Task: Design a Roller Coaster

Student Text Pages
178–179

Suggested Timing
80 min

Materials and Technology Tools
- graphing calculators
- grid paper

Related Resources
- BLM G–5 Grid Paper
- BLM 3–15 Chapter 3 Task Rubric

Accommodations

Gifted and Enrichment–challenge students to research and report to the class on the mathematics behind some famous roller coasters

Visual–encourage students to use technology to graph the relations

Motor–give students extra time to complete the Task

Ongoing Assessment

- Use **BLM 3–15 Chapter 3 Task Rubric** to assess student achievement.

Specific Expectations

1.4, 3.2, 3.3

Teaching Suggestions

- You may wish to have students work in pairs to complete the Task.
- Have students read the entire Task. Discuss the Task and ensure students understand what they are being asked to do.
- You may wish to discuss students' responses for parts a) to d) prior to having students work on part e). Students may have various solutions for their roller coaster design. You may want to discuss various reasonable restrictions with the class. Setting some restrictions on the parameters will aid you in marking the various solutions.
- Distribute copies of **BLM G–1 Grid Paper**.

Hints for Evaluating a Response

Student responses are being assessed for the level of mathematical understanding they represent. As you assess each response, consider the following questions:

- How much assistance did the student need to determine the quadratic equation and the height of the camera?
- How much assistance did the student need to design part of a roller coaster ride, including the sketch and the equations?
- Which parts of the Task did the student complete/not complete?
- Did the student present work that was clear and easy to follow?
- Did the student demonstrate an understanding of the sine functions?

Level 3 Notes

- Student demonstrates understanding of the quadratic function and the meaning, in terms of the different forms of the equation, of key features of the parabola.
- Student demonstrates understanding of problem solving techniques.
- Student uses mathematical language effectively.
- Student's solution is clearly organized and choices are justified.
- Student makes minor errors.
- Student's roller coaster design is supported with sketches, equations of quadratic functions, and a description of the ride experience.

Level 3 Sample Response

a) The coordinates of the vertex are (17, 72.25) and the coordinates of another point on the parabola are (0, 0).

$h = a(d - 17)^2 + 72.25$
$0 = 289a + 72.25$
$a = -0.25$

$h = -0.25(d - 17)^2 + 72.25$
$h = -0.25d^2 + 8.5d - 72.25 + 72.25$
$h = -0.25d^2 + 8.5d$

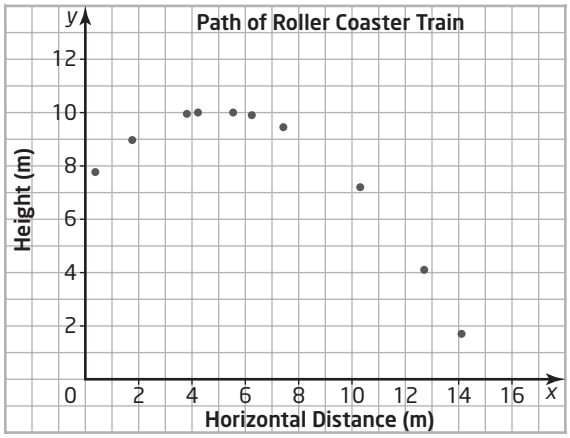
b) The end of the lift hill is 32 m horizontally from the beginning. The camera should be 28 m horizontally from the beginning of the lift hill. The height of the track 28 m from the beginning of the lift hill is 42 m. The camera should be at the point (28, 45) or 45 m above the ground.

c) The valley starts at the point (32, 16) and extends for 20 m, so it ends at the point (52, 16). The vertex is located at the minimum point of the parabola, which is 14 m below the start and end points, so its h-coordinate is $16 - 14 = 2$. The vertex is halfway between the start and end points, so its d-coordinate is $\frac{32 + 52}{2}$, or 42. Use the coordinates of the vertex and another point with the vertex form of the quadratic equation to determine an equation that models the profile of the valley.

$h = a(d - 42)^2 + 2$
$16 = 100a + 2$
$a = 0.14$

$h = 0.14(d - 42)^2 + 2$
$h = 0.14d^2 - 11.76d + 246.96 + 2$
$h = 0.14d^2 - 11.76d + 248.96$

d) Draw a scatter plot to visualize the path of the roller coaster train.



From the scatter plot, the vertex of the parabola is approximately (5, 10), and the h-intercept is approximately (0, 7.5). Use these points to determine an equation that models the curve.

$7.5 = a(0 - 5)^2 + 10$
$7.5 = a(-5)^2 + 10$
$7.5 = 25a + 10$
$-2.5 = 25a$
$a = -0.1$

$h = -0.1(d - 5)^2 + 10$ or in standard form $h = -0.1d^2 + d + 7.5$.

e) Answers may vary.

What Distinguishes Level 2

- Student demonstrates some understanding of the quadratic function and the meaning, in terms of the different forms of the equation, of key features of the parabola.
- Student demonstrates some understanding of problem solving techniques.
- Student uses mathematical language somewhat effectively.
- Student's solution is somewhat organized and choices are partially or ineffectively justified.
- Student makes some significant errors.
- Student's roller coaster design is somewhat supported with sketches, equations of quadratic functions, and a partial or inaccurate description of the ride experience.

What Distinguishes Level 4

- Student demonstrates thorough understanding of the quadratic function and the meaning, in terms of the different forms of the equation, of key features of the parabola.
- Student demonstrates thorough understanding of problem solving techniques.
- Student uses mathematical language highly effectively.
- Student's solution is highly organized and choices are clearly justified.
- Student makes very few or no errors.
- Student's roller coaster design is accurately and effectively supported with sketches, equations of quadratic functions, and a clear, thorough description of the ride experience.