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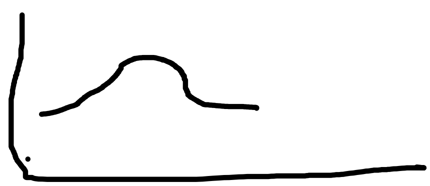
GROUP#:8

Lab 2. Ball Toss and Error Analysis

-- BALL TOSS --

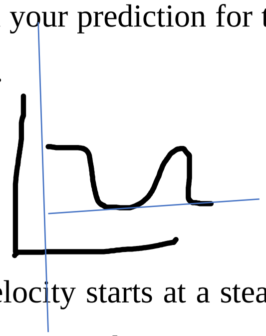
PRELIMINARY QUESTIONS

1. Consider the motion of a ball as it travels straight up and down in freefall. Sketch your prediction for the position vs. time graph. Describe in words what this graph means.



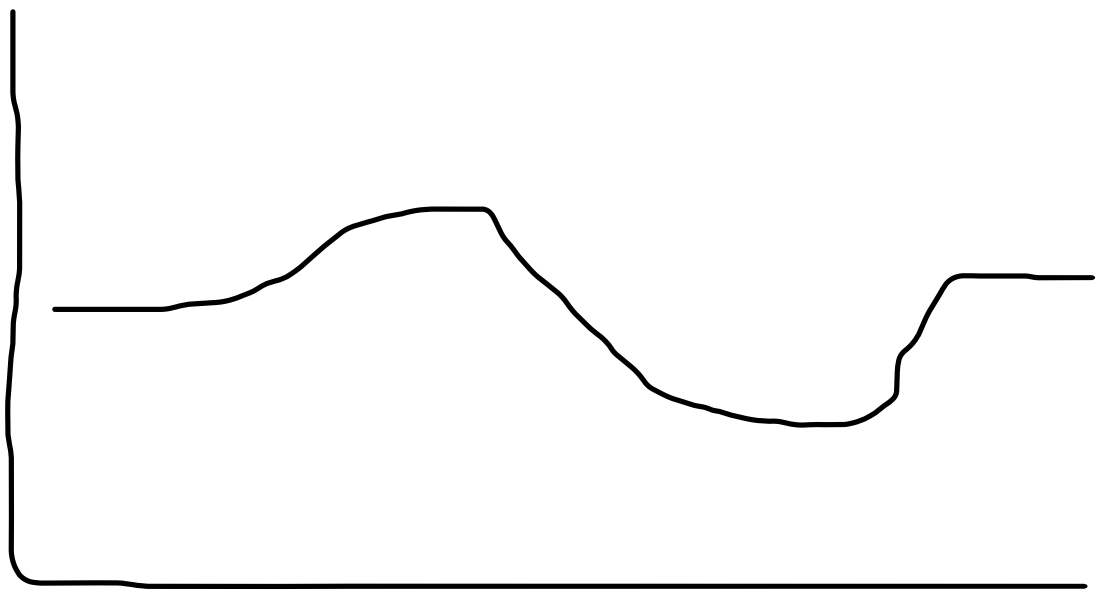
The rough sketch above displays that the ball goes straight up and then returns to its original position after a few seconds.

2. Sketch your prediction for the velocity vs. time graph. Describe in words what this graph means.



The velocity starts at a steady rate, but when reaching the maximum height, the velocity will be zero. When returning back down, the velocity will be the same as it when the ball was going upwards, until it hits the ground and becomes zero.

3. Sketch your prediction for the acceleration vs. time graph. Describe in words what this graph means.

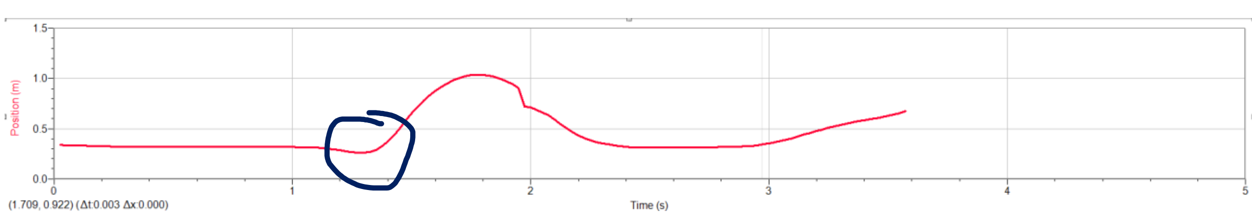


The throw will cause positive acceleration, it will then peak and abruptly reverse.

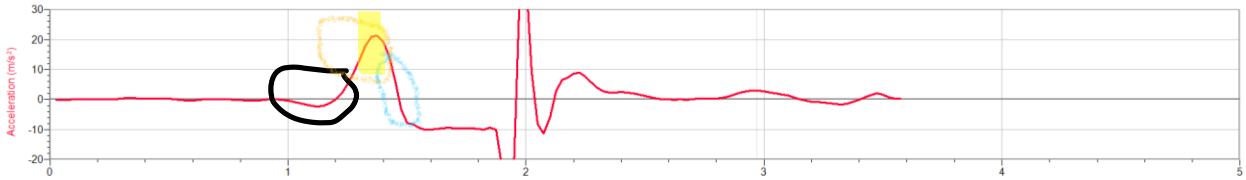
ANALYSIS

NOTE: SHOW ALL YOUR WORK WHERE CALCULATING IS INVOLVED

1. Print or sketch the three motion graphs. The graphs you have recorded are fairly complex and it is important to identify different regions of each graph. Click Examine, and move the mouse across any graph to answer the following questions. Record your answers directly on the printed or sketched graphs.
   a. Identify the region when the ball was being tossed but still in your hands:
      i. Examine the velocity vs. time graph and identify this region. Label this on the graph.



ii. Examine the acceleration vs. time graph and identify the same region. Label the graph.



b. Identify the region where the ball is in free fall:

i. Label the region on each graph where the ball was in free fall and moving upward.

Colored in yellow/orange

ii. Label the region on each graph where the ball was in free fall and moving downward.

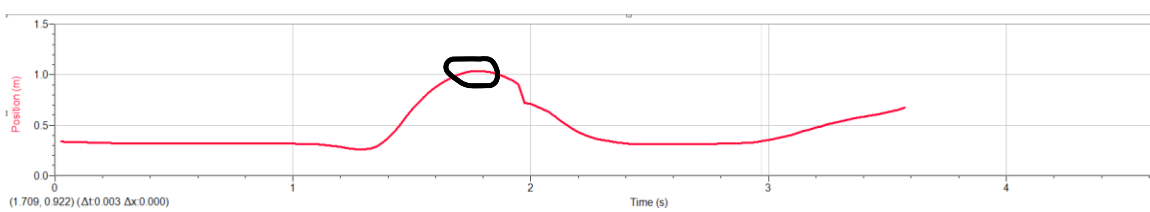
Colored in light blue

c. Determine the position, velocity, and acceleration at specific points.

i. On the velocity vs. time graph, decide where the ball had its maximum velocity, just as the ball was released. Mark the spot and record the value on the graph.

20 m/s^2 colored in yellow

ii. On the position vs. time graph, locate the maximum height of the ball during free fall.



iii. Mark the spot and record the value on the graph.

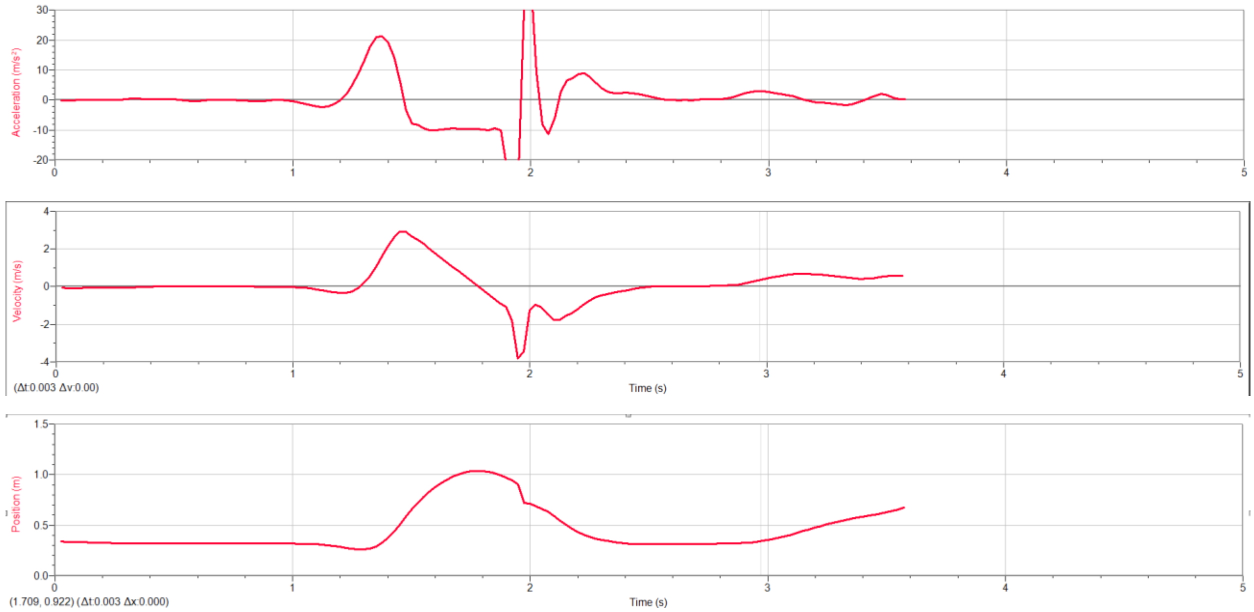
~1 meter

iv. What was the velocity of the ball at the top of its motion?

At its max position, it flattened at zero as the force of gravity cancelled out its upward trajectory.

v. What was the acceleration of the ball at the top of its motion?

If I'm understanding correctly, it is 0 as the effect of gravity has reduced the upward acceleration at the vertex.



2. What does a linear segment of a velocity vs. time graph indicate? What is the significance of the slope of that linear segment?

   It means the velocity is constant, or the change of velocity suggests it is moving on a straight path. In this case, though, the slope (acceleration) once in free fall indicates it is under the effect solely of earth's gravity minus whatever wind resistance was occurring.

3. The graph of velocity vs. time should be linear. To fit a line to this data, click and drag the mouse across the free-fall region of the motion. Click Linear Fit.

4. How closely does the coefficient of the t term in the fit compare to the accepted value for *g*?

   Around +/- 10%, but this may be due to our data collection.

5. The graph of acceleration vs. time should appear to be more or less constant. Click and drag the mouse across the free-fall section of the motion and click Statistics.

6. How closely does the mean acceleration compare to the values of *g* found in Step 4?

   Not far off, seeing as our data collection clearly wasn't perfect or the tools themselves were throwing errors in data.

-- **ERROR ANALYSIS** --

EVALUATION OF DATA

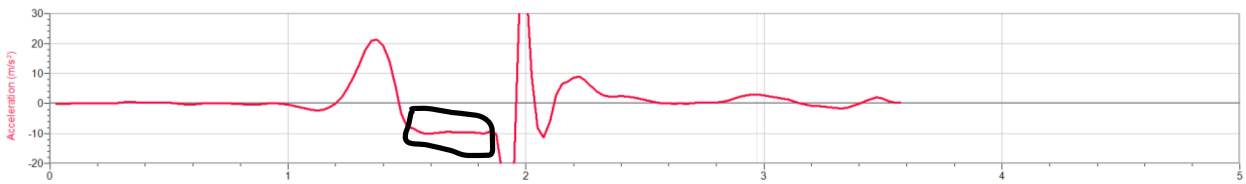
NOTE: SHOW ALL YOUR WORK WHERE CALCULATING IS INVOLVED

1. How do you account for the fact that the values of the slope were nearly the same, whereas the values of the intercept were much more variable?

   The values of the slope were dependent on the acceleration, which has been established to generally be around –9.8m/s for an object in free fall. The intercept represented the velocity, which was changing over time.

2. It is highly unlikely that you obtained identical values of the slope of the best-fit line to the velocity vs. time graph for each of your trials. How might you best report a single value for the acceleration due to gravity, a_g, based on your results? Perform the necessary calculation.

   Well, you don't need to calculate it out as it's understood to be 9.81 m/s^2, minus whatever minute effect air resistance has. Though I would take the following segment of the graph in acceleration, which is calculate by the slope of velocity time graph:



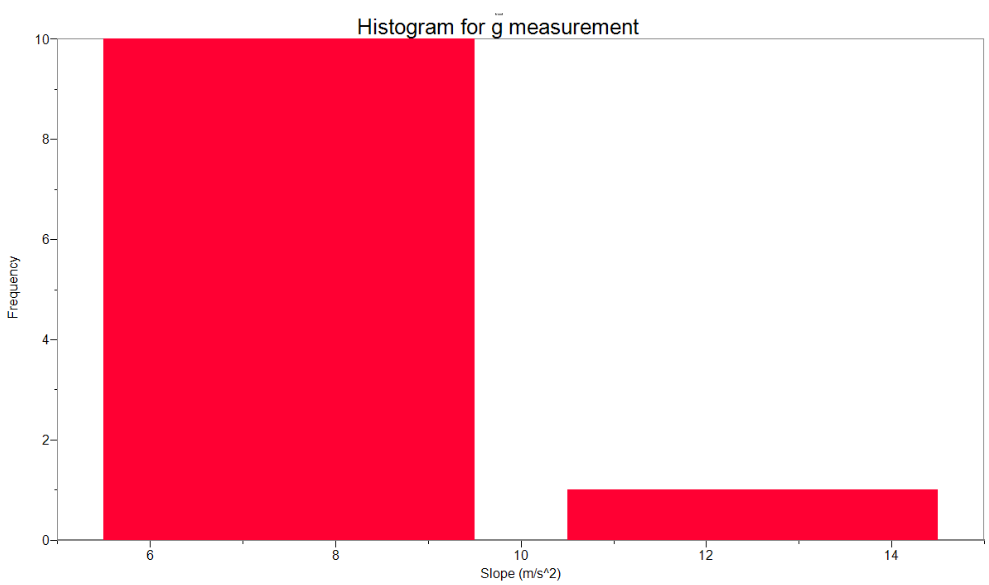
3. How does your experimental value compare to the generally accepted value (from a text or other source)? One way to respond to this question is to determine the percent difference between the value you reported and the generally accepted value. Note that if you simplify your units of slope, they will match those of the reported values of a_g.

   VERY close in my opinion, considering the issues we had with spikes/errors in collecting our data.

   Our average value was 9.581 m/s^2, with a few outliers closer to 8 and 11 skewing the results.

   Our closest value to 9.81 m/s^2 came in at 9.852 m/s^2 or less than half a percentage off.

4. Your determination of the percent difference does little to answer such questions as, "Is my average value for a_g close enough to the accepted value?" or "How do I decide if a given value is too far from the accepted value?" A more thorough understanding of error in measurement is needed. Every time you make a measurement, there is some random error due to limitations in your equipment, variations in your technique, and uncertainty in the best-fit line to your data. Errors in technique or in the calibration of your equipment could also produce systematic error. We'll address this later in the experiment. In order to better understand random error in measurement, you must return to your experimental apparatus to collect more data.
5. Begin the data-collection program "Picket Fence" in folder Lab02 as you did before and drop the picket fence through the photogate another 20 times, bringing the total number of trials to 25. Since you are now investigating the variation in the values of a_g, you need only record the value of the slope of the best-fit line to the velocity-time graph for each trial. Record the value of the slope in the Table on page 19.
6. Launch the Logger Pro file Lab02-histogram. Enter your values of slope in the Table on page 19.
7. In your discussion, you will decide how best to configure the features of the histogram so as to represent the distribution of your values in the most meaningful way. To do this, choose Options>>Additional Graph Options>>Histogram Options, and adjust the settings under the Bin and Frequency Options tab.



8. Determine the average value of a_g for all 25 trials. How does this compare with the value you obtained for the first 5 trials? In which average do you have greater confidence? Why?
   9.59 m/s^2 for all 25. For the first five: **9.64 m/s^2**. The first five, surprisingly, was more accurate.
9. In what range (minimum to maximum) do the middle 2/3 of your values fall? In what range do roughly 90% of the values closest to your average fall?
   [9.373 m/s^2, 9.756 m/s^2]
   [9.119 m/s^2, 9.852 m/s^2]
10. One way to report the precision of your values is to take half the difference between the minimum and maximum values and use this result as the uncertainty in the measurement. Determine the uncertainty in this way for each range of values you determined in Step 9.
    ~9.5645
    ~9.4855
11. In what place (tenths, hundreds, thousandths) does the uncertainty begin to appear? Discuss whether it is reasonable to report values in your average beyond the place in which the uncertainty begins to appear. Round your average value of ag to the appropriate number of digits and report that value plus the uncertainty.
    Ten-thousandths, though the spikes in data make determining uncertainties more difficult, and retesting the values with a better understanding of the process would be necessary.

<u>Data BELOW</u>

DATA TABLE

Slope (m/s^2)	Intercept (m/s)
9.756	0.3212
9.636	0.9475
9.553	0.4625
9.628	1.079
9.656	1.044
9.119	
9.448	
9.373	
9.767	
9.300	
9.702	
8.970	
9.752	
9.424	

10.21
9.852
9.681
9.713
9.751
8.733
9.711
9.782
9.755
9.735