ACTIVITY 3

Using a Quadratic Function to Model Vertical Motion

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.

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**ASK YOURSELF...**

What do all the points on this graph represent?
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.