

Hands CAN BE A CON BE

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Toxic Popcorn Design Challenge

*adapted from the tryengineering.org

Lesson Goal

The goal of this lesson is that teams of students use the engineering design process to solve the Toxic Popcorn Challenge. Students must develop a product and process to transfer toxic popcorn to a safe location and save the city.

Materials

One full set of material for each team

2 containers (plastics containers with lips are great)- should be slightly different size than the containers used for the actual toxic zone

100-200 pennies in a zip lock bag (represents the toxic popcorn)

6-8 pieces of 7.5 foot rope

1 bicycle tire tube 18" diameter

1 hula-hoop 3'-4' diameter (other options: rope taped down or a circle cut from a paper table cloth)

1 piece of large flip chart paper

1 marker

Student worksheet

One full set of material for ACTUAL TOXIC ZONE

2 containers (plastics containers with lips are great)

Popcorn kernels (fill about 1/2 of the container)

1 hula-hoop 3'-4' diameter (other options: rope taped down or a circle cut from a paper table cloth)

Procedure

- 1) Break class into teams of 4 (or up to 6).
- 2) Hand out the Toxic Popcorn worksheet.
- 3) Discuss the Scenario, Design Challenge, Criteria, Constraint and Materials.
- 4) Provide each team with their testing materials. Discuss why they can't "test" at the "actual" toxic site and explain that you were able to find some similar items that they can use to test their device and process.
- 5) Explain that they only have 60 minutes to save the city. They will have 40 minutes to design, build, test, and redesign their solution and the class will have 10 minutes to choose the very best class solution and save the city. So students don't feel rushed, you can take two periods and give a full period to design and test and take another period to choose the best design and save the city.
- 6) Use a timer or an on-line stopwatch (count down feature) to ensure you keep on time. (www.online-stopwatch.com/full-screen-stopwatch). Give students regular "time checks" so they stay on task. If they are struggling ask questions that will lead them to a solution quicker.
- 7) Provide each team with one large flip chart paper to draw their design and write out (as well as sketch) their final process. Each team must be prepared to explain their design and process to the class.
- 8) After 40 minutes of designing, building, testing and revising, have each team explain their final design and process with the class using their flip chart paper as an aid. Have the class vote on the design that they think will save the city. Remind the students that this is not about them, but about saving the city and choosing the best design possible.
- 9) Have the chosen team implement their process. Remind them how important communication is for success and that you want to hear them communicate with each other. Tell the rest of the class to offer encouragement and support. It is fun if the rest of the class forms a circle around the team and

cheers on the team. If they see something that is going wrong they need to share that with the team trying to save the city. For example, "John, be careful your left hand it close to the circle. Remind students that THE CLASS needs to save the city so we all need to help by supporting the team implementing their process.

10) Once the team chosen hopefully saves the city, let each team implement their process. It is important that each team get an opportunity to do this. They worked hard on their design and need to know if they could have saved the city. The class should continue to provide encouragement and support to each implementing team.

NOTE: In connection with the toxic popcorn activity, you may want to take time to discuss toxic materials and the ethics of illegal dumping. You could lead a class discussion about the effects of toxic waste dumping and more specifically the damage pollution has done to our planet. For an overview of toxic waste view: (http://environment.nationalgeographic.com/environment/global-warming/toxicwaste-overview.html)

Possible Solutions

There are multiple solutions, but here are two of the more common successful solutions.

Lifting the Container

Tire Tube. The tire tube is just a large rubber band. Most students realize its value and use it in their design.

Tension. Students tie two ropes on either side of the tire tube and once it is around the container they pull. Using TENSION, the students can lift the container with the toxic popcorn.

Compression. Students make a figure 8 with the tire tube and then fold it over so they have a circle that is smaller than the diameter of the container. They tie an equal number of ropes around the tire tube and pull so that the tire tube is larger than the diameter of the container. Once the tire tube is around the container, they can let go and the tire tube will snap onto the container using compression.

Just Ropes. Some students attempt to use just ropes and not use the tire tube. With containers that have lips, this can be successful, but most often fail because of the lack of control. You'll also see students attempt to lasso the container. Even if they do get the rope over the container; they cannot tip it with one rope without having their hand cross the plane of the circle. Try to redirect them by asking questions that lead down a successful path.

Tipping the Container

The process of tipping the container can be done with as few as two students. With the tension or compression method, after the container is lifted with two ropes on each side of the tire tube, the two people can together tip the container by, in unison, moving one rope to the top and the other to the bottom so that their hands are ultimately crossed. They need to do this very slowly and steadily or it can go too fast with popcorn missing the container. Another model is to have 3 ropes, using two ropes to lift the container with tension and one other rope (or two tied together for length) to do the tipping. Two people would stand next to the two lifting the container with their rope across the circle and on one side of the container. They can then pull the bottom of the container upward slowly tipping it and transferring the popcorn into the other container.

Student Resource:

What is the Engineering Design Process?

In order to understand the Engineering Design Process you first need to understand technology and engineering.

Technology is all around us. It is any product (an object created by a person) or process (a series of steps that brings about a result) that is designed by people to solve a problem. Most of the things you are in contact with each day are technology. For example: paperclip, cup, glasses, stapler, bottle, and pencil etc. What technology do you use every day?

Engineering is the application of science and mathematics to design or redesign technology to solve problems and meet needs. Where scientists study the natural world, engineers design the human-made world.

Engineers design everything from sandwich bags to submarines, robots to roller coasters and air bags to artificial hearts! Can you name more technology that engineers have designed? Check out the Greatest

Engineering Achievements of the 20th Century: (www.greatachievements.org) and see how engineers have made the world a better place. Engineering is a profession with a vast number of disciplines. For example: mechanical engineering, electrical engineering, civil engineering, biomedical engineering, systems engineering, ocean engineering, materials engineering, etc. Can you name more disciplines? To learn more about engineering and the different disciplines, visit www.tryengineering.org

The Engineering Design Process

All engineers have one thing in common and that is the process they use to solve problems -- it is called the engineering design process. The engineering design process is to engineering what the scientific method is to science.

Identify the Problem

What is the problem you want to solve?

Research Problem

What do you know about the problem? Find out as much about the problem as you can. What are the criteria (conditions that the design must satisfy—its overall size or weight, etc.) and constraints (limitations with material, time, size of team, etc.) of this problem?

Develop Possible Solutions

Brainstorm as many solutions as possible.

Select Best Possible Solution

Which of your designs do you think is the best possible solution?

Construct Prototype

Using the materials given, build a prototype (a working model) of your design. Don't forget about the criteria (conditions that the design must satisfy) and constraints (limitations that need to be designed around).

Test & Evaluate Solution

Test and evaluate your design. Did you satisfy the criteria and constraints?

Redesign

Did your design solve the problem? If not, brainstorm a new design, build and test it until you have successfully solved the problem.

Communicate

At each step in the process you must communicate with your team members. You need to also communicate with others outside of your team to get feedback on your design. You need to communicate verbally as well as by describing your design thorough writing and drawings. Communication is at the core of the engineering design process.

Student Worksheet: Toxic Popcorn Design Challenge

Scenario

A can of highly toxic popcorn has contaminated a circle of approximately 4 feet in diameter. The toxic area extends to the ceiling. If the toxic popcorn is not transferred to a safe container for decontamination, then it will contaminate and destroy the entire city. The popcorn is estimated to have a safe life of exactly 60 minutes before it explodes. It's up to us to save the city!

Design Challenge

Inside the circle you will find two containers. One (unsafe container) is half full of the toxic popcorn. The other (safe) container is available for decontamination. Find a way to safely transfer the toxic popcorn from the unsafe container to the safe container, using only the materials provided to you.

Criteria

- 1. No one may cross the plane of the circle with any part of the body.
- 2. The popcorn and containers cannot cross the plane of the circle. Only the ropes & tire tube may cross.
- 3. No spills are allowed, or the popcorn will explode.

Constraints

- 1. You may use only the materials provided.
- 2. The popcorn must be transferred within 60 minutes or there will be a disaster.

| Team members: | | | | | |
|---|--|--|--|--|--|
| Identify, Research, and Design Stage | | | | | |
| Meet as a team and discuss the problem you need to solve. Then develop and agree on a process for solving the challenge. You'll need to determine what materials you want to use. | | | | | |
| Draw your design below, and be sure to indicate the description and number of parts you plan to use. | | | | | |
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Construction Phase

Choose your best product design and your best process design. Build your design. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

Testing and Evaluation Phase

Each team will test their design and process. If your design and process were unsuccessful, redesign and test again. Continue until you are happy with your solution. Be sure to watch the tests of the other teams and observe how their different designs worked.

| Sketch your Redesigned idea (make sure to label your sketch): | | | | | | |
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Evaluation Phase

- 1) Did your solution save the city?
- 2) What went well?
- 3) What didn't go well?
- 4) What is your favorite step in the engineering design process and why?
- 5) What is your favorite element of your design and why?
- 6) If you had time to redesign again, what changes would you make?

Newton's Cart Lab

Small student teams use a wooden car and rubber bands to toss a small mass off the car. The car, resting on rollers, will be propelled in the opposite direction. During a set of experiments, students will vary the mass being tossed from the car and change the number of rubber bands used to toss the mass. Students will measure how far the car rolls in response to the action force generated.

Materials

Newton Cars (see separate instructions)
Cotton string
Two rubber bands
Medicine bottles or film canisters
25 straight drinking straws or dowel rods of similar size
Meter stick or ruler
Metric beam balance or scale
Scissors
Many pennies
Eye protection

Newton Car Materials

One 1" X 3" X 8" inch board Long wood screws Wood glue

Management

This activity requires a smooth floor or long tables for a rolling surface. Be sure teams understand how to set up the car and are consistent in their placement of straws. Demonstrate the "loading" of the car. After attaching the rubber band and string to the car, press the bottle into the "V" of the rubber bands. This process must be done the same way each time. Also demonstrate the string cutting process. The string must be cut and the scissors moved out of the way in one smooth and quick movement.

Procedure:

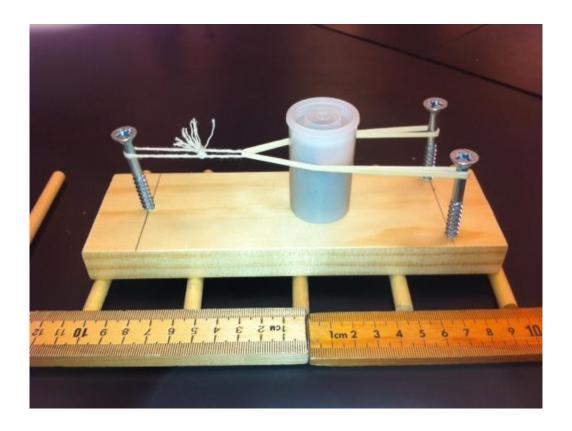
- 1) Set up the Newton Cart shown in the picture. Slide the rubber band through the first string loop. Slip the ends of the rubber band over the two screws. Pull the string back to stretch the rubber band, and slip the loop the third screw to hold the string.
- 2) Lay the dowel rods out on the floor. Place them like railroad ties. Put the cart on top of the dowel rods at one end of the line.
- 3) Mark the location of the cart on the floor.
- 4) Place pennies into the canister.
- 5) Using the scissors, cut the string.
- 6) Measure how far the cart moved.

Student resource:

Although the purpose of the Newton Car is to investigate Newton's second law of motion, it provides an excellent demonstration of all three laws. The car is a slingshot-like device. Rubber bands are stretched between two posts and held with a string loop ringing a third post. A bottle, holding various materials that can be changed to vary its mass, is placed between the stretched rubber bands. When the string is cut, the bottle is tossed off the car and the car travels the other way on straw rollers.

Newton's first law is demonstrated by the act of exerting a force. The car remains at rest until the mass is expelled, producing a force. The car then moves. The action force exerted on the car produces an equal and opposite reaction force. The car moves the other way from the tossed bottle. This demonstrates Newton's third law.

How far the car moves demonstrates the second law. The magnitude of the force is determined by how much mass is tossed and how fast it is accelerated off the car. By varying the mass and the number of rubber bands, students are able to see a visual demonstration of the relationship of mass and acceleration on force. As acceleration increases, so does the force. However, if the amount of force acting on the car remains the same and the amount of mass is increased, the acceleration will go up. Decreasing the mass in this same scenario will cause the car's acceleration to decrease as well.



Student Worksheet: Newton's Cart Challenge

Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of controlling the variables which affect the Newton's Cart to allow it to move between 30-40cm consistently.

Research Phase

Read the materials provided to you by your teacher.

Planning and Design Phase

Several variables can be altered to generate the 30-40 cm distance consistently. List these variables below and determine which one you will be altering in order to solve the problem.

Presentation Phase

Present your plan to the class and consider the plans of other teams. Be sure to watch what other teams are planning and consider the aspects of different designs that might be an improvement on your team's plan. You may wish to fine tune your own design at this phase.

Build it! Test it!

Follow through with your team's design and see if your ideas will work.

Presentation

Present your findings to the class regardless if you were successful or not.

Reflection

Complete the reflection questions below. You may need to consult with other groups within the class to answer these questions.

- 1) How did changing the <u>mass</u> of the bottle affect how far the **Newton's Car** moved?
- 2) How did changing the **mass** of the bottle affect how far the **bottle** traveled?
- 3) How did changing the number of <u>rubber bands</u> affect how far the **Newton's Car** moved?
- 4) How did changing the number of **rubber bands** affect how far the **bottle** moved?
- 5) Which Law of Motion explains why the Newton's Cart moves backward?
- 6) Which Law of Motion explains why it is more difficult for the rubber band to move the bottle as you add more mass?
- 7) Which Law of Motion explains what happens to how far the bottle travels when you add more rubber bands?

Tall Tower Challenge

*adapted from the tryengineering.org

Teacher Resources

Lesson focuses on the growth of tall buildings and their structures. Students work in teams to develop the tallest tower they can build with limited materials that can support the weight of a golf ball for two minutes. The golf ball must be supported near the top of the tower, with the bottom of the ball no more than 20% below the upper height of the tower. They develop a design on paper, build their tower, present and test their tower to the class, evaluate their results and those of their teammates, and complete reflection sheets.

Materials

Student Resource Sheets
Student Worksheets
Rulers
Set of materials for each team:
1 golf ball
25 plastic straws
25 pipe cleaners
12 metal paperclips

Procedure

- 1) Show students the student reference sheets. These may be read in class or provided as reading material for the prior night's homework.
- 2) To introduce the lesson, discuss with students the increase in the height of buildings over the last century. Perhaps consider what the highest building in your community might be, and compare that with some of the tallest buildings in the world.
- 3) If possible, have students explore the design and manufacturing resources on the Burj Khalifa Tower Design and Construction website and have them consider the shape of the tallest structures. (www.burjkhalifa.ae/language/en-us/the-tower.aspx)
- 4) Teams will consider their challenge and draw a diagram of their planned tower on paper.
- 5) Teams next construct their towers, and test them within their team.
- 6) All teams then present their towers to the class and demonstrate the ability of the tower to hold the golf ball.
- 7) All towers are measured to determine the tallest tower.
- 8) Student teams complete a reflection sheet and share their experiences with the class.

Student Resource: Tall Structures



CN Tower

The CN Tower located in Toronto, Ontario, Canada, is a communications and observation tower standing 553.3 metres tall. It was the tallest recognized as free-standing structure on land in the world for 31 years until it was recently surpassed in height by the Burj Khalifa in Dubai in the United Arab Emirates. The Burj Khalifa was built in 2009 and is 828 meters high. The third tallest is the Willis Tower (formerly known as Sears Tower) in Chicago, Illinois, U.S.A., which stands at 527m (1,729.0 ft) when measured to its pinnacle, The tallest wooden structure is the Gliwice Radio Tower in Poland, which stands at 118 meters high and was built in 1935.

In January 2010, the world's highest outdoor observation deck located in Burj Khalifa, has opened to the public. Hundreds of people, mostly families, queued up for tickets to Level 124 of Burj Khalifa – and the chance of being among the first to experience its stunning views across the city. The view is said to be similar to what you might see from an airplane. The ascent to the 124th floor is by a double-deck elevator, each deck carrying up to 14 people and travelling at 10 meters per second. In less than a minute, the elevator reaches the observation deck, the world's only public observatory at this height with an outdoor terrace. High windows circle the entire viewing platform, and visitors can scan the horizon and the distant streets below through computerized viewfinders, which also have pre-programmed day and nighttime vistas of the city and surrounding region.



Burj Khalifa

Student Worksheet: Applying Technology to Solve Problems

Engineering Teamwork and Planning

You are part of a team of engineers given the challenge of building the tallest tower you can build using only 25 straws, 25 pipe cleaners, and 12 paperclips.

You do not need to use all the materials, but your tower must support the weight of a golf ball for two minutes. The golf ball must be supported near the top of the tower, with the bottom of the ball no more than 20% below the upper height of the tower.

Planning and Design Phase

| Think about the different ways you can bend or change the shape of straws, pipe cleaners, and paper clips You may cut these items, but cannot use tape or other materials to connect them together. In the box below draw your plan for the tower. | | | | | |
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Build your tower and test it to see if it can support the golf ball. Then, answer the questions below:

- 1) How similar was your design to the actual tower you built.
- 2) If you found you needed to make changes during the construction phase, describe why your team decided to make revisions.
- 3) Did you use all the parts provided to you? Were any of the parts used only to increase the height of the tower?

Presentation and Measurement

Present your tower to the class and have your teacher measure the height of the tower. Bear in mind that the golf ball must be supported near the top of the tower, with the bottom of the ball no more than 20% below the upper height of the tower. If the ball is lower that 10% from the top, your tower will be disqualified. Complete the box below for your tower:

| Overall height of the bottom of the ball on/in tower | Distance from bottom of golf ball to top of tower | Percentage of tower supporting golf ball |
|--|---|--|
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Evaluation

Complete the evaluation questions below:

- 1) Describe the shape or construction of the tower that was the tallest and won the challenge? How was this tower different from yours, if yours did not win?
- 2) If you had a chance to do this project again, what would your team have done differently?
- 3) Do you think that this activity was more rewarding to do as a team, or would you have preferred to work alone on it? Why?
- 4) If you could have used one additional material (tape, glue, wood sticks, foil -- as examples) which would you choose and why?
- 5) Do you think that once a building is designed and approved for construction that many aspects are changed during the building process? Why or why not?
- 6) How long do you think it will take before a building is constructed that surpasses the height of the Burj Khalifa? Where do you think it will be built? Why?