Coaster Creators

Extension Activities

Recommended Grade Levels: Grades 3 – 8

Major Concepts

- Potential and kinetic energy
- Engineering process
- Gravity
- Momentum
- Friction

Key Words

Energy – In science, we say that energy is the ability to do work, but by 'work,' we can mean a lot of different things! Energy is 'at work' anytime something lights up, makes noise, or moves. Energy can neither be created nor destroyed! It simply changes form.

> **Potential energy –** "Stored" energy, relative to an object's location or stresses within itself. Potential energy is energy that *could* do something, and just isn't doing it yet. A ball atop a hill, an arrow pulled back in a bow, or swing lifted up to its highest point and held are all examples of potential energy.
>
> **Kinetic energy –** Energy in motion. In the three examples of potential energy above, when and how would it be transferred into kinetic energy?

Force – A "push" or a "pull." Forces can be contact (working only when objects touch) or non-contact (pushing and pulling without physical contact).

Gravity – A force that draws all things with mass toward one another; practically, gravity is a non-contact force that pulls objects toward larger objects. Particles of dust are drawn in by our gravity; we're drawn toward the center of the Earth; the Earth is drawn toward the sun; Earth's oceans are drawn toward the moon (the tide). Why is it inaccurate to say that gravity is a force that pulls things "down?"

Friction – A contact force that one surface encounters when moving over another. Friction is the force that resists movement. Newton's Law says that an object in motion will stay in motion, so if we were to roll a ball, it would roll across the country and end up in an ocean, right? No! The *other* half of Newton's Law says that it will stay in motion *until acted upon by another force*. Energy lost to friction slows a rolling ball.

COSI Connection

COSI's **GADGETS** exhibition explores how simple machines, force and motion, energy, and engineering power the world around us.

- Energy is at work in the world around us wherever things light up, make noise, or move. Can you find something that lights up inside of Gadgets? Something that makes noise? Something that moves?
- At the exhibit's entrance, you have the chance to design, build, and test your own floating contraption in the Gadgets Wind Tubes. Create a challenge for yourself (for example, construct an object that can float for 8 seconds) and test it out. If it doesn't work the first time, change something about your design and try again! What does it take to build an object that can complete your challenge?
- Electricity and magnetism are closely related. Check out the Ring Thrower inside the exhibit where a push of a button electrifies a metal coil, creating an electromagnetic field that repels (or pushes) an aluminum ring. How can this relationship between electricity and magnetism – a non-contact force – be used on a roller coaster to either speed it up, or slow it down?
- The Ball Wall allows you to rearrange pieces of a magnetic ball ramp to create your own roller coaster route. Experiment with the track pieces and the wheels that alter the coaster's course to see what the ball can do. How can you make the ball move quickly? How can you slow it down? How does altering its path change its speed or motion?
- Engineering isn't always easy! Check out the Build-a-Duck interactive. Your goal is to construct a rubber duck that will improve sales for the company. But how do you balance the input of engineers, designers, market researchers, and more? Can you build a duck that improves sales for the company?

Additional Resources

- *Roller Coasters* by Virginia Loh-Hagan Edd (Grades 3 – 5)
- *Scientriffic: Roller Coaster Science* by Chris Oxlade (Grades 3 – 8)
- TED Talk: "Life Lessons Through Tinkering" by Gever Tulley

Coaster Creators

ACTIVITY SUITE A: Playground Physics

- **Objective:** Students will explore the relationship between potential and kinetic energy as it relates to momentum and motion.
- **Time:** 30 minutes
- **Grade Levels:** Grades 3 – 5

Key Words

Potential energy – "Stored" energy, relative to an object's location or stresses within itself. Potential energy is energy that *could* do something, and just isn't doing it yet.

Kinetic energy – Energy in motion.

Friction – A contact force that one surface encounters when moving over another. Friction is the force that resists movement.

Introduction

Energy powers the world around us! Anytime something lights up, makes noise, or moves, it's using energy to do it. With roller coasters, potential energy is built up as a roller coaster is pulled up the lift hill, then turned into kinetic energy when it crests the hill and begins its descent. From that point on, gravity alone powers the ride through its course, pulling the train toward the center of the Earth while its kinetic energy is gradually lost to friction, sound, and heat.

Experiment 1: Potential and Kinetic Energy

Materials

- Playground slide
- Playground ball
- 3 – 4 cones

What to Do

Explain to students that they're going to become scientists to test the relationship between potential and kinetic energy by making observations.

Bring students out to the playground to experiment with the slide. Have a student carry a playground ball to the top of the slide. We want to experiment with potential and kinetic energy, so note to the students that, resting at the top of the slide, the ball's potential energy is at its highest! Instruct the student to simply inch the ball forward until gravity takes over, being careful not to apply force by pushing the ball. Allow the ball to roll until it stops, then mark the spot with a cone.

Repeat the experiment, this time lifting the ball only halfway up the slide. Mark its ending spot with another cone. When you lifted the ball halfway up the slide, did it travel half as far as the first ball? Why or why not?
Ask students to make a prediction: how far do you predict the ball will roll if it's lifted ¼ of the way up the slide? What about ¾?

If the resulting ratios aren't perfect, why? How does friction affect this experiment?

Experiment 2: Friction

Materials

- Playground slide
- Wax paper (or nylon jackets)

What to Do

Allow students to ride the slide from the top to the bottom.

Then, ride again but this time, while seated on a piece of wax paper (or a nylon jacket).

Which ride is faster? Why would that be? Wax paper helps to reduce friction, meaning less energy is lost to its resistance. Can you think of other ways you could decrease friction? How can roller coasters minimize friction? (HINT: Think of which part of the roller coaster train is actually touching the tracks. What kinds of materials could the wheels be made of to reduce friction that would slow the train and wear away at the track? Engineers work to answer this question, and today many steel roller coaster manufacturers make their wheels out of polyurethane or nylon!)

Conclusion

The same energy forces that power roller coasters also power the world around us! Potential and kinetic energy, friction, and momentum are areas of study in physics, which explores the force and motion that surround us. Engineers work to build more efficient systems and objects using these same forces to their advantage!

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ACTIVITY B: To Spill or Not To Spill?

- **Objective:** Students will explore color as visual information tied to preexisting psychological concepts.
- **Time:** 10 minutes
- **Grade Levels:** Grades 3 – 5

Introduction

It's not magic that keeps people in roller coaster cars as they travel through loops – it's physics! Centripetal force and inertia are forces that keep riders "glued" to their seats while they're upside down!

Materials

- Bucket
- String
- Water

What to Do

Ask students, have you ever been on a roller coaster that's gone upside down through a loop? At first glance, many people think that if they go through a loop on a roller coaster, they might fall out of their seats! In reality, the opposite is true! When passing through a loop, riders feel "heavier" than they really are, with additional G-force (or gravitational force) than normal.

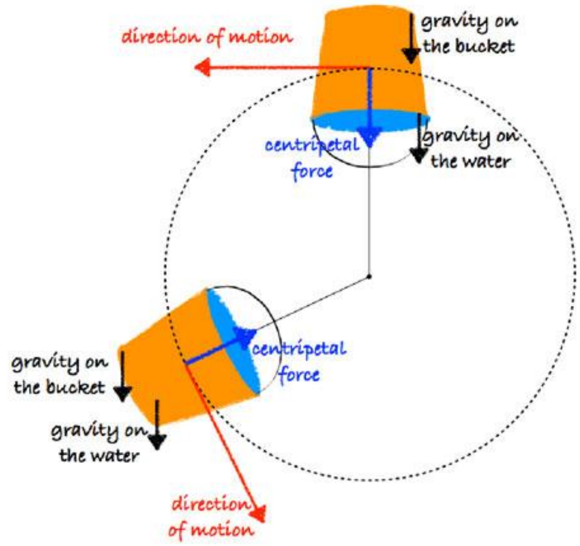
Introduce to students a plastic bucket filled no more than halfway with water. Ask students to make a prediction: what would happen if you slowly lifted the bucket and turned it upside down over your head? It would spill of course! But why? Gravity is the force that pulls everything on Earth toward the center of the planet, including water!

Move to an open area that can get wet (in case of an experimental failure) and be sure students and obstacles are out of the way. Swing the bucket back and forth gradually, gaining speed and height with each, until you can spin the bucket completely upside down through a circular path. Does the water spill?

What if you slow it down? How slow do you need to go before the experiment no longer works? What does this experiment have to do with roller coasters?

Conclusion

Is the water defying gravity? No! Gravity is still pulling the water toward the center of the Earth. However, inertia is the force that makes water want to continue moving in a straight line thanks to its forward momentum. The circular path you swing in creates centripetal motion – the water *wants* to move forward, but the bucket keeps getting in the way. You feel the same effect when a car turns sharply, and you end up leaning in the opposite direction – your body tries to continue moving forward even as the car moves around you.



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ACTIVITY C: Construction Cups

- **Objective:** Students are challenged to solve how to engineer sturdy structures with light-weight materials.
- **Time:** 15 – 20 minutes
- **Grade Levels:** Grades 1 – 6

Materials

- Plastic cups (x100 – 150)
- Cardstock

Key Words

Potential Energy – The energy stored when an object is at rest. All objects have the potential to move in some way, but they can't until another force acts on them, such as gravity. Think of a roller coaster. At the top of the first hill, it's filled with potential energy – it *could* do something, it's just not doing it *yet*.

Kinetic Energy – Energy released in motion. As the roller coaster crests the hill, what happens next? It flies down the hill! More potential means more kinetic!

Introduction

There can be many types of engineers: chemical engineers help create new medicine, electrical engineers work with electricity. Civil engineers are scientists who design and build structures like skyscrapers or bridges, and that is the role we will take on today. Engineers always face challenges of where they are building, what materials they are able to use, or how much time they have to build something.

They also have to think about potential and kinetic energy. Tall buildings have a lot of potential to fall over. If the engineer does their job, even the strongest winds won't be able to knock the tower down, making that potential energy turn into kinetic energy. Let's try to solve some problems that can come up while designing and building structures.

What To Do

- Split students into groups of 3-4.
- Pass out an even number of cups to each group.

- Now, come up with 2 or 3 challenges for the students to complete, and give them about 5 minutes to complete each challenge. Here are some examples:
    - Try to build the tallest and sturdiest tower. Test the towers by creating wind from a fan, or by waving a paper or poster board.
    - Can your group build a tower over 10 cups tall using only one cup as the base?
- With each challenge, have a small discussion about the limited materials and time constraints. Now add in another material such as cardstock and allow the groups another 5 minutes to recreate one of the challenges. Did the added material help in any way?
- Bonus: Have the entire class build one giant structure together!

Conclusion

Discuss some of the problems that groups had to solve in order to complete their challenge in time. Working together is important, especially when working on large scale projects like building skyscrapers. Ask students if they have seen a construction site, and if they know about the different people that work there? There may be different types of engineers, architects, plumbers, welders, masons, electricians, etc. who all have to communicate with each other in order to build an amazing, but safe, structure.