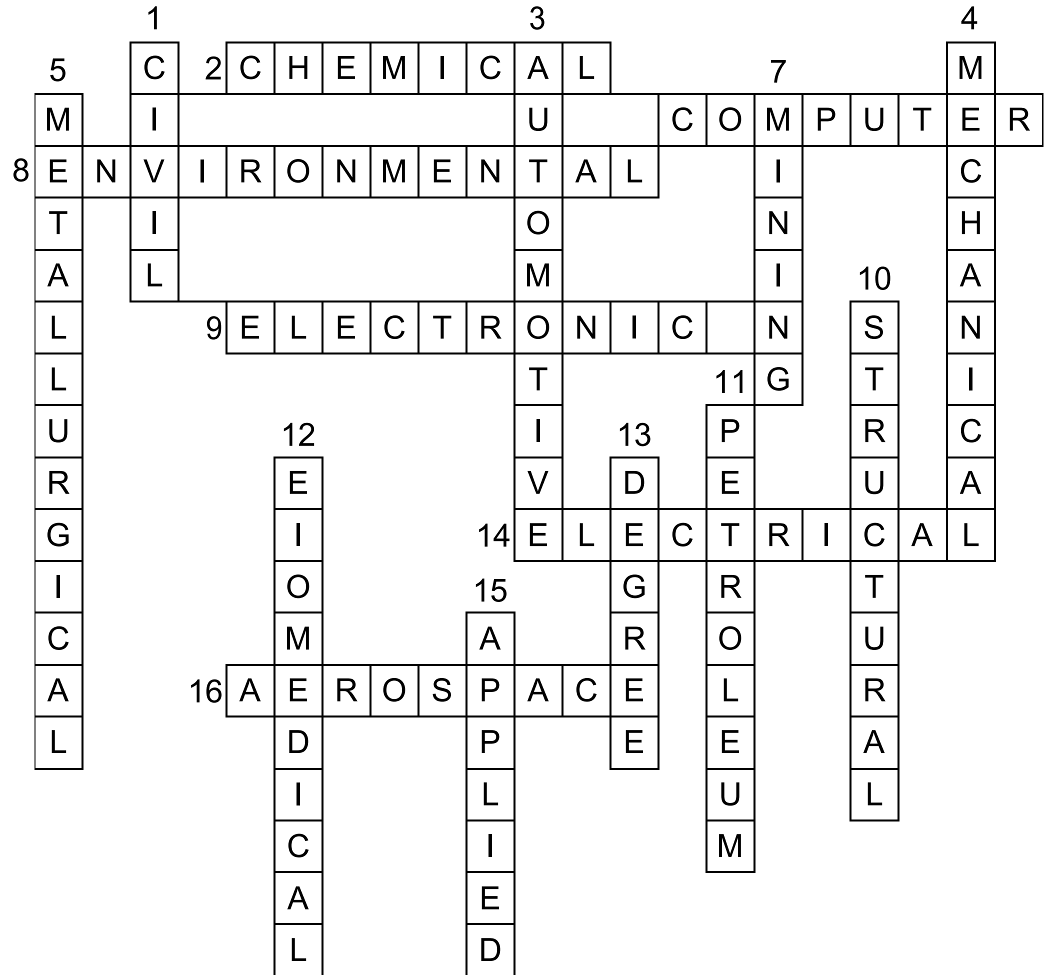
2. This type of engineer uses chemistry to design various products, from food to cleaning products to explosives and beyond!
6. These engineers specialize in computer hardware and software.
8. This type of engineer designs systems that work to prevent pollution.
9. This type of engineer designs things like televisions and video games.
14. Without this type of engineer, we wouldn't have power in our homes!
16. This type of engineer research and design airplanes and other flying equipment. They designed, for example, the Canadarm on the space shuttle.

**Down**

1. This is one of the oldest types of engineering. They design roads, bridges, railways, buildings, etc.
3. This type of engineer designs vehicles.
4. This type of engineer designs machines, engines and other equipment, including moving parts.
5. This type of engineer specializes in extracting metal from ore.
7. This engineer focuses on extracting minerals from the Earth's crust.
10. One thing this type of engineer designs is tall skyscraper buildings.
11. These engineers explore, recover and develop methods to process oil and gas.
12. This type of engineering combines engineering with human anatomy.
13. An engineer has a university____________.
15. Engineering is also called_________science.

# Discover Engineering Crossword Puzzle

Answer Key



# Build a Shelter

This activity is quite simple and is best for Sparks or Embers. Try one (or more) of the other "Build" activities for older youth.

Structural engineers design and build structures. Your challenge is to build a self-supporting structure that will protect a small stuffed animal from the weather.

**Directions**

1. Explain to the youth that one type of engineer is a structural engineer and that they design structures. Can they name some structures? (i.e. house, school, library, hospital, any building!)
2. Tell the youth they will be structural engineers today and design a structure to protect their small stuffed animal from the weather.
3. Let the youth use their imaginations to build and decorate their structures.
4. When everyone is finished, have them share their structural creations and explain how they protect their animal.
5. You could test the structures by shining a bright light at it (simulating the sun) or blowing on it (simulating the wind).

**Supplies**

- ask each youth to bring a small stuffed animal from home, or provide a small toy for each youth to build a structure for
- variety of building materials, such a construction paper, cardboard tissue tubes, popsicle sticks, drinking straws, toothpicks etc.
- tape
- markers or pencil crayons

# Build a Solar Still

Clean water is essential for human health and is extremely scarce in many places worldwide. What do you do if you live in a place without enough rainfall to provide fresh water for everyone's needs? Desalination projects, which remove the salt and other minerals from seawater to make it safe for human consumption and irrigation, are one way of easing the shortage. (Large-scale desalination projects are also expensive and consume large amounts of energy.) Build your own miniature, renewable-energy desalination project in this activity: a solar still that distills fresh water from salt water.

**Directions**

1. Set the glass in the middle of the bowl. Find a shorter glass if it sticks higher than the bowl's rim.
2. If you use flexible plastic tubing, place one end in the glass, making sure it goes down to the bottom. Lay the other end over the edge of the bowl; tape it in place if need be.
3. Pour salt water into the bowl, so it comes about halfway up the glass. Be careful not to get salt water into the cup.
4. Put plastic wrap over the top of the bowl, covering it completely. Tape it in place if you think it might not stick very well. The plastic wrap should be just a little bit loose across the top of the bowl, not stretched absolutely tight.
5. Gently set the pebble on the plastic directly over the glass.
6. Place your still in a warm, sunny location and leave it alone. After several hours, you should see that some water is collected in the glass. Taste it. Is it salty or fresh?

**Note:** If you have used plastic tubing or a straw, you can sip your distilled water without taking your still apart. Otherwise, remove the plastic wrap and take the glass out to taste the water.

**Explanation**

The sun warms up the water in the bowl and makes it evaporate. The evaporated water collects on the underside of the plastic wrap and runs downhill (thanks to the pebble weighing down the middle of the plastic) into the glass. This water is fresh, not salty because the salts and other minerals in the

**Supplies**

- ❑ large mixing bowl
- ❑ drinking glass (shorter than the depth of the bowl)
- ❑ flexible plastic tubing (optional)

**Note:** Use only clean plastic tubing for this activity—don't use something you've found in the garage. If you like, you can substitute a couple of drinking straws stuck together to make a really long straw.

- ❑ water mixed with table salt

**Note:** Mix enough salt into the water so that you can really taste it when you put a drop on your tongue. Do not drink salt water.

**Note:** Do not use road salt for this activity; it is not safe for consumption.

- ❑ plastic wrap
- ❑ masking tape
- ❑ small pebble or similar object

saltwater doesn't evaporate – they are left behind in the bowl. Suppose you leave your still undisturbed long enough. In that case, some crusty white material might be collected along the water's edge. That's the salt that's left behind.

This kind of still can also be used to purify brackish water to make it safe for drinking. And, unlike large-scale commercial desalination plants, it does not require much energy from fossil fuels or nuclear sources.

# Egg Protectors

Can you keep an egg from breaking when you drop it? Thinking of ways to protect an egg is similar to what engineers had to think about when they designed things like bicycle helmets to protect people from getting hurt. Are there other things that help absorb impacts and protect things from injury? Some examples may include hockey pads, airbags, car bumpers, etc.

This is a challenging activity that may take some time. It is great for camps when you have more time to design and build an egg protector.

When selecting a location for this activity, keep an eye on safety. Having youth reach over a railing on a low balcony to drop their eggs is probably okay; letting them dangle off the edge of a shed roof is not. Do not hang out windows. Also, make sure the area you choose can be easily cleaned up.

CAUTION: Raw eggs may contain harmful microorganisms. Make sure to wash your hands with soap after handling the eggs.

**Directions**

1. Set up the "Egg Launch Zone" before the activity. Spread out several garbage bags to mark the egg launch zone and for easy cleanup if some eggs do not survive the fall.
2. Have the youth work in pairs or in teams of 3-4. Have them brainstorm some possible designs.
3. Use whatever materials you can find to build a gadget that will keep your egg from breaking when you drop it from a raised location (it has to be at least 3 metres above the ground).
4. If you have enough eggs, experiment to see if you can improve your design or develop a new, completely different design.
5. Alternatively, use a plastic Easter egg to work with and test your egg protector before using a real raw egg.
6. When everyone is ready for the Egg Launch, have the youth vote on the "most creative or innovative." or the "prettiest" egg protector. Then, proceed with the egg launch.

**Supplies**

- ❑ raw egg
- ❑ plastic Easter egg
- ❑ a variety of found materials (paper, tape, toothpicks, straws, popsicle sticks, pipe cleaners, streamers, packing beads, feathers)
- ❑ plastic garbage bags
- ❑ raised location, like a low balcony or a flight of steps, in an area that can be easily cleaned up

**What else you can do with this:**

If raw eggs are too challenging (or messy), hard-boil them first. As a bonus, you may be able to salvage some of them afterwards for egg salad!

You can also use small water balloons for this experiment instead of eggs.

**Explanation**

The egg in the egg protector held 3 metres above the ground has gravitational potential energy stored in it. When the egg is released, its potential energy (stored energy) is converted into kinetic energy (motion energy).

# Bridge Building

Use simple materials to build a bridge and test its strength.

If you don't have a glue gun, you can use white or wood glue to build your bridge, but it takes much longer. Glue-gun glue dries almost instantly; white or wood glue takes quite a while. You might need to build your bridge in stages, letting each stage dry before you add another.

**Option 1: Directions – with glue**

1. Draw two lines about 15 cm apart down the middle of the cardboard. This represents a river.
2. Use toothpicks and glue to build a bridge across the river. Your bridge must be at least 5 cm high in the middle of the river, and you cannot use any supports in the middle of the river—only on the sides.
3. Let your bridge dry completely, then set the paper cup in the middle. Add coins or marbles to the cup.
4. How many can your bridge support before it collapses?

**Supplies**

- ❑ large piece of cardboard
- ❑ pencil or pen
- ❑ flat toothpicks or craft sticks
- ❑ glue gun and glue sticks
- ❑ small paper cup
- ❑ coins, marbles or other small objects

**Note:** If you don't want to break your bridge, stop adding coins when it starts to bend and take the weight off right away.

5. Encourage the youth to use the engineering process:

   1. **Design → 2. Build → 3. Test → 4. Refine/Change**

**Option 2: Directions – with tape**

6. Use the materials to build a bridge that spans 5 inches (the index card's length) with a roadbed at least 1 ½ inches above the ground. No part of the 5-inch roadbed or supports directly under the roadbed may touch the ground.

Once complete, bridges will be tested by applying weight to the bridge's centre until failure. Failure occurs when the roadbed touches the ground.

7. Encourage the youth to use the engineering process:
   - **Design → 2. Build → 3. Test → 4. Redesign/Change**

**Supplies**

- ❑ 2 index cards (3" x 5")
- ❑ 2 paper clips
- ❑ tape
- ❑ scissors

**For load testing:**

- ❑ small paper cup
- ❑ coins, marbles or other small objects

**Explanation**

Engineers build bridges with strong materials (e.g., steel) that can carry heavy loads. When designing bridges, they must consider structural materials including fasteners, how big the bridge should be, how heavy it is, and the types of stresses or forces the bridge will be subjected to (e.g. tension, compression, etc.).

# Rockets

**Option 1: Balloon Rockets**

In this activity, you will launch a rocket and use it to carry a payload into space. Designing a rocket helps you explore different types of forces and motion.

**Note:** Long, straight balloons are best for balloon rockets but can be very hard to blow up. If you can't find a balloon inflator, round balloons will work, too.

The payload, or cargo, can be any small, somewhat heavy object. A large marble, a small pebble or a couple of loonies will work.

**Directions**

1. Tie one end of the string or fishing line to a high point, like a curtain rod or a hook high on the wall, or tape it as high as possible.
2. Thread the other end of the string through the straw.
3. Inflate the balloon and clip the end closed with a clothespin (don't tie it).
4. Tape the balloon to the straw, pull the string tight, and unclip the clothes peg. The balloon should shoot up along the string like a rocket being launched. If it doesn't go very far, figure out what you must do to improve your rocket design.

Use scrap paper or cardboard, paper cups, etc., to build a payload container for your payload. Attach the payload container to the balloon rocket and load it in your payload.

5. Launch your rocket again. How far does it go? Does the payload make it all the way, or does it fall out? Can you improve the design so your rocket can go farther or faster? How heavy a payload can your rocket carry?
6. Encourage the youth to use the engineering process:

   **1. Design → 2. Build → 3. Test → 4. Redesign/Change**

**Supplies**

- ❑ string or fishing line
- ❑ straw
- ❑ balloon
- ❑ clothespin
- ❑ tape
- ❑ scrap paper, cardboard, plastic or paper cups, etc.
- ❑ small, somewhat heavy object to use as the payload

**Explanation**

The science Newton's Third Law says that for every action, there is an equal and opposite reaction. In other words, if you push on something, like a wall, the wall will push back on you just as hard.

The engineering: When you blow up the balloon, you are squeezing a lot of air into a small space and stretching the balloon out while at it. Then, when you take the clothes peg off the end of the balloon, the balloon pushes all that air out of the opening. But remember Newton's Third Law: the balloon pushes the air out, but the air also pushes the balloon. That's what makes the balloon shoot along the string.

**What else you can do with this:**

Depending on your group's age, interest level and competitive nature, you could have contests to see who can make their balloon rocket go farthest or fastest.

Launch one particular rocket design with different payloads and measure the distance it goes with each payload. Record the data and make a graph comparing the distance with the weight of the payload. (And use this activity for the Math challenge too!)

**Option 2: Paper Rockets**

In this activity, you will launch a paper rocket using a straw. Designing a rocket helps you explore different types of forces and motion.

**Directions**

1. Have the youth work in pairs for this activity.
2. Mark off a rocket launch area with a designated target.
3. Use a pair of scissors to cut a piece of paper that has the dimensions 2 inches x 9 inches.

Use a pencil to wrap the piece of paper diagonally around the pencil. The piece of paper should overlap as it goes around the pencil. Make sure to start at the end of the pencil where there is an eraser and end at the tip of the pencil.

**Supplies**

- ❑ strip of paper (2” x 9”)
- ❑ pencil
- ❑ tape
- ❑ straw
- ❑ scissors

4. Once the wrapping is done, place tape along the paper tube (at the top and bottom, about ¼ way down the tube and about ¾ way down the tube).
5. Fold the top end of the rocket so that it makes a pointy tip to the rocket. Secure with tape.
6. Next, cut 2-4 fins with the remaining scrap paper and tape the fins to the bottom of the paper tube rocket.
7. Carefully slide the paper tube rocket off the pencil.
8. Slowly slide the paper tube rocket over a straw with a diameter smaller than the rocket's.
9. At the bottom end of the rocket, blow into the straw to make the rocket fly into the air.

Try to aim the rocket at the launch target. Test if blowing harder into the straw will cause the rocket to go farther or higher.

10. Have the youth compare the differences in the rocket designs (e.g. balloon rockets versus paper rockets).

**Explanation**

When air is blown into the straw, this causes the pressure to increase within the straw. There is now a difference in the air pressure inside the straw and the pressure in the atmosphere. This results in an unbalanced force, and the force launches the rocket off the straw.

# Coin Sorter

You've been out all weekend doing a cookie blitz, and now you have a box full of change to sort through. You could do it by hand, of course, or you could build yourself a coin sorter.

We don't recommend using your cookie money when designing your coin sorter – it is too easy to lose it while you design and redesign. Test your coin sorter out with random change from your pocket first, and once you get it working well, you can use it on your cookie money.

**Directions**

1. Find a partner or two so that you can put your heads together and share ideas.
2. Design a coin sorter using scrap cardboard, cardboard boxes and other found materials. Your goal is to be able to drop loose change into the top and have it come out the bottom sorted into nickels, dimes, quarters, loonies and toonies.
3. Encourage the youth to use the engineering process:

   **1. Design → 2. Build → 3. Test → 4. Redesign/Change**

**Supplies**

- ❑ scrap cardboard, paper, cardboard tubes and other found materials
- ❑ cardboard boxes of different sizes
- ❑ paper coin tubes in a variety of sizes
- ❑ scissors
- ❑ tape and/or glue
- ❑ pocket change

# Build a Robot

How do I build it? Let me count the ways...

There are lots of ways to build a robot. How you do it depends on what you want your robot to do and what materials you have on hand. Consequently, instead of giving step-by-step instructions here, we'll point you toward some resources to get you started:

- **Imagination Robot**: This is a good option for Sparks and Embers. Use found objects (empty boxes, paper towel tubes, egg cartons, whatever) to build a robot of your imagination. Optional: design it to do a specific job.
- **NanoRover** (https://spaceplace.nasa.gov/nanorover/en/): Instructions from NASA for building a balloon-powered miniature rover for exploring planets and asteroids.
- **Robotic Arm** (https://tryengineering.org/teacher/build-your-own-robot-arm/): Build a robotic arm to pick up an empty styrofoam cup.
- **A variety of hydraulic devices**. Some include instructions, and some include only videos on how they operate. https://diy.org/skills/mechanicalengineer/challenges/718/
- **A hydraulic robot made from cardboard and duct tape**: http://www.instructables.com/id/Hydraulic-robot-made-of-cardboard-and-scotch-duct-/?ALLSTEPS

**What else you can do with this:**

More and more companies are providing robot-building kits and resources geared especially for kids. Some of these kits are expensive, so see if you can borrow them from a school or other organization. Alternatively, you might want to look at using these activities at a District/Area event to provide more youth with a great experience for the expense.

Please note: although we have personally played with some of these products, we have not fully tested all available kits. Therefore, we cannot offer any useful comments about quality, suitability, etc. Please use your judgment and check the vendors' return and privacy policies before ordering anything online.

- **Lego** (*www.lego.com*): With products that range from simple building blocks to architectural kits and robotic kits, there is something to suit any age and interest. Available online or at any toy store, prices vary depending on the complexity and coolness of the product.
- **OWI Robots** (*www.owirobots.com*): Kits for building various robots, including solar-powered ones that don't require batteries. Prices are generally lower than for other robot-building kits ($15-$50), which may indicate lower quality (we haven't tried these ones).
- **Tamiya** (*www.tamiyausa.com*): A variety of building, modelling, and robot kits. Look for complete robot kits in the "Educational" category. Prices vary depending on the kit, but most are comparatively affordable ($20-$50).
- **PicoCrickets** (*www.picocricket.com*): Make musical sculptures, interactive animals, etc. Designed for ages 8 and up, younger kids may be able to use the kit with adult help. Kits are US $250.

# Build a Light Bulb

Incandescent light bulbs had existed for decades before Thomas Edison patented his invention. So, what's the big deal about Edison's version? Find out a little bit about the challenges he faced by building your own light bulb.

**Note:** Wear safety glasses for this experiment and ensure youth are closely supervised. When you connect the two wires to the batteries, make sure the ends of the two wires do not touch each other directly—this will short out the battery. The filament will get very hot – do not touch it!

For younger youth, this is much better as a demonstration than a hands-on activity.

**Directions**

1. Put on your safety glasses.
2. Take the lid off the jar. Using the hammer and nail, poke two small holes into the lid.
3. Cut the insulated copper wire in half, and remove a small length (about 1 cm) of insulation from each end of both wires. Wire strippers make this pretty easy, but if you don't have any, use a wire cutter or small knife to cut through the insulation (not the wire itself). This can take some practice.

   **CAUTION:** Be careful not to cut yourself.
4. Stick a copper wire through each hole in the lid. The short end of each wire (about 5 cm long) should be on the inside of the lid, and the long end on the outside. Bend each short end into a small hook. Tape the long ends down to the lid.
5. Most picture wire is thicker than you need. To
6. make it thinner, unravel the strands of the picture wire, then tightly twist two or three strands back together. This will be the filament for your light bulb (the part that glows and gives off light).
7. Set the picture-wire filament on the two hooks of copper wire, bending and pinching as needed to keep it in place. Put the lid back on the jar tightly.

**Supplies**

- ❑ safety glasses
- ❑ small glass jar with a lid, or a cork stopper that fits the jar
- ❑ hammer and small nail
- ❑ 1 m of insulated copper wire
- ❑ wire stripper with cutter
- ❑ small length of picture wire
- ❑ 3 D-size batteries

**Note:** Do not use a higher-voltage battery!

Connect the long ends of the two copper wires to each terminal on the battery, and watch what happens.

**CAUTION:** The filament will get really, really hot. Do NOT touch it. The copper wires might also get hot, so be careful when handling them.

## Explanation

How long does your light bulb last before it burns out? This was a major problem with early light bulbs – they didn't last long enough to be practical. Thomas Edison experimented with hundreds of designs before he devised a viable one. Then he had to invent the electrical system – generation facilities and distribution.

systems that could provide electric power at an affordable price – to provide an infrastructure for using his light bulbs.

**What else can you do with this**

Experiment a little to see if you can optimize the performance of your light bulb. What happens if you use more or fewer strands of the picture wire to your filament? What if you reduce the number of batteries? (Caution: Do not add any more batteries.)

# Wind Energy Pinwheels

Governments and corporations around the world are seeking out clean, renewable sources of energy. The wind is one such source of energy. In this experiment, build your own pinwheel to catch wind energy and see if you can use it to do something useful.

**Directions**

1. Allow some time for the youth to decorate their pinwheel squares.
2. If using the square paper option, cut a diagonal line from each corner toward the paper's center. Do not cut all the way through; cut only about 2/3 of the way from the corner to the center.
   - On each corner, bend one point down into the centre of the paper. Poke the pin through the points and the center of the paper to hold your pinwheel together.
   - (Optional) Put the bead onto the pin before poking it into the pencil's eraser. This helps the pinwheel to better rotate.
3. Poke the pin into the eraser at the top of the pencil. Blow on it.
4. **Discuss**: What happens when you blow on it? How does the shape/design of the pinwheel help it to work? Where do we see structures like this in the real world? What job are they doing?
5. Show the youth some images of modern windmills, etc., from different places that use the energy from wind to generate power.

**Supplies**

- ❑ paper, cut into a square. *Option for older youth: use a more complex pinwheel template. See [http://www.electricpinwheels.com/Free_Pinwheel_Templates.html](http://www.electricpinwheels.com/Free_Pinwheel_Templates.html)*
- ❑ scissors
- ❑ straight pins with large heads
- ❑ bead (optional)
- ❑ pencil/dowel
- ❑ markers or pencil crayons

**What else can you do with this**

Can you make your pinwheel work? Try building a structure that uses the spinning pinwheel to lift a small load. You might want to use building blocks (e.g., Lego or K'nex), scraps of wood or dowelling, string or other found materials. Try a small envelope or paper basket with a few pennies or paper clips for a load.

# Solar Cooking

The sun is an obvious source as we look increasingly to renewable, sustainable energy sources. In this activity, design and build a solar cooker and use it to cook a snack.

**Note:** There are lots of different solar cooker designs. If you haven't already learned how to make one at a Guide camp, talk to other Guiders in your area to see if anyone knows how. Alternatively, check your local library or bookstore for reference books, or look online. Here are a couple of links to get you started:

- Pizza-box solar cooker: http://www.ehow.com/how_4850541_solar-ovens-pizza-box.html

### Directions

1. Build your solar cooker.
2. Assemble a s'more from two graham wafers, a marshmallow, and a piece of the chocolate bar. Wrap it in foil and place it in your solar cooker.
3. Arrange your solar cooker to capture the sun's energy and cook your s'more.

   **CAUTIONS:** Despite their simple appearance, solar cookers get hot! Use the same precautions handling them and the food you cook in them as you would with any other oven.

### Supplies

- ❑ as required for the type of solar cooker you want to build

**Note:** When selecting materials, choose only non-toxic materials that will not produce toxic fumes when they heat up.

- ❑ graham wafers
- ❑ marshmallows
- ❑ chocolate bar
- ❑ aluminum foil

### What else can you do with this

Once you understand the basic principles of solar cookers, see if you can improve the design or invent your own.

For an interesting look at a real-life application for solar cooking, check out the article "How are solar cookers saving lives in Chad and Darfur?" (http://science.howstuffworks.com/environmental/green-science/solar-cookers-save-lives.htm)

# Go Fly a Kite

Kite-flying is a great, fun way to experiment with aerodynamics. Buy one, or better yet, make one, then go fly it!

**Note:** If you already have a kite-making method, use it. Likewise, if you know someone who is an expert at kite-making, feel free to have them lead your meeting. If you need some instructions or ideas, try these links – just a small selection of the thousands of websites out there with information on kites:

Information and instructions for a wide variety of kites (some simple, some complex):

- http://www.howtomakeandflykites.com/
- Sew a nylon kite: http://sewing.about.com/library/weekly/aa032898.htm
- Instructions for lots of different kinds of kites: http://www.my-best-kite.com/how-to-make-a-kite.html

The Big Wind Kite Factory in Hawaii has free instructions online (www.bigwindkites.com). Their promise is "20 kids * 20 kites * 20 minutes". The instructions below have been reprinted with permission.

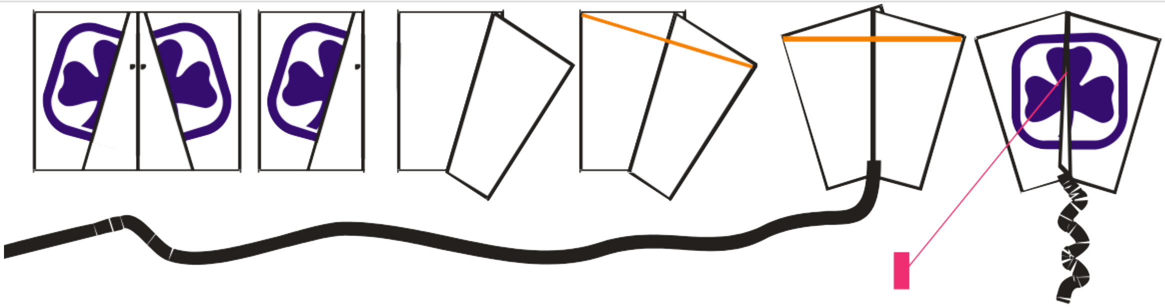
**Directions**

1. Lay the paper on the table in landscape format (long side down). Fold the paper in half, side to side.
2. Fold the paper diagonally along the diagonal lines.
3. Flip over and tape the spine.
4. Tape the cross stick perpendicular to the spine.
5. Tape the tail to the bottom of the kite.
6. Flip the kite over and fold the spine back and forth.
7. Punch a hole in the spine opposite the crossbar.
8. Tie string through the hole and fly.
9. Bring scissors to the flying field.
10. Cut knots and tangles quickly, re-tie and keep them flying.
11. If one side of a kite gets crunched, crunch the other side.
12. On windy days, a longer tail helps balance the kite. A shorter tail provides the kite with more lift. Consider what direction the wind is blowing.

**Supplies**

- ❑ 8 1/2" x 11" copy paper (not construction paper)
- ❑ 8" bamboo BBQ shish-kabob sticks
- ❑ surveyor's flagging plastic tape. Available at hardware or dollar stores.
- ❑ tape
- ❑ string (about 6 to 10 feet per kite)
- ❑ piece of 1"x 3" (to wind the string on)
- ❑ scissors
- ❑ hole punch

**CAUTION:** Do not fly kites near power lines.Pick an appropriate day, time and place to fly the kites.



**Explanation**

Kites will fly when the lift (the upward force) is greater than the kite's weight (the downward force due to gravity). Lift is due to the kite's shape, surface area, and inclination. Drag, or air resistance also comes into play because it works in the opposite direction to the kite's motion.

**What else can you do with this**

Build a variety of different kites and compare their performance. Which flies highest? Which is the most steerable? Do variations in size or materials matter?

# Paper Airplanes

Paper airplanes are another way to learn about aerodynamics.

You can find instructions for a wide variety of paper airplanes by searching online.

**Part 1: Directions – Distance Testing**

**Supplies**

- ❑ 8 ½" X 11" paper
- ❑ paper airplane patterns
- ❑ large area with no wind (can be either inside or outside)
- ❑ measuring tape
- ❑ chart to record findings

1. Make several of each of the five different paper airplanes using the same size and weight of paper. Take your time because they should all be as similar as possible.
2. When you've finished, you will test them. Throw each type of plane five times, recording the distance on your chart. It's important to throw them in the same way with the same force each time.
3. Do this for each of the five planes, recording the distance.Try to use the same plane for all five throws, but if it gets damaged, use another.
4. Don't use the furthest or shortest distance for each model to make the results more accurate. For example, if for Airplane Model #1, you threw 25 ft., 30 ft., 18 ft., 20 ft., and 21 ft., then you would take away both the 18 and 30 ft ones, Add the remaining 3 (25 + 20 + 21 = 66) and divide by 3. The average distance is 22 ft.
5. Which planes flew the furthest? Why do you think they were the best fliers?
6. Encourage the youth to use the engineering process:

   **1. Design → 2. Build → 3. Test → 4. Redesign/Change**

**What Else Can You Do?**

Take the model that flew the furthest and see if you can modify it to fly even further. This can be done by changing folds slightly, adding weight, or any other method you think might work. Remember to test it 5 times to get the average distance.

To try some additional space activities, go to NASA for students. (http://www.nasa.gov/audience/forstudents/#.UyyWrYXwp9Z)

| Throw # | Distance Thrown | | | | |
|---|---|---|---|---|---|
| | Model #1 | Model #2 | Model #3 | Model #4 | Model #5 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| Avg Distance | | | | | |

**Part 2: Directions – Accuracy Testing**

1. Use a hula-hoop suspended on a tabletop as a target for the paper airplanes.
2. Mark off the launch line with painter's tape on the ground. The hula-hoop target should be 5 metres away from the launch line.

Design and create a paper airplane of your choice using a piece of paper. Make sure to put your name on the paper airplane to identify it.

3. Launch all the paper airplanes and see which design had the best accuracy and worked the best.
4. Encourage the youth to use the engineering process:

   **1. Design → 2. Build → 3. Test → 4. Redesign/Change**

**Supplies**

- ❑ 8.5" x 11" paper
- ❑ paper airplane patterns
- ❑ masking tape
- ❑ painter's tape
- ❑ scissors
- ❑ hula-hoop
- ❑ table

# Hoop Gliders

Engineers are constantly looking for ways to improve existing designs. Try this hoop glider design, then make adjustments to see how changes in a design can affect performance.

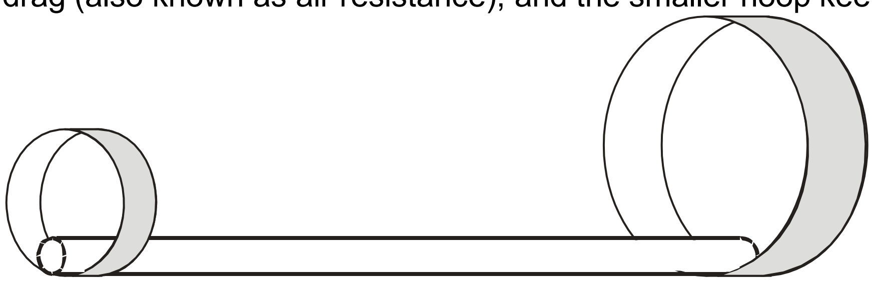
**Directions**

1. Cut the index card into three pieces of 1" x 5" strips.
2. Tape two pieces of paper into a large hoop, overlapping the ends by about ½ inch.
3. Tape the remaining piece of paper into a small hoop.
4. Tape the hoops to opposite ends of the straw, with the straw lined up on the inside of the hoops.
5. Hold the straw in the middle and throw it.
6. Now try some adjustments – what happens if:
   - The hoops are moved to different locations on the straw?
   - The length of the straw is adjusted (cut to make it smaller, or tape another straw on to make it longer)?
   - More hoops are added?
   - The hoops aren't lined up?
   - The hoops are a different shape?

**Supplies**

- ❑ 3” x 5” index card
- ❑ a straight plastic drinking straw
- ❑ tape
- ❑ scissors

Discuss: The two sizes of hoops help to balance the straw. The larger hoop creates drag (also known as air resistance), and the smaller hoop keeps the glider on course.



# Reverse Engineering

Engineers imagine, invent and build things. And engineers also take things apart to figure out how they were made. By reverse-engineering an existing product, an engineer can figure out ways to improve it or use its technology or components for a different product or application. Explore the process of reverse engineering in this activity!

**Note:** In this experiment, you reverse engineer (i.e., take apart) a toy to figure out how it works. You will need a small toy that moves independently but is not battery-operated. For example:

- Pull-back Toy car: the kind you can drag along the floor and then let go, and it zips off on its own.
- Top: the kind that has a handle on top that you push down to make the top spin
- Any wind-up toy

Reverse engineering is more than just taking something apart. As you take the toy apart, you must carefully observe all the pieces, how they fit together and what they do. Ideally, you should be able to put the toy back together again after studying it. (If you can't, however, you might want to use an old, still-functioning toy that nobody plays with anymore.)

**Directions**

**Supplies**

- ❑ small, self-propelled toy (see notes above)
- ❑ paper
- ❑ pen or pencil
- ❑ screwdriver
- ❑ other tools as needed

1. Spend a few minutes playing with the toy. Test it out and see what it does.

   Try to imagine the mechanism inside the toy. How do you think it works? Draw a detailed diagram showing how you think it looks on the inside. Use labels to explain what different parts are and what they do.
2. Use the screwdriver (and any other tools you might need) to take the toy apart. Remember, you don't want to destroy it! Take it apart carefully and take care not to lose any pieces.
3. Draw another diagram showing what the toy actually looks like on the inside. Again, label all the parts and briefly describe what they do. How close or different was your first guess?
4. Now that you know how the toy works, try to:
   - Figure out a way to improve it. Can you eliminate any parts (which would reduce the cost of the toy) or make them work differently?
   - Figure out a different way to use the toy's mechanism. Can you invent a new kind of toy using the same mechanism?

# Rubber Band Power

You can do many things with a rubber band besides holding papers together or giving your little brother painful snaps. Try one or more of these activities to build your rubber band-powered toy.

There are lots of different toys you can make and many variations on the methods for each. Here are some resources to get you started. Try the two-wheeled car below, one of the following online ideas, or invent your rubber band creation.

Paddle boat: http://www.e-scoutcraft.com/misc/paddle_boat.html

Toy car launcher: http://www.instructables.com/id/Rubber-Band-Powered-quotHot-Wheelsquot-type-Ca/

**Directions for Two-Wheeled Car**

**Supplies**

- ❑ 2 CDs
- ❑ 5.5" x 5.5" square piece of corrugated cardboard
- ❑ 2 ¼" faucet washers
- ❑ poster putty
- ❑ ruler
- ❑ scissors
- ❑ rubber bands of different lengths and widths
- ❑ masking tape
- ❑ thin wooden skewer or wooden craft dowel

1. Position the square cardboard piece so that the groove runs left and right.

   Use scissors to cut out a 2" wide x 1.5" deep rectangle in the middle of one of the sides of the cardboard. This is called the "catch".
2. Carefully slide the thin wooden skewer through the sides of the cardboard along the corrugation so that the two ends of the skewers are approximately the same length, sticking out on either side. The skewer will be the axle of the car.
3. Locate the middle of the skewer. Wrap a piece of tape around the centre of the skewer.

   Place the faucet washer into the hole at the centre of the CD. Slide the washer and CD onto the axle of the car. Add poster putty on either side of the washer to securely join the CD, washer and putty to the car's axle. Make sure that this is a tight fit. The CD should not be able to rotate with the axle.
4. Repeat Step 5 with the other wheel.
5. Tape a rubber band to the cardboard on the opposite end of the axle.
6. Secure the rubber band's other end and secure it to the catch.
7. Wind the rubber band by rotating the axle.
8. To launch the car, allow the rubber band to unwind. Observe how far the car goes.

**Explanation**

When you wind the rubber band around the axle, the rubber band has potential elastic energy (stored energy). When the rubber band unwinds, the potential energy is transformed into kinetic energy, making the car go.

**What else can you do with this**

Invent your toy and figure out how to power it with a rubber band.

# Build a Sail Car

Use your imagination to design and build a sail car, then race it across the floor.

**Directions**

Use the listed materials to build a vehicle you can propel with only your breath. You do not have to use all the materials, but you cannot use anything extra.

1. Set your car on the floor. Use your breath to move it across the room. Does your design work? Can you think of any improvements?
2. Once you are happy with your design, challenge your friends to a sail car race.
3. Encourage the youth to use the engineering process:

   **1. Design → 2. Build → 3. Test → 4. Redesign/Change**

**Supplies**

- ❑ 4 lifesavers
- ❑ 4 plastic drinking straws
- ❑ 3 sheets of paper
- ❑ 1 m of masking tape
- ❑ 2 paperclips
- ❑ scissors

**What else can you do with this**

You can make this activity more challenging by reducing the materials available or by changing the materials altogether.

# Build a Mousetrap Car

Explore the physics behind a mousetrap car. The car will be propelled into motion by the release of a mousetrap. Design one that will travel the farthest distance.

WARNING: due to the dangerous nature of the mousetrap, this activity is not recommended for younger youth.

## Directions

The youth are allowed to work in pairs. Brainstorm and think of a design for a mousetrap car. Consider a lever arm, the shape of the car frame, the number of wheels needed (2 or, 3 or 4 wheels) and the diameter of the wheels.

1. The car should be set into motion by the release of the mousetrap.
2. **CAUTION**: Be careful when handling a mousetrap so your fingers do not get pinched or trapped.
3. Mark off the starting line and use a metre stick to measure how far the mousetrap goes.
4. Encourage the youth to use the engineering process:

   **Design →2. Build → 3. Test→** 4. **Redesign/Change**

**Supplies**

- ❑ mousetrap
- ❑ 2-4 CDs or LP records
- ❑ masking tape
- ❑ wooden dowels
- ❑ fishing line/string
- ❑ glue
- ❑ glue gun
- ❑ wire cutters
- ❑ wires
- ❑ metre stick

## Explanation

The coil spring on the mousetrap stores potential energy. When the mousetrap is released, some potential energy in the spring is converted into kinetic energy. The rest is lost to friction as the mousetrap car's different parts rub together and move along the ground.

# Build a Boat or Raft

Engineers are always coming up with designs that fulfill a purpose. Sometimes, the design doesn't work the first time – that's okay! When you make a mistake, you learn from that mistake and make alterations in your redesign. This is all part of the design process.

**Option 1: Directions – Aluminum Boat (1 credit)**

Engineers have modified their designs of boats so that the boats can hold heavier loads. This activity aims to build a boat to hold the most dimes in one minute.

**Supplies**

- ❑ a piece of aluminum foil (6” x 6”)
- ❑ plastic washing tub
- ❑ water
- ❑ 100 dimes
- ❑ stopwatch

1. The youth are allowed to work in pairs. Brainstorm and think of a design for the aluminum boat.
2. Using only the aluminum foil given, fold it to shape it like a boat or a barge.
3. Add some water to the washing tub so that it is half full.
4. Place the aluminum boat on the water in the washing tub. There should be one tub for each aluminum boat.
5. When all the groups are ready, set the stopwatch to 1 minute.
6. Carefully place the dimes one by one into the aluminum boat. Count the number of dimes that can fit into the boat before it sinks.
7. Encourage the youth to use the engineering process:

   **Design → 2. Build → 3. Test → 4. Redesign/Change**

**Explanation**

Water has a density of 1 g/mL. Objects with a density of less than 1 g/mL will float. So why does aluminum with a density of 2.7 g/mL float? It is because, the average density of the aluminum boat (the aluminum foil and the air) is less than that of the water around it. As soon as the downward force is greater than the buoyant force (the upward force exerted), the object will sink.

**Option 2: Directions – Raft (2 credits)**

Divide the youth into teams. Engineers work both individually and in teams. This particular challenge will be completed in a team.

1. Explain to the youth that they are trapped on a desert island and only have a few materials available. They must build a raft to escape the island, and to ensure that the raft is sturdy enough, they must test it out by putting it into the water and testing how much weight it can hold.
2. Note: the supplies list is a suggestion. Whatever supplies you use, ensure that all teams have the same supplies.

**Supplies**

- ❑ a container filled with water for testing the rafts in
- ❑ towels to clean up with
- ❑ 10 drinking straws
- ❑ 2 craft sticks
- ❑ 3 pipe cleaners
- ❑ 1 square sheet of aluminum foil
- ❑ string
- ❑ masking tape
- ❑ coins or other objects to weight test the finished

Encourage the youth to brainstorm their ideas first before beginning to build. There are no wrong suggestions when brainstorming, and nobody can say anything negative about anybody else's ideas. So, come up with as many crazy ideas as you can! Once the team has brainstormed, they can devise a plan for their raft.

3. Note: you could hold off on releasing supplies to each group until they show you they have a design plan.
4. Have the teams build their rafts and test them. Set a time limit to complete the activity so all rafts can be tested together.
5. Encourage the youth to use the engineering process:

   **Design → 2. Build → 3. Test → 4. Redesign/Change**

# Build a Rollercoaster

Explore forces and motion as you build a rollercoaster for your marbles.

**Directions**

1. The youth are allowed to work in pairs. Brainstorm and think of how to put together the rollercoaster.
2. Use a pair of scissors to cut the file folders into strips of 3" x 11".
3. Fold these file folder pieces lengthwise to have walls on either side of the track. They should resemble gutters. Ensure the tracks are wide enough for the marbles to move along the tracks.
4. Use tape to attach the tracks to a large foam board. The tracks could have hills, loops and curves.
5. Use golf tees or skewers to help support the tracks. Secure them to the foam board by inserting them into the board and taping them to the tracks.
6. Release a marble at the start of the rollercoaster and watch it as it travels along the rollercoaster.

**Supplies**

- ❑ file folders
- ❑ masking tape
- ❑ marbles
- ❑ scissors
- ❑ large foam board
- ❑ golf tees or skewers

**Explanation**

The marble has gravitational potential energy (stored energy). As it rolls down the rollercoaster, some of this potential energy is converted into kinetic energy (energy of motion). The rest is lost due to friction with the marble hitting the sides of the tracks or trying to overcome air resistance.

# Marshmallow Structures

Structural engineers know all about shapes! They know that triangles are the strongest shapes. Demonstrate the strength of shapes with this building activity.

**Directions**

1. Set out boxes of toothpicks and mini marshmallows.
2. Encourage youth to try and construct 3D shapes (structures) with these materials. Can they make a tall tower? Keep these materials to one side for sharing.
3. Encourage the youth to use the engineering process:

   **1. Design → 2. Build → 3. Test → 4. Redesign/Change**

**Supplies**

- ❑ flat toothpicks
- ❑ mini marshmallows

**What else can you do with this**

Limit the supplies to 20 toothpicks and 10 marshmallows per tower.

Try building with different-sized marshmallows or with dry spaghetti instead of toothpicks.

Compare a narrow base with a wider base.

Try supporting something on your tower, such as blocks or books! Try building a different type of structure, e.g. a bridge.

Try building the tallest marshmallow tower.

# Marshmallow Catapult

Catapults were first used in ancient Greece and China as weapon launchers. Challenge youth to design their catapults with various materials, or follow the instructions below.

Some links for catapult ideas are as follows:

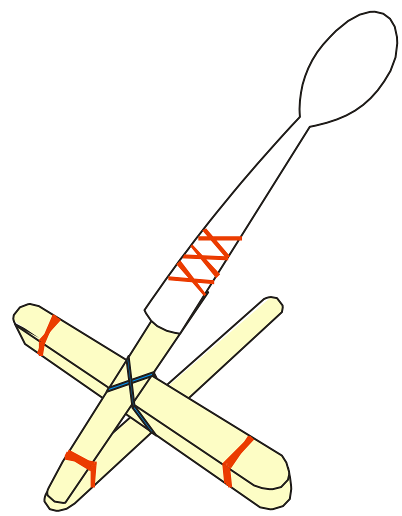
- Catapult Crazy: http://www.stormthecastle.com/catapult/index.htm
- Easy Catapult (includes a link to catapult games): http://spaghettiboxkids.com/blog/easy-to-make-catapult/

**Directions**

**Supplies**

- ❑ about 10 popsicle sticks
- ❑ 5 rubber bands
- ❑ plastic spoon
- ❑ mini marshmallows

1. Stack all but two of the popsicle sticks on top of each other.
2. Tightly wrap a rubber band around each stack end to keep all the sticks together.
3. Tightly wrap a rubber band around one end of the remaining two popsicle sticks.
4. Insert the larger popsicle stick stack between the two sticks, pushing the stack close up to the rubber band.
5. Crisscross a rubber band around the two pieces, as shown.
6. Attach the plastic spoon to the top of the catapult using the remaining rubber band.
7. Put a mini marshmallow on the spoon, pull back and release.



**What else can you do with this**

Make a catapult using a chair, 4 elastic bands and a ring from a milk container lid. Connect the 4 elastic bands to the lid ring and use that as a catapult. Turn the chair upside down so that the legs are sticking up. Attach the other end of the elastic bands to the two legs of the chair, and you now have a catapult/slingshot to launch your object.

**Explanation**

The catapult is a lever, which is a type of simple machine. Levers have a beam (the stick and spoon assembly here) attached to a hinge or fulcrum (the hinge is the crisscrossed rubber band location). They are used to increase the amount of force applied to an object. In this case, a small amount of force (pushing down on the spoon) will fling the marshmallow much farther away than if you threw it with the same effort.

# Kitchen Cookie Engineering

Chemical engineers use chemistry in practical applications. There are chemical engineers who work at the factory where Girl Guide cookies are made! They have tested different combinations of ingredients to create the cookies we enjoy today.

Test your kitchen engineering skills by baking chocolate chip cookies. Each group will alter the ingredients slightly to see how these alterations vary the results in the cookies.

Before beginning this activity, if possible, watch "The Chemistry of Cookies" http://youtu.be/n6wpNhyreDE. If your meeting place has no Internet connection, you can download videos to playback while not online. See http://www.wikihow.com/Download-YouTube-Videos for instructions.

### Directions

Divide the youth up into as many groups as recipes you will try.

Including the control recipe, there are 6 different recipes to try here. You could bake the cookies as a round-robin activity.

**Supplies**

- ❑ baking supplies and ingredients, as listed in the recipes

### Control Recipe

You could either have one group make the control recipe or have a Guider prepare it before the meeting. This is an adaptation of the Nestle Tollhouse Chocolate Chip Cookie recipe.

### Ingredients

1 cup plus 2 tablespoons all-purpose flour
½ teaspoon baking soda
½ teaspoon salt
1 stick (4 ounces) unsalted butter, at room temperature
¼ cup plus 2 tablespoons granulated sugar
¼ cup plus 2 tablespoons packed brown sugar
½ teaspoon vanilla
1 large egg
1 cup semi-sweet chocolate chips

### Recipe Directions

1. Preheat oven to 350°F.
2. Line baking sheets with parchment paper.
3. Combine the flour, baking soda, and salt in a medium bowl.
4. In another bowl, beat the butter, granulated sugar, and brown sugar until creamy (about 2 minutes). Mix in the egg and vanilla, beating well to combine. Gradually beat in the dry flour mixture. Stir in the chocolate chips.
5. Scoop 1 ½ tablespoon-sized balls and place onto prepared baking sheets.
6. Bake for 9 to 11 minutes or until golden brown. Cool for 2 minutes before removing to wire racks to cool completely.

### Baking Powder Group

Make the basic cookie recipe, but replace baking soda with baking powder.

### Extra Flour Group

Make the basic cookie recipe, but use 2 cups of flour.

### Melted Butter Group

Make the basic cookie recipe, but melt the butter before mixing it with the sugars.

### Granulated Sugar Group

Make the basic cookie recipe, but use ¾ cup of granulated sugar and do not use brown sugar.

### Brown Sugar Group

Make the basic cookie recipe, but use ¾ cup of brown sugar and do not use granulated sugar.

### After Baking

After all cookies have been baked and cooled, compare the results. How is each batch of cookies different? Remember to use all your senses to do this. How would a chemical engineer use this information?

### What else you can do with this:

You could experiment more and alter ingredients depending on what interests you (butter vs. margarine, 1 egg vs. 2 eggs, different types of flour, etc.)

Optional: After making your cookies, try "The Great Cookie Extraction" from the Eco Pak challenge – this activity illustrates how mining engineers work with environmental engineers and will earn you another credit towards your STEM Engineering challenge crest.

# PROGRAM CONNECTIONS

The Girls First program is youth-driven and designed to be highly flexible and agile. We encourage you to visit the Digital Platform to determine how this challenge fits into the Program Areas and Themes.

You may want to start exploring the following Program Areas:

- Into the Outdoors
- Experiment and Create
- Build Skills

This is not a comprehensive list, and remember that you can apply your activities to the Girls first program as you see fit.