Activity 10 - Bouncing Ball

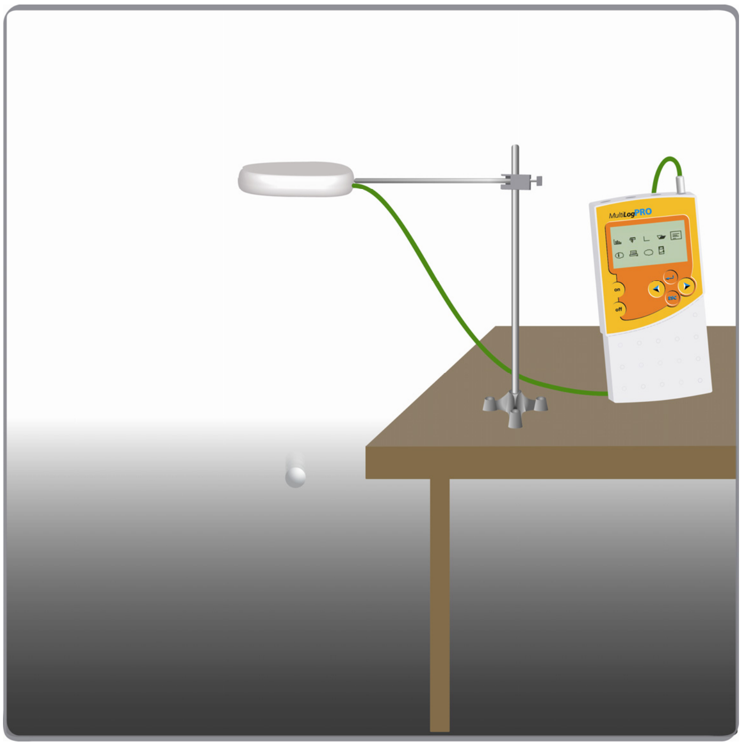

Figure 10-1

Introduction

In this activity you will use the Distance sensor to record Position vs. time data of a ball bouncing on the floor. You will then concentrate on one bounce and analyze the graph in order to formulate the standard quadratic presentation of the graph.

The position (height) of the ball is a quadratic function of the time. The standard form of a quadratic function is:

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

Where x represents the time and y stands for the ball's position and a, h, and k are the parameters of the motion, determined by the incline slope, and by the initial position and initial velocity of the cart. These parameters can also be derived from the Position vs. time graph. The graph is a parabola and the coordinates of its vertex are (h,k).

The quadratic function can also be written as:

(2) $$y = ax^2 + bx + c$$

Equipment

- MultiLogPRO, Nova or TriLink data logger
- Distance sensor
- Table tennis ball or basketball
- Table stand with rod, right angle clamp and rod

Equipment Setup Procedure

1. Assemble the equipment as shown in Figure 2-1.
2. Turn on the data logger
3. Connect the Distance sensor to input 1 (I/O-1) of the data logger
4. Connect the data logger to the computer
5. Run MultiLab
6. Click **Setup wizard** on the upper toolbar and program the data logger according to the specifications below

Data Logger Setup

Sensors:

Input 1: Distance

Properties : measurement: check **Distance (Incoming)**
uncheck **Distance (Outgoing)**

Rate:

25 samples per second

Recording time:

20s (500 samples)

Experimental Procedure

When collecting motion data we should first set the positive direction of motion and the origin of our coordinate system. The data logger was already programmed (see data logger setup above) to consider motion toward the sensor (incoming) as positive. To set the origin, use the Set Zero tool.

Set the current readings to zero

1. Make sure that nothing stands between the Distance sensor and the floor
2. Click **Setup wizard** on the upper toolbar
3. Click **Properties** next to *input 1: Distance*, then click the **Set Zero** tab
4. Check the **Set the current reading to zero** check box, then click **OK**
5. Click **Finish**

MultiLab sets the floor level to zero for all subsequent data recordings

Collect the data

1. Hold the ball half a meter beneath the Distance sensor
2. Click **Run** on the upper toolbar to begin recording data
3. Release the ball
4. When logging ends save your data by clicking **Save** on the upper toolbar

Data Table

Quantity	**value**
Vertex (h,k)	
y axis intercept $(0,y_3)$	
Parameter a	
Parameter b	

Parameter c	
Model equation	
Manual curve fit equation (standard form)	
Manual curve fit equation (general form)	

Data Analysis

Trim unwanted data

Trim any unwanted data keeping only a part that describes one "smooth" bounce:

1. Click **Toggle first cursor** on the graph toolbar to display a cursor on the graph. Drag it to the point where the chosen bounce starts

2. Click **Toggle second cursor** on the graph toolbar to display a second cursor on the graph. Drag it to the point where the chosen bounce ends

3. Click **Graph** on the menu bar, then click **Crop**

4. Click **Add graph to project** on the graph toolbar to preserve the current graph, then click **Save**

> **Note**: Notice that a new graph icon has been added to the **Data Map** under the graph category

Modeling the graph

1. Click **Toggle first cursor** on the graph toolbar to display a cursor on the graph. Drag it to the parabola's vertex and record the point coordinates in your data table

> **Note:** The point coordinates appear in the information bar at the bottom of the graph window.

2. Drag the cursor to the y-intercept and record the coordinates in your data table

3. Calculate the parameter a

4. Use equations (1) and (2) to calculate the parameters b, and c

5. Write down the model equation in your data table

Plotting the model function on the graph

1. Click **Analysis wizard** on the main toolbar, then click the **Functions** tab

2. Select **Linear** in the **Functions** drop list

3. Select **Cropped data: Time** in the **G1** drop list

4. Enter the corresponding values from your data table into **A, B** and **C** edit boxes

5. Check the **Synchronize scale with** check box and select **Cropped data: Exp. # - Distance** in the drop list

6. Type **m** in the **Unit** edit box

7. Click **OK**

8. Click **Add graph to project** on the graph toolbar to preserve the current graph, then click **Save**

Find the best fit function by trial and error

You can also use MultiLab's manual curve fit tool to find the best line fit to your data by trial and error

1. Click **Analysis** on the menu bar, then click **Manual curve fit** to open a dialog

2. Select **Time** in the X-axis list by clicking on it

3. Select **Cropped data: Exp. #- Distance (incoming) I/O-1** in the Y-axis list by clicking on it

4. Click **OK**

Select the Quadratic fit type by clicking on it

5. Change the x-axis units to seconds:

   - Click **Properties** on the graph toolbar, then click the **Unit** tab
   - Select **Second** in the **Prefix** options

6. Use the sliders to fit the line to your data. Notice the effect of each slider both on the fit equation and on the fit graph

7. The fit equation appears at the bottom of the fit window. Record it in your data table.

8. Click **Add fit to Project** on the manual curve fit window to add the resulting fit to the data map and exit the manual curve fit mode

9. Save your data by clicking **Save** on the upper toolbar

Questions

1. Is the quadratic model a good model for formulating the motion of the bouncing ball?

2. Compare the two modeling methods you used.