Using a Quadratic Function to Model Vertical Motion

HABITS OF MIND
- Model with mathematics.
- Use appropriate tools strategically.

You can model the motion of a pumpkin released from a catapult using a vertical motion model. A **vertical motion model** is a quadratic equation that models the height of an object at a given time.

› Consider the equation for a vertical motion model.

$$y = -16t^2 + v_0 t + h_0$$

In this equation, y represents the height of the object in feet, t represents the time in seconds that the object has been moving, v_0 represents the initial vertical velocity (speed) of the object in feet per second, and h_0 represents the initial height of the object in feet.

1 Which characteristics of this situation indicate that you can model it using a quadratic function?

Suppose that a catapult hurls a pumpkin from a height of 68 feet at an initial vertical velocity of 128 feet per second.

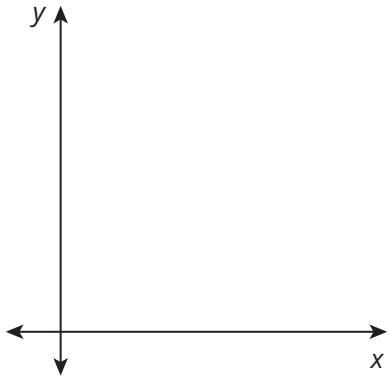
2 Write a function for the height of the pumpkin, $h(t)$, in terms of time, t.

3 Does the function you wrote have a minimum or maximum? **How can you tell from the form of the function?**

4 Use technology to graph the function. Sketch your graph and label the axes.

ASK YOURSELF...
What do all the points on this graph represent?

Punkin' Chunkin'



5 Use technology to determine the maximum or minimum point and label it on the graph. **Explain what it means in terms of the problem situation.**

6 Determine the *y*-intercept and label it on the graph. **Explain what it means in terms of the problem situation.**

7 Use a horizontal line to determine when the pumpkin reaches each height after being catapulted. Label the points on the graph.

(a) 128 feet

(b) 260 feet

(c) 55 feet

8 Explain why the *x*- and *y*-coordinates of the points where the graph and each horizontal line intersects are solutions.

9 When does the catapulted pumpkin hit the ground? Label this point on the graph. **Explain how you determined your answer.**

The time when the pumpkin hits the ground is one of the *x*-intercepts, (*x*, 0). When you use an equation to model a situation, you refer to the *x*-coordinate of the *x*-intercept as the *root*. The **root** of an equation indicates where the graph of the equation crosses the *x*-axis.

REMEMBER...

The zeros of a function are the *x*-values when the function equals 0.