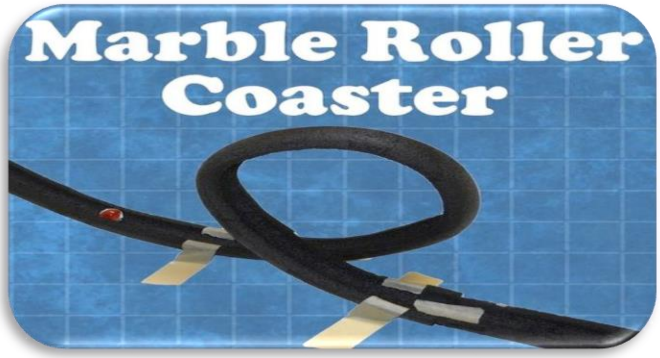
Roller Coaster Adventures



Next Generation Science Standards:

- Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
- Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Learning Objectives: students will be able to:

- Relate that engineers create things to benefit society.
- List some of the components of the engineering design process.
- Obtain information about how different communities protect Earth's resources through renewable resource design.
- Compare and contrast the scientific method and the engineering design process.
- Explain why brainstorming is important to engineering design.
- List several rules of a brainstorming session

Essential Vocabulary:

acceleration: How quickly an object speeds up, slows down or changes direction. Is equal to change in velocity divided by time.
critical velocity: The speed needed at the top of a loop for a car to make it through the loop without falling off the track.
force: Any push or pull.
friction: A force caused by rubbing between two objects.
g-force: Short for gravitational force. Is equal to the force exerted on an object by the Earth's gravity at sea level.
gravitational constant: The acceleration caused by the Earth's gravity at sea level.
gravity: A force that draws any two objects toward one another.
kinetic energy: The energy of an object in motion, which is directly related to its velocity and its mass.
potential energy: The energy stored by an object ready to be used. (In this lesson, we use gravitational potential energy, which is directly related to the height of an object and its mass.)
speed: How fast an object moves and is equal to the distance that object travels divided by the time it takes.
velocity: A combination of speed and the direction in which an object travels.

Materials:

- 2-meter (6 foot) long foam tube (1/2" pipe insulation) cut in half lengthwise
- glass marble
- wooden marble
- steel marble
- paper or plastic cup
- roll of masking tape
- set of markers, crayons or pencils
- blank sheet of paper
- stopwatch
- Roller Coaster Specifications Worksheet, one per student or one per group
- Scoring Rubric, one per group

Procedures:

1. Divide the class into engineering groups of three or four students each.
2. Hand out the scoring rubrics for the class competition. Tell the students: In our roller coaster models, the glass marble simulates a normal car, the wooden marble represents an empty car, and a steel marble represents a full car.
3. Have groups start designing their roller coasters, brainstorming and sharing ideas and agreeing on a design. Have students draw their roller coasters on paper, name them, and make signs. Allow up to 30 minutes for this. Look over their drawings to ensure that their proposed designs are physically possible. If not, point out those aspects of the roller coaster design that they may want to rethink.
4. Give each group a foam tube track, masking tape and cup, and let them build their roller coasters using classroom materials. Expect students to be able to build their first design in 10 minutes or less. Use the cup to catch the marble at the track end.
5. Give students marbles so they are able to test their roller coasters and make any necessary changes. This is the most time-consuming step and students may need up to 45 minutes to redesign their tracks.
6. Hand out a stopwatch to each group and give them time to complete the worksheet, in which they determine certain specifications of their roller coasters.
7. Start the class competition by telling the students: Similar to what you did today, engineers create small-scale models to help them test and analyze their structural designs.
8. Have each group present its roller coaster model to the class. Use the scoring rubric to evaluate the roller coaster model designs. Discuss the results as a class, as described in the Assessment section.

Differentiation:

High School - introduce equations for potential and kinetic energy so students can calculate both forms of energy and verify the law of conservation of energy. Have students explore loops along with the concept of critical velocity. Have students find the starting height of a roller coaster necessary to complete a loop of a given height

Elementary - eliminate much of the physics exploration behind the lesson content. Have students build their own roller coasters and discover for themselves many of the concepts that are discussed in detail at higher grade levels (such as energy conservation, friction and gravity), and they may also be capable of understanding some basic explanations of friction and gravity.

Roller Coaster Adventures' Scoring Rubric

Creativity Points

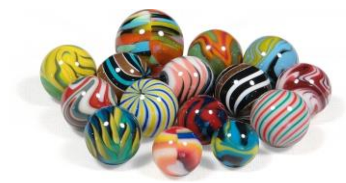
Points are awarded for each of the following items included in a group's roller coaster.

Every 50 cm of height	1 point	
90º turn	1 point	
180º turn	2 points	
270º turn	3 points	
Loop	3 points	
Corkscrew	4 points	

Performance Points

Points are awarded for each type of marble that successfully completes the roller coaster and lands in the paper cup.

Wooden marble	3 points	
Glass marble	3 points	
Steel marble	3 points	



Reflections

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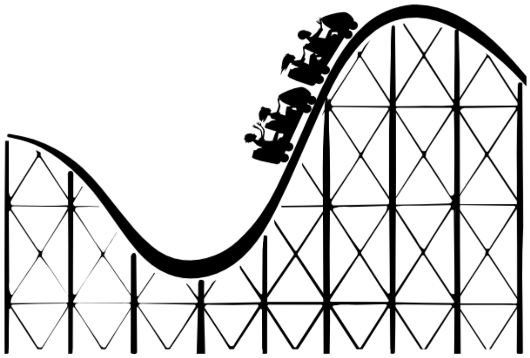

Roller Coaster Engineers

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Roller Coaster Worksheet

Roller Coaster Name: ____

Draw a sketch of your roller coaster in the space below:

Height in cm: ________________
\# of Loops: ________________
\# of Corkscrews: ________________
\# of Turns ________________

- Place a 1 next to a point on your roller coaster where the cars *accelerate*.
- Place a 2 at a point on your roller coaster where the cars *decelerate*.
- Place a 3 next to the point where cars have the greatest *potential* energy.
- Place a 4 next to the point where cars have the greatest *kinetic* energy.
- Place a 5 at a point where the rider experiences a g-force *greater than 1 g.*
- Place a 6 at a point where the rider experiences a g-forge *less than 1 g.*

https://phet.colorado.edu/en/simulation/energy-skate-park-basics