Physics at Play!

ROLLER COASTERS

INFORMATIONAL READING COMPREHENSION

Read the informational passage and answer the questions that follow.

1 Riding a roller coaster can be a thrilling or terrifying experience, depending on how you look at it. Either way, that experience is a scientifically designed one. The dramatic ups and downs of roller coaster rides are what make them so exciting, and all that motion is made possible by the laws of physics.

The Fundamentals of Fun

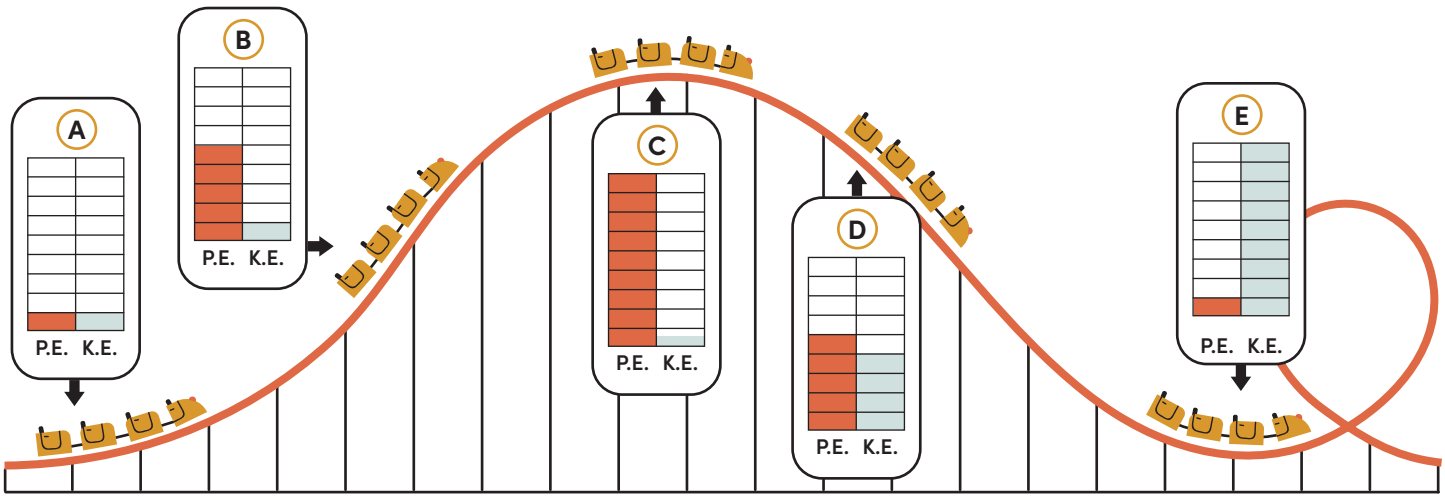
2 Most roller coasters do not use engine power to twist and turn you along a track. Instead, they rely on a carefully designed structure that uses basic physics principles to provide energy and drive the roller coaster.

3 For roller coasters, the main working force is **gravity**. Gravity pulls objects toward each other's centers. All objects have their own gravitational pull, but objects with more mass—like Earth—have more gravitational pull. Our planet's gravity is a strong force pulling us and everything else in our world down to Earth.

4 To take advantage of the force of gravity, roller coaster cars are pulled to the top of a steep hill by a lift mechanism, such as a chain lift or catapult-launch system. At the top of the hill, the roller coaster has **potential energy**, the stored energy based on its position. The higher up the coaster is, the more potential energy it has. Here, at the highest point of the ride, the coaster has all the energy it needs to complete the course.

5 When the coaster's train is released at the top of the hill, gravity takes effect and all that potential energy begins to transform into **kinetic energy**, the energy of motion. As the coaster accelerates down the first hill, more and more potential energy is converted into kinetic energy.

6 By the time the train reaches the bottom of the hill, most of the roller coaster's potential energy has turned into kinetic energy. However, as the next hill starts, the balance of forces changes. The train starts losing kinetic energy—slowing it down and building potential energy back up as it climbs.



Potential energy **(P.E.)** *changes to kinetic energy* **(K.E.)** *and back again throughout the ride.*

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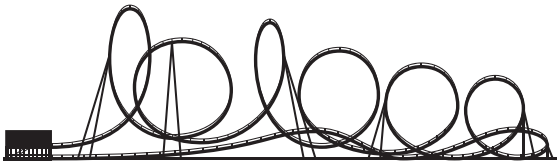
Continue reading. Then answer the questions that follow.

7 This exchange of energy continues as the roller coaster travels its course. With every change of direction and speed, the riders come along for the crazy, wild ride, sometimes being pushed down into their seats, other times feeling as though they're rising out of them.

8 These effects are partially due to Newton's First Law of Motion, sometimes called **inertia**, which states that an object at rest or in motion will stay that way unless a force acts on it. On a roller coaster, your body wants to continue in the direction it's going, but the roller coaster's track and car, along with gravity, force your body to go a different way. Imagine this: You reach the top of a hill, and your body wants to continue on its upward path; however, the coaster car heads down the hill, pulled by gravity. You feel yourself rising up out of your seat a little as your body tries to keep going up. Some roller coaster enthusiasts call this "air time," and it's a fun result of physics fundamentals!

A Never-Ending Story?

9 As potential energy and kinetic energy are converted back and forth, it's tempting to think that a roller coaster ride could go on forever. In fact, according to a physics law known as the Law of Conservation of Energy, energy is never actually lost; it can only be transformed into other types of energy. Since there are forces other than gravity at work during a roller coaster ride, the coaster eventually slows down and stops.



10 Two main forces rob the coaster of its potential and kinetic energy: friction and air resistance. **Friction** occurs when objects rub against each other. When a coaster's wheels rub against the track, some of the kinetic energy transforms into thermal energy. This means there's less kinetic energy to be converted back into potential energy at the top of the next hill.

11 Similarly, **air resistance**—friction between the air and the coaster—can transform energy into heat energy, slowing the coaster down and resulting in less energy overall for the coaster to complete its run. In fact, on windy days, increased air resistance might make it necessary to close down the ride. On those days, the coaster may not have enough energy to make it to the top of hills and loops and all the way to the end of the track.

A Smooth Operation

12 Physics is not the only area of science that engineers use when designing roller coasters. In order to simulate a thrilling—and safe—experience, they consider concepts in other fields such as biology, geology, climatology, and psychology.

13 Roller coaster designers use physics to control the riders' experience. So the roller coaster has enough energy to complete the ride, they make the first hill as tall as possible. To ensure that the ride flows smoothly, they grease the tracks and design aerodynamic cars to reduce friction.

14 By creatively manipulating the mechanics of motion, roller coaster engineers keep finding new ways to turn physics into fun. Whether it's a steel coaster, a wooden coaster, a floorless coaster, or a spinning coaster, the laws of physics are at the heart of it all.

INFORMATIONAL READING COMPREHENSION:

Physics at Play! ROLLER COASTERS

Answer the following questions about "Physics at Play: Roller Coasters."

1. What is the central idea of the text?

a. Roller coasters do not need engines in order to take the riders through an exciting ride.

b. Thrill-seeking engineers with specialized physics knowledge design roller coasters.

c. Roller coasters utilize a combination of physics concepts to take passengers from start to finish.

d. Roller coasters rely on gravity, potential and kinetic energy, and inertia to keep passengers safe.

2. How does the author develop the central idea over the course of the text?

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3. Based on information in paragraph 8, what is inertia?

a. the tendency of an object to remain still or on a constant course unless a force makes it change

b. a law of motion stating that energy can be changed into other forms but never truly lost

c. the tendency of an object to be drawn toward the center when moving along a circular path

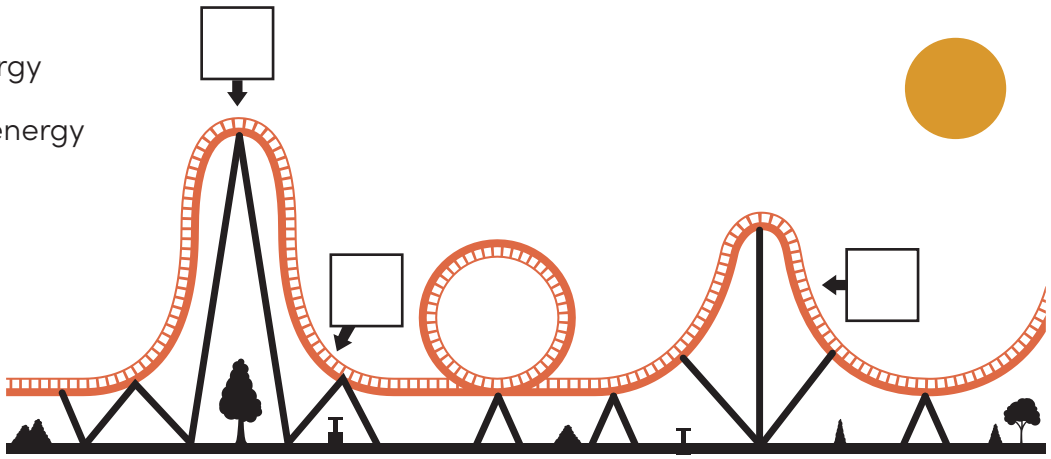
d. a law of motion stating that the higher an object is positioned, the more potential energy it has

4. Label the image of a roller coaster with **A**, **B**, and **C**, based on the associated descriptions below. Then, cite evidence from the passage to support your answers on the lines below the drawing.

A. a mostly even mix of potential and kinetic energy

B. a point of mostly kinetic energy

C. the point of maximum potential energy



EVIDENCE:

A. _____

B. _____

C. _____

INFORMATIONAL READING COMPREHENSION:

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Keep going! Answer the following questions about "Physics at Play: Roller Coasters."

5. What similar effect do **friction** and **air resistance** have on a roller coaster's energy?

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6. Part A. Why must the first hill of a roller coaster be the tallest hill of the ride?

a. so that friction and air resistance do not reduce the coaster's energy
b. so the roller coaster has enough energy left to climb other hills later in the ride
c. so the force of gravity can turn the kinetic energy into potential energy
d. so the roller coaster can use all of its energy before the loop-the-loops and other hills

Part B. Cite evidence from the text that supports your explanation.

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7. What is the most likely reason the author chose to include the section **A Smooth Operation**?

a. to suggest that safety is the top priority for roller coaster engineers
b. to advocate for more research and safety standards in roller coaster design
c. to provide examples of how many engineers control a roller coaster ride
d. to educate about the role that science plays in the design process

8. Summarize the information in the last section of the passage, **A Smooth Operation**.

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