

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide direction.

{Information in curly brackets is not included in your report; it's only for guidance.}

{Title Page}

The Simple Pendulum

Your name here, underlined.

Date Conducted: 12 February 2013

Date Submitted: 19 February 2013

First & Last Name(s) of your partner(s) here.

Page Break

Introduction *{Motion with Air Drag}*

Ever wonder why a crumpled coffee filter falls more quickly than an open one? In this experiment, we attempted to understand the effects of air drag on falling objects, specifically coffee filters. By varying the number of coffee filters dropped at one time, we will be able to come to an understanding of the relationship between air drag, an object's surface area, and an object mass. In this experiment, we will define representative variables where a is a constant, F_D is the drag force, and we are attempting to find of n , the exponent of the velocity, v .

Introduction *{Motion with Air Drag}*

If you drop a bowling ball and a feather on a normal day on earth, why don't they hit the ground at the same time? Sure, the feather may have less mass but it is due to its surface area that it is more susceptible to the force of air drag, F_D . Air is a medium like water, or oil. The molecules of air create a force against a falling body that is called air drag. However, drag forces depend on the speed v of an object falling through a medium. In this experiment we dropped stacks of coffee filters, because they are more susceptible to drag than bowling balls and much safer, with varying masses to measure their terminal velocities v_t or the maximum speed they reach when falling. There are two different equations to calculate this, one if we assumed it met its terminal velocity immediately and one for if we did not.

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Procedure {Centripetal Force}

For this experiment, it is important to master the technique in swinging the rubber stopper attached to the string at a constant radius above your head to obtain accurate data. First, we measured 20cm increments up to 100cm on the string, which passed through the glass rod. One lab partner then proceeds to swing the apparatus, while the other one times how long it takes for the system to complete twenty revolutions using a stopwatch. This value was recorded in a table, and compared with the times it takes using the same mass attached the bottom of the string at different lengths, then using different masses attached to the bottom of the string at a consistent radius.

Equations {Projectile Motion}

Equation for velocity as it relates to distance in the x-direction, H, and distance in the y-direction, R.

$$V_0 = R \sqrt{\frac{g}{2H}} \quad (\text{Equation 1})$$

Average length of shot at height $\theta = 0^\circ$ determined by 6 trials.

$$\frac{\Sigma(\text{Trials 1-6})}{6} \quad (\text{Equation 2})$$

Equations used to determine directional velocity of ball in the x-direction and y-direction

$$v_x = v_0 \cos\theta \quad v_y = v_0 \sin\theta \quad (\text{Equations 3.1 \& 3.2})$$

Kinematic Equation used to determine coefficients used in quadratic formula

$$Y_f = Y_i + v_{iy}t + \frac{1}{2}a_yt^2 \quad (\text{Equation 4})$$

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Quadratic Formula used to determine time (t) for launched ball to hit the ground.

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad (\text{Equation 5})$$

Kinematic Equation used to predict horizontal distance, R, the ball will travel.

$$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \quad (\text{Equation 6})$$

Equation used to determine percent difference between predicted and actual values.

$$\% \text{ Difference} = \frac{|E_1 - E_2|}{E_1 + E_2} * 200 \quad (\text{Equation 7})$$

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Data and Data Analysis *{Motion with Air Drag}*

Table 1: Coffee Filters: Properties and Fall Time

	m (g)	T (± 0.158 s)	T_{ave} (± 0.9 s)	d (± 0.0001 m)
1 Filter	0.0007 \pm 0.0001	7.170 6.560 7.250	7.1	0.1780
2 Filters	0.0014 \pm 0.0001	5.100 5.000 5.545	5.2	0.1780
3 Filters	0.0021 \pm 0.0002	3.810 4.030 4.150	3.9	0.1780
4 Filters	0.0028 \pm 0.0002	3.320 3.640 3.510	3.5	0.1780

(m is mass, T is time taken to fall a distance D of 5.3920 \pm 0.0002m, T_{ave} is the average time for the trials of each stack, d is the average diameter of a coffee filter)

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Table 2: $V_t = D/T$

	$v_t (\pm 0.9 \text{ m/s})$
1 Filter	0.8
2 Filters	1.0
3 Filters	1.4
4 Filters	1.5

(The terminal velocity m/s assuming that terminal velocity is reached immediately after being dropped)

Table 3: $V_t = gT - (g^2T^2 - 2gD)^{1/2}$

	$v_t (\pm 0.9 \text{ m/s})$
1 Filter	0.9
2 Filters	1.0
3 Filters	1.0
4 Filters	1.0

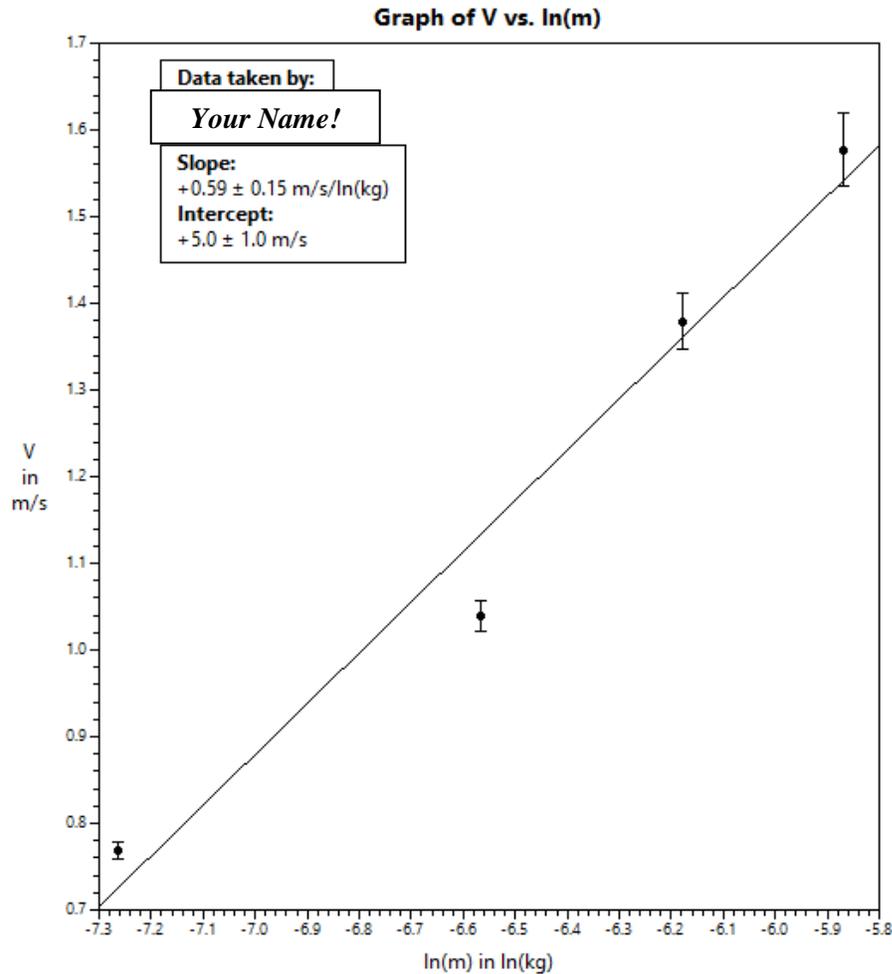
(The terminal velocity in m/s factoring in assuming that the velocity consists of two parts, free-fall with acceleration g for a period of time T followed by constant terminal speed for another period of time)

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Figure 1. Velocity vs $\ln(m)$



(Velocity vs $\ln(m)$). The general equation used is $y=mx+b$ and the equation used is $V_i = gT - (g^2 T^2 - 2gD)^{1/2}$

General equation: $y=mx+b$

Known equation: $\ln(V_i) = 1/n \ln(m) + 1/n \ln(g/\alpha)$

$y = \ln(V_i)$ $m = 1/n$ $x = \ln(m)$ $b = 1/n \ln(g/\alpha)$ The slope = $m = 1/n = 0.59 \pm 0.15 \text{ m/s/kg}$

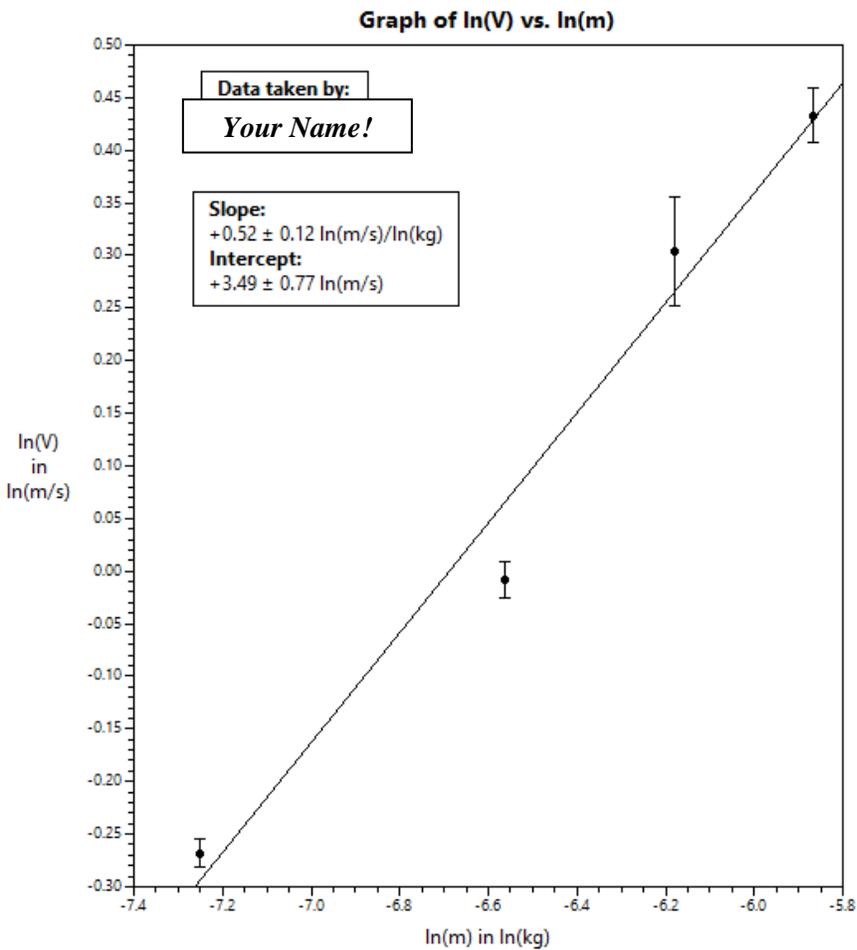
$b = 1/n \ln(g/\alpha) = 5.0 \pm 1.0 \text{ m/s}$

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Figure 2 $\ln(V)$ vs $\ln(m)$



($\ln(V)$ vs. $\ln(m)$ with a general equation of $y=mx+b$ and the equation used is $V_t = D/T$ or terminal velocity equals Distance over average time of fall)

General equation: $y=mx+b$

Known equation: $\ln(V_t) = 1/n \ln(m) + 1/n \ln(g/\alpha)$

$y = \ln(V_t)$ $m = 1/n$ $x = \ln(m)$ $b = 1/n \ln(g/\alpha)$ The slope = $m = 1/n = 0.52 \pm 0.12 \text{ m/s/kg}$

$b = 1/n \ln(g/\alpha) = 3.49 \pm 0.77 \text{ m/s}$

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Data & Data Analysis {Motion with Air Drag}

Table 1: Comparing Masses and Time Over Constant Distance of Various Numbers of Filters

# Of Coffee Filters	Mass (g) ($\pm 0.0001\text{g}$)	Distance dropped (m) ($\pm 0.0001\text{m}$)	Trial 1 (s) ($\pm 0.152\text{s}$)	Trial 2 ($\pm 0.152\text{s}$)	Trial 3 ($\pm 0.152\text{s}$)	Average Time ($\pm 0.09\text{s}$)
1	.7128	3.2901	4.05	3.77	3.50	3.77
3	2.2780	3.2901	2.04	2.12	1.85	2.00
5	3.4430	3.2901	1.52	1.69	1.73	1.65

This table tells the mass of the stack of coffee filters, and shows the recording of the three trials taken to determine an average time it takes for the coffee filters to hit the ground after being dropped from a constant height, given in the table.

Table 2: Determining Terminal Speed Using Equation 2

# Of Coffee Filters	Terminal Speed using Equation 2 (s)
1	$.87 \pm 0.02$
3	1.65 ± 0.08
5	1.99 ± 0.11

This table presents the terminal speed at each number of coffee filters tested using Equation 2.

Table 3: Determining Terminal Speed Using Equation 3

# Of Coffee Filters	Terminal Speed using Equation 3 (s)
1	$.88 \pm 0.02$
3	1.72 ± 0.09
5	2.13 ± 0.14

This table presents the terminal speed at each number of coffee filters tested using Equation 3.

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Table 4: Calculated Reynold's Number for One Coffee Filter

# of Coffee Filters	Calculated Reynold's Number
1	10,400

This table presents the Reynold's Number for one coffee filter, which is determined by using an equation that applies given constants and variables from this experiment.

Table 5: Coffee Filter Drag Constant

Method	Constant, n
Equation 2	1.89 \pm .14
Equation 3	1.78 \pm .12

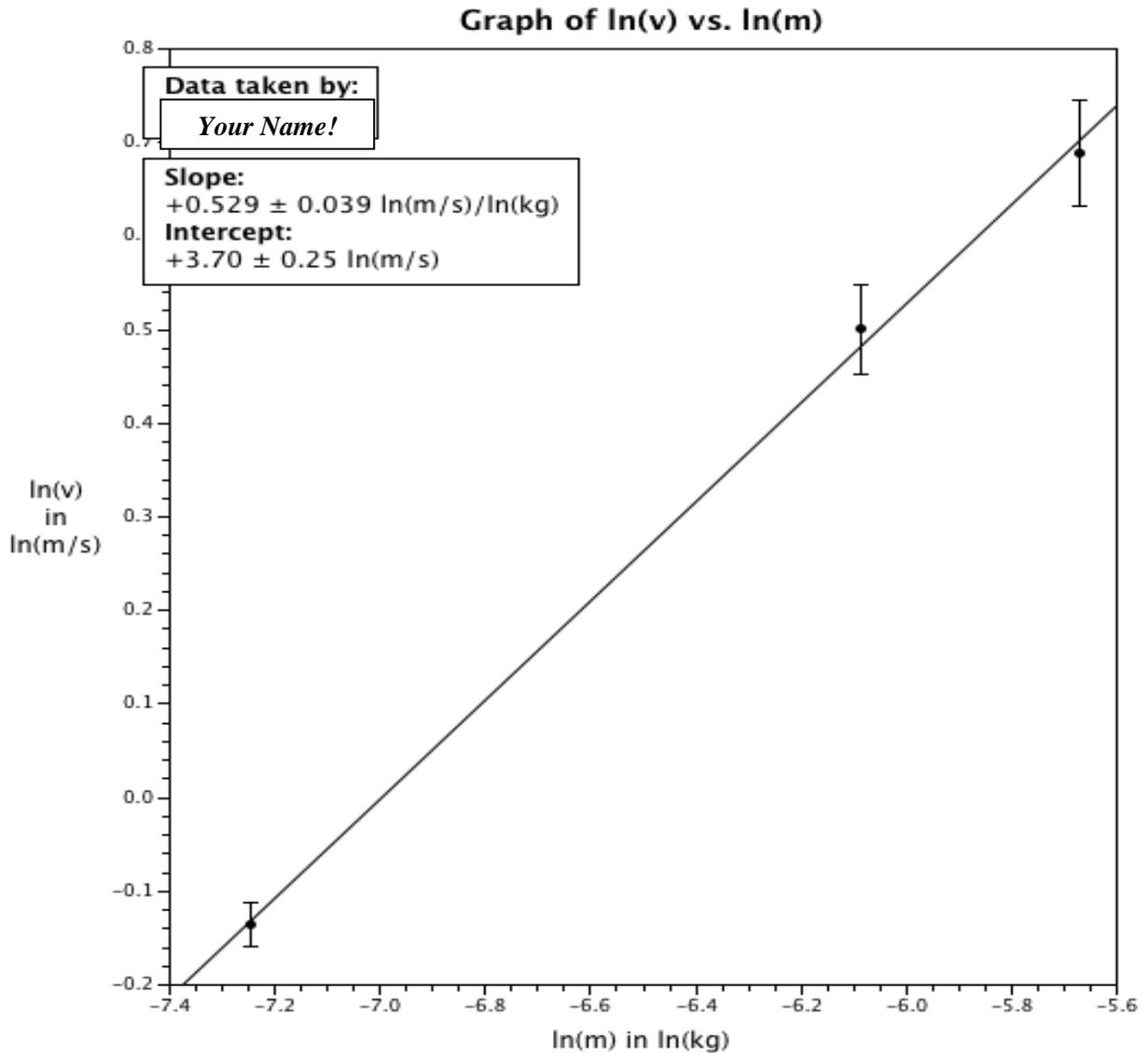
This table presents the determined constant n , from applying the previously found values to an equation.

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Graph 1: Graph of $\ln(v)$ vs. $\ln(m)$ Using Equation 2 to Determine Velocity {Analysis Missing}



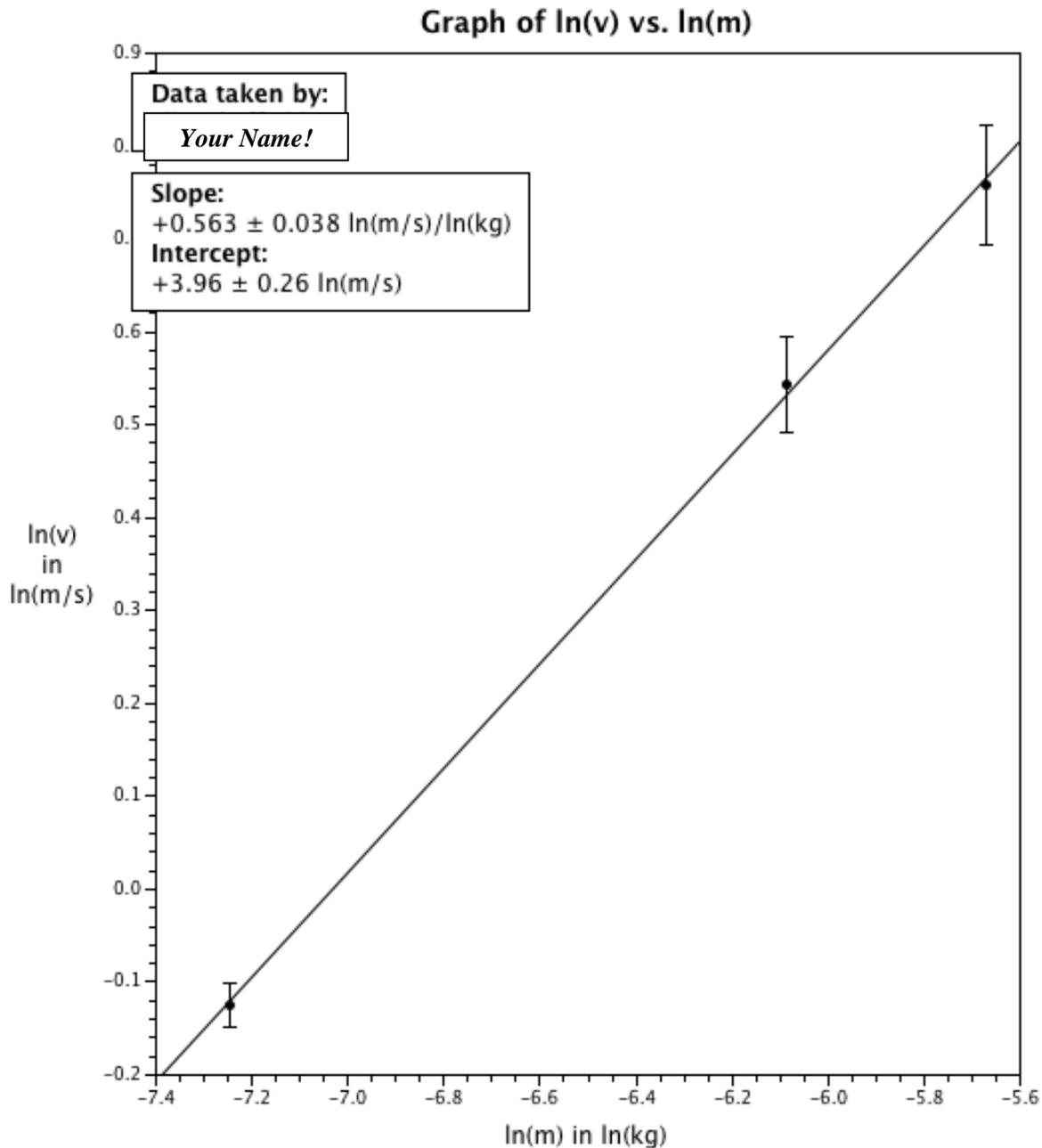
This graph of the natural log of velocity as a function of the natural log of the mass gives the value of $\frac{1}{n}$ as the slope of the graph according to the values given by Equation 2 of terminal speed. By determining the inverse of the slope, it allowed us to determine the value of constant n .

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Graph 2: Graph of $\ln(v)$ vs $\ln(m)$ According to Velocity Calculated by Equation 3 {Analysis Missing}



This graph also presents the value of $\frac{1}{n}$ as the slope of the graph, but this graph is of the natural log of the values of terminal velocity determined by Equation 3 versus the natural log of the mass of the coffee filters. Just as with graph 1, the inverse of the slope allowed us to determine the constant n .

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Results {Centripetal Force}

Table 1: Results Table comparing values of g

Method	$ \bar{g} $ (m/s ²)
I: Experimental Value testing length	25 ± 6
II: Experimental value testing mass	$23.691 \pm .004$
III: Theoretical Value	$9.800 \pm .001$
% Difference between I,II	7%
% Error between II, III	160%
% Error between I,III	140%

Discussion of Results {Centripetal Force}

The objective of this experiment was to determine the value of g through two different experiments. Although the values we came up with do not even remotely compare to the value of g , these results are helpful in allowing us to determine the accuracy and validity of this experiment. The final outcome of this experiment was not consistent with our expectations, as we expected to come up with a value for g that was much closer to the theoretical value. In this experiment there were multiple possible sources of error. One source of error could come from the elasticity in the string fibers. As the experiment continues and the string is being used more and more, the fibers of the string could stretch out more, altering the length of the string from the original length that was original measured and making it greater than this original value. Another source of error could be the assumption that is made that the masses used are exactly equal to their stated value. If these masses have been used many times before, the effects of those experiments, paint chipping on the masses, or chemical interactions, could have affected the mass, which inherently makes our assumption false that they are equal to the stated value. Also, air drag and air pressure are not accounted for in this experiment, which could have an effect on how the mass and string apparatus revolves. Our data, although not extremely accurate, does verify the fact that there is a value of g and it does significantly impact all interactions on the Earth.

Samples of Student Report Sections

The report sections that follow are from various experiments.

Although they are not perfect, they are very well done and should provide guidance.

Conclusion {Air Track Dynamics}

This experiment was helpful in making connections between force as it relates to an object's mass and acceleration. It was also helpful in understanding the difference between mass and weight, as the weight of the masses is found by using the balance, or multiplying the mass by g to determine its force. Part I as compared to Part II allowed me to see that even when the system's mass does not change, the acceleration can vary greatly based on how much mass is on the hanger versus the glider. The acceleration was more greatly effected when mass was added to the hanger then when it was added to the glider. This increase in acceleration also demonstrates an increase in force, according to Newton's second law. Newton's second law was verified in this experiment because it was evident that as mass increased and acceleration increased, the net force also increased.

To improve the accuracy of our results, I would make it a necessary step to determine the mass to a more precise variable and take the masses of the masses to ensure that they are exactly accurate rather than making that assumption. Our predicted value had a 20% difference than the value determined by the slopes of the graphs, which I believe is due to the excess weight on our hanger from super glue. To avoid this, I would use materials true to their original form. It might also be beneficial to run more trials for each part so that we know that the averages are true and with more points, our slope will be more accurate as compared with the computer generated slope.