Use the Reading Guide to help you understand the passage.

Learning on a Loop: The Science of Roller Coasters

Reading Guide

How does the introduction appeal to readers who may have trouble with scientific concepts?

Notice that the author sets scientific terms in italics. How does this format help readers?

How are potential and kinetic energy alike and different? Why do they matter to roller coaster rides?

Imagine the fear and anticipation you feel as you are strapped into a roller coaster car. The car rides up the long first hill, tips over the top, and rushes down for the thrilling ride. Flying up and down the hills and through the turns and the loops, you wonder, "How does a roller coaster work? Why do my insides feel churned and tossed?"

Although roller coasters continue to get taller, longer, faster, and more complex, the science behind them has always been basically the same. The terms that explain them—like *gravity* and *acceleration*—sound complicated, but are easily understood. It starts at the bottom of the ride.

Roller Coaster Basics

A roller coaster is a series of connected passenger cars that moves along a track. Unlike a passenger train, a roller coaster has no engine to power it. A roller coaster's cars are pulled to the top of the first hill by a motorized chain or a series of magnets and then released. Once the cars release from the top of the hill, only momentum from gravity powers them through the rest of the ride.

Fulfill Your Potential

The cars must be pulled to the top of a tall hill to build up potential energy. *Potential energy*, or stored energy, depends on position. As the diagram shows, the higher the cars are in the air, the more potential energy they have. A car's greatest potential energy is at the top of the first, tallest hill (A). Potential energy can then change to *kinetic energy*, the energy of motion. As the car races down, it gains kinetic energy (B). These energy words might seem unfamiliar, but experiencing them is not. When you pedal a bike up a steep hill, you are storing potential energy. The potential energy changes to kinetic energy on the fast ride down the other side—when you don't have to pedal!

A roller coaster's energy changes between potential and kinetic throughout a ride. When the car is at the bottom of the first hill (C), it has its maximum speed, the greatest kinetic energy, and the least potential energy. The car begins to lose speed but gains potential energy as it travels up the next hill (D).

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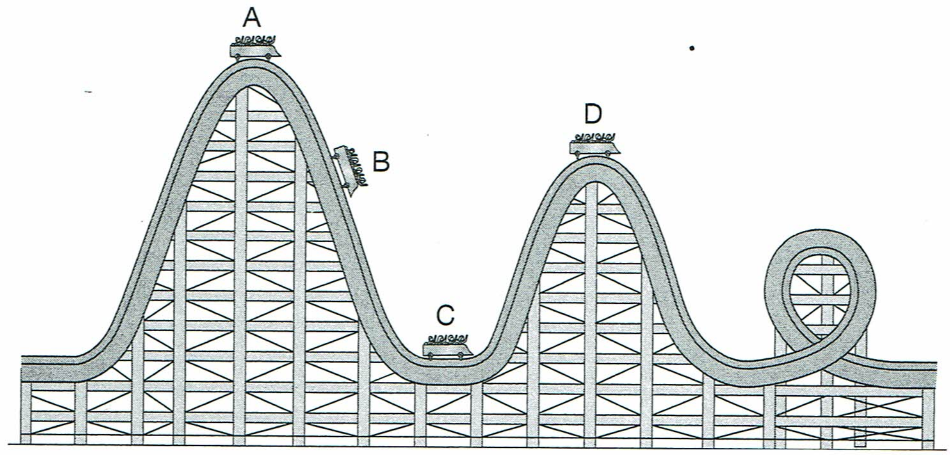
Why has the author included this diagram? What does it show?

The author explains gravity and inertia as a *tug-of-war.* How does the comparison add to your understanding of these concepts?



A Mutual Attraction

Let a coin go from between your fingers and it will fall to the ground. Why? Gravity exerts a downward force on the coin and pulls it toward Earth. *Gravity,* an attraction between two objects, is the same force that pulls a roller coaster car down a hill. The higher the car starts in the air, the more distance gravity can pull it down. The more distance gravity can pull it down, the faster it can go.

Go, Go, Go

As the roller coaster car tips over the first hill, the tracks come into play. They control the fall. The tracks guide where the car goes as it races toward the ground. Gravity pulls down on the car, and the car *accelerates,* or starts moving faster and faster. When the car goes back up a hill along the tracks, gravity continues to pull the car downward, and its speed decreases.

The First Law

Why doesn't the car stop entirely when it turns up a hill? The answer is explained by a physics law called "Newton's First Law of Motion," named for the seventeenth-century physicist Isaac Newton. This law is about *inertia*—objects in motion stay in motion, while objects at rest stay at rest. So, there is a tug-of-war as the car zooms through a dip in the track. *Inertia* makes the car want to keep moving up the track, but gravity wants to pull the car back toward Earth. In a roller coaster, the design is just right so that the car can reach the top of the next hill and keep traveling through the ride.

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The text on this page explains the meaning of the key terms *acceleration* and *friction*. Underline the phrases or sentences that define these terms.

If you started a roller coaster ride on a very tall hill, could the ride go on forever? Why or why not?

As you read the conclusion, consider who the target audience of this text might be. Was it written for scientists or for people with a limited knowledge of scientific concepts?

Acceleration = Thrills

The pushes, pulls, and stomach flips that make a coaster ride so exciting result from acceleration. Speed is how fast you go, but *acceleration* is a change in speed or direction. Think about riding in a car. Moving along at the same speed in the same direction, you hardly notice the ride at all. If the driver stops suddenly or makes a sharp turn, however, you notice it. You feel the change in acceleration because your body is also following Newton's first law of motion. The car stops, but your body continues forward—thus explaining the need for seatbelts. The car makes a sharp right turn, and your body leans to the left in an attempt to keep moving forward. The same thing happens on a roller coaster. Whenever the cars speed up, slow down, or take a turn, the rider feels that change.

Feel the Friction

If you look at any roller coaster from a distance, you will notice that the first hill is always the tallest. The reason is not to make the ride more exciting, but because of friction. *Friction* is energy lost as heat when two things rub together. On a roller coaster ride, some of the initial energy gained by pulling the car to the top of the first hill is lost to friction. There is friction between the cars and the track, and between the cars and the surrounding air. To account for the energy lost to friction, the hills must get a little bit shorter as the ride goes on.

Like the ride itself, it is a thrill to know how gravity, acceleration, inertia, and friction make a roller coaster work. Flying through a loop upside down is always an adrenaline rush, though, no matter how much you know about the science that keeps you in the seat!

Answer the following questions.

1 Read the domain-specific terms on the left. Then, match each term to the example on the right that **best** demonstrates its meaning.

A. gravity	**1.** A roller coaster's track affects how the roller coaster moves.
B. potential energy	**2.** When you drop something, it falls to the ground.
C. inertia	**3.** A car at the top of a hill has a lot of stored energy.
D. friction	**4.** A wagon rolling down a hill gains energy.
E. kinetic energy	**5.** When a car brakes sharply, the driver's body continues to move forward.

2 The following question has two parts. First, answer Part A. Then, answer Part B.

Part A

Which of the following **best** describes how the author organizes the text?

A. part to whole

B. sequence

C. spatial

D. whole to part

Part B

Use details from the passage to support your answer to Part A.

Write your response on the lines below.

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3. What is the author's purpose for including the example of pedaling a bike up and down a hill?

   A. to make the text more interesting

   B. to explain a concept in more familiar terms

   C. to contrast roller coasters and bicycles

   D. to compare roller coasters to hills

4. Which of the following sentences is a speculation made by the author?

   A. A roller coaster's energy changes between potential and kinetic throughout a ride.

   B. Speed is how fast you go, but *acceleration* is a change in speed or direction.

   C. Moving along at the same speed in the same direction, you hardly notice the ride at all.

   D. If you look at any roller coaster from a distance, you will notice that the first hill is always the tallest.

5. How does the diagram of potential and kinetic energy contribute to readers' understanding of the passage?

6 Compare and contrast the information you learned about roller coasters from "Try It: Roller Coaster Design" and "Learning on a Loop: The Science of Roller Coasters." Which passage is more informative? Which passage presents information in a way that is easier to understand? In your response, evaluate each author's purpose, structure, and use of supporting details to explain scientific concepts. Be sure to cite specific details from **both** passages.

Write your response on the lines below.

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