



**SCIENTISTS**  
IN SCHOOL  
**SCIENTIFIQUES**  
À L'ÉCOLE

# Teacher Resource Package



Let us help you piece together the science!

**Background Information** an overview of the topic and theoretical concepts.

**Hands-on Activities**

Activity 1 - pen/paper activity

Activity 2 - short, easy-to-do activity (30-60min)

Activity 3 - short, easy-to-do activity (30-60min)

Activity 4 - longer activity (greater than 1 hr)

Activity 5 - complex activity

**Teacher Resources**

Literary Resources

Website Resources

Interactive White Board Resources

Multi-media

**Student Resources**

Literary Resources

Interactive Websites

***Please help us improve our teacher resource packages!***

If you have any feedback about this package or suggestions for new resources to include, please don't hesitate to contact us at: [inquiries@scientistsinschool.ca](mailto:inquiries@scientistsinschool.ca).

# Engineering Challenges

So what does an engineer actually do? As you guide your students to prepare for high school, you may ponder what career paths they might want to take in the future. Engineering is a terrific way to blend science, math and even their creative skills. Your students probably have been engineers already, in the classroom or at home, where they have been creating or designing and they just didn't realize it! We all like to create and when we combine the technical concepts behind it, then we can become real innovators. Engineers are problem solvers and are interested in building and making things better and more efficient. For example, consider the evolution of the school bag. In the 1930's, school aged students used a simple leather strap to hold their books. The 1950's and 1960's saw the school bag develop into the more traditional two-strap leather backpack as well as durable leather satchels with short handles (purses). Today, students carry lightweight ergonomic nylon backpacks and many are even on wheels! The latest school bags are designed to handle heavier textbooks and laptops as well as be aesthetically pleasing with designer graphics. It is truly amazing how the creative, problem-solving engineers help to shape our world!

## Background Information

### Types of Structures

Structures are objects that serve a purpose such as supporting a load, containing an object or spanning a distance. They can be classified by their design: shell, frame or solid structures.

- Shell structures have an outside layer of material that holds the object together. This type of structure is lightweight as it is hollow inside and does not have a frame supporting it. All shell structures have a curvature element either in cylindrical, dome or saddle shapes. The shape of the shell helps to spread forces to the whole structure so that it can support the load. Examples of shell structures include food or beverage cans, bubbles, igloos and sea shells. Buildings that exhibit a shell structure are the famous Sydney opera house and the Calgary Saddledome. These buildings are constructed with concrete pieces that are joined together in a curved shape.
- Frame structures have a supporting framework comprised of parts fastened together. This design allows the structure to be light and economic, yet still be strong enough to support heavier loads. Without the frame, this type of structure would not be able to stand on its own. A frame structure can be either two dimensional or three dimensional. Examples of a 2-D frame structure include a picture frame, spider web and fence. A 3-D frame structure would include a face mask, a house frame and the Eiffel Tower. The Eiffel Tower was designed for the World's Fair in 1889 by engineers G. Eiffel, M. Koechlin and E. Nougier. The 324 m famous tower was constructed from 18,000 pieces of wrought iron that are supported on masonry piers. The engineers demonstrated that the lattice wrought iron could be just as strong as stone but much lighter.
- Solid structures are comprised of one solid piece of material. They are structurally rigid and rely on their own mass to resist the forces that act on it. This type of structure is heavier than a hollow structure of the same size and material. Examples of solid structures include mountains, dams and the CN tower. In contrast to the Eiffel tower, the CN tower is a solid 553 m structure consisting of reinforced concrete in its three support legs with a hollow concrete hexagon in the centre that provides stability for the structure.

Many structures are really a combination of the three classes. A hockey helmet is a shell (helmet) and a frame (wire cage) structure. A turtle's body is supported by a frame (skeleton) and protected by a shell (scales that make up a turtle's shell).

When engineers design a building or an object, factors like strength and cost are important considerations in deciding what type of structure to use. For example, when constructing a dam, it is necessary to invest in a solid structure in order for it to withstand the strong forces from the water. A solid structure will have higher costs involved with the increased amount of materials needed for construction but this will be necessary for optimal performance of the dam. In contrast, an engineer designing a bridge may decide that although a solid structure would be very strong, it may be too heavy to span a long distance. In this situation, a frame structure would be chosen to provide the strongest and most cost effective bridge to meet the design needs of a longer span.

## Internal and External Forces

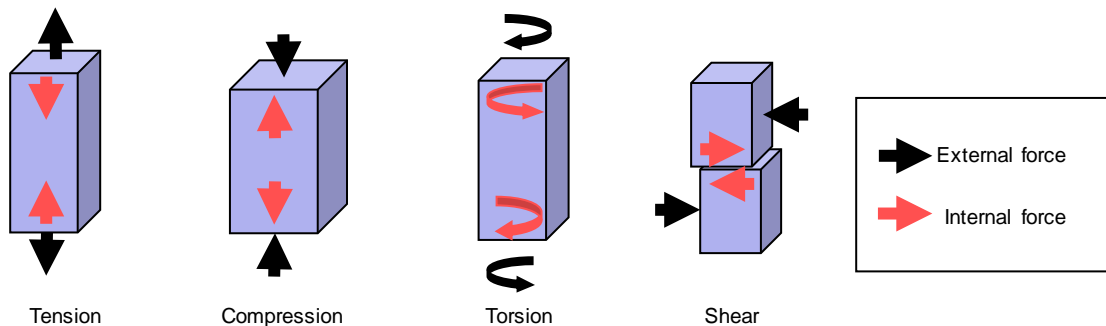
A force is a push or pull that either changes an object's shape or the position of an object. As engineers design structures to withstand forces from various loads, they depict the magnitude, location and direction of forces in their architectural drawings using arrows called vectors. The magnitude of force is calculated by the equation:

$$\text{Force} = \text{mass} \times \text{acceleration} (F = m a), \text{ measured in the standard unit of Newtons (N).}$$

Since the acceleration on Earth is  $9.8 \text{ m/s}^2$ , the force of gravity pulling down on an object that has a mass of 100 g would be  $F = 0.1 \text{ kg} \times 9.8 \text{ m/s}^2 = 0.98 \text{ N}$ .

A structure is designed to withstand the force of its own weight, referred to as the static or dead load, as well as to support the load applied to it, called the dynamic or live load. Static loads are considered to be permanent and do not change over time. They are easily determined as the weight of the materials used in a structure. Dynamic loads are temporary loads that the structure was designed to withstand, such as the cars in a parking garage, the vibration from a train on a bridge or the people in an office building. There are also environment loads to consider such as those that are caused by earthquakes, wind storms, rain, snow, and temperature change.

When external loads or forces are applied to a structure, internal forces or stresses develop within. The internal forces work to resist the outside forces and keep the structure together. Each structural member, or piece of the structure, may experience internal forces such as tension (pulling force), compression (pushing force), torsion (twisting force) and/or shear (sliding force). If a structure can not withstand these forces, the structure will snap, buckle, or rip apart. A structure's strength is considered to be its ability to resist deforming or failing under these forces. The job of an engineer is to estimate the external loads acting on the structure, calculate the resulting internal stresses and design structural members that are strong enough to carry the loads without breaking.



Tension occurs when a member of the structure is pulled in opposite directions such as when steel wire is used in a suspension bridge to support the deck. The wire would have internal force acting against the external pull of the weight of the deck. Tensile strength is considered the maximum force the structure can take under tension before snapping.

Compression occurs when a member of a structure is pushed together such as concrete columns supporting a building. The weight of the building applies external forces on the columns while the

columns internal forces push back. Compressive strength is the maximum compressive load a structure can withstand before buckling.

Torsion is present when a twisting or torque is applied and is considered a combination of tension and compression. There is torsion when a wrench is used to twist on a bolt. Torsion strength is the ability to withstand torque and not deform or rip.

Shear forces occur when parts of a structure move in parallel and opposite directions but they are not aligned. It is also a combination of both tension and compression. If these forces were aligned they would simply be compressive forces. Bolts that hold structures together are under shear forces. Shear strength is measured by how much force a structure can take before ripping or tearing apart.

## **Centre of Gravity**

When the earth's gravitational pull acts on an object, it acts on each particle of its mass and we call that weight. This pull is concentrated on one imaginary point in the object called its centre of gravity. This is the point around which the mass is evenly distributed. In order for engineers to design stable structures, they must understand where the centre of gravity is located. The stability of a structure can be improved by finding methods of moving the centre of gravity lower, by widening or adding more mass to the base. In structural design, this is achieved by constructing deep, heavy and solid foundations.

## **Structural Design**

As engineers design and build a multitude of different structures in society, they must consider safety as a priority. They must understand the load that will be applied, the environment it will be used in and the budget of the project, in order to construct a safe, economical structure. Engineers utilize many different structural methods to meet these needs while continuing to be cost effective. Techniques that are used in home building may include: I-beams for floor joists, trusses to support a roof structure and concrete footings for supporting the load of the entire house. Specific shapes such as triangles, cylinders and arches are commonly used in structures as they are very strong and can withstand forces well.

Although safety is of the utmost importance, engineers must also ensure their design is efficient from the perspective of material costs, building costs, space, etc. They need to understand what the purpose of the structure is, to ensure they do not over engineer. A factor of safety is built into engineering each part of a structure. The equation representing this is:

$$\text{Factor of safety} = \text{Strength of material} / \text{Load on material.}$$

If the safety factor is 1, then the structure can only hold that particular load. If the safety factor is less than 1, then the structure is likely to fail. Generally, engineers use a factor of 2 for each structural member when designing buildings. This can vary in other applications. In the automobile industry the safety factor used is 3, while in the aerospace industry the safety factor is usually 1.5 to avoid excess weight. However, there are strict safety checks to balance the risk of a lower safety factor. Higher safety factors often mean that either more material is used or it is stronger and more costly.

To illustrate the relationship between the safety factor and over engineering, let's design a bookshelf. A bookshelf may be designed with a safety factor of 10 and be able to withstand a load of 1,000 kg. The bookshelf would be constructed with many supports, reinforcements and strong material such as steel. However, if the true purpose of the bookshelf was to hold 50 textbooks with a total weight of 100kg, then this design has been over engineered and is much more expensive than it needed to be. Instead of a safety factor of 10, engineers would design the bookshelf with a safety factor of 2 so it can hold 200 kg to allow for situations when it is overloaded, misused and to allow for degradation over time.



## Material Selection

Material choice is a key part of structural design and building. Choosing the best materials to meet the load requirements, as well as staying in budget, is part of an engineer's role. Common building materials include wood, concrete, masonry, iron, aluminum, and steel. These materials have characteristics that lend themselves to providing strength by being able to withstand forces such as tension and compression, thus ensuring safety in a structure's design.

Composite materials are also useful in improving strength but many also provide a low weight to strength ratio thus reducing cost. Concrete is a combination of cement and aggregate (stones) which creates a strong compressive material used heavily in construction. Concrete may also be structurally reinforced by adding steel rods, called rebar, to improve its tensile properties as well as creating a material that has a high tolerance for temperature change. These improved material properties can help prevent failure in bridges and columns in massive structures. Performance racing cars utilize carbon fibre (polymer combined with carbon) for its lightweight but high strength properties. The higher cost associated with the use of this almost unbreakable material is minimal compared to the benefit of additional safety for the drivers.

## Aesthetics and Ergonomics

Many structures are designed with symmetrical parts that simplify the design, yet also create a more aesthetically pleasing result. With a symmetrical design, engineers can model and study affects of forces more easily than with more complicated designs. Another advantage to symmetrical designs is that the process involved during the construction phase is simpler.

Ergonomics is the study of the relationship between the natural movement of the human body with workplace equipment. Successful products that prevent injuries and discomfort are a result of the combined science disciplines of engineering and ergonomics. A chair that is curved to fit our body and is flexible would be more comfortable than one that is straight and not flexible.

### Fun Fact: Cool engineers!

Did you know the word "engineer" derives from the Latin meaning "cleverness"? Engineers not only create super structures such as high-rises but they also develop lots of fun things such as televisions, water slides and Ferris wheels! The Ferris wheel, designed by George Ferris in 1893 at the World's Fair in Chicago, is considered an engineering feat. It was supported by two 42 m supports and the wheel spun on a 14 m long forged steel axle.

### Fun Fact: Oldest type of engineering?

Civil engineering is considered to be the oldest discipline of engineering as it deals with building anything! The first known civil engineer was Imhotep, who built pyramids using shaped stones. In 2611 BC, he created the famous stepped pyramid of King Djoser, located at Saqqarah in Egypt.

## Activity 1: Reverse Engineering!

**Time:** 30-60 minutes

**Other Application:**  
Language

**Key Terms:** shell, frame, solid, fasteners, material, strength, stability

**Group Size:** Individual or pairs

**Materials:**

- “Reverse Engineering!” worksheet per student
- pencils
- screwdrivers (varying sizes, Philips, flat)
- sandwich baggies

**Learning Goal:** Students will learn how to backwards or reverse engineer.

The engineering design cycle is:  
Ask → Imagine → Plan → Create → Improve.

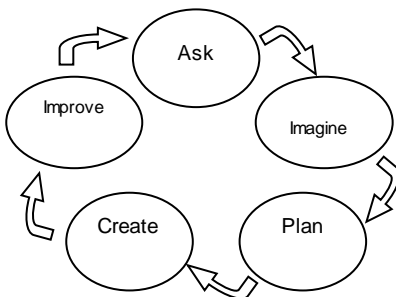
The reverse engineering process is:  
Identify → Observe → Implement → Create.

Students will identify a simple object, like an inexpensive toy or appliance. They will take it apart to observe and investigate the types of structures (shell, frame, solid), materials, fasteners and simple machines that are used. They will look at the objects' limitations. They will then brainstorm what could be implemented to redesign it to improve the object. Increasing strength, reducing cost and/or improving functionality are areas to explore. In the end, the students will suggest what new object they could create to improve upon the existing one.

**Procedure:**

1. Ask students to bring in a simple, unused and inexpensive toy or appliance to take apart for investigative purposes. Some examples of toys that work well include wind-up toys, music boxes, wind-up clocks and spring loaded toys. Avoid electrical and electronic items as electronic circuitry will be beyond the scope of this activity.
2. Hand out copies of the worksheet “Reverse Engineering!” Students can work individually or in pairs. Each student should complete their own worksheet.
3. Students should first clearly **identify** their object and record notes on their worksheets. What is it? What is its purpose? How does it work?
4. Students will **observe** their object and list if it has a shell, frame, or solid structure or a combination of structure types, as well as any observable fasteners used.
5. Students will test their object to observe how it works. Ask them to predict what mechanisms may be inside to allow it to work.
6. Students can use screwdrivers to disassemble their object. Use baggies to store loose screws and parts so that they do not get lost. Observe and record the materials, fasteners, simple machines and mechanisms used inside the object.
7. Record any limitations of the object.
8. Brainstorm and record ideas about what could be **implemented** to make their object better (e.g. change materials, add a mechanism, or simplify by removing unnecessary parts, etc).
9. Record what new object they would **create** to improve on the original object.

### Engineering Cycle



## Observations:

Sample observations of a “Reverse Engineering!” activity using a wind-up train:



### Observe product (disassemble):

What type of structure is it?

- shell structure

List materials, fasteners and mechanisms:

- mostly made from plastic and some metal pieces

Disassemble and record any mechanisms or simple machines used inside.

- the toy works by winding it up which gives it forward motion; it uses a stand alone wheel and axle; a wheel and axle is attached to gears that are connected to the wind up handle; a spring coil transfers the winding motion to the gears which then turns the wheel and axle.

What are the limitations of the product?

- the toy can not go backwards or turn, just moves forwards

### Implement changes:

Brainstorm ways to improve the product:

- a possible idea would be to allow the stand alone wheel and axle to turn, so there is more than just forward motion, particularly if it runs into an obstacle

What does it improve?

- it makes the toy more functional as it adds more interest during play

### Create new or improved product:

- I would create a wind up train that can turn in different directions rather than just in a forward motion

## Discussion:

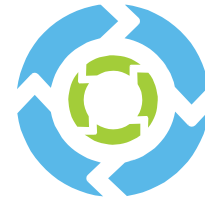
Discuss with students how this process is different from the engineering design process. The engineering design process involves brainstorming and imagining a new product, planning how to build it, building a prototype of the product, testing the product and improving the product until there is a final result. In contrast, reverse engineering requires observing an existing product, investigating the existing function, brainstorming ways to improve the product and then applying those improvements for the final product.

Discuss and compare the different innovative ideas students came up with. Discuss how it improved on the product – e.g. compare cost of production, the possible better functionality or aesthetics, etc.





## Reverse Engineering!



**Identify product:**

**Observe product (disassemble):**

What type of structure is it?

List materials, fasteners and mechanisms:

Disassemble and record any mechanisms or simple machines used inside.

What are the limitations of the product?

**Implement changes:**

Brainstorm ways to improve the product:

What does it improve?

**Create new or improved product:**

## Activity 2: Art of Balancing

**Time:** 90-120 minutes

**Other Application:** Art, Language

**Key terms:** frame, shell, solid, balance, symmetry, centre of gravity

**Group Size:** Individual

### Materials:

#### Shell Structure:

- moulds with curvature shape: recyclable plastic containers, jars, balloons
- newspaper
- vaseline, oil, dish-washing liquid or plastic wrap to line mould (optional)
- flour & water
- 250 ml measuring cup
- mixing bowls
- spoons

#### Frame structure:

- wire (approx 20 gauge steel wire)
- wire cutters or heavy duty scissors
- pliers

#### Base and Decorating:

- clay
- ruler or other straight edge for cutting clay
- sharpened wooden pencils, skewers or skinny dowels
- paint or markers
- tissue paper (frame)
- glue

**Learning Goal:** Students will learn about the different types of structures and about the centre of gravity of a structure.

There are three main types of structures:

- frame - structure that has a framework that supports the object (e.g. picture frame);
- shell - structure made of a curved outside layer of material that is hollow on the inside (e.g. pop can);
- solid - structure that is a solid mass of material (e.g. dam).

The centre of gravity of an object is the most stable point of the object – the point at which the object balances from left to right, front to back, and top to bottom. For objects with symmetry, the centre of gravity is always located along the axis of symmetry.

### Procedure:

1. Instruct students that the purpose of this art/science project is to create either a frame or a shell structure. They will then balance their structure on a solid base on a single point.
2. Students may choose to make a shell structure, using papier-mâché techniques, or a frame structure, using pieces of wire.
3. Shell structure instructions:
  - a. Ask students to bring in an object with a curved shape (cylindrical, dome or saddle shaped) to be used as the mould for their shell structure. Recycled containers, bowls and balloons are examples of possible moulds. A suggestion for easy mould removal is to layer the mould with a thin layer of vaseline, oil, dish-washing liquid or plastic wrap prior to applying the first layer of papier-mâché.
  - b. Make the paste for papier-mâché in a mixing bowl by adding 250 ml (1 cup) of flour with 250 ml of water and stirring until it is the consistency of batter.
  - c. Rip up newspaper in strips (5-8 cm long) and dip into the paste. Remove excess paste using fingers.
  - d. Place strips on or in the mould of a shape of their choice (or multiple shapes). Continue covering by overlapping the strips until the mould is covered on three sides. The inside of a container works well or an entire balloon (that can be popped after it has hardened).
  - e. Allow to dry overnight and then repeat for a second layer. Students can use paper towels or plain paper instead of newspaper for the second layer to provide a clean surface to decorate when completely dry.
  - f. Once dry (overnight), the shell structure can be removed from the mould and scissors may be used to trim edges.

4. Frame structure instructions:

- a. Supply wire, pliers and wire cutters to students.
- b. Ask students to plan what their structure will look like, estimate the pieces required and how they will put it together.
- c. Students will create their structure by bending and shaping their structure, using the wire as its frame. To help shape their wire, students may use forms (plastic containers, etc.) that can be removed afterwards.

5. Students will create a solid structure base out of clay. Solid base structure instructions:

- a. Provide a piece of clay, approximately 2.5 cm cube, to each student.
- b. Ask students to review where their shell or frame structure's centre of gravity is and where it can balance on one point.
- c. Position a skewer, dowel or sharpened pencil upright in the base, ensuring it will be stable to hold up their art piece.
- d. Shape the clay to create a solid base in any shape as long as the base is able to hold the structure stable while it balances on a single point.
- e. Test the base with their shell/frame structure and make any adjustments as necessary. Allow the base to dry completely overnight without the shell/frame on it.
- f. When it is dry, decorate the art structure and base using paint or markers. For the frame structure, students could add a skin to the frame using tissue paper (e.g. like a leaf or skin-frame canoe).
- g. Balance the art piece and place their structure for display.

**Observations:**

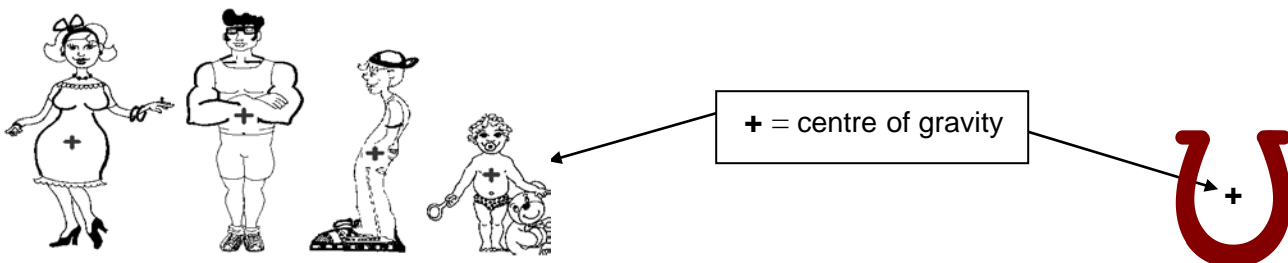
Some sample photographs of artwork:



**Discussion**

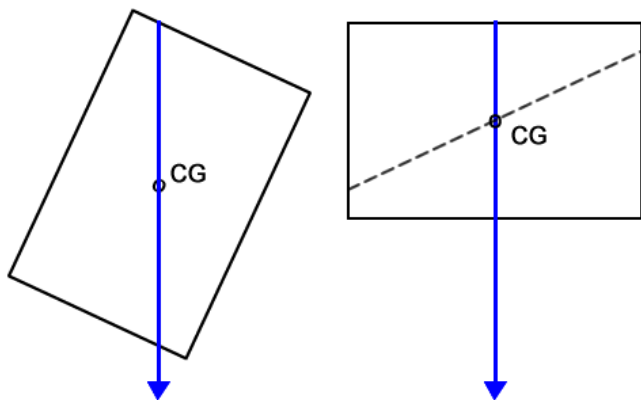
Ask students if their art piece was a frame or shell structure. Did symmetry help with balancing their piece? How difficult was it to find the balancing point?

Is their art piece balanced on the centre of gravity? No, since the centre of gravity is not always on the object itself – e.g. a shell of a sphere or a horseshoe. The centre of gravity is the point where the mass is centred.



Source: [http://mahdisjalalvandi-sph3u.blogspot.ca/2010/09/physics-of-tall-structures\\_12.html](http://mahdisjalalvandi-sph3u.blogspot.ca/2010/09/physics-of-tall-structures_12.html)

Ask students to identify where their objects' centre of gravity is. There is a simple method, called the plumb line technique, that students can use to roughly estimate the centre of gravity. A short Youtube video at <http://www.youtube.com/watch?v=HaaL2wucyRE> is a great demonstration of the use of plumb lines. This technique uses the force of gravity to deduce where the centre of gravity is on an irregular shape. The students can make a plumb line by taking a 20 cm piece of string and attaching it to a small mass, such as a small rock or magnet. The students will then hang the plumb line by sticking one end onto a part of their art object using masking tape or a pin. They let the string and the object hang freely at this point (can hold it up with a finger) and where the string hangs (plumb line), somewhere below it is the centre of gravity. Repeat this step a number of times using different parts of the object and making note where the plumb line hangs each time. By comparing where this plumb line crosses other plumb lines, students can estimate where the centre of gravity is.



Source: Ron Kurtus, [http://www.school-for-champions.com/science/gravity\\_center.htm](http://www.school-for-champions.com/science/gravity_center.htm) (27/11/13)

What shape did they make their base to make it stable? When the base is wider, the structure becomes more stable. Which do they think was harder to balance, the shell or frame? Why? The shell structure may have been more difficult as it is heavier. Therefore, finding the spot to balance was more crucial as the heavier, uneven mass would tip easily.

**Fun Fact: Concrete Canoe!** In the 1960's, the American Society of Civil Engineers (ASCE) challenged university students to use their engineering knowledge and creativity to build a concrete canoe, by applying the concept of a shell structure. This has evolved into a global racing competition that tests their creations! In Canada, the Canadian National Concrete Canoe Competition (CNCCC) is held at different universities across the country each year.

## Activity 3: Build this House!

**Time:** Day 1 (building):  
45-60 min with drying time in  
between;  
Day 2 (testing): 45-60 min

**Other Applications:** Math,  
Art, Language

**Key terms:** compression,  
tension, shear, load, truss,  
beam, reinforcement, solid,  
frame.

**Group Size:** 2-4 students

### Materials:

- “Build this House!”  
datasheet per student
- kitchen scale
- sets of mass (20 x 500 g)  
(e.g. bags of rice, beans,  
pasta etc)
- nylon straps  
(2 – 5 cm wide)
- glue (truss and I-beam)

### Reinforced concrete per group:

- air-dry clay (500 g)
- clay cutting tool
- 6 cm long material pieces  
such as pipe cleaner,  
string and steel wire  
(approx 20 gauge)
- paper bag with handles or  
cloth bags

### I-Beam per group:

- 3 popsicle sticks per  
beam

### Truss per group:

- 30 popsicle sticks per  
truss roof structure

**Learning Goal:** Students will learn about modern house construction.

Beams are a structural element designed to withstand a load by resisting bending. The advantage of I-beams over regular beams is that the two horizontal portions of the “I”, called flanges, resist the bending movement. The vertical portion is called the web and it resists shear forces. Trusses are comprised of one or more triangle shapes which can withstand compressive and tensile forces. Reinforced concrete, a composite material containing steel bars (rebar), is used to increase tensile strength and prevent deformation. The following Youtube video effectively illustrates the steps of modern home construction:

<http://www.youtube.com/watch?v=FQvFzdFlp08> (11/06/15)

### Procedure:

1. Review concepts of home construction and show Youtube video. Hand out a copy of “Build this House!” datasheet.
2. Divide the class into groups of 2-4 students to perform various experiments to illustrate the advantages of modern elements of home construction.
3. **Reinforced Concrete:** Students will simulate concrete by using clay and comparing the strength of concrete versus reinforced concrete.
  - a. Building (Day 1): Provide groups with a 500 g clay block. Ask students to cut and shape into small bricks of about 8 x 1.5 x 1.5 cm. in size. Make 3 bricks and mark them with “C” for concrete.
  - b. Choose a type of reinforcement (wire, string or pipe cleaner) and make note of what was used. Make another 3 bricks and embed one piece of the chosen reinforcement material in the clay to simulate a reinforced concrete brick. Do not use more than one piece of material as the clay will crack while drying. Mark them with “RC” for reinforced concrete.
  - c. Predict whether the brick will be strong or weak by circling the appropriate word. Ensure that the bricks are marked clearly and allow the bricks to dry overnight.
  - d. Testing (Day 2): Once dry, lay a concrete brick between 2 desks, supported on each edge. Hang a strap over the brick and attach a paper bag to the strap. Gently add 500 g at a time to the bag and observe how much load the brick can hold before failing. Repeat for each concrete sample and record the load each could sustain on the datasheet.
  - e. Repeat the experiment for the reinforced concrete bricks and record the observations on the datasheet.

- f. Record any evidence of failure for each type of brick (e.g. evidence of shearing, breaking, cracking, tension and compression).
  - g. Summarize what was discovered – which brick was stronger?
4. **Building with I-Beams:** Students will simulate an I-beam using popsicle sticks and compare its strength to a simple beam (one popsicle stick).
- a. Building (Day 1): Encourage students to create their own I-beams using popsicle sticks and glue.
  - b. The steps for a successful I-beam involve placing one popsicle stick on the desk to represent one of the flanges. Lay glue across the whole length of the flange and stand a second popsicle stick, representing the web, on its edge on the glue. Let it dry for one hour (may need to prop up to make it stay). Place a line of glue along the top edge of the second popsicle stick (web) and then place the third popsicle stick on the top (flat) and let dry. This completes the “I”. Ensure the I-beam stays in place and allow to dry overnight. For each beam, predict whether it will be strong or weak.
  - c. Testing (Day 2): Place a simple beam (one popsicle stick) spanning the space between 2 desks. Place a strap over the beam and add a load (500 g mass) to test its strength. Increase the load, up to 3000g, until the beam fails. Record the load it could sustain before failing.
  - d. Once dry, test the I-beam by placing it in between 2 desks and add a load with a strap over the beam. Test until the I-beam fails or up to 3000g. Record the observations on the datasheet.
  - e. Record any evidence of failure for each type of beam (e.g. bending, snapping).
  - f. Summarize what was discovered – which one was stronger? Why?
5. **Truss Construction:** Students will build trusses using popsicle sticks and glue. They will test the strength of a roof built with trusses compared to a flat roof.



- a. Building (Day 1): Encourage students to create their own trusses to support a roof by using popsicle sticks and glue. Remind students that trusses consist of triangles that provide a strong shape as well as a slope to allow for the snow load to slide off.
- b. Suggested steps for a successful truss involve gluing together the truss roof system with 3 triangles on a base (2 sticks). Build the 3 triangles and let them dry for one hour. Attach the triangles to the base by laying the 2 popsicle sticks on the desk and glue one triangle at each end of the popsicles sticks and the third triangle in the middle. Let dry before creating the roof.
- c. Add popsicle sticks to the slopes of the roof and allow to dry overnight.
- d. Build a flat roof by assembling a square base and adding popsicle sticks to cover the square. Allow to dry. Predict which roof will be stronger.
- e. Testing (Day 2): After drying overnight, test the roof strength by adding a load to the roof by hanging masses from the roof using straps to see how much each can hold until it buckles. Record the load it could sustain on the datasheet.
- f. Record any evidence of failure for each type of roof (e.g. bending, deformation, snapping).
- g. Summarize what was discovered – which one was stronger? Why?



**Observations:**

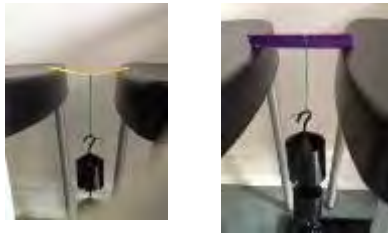
The following photographs illustrate some potential results.

(1) Concrete vs. Reinforced Concrete



Concrete sheared apart under the load which also happens with reinforced concrete yet it is held together by reinforcement.

(2) Simple Beam vs. I-Beam



The simple beam bent and then snapped under tension. The I-beam did not bend or fail.

(3) Flat Roof vs. Truss Roof



The flat roof buckled under compression and would eventually collapse. The truss roof is very strong.

Sample values for the maximum load (g) carried by the simulations of the various structural elements.

	Concrete Block			Rebar Concrete Block		
Observations (load (g))	Sample #1 3500g	Sample #2 2000g	Sample #3 3000g	Sample #1 4500g	Sample #2 5500g	Sample #3 5000g
	Simple Beam			I-Beam		
Observations (load (g))	500g			10, 000g+		
	Flat Roof			Truss Roof		
Observations (load (g))	1000g started to bend			10, 000g+ did not bend/change		

## Discussion

Discuss with the students how each of these common construction techniques is used in today's construction. Reinforced concrete is used in the foundation of the building, which has to be strong to hold up the entire weight of the house. I-beams help support the weight of the house on the load bearing area. Roof trusses are used to create a slope on the roof to allow water and snow to flow off as well as provide a strong structure above to keep the house protected from the elements.

Why look at more than one brick? To ensure that results are reproducible, it is best to do the experiment three times in case one brick does something out of the ordinary (i.e. if one of the reinforced bricks has a crack already, then it may fail quicker than a regular brick). This experiment is more susceptible to variations as the bricks are made by hand from clay and the differences in the results are not very large. Therefore, by increasing the sample size, the results will help clearly illustrate which is stronger. The other experiments, using the I-beam and trusses, have larger differences in loads and therefore the variation in the samples is negligible in the results.

Compare results within the class to see if there was any difference depending on the type of reinforcement material chosen for the concrete/clay bricks. Adding reinforcements to the concrete/clay allowed a larger load to be carried before failure. When the clay bricks failed, then the reinforcement helped to hold the pieces of concrete together. There should not be a noticeable difference in the type of material used for reinforcements.

What was the failure mode of the concrete, beams and roofs? The load (strap with masses attached) applied a force of gravity downwards. The load caused the concrete bricks to have internal forces of tension on the underside and compression on the top side. They catastrophically failed by shearing apart. The reinforced concrete initially failed by cracking and then the bricks separated. The reinforcements helped hold the material together and provided more elastic properties. The load caused the simple beam to fail by bending, as a result of tension on the underside and compression on the top side of the beam. The I-beam supported the load because the web resisted shear forces and the flange resisted bending. The flat roof will bend and deform under the load. The truss roof is very strong and held its shape because the triangles helped distribute the forces from the load.

What would happen to a house if any of these failed? The house would not be safe to live in and potentially collapse.

## Extension:

Students could make a model of a house using these construction methods. For example, build a 2 story house and use I-beams for the support between the floors and use popsicle sticks layered side by side for the flooring and walls. The truss roof they built could also be incorporated as well.

**Fun Fact: Passive house?** A passive house is a very well-insulated air tight building that is energy efficient. A passive house will have 75% less heat consumption compared to a regularly constructed home. It is heated by "passive" methods such as using sunlight and reducing the heat transfer through walls. One of the first passive buildings in Canada was the Saskatchewan Conservation house in 1977. This airtight house is made with windows and walls of high thermal ratings and an efficient heat recovery ventilation system.

Name: \_\_\_\_\_



## Be a Construction Engineer!



Concrete Block				Rebar Concrete Block		
Prediction	strong	weak		strong	weak	
Observations	Sample #1	Sample #2	Sample #3	Sample #1	Sample #2	Sample #3
Load (g)						
Evidence of failure						
Discovery						
Simple Beam				I-beam		
Prediction	strong	weak		strong	weak	
Observations						
Load (g)						
Evidence of failure						
Discovery						
Truss Roof				Flat Roof		
Prediction	strong	weak		strong	weak	
Observations						
Load (g)						
Evidence of failure						
Discovery						

## Activity 4: For the Thrill!

**Time:** 90-120 minutes

**Other Applications:** Art, Social Studies, Math, Language

**Key terms:** forces, gravity, frame structure, stability, strength, truss, columns

**Group Size:** Small groups (2-4 students)

**Materials:**

- “For the Thrill!” datasheet per student
- paperboard boxes (cracker, cereal boxes)
- paper towel rolls
- wooden popsicle sticks
- skewers and/or dowels (various sizes)
- styrofoam pool noodles
- styrofoam or cardboard base (approx 2.5 cm thick, 30 cm x 90 cm)
- glue
- masking tape
- scissors
- large marbles

**Learning Goal:** Students will learn about designing a roller coaster and the business proposal process.

Roller coasters originally developed from sleds on simple ice hills in Russia into the thrill seeking super steel structures that push the boundaries of speed, height and the psyche! There are a wide variety of coasters found in theme parks all around the world: from wooden coasters to steel, ones that sit, suspend or fly the riders, take them for dips, loops and turns of all sorts.

In the 1920’s, wooden coasters were built using wooden trusses that support a steel track. These original coasters were generally inflexible and therefore the motion could only be up and down. By the 1960’s, the steel roller coaster was introduced and allowed for a smoother, faster and more complex ride.

**Procedure:**

1. Review the history of roller coasters.
2. Explain to students that you, the teacher, are the owner of a theme park. You are putting out a request for proposal (RFP) for companies to submit a business proposal to build a new roller coaster in your park.
3. Divide students in small groups. Each group will represent a company that will design and construct a roller coaster model with at least 3 thrill elements (e.g. dips, turns, loops, tunnels, corkscrew (spiral) or launch). You, as the owner, will assess each coaster and score them out of total of 100 points. The highest score would receive the contract.
4. Review with students the structural components of a roller coaster and how they can be modeled with materials on hand:
  - a. Supports: The roller coaster supports can either be created from popsicle sticks (represent wooden trusses) or paper towel rolls, pool noodles or wooden skewers (represent columns) that will simulate steel coasters.
  - b. Base: The base can be created from either styrofoam or cardboard to provide stability and flexibility to change position of supports / columns.
  - c. Fasteners: 2 x 1 m lengths of masking tape will be provided to represent fasteners for the structure.
  - d. Track: The track can be created out of boxboard boxes – either 2 large cereal boxes or 4 small cracker boxes.
  - e. Large marbles will be used to represent the cars or train of a roller coaster.



5. The maximum score on the proposal is 100 and the assessment score is divided into 4 categories (25 points each). Review the criteria for a successful project within each category:
  - a. Budget: There will be a set of materials provided that will represent the base budget. Companies have an option to “purchase” more materials if they need to. They will receive a deduction of 1 point for every set of materials they order above the base. The amount of material wasted and/or recycled will also be assessed.
  - b. Safety: The strength and stability of the different features of the coaster will be assessed (support, track, base, fasteners as well as overall strength/stability when tested).
  - c. Creativity: The thrill/speed of each of the three thrill elements as well as overall creativity.
  - d. Execution: The teamwork involved in designing and building the coaster will be assessed as well as how well the coaster meets the needs of the target audience and overall aesthetics of the structure.
6. Hand out “For the Thrill!” datasheet to each group. Students will work together in their group and create a name for their company, record all the engineers and choose the target audience for their coaster (kids, families or thrill seekers).
7. Provide students time to develop a plan and design their roller coaster. It should contain a minimum of 3 thrill elements. It does not have to be a continuous track (closed loop). Some potential websites they could be directed to for ideas and different roller coaster elements are: <http://rollercoasterriderblog.wordpress.com/dictionary/>;  
<http://coasterlands.webs.com/coastertrackelements.htm>.
8. Students will be choosing their materials and providing you with their requests:
  - a. Base: styrofoam or cardboard
  - b. Support (column and/or truss):  
Truss - 200 popsicle sticks (with glue); or  
Columns - 5 paper towel rolls or 1 pool noodle (150 cm) or 25 wooden skewers.
  - c. Fasteners: no choice, provide each group with 2 x 1 m masking tape
  - d. Track: 2 large cereal boxboard boxes or 4 smaller cracker boxboard boxes
9. Students will construct their roller coasters. Construction may take a few days in order to allow the glue used to assemble trusses to be dry. As their construction progresses, they may need to order more supplies. For each set of materials ordered, keep track and deduct one point from their assessment score (budget & material usage). A “set” of extra materials includes:
  - a. Support: 1 set = 50 popsicle sticks or 1 paper towel roll or 1/5 of a pool noodle or 5 skewers
  - b. Fasteners: 1 set = 1 m masking tape
  - c. Track: 1 set = 1 small box
10. Students should continuously test their roller coaster creation with a marble and make adjustments as required.
11. Once all roller coaster models are completed, allow students to prepare a short presentation to the theme park owner (teacher).
12. The theme park owner will evaluate each group’s design using the Proposal Evaluation sheet provided to determine who will win the contract. Each category is worth 25 points – budget, safety, creativity and execution. Within each category, there are 5 subcategories that are each worth 5 points. Some suggestions have been included to assist in evaluation:

- a. Budget: Each structure component represents a subcategory – support, track, fasteners and base. For each structure component, a score of 5 would be if no additional materials were requested; 4 points if one additional set requested, etc. The score for the recycling or waste subcategory would be dependent on whether the students cleaned up, recycled unused materials and placed waste materials in the appropriate place.
- b. Safety: Each subcategory examines the strength/stability of each structure component - support, track, fasteners and base. For example, for support component, a score of 5 would be if all parts are stable and they do not move or waver from the base to the track as compared to a score of 1 when it falls apart and does not support the track. The last subcategory examines the strength/stability of the structure overall when it is tested.
- c. Creativity: For the first subcategory, speed/thrill, a score of 5 would represent a ball that runs smoothly through the track at high speed versus a score of 1 when the ball does not complete the run. For each feature, a score of 5 would be given if the feature is not repeated and is unique, complex and works well. For creativity, a score of 5 would be given when the coaster is unique and contains more than 3 working features.
- d. Execution: A subjective category and is dependent on group dynamics as well as other roller coasters created in the class.

### **Discussion:**

Discuss with the students what their steps were for planning and building their creations. Did they follow the engineering design steps of Ask → Imagine → Plan → Create → Improve?

What were their biggest challenges? Discussion may revolve around being able to work effectively as a team, difficulty in planning or building.

How does this activity relate to the everyday reality of business proposals from engineering firms? Compared to a real business proposal, there are many similar steps such as planning stages, designing the coaster and then a cost estimate. The success criteria in a real business would be very similar to that in this activity (e.g. cost budget, safety/stability, creativity and execution of building).

### **Fun Fact: Origins of the Roller Coaster**

In the 1400's, ice hills were made in Russia using wooden frames at a height of approximately 20-25 m with a 50 degree drop. These "Russian Mountains" are considered the beginnings of the roller coaster.

A driver would guide riders down this human made slope on a wooden sled. In St. Petersburg, Catherine II of Russia enjoyed them so much that she had them built on her property. Eventually, wheels were added to these coasters so they could enjoy them in the summer as well.



Name: \_\_\_\_\_



## For the Thrill!



Company Name: \_\_\_\_\_

Company Engineers: \_\_\_\_\_  
 \_\_\_\_\_

Target Audience (circle):      Kids                      Families                      Thrill seekers

Thrill Elements (list): \_\_\_\_\_  
 \_\_\_\_\_

Design (draw, notes on back of page)

Materials:

Structure Components	Materials (circle choice if applicable)	Extra Materials (list)
Base	Styrofoam                      Cardboard	
Support	Truss (200 popsicle sticks)      Column (5 paper rolls or 1 pool noodle or 25 skewers)	
Fastener	2 x 1 m tape	
Track	2 large boxes                      4 small boxes	



## For the Thrill!

### Proposal Evaluation by Theme Park Owner (teacher)

**Company Name:** \_\_\_\_\_

**Company Engineers:** \_\_\_\_\_  
 \_\_\_\_\_

**Budget: Material usage: (25 points)**

Support (columns, truss)	1	2	3	4	5
Track (paperboard)	1	2	3	4	5
Fasteners (tape)	1	2	3	4	5
Base	1	2	3	4	5
Recycling, waste	1	2	3	4	5

**Safety: Stability & Strength (25 points)**

Stability/strength of support	1	2	3	4	5
Stability/strength of track	1	2	3	4	5
Strength of fasteners	1	2	3	4	5
Stability/strength of base	1	2	3	4	5
Stability/strength when tested	1	2	3	4	5

**Creativity: Thrill, speed, number of features (25 points)**

Thrill / speed	1	2	3	4	5
Feature #1	1	2	3	4	5
Feature #2	1	2	3	4	5
Feature #3	1	2	3	4	5
Creativity, additional features	1	2	3	4	5

**Execution: Met target audience needs & aesthetics (25 points)**

Teamwork - planning stage	1	2	3	4	5
Teamwork - building stage	1	2	3	4	5
Met target audience needs	1	2	3	4	5
Aesthetics	1	2	3	4	5
Presentation	1	2	3	4	5

**Overall score for roller coaster proposal:** \_\_\_\_\_

## Activity 5: Acadian life

**Time:** 90-120 minutes

**Other Applications:** Art, Social Studies, Language

**Group Size:** 2-4 students

**Materials:**

- balsa wood or cardboard or corrugated plastic
- scissors or saw (depending on material used)
- large tin foil tray or plastic container
- hinge or wire to attach valve
- clay or soil
- duct tape
- craft moss or grass

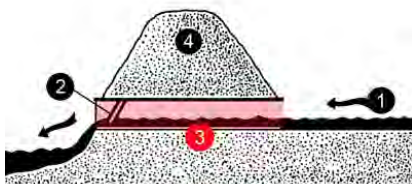
**Learning Goal:** Students will learn about aboiteaus and how they were engineered.

Aboiteaus were used by 17<sup>th</sup> century Acadian French colonists when they settled in the Bay of Fundy area, Quebec, and Maine. Aboiteau farming was a technique to transform marshland into fertile farmland. Earthen dykes were built to prevent high ocean tides from entering the land. This dyke system, aboiteau, used a one way water gate that allowed fresh water in at low tide yet kept the salty sea water out at high tide. Aboiteaus allowed the Acadians to develop land for agricultural use and prevent fertile farmland from being washed away from the high sea water tides. During this time, the Acadians reclaimed approximately 6,000 hectares of fertile salt marsh lands by the sea. Within a span of a few years, this land was desalinated by rain and snow and became suitable for farming. The government has protected approximately 17,400 hectares of dyke land in Nova Scotia.

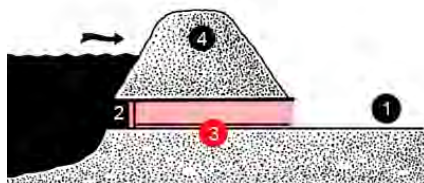
**Procedure:**

1. Provide students with the task of imagining life as an Acadian farmer. Near the ocean, the nutrients in farmland can often get washed away due to the high tides. Instruct students that they will be re-creating a technique that was used to farm the land so Acadian farmers could survive. Students will construct a model of an “aboiteau” that contains a one way valve to keep the sea water out yet is able to allow excess fresh water from the marshes to drain from the land.
2. Students will research Acadian life and the construction of the aboiteau and earthen dyke systems. Some excellent websites for information include:  
<http://www.pc.gc.ca/lhn-nhs/ns/melanson/natcul/aboiteau.aspx>;  
<http://www.landscapeofgrandpre.ca/the-acadians-and-the-creation-of-the-dykeland-1680ndash1755.html>;  
<http://www.ameriquefrancaise.org/en/article-457/>.
3. Students may proceed in building their aboiteau from balsa wood, corrugated plastic or cardboard.
4. Encourage students to create a one-way valve, called a sluice or clapper valve, which will allow the flow of fresh water out and keep the sea water from flowing in. Consider the size of the model so that it can be placed in a plastic container. Suggestions are provided below for valve construction.

Aboiteau at low tide:



Aboiteau at high tide:



Source: <http://www.pc.gc.ca/lhn-nhs/ns/melanson/natcul/aboiteau.aspx>

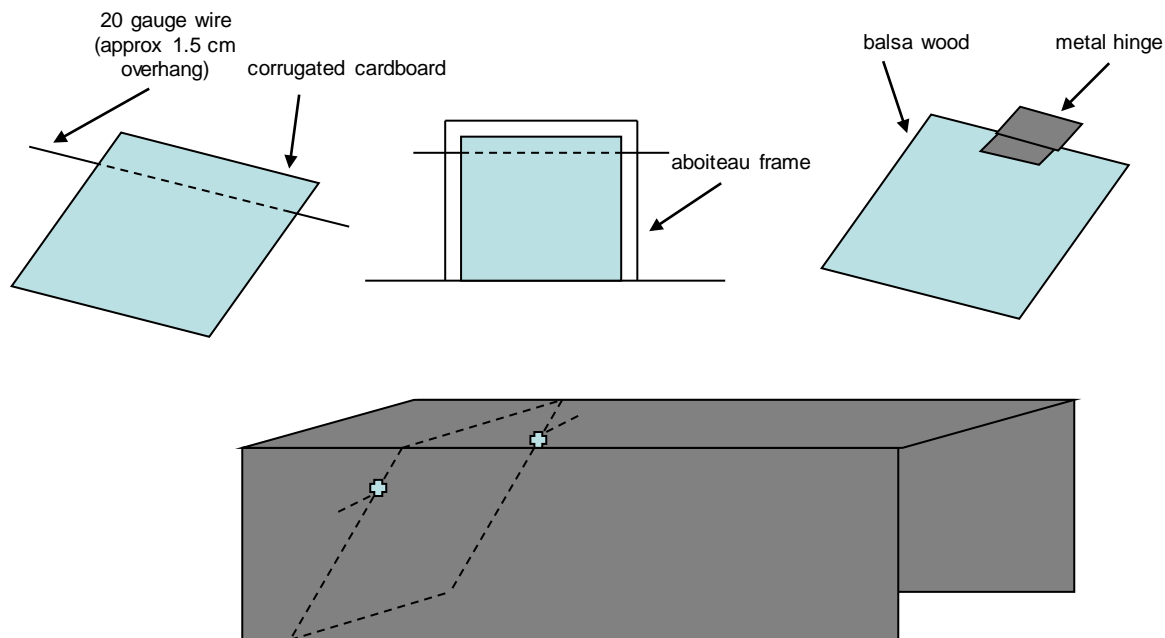
Using wire and corrugated cardboard:

- a. Cut a piece of corrugated cardboard that is the same width as the interior of the aboiteau frame and height approximately 25% longer than the height of the aboiteau frame. Cut so that the corrugation runs horizontally (along the width).
- b. Cut a heavy gauge wire (approximately 20 gauge) that is about 3 cm longer than the width of the valve piece.

- c. Slide the wire through one of the corrugated spaces near the top of the valve piece, with approximately 1.5 cm overhanging on each side.
- d. Position the valve piece in the aboiteau frame on an angle and near the mouth, and secure it by poking holes with the wire overhang into the inside of the frame. Place aboiteau.

Using a simple metal hinge and balsa wood:

- a. Cut a piece of balsa wood that is the same width as the interior of the aboiteau frame and height approx 25% longer than the height of the aboiteau frame. Cut so that the corrugation runs horizontally (along the width).
- b. Attach a metal hinge by securing with duct tape at the top of the valve piece.
- c. Attach the top part of hinge with tape to the inside top of the aboiteau frame, positioning the valve so that it is on an angle, near the mouth of the aboiteau.



5. Clay, soil or cardboard may be used in the model to show the elevation of the land as compared to the marshlands and the sea with the dyke system connecting them.
6. On top of the aboiteau, the dyke system must be high enough to keep the high tide of the sea out. They can simulate this with mud or soil covered with craft moss or grass.
7. Complete the model with elements found around the dyke such as plants on the farm side and sea on the other side.

**Observations:**

The website, <http://www.landscapeofgrandpre.ca/the-acadians-and-the-creation-of-the-dykeland-1680ndash1755.html>, has a great side-view visual of a model aboiteau.

Photos of a possible aboiteau construction:



This model was created using corrugated plastic. The valve was created with the same material. Wire was used for the hinge. The sides were sealed with clay.



**Discussion:**

Discuss with students what tools the Acadians may have used, how many people and how long would it take to build these dyke systems. The tools used by the Acadians included basic hand tools such as shovels called ferrées, axes, pitchforks and wheelbarrows. There were 5-10 workers per day that built approximately 5 m long sections with a 2-7 m width. The dykes could be up to 5 km long.

How would construction differ compared to modern dyke systems with technological developments that are available today? The use of heavy machinery would allow construction to be relatively quick. The materials used today would likely be of polyethylene pipe rather than wood. There would be additional shore protection with rocks and concrete to prevent erosion on shorelines.

**Extension:**

Students could research and construct a modern dyke system to compare the similarities and differences with the system built in Acadian communities.

**Fun Fact: ONroute!** ONroute are vehicle service stations in Ontario that are more than meets the eye! They incorporate 3 specific elements in their designs: glass atrium, stone walls from local areas and wood canopies. They are aesthetically pleasing as well as environmentally friendly! These buildings are all built to the LEED (Leadership in Energy and Environment Design) standards, to be environmentally responsible and sustainable by using less water, lighting and heating/cooling among many other green initiatives.

(see <http://onroute.ca/eco/> for more info)

**Fun Fact: Hands-on Learning!**

The Ontario Science Centre, located in Toronto, is one of the world's first interactive Science and Technology museums. Its innovative architecture, designed by Raymond Moriyama in 1964, has three main buildings that are connected by walkways and escalators that descend down and follow the natural descent into the ravine of the Don River. The buildings encompass and integrate nature into the experience.

## Teacher Resources

### Literary Resources

*Megastructures*. Ian Graham. 2012. Firefly Books. ISBN 978-1-77085-111-5. A book on all types of structures.

*Extreme Structures* – David Jefferis. 2006. Crabtree Publishing Company. ISBN 978-0-7787-2858-0. A book about extreme structures built in the 21<sup>st</sup> century, including domes.

*Amazing Built Structures*. Nicolas Brasch. 2010. MacMillan Library. ISBN -9781420268997. A book on technology used to build well know structures around the world.

*Marvels of Engineering*. The National Geographic Society. 1992. National Geographic Books. ISBN 0-7922-7351-6. A book on world's engineering marvels.

*Basic Structures for Engineers and Architects*. Philip Garrison. 2005. Blackwell Publishing. ISBN 978-1-4051-2053-1. Textbook of structure concepts and equations.

### Website Resources

<http://www.pbs.org/wgbh/buildingbig/bridge/index.html> (11/06/15)

PBS website on different bridges, tunnels, dams, domes, showing forces that act on the structures.

<http://www.instron.com> (11/06/15)

Website describing tension and compression testing.

<http://www.cagbc.org/AM/PDF/Passive%20House%20in%20cold%20climates.pdf> (11/06/15)

Description of the energy efficient concept “Passive” house.

<http://www.thegreatcourses.com/tgc/special/worlds-greatest-structures.aspx> (11/06/15)

Video on great shell structures around the world.

<http://www.teachengineering.org/engrdesignprocess.php> (11/06/15)

Review of the engineering design process and cycle.

<http://www.chba.ca/buying/steps-owning-new/construction%20process.aspx> (11/06/15)

Review of the home construction process in Canada.

<http://www.sciencebuddies.org/engineering-design-process/engineering-design-compare-scientific-method.shtml> (11/06/15)

Description of the engineering design process compared to scientific method.

### Interactive White Board Resources

#### “Force and Motion”

<http://exchange.smarttech.com/details.html?id=23aa9c81-14f3-4e2b-b4e5-766de82d1d02> (11/06/15)

A lesson on forces acting upon various objects.

### Multi-media

<http://www.youtube.com/watch?v=5odllpAr9yA> (11/06/15)

Youtube video of building wooden and steel roller coasters.



## Student Resources

### Literary Resources

*Earth Friendly Buildings, Bridges and more.* Etta Kaner. 2012. Kids Can Press Ltd. ISBN 978-1-55453-570-5. A book that reviews foundations, bridges, tunnels, domes, dams.

*Extreme Structures* – David Jefferis. 2006. Crabtree Publishing Company. ISBN 978-0-7787-2858-0. A book about extreme structures built in the 21<sup>st</sup> century, including domes.

*Amazing Built Structures.* Nicolas Brasch. 2010. MacMillan Library. ISBN -9781420268997. A book on technology used to build well known structures around the world.

*History Makers: Engineers.* Richard Tames. 2003. Chrysalis Education. ISBN 1-93233-380-0. A historical look at different engineers who made a significant contribution to society.

*Into the Next Millennium- Engineering.* Deborah Cannarella & Jane Fournier. 1999. The Rourke Press Inc. ISBN 1-57103-272-X. A timeline of engineering feats in history.

*Engineering the City – How infrastructure works.* Matthys Levy & Richard Panchyk. 2000. Chicago Review Press, Inc. ISBN 1-55652-419-6. Book with information on how to sustain a city and projects to simulate.

*Fantastic feats and failures.* David Garrison, Shannon Hunt, Jude Isabella. 2004. Kids Can Press. ISBN 1-55337-633-1. Review of engineering successes and failures.

### Interactive Resources

<http://www.pbs.org/wgbh/buildingbig/index.html> (11/06/15)

Test out different materials, shapes, forces, loads and discover their effect on structures.

<http://kids.discovery.com/games/build-play/build-a-coaster> (11/06/15) Build a roller coaster.

<http://www.learner.org/interactives/parkphysics/coaster/> (11/06/15)

Build a roller coaster including a check on safety.

“Fat Birds Build a Bridge!” (10/11/13)

An interesting puzzle game App for Ipad/Ipod for building and testing bridges.

“Link!” (10/11/13)

A game App for Ipad/Ipod that uses principles of civil engineering to create stable structures.

“Bridge Constructor Playground” (10/11/13)

A game App for Ipad/Ipod for building bridges.

“Bridge Constructor” (15/10/13)

App for Ipad/Ipod to build strong bridges within a certain budget

### References

In addition to resources listed above, the following websites were also used to develop this package:

<http://www.landscapeofgrandpre.ca/the-acadians-and-the-creation-of-the-dykeland-1680ndash1755.html>;

<http://www.pc.gc.ca/lhn-nhs/ns/melanson/natcul/aboiteau.aspx>;

<http://docs.informatics.management.dal.ca/cmidsocs/cgi-bin/library?e=d01000-00--0bofep1--00-1--0-10-0--0--0prompt-10---4-----0-11--11-en-50--20-about---00-3-1-00-0011-1-0utfZz-00&a=d&c=bofep1&cl=CL4.1.2&d=HASH017c552569f9fe48e2c64949>;

[http://www.huffingtonpost.com/2013/09/03/backpack-school-bags\\_n\\_3860144.html](http://www.huffingtonpost.com/2013/09/03/backpack-school-bags_n_3860144.html);

[http://www.school-for-champions.com/science/gravity\\_center.htm](http://www.school-for-champions.com/science/gravity_center.htm).



Get kids excited about science

## Science Education Through Partnership

Scientists in School is a leading science education charity that reaches more Kindergarten to Grade 8 youth than any other science non-profit in Canada – 703,000 in the 2017-18 school year.

Through our hands-on, inquiry-based science, technology, engineering, math (STEM) and environmental classroom and community workshops, we strive to ignite scientific curiosity in children so that they question intelligently; learn through discovery; connect scientific knowledge to their world; get excited about science, technology, engineering and math; and have their interest in careers in those fields piqued.

By making science a verb - something you do - our workshops allow children's natural curiosity to reign, inspire kids to see themselves as scientists and engineers, and make connections between science and the world around them. This sets the stage for a scientifically-literate future generation who will fuel Canada's economic prosperity and think critically about the scientific challenges facing our society.

Scientists in School relies upon corporate, community, government and individual donors, as well as school board partners for support to develop new programs, continuously improve our existing programs, reach new geographic areas, provide complimentary workshops to less-privileged schools, and subsidize the cost of every one of our 25,040 annual classroom workshops.

### Our Partners

#### Catalyst Level:

Natural Sciences and Engineering Research Council (NSERC), TD Friends of the Environment Foundation, Toronto Pearson International Airport

#### Innovation Level:

Amgen Canada, John and Deborah Harris Family Foundation, Nuclear Waste Management Organization, Ontario Power Generation, RBC

#### Imagination Level:

ArcelorMittal Dofasco, General Motors Canada, McMillan LLP, Pure Green Earth Fund, Superior Glove Works Ltd., TELUS

#### Discovery Level:

Ajax Community Fund at Durham Community Foundation, AtlasCare, Bruce Power, Cameco, Hamilton Community Foundation, MilliporeSigma, Ottawa Community Foundation, pharmaKARe consulting, Purdue Pharma, Syngenta, Systematix Inc., The Johansen-Larson Foundation, The McLean Foundation, The Township of Tiny, Waste Management

#### Exploration Level:

Brampton and Caledon Community Foundation, Brockville and Area Community Foundation, City of Brantford, Guelph Community Foundation, Huronia Community Foundation, Jackman Foundation, Lee Valley Tools, Niagara Community Foundation, Ontario Teachers Insurance Plan (OTIP), Rotary Club of Lethbridge Sunrise, Siemens Milltronics Process Instruments, The Source, Veridian Connections, Whitby Mayor's Community Development Fund, Youngs Insurance Brokers Inc.