**Roller Coasters**

Major Concepts: Potential and Kinetic Energy  
Minor Concepts: Transfer of Energy

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Technology: stopwatches  
Computers  
Calculators

Core Content  
Physical Science – Motions and Forces  
SC-M-1.2.1 The motion of an object can be described by its relative position, direction of motion, and speed. That motion can be measured and represented on a graph.

Program of Studies  
Grade 6 Physical Science (Motions and Forces) Students will describe, measure, and represent an objects motion.  
Grade 8 Physical Science (Motions and Forces) Students will measure and represent (e.g. graph) forces on objects and motions (e.g. constant speed, changing speed) of objects.

**Pretest on potential and kinetic energy**

Challenge:

With hearts pounding, hands sweating, and your stomach churning most of us have climbed aboard a roller coaster for the thrill of defying our fears. As you tighten your seat belt, lock the handle bar across your lap and gaze at that first steep hill the only thought in your head, “is it too late to go to the bathroom again?” (Well, that’s probably the adults you are with stalling, trying to think of a way to get off before the ride starts.) But you, my bright science students, are only thinking how does this car stay on the track. What is needed to make the ride the best? What factors do designers
of roller coasters consider as they plan the ride? At what height should the first hill be? How steep can the drops be? A loop or two? How long should the ride be?

Let’s find the answers.
Task # 1. Designing the first hill.

A basic feature of the roller coaster is to get maximum speed on a downhill fall. Let’s take a look at some roller coasters.

It has been said that the shortest distance between two points is a straight line. But is it the fastest? Try different paths to simulate the path of a roller coaster car down the first hill. Design an experiment to determine which path results in the fastest time. Look at paths A, B, and C below, now design your own path that will give you the fastest time.

![Diagram of roller coaster paths A, B, and C](image-url)
<table>
<thead>
<tr>
<th>Hill</th>
<th>Time 1</th>
<th>Time 2</th>
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<td>A</td>
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Task # 2 Design a loop.

The normal force of gravity on your body is the weight you experience, or 1G. By motion, we can cause centripetal force to add to or subtract from the gravitational force. If we counter the gravitational force with 1G away from the center of the earth, you will experience weightlessness. If we add 1G of force in the same direction as the center of the earth, we say you are experiencing 2G’s.

Read the following from the Internet from Roller Coaster Physics 141.104.22.210/Anthology/Pav/Science/Physics/book/home.html Go to weightlessness.

A loop in the path of a roller coaster provides centripetal force that can counter or add to gravitational forces.

Determine how big the loop must be for a steel ball to be weightless at the top of the loop. See the following for ideas. (Go to Roller Coaster Physics Loops)

Try loops of different radii.

Draw and label your design.

Now design a drop that will cause the steel ball at its highest point to experience 1G of force away from the center of the Earth. Draw and label your designs.
Task # 3 Designing a simulated roller coaster ride and describing the motion of the forces on passengers during the ride.

Using a 7 meter length of plastic tube, design a simulated roller coaster ride with at least one loop and two hills. Draw and label your design.

A. Total time of ride
B. Height of initial drop
C. Force at the top of loop
D. Force at the top of the first hill after loop
E. Point of maximum and minimum kinetic energy
F. Point of max. and min. potential energy
G. Speed after last hill
Task #4 Designing a roller coaster on the Internet.  
Go to the following site.  Funderstanding  
www.funderstanding.com/k12/coaster/  

Additional Internet resources – Amusement Park Physics  
www.learner.org/exhibits/parkphysics/  

Amuse Me: Theme Park Physics  
Library.thinkquest.org/C005075F/
For this open response you get to choose - either Transfer of Energy or Forces and Motion

Forces and Motion Open Response
Multiple choice - Write the letter to answer each question.

1. Gravitational potential energy is dependent on
   A. speed and height
   B. weight and height
   C. time and weight
   D. acceleration and kinetic energy

2. A stretched rubber band has
   A. potential energy
   B. kinetic energy
   C. nuclear energy
   D. electromagnetic energy

3. Velocity is speed and
   A. motion
   B. mass
   C. distance
   D. direction

4. The property of matter that resists a change in motion is
   A. inertia
   B. friction
   C. gravity
   D. weight

Below is the diagram of a roller coaster. The roller coaster starts from rest at point A. Describe the forces acting on the roller coaster car at points A, B, and C. Where there is more than one force, indicate which force is greater.
For this open response you get to choose - either Transfer of Energy or Forces and Motion.

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