Two 50-minute classes.

**Overview**

This lesson provides a hands-on opportunity for students to explore concepts related to energy and motion. Building and running foam insulation coasters allows students to identify and manipulate the effects of gravity, momentum, friction, potential energy, and kinetic energy.

**Subject Matter**

Physical Science

**Learning Objectives**

Students will be able to:

- Define gravity, force, momentum, friction, potential energy, and kinetic energy.
- Identify potential and kinetic energy of roller coaster cars by their position on a track.
- Design and build a foam insulation roller coaster implementing laws of motion.
- Draw and label their designs identifying where their marble is in a position of potential and kinetic energy.

**Standards**

National Science Education Standards
http://bob.nap.edu/html/nses/html

Physical Science
- Position and motion of objects
- Light, heat, electricity, and magnetism (Forms of Energy)

Unifying Concepts and Processes
- Systems, order, and organization
- Evidence, model, and explanation
- Constancy, Change, and measurement
- Form and function

Louisiana Science Frameworks:
State Standards for Curriculum Development
http://www.doe.state.la.us/DOE/assessment/standards/SCIENCE.pdf

PS-E-B2: Exploring and recognizing that the position and motion of objects can be changed by pushing or pulling (force) over time;

PS-E-B4: Investigating and describing how the motion of an object is related to the strength of the force (pushing or pulling) and the mass of the object;

PS-E-C5: Investigating and communicating that gravity can exert force on objects;

PS-E-C6: Exploring and describing simple energy transformations.

**Media Component**

Video:
Teams: Forces In Motion, Program number 2: Measuring Forces

Web site:
http://www.learner.org/exhibits/parkphysics/coaster.html

This Web site is the work of a partnership between the Annenberg Foundation and the Corporation for Public Broadcasting. It focuses on providing resources to teachers. The mandate of the Annenberg/CPB is to use media and telecommunications to advance excellent teaching in American schools.
Per Student:
- **Amusement Park Now Hiring** Information sheet (see attached)

Per Each Team of 4 Students:
- Stopwatch
- 5 or more marbles
- 4 pre split sections of foam pipe insulation
- 1 roll of masking tape
- 2 or more cardboard tubes (paper towel rolls)
- Supports to create hills and turns (books, chairs, boxes etc.)

Per Teacher:
- 1 marble
- 1 section of foam pipe insulation
- Cardboard tube
- Chalkboard or chart paper
- Digital camera

**PREP FOR TEACHERS:**

Prior to teaching this lesson:
1. CUE the video to the segment on the roller coaster field trip. On the screen you will see the question “How does a roller coaster move?” The audio is jazz music.

2. Bookmark the following website on each computer in your classroom: [http://www.learner.org/exhibits/parkphysics/coaster.html](http://www.learner.org/exhibits/parkphysics/coaster.html)

3. Purchase black foam pipe insulation from your local home improvement store. Lowe’s sells them for .97 a piece. As each team needs 4 split sections, purchase 2 sections for each team of students. You may want to buy an extra section for teacher demonstration.

4. As the foam insulation is already split on one side, you only need to finish splitting it on one side. One section that you purchase will now give you two split sections.

5. Tape up a small section of foam insulation to a wall about 2 meters from the floor in order to demonstrate various concepts of force and motion.

When using media, provide students with a **FOCUS FOR MEDIA INTERACTION**, a specific task to complete and/or information to identify during or after viewing of video segments, Web sites, or other multimedia elements.
INTRODUCTORY ACTIVITY:
1. Tell your students that they are all engineers who have been out of work for a while. Tell them that they are all desperately looking for a good job with a good company. One day they all see an advertisement in the newspaper for a job they would all really love to have! Distribute the attached document Amusement Park Now Hiring! to your students. Ask your students to carefully read over the document.

2. After your students have completed reading the document, ask them what kinds science concepts a roller coaster engineer might need to know about. (Students will probably have a hard time coming up with an answer for this. Some will say that they have to know how to build things.) Guide students to think about concepts such as gravity, friction, momentum, and energy as they might relate to a roller coaster.

LEARNING ACTIVITIES:
1. Tell your students that before they begin building you will discuss with them some very important concepts that roller coaster engineers need to consider in their design.

2. Hold up a marble. Ask students what will happen if you let the marble go. (Students will probably say that the marble will fall. Guide students to realize that gravity makes the marble fall and that gravity is a pulling force.) Write the following on the board or on chart paper: Show students how the force of gravity acts on the marble when you drop it onto the foam pipe insulation you prepared for teacher use. Ask your students what would happen if you taped your marble track higher or lower and then let a marble go. (Most students will probably say that the marble will travel faster when the track is taped higher and that the marble will travel slower when the track is taped lower.) Encourage students to use this knowledge when encountering problems with their design. For example, to slow down a marble that jumps off of a coaster, students could make the track less steep by using supports or by not starting the track so high off the floor.

3. Explain to students that the marble gains strength or force by motion. This is called Momentum. Ask your students if they know what friction is and how friction may affect their roller coasters. (Students will probably say that friction is when two things rub together, and that the marble and the track will be rubbing together. Guide students to understand that the force of friction can stop or slow down their marbles. For example, if a marble is not making it to the end of a track, straightening a curve can reduce energy loss due to friction. Making certain that tape between tracks is smooth can reduce energy loss due to the marble bouncing around too much.)

4. Explain to students that they will now be looking at a segment of video to find out how roller coasters really work.

5. Insert the video Teams: Forces In Motion. Program number 2: Measuring Forces into your VCR. Provide your students with a FOCUS FOR MEDIA INTERACTION, asking them to listen for the words potential energy and kinetic energy, paying particular attention to how important these are for a successful roller coaster.

START the tape on the screen that shows the question “How does a roller coaster move?”, and the audio is jazz music. PAUSE the tape when the screen shows the definition “Kinetic energy is stored energy in motion.” The audio is that of the host reading the definition.

6. Write the following on the board or on chart paper: Potential Energy-stored energy waiting to be used and Kinetic Energy-stored energy in motion. Lead a discussion about potential and kinetic energy using your teacher model to assist you. (Guide students to see that increasing the marble’s height increases the marble’s potential energy.) Roll a marble down your track and ask students what happens to the marble’s potential energy when you release the marble. (Students are likely to say that the marble’s potential energy was changed to kinetic energy.) Ask students if a marble would ever be able to get over a hill higher than its initial starting height. (Students will likely say no but will probably have a difficult time explaining why. Guide them to understand that a higher hill would require more potential or kinetic energy than is available.) Ask students if a larger marble would have an affect on its initial potential energy. (Students will likely say that the larger marble will have more potential energy.)

7. Provide your students with a FOCUS FOR MEDIA INTERACTION, asking them to look at the position of the three roller coaster cars in the video and decide if each is in a position of potential or kinetic energy. PLAY the tape from the previous pause point until the screen shows an activity sheet with the three roller coaster cars. PAUSE the tape and give the students a few moments to decide on their answers. Lead a discussion knowing that the first car is in a position of potential energy, the second car is in a position of kinetic energy, and the third car is in a position of potential energy.

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CULMINATING ACTIVITIES

1. Divide students in teams of 4 or 5. Distribute materials to students and let them begin designing their tracks. They should be given at least 40 minutes to do this activity (more if you can spare the time). Even with a small classroom there is ample space for this project. With 5 teams it is possible to clear "lanes" in the class for students to work. Walk around the room to monitor progress and help with problems. It is a good idea to warn students when they only have ten minutes left to build.

2. If you have a digital or Polaroid camera, it would be a good idea to take pictures of their designs, as they might need to refer to these pictures for assessment.

3. Let each team take turns running their roller coasters so all of the students can see. Lively discussions will take place at this point.

4. As an assessment of this lesson have each student produce a sketch of his or her roller coaster design. You can use a digital camera to take a picture of each design in order to let students complete this assessment at another time. Have students label their designs identifying where their marble is in a position of potential or kinetic energy.

5. Tell students that when it is their turn on the computer this week they will be able to design a virtual roller coaster. Show students how to find the book marked web site: http://www.learner.org/exhibits/parkphysics/coaster.html
Tell them to click on Design A Roller Coaster. Provide your students with a FOCUS FOR MEDIA INTERACTION by telling them that their mission is to design a roller coaster that is both fun and safe. Tell them that the computer will judge their coaster when they are finished with the design.

CROSS-CURRICULAR EXTENSIONS

LANGUAGE ARTS:
• Write a paragraph telling about your roller coaster. Be sure to tell about the different forces and energy involved in designing a successful coaster.

MATHEMATICS:
• Measure the speed of the marble using the formula: speed equals distance divided by time. 
  \( s = \frac{d}{t} \) Students will need to use rulers and stopwatches for this activity.

COMMUNITY CONNECTIONS:
• Schedule a Saturday fieldtrip to a local amusement park.
• Have a roller coaster engineer or designer come to speak to the class.
AMUSEMENT PARK
NOW HIRING!

ENGINEERING TEAM WANTED
TO DESIGN THE WORLD’S BEST ROLLERCOASTER

If you are interested in this Job, please build a small working model of your roller coaster.

While the general design is up to you, in order to be considered for this job we would like to see AT LEAST one of the following in your design: Loop, Hill, Turn