

## Roller Coaster – Conservation of Energy

[http://www.mhhe.com/physsci/physical/giambattista/roller/roller\\_coaster.html](http://www.mhhe.com/physsci/physical/giambattista/roller/roller_coaster.html)

**Purpose:** To investigate conservation of energy and the amounts of kinetic and potential energy in different parts of a rollercoaster and to design a rollercoaster with two hills and one loop that will get the cart safely to the end.

**Background:** (From “Funderstanding Roller Coaster”)

**Energy** is the ability of a body (for example, the roller coaster) to do work.

**Kinetic energy** - energy that is being used, the energy caused by motion.

**Potential energy** - energy that is stored for later use.

**Law of Conservation of Energy** - Energy can change from one form to another but cannot be created or destroyed.

When you ride a roller coaster a motor does the work to get you up the first hill. As the coaster is being pulled up the hill by the motor it is storing more and more potential energy. That potential energy is turned into kinetic energy as gravity pulls you down the first hill. The farther you go down the hill, the more potential energy is changed into kinetic energy, which you feel as speed. The ride goes fastest at the bottom of the hill because more and more of the potential energy has been changed to kinetic energy.

As you go up the next hill, kinetic energy is changed into potential energy and the ride slows down. The higher you go, the more energy is changed and you feel the car slow down. This conversion of kinetic energy to potential energy and vice versa continues as you go up and down hills for the rest of the ride. The total energy does not increase or decrease; it just changes from one form to the other. Notice that the first or lift hill is the highest point in the coaster. Why is that?

However, some of the energy is changed into friction. Wind resistance, the rolling of the wheels, and other factors all use some of the energy. Coaster designers know that friction plays a part in the ride. Therefore, they make each successive hill lower so that the coaster will be able to make it over each peak.

A roller coaster works because of two things: gravity and the law of conservation of energy. A roller coaster is similar to a slide except it is longer and you ride in a train car rather than on the seat of your pants. The wheels reduce friction: it's easier to let something roll than to let it slide.

## Procedure: (Let's design a rollercoaster!)

1. Go to

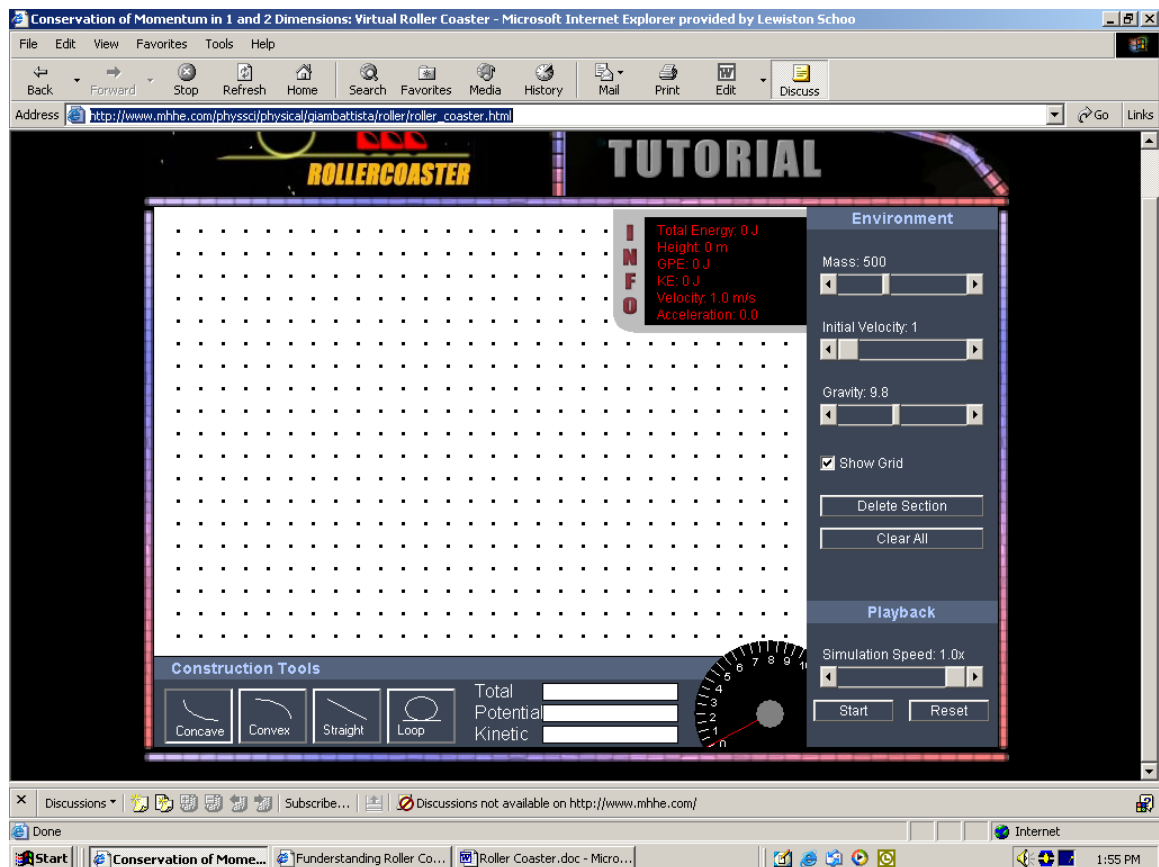
[http://www.mhhe.com/physsci/physical/giambattista/roller/roller\\_coaster.html](http://www.mhhe.com/physsci/physical/giambattista/roller/roller_coaster.html)

2. Use the construction tools to build a rollercoaster with two hills and a loop. At least one point on your rollercoaster should reach the bottom. To remove a section, click it (it should turn red) and then press the “delete section” button.

3. Choose a mass and an initial velocity. Leave gravity at  $9.8 \text{ m/s}^2$  because that is what it is on earth.

4. Click “Start” to test your rollercoaster. If the cart does not make it to the end, press “Reset”. You may then modify your rollercoaster by adding and removing sections. If you wish to start from scratch, click “Clear All”.

5. Continue to test and rebuild your rollercoaster until you have one that works. Draw this rollercoaster below.



6. Describe what happened to your rollercoaster on unsuccessful tests and what you had to do to change it.

7. What are the equations for (“google” this)

a. kinetic energy?

b. potential energy?

8. Let's take a look at the kinetic, potential and total energy at different points along the track. Press "Reset". Lower the simulation speed and press "start". By pressing "pause" every so often, find the following places on your rollercoaster. Label these spots with a, b, c, d, e, respectively, on your rollercoaster drawing. You may need to run the simulation a few times to find these places.

a. the highest amount of potential energy

b. the highest amount of kinetic energy

c. more potential energy than kinetic energy and both are greater than zero

d. more kinetic than potential energy and both are greater than zero

e. half kinetic and half potential energy.

9. As the cart goes down a hill, what kind of energy decreases? What kind of energy increases?

10. As the cart goes up a hill, what kind of energy increases? What kind of energy decreases?

11. In this simulation what is always true about the sum of potential and kinetic energy? What law does this illustrate?

12. In a rollercoaster such as Excalibur at Funtown, USA, where does the cart get all the initial energy it will need to get it to the end of the rollercoaster?

13. In this simulation, there is no friction, but there is, of course, in a real rollercoaster. This means that some of the energy of the cart is given off as heat energy and is no longer useful to the cart. If this is so, why must the first hill of a rollercoaster always be the highest? (Think of the law of conservation of energy.)

14. Time to play! Build a rollercoaster of any design of your choosing. Record your successful design below. Label your rollercoaster according to spots of varying amounts of kinetic and potential energy as you did in question #8.

The screenshot shows a web browser window titled "Conservation of Momentum in 1 and 2 Dimensions: Virtual Roller Coaster - Microsoft Internet Explorer provided by Lewiston School". The address bar shows the URL: [http://www.mhhe.com/physci/physical/giambattista/roller/roller\\_coaster.html](http://www.mhhe.com/physci/physical/giambattista/roller/roller_coaster.html). The main content area features a grid for building a roller coaster track, with the word "TUTORIAL" in large letters at the top right. On the right side, there is an "Environment" control panel with the following settings: Mass: 500, Initial Velocity: 1, Gravity: 9.8, and a checked "Show Grid" option. Below this is a "Playback" section with "Simulation Speed: 1.0x" and "Start" and "Reset" buttons. On the left side of the grid, there is an "INFO" box displaying: Total Energy: 0 J, Height: 0 m, GPE: 0 J, KE: 0 J, Velocity: 1.0 m/s, and Acceleration: 0.0. At the bottom left, there are "Construction Tools" for Concave, Convex, Straight, and Loop sections. In the bottom right, there are input fields for "Total Potential" and "Kinetic" energy, and a speedometer-like gauge. The browser's taskbar at the bottom shows several open windows, including "Conservation of Mome...", "Funderstanding Roller Co...", and "Roller Coaster.doc - Micro...". The system clock in the bottom right corner shows 2:21 PM.