Acceleration and Freefall

Procedure

Overview

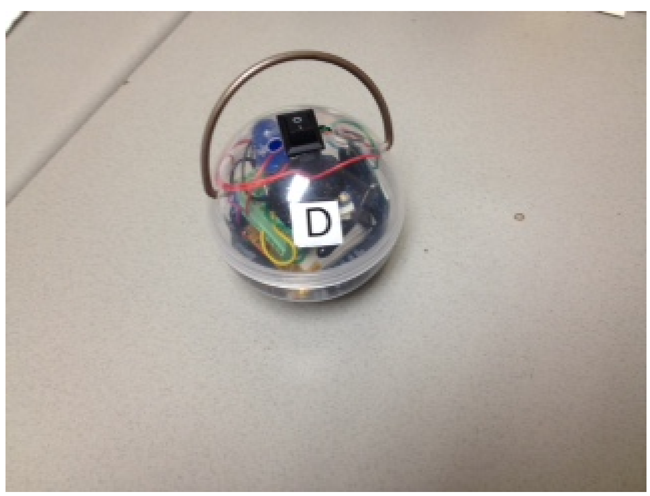
We will be using the one-dimensional kinematic formula you have seen in lecture for the final position y_f of an object falling under the influence of gravity

$$y_f = y_0 + v_{0y}t + \frac{1}{2}a_y t^2,$$

where the symbols have their conventional meaning.

Each team will make a single successful drop inside the lab and a single succesful drop outside the lab, from the top floor of the airline parking garage just east of the lab. The data files and the appropriate plots, described below, in each case will be automatically transferred to ipl.physics.smu.edu. These plots may be downloaded for inclusion in the Data section of your lab report at the following link: [http://ipl.physics.smu.edu/new-apple/three (http://ipl.physics.smu.edu/new-apple/three)](http://ipl.physics.smu.edu/new-apple/three)
You will determine the time-of-flight of the projectile from examining these plots.

Each team will have its own "apple" to drop, a transparent plastic sphere with electronics inside it. See the figure.



The TA or lab manager will give each team their own apple. The apple is named with a letter labeled on the side of it and that label is used in the name of the data file that stores their flight data. For example, the apple shown in the figure above is labeled *"D"* and its plot file is named *"Lab32-D.pdf"*. Remember your apple's name!

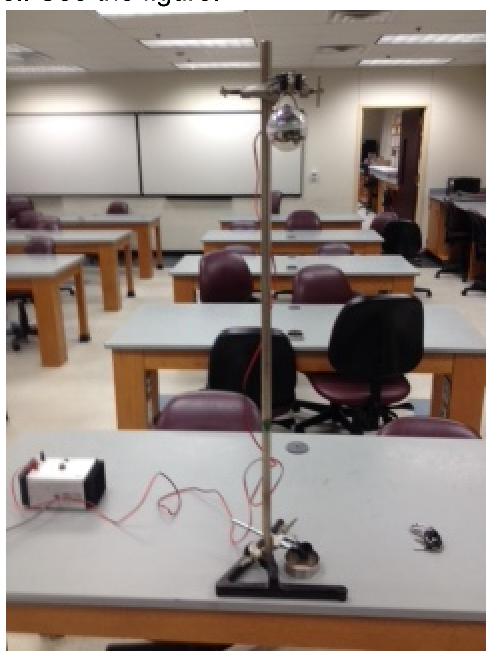
The apple has a power switch on its top and a blue LED and an "accelerometer" inside. When the apple is turned on, the LED will blink several times and then glow steadily. Data is collected and transmitted ONLY when the LED is shining steadily. Hence, ONLY when the LED is shining steadily should the apple be dropped. Similarly, after the drop do NOT disturb the apple until the LED goes off. Once the LED is off, you are free to retrieve the apple. Your data and plot is now on ipl.physics.smu.edu.

The accelerometer is the device inside the apple that determines the time-of-flight of the apple. It is similar to the device inside your smartphone or tablet that determines the orientation of either. This is explained more in a PHYS 1106 lab "Capacitance."

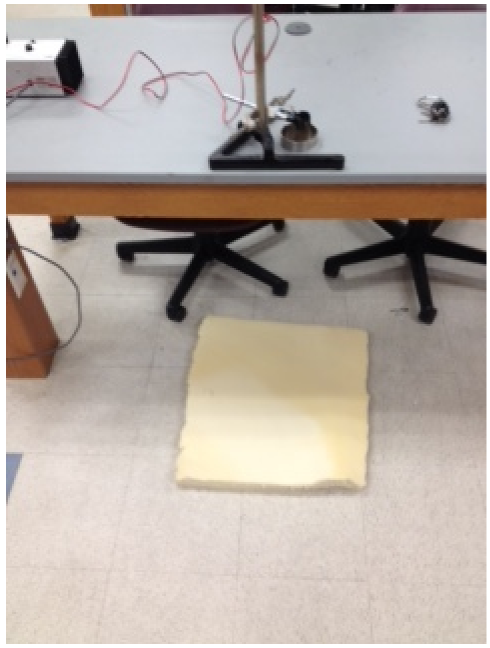
Only one apple can be dropped at a time. Otherwise, data from two different apples will get jumbled together. Hence, each team will need to take turns. The TA or lab manager will direct each group in sequence.

Short drop procedure

Set up the stand with a solenoid magnet. Wire the solenoid to its power supply (PS) and then connect the voltmeter in parallel. See the figure.



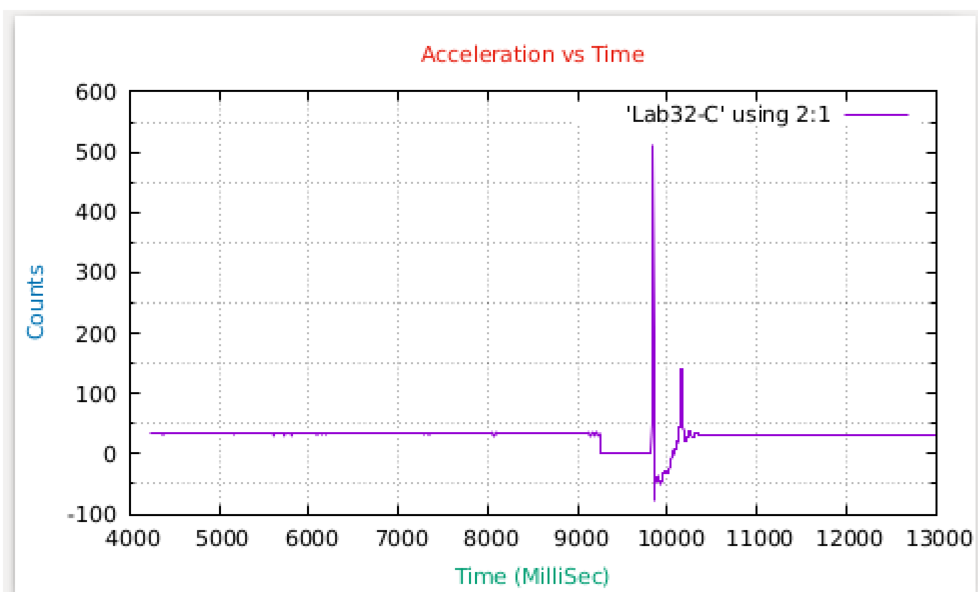
Place the box containing the cushioned landing pad on the floor beneath the solenoid magnet. See the figure.



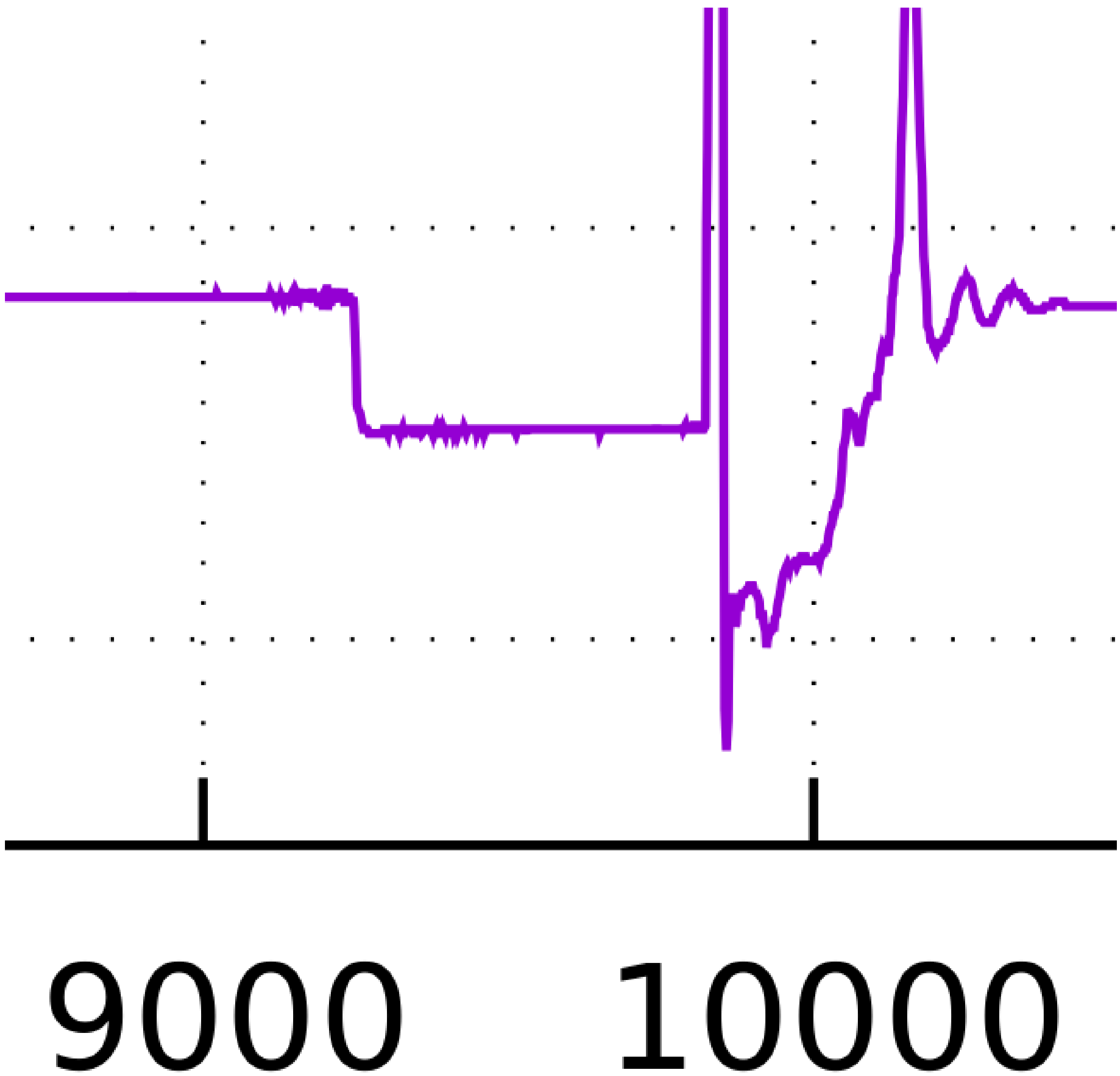
- Turn on the power switch on the PS and adjust the voltage to 8 volts.
- With PS on, attach the apple's handle to the solenoid.
- Using the two-meter stick, carefully measure the drop distance from the bottom of the apple to the cushioned landing pad in the box.
- Turn on the power switch to the apple. Wait for the LED to stop blinking and to shine steadily.
- Turn off the power on the PS. The apple will fall very soon after this and land on the cushioned landing pad. **WAIT FOR THE LED TO GO OFF**.

Each time the apple is dropped, its data file is ***overwtitten*** and its plot is ***regenerated***. Therefore, it is imperative to download and save these file ***before*** performing the long drop. The next group should now perform their own drop until all teams have nade their individual drops.

Short Drop Plots - Samples



Zoomed Data Plot: Short Drop - Sample



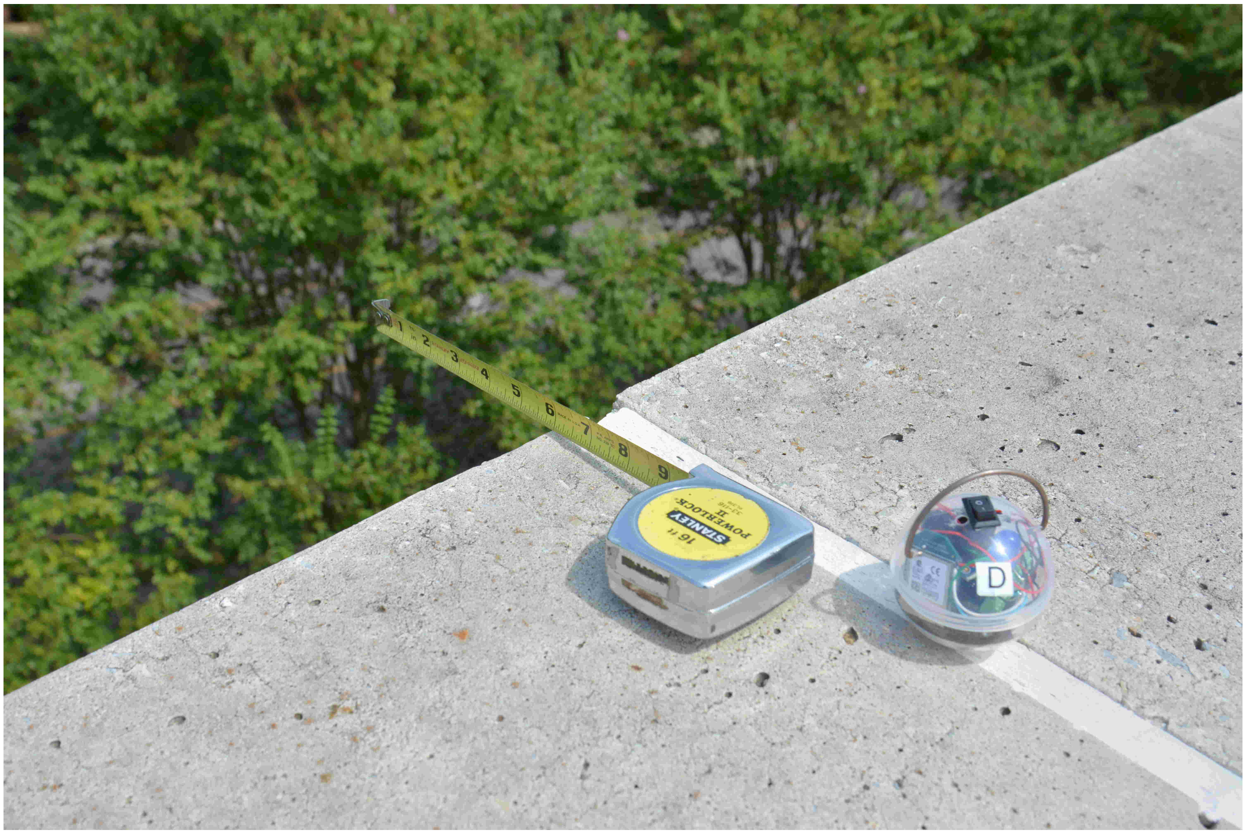
Long Drop Procedure

The long drop takes place from the North side of airline garage. The details are similar to the short drop procedures. The blue bean bag needs to be carried over to the NORTH side of the airline garage and as shown in the figure.

Level the top of the bean bag as best you can and make sure it is pressed up against the wall. Compare its position to the nearby electrical conduit that exits the garage. The bag should be adjacent to the wall with no gaps. See the figure.

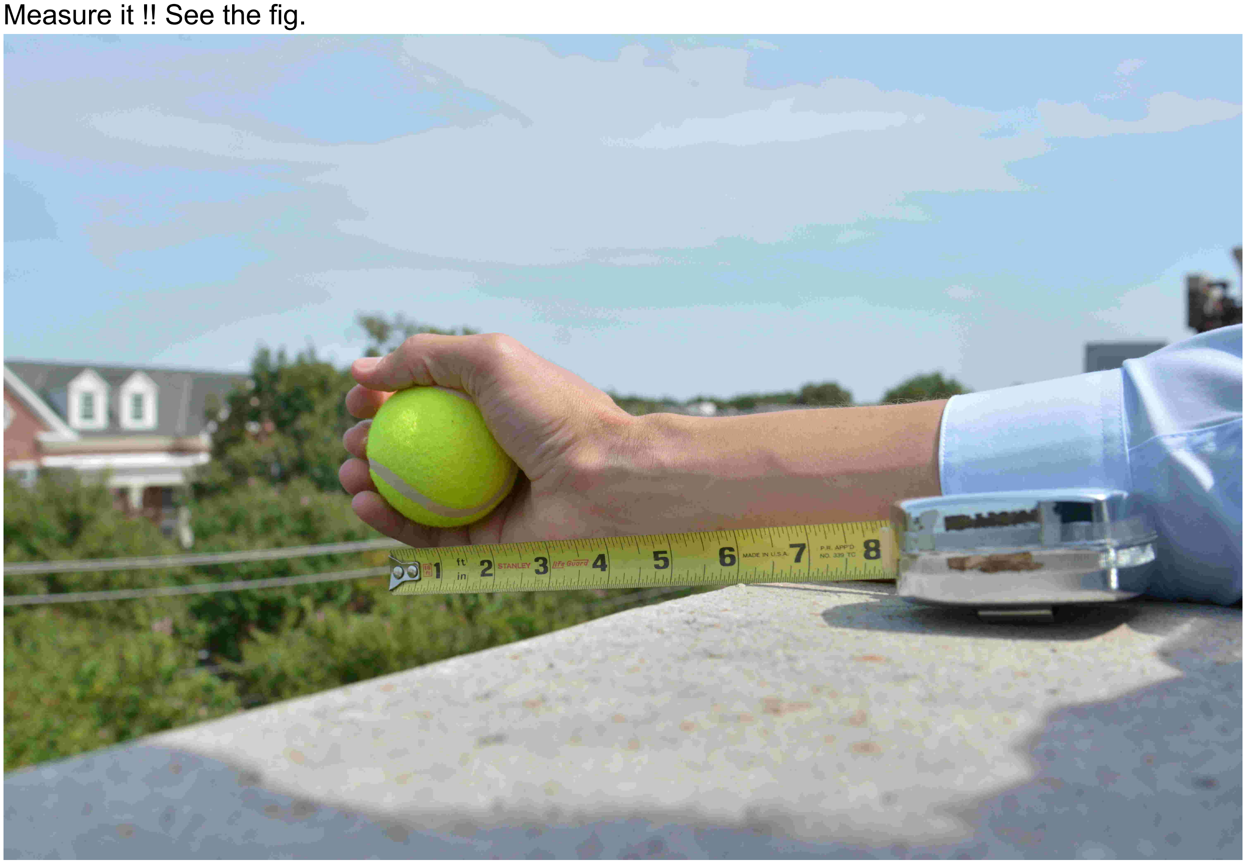
At least one team member should stay by the bean bag as the others go to the top floor of the garage.

Team members should take their apple to the top most floor of the garage and walk to the north wall. Above the bean bag you will see a white expansion joint at the top of the wall. This is your marker for where to drop the apple. See the fig.



To verify alignment of the mark with the bean bag, you will need to drop a tennis ball to verify it hits te center of the bean bag. That procedure to described in the next paragraph.

To drop properly a tennis ball, find the expansion joint mentioned above and position your hand holding the tennis ball so that the nearest edge of the ball 6 inches from the outer wall edge. Measure it !! See the fig.

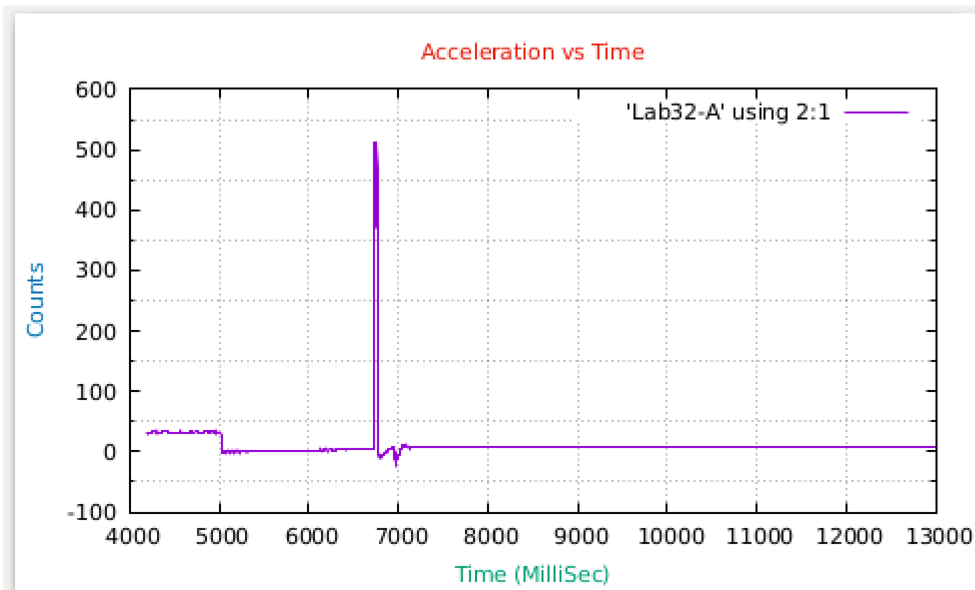


A TA or the lab manager will provide you with a measuring tool. You arm should also be level. Release the ball and see where it lands. The bottom team member should adjust the bean bag appropriately. The tennis ball drop should be repeated to verify the alignment.

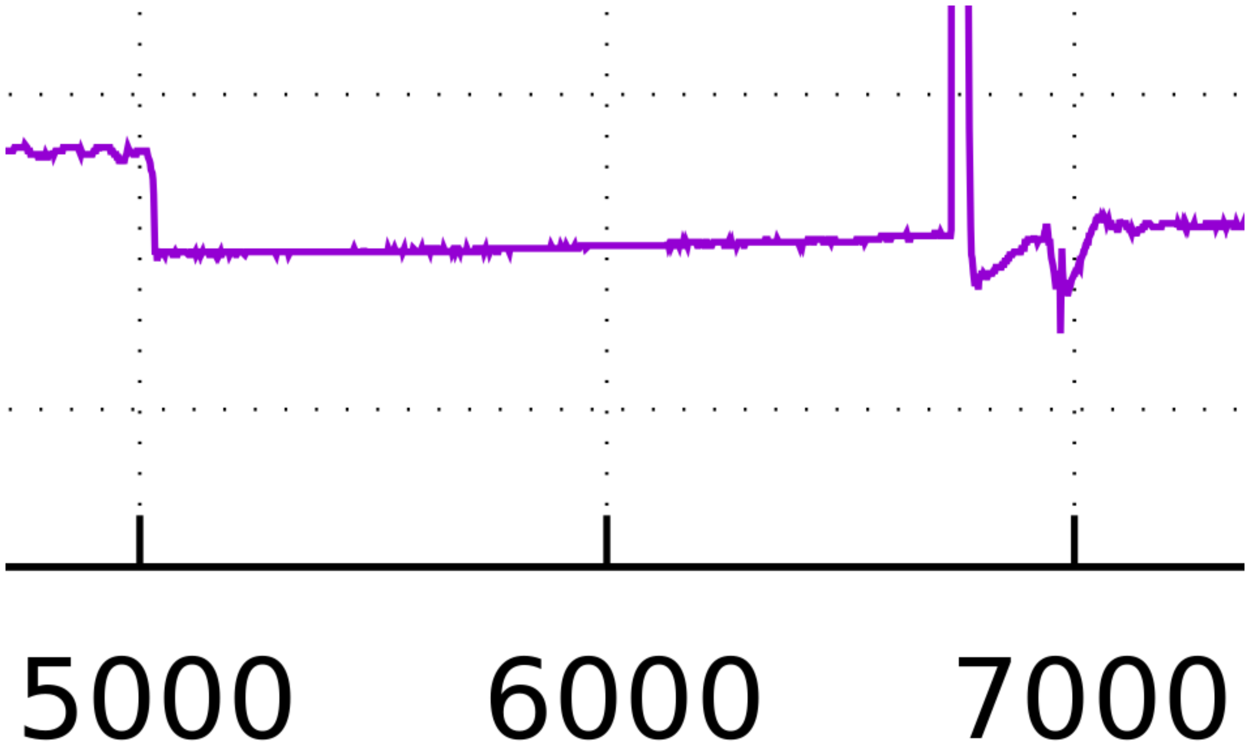
To drop the apple, you position it as you did for the tennis ball, TURN ON the apple, wait for the LED to shine steadily, and then release. **THE BOTTOM TEAM MEMBER SHOULD NOT TOUCH THE BALL UNTIL THE LED GOES OUT**. Do **NOT** disturb the apple **until the blue LED is extinguished**, signaling the data has been transferred to the computer inside the lab. Once the the LED is extinguished, the apple can be retrieved and the next team can drop its apple. Once your data is transmitted, return to the lab to complete the analysis.

If you are the last team to drop an apple, you need to retrieve the bean bag and the tape measure. The TA and/or the lab manager will collect the raspberry pi.

Long Drop Plots - Samples



Zoomed Data Plot: Long Drop



Analysis

You need to determine the flight time of each type of drop. This is determined from the plots above, where each figure shows a plot of a "count", a number proportional to the acceleration, versus time. Since we are interested in the fall time, we look at the duration of the first flat step-down portion of the plots. The leading falling edge us slightly rounded before it becomes flat and then has a sharp upturn at the end of flight as the ball begins to bounce. The time on the horizontal axis is displayed in milliseconds but we will need the time in **seconds**. Make sure you know how to convert one to the other.

Find the time of flight and its propagated error $t_f \pm \Delta t_f$ for **each** type of drop.

To determine the time of flight t_f we measured its horizontal length l_f on the zoomed plot with a ruler to the nearest half millimeter. On the same zoomed plot, measure the length l_t of one/two seconds for the short/long drop with a ruler to the nearest half millimeter. The time of flight can be calculated as follows: $t_f = \dfrac{l_t}{l_f} \times 1s$ for the short drop and $t_f = \dfrac{l_t}{l_f} \times 2s$ for the short drop.

Find the free fall acceleration and its propagated error $g \pm \Delta g$ for **each** type of drop.

Are your free fall accelerations in agreement with the standard value $9.8\ \mathrm{m/s^2} \pm 0.01\ \mathrm{m/s^2}$ (that is, do the error ranges overlap)? See *Taylor* page 5 if you are confused.

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Title Block

Date:
Group Number:

Author:
Partner 1:
Partner 2:

Abstract

Data

Analysis

Sources of Error

Two random and two systematic with explainations for each type of drop.

Conclusion