Roller Coaster Challenge

Objectives:
Students will:
1. Understand the principle of conservation of energy.
2. Know that mechanical energy forms gravitational potential energy and kinetic energy.
3. Explain the losses of mechanical energy to heat due to friction.
4. Predict the conditions under which a person will feel lighter or heavier in a moving vehicle.

Materials
Each group should have the following:
- Tennis ball (or similar-sized ball)
- Two pieces of 70 cm × 200 cm corrugated cardboard or foam board
- Heavy-duty scissors
- Box knife
- Meterstick
- Hot glue and glue gun

Procedures

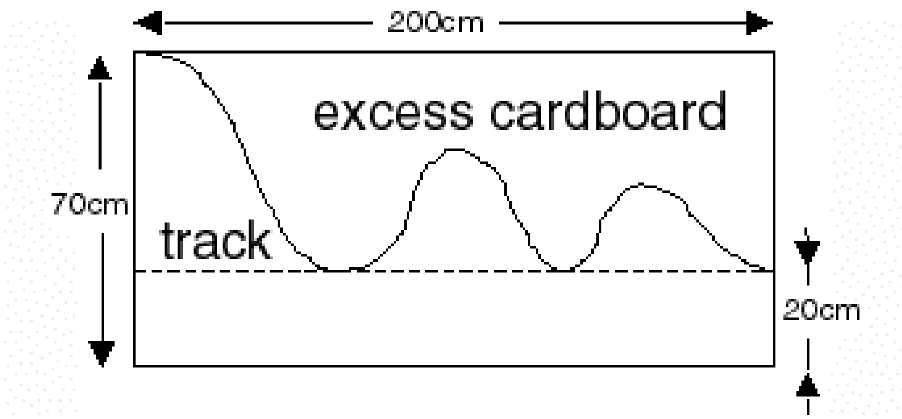
1. Tell students they will be designing and constructing cardboard "tennis ball" roller coasters with three hills. The tennis ball in each design must start from the top of the first hill, roll up and down the other two hills, and exit the end of the track. Each roller coaster will be judged in a class competition. The track with the greatest total of vertical heights for all three hills-if the tennis ball completes the course-will be named the winning design.

2. Have students consider the following when designing their roller coasters:

   - Can all the hills be the same height? If not, why?
   - Can they get bigger or must they get smaller?
   - How will you determine how big or how small the hills can be and still win this contest?
   - Does the steepness of the hill count?
   - Is it better to make the hills steep or not so steep? Why?
   - How curvy should the tops of the hills and the valleys be?
   - Should you design sharp turns or smooth turns? Why?
   - What provides resistance on the roller coaster causing the tennis ball to slow down? How can this resistance be reduced?

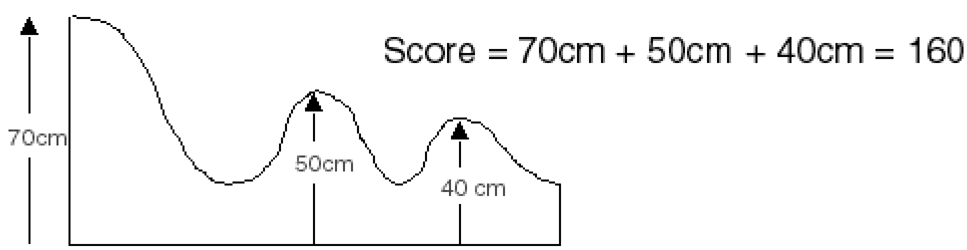
Leave students with enough time to make revisions to their original design-an important factor the world of design and engineering.

3. Divide students into small groups and give each group the materials listed earlier. The left and right roller coaster tracks will be made from the two pieces of corrugated cardboard that must be cut out as identical shapes. Each valley in the roller coaster must dip to a height of 20 centimeters from the bottom of the cardboard. Have students use heavy-duty scissors or a box knife to cut out both tracks. They will probably have their own ideas on how the roller coaster should be shaped, but here is an idea on how to lay out the roller coaster on the cardboard.



4. From the excess cardboard, students should cut out twenty-five 4 cm × 12 cm rectangles. These rectangles will serve as spacers between the two cutout tracks. Put glue along both of the 12-centimeter edges and fasten them to various places between the two tracks so that the tracks are rigid and separated by a distance of 4 centimeters.

5. Here is an example of how the score for a roller coaster should be calculated for the contest. Measure the heights of each of the three required hills and add them up. The roller coaster with the greatest total height of three hills, whose tennis ball successfully completed its journey, is the winner.



Extensions:

1. Consider your favorite roller coaster ride and imagine that it could be transported to the planet Mercury or the planet Jupiter. On which planet would the ride be more thrilling or less thrilling than it is here on Earth. Explain your choices.

2. Relate the principle of "conservation of energy" in an analysis of a roller coaster ride from start to finish. Include in your discussion the names of all relevant energy forms and where and when on the ride energy transformations are occurring.

3. Imagine that you are among the first group of passengers to test out a newly constructed roller coaster. The slide down the first hill is thrilling, but before you get to the top of the second hill, you start sliding backward and get trapped between the first two hills. Discuss what practicalities the designer forgot to include in transforming his creation from the idealized blueprint to the real world.

4. Some roller coasters feature an upside-down "loop." Explain why these features are always placed at the beginning of the ride and never near the end.

5. It's all fun and games until somebody gets hurt. Imagine that you are designing the world's ultimate roller coaster. Describe the features you would incorporate into your design and explain what limits you would put on those features to prevent fun from becoming dangerous.

6. Not everyone enjoys the thrilling experience of a roller coaster ride. Theorize and discuss the scientific, physiological, psychological, and sociological reasons for why some seek such thrills and others avoid them.

Riding on the Gravity Express

Amusement park rides, water park rides, and rides in the local playground provide thrills while gravitational potential energy (GPE) and kinetic energy (KE) transform from one to the other. Make a list of such rides and explain where in the ride the GPE and the KE are the greatest. Where do the forces act in each ride providing the resistance that converts the total GPE and KE into heat?

The Thrill Factor

On rides such as roller coasters (and even swings), where the rider experiences fast changes in velocity due to increases or decreases in speed or simply changes in direction, the rider is subjected to unbalanced forces that give the rider an illusion of feeling heavier or lighter than normal. Through our sensing of these unbalanced forces, we judge the "thrill factor" of a ride to be high when they occur frequently in a ride. Some of the best rides give us the illusion of weightlessness for short periods of time. Where on the roller coaster would you expect to feel heavier, and where would you feel lighter? Use Newton's law of inertia to explain these illusions of heaviness and lightness, also known as positive and negative "g forces." Students can design and conduct experiments and demonstrations to back up their explanations.