INNOVATION AT PLAY

**TEACHER ACTIVITY**

# ROLLER COASTER DESIGN

Your hands are sweaty, your heart's beating quickly, and your stomach doesn't feel quite right. Are you going to survive going upside down on this roller coaster?

Collaborate with a classmate to work your way through the following steps and find out more about the forces that will help keep you alive!

## STEP 1: CONNECT

Centripetal force helps a body follow a curved path without falling toward the center. Thanks to centripetal force (and your seatbelt!), you and the roller coaster car don't fall off the track when you go upside down!

How do you think centripetal force works?

## STEP 2: INVESTIGATE

Let's take a look at centripetal force in a situation where your life *isn't* at stake. (Hopefully you don't mind the risk of getting a little wet!) You'll need a bucket (with a handle) and some water.

Begin by filling the bucket with a little bit of water.

Then pick up the bucket by the handle, and begin to move your arm back and forth. When you are ready, quickly move the bucket toward the sky and then back down, making a complete circle (like your arm is a windmill!). Be consistent and continue to move your arm in a circular motion—in the same direction and with the same amount of speed.

Can you add more water and have the same effect?

## STEP 3: DISCUSS

- *What happened to the water? Why do you think this occurred?*

  You (hopefully!) saw that the water stayed in the bucket. This happened because of centripetal force, which is a physical force that pushes or pulls an object toward the center of a circle.

- *What provided this centripetal force?*

  Though the water's velocity wanted it to go flying outwards, the centripetal force provided by the bucket interrupted its path and kept the water inside. As long as you moved the bucket quickly enough, the centripetal force of the bucket against the water

### HOW DOES CENTRIPETAL FORCE AFFECT YOU AND THE UNIVERSE AT LARGE?

Driving a car on a curve, roller-skating or ice skating around a rink, the swings ride at a carnival, satellites rotating around the Earth, and planets rotating around the Sun all rely on centripetal force for stability.

will be stronger than gravity and the water will stay safely in the pail and off of your head. Want to learn more? Visit https://tinyurl.com/mr687zru.

- *Where else may centripetal force help you out?*

  Think about any situation that involves a curve, a loop, or an orbit. Centripetal force is likely the main reason that you (or the moving object) stay safe and stable!

## STEP 4: MATERIALS

Let's build a roller coaster so you can keep experimenting with centripetal force! You'll need:

- several feet of foam pipe insulation (at least 1½ inches in diameter)
- glass marbles of different sizes (all of which fit inside the foam pipe insulation)
- box cutter
- masking tape

## STEP 5: THE CHALLENGE

Let's put centripetal force to the test by building your own marble roller coaster, complete with at least one drop and one complete loop.

Choose an empty wall or side of a building as your base. Then cut the foam pipe insulation in half to make a half-pipe. This is the track on which the roller coaster cars (i.e., your marbles) will travel.

Bend and cut the foam pipe insulation to your heart's content as you design your coaster. Do your best to make the ride as wild as possible! Then use the masking tape to attach the track to the wall. Experiment with different designs and different marbles to see what combination yields the most thrilling ride.

Once your marble successfully makes its way through the coaster, consider:

- Newton's First Law states that an object will continue moving along a straight path unless acted upon by an outside force. How is this law apparent throughout your roller coaster ride?
- At what point(s) during the ride does centripetal force keep your roller coaster car stable and safe?
- Newton's Second Law states that Force = Mass x Acceleration. What role does the force of gravity play in your coaster design and how does this affect its success?

### LOOKING FOR AN ADDED CHALLENGE? THINK ABOUT:

What is the lowest starting point your coaster can have and still be successful?

How can you increase your car's speed as it races around the tracks?

Don't stop with just hills and a loop. What about twist and turns?

### KEY PLAYERS

It's not just centripetal force that's at work here. Kinetic energy, potential energy, and friction all have an important role to play too. Can you point out examples of these forces as your marble whips around the track?

## STEP 6: SHARE

Now that you've built your own thrill ride, create a quick video that shows off your roller coaster in action and explains the forces at work that keep your marble on the track! Use the hashtags #InnovationAtPlay and #Coaster to help others find your video.

### NGSS STANDARDS

- HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- Disciplinary Core Idea: PS2.B: Types of Interactions: Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4).

### COMMON CORE ELA STANDARDS

- CCSS.ELA-LITERACY.CCRA.SL.4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.