KCMO PD Workshops - Scott McQuerry

Fall 2013

Newton's favorite drink? Gravi-Tea

SCIENCE PIONEERS

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.

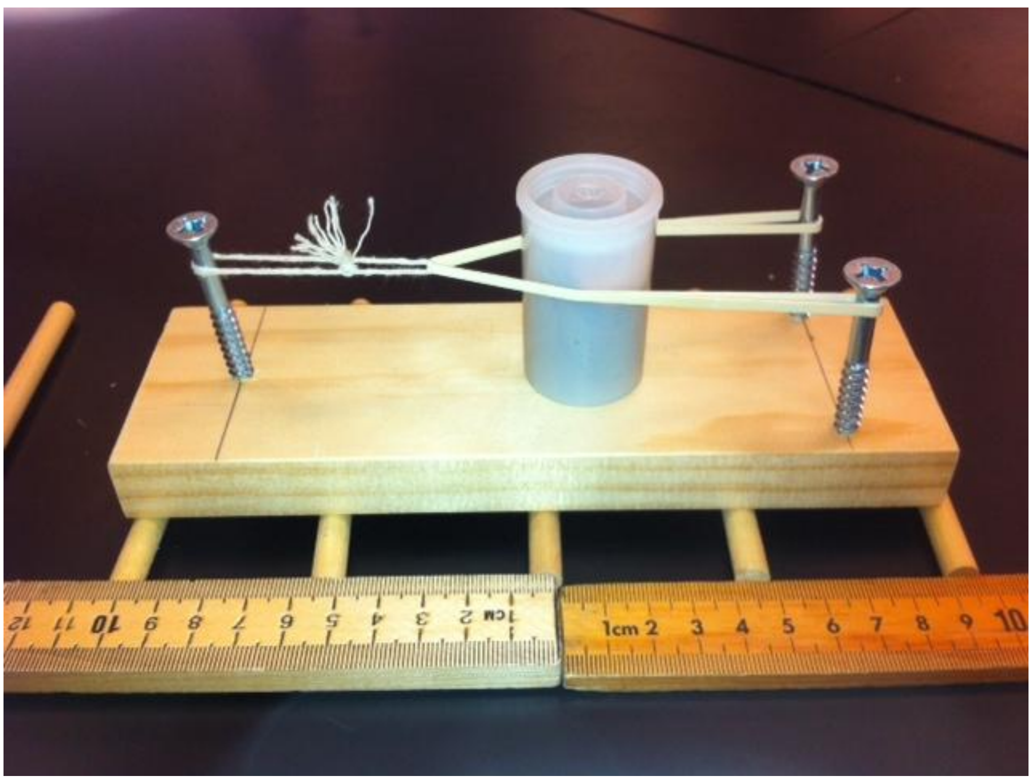
Procedure:

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. The greater the mass of the bottle and its contents and the greater the acceleration (more rubber bands), the greater the force. The effect is that the car will travel further in the opposite direction.



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 30-40 cm 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 **mass** 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 **rubber bands** 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

The CN Tower (picture to the left), located in Toronto, Ontario, Canada, is a communications and observation tower standing 553.3 metres tall. It was recognized as the tallest 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.

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.

Construction Phase

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.

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?