Ups and Downs in Design

OBJECT

The science behind how things move (physics) is of great importance to engineers. The goal here is for students to understand the basics of engineering design associated with kinetic and potential energy as they design, build, and test foam tubing roller coasters.

GRADE LEVEL

Appropriate for middle through high school, depending on depth of discussion and extensions. Referenced worksheets for students are on *http://www.eweek.org/site/DiscoverE/activities/index.shtml*

DISCUSSION

Potential energy: Energy an object has because of its relative location.

Kinetic energy: Energy associated with motion of an object.

Gravitational force: Force exerted between the earth and an object that attracts the object toward the earth.

Roller coasters at amusement parks utilize potential energy and kinetic energy. Typically the roller coaster car is pulled up by a motor, gaining its potential energy. Once at the peak point, there are no motors connected to the car in any way. The car begins its winding and looping decent along a track that has been designed to safely transfer the potential energy into kinetic energy while making it a thrilling ride. The diameter of the loops that the car will traverse without falling out is dependent on the kinetic energy obtained by the car.

If the car is going through a loop-de-loop, and does not have enough kinetic energy, the car will not stay on the track as it reaches the peak of the loop. See Worksheet 1 for measurement formulas and reference diagram.

Ideally, all the potential energy is converted to kinetic energy. This never holds true, as some of the energy is lost to friction. Because of the loss of energy, the peak of the loops must be lower than the initial starting point of the car.

MATERIALS

- 5-7 six-foot lengths of foam pipe insulation tubing cut in half lengthwise per group.
- masking tape
- round toothpicks (approx. 20 per group)
- 16mm marbles (5 per group)
- container to catch marbles
- flexible tape measure
- scissors and ruler
- two different colored stickers: one marked "P", the other "K"

ACTIVITY

The challenge: to design a roller coaster ride to be as “loopy” as possible and safe while keeping building costs to a minimum.

Part 1: ***Design and Preliminary Testing***

Discuss worksheet 1 (Reference Diagram). Hand out Worksheet 2 (Building Guidelines). Break the class into groups of 3.

1. Give each group one marble, a container to catch the marble, one foam piece, one toothpick, and a one-foot piece of masking tape.
2. Have each group design and test a preliminary prototype.
3. As they test, each group should be planning their final design and the amount of materials that will be needed (Worksheet 3). After 15 minutes, have the students return the materials from the preliminary prototypes and obtain the materials listed in Worksheet 3 from the "store." Once materials have been bought they may not be returned or exchanged.

Part 2: *Final Design and Testing*

1. Allow 10 minutes to finalize designs. Groups use P and K stickers to mark the places on their roller coasters that have the greatest kinetic and potential energy.

2. Test each roller coaster. Each must be able to stand alone, and the marble must travel completely from start to finish. Allow 2 tries.
3. Have groups measure the diameter of each loop in the roller coaster and total the cost of purchased materials in Worksheet 3.
4. Cost analysis: Have students compute the loop diameter to cost ratio.
5. Discuss results. Was there a stronger design/construction that seemed to work? How did potential and kinetic energy play a role? Most importantly: Is the ride safe?

    • Why do most roller coasters have corkscrew turns instead of loop-de-loops? It takes a lot of kinetic energy to make it all the way around a loop-de-loop. Corkscrew turns (twisty downhill turns) simply use the potential energy to gain speed through the turn.

CONNECT TO ENGINEERING

Engineers use their math and science know-how in all areas of an amusement park. They need to understand how to make rides fast and fun, without compromising structural integrity which is needed for ride safety. Engineers use other skills to make line wait-times shorter, park layout inviting and environmentally friendly, services like food delivery and trash control efficient, and park security up-to-date.

Activity Extensions: see ***www.eweek.org*** (K-12 section) and ***www.myphysicslab.com/RollerSimple.html***

This activity adapted from the TeachEngineering Digital Library based on the "Making The Connection" activities from Women in Engineering Program and Advocates Network (WEPAN) www.wepan.org. JETS has partnered with the Engineering Pathway (www.engineeringpathway.org) and the TeachEngineering Digital Library *(www.teachengineering.org)*. See *www.jets.org*.