<u>Potential vs. Kinetic Energy</u>

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Please Do Not Miss…

If you only have a limited amount of time, please don't skip…

- **A Marble Run: Potential vs. Kinetic Energy**

Overview

Have you ever been on a roller coaster? Do you have a favorite roller coaster? Why was it your favorite? What if you could design your own roller coaster, what would it be like? Engineers design roller coasters. Do you think that would be a cool job? This week, you get to use the principles of physics to be an engineer who constructs your own marble roller coaster.

Background Information

My favorite part of a roller coaster is the giant hill. I can feel my heart beat faster and faster as the cars slowly make their way up the hill. When they hit the very top, gravity takes over converting **potential (stored) energy** to **kinetic energy (energy in motion)** as the rollercoaster rushes down the steep hill. I scream my lungs out! The full weight of the train rushes downward and into the first curve or spiral. A chain pulls the cars up the hill. As they rise, the cars are gaining more and more potential energy. The chain is working against the force of gravity. At the top of this hill, all of this potential energy is released into kinetic energy as the train rushes down the hill with the force of **gravity**. A **force** is simply a push or a pull.

The marble will gain speed or kinetic energy as it rushes down the hill and slow down as it comes up the next hill. **Energy is never created or destroyed. It just converts from one form to another.** As the marble loses kinetic energy (slowing down) as it goes up hill, it is gaining potential energy the higher it gets.

Isaac Newton was a great scientist and mathematician who lived in England in the 1600's. As the story goes, he was one day sitting under an apple tree when an apple fell and hit him on the head. Why, when nothing pushes or pulls an apple, does it fall down to the ground? This was the beginning of Isaac Newton's studies on gravity. Gravity is a force of attraction that keeps objects on the ground.

Isaac Newton was fascinated with why objects move the way that they do. He created three laws that we still use today to explain motion. In his **first law of motion (the law of inertia),** he discovered that an object at rest wants to stay at rest, unless an unbalanced force pushes or pulls on that object. Also, an object moving in one direction will stay moving in that direction unless an unbalanced force pushes or pulls it in a new direction. For example, a soccer ball will stay sitting on the grass unless someone come and kicks it. A skateboarder will keep rolling in the same direction unless he runs into a sidewalk.

Newton's **second law of motion** is also easy to understand. You are pushing two people on a swing. One is a baby and the other is a large man. If you want them to go high, which one will you have to push harder? Newton's 2^{nd} law says that an object of greater mass takes more force to accelerate or make move. Force = Mass x Acceleration. Have students race marbles on the track: one smaller and one larger. Newton's 3^{rd} law states that whenever an object pushes another object, it gets pushed back too.

Friction is the idea that objects in motion rub against things, eventually causing them to stop. Friction can prevent an object from moving or can make a moving object slow down.

If you liked this lesson, maybe you could become a **civil engineer** when you get older, someone who builds bridges, roads, buildings and other structures.

Main Ideas

- **Potential energy** is stored energy. It is energy due to position. A ball on a shelf has a lot of energy because if it were even slightly tapped, it could roll a long, long way.
- **Kinetic energy** is the energy of motion.
- **Isaac Newton** was a great scientist who studied motion and gravity.
- **Gravity** is a force of attraction that keeps objects on the ground.
- A **force** is simply a push or a pull.
- His first law of motion (the **law of inertia**) states that an object at rest wants to stay at rest, unless an unbalanced force pushes or pulls on that object.
- His **second law** says that an object of greater mass takes more force to accelerate.
- **Friction** is the idea that objects in motion rub against things,

eventually causing them to stop.

- **Projectiles** that are launched from higher heights will travel farther than those launched from lower heights.
- **Civil engineers** build bridges, roads, buildings and other structures.

Materials Needed

- *Gravity* by Jason Chin
- Marble Run
- Marbles

Preparation

1. Read "Background Information" to become more familiar with the properties of potential and kinetic energy.
2. Read through *Gravity* by Jason Chin. Prepare questions that you can ask along the way.
3. Make sure that you have all the supplies that you will need for each day's experiment or craft.

Opening

Read through *Gravity* by Jason Chin.

A Marble Run: Potential vs. Kinetic Energy

Begin by allowing students just to experiment with the marble run. Give each student 1 marble to use. They can work individually or with a partner to build different tracks. Discuss the difference between potential and kinetic energy. Point to how they are used on the marble run.
Materials: marble run, marbles

Extensions:

1) As they get the hang of it, see if the group can build one enormous track using every single piece. Have students draw a diagram of the marble run. Have them label changes in kinetic and potential energy.
2) Use a stopwatch to time how long it takes the marble to complete the track. Time 5 marbles. Find the average of their times.
3) Projectiles that are launched from higher heights will travel farther than those launched from lower heights. Create a marble run that projects marbles from different heights. Measure how far they roll. Do

they roll farther from the lower or higher height? Project them onto a smooth surface and then onto a carpet. Do they roll farther on cement or on carpet? Discuss the concept of friction.

4) Does the **friction** of the track ever beat out the **force of gravity**, causing the marble to come to a complete stop? Did you have to use the **force** of your finger to push or pull the marble to make it go again? Experiment with making tracks at different levels of steepness.
5) Have students make two different tracks that meet up at some point. See if they can make two different marbles collide by experimenting until they start them at exactly the right times.

Further Exploration

Motion Quiz

1. **How does the height of an object affect its potential energy?** Objects have more potential energy when they are higher.
2. **When you hit a baseball with a bat, are you using a push or a pull?** push
3. **When you open a refrigerator door, are you using a push or a pull?** pull
4. **At the grocery store, is it easier to push an empty cart or one filled with groceries?** empty
5. **Does a carpet create a little bit of friction or a lot of friction?** Lot **Does a playground slide create a little bit of friction or a lot of friction?** little
6. **When you jump up on a trampoline, how come you always come back down?** Gravity **What would happen if you jumped on a trampoline in outer space?** You would keep flying in that direction until you ran into something

Newton's Laws on the Playground

1st Law – Push a friend on a swing. The force of your push made an object at rest start moving.
2nd Law – Push a friend down the slide. What happens when you push them gently? What happens when you push them hard? Push two friends on a swing. Give them both equal pushes. Does the smaller or larger person go higher?
3rd Law – Go up and down on a seesaw or teeter-totter with a friend. How does a seesaw work? What happens when you run into someone on the playground?

Wrap Up

- Have students build one enormous track using every single piece.
- Try Galileo's ball dropping experiment. Which ball hits the ground first?
- Give students the Motion Quiz.
- Take students outside to a playground. Have them brainstorm how they use Newton's laws every day on the playground.
- Have students explain Newton's three laws to a friend.

Signs of Success

The student will…

- Demonstrate engagement and curiosity while building a marble run.
- Describe what they have seen or done, explain what they still want to try, and make predictions for outcomes for new ideas.
- Come up with motion experiments of their own that they would like to try.
- Demonstrate to a friend Newton's 3 Laws on the playground.

Other Books to Explore

Stop That Ball! By Mike McClintock
Irma The flying Bowling Ball by Tom Ross
Little Pig's Bouncy Ball by Alan Baron
The Science Book of Gravity by Neil Ardley
Forces Around Us by Sally Hewitt
Gravity by Susan Canizares and Daniel Moreton
Real Stuck, Way Up by Benette W. Tiffault
Rolling Along with Goldilocks and the Three Bears by Cindy
Meyers Forces and Motion by Angela Royston
Find Out About Pushes and Pulls by Terry Jennings
Wheels by Annie Cobb
Push It or Pull It? by Rozanne Lanczak Williams
Mama Zooms by Jane Cowen-Fletcher
Wheels by Susan Canizares and Daniel Moreton
Push or Pull by Susan Canizares and Betsey Chessen

Note: For older students, NASA has a really neat resource that correlates with this lesson. It can be found at:

http://er.jsc.nasa.gov/seh/amuse_park_physics.pdf

Pennsylvania Educational Standards

Reading 1.2.3 A, D, E
1.6.3 A, B
1.8.3 A, B

NRC National Science Educational Standards
Content Standard A: Science as Inquiry
Content Standard B: Physical Science

AAAS Benchmarks for Science Literacy
12A Values and Attitudes 12D Communication Skills

Sample Schedule For Making It A Week Long Unit

Day 1:
Introduce the difference between kinetic and potential energy.
Break out the marble run.
Let the students play with them for the remainder of class.

Day 2:
Introduce Isaac Newton and the concept of gravity.
Read *Gravity* by Jason Chin
Play with the marble run.

Day 3:
Introduce Newton's 3 Laws of Motion.
Tug of War
Marble Run

Day 4:
Discuss the concept of friction.
Projectile Experiment

Day 5:
Motion Quiz
Take students outside for Newton's Laws on the Playground