***DevilPhysics***

***AP Physics / IB Physics***

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Period: \_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Baddest Class on Campus***

**AP Acceleration Due to Gravity**

***In this activity you will determine the time of fall of a tennis ball and groups of coffee filters dropped from a known height in order to calculate the ball’s acceleration.***

**State a Hypothesis**

On the lines below, write a hypothesis of what you think will happen. Include in your hypothesis what you think the rate of fall will be, what could possibly hinder the object’s rate of fall, expected differences in the rate of fall of the different objects, and any outside factors that could possibly influence your data.

**Materials:**

|  |  |  |  |
| --- | --- | --- | --- |
| * 5 people | * Tape measure | * Tennis ball | * Protective goggles |
| * Clipboard | * Pen or pencil | * Stopwatch | * Closed-toed shoes |
| * 19 coffee filters |  |  |  |

**Procedure:**

1. Assign Duties to Team Members:
   1. Ball Dropper (tennis ball)
   2. 2 X Ball Catchers/ Retrievers (protective goggles, closed-toed shoes)
   3. Timer (stopwatch)
   4. Recorder (clipboard, pen/pencil, lab sheet)
   5. *If your team only has 4 members, the duties of Timer and Recorder can be combined.*
2. Using the tape measure, determine the height of the drop zone by measuring the distance from the planned drop point to the ground.

Vertical height of drop zone = m

1. Timer announces “Ready” to Ball Dropper.
2. Ball Dropper announces “Ready” to Timer.
3. Timer announces “Drop” while simultaneously starting stopwatch.
4. Ball Dropper releases tennis ball at the release point used in the vertical distance measurement.
5. Timer stops the stopwatch when the ball hits the ground.
6. Timer gives the elapsed time to the Recorder who records the time in the table below.
7. Ball Catcher catches the ball after the first bounce and throws it back to the ball dropper. Coffee filters will have to be carried back to the top by the Retriever. Alternate positions to minimize fatigue.
8. Repeat for a total of 5 trials and then do the same thing for 3 coffee filters together, 6 coffee filters together, and 10 coffee filters together. To save time going up and down stairs, do 1 trial for each item before starting the next trial.
9. At the completion of 5 trials, all team members must copy the times onto their own lab sheets. Processing of data will be done individually

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Time (s)** | | | |
|  | Tennis Ball | 3 Coffee Filters | 6 Coffee Filters | 10 Coffee Filters |
| **Trial 1** |  |  |  |  |
| **Trial 2** |  |  |  |  |
| **Trial 3** |  |  |  |  |
| **Trial 4** |  |  |  |  |
| **Trial 5** |  |  |  |  |

**Processing Data (This is to be done individually):**

**Part 1 -- Acceleration Due to Gravity:**

1. Compute an average time of fall for each item and put in the table below.
2. Derive an equation for acceleration. Be sure to show all work and include units.

1. Calculate an experimental value for the acceleration due to gravity from your data for each item using the average you just computed. Write it in the table below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tennis Ball | 3 Coffee Filters | 6 Coffee Filters | 10 Coffee Filters |
| Average Time |  |  |  |  |
| Acceleration |  |  |  |  |

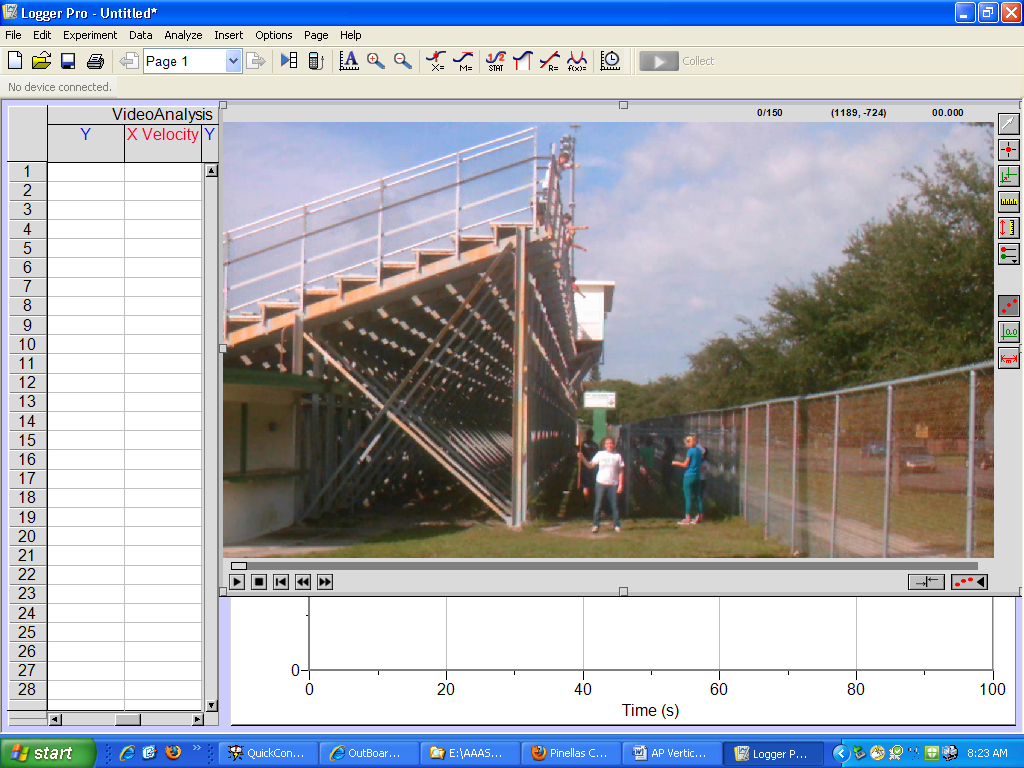
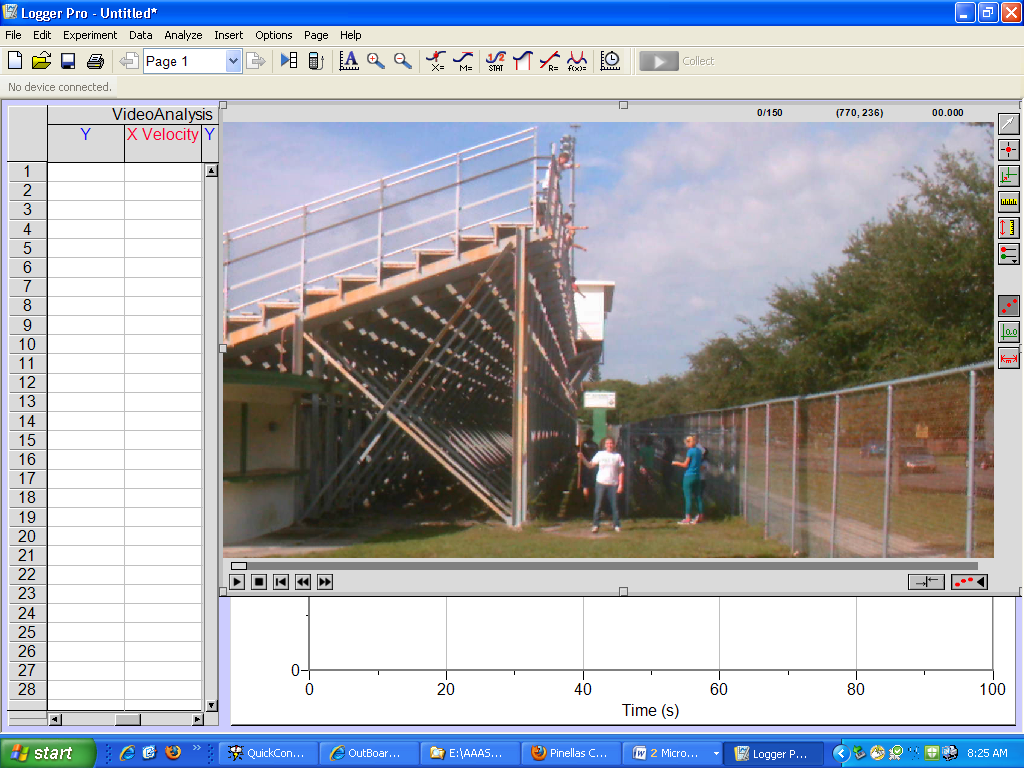
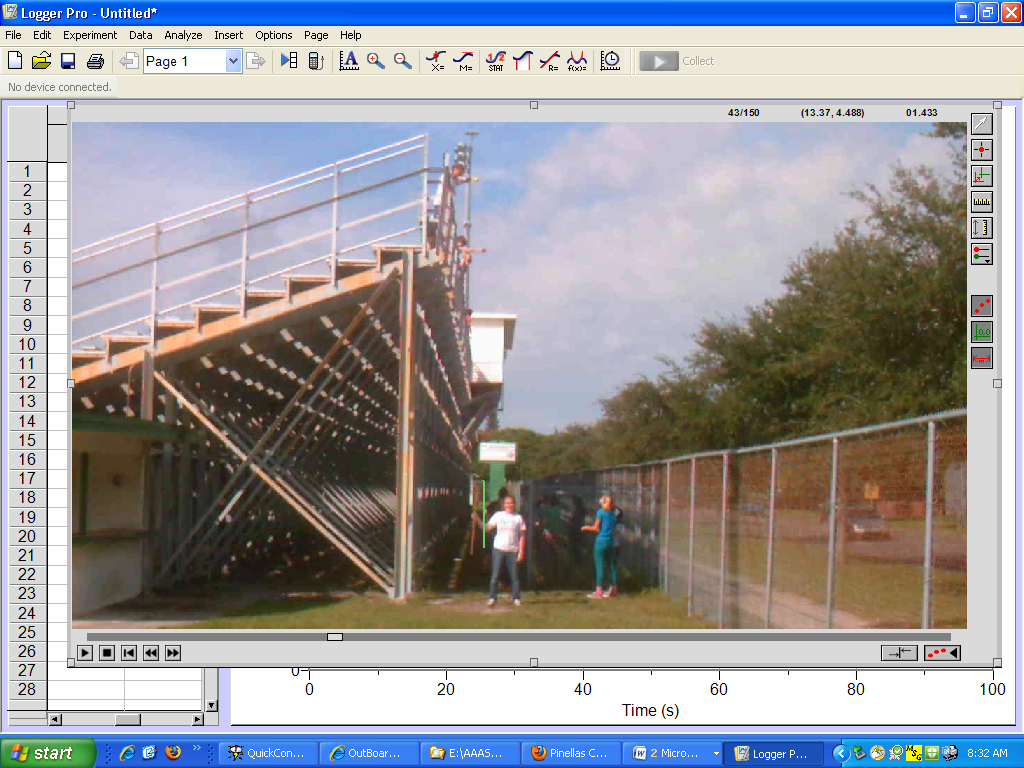
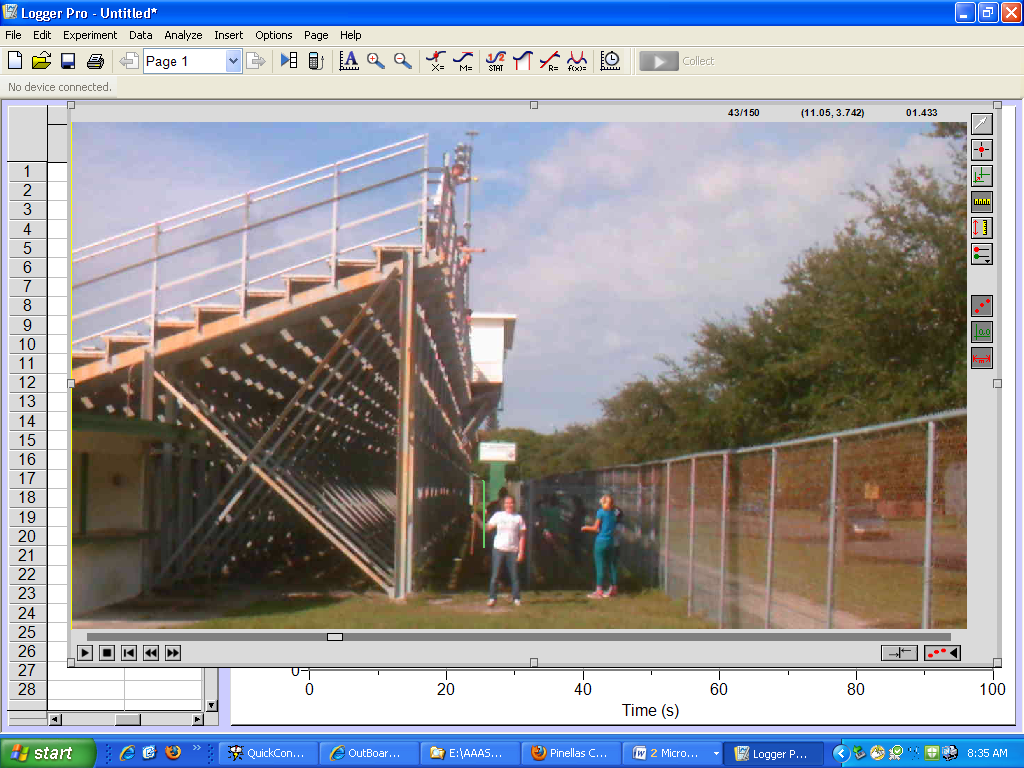
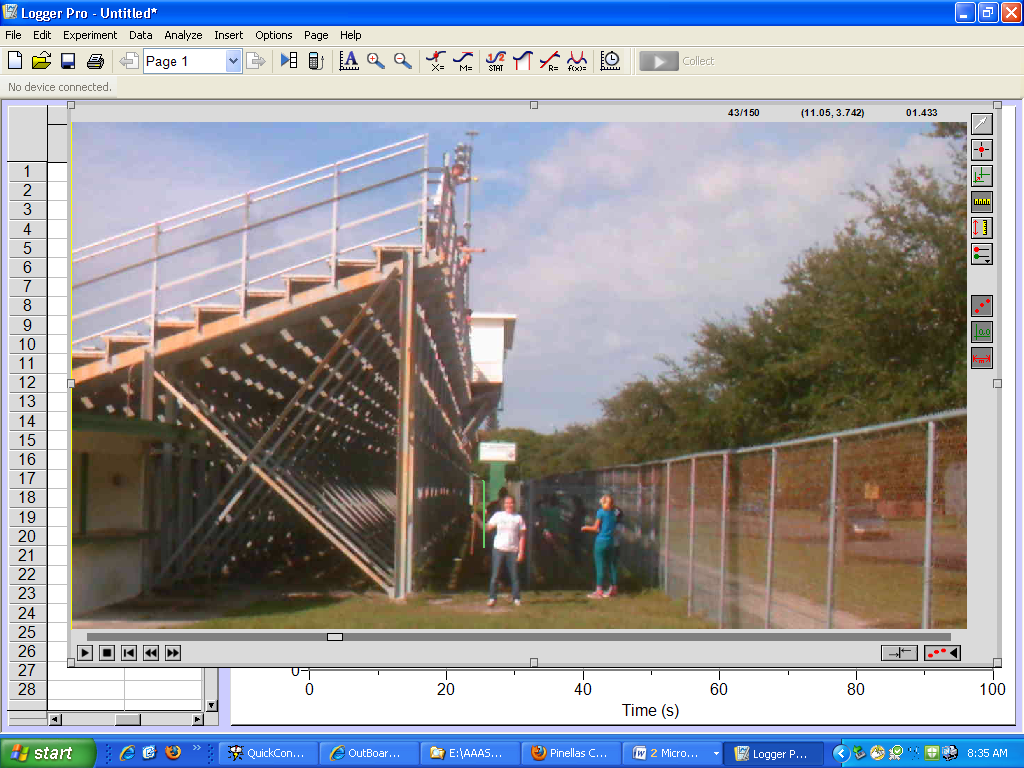
1. Using the known value of g = 9.81 m/s2, calculate the percent error of each experimental value calculated above.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tennis Ball | 3 Coffee Filters | 6 Coffee Filters | 10 Coffee Filters |
| Acceleration |  |  |  |  |
| Percent Error |  |  |  |  |

1. For the tennis ball, what do you think was the major contributing factor for the difference between your experimental value for g and the published value?

1. Why do you think the coffee filters fell slower than the tennis ball?

**Part 2 -- Obtaining Data from Video:**

1. Download the video assigned to your group from the class website to your memory stick and to your server folder (R2D2 folder).
2. Open Logger Pro 3.8.2 on your netbook. ***(Note: If you would like a copy of Logger Pro 3.8.2 to install on your computer at home, see Mr. Smith with a memory stick)***
3. Click on “Insert” at the top, and then “Movie” in the dropdown menu.
   1. Find the video assigned to your group on your memory stick.
   2. Move and size the video so that the entire frame is visible, but as large as possible.
4. Click on the “Enable/Disable video analysis” icon .
5. Click on the “Set Scale” icon .
   1. Use the crosshairs of your cursor to drag a line from the top to the bottom of the meter stick held by our lovely Devil Physics spokesmodel.
   2. When the popup menu appears, make sure it says 1 meter and click Ok.
   3. You have now calibrated the video in terms of distance.
   4. Ensure the three icons to the right are toggled on.
6. Toggle the “Add Point” icon .
   1. Hit the play button until the object is dropped and then stop it. Back the video up to the point just before it is released by using the  buttons.
   2. Click on the initial point by moving the cursor crosshairs over the object and left clicking. When you do this, the movie will advance one frame. Continue to add points for each frame. You should have a trail of points showing.
7. When you have marked all your points, make the movie smaller and click on the graph. The movie will move behind the graph.
8. Right click on the graph and select “Copy”. Open a Word document or this lab handout and hit Ctrl-V to insert the graph. Insert the graph below for your final report.

***INSERT LOGGER PRO GRAPH HERE***

1. Click on the data table. Drag the right edge of the table to the right so that all the data columns are visible. While holding down the SHIFT key, click on the headings for each column. This should highlight all of your data. Now hit Ctrl-C. This copies the highlighted data to your clipboard.
2. Open an Excel document.
   1. Right click on the cell where you want to insert your data. Click on “Paste”.
   2. While all the data is still highlighted, switch “General” to “Number” at the top and set the number of decimal places to 4.
   3. Type in appropriate column headings.
   4. Save the Excel file to your memory stick before you forget.

**Obtaining Data from Video:**

1. In your Excel data table, delete the information for X-Distance and X-Velocity since we aren’t concerned with it.
2. Use your data to create a graph of velocity vs. time. The graph should be a scatter plot with a linear line of best fit and an equation for that line of best fit. In order to make the data more visible, change the start of your x-axis from “0” to a time just before the drop. Massage the other aspects of the graph to give the best picture. Remember to include labels and headings. Paste the graph below.

***INSERT EXCEL VELOCITY VS. TIME GRAPH HERE***

1. What was the object in your video, tennis ball or coffee filter?
2. From the video analysis data, what do you notice about the rate of increase of the velocity?
3. Add a column to your Excel spreadsheet to compute an instantaneous acceleration. Remember that acceleration is the change in velocity divided by the change in time. At the bottom of the table, compute an average acceleration using final velocity minus initial velocity divided by final time minus initial time. The example below should help.
4. Paste a copy of your complete data table below. Remember to include headings with units (which are not in the example).

***EXAMPLE EXCEL DATA TABLE***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **A** | **B** | **C** | **D** |
| **1** | **Time** | **Y-Dist** | **Y-Velocity** | **Acceleration (Δv/Δt)** |
| **2** | 1.4333 | 6.8608 | -0.7400 |  |
| **3** | 1.5667 | 6.7862 | -0.9908 | **=(C3-C2)/(A3-A2)** |
| **4** | 1.6333 | 6.6967 | -1.4853 | -7.4183 |
|  |  |  |  |  |
| **32** |  |  | **Average** | **=(C32-C2)/(A32-A2)** |

***INSERT EXCEL DATA TABLE HERE***

1. Use your data to create a graph of acceleration vs. time. The graph should be a scatter plot with a linear line of best fit and an equation for that line of best fit. In order to make the data more visible, change the start of your x-axis from “0” to a time just before the drop. Massage the other aspects of the graph to give the best picture. Remember to include labels and headings. Paste the graph below.

***INSERT EXCEL ACCELERATION VS. TIME GRAPH HERE***

1. From the video analysis data, what do you notice about the acceleration of your object?
2. What aspects of the video analysis process may have contributed to erratic data for velocity and, in turn, acceleration?

***One More Page – Turn Over***

**Conclusions:**

1. What general conclusions can you make from this lab?

1. Discuss any outside factors that may have affected your data and how they might have influenced your calculation for “g” (higher or lower than actual).

1. How would you change this experiment to improve the accuracy of the data?