# Energy Transfer: Gravitational Potential Energy to Kinetic Energy

Exploration

The law of conservation of energy tells us that energy can neither be created nor destroyed. Instead it changes from one form of energy to another. Potential energy is energy that is stored in an object. Potential energy can transfer into other forms of energy like kinetic energy. Kinetic energy is energy in an object because of its motion. For example, a ball held in the air has gravitational potential energy, because if released, the force of gravity will transfer the potential energy to kinetic energy as the ball moves faster and faster toward the Earth. The higher the ball the more gravitational potential energy it has because when released, it will fall for a greater distance, generating more kinetic energy.

Materials

- PocketLab with VelocityLab app
- Ramp
- Teacher Geek Cart
- Meter Stick
- Material to add mass (pennies, mass set, etc.)
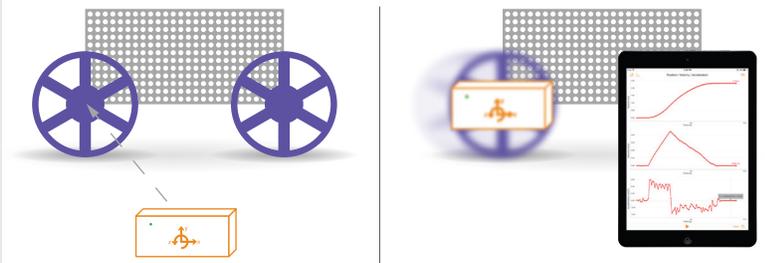
Objective

In this exploration students will:

1. Collect data to calculate the different types of energy in a system at different instances

2. Create graphical displays of data to represent the amount and type of energy in a system at different instances

3. Determine how the kinetic energy of an object is related to the mass of the object and the speed of the object.

Formulas and Key Words

Define the following terms:

Gravitational Potential Energy (GPE)	Kinetic Energy (KE)	Velocity (v)
Conservation of Energy	Thermal Energy (TE)	Friction

Use the following formulas in today's lab:

GPE = mgh

KE = $\frac{1}{2} mv^2$

Part A: Teacher Demo

Your teacher will find the mass of the cart and set a ramp at a low angle. Your teacher will then place the cart at the top of the ramp and measure the height of the cart on the ramp. Record the data collected below.

Height of cart: Mass of cart:

1. As a group, calculate the Gravitational Potential Energy of the cart at the top of the ramp. The PocketLab should be connected to the VelocityLab app and attached to the wheel of the cart. Your teacher will display and record the velocity data.
2. When your teacher releases the cart observe how the velocity graph changes.
3. Record the velocity of the cart at the five different points from the table below.

Location of cart	Top of ramp	¼ down the ramp	½ down the ramp	¾ down the ramp	Bottom of ramp
Velocity					

4. At each location, using the data collected and the definitions and formulas listed above to calculate the GPE, KE, and TE at each location on the ramp.

Location of cart	Top of ramp	¼ down the ramp	½ down the ramp	¾ down the ramp	Bottom of ramp
GPE					
KE					
TE					

5. Draw a bar graph displaying the distribution of energy at each location. What pattern do you notice?

Part B: Lab Groups

1. In your group, begin by fixing your ramp to a specific height and find the mass of your groups cart. Place the cart at the top of the ramp and measure the height of the cart.
    Record your data below.
    Height of cart: Mass of cart:

2. Write a hypothesis that predicts how increasing the mass of the cart will affect the total energy in the system and the distribution of energy as the cart rolls down the ramp. Specifically, how will increasing mass affect the velocity of the cart, the GPE, KE, and TE of the cart?

3. Using the mass set and your other materials, design an experiment that will accurately test your hypothesis. Write out your design. Be sure to include what the independent variable(s) is and how you will change it, what the dependent variable(s) is and how you will measure it, and how you control any variables that need to be controlled. You must test at least four different masses for the cart.

4. Use the data table on the next page to collect your data

	Location of cart	Top of ramp	¼ down the ramp	½ down the ramp	¾ down the ramp	Bottom of ramp
m_1	Velocity					
	GPE					
	KE					
	TE					
m_2	Velocity					
	GPE					
	KE					
	TE					
m_3	Velocity					
	GPE					
	KE					
	TE					
m_4	Velocity					
	GPE					
	KE					
	TE					

5. Draw a bar graphs displaying the distribution of energy at each location. What pattern do you notice?

Conclusion

1. Was your hypothesis valid or invalid? Why or why not? Support your claim with evidence gathered during the lab.
2. Describe the relationship between the kinetic energy of an object and that object's mass and speed. How would this relationship work in other scenarios, besides a cart rolling down a ramp?

Engineering Challenge

Have you ever noticed that roller coasters don't have engines? Some vehicles don't need engines to give them energy. Instead, gravity can provide all the energy needed.

At the beginning of most roller coasters an electric winch connects to the car and pulls it high up to the top of the roller coaster track. The winch and the car detach, but the car is left with an incredible amount of gravitational potential energy. As the car goes down the first big drop and through the rest of the track, energy is constantly being transferred back and forth between gravitational potential energy and kinetic energy. Some energy is also lost from friction in the form of thermal energy. In order to get up all of the hills and loops of the track, the car must have enough energy because the car does not have a motor to add energy into the system. Therefore the track must be carefully designed so there is always enough energy in the system to make it through the whole track.

Materials

- PocketLab with VelocityLab app
- Two Teacher Geek wheels
- Tape
- BluTrack

Objective

In this exploration students will build a track that meets the following criteria:

1. The car must never be "stuck" between hills of the track and must reach the end of the track.
2. The track must have at least 2 hills
3. The track must be safe. The car cannot fly off the

Set-up

The two wheels and the PocketLab will be the "car" of the roller coaster. The PocketLab will act as an axle and hold the two wheels together. This will be narrow enough for each wheel to travel along one side of the track. Using the tape, attach the PocketLab to the wheels so it holds the two wheels together and acts as an axle. The wheels and the PocketLab should then spin about the PocketLab's x-axis. See the diagram below. (As a bonus challenge you can modify a Teacher Geek cart so it is skinny enough to fit on the BluTrack and use that instead).

Teacher geek
wheels

PocketLab
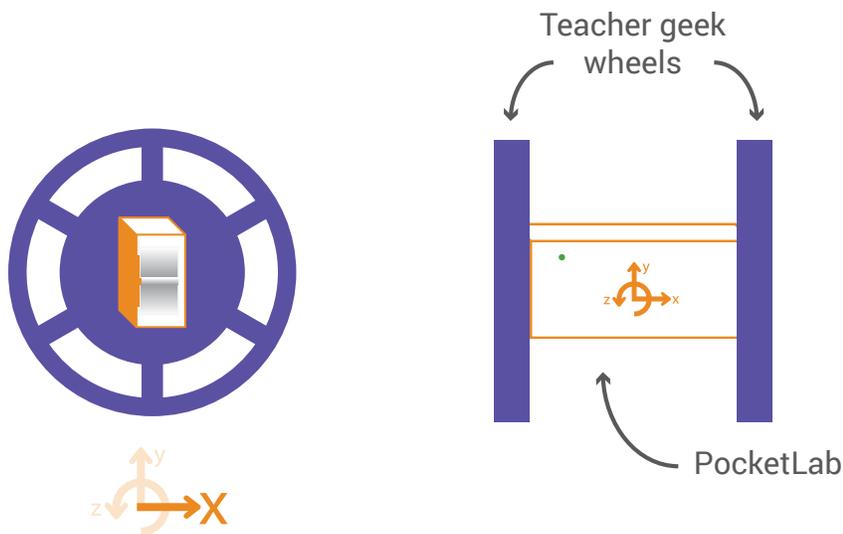
Redesign and Design

For each track design you build, draw a detailed diagram of the design. Label the height of each hill and dip in the track. Label the distance between hills. Test each design. For each design calculate the GPE, KE, and TE at several points along the track (at the top of the initial drop, bottom of initial drop, start of hill 1, top of hill 1, bottom of hill 1, start of hill 2, top of hill 2, bottom of hill 2, and end of the track). If your initial design does not meet the criteria, think critically about why, redesign your track and test again. Write a short paragraph that describes and justifies the decisions you made for each of your designs.