Unit 4, Lesson 14

Graphs That Represent Situations

Let's examine graphs that represent the paths of objects being launched into the air.

14.1 A Jumping Frog

The height in inches of a frog's jump is modeled by the equation $h(t) = 60t - 75t^2$, where the time, t, after it jumped is measured in seconds.



1. Find $h(0)$ and $h(0.8)$. What do these values mean in terms of the frog's jump?

2. How much time after it jumped did the frog reach the maximum height? Explain how you know.

14.2 A Catapulted Pumpkin

The equation $h = 2 + 23.7t - 4.9t^2$ represents the height of a pumpkin that is catapulted up in the air as a function of time, t, in seconds. The height is measured in meters above ground. The pumpkin is shot upward at a vertical velocity of 23.7 meters per second.

1. Without writing anything down, consider these questions:
   - What do you think the 2 in the equation tells us in this situation? What about the $-4.9t^2$?
   - If we graph the equation, will the graph open upward or downward? Why?
   - Where do you think the vertical intercept would be?
   - What about the horizontal intercepts?
2. Graph the equation using graphing technology.
3. Identify the vertical and horizontal intercepts, and the vertex of the graph. Explain what each point means in this situation.

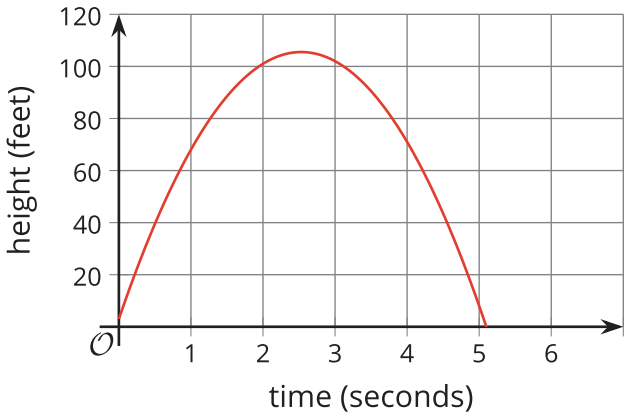
Are you ready for more?

What approximate initial vertical velocity would this pumpkin need for it to stay in the air for about 10 seconds? (Assume that it is still launched from 2 meters above ground and that the effect of gravity pulling it downward is the same.)

CC BY NC 2024
Illustrative Mathematics®

14.3 Flight of Two Baseballs

Here is a graph that represents the height of a baseball, h, in feet, as a function of time, t, in seconds, after it was hit by Player A.



Player B hits a baseball that has its height, in feet, t seconds after it was hit represented by the function $g(t) = (-16t - 1)(t - 4)$. Without graphing function g, answer the questions, and explain or show how you know.

1. Which player's baseball stayed in flight longer?

2. Which player's baseball reached a greater maximum height?

3. How can you find the height at which each baseball was hit?

14.4 Information Gap: Rocket Math

Your teacher will give you either a problem card or a data card. Do not show or read your card to your partner.

If your teacher gives you the problem card:

1. Silently read your card, and think about what information you need in order to answer the question.
2. Ask your partner for the specific information that you need. "Can you tell me _____?"
3. Explain to your partner how you are using the information to solve the problem. "I need to know _____ because . . . ." Continue to ask questions until you have enough information to solve the problem.
4. Once you have enough information, share the problem card with your partner, and solve the problem independently.
5. Read the data card, and discuss your reasoning.

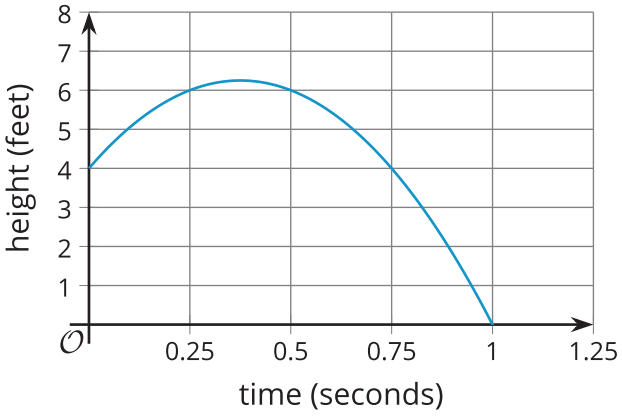
If your teacher gives you the data card:

1. Silently read your card. Wait for your partner to ask for information.
2. Before telling your partner any information, ask, "Why do you need to know _____?"
3. Listen to your partner's reasoning and ask clarifying questions. Give only the information that is on your card. Do not figure out anything for your partner! These steps may be repeated.
4. Once your partner has enough information to solve the problem, read the problem card, and solve the problem independently.
5. Share the data card, and discuss your reasoning.

Pause here so your teacher can review your work. Ask your teacher for a new set of cards, and repeat the activity, trading roles with your partner.

Lesson 14 Summary

Let's say that a tennis ball is hit straight up into the air, and its height, in feet, above the ground is modeled by the equation $f(t) = 4 + 12t - 16t^2$, where t represents the time, in seconds, after the ball is hit. Here is a graph that represents the function, from the time the tennis ball was hit until the time it reached the ground.



In the graph, we can see some information we already know, and some new information:

- The 4 in the equation means the graph of the function intersects the vertical axis at 4. It shows that the tennis ball was 4 feet off the ground at $t = 0$, when it was hit.
- The horizontal intercept is $(1, 0)$. It tells us that the tennis ball hit the ground 1 second after it was hit.
- The vertex of the graph is at approximately $(0.4, 6.3)$. This means that about 0.4 second after the ball was hit, it reached the maximum height of about 6.3 feet.

The equation can be written in factored form as $f(t) = (-16t - 4)(t - 1)$. From this form, we can see that the zeros of the function are $t = 1$ and $t = -\frac{1}{4}$. The negative zero, $-\frac{1}{4}$, is not meaningful in this situation, because the time before the ball was hit is irrelevant.