**Objectives**

* Record height vs time for a bouncing ball
* Model a single bounce with both the general and vertex forms of the parabola.

**Materials**

* TI-Nspire handheld or computer and TI-Nspire software
* CBR 2 or Motion Detector & data-collection interface ball (Racquetball or Basketball size)

**Procedure**

1. Switch the switch on your Motion Detector to “Normal,” note: not all motion detectors have this feature, if yours does not it is okay. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire.
	1. If using a CBR 2 you do not need a data-collection interface
2. Place the Motion Detector about 3 feet (1.5 meters) from the floor. The disc should be pointing downward.
3. Select “New Experiment” from the “Experiment” menu. The default settings for the data-collection parameters for the Motion Detector will be what we use for this experiment. Double check to be sure default settings are correct though, Rate: 20 samples per second and Duration: 5 seconds. The total number of points collected should be 101.
4. DataQuest has to be set up so that positions above the floor will be considered positive. Select “Set Up Sensors,” in the “Experiment Menu” select “Zero.” Then choose “Set Up Sensors,” “Experiment Menu,” “Reverse.”
5. Press the “Graph View” button. Select “Show Graph,” “Graph 1.” The screen should show the Positions vs Time Graph.
6. Drop the ball a few more times, keeping the ball traveling straight up and down as much as possible. Be sure the ball never gets closer than about 520 inches (15 cm). Keep your hands away from the ball once you have dropped the ball so that the Motion Detector does not accidently record your movement as the balls.
7. Start data collection.
8. When all the data has been collected, make a graph of position vs. time. Examine the graph, there should be a series of parabolic regions.

**Data Table**

|  |
| --- |
| Vertex |
| X-Coordinate | Y-Coordinate |
|  |  |

|  |  |  |
| --- | --- | --- |
|  | Values calculated from vertex form | Values from regression |
| a |  |  |
| b |  |  |
| c |  |  |

**Analysis**

1. Select the data matching to the ball’s position between two bounces.
	1. Select one parabolic part of the data.
	2. Choose “Strike Data,” “Outside Selected Region” from the Data menu. DataQuest will remove the data for you that is outside your region you chose. A new graph will now be displayed with just the portion of the parabolic region you selected. Choose “Autoscale Now” from the Graph Menu to help see the graph better.
2. Click on any data point and use the left and right cursor arrows to trace across the graph to find the x and y coordinates of the vertex of the parabola. Record the coordinates in the first data table.
	1. Answer Analysis Question #
3. Now use your data to fit the form for a quadratic model, $y=a(x-h)^{2}+k$. You already have the values for the parameters h and k. Try plotting the model by using a guess for your a. You will first need to enter your equation to be graphed.
	1. Insert Graphs page
	2. Insert the Sensor Console to input the graph from DataQuest. Make sure your data shows up before closing the Sensor Console.
	3. Select “Zoom,” so that you can see all your data.
	4. Select “Function” from the “Graph Type” menu.
	5. Enter in your equation in the “Entry Line.” Start with putting in 1 as the initial parameter

$f1\left(x\right)=a(x-h)^{2}=+k$

* 1. Play with the parabola to find the best values for a, h, and k. Drag the ‘arms’ to change the parabola’s curve and direction.
	2. When you have found the best values for a, h, and k, plug those values back into your equation and record your equation for Analysis Question 2.
1. The standard form for a quadratic is $y=ax^{2}+bx+c$. The coefficient a is the same as the a you just found for the vertex form, and b and c are related to h and k that you also already found. To determine what b and c are, expand the vertex form and find the like terms. Record the values of a, b, and c in the middle column of the second data table.
2. You can also find the parameters using DataQuest and performing a quadratic regression on the data to find the best-fitting parabola for your data.
	1. Go to your DataQuest page.
	2. Select “Curve Fit,” “Quadratic Form.”
	3. Record the a, b, and c in the third column of your second data table.
	4. Select “Ok.” Then answer Analysis Questions 3-5.

**Analysis Questions**

1. The ball bounced straight up and down under the detector, but the plot you are seeing might seem that the ball is moving sideways as it bounced up and down. Explain why the graph looks the way it does.
2. Record your vertex form of your parabola. (Analysis 3)
3. Are the values of a, b, and c in the quadratic equation consistent with the values you found in Analysis 4?
4. Describe how the parameter a effects the graph $y=a(x-h)^{2}+k$. How does the magnitude of a an the sign of a change the graph?
5. Now suppose that you chose the parabolic section just to the right of the one you actually chose. Describe how h and k would change if this new section was to fit with the equation $y=a(x-h)^{2}+k$.