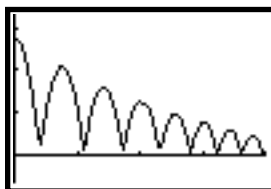


TASK 3.1.1: BALL DROP**Solutions**

- Using a graphing calculator and a data collection device, run a bouncing ball program (see technology notes). Sketch the graph of the height of the ball against time below.

Sample Data:

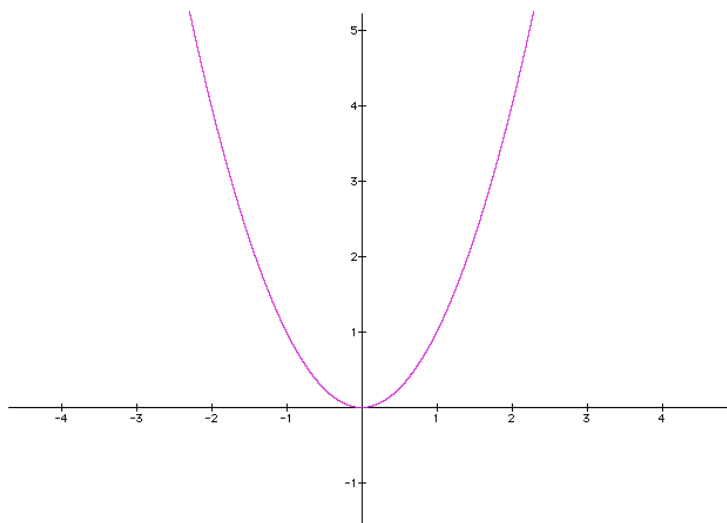


- Choose one of the parabolas and use the trace feature of the calculator to find the coordinates of the maximum point.

Answers will vary according to data.

- Use your knowledge of parabolas and transformations of functions to find the function rule of the parabola chosen in question 2. Enter the function into the graphing calculator to view the graph compared to the scatter plot in order to check your work.

- What is the parent function for one of the bounces? $y = x^2$
- What does the graph of the parent function look like?



- What is the first difference, or transformation, you see between the parent and the bounce? *The bounce is upside-down, or reflected across the y-axis.*

Algebra II: Strand 3. Quadratic Functions; Topic 1. Uncovering Quadratics; Task 3.1.1

- How can we write the function rule of such a parabola? $y = -x^2$
- What do the coordinates of the maximum of the bounce tell us? *It tells us the vertical and horizontal shift.*
- Apply the shifts given by the maximum. *Say our maximum is at (1.649, 2.377). Then our rule would be $y = -(x - 1.649)^2 + 2.377$.*
- Graph the function above together with the scatter plot. How does it fit? *From here participants will need to adjust the opening of the parabola. This is done by multiplying the squared term, $-(x - 1.649)^2$ by a scalar. Ask participants to guess and check until they find a nice fit.*
- The scalar that participants find should be -16 if the data were measured in feet and -4.9 if the measurement were done in meters. Why do these numbers “show up?” *Remind participants of the position equation from physics where $d = \frac{1}{2}at^2 + v_0t + d_0$, a is the acceleration due to gravity, v_0 is the initial velocity, and d_0 is the initial height, d is the height at time, t .*
- What is the acceleration due to gravity measured in feet? *a is -32 feet per second².*
- What is the acceleration due to gravity measured in meters? *a is -9.8 feet per second².*

Note that the scalar value that participants found agrees with the theoretical

coefficient of x^2 in the position equation, $-\frac{1}{2}a = -\left(\frac{1}{2}\right)32\frac{\text{ft}}{\text{sec}^2} = -16\frac{\text{ft}}{\text{sec}^2}$,

$$-\frac{1}{2}a = -\left(\frac{1}{2}\right)9.8\frac{\text{m}}{\text{sec}^2} = -4.9\frac{\text{m}}{\text{sec}^2}.$$

Math notes

Make certain that the participants understand that the graph is of the height of the ball with respect to time, not the path of the ball.

Teaching notes

It may be a good idea to come to class with some “good” data from a previous ball drop experiment stored in your calculator, so you have a backup to use.

Some participants may choose to find the intercepts of the bounce as well as the coordinates of the maximum. With these three points, they can solve a system of three unknowns (A, B, and C) in the general quadratic $y = Ax^2 + Bx + C$. This is mathematically correct and a good practice for solving systems of equations. In this module, however, the main purpose of the activity is as an illustration of the use of transformations. Another approach is a blend of the two mentioned here. A group could use the vertex coordinates and apply horizontal and vertical shifts, then use another coordinate to find the scalar parameter algebraically instead of using guess and check.

After participants find their function rule, take some time for the groups to share their approaches and discuss the merits of each.

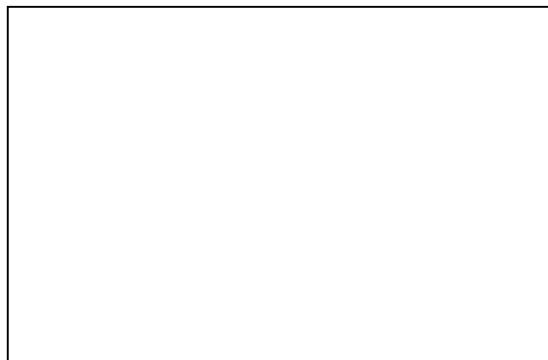
Technology notes:

To run the Ball Bounce program:

1. From the home screen, press the APPS button on your calculator.
2. Using the down arrow button, select 2: CBL/CBR and press ENTER twice.
3. Using the down arrow button, select 3: Ranger and press ENTER twice.
4. From the MAIN MENU, use the down arrow to select 3:APPLICATIONS.
Select 2: FEET, then select 3: BALL BOUNCE.
5. Follow the directions on the screen.

TASK 3.1.1: BALL DROP

1. Using a graphing calculator and a data collection device, run a bouncing ball program. Sketch the graph of the height of the ball against time below.



2. Choose one of the parabolas and use the trace feature of the calculator to find the coordinates of the maximum point.

(____, ____)
3. Use your knowledge of parabolas and transformations of functions to find the function rule of the parabola chosen in question 2. Enter the function into the graphing calculator to view the graph compared to the scatter plot in order to check your work.