Acceleration due to Gravity

Using a Vernier motion detector, we will drop three objects to observer the acceleration due to gravity.

Materials (per group):

- One Baseball
- One Book
- One Piece of Paper
- TI-Nspire
- Motion Detector

Procedure:

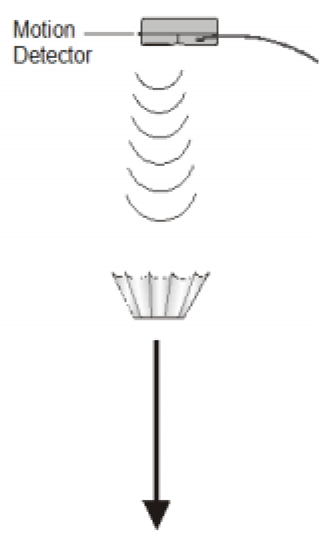
1. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire.

2. Position the Motion Detector about 1.5 m above the floor, so that the disc is pointing straight downward.

3. Choose New Experiment from the Experiment menu. For this experiment, the default data-collection parameters for a Motion Detector will be used (Rate: 20 samples per second; Duration: 5 seconds). The number of points collected should be 101.

4. DataQuest needs to be set up so positions above the floor will be read as positive Position. That is, the Motion Detector will read distance above the floor. Choose Set Up Sensors ► Zero from the Experiment menu. Then choose Set Up Sensors ► Reverse from the Experiment menu.

5. Click the Graph View tab ( ). Choose Show Graph ► Graph 1 from the Graph menu. Only the Position vs. Time Graph will be displayed.



6. Practice dropping the objects so that they fall straight down beneath the Motion Detector and be certain to minimize the sideways travel. Dropping the object from about waist high works well. The object must never get closer than 15 cm from the detector. **Be sure to pull your hands away from the object after you drop it so the Motion Detector does not detect your hands.**

7. Start data collection.

8. When data collection is complete, a graph of position versus time will be displayed. Examine the graph; it should contain a series of parabolic regions. Check with your teacher if you are not sure whether you need to repeat the data collection.

Analysis of Data:

After completing the activity, you may have noticed that the graph resembles a series of parabolas. This means that the equation of any singular parabola can be calculated using the quadratic:

$$Y=ax^2 + bx + c$$

However, for our analysis, we will use the *Vertex Form:*

$$Y=a(x - h)^2 + k$$

Where **h** is the x-coordinate of the vertex, **k** is the y-coordinate of the vertex, and **a** is the parameter.

Select one of the parabolas and answer the following questions.

Object 1:_____________________________

Vertex	
x-coordinate	*y*-coordinate

	Values calculated from vertex form	Values from regression
a		
b		
c		

1) Select the data corresponding to the object's position from when it is released to when it hits the floor the first time. That is, select just one parabolic portion of the data if there are multiple.

a) Choose Strike Data ► Outside Selected Region from the Data menu. DataQuest will remove data outside the region you just marked. A new graph showing only the parabolic portion of the data will be displayed. Choose Autoscale Now from the Graph menu.

2) Click any data point and use ► and ◄ to trace across the graph to determine the x- and y coordinates of the vertex of the parabola (also known as the maximum point on the curve). Record them in the first data table.

3) Now, fit the vertex form of the quadratic y = a(x – h)2 + k to your data. Since you have values for **h** and **k**, you can try plotting the model using a guess for the **a** parameter. First, enter your model equation for graphing.

a) Insert a Graphs page.

b) Insert the Sensor Console in order to input the graph from DataQuest. Verify that your data appears and then close the Sensor Console.

c) Choose "Zoom – Data" from the Window/Zoom menu to view all of your data.

d) Choose "Function" from the Graph Type menu.

e) Enter your model equation into the Entry Line, replacing **h** and **k** with the values you found earlier. Enter "1" as the initial value for the parameter **a**.

f1(x) = a*(x-h)^2+k

f) Experiment with moving the parabola to find the best values for **a, h** and **k.** This is done by grasping the parabola to translate and dragging the "arms". When you have found the best value for parameter **a**, use your optimized value for **a** and the values of **h** and **k** you determined earlier to complete the vertex form.

4. Repeat the steps above to check the other objects using the data tables below.

Object 2: ___________________________

Vertex	
x-coordinate	*y*-coordinate

	Values calculated from vertex form	Values from regression
a		
b		
c		

Object 3: ___________________________

Vertex	
x-coordinate	*y*-coordinate

	Values calculated from vertex form	Values from regression
a		
b		
c		

Follow Up Questions:

1) Were there any of the objects that didn't act like the others when falling?

2) If we were to exclude any objects that didn't fall in a uniform pattern like the others, what would your estimate be for the acceleration due to gravity?

3) What do you think is the reason why not all of the objects had the same acceleration due to gravity?