Falling Object Lab

(adapted from Texas Instruments Inc.)

Quadratic Functions

Objectives: Model a quadratic function. Graph height as a function of time.
Students will find appropriate values for A, H, and K in the vertex form of a quadratic function: $Y = A(X - H)^2 + K$ given its graph

Materials: Ball (Racquetball or basketball work well).
TI-83 Plus or TI-84 Plus graphing calculator
CBR 2 motion detector
Easy Data Application

Procedure:

1. Set up Motion Detector and calculator.
   - Connect your calculator to the CBR2 and turn it (your calculator) on.
   - Start the EasyData application, if it is not already running.
   - Select FILE from main screen and then select **New** to reset the application.
   - Press Setup (WINDOW), then 1: Dist. Change units to feet be pressing Units (ZOOM), then 2: (ft). Press OK (GRAPH)
   - Under the Setup menu, press 4: Ball Bounce
   - Open pivoting head to the CBR 2. (Set sensitivity to normal)

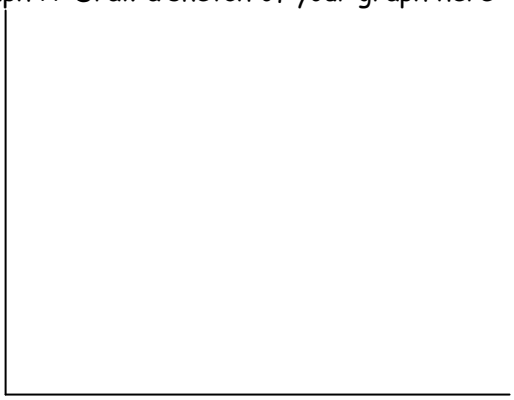
2. Position CBR 2 about 4.5 - 5 feet above the floor, so the disc is pointing straight downward.

3. To expedite the data collection use three students; one to release the ball, one to hold the CBR 2 on the release the ball, and one to run the calculator.

4. Practice dropping the ball so that it bounces straight up and down beneath the CBR 2. Minimize the ball's sideways travel. Dropping the ball from 1 foot under the CBR2 (no closer) works well. Pull your hands away from the ball so the CBR 2 does not detect your hands.

6. Select START to begin data collection. Follow the instruction on your screen for the Ball Bounce activity to collect data.

7. When the data collection is complete, a graph of height versus time plot will be displayed. Examine the graph; Does any piece look familiar? The graph should contain a series of parabolic arches.
   (If necessary, to repeat the data collection, select MAIN to return to the main screen and repeat step 6.)
   Graph A: Draw a sketch of your graph here:



Analysis:

The height vs. time plot of one bounce forms a parabola. The equation that describes this motion is quadratic: $Y = A(X - H)^2 + K$, where A affects the width of the parabola and (H, K) is the vertex of the parabola.

1. The plot is in TRACE mode. Trace along the plot to find the vertex of the first parabolic arch. Record the maximum height of your parabola : _____
   Record the corresponding time of this height: _____
   Graph B: Draw a sketch of the height of the ball during the first full bounce (with the above vertex) here:

2. Select MAIN to return to the main screen. Choose QUIT and then select OK to quit EasyData.

3. In the Y= menu, enter the vertex form of the quadratic function for Y_1, as follows
   $Y_1 = A(X - H)\text{^}2 + K$ (You need to type it in WITH the A, X, H, and K as shown.)

4. On the Home Screen, store the value of your height in variable K; store the corresponding time in variable H; store 1 in variable A.

   For example, to store the value 4 into the variable K, Press
   4 STO> ALPHA K ENTER; (stores the number 4 into the variable K)
   2.5 STO> ALPHA H ENTER (stores the number 2.5 into the variable H)
   1 STO> ALPHA A ENTER; (stores the number 1 into the variable A).

5. Press GRAPH to display the graph.
   Graph C: Draw a sketch of the graph here:

6. Try A = 2, 0, -1. Complete the chart on the student worksheet question # 7.

7. Choose a value of your own for A until it is a good match with Graph B.

Name(s) _____

Student Worksheet

Objectives: Write a model for a quadratic function, given its graph. Graph height as a function of time.

Materials: Ball (Racquetball or basketball work well) CBR 2 motion detector
TI-83 Plus or TI-84 Plus graphing calculator Easy Data Application

Questions:

The Distance-Time plot of one bounce forms a parabola. The equation that describes this motion is quadratic: $y = A(x - H)^2 + K$ where *A* affects the width of the parabola and (H,K) is the vertex of the parabola.

1. Which variable, distance or time, is the independent variable? _____

2. Which variable, distance or time, is the dependent variable? _____

3. Explain in your own words what the plot shows.

4. What does H represent for this activity?

5. What does K represent for this activity?

6. What were the values of H and K for your vertex of your ball bounce?

7. Complete the chart below. In addition to the values given, choose 3 of your own values for A.

A	How does this graph compare to the original data plot ?
1	
2	
0	
-1	

8. What effect do the following values for **A** have on the parabola?

Positive?: _____

Negative?: _____

Zero? :_____

Increasing?: _____

Decreasing?: _____

9. Did A=1 match your plot for your parabolic bounce? Why or why not?

10. What was the value of A that best fit your parabolic ball bounce?