# Lesson Plan for Roller Coasters

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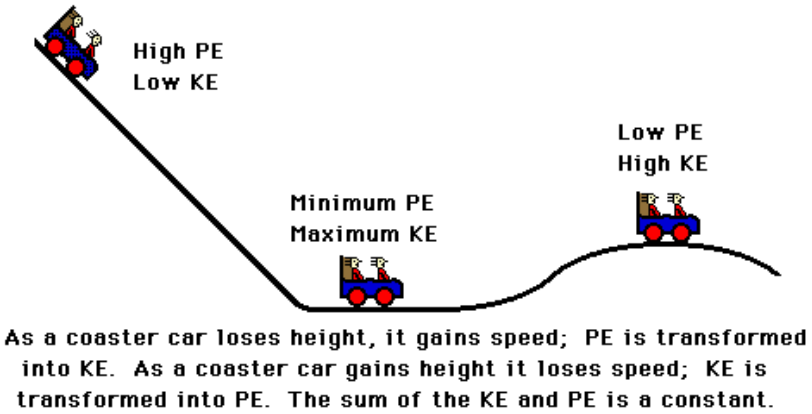
## Introduction/Background Info

Many conservation of energy concepts can be explored by building a simple roller coaster. As the roller coaster cart moves around its track, it goes up and down hills, and in the process variably loses and/or gains gravitational potential and kinetic energies, and also gradually loses thermal energy. It is very important for the student to know and understand the idea that the total energy of the roller coaster *system* is the same throughout the roller coaster cart's entire motion around the track, and that the amount of gravitational potential energy plus kinetic energy decreases as a result of thermal energy being dissipated from the roller coaster cart into the surroundings (in the form of heat and friction). Energy is always conserved and cannot be created or eliminated.

## Student Objectives

To understand the concepts of and relationships between gravitational potential energy, kinetic energy, thermal energy and total energy (total energy = potential energy + kinetic energy + thermal energy) through building a track and understanding the position and velocity of the roller coaster cart relative to the amount of a specific, particular type of energy they have at particular points of their motion/position on the track.




## Topic(s)

- Conservation of Energy
- Total Energy
- Kinetic and Gravitational Potential Energy
- Thermal Energy (resulting from friction)
- Velocity (introduce as speed with direction)

**Overview of Lesson Process**

To begin, start by asking the students about their experiences with roller coasters.

1. Discuss the different kinds of roller coasters there are (what they see at a typical amusement park).
2. Ask if they notice that at the beginning of the ride the roller coaster cart is usually pulled up to a very high (usually highest) point of the ride or if it is shot out to a very high velocity (speed).
3. Ask if they notice that the height of the roller coaster decreases as the ride goes from start to finish.
4. Introduce concepts of gravitational potential energy, kinetic energy, and total energy in a frictionless setting.
5. Introduce how the roller coaster system would change in the presence of friction (in relation to thermal energy from heat and friction).
6. Build a roller coaster (marble) track!
7. Test the track to make sure that the roller coaster cart (marble) goes from start to finish.
8. Fix/Change the track design as needed.
9. Review the different types of energies and the relationships/concepts.

**Materials**

- Pipe Insulation (for making roller coaster)
    - *Can be purchased from any hardware store, cut tube in half to make track, ~$10-15*
- Marble or substitute with rubber balls (to serve as roller coaster carts)
- Cardboard (to make additional ramps or decorations)
- A lot of tape (masking, clear, etc.)
- *Any other supplies for construction/decoration*

Most supplies can be obtained from dollar/general stores. Rough total for supplies is $30*

**Procedures**

Phase I

1. Discussion of Energy. What is Energy?
2. Introduce concepts of Gravitational Potential Energy, Kinetic Energy, and Total Energy.
3. What are some examples where these concepts can be applied? (ex. falling object, free fall rides, skydiving).
4. Talk about how energy relates to the motion of roller coasters as they travel around their tracks, gaining Gravitational Potential Energy as it gets pulled up to the highest hill, and varying Gravitational Potential and Kinetic Energies as it moves up and down the hills (as well as loops and twists).
5. Have students determine the relative Gravitational Potential and Kinetic Energies of roller coasters at different positions.
6. Introduce Thermal Energy from heat and friction.
7. Discuss the engineering design process that goes into the making of roller coasters (ex. Considerations for making the relative heights of hills from energy concepts).
8. *Optional: Introduce possible calculations of velocity (speed) from kinetic energy ($KE = \frac{1}{2}mv^2$). Introduce units of Joules and meters per second.*

Phase II

1. Build a roller coaster or split up into teams to build roller coasters of different designs
2. Make as many different types of turns, twists, loops, and hills as possible.
3. Review concepts.

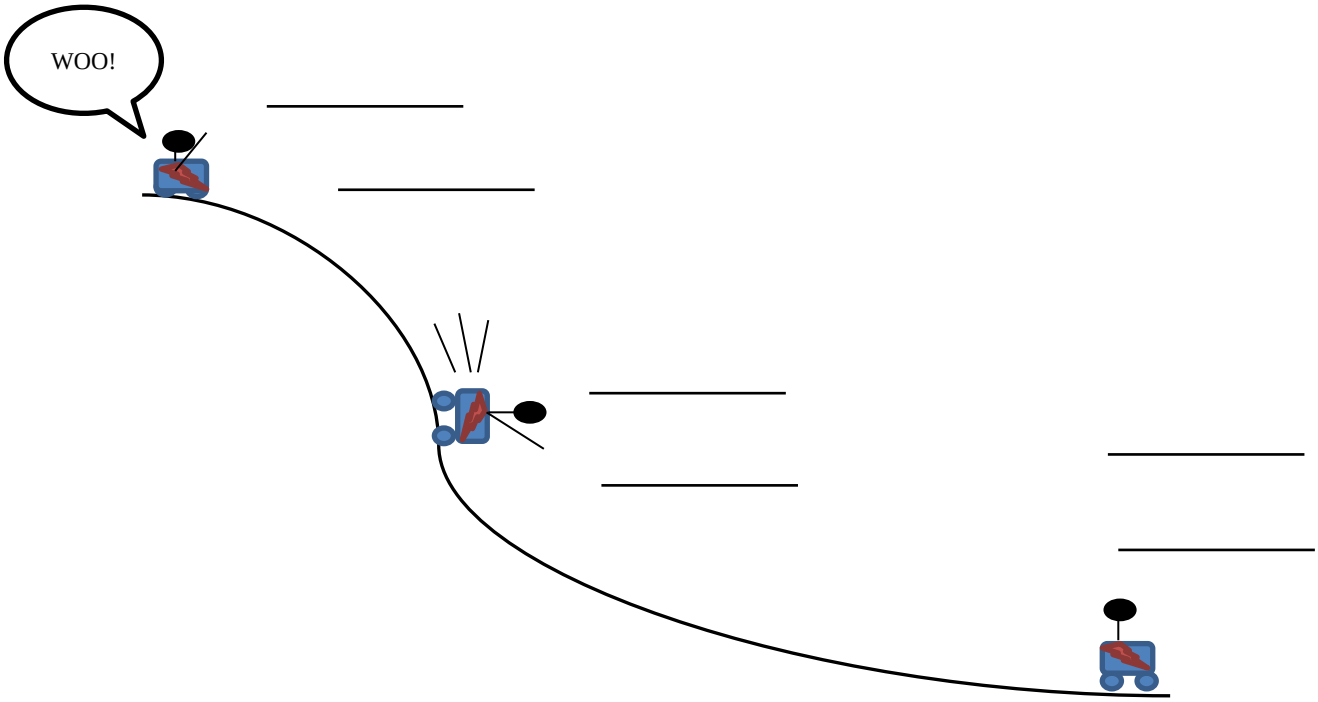
**Resources**

Original Idea: concepts learned from Giancoli, Douglas C. *Physics for Scientists and Engineers*. 4th edition, 2009.

# Roller Coasters Worksheet

**Energy Discussion**

With your mentor, fill in the blanks below. Does each cart have **High**, **Medium,** or **Low** *Kinetic* Energy? Does each cart have **High**, **Medium**, or **Low** *Potential* Energy?




What is the difference between **SPEED** and **VELOCITY**?

Where does the cart reach the highest velocity?

Build your roller coaster! Discuss with your mentor what would happen if you built your roller coaster from a higher starting height. Experiment and see what happens!