APPLICATION TASK | # Create a Roller Coaster Ride

Name: ____________________

Goal

Use nonlinear functions to model a roller coaster ride.

Language Objective

Using mathematical language and linking words and phrases to connect ideas, describe the use of nonlinear functions in modeling real-world situations.

Why Use Nonlinear Functions to Model Real-World Situations?

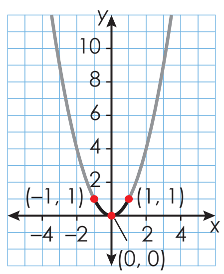
Sometimes the relationship between two real-world quantities is not linear.

Essential Question **How can you model real-world situations with nonlinear functions?**

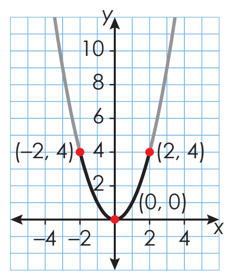
In this task, you are creating a **roller coaster** ride from graph sections of the **nonlinear** functions $y = x^2$ and $y = -x^2$. You will develop two plans for different roller coaster rides.

Constraints:

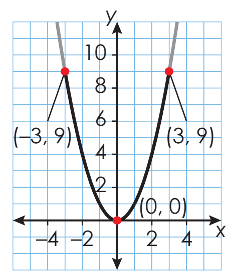
- The roller coaster ride can start at any height, but there must be at least two hills.
- Sections can be shifted up and to the right in whole-number increments.
- The heights of the hills should decrease from left to right.



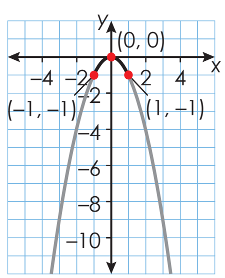
$y = x^2$: $-1 \le x \le 1$



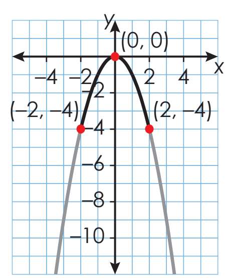
$y = x^2$: $-2 \le x \le 2$



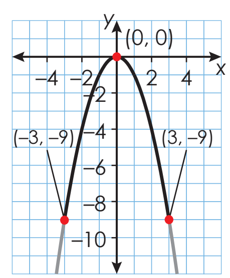
$y = x^2$: $-3 \le x \le 3$



$y = -x^2$: $-1 \le x \le 1$

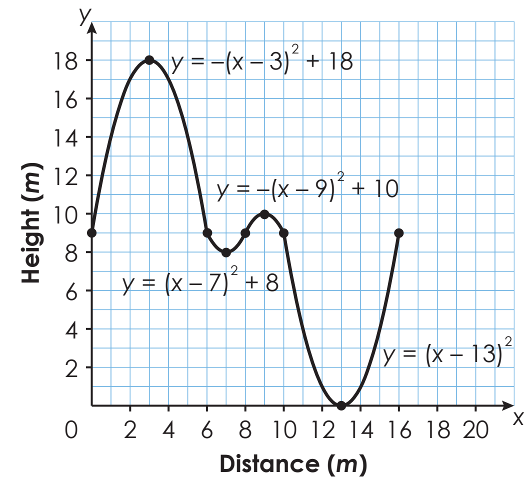


$y = -x^2$: $-2 \le x \le 2$



$y = -x^2$: $-3 \le x \le 3$

SAMPLE PLAN



Increasing Height Intervals	Decreasing Height Intervals
$0 < x < 3$ $7 < x < 9$ $0 < x < 3$	$3 < x < 7$ $9 < x < 13$

Did You Know? **The 570-foot-tall Skyscraper in Orlando, Florida, will be the world's tallest roller coaster.**

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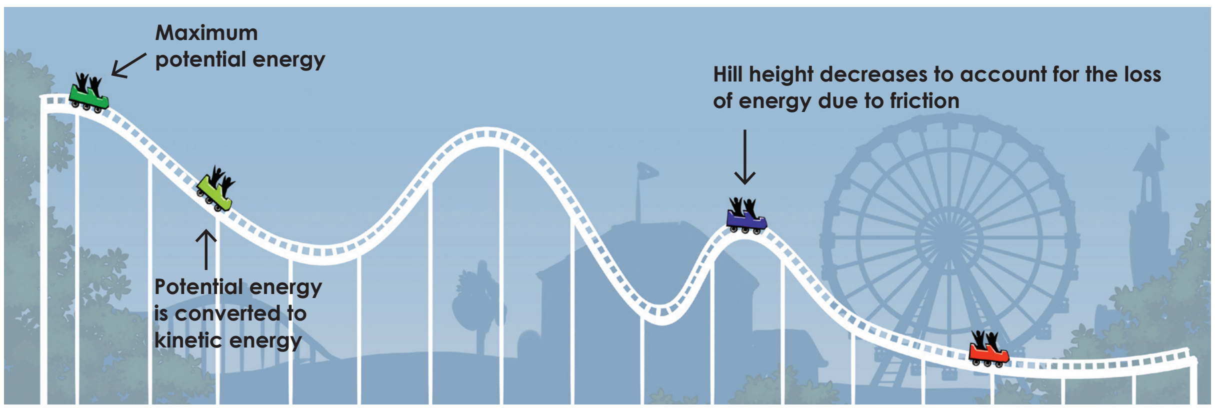
Background

A roller coaster car goes up and down **steep** hills as it travels across the coaster track. To begin with, the car is pulled to the top of the first hill by a mechanical **winch**. As it is pulled, the car acquires energy that subsequently decreases due to **friction** as the car rubs against the roller coaster track.

There are different kinds of energy involved in a roller coaster ride. **Potential energy** is the energy stored in the roller coaster car that has the potential to be used. Potential energy is often referred to as energy at rest. To illustrate this, look at the diagram shown. The roller coaster car has the maximum amount of potential energy when it is at the highest point, right before it is released to begin the ride.

Energy cannot be created or destroyed, but it can be converted into different forms for use. With this in mind, you will note that when the roller coaster car begins to move down the hill, the car's potential energy is being changed into **kinetic energy**, which is energy in motion.



Think about It How is this type of model similar to and different from a real roller coaster? Why might a model be convenient to use? Use linking words and phrases in your answer.

A real roller coaster and this model are similar because ______________________

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ACADEMIC VOCABULARY

Supporting Words

friction: the resistance of motion when one object rubs against another object, slowing each other down

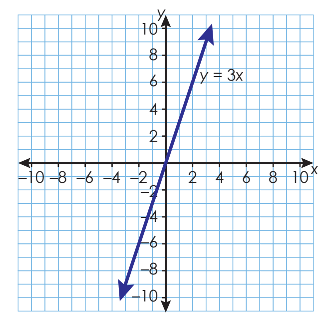
kinetic energy: the energy that is in motion

potential energy: the stored energy in an object based on how it is positioned

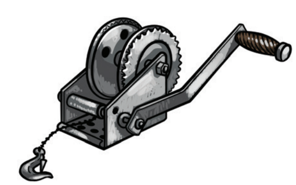
roller coaster: a ride at an amusement park with cars that roll on tracks with sharp curves and steep hills

steep: describes a sharp slope

Example: The graph of the line $y = 3x$ has a steep slope.



winch: a device used to lift or move an object, turned by a crank or other power source



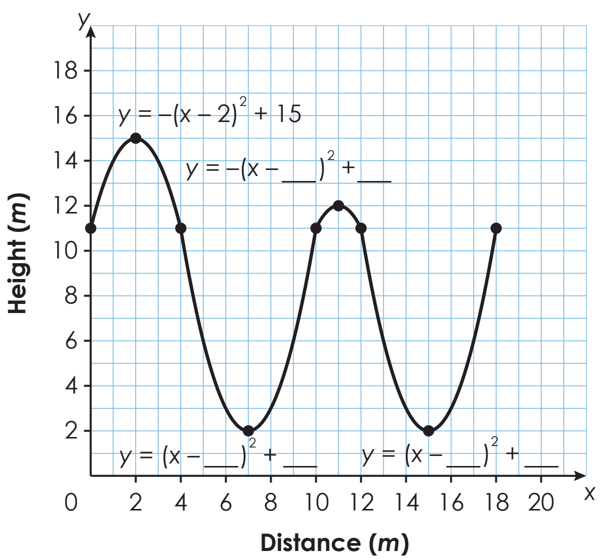
A | Understand

Name: ______________________

Solve a similar problem A **continuous** roller coaster ride starting at x = 0 has been created using 4 graph sections from page 1.

Analyze the graph to see how it meets each constraint. To begin with, complete the equations to label each section that was shifted. Then, complete the table to describe the height intervals for the roller coaster.

Constraints	Equation Notes
• There must be at least two hills. • The heights of the hills must decrease from left to right. • The roller coaster can start at any height.	$y = (x - h)^2 + k$ $y = -(x - h)^2 + k$ h: units shifted right k: units shifted up



Increasing Height Intervals
$0 < x < 2$
___ $< x <$ ___
___ $< x <$ ___

Decreasing Height Intervals
___ $< x <$ ___
___ $< x <$ ___

Think about It Use the vocabulary from page 4 to complete the sentence.

The roller coaster is made from nonlinear graph sections that are ______________.

Explain your reasoning using linking words and phrases and mathematical language.

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Talk about It Talk about how to solve this problem with a partner. Discuss how the sample solution in ***section A*** meets the requirements of the task. Is there another way that you could solve the problem?

LINKING WORDS AND PHRASES

Mathematicians use linking words and phrases to link related ideas as they solve real-world problems. Below are some possible words and phrases you can use as you write and discuss creating a plan for a roller coaster.

due to the fact that
frequently
importantly
on the other hand
since
subsequently
to illustrate
with this in mind

Previously used linking words and phrases:

as a result
because
consequently
for instance
to begin with

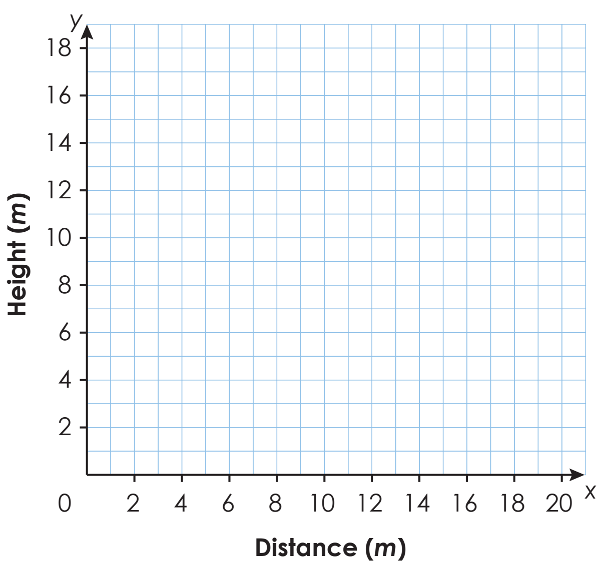
B | Organize

Name: ______________________________

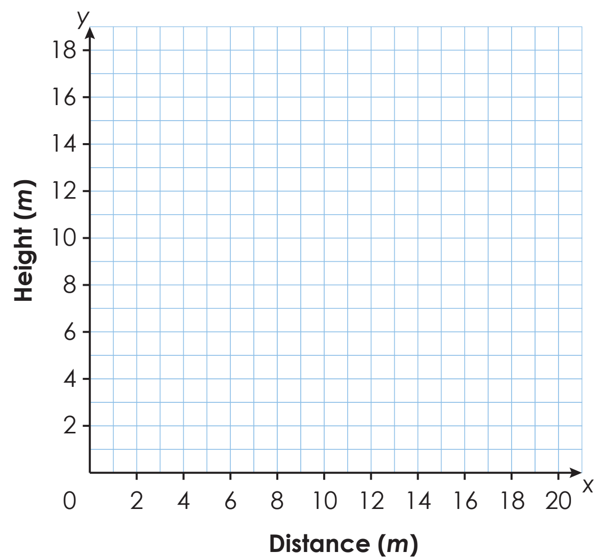
Create two continuous roller coaster rides starting at x = 0. Add labels to show the equation for each section after it is **translated**.

Constraints	Equation Notes
• There must be at least two hills.	$y = (x - h)^2 + k$
• The heights of the hills must decrease from left to right.	$y = -(x - h)^2 + k$
• The roller coaster can start at any height.	h: units shifted right
• Use the 4 graph sections from page 1 for the roller coaster ride.	k: units shifted up
• Shift sections up and to the right in whole-number increments.	

Plan 1



Plan 2



Explain It How is the **vertex** of each graph section related to where the height is **increasing** and **decreasing**? Use linking words and phrases to explain your reasoning.

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MATHEMATICAL LANGUAGE

Major Words

continuous: going on without a gap or interruption

decreasing: Describes a section of a graph or function where the *y*-values decrease as the x-values increase. The graph section appears to be going down from left to right.

increasing: Describes a section of a graph or function where the *y*-values increase as the x-values increase. The graph section appears to be going up from left to right.

linear: Describes a function that has a constant rate of change. The graph of a linear equation is a straight line.

nonlinear: Describes a function that does not have a constant rate of change. The graph of a nonlinear equation is not a straight line.

translation: a transformation that moves a figure or object a certain distance without changing it in any other way

vertex: the minimum or maximum point of a parabola

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C | Solve

Complete the table for each of your plans. Fill in the blanks to describe where the height is increasing and decreasing over time for the roller coaster ride. Then analyze the plans.

Plan 1

Increasing Height Intervals	Decreasing Height Intervals
___ $< x <$ ___ ___ $< x <$ ___ ___ $< x <$ ___	___ $< x <$ ___ ___ $< x <$ ___

Plan 2

Increasing Height Intervals	Decreasing Height Intervals
___ $< x <$ ___ ___ $< x <$ ___ ___ $< x <$ ___	___ $< x <$ ___ ___ $< x <$ ___

Explain It Why are $<$ signs used to describe where the height is increasing or decreasing rather than $\leq$ signs?

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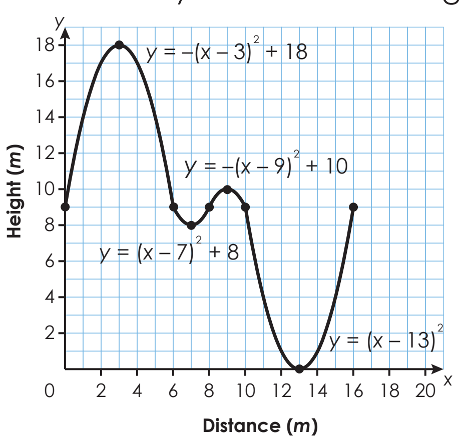
D | Check

You can check your work from ***sections B*** and **C** by solving equations to find the vertex coordinates for each graph section. Complete the table for the Sample Plan. Then check your own work using the same process.



Equation	Vertex (x-value)	Solve for y
$y = -(x - 3)^2 + 18$	3	$y = -(3 - 3)^2 + 18 = 18$
$y = (x - 7)^2 + 8$	7	$y = ($___ $- 7)^2 + 8 =$ ___
$y = -(x - 9)^2 + 10$	___	$y = -($___ $- 9)^2 + 10 =$ ___
$y = (x - 13)^2$	___	$y = ($___ $- 13)^2 =$ ___

Explain It What should the result be when you solve each equation for y if the work is correct? ______________________

CONNECT TO SCIENCE

Roller coaster cars do not have engines. A mechanical winch pulls a roller coaster car up to the maximum height of the first hill.

What causes the car to move after it reaches the maximum height of the first hill?

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Why must the heights of the hills decrease as the ride continues?

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Extend Create a longer roller coaster ride starting at $x = 0$ to a maximum distance of $x = 40$. In addition to showing a greater length of the x-axis, what other changes will you need to make to your display of the graph? Explain.

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