Physics Laboratory Report

Lab number and Title: Lab 112 – Newton's Second Law

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Course & Section Number: PHYS111A 011 **Instructor's Name: Professor Nguyen**

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1. INTRODUCTION

Lab 112 was an experiment regarding what we learned in class that day, Newton's Second Law of Motion. The experiment was split into two parts which were very similar besides one change, and our group was responsible for measuring the data and finding answers. We were looking primarily at acceleration, velocity, and time from the experiment, and we had to measure mass and the angle (angle was only in part two) to help us calculate the force values. We assumed friction was 0 because of the air valves, which made it negligible.

In Thursday's class, we learned about Newton's Laws of motions, and specifically Newton's Second Law stating the sum of a forces on an object are equal to mass multiplied by acceleration. When written on paper, it is shown as $\Sigma F = ma$, where "ΣF" represents the sum of all forces acting on an object, "m" represents the mass, and "a" represents the acceleration. While doing the experiment, it was important that this be done twice for both masses (mass one being the glider, and mass two being the weight at the bottom of the string). Furthermore, we had to take into consideration the x and y components, especially in part two which had an angle and therefore had both x and y for mass 1. We are also familiar with tension force, which was the force that would be acting through the string, and that it is equal from both sides.

1 EXPERIMENTAL PROCEDURE (10 points)

Part One

The full procedure is described in the manual and in the instructions provided in class. In summary, we had a frictionless (near 0 friction) surface with a glider attached to a suspended mass connected through a string. Two photogates, set up at set locations as provided in class, captured the values of the experiment and gave us velocity and time, from which we were able to get acceleration.

Givens:

- Starting Position from Photogate 1 (X_0)
- Distance Between Photogate 1 and Photogate 2 (L)
- Size of Glider Piece (X_p)
    - This only accounts for the size of the piece on top of the glider which gets calculated in the photogates.
- Mass of Suspended Weight (M_h)
- Mass of Individual Weights (M_1)
- Mass of Glider (M_g)

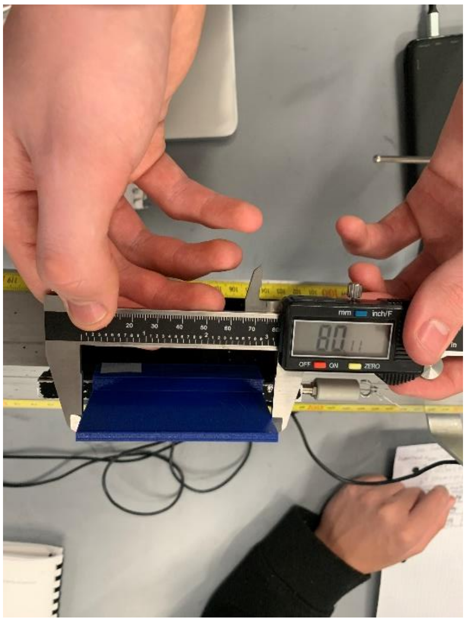
Mass of Glider (0.208kg)

Mass of Individual Weight (0.0504kg)

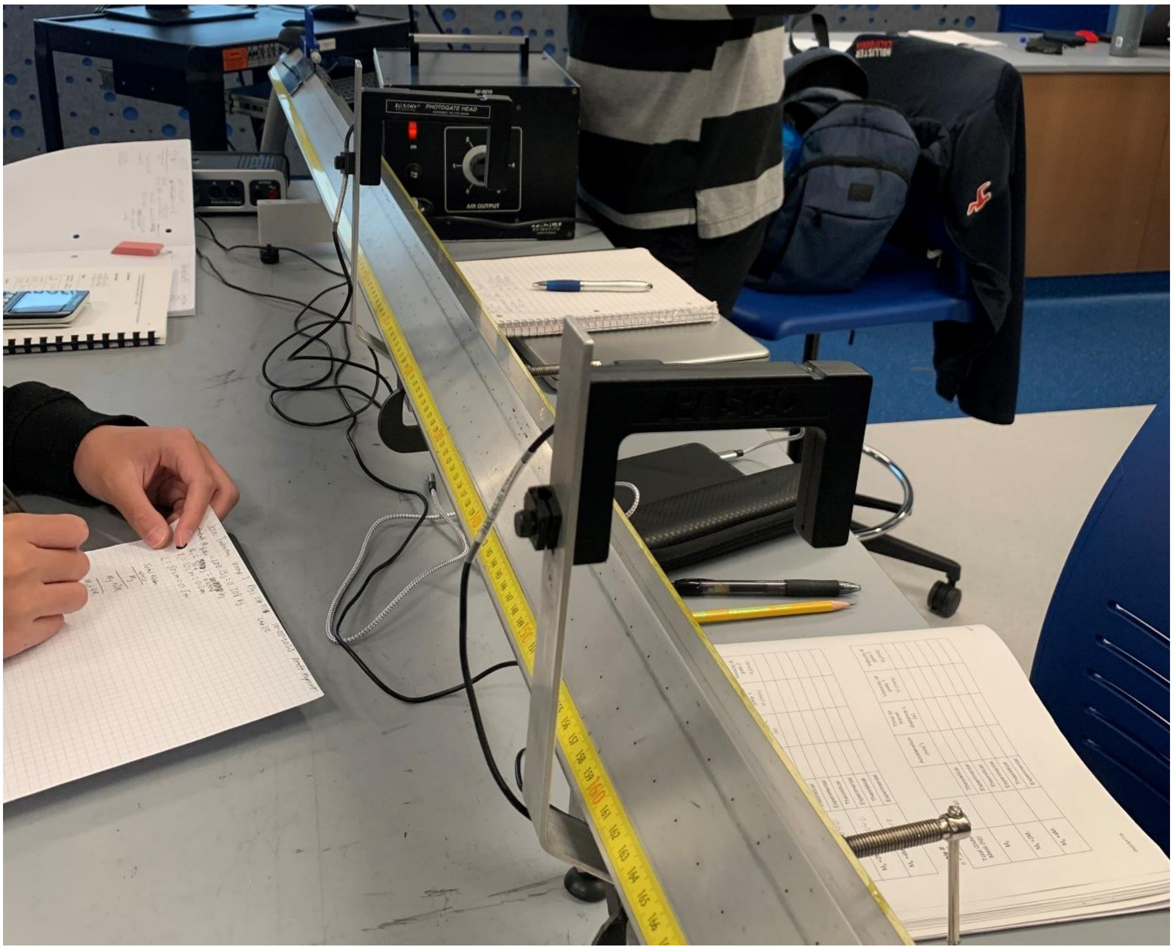
Mass of Suspended Weight (0.0410kg)

Distance of Photogate 1 (1.10m)

Distance of Photogate 2 (1.60m)



Size of Glider Piece (0.0801m)



Experiment Setup

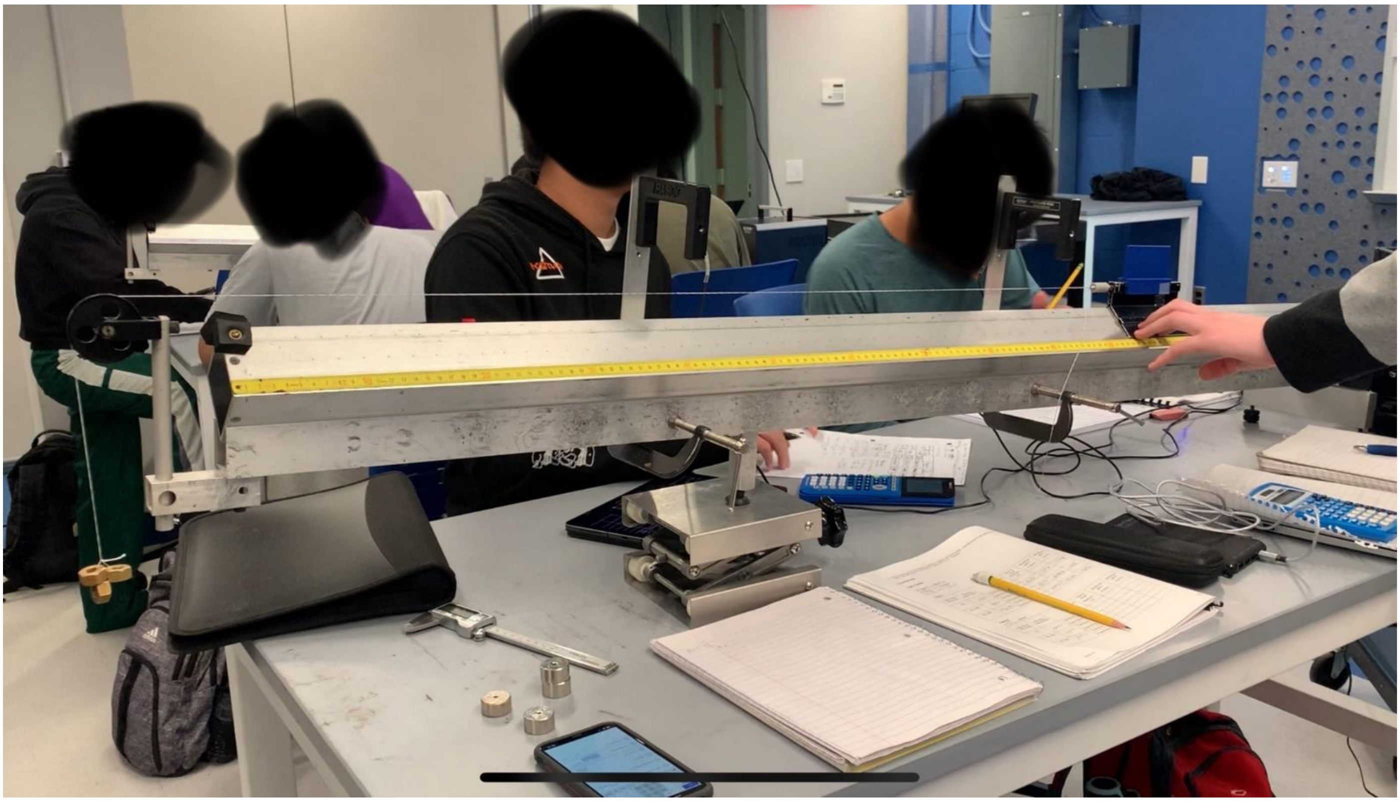
Part Two

The procedure for part two is also in the manual. All values remained the same as in part one except the angle of incline of the platform, which was raised to 5 degrees.

Givens:

- Starting Position from Photogate 1 (X_0)
- Distance Between Photogate 1 and Photogate 2 (L)
- Size of Glider Piece (X_p)
- Mass of Suspended Weight (M_h)
- Mass of Individual Weights (M_1)
- Mass of Glider (M_g)
- Incline of Platform (Θ)

Angle of Platform (5°)



Experimental Setup

2 RESULTS

Part One

Time at Photogate 1	Time at Photogate 2	Time Between Photogates	Velocity at Photogate 1	Velocity at Photogate 2
0.112s	0.0597s	0.515s	0.731m/s	1.36m/s
0.120s	0.0637s	0.551s	0.665m/s	1.25m/s
0.142s	0.0735s	0.643s	0.563m/s	1.088m/s

The values for these are the averages we took. Row two is the first experiment (with no extra weight), row three is the second (with two m1) and row four is the third (with four m1).

Variables	How to Get Them	Value
X_0 (Start Position)	Given	0.2m
L (Distance between Photogate 1 and 2)	Given	0.5m
X_p (Size of Glider Piece)	Measured	0.081m
M_h (Mass of Suspended Weight)	Measured	0.0410kg
M_1 (Mass of Individual Weight)	Measured	0.0504kg
M_g (Mass of Glider)	Measured	0.208kg
T_1 (Time at photogate 1)	Measured in Experiment	Chart Above
T_2 (Time at photogate 2)	Measured in Experiment	Chart Above
T_L (Time between photogates)	Measured in Experiment	Chart Above
V_1 (Velocity at P1)	Measured in Experiment	Chart Above
V_2 (Velocity at P2)	Measured in Experiment	Chart Above
a (Acceleration)	Calculated	Shown Below

Values for Acceleration

Theoretical	Measured
1: 1.60 m/s	1: 1.23 m/s^2 (EP: 23%)
2: 1.15 m/s^2	2: 1.07 m/s^2 (EP: 6.9%)
3: 0.892 m/s^2	3: 0.816 m/s^2 (EP: 8.5%)

Error percentage was calculated using the formula |(measured-theoretical)/theoretical|*100

Lab 112
Calculations

1: $\sum F_i = ma \rightarrow \vec{F_x} = m_g a \rightarrow F_t = m_g a$

2: $\sum F_i = ma \rightarrow \vec{F_y} = m_h a \rightarrow F_t = m_h(g-a)$

$F_{t_1} = F_{t_2} \rightarrow m_g a = m_h g - m_h a$

$m_g a + m_h a = m_h g \rightarrow a(m_g + m_h) = m_h g$

$$\boxed{a = \frac{m_h g}{m_g + m_h}}$$

Pt 1: $a = \frac{m_h g}{m_g + m_h}$ $\quad a = \frac{0.0410(9.8)}{0.208 + 0.0410}$

$\boxed{a = 1.60 \, m/s^2}$

Pt 2: $a = \frac{m_h g}{m_g + m_h}$ $\quad a = \frac{0.0410(9.8)}{(.208 + 2(0.0504)) + 0.0410}$

$\boxed{a = 1.15 \, m/s^2}$

Pt 3: $a = \frac{m_h g}{m_g + m_h}$ $\quad a = \frac{0.0410(9.8)}{(.208 + 4(0.0504)) + .0410}$

$\boxed{a = 0.892 \, m/s^2}$

Theoretical a values:

1: $1.60 \, m/s^2$

2: $1.15 \, m/s^2$

3: $0.892 \, m/s^2$

Lab 112

Calculations

Run 1

$V_1 = 0.731 \, m/s$ $V_2 = 1.365 \, m/s$ $t_L = 0.515s$

$a = \frac{\Delta V}{\Delta t}$ $a = \frac{(1.365 - 0.731)}{0.515}$ $\boxed{a = 1.23 \, m/s^2}$

Run 2

$V_1 = 0.665 \, m/s$ $V_2 = 1.254 \, m/s$ $t_L = 0.551s$

$a = \frac{\Delta V}{\Delta t}$ $a = \frac{(1.254 - 0.665)}{0.551}$ $\boxed{a = 1.07 \, m/s^2}$

Run 3

$V_1 = 0.563 \, m/s$ $V_2 = 1.009 \, m/s$ $t_L = 0.643s$

$a = \frac{\Delta V}{\Delta t}$ $a = \frac{(1.009 - 0.563)}{0.643}$ $\boxed{a = 0.816 \, m/s^2}$

Measured a values:

1: $1.23 \, m/s^2$
2: $1.07 \, m/s^2$
3: $0.816 \, m/s^2$

Part Two

Time at Photogate 1	Time at Photogate 2	Time Between Photogates	Velocity at Photogate 1	Velocity at Photogate 2
0.141s	0.0746s	0.648s	0.565m/s	1.072m/s
0.223s	0.119s	1.03s	0.358m/s	0.675m/s
0.559s	0.288s	2.55s	0.143m/s	0.278m/s

The values for these are the averages we took. Row two is the first experiment (with no extra weight), row three is the second (with two m1) and row four is the third (with four m1). This chart has different values than part one because of the angle. On average, velocities are lower, and times are higher.

Variables	How to Get Them	Value
X_0 (Start Position)	Given	0.2m
L (Distance between Photogate 1 and 2)	Given	0.5m
X_p (Size of Glider Piece)	Measured	0.081m
M_h (Mass of Suspended Weight)	Measured	0.0410kg
M_1 (Mass of Individual Weight)	Measured	0.0504kg
M_g (Mass of Glider)	Measured	0.208kg
ϴ (Angle of Platform)	Measured	5.00°
T_1 (Time at photogate 1)	Measured in Experiment	Chart Above
T_2 (Time at photogate 2)	Measured in Experiment	Chart Above
T_L (Time between photogates)	Measured in Experiment	Chart Above
V_1 (Velocity at P1)	Measured in Experiment	Chart Above
V_2 (Velocity at P2)	Measured in Experiment	Chart Above
a (Acceleration)	Calculated	Shown Below

Values for Acceleration

Theoretical	Measured
1: 0.900 m/s	1: 0.782 m/s^2 EP: 13.1%
2: 0.395 m/s^2	2: 0.308 m/s^2 EP: 22.0%
3: 0.115 m/s^2	3: 0.0529 m/s^2 EP: 54.0%

Lab #2

Calculations

1: $\Sigma F_x = F_t - M_g \sin\theta = ma \rightarrow F_t = m_g(g\sin\theta + a)$

$\Sigma F_y = F_n - m_g g\cos\theta = 0 \rightarrow F_n = m_g g\cos\theta$

2: $\Sigma F_x = 0$ (no forces acting in x component)

$\Sigma F_y = F_t - m_h g = -m_h a \rightarrow F_t = m_h(g-a)$

$F_t = F_t \rightarrow m_g(g\sin\theta + a) = m_h(g-a)$

$\rightarrow m_g g\sin\theta + m_g a = m_h g - m_h a$

$\rightarrow m_g a + m_h a = m_h g - m_g g\sin\theta$

$\rightarrow a = \dfrac{(m_h - m_g\sin\theta)g}{m_g + m_h}$

Pt 1: $a = \dfrac{(0.0410 - 0.208\sin\theta)(9.8)}{0.208 + 0.0410}$

$a = 0.900\,m/s^2$

Pt 2: $a = \dfrac{(0.0410 - (.208 + 2(.0504))\sin(5°))(9.8)}{(0.208 + 2(0.0504)) + 0.0410}$

$a = 0.395\,m/s^2$

Pt 3: $a = \dfrac{(0.0410 - (.208 + 4(.0504))\sin(5°))(9.8)}{(0.208 + 4(0.0504)) + 0.0410}$

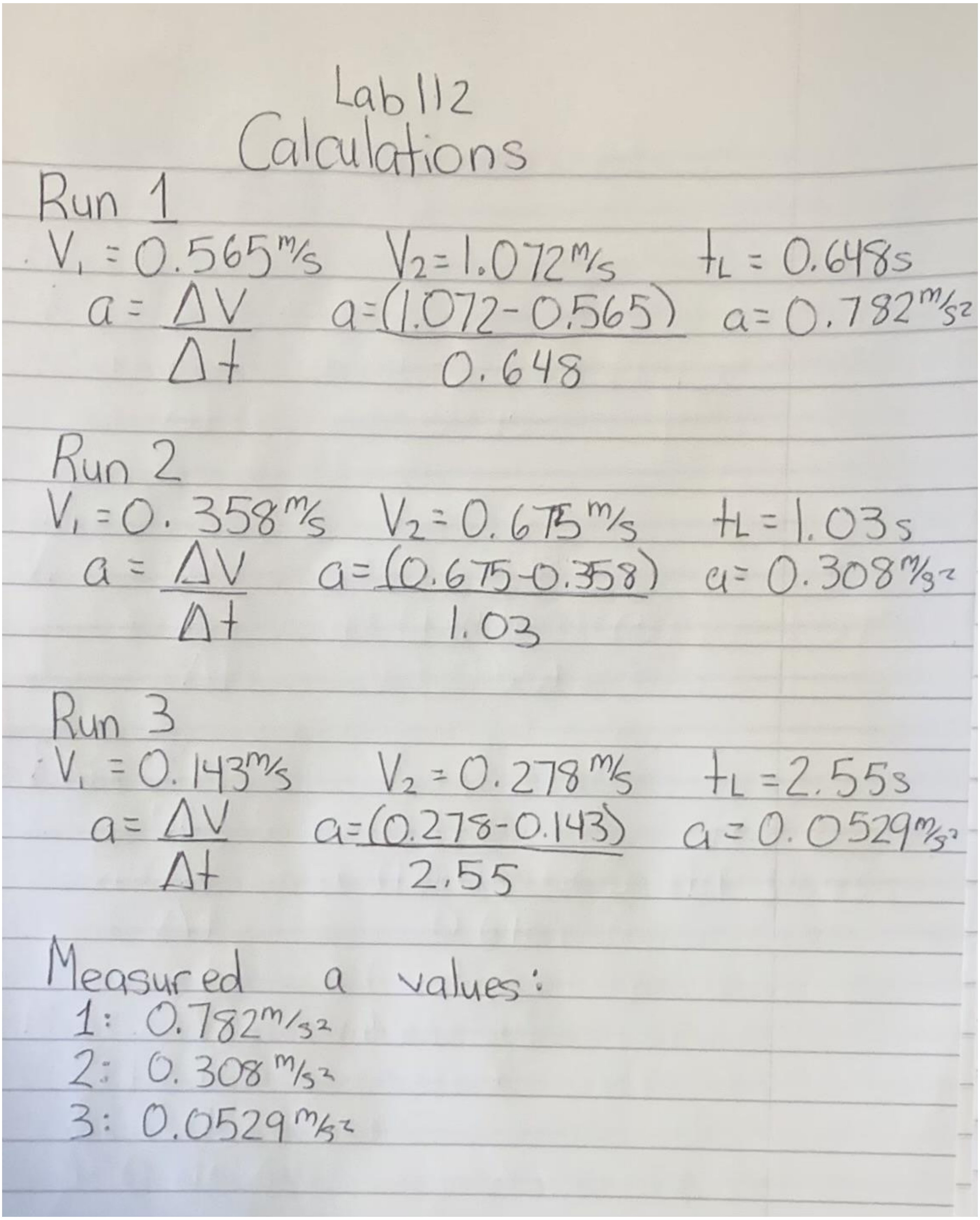
$a = 0.115\,m/s^2$

Theoretical a values:

1: $0.900\,m/s^2$

2: $0.395\,m/s^2$

3: $0.115\,m/s^2$



Lab 112
Calculations

Run 1

$V_1 = 0.565\,m/s$ $V_2 = 1.072\,m/s$ $t_L = 0.648\,s$

$a = \frac{\Delta V}{\Delta t}$ $a = \frac{(1.072 - 0.565)}{0.648}$ $a = 0.782\,m/s^2$

Run 2

$V_1 = 0.358\,m/s$ $V_2 = 0.675\,m/s$ $t_L = 1.03\,s$

$a = \frac{\Delta V}{\Delta t}$ $a = \frac{(0.675 - 0.358)}{1.03}$ $a = 0.308\,m/s^2$

Run 3

$V_1 = 0.143\,m/s$ $V_2 = 0.278\,m/s$ $t_L = 2.55\,s$

$a = \frac{\Delta V}{\Delta t}$ $a = \frac{(0.278 - 0.143)}{2.55}$ $a = 0.0529\,m/s^2$

Measured a values:

1: $0.782\,m/s^2$
2: $0.308\,m/s^2$
3: $0.0529\,m/s^2$

3 ANALYSIS and DISCUSSION

The main factor that was used during the calculation of the theoretical values was the use of Newton’s Second Law ($\Sigma F = ma$). This was simplified since the glider had no vertical value (because Fn and Fg cancel each other out), and the suspended mass had no horizontal force being applied. As shown in the calculations in the section above, we can set the two equations equal since the force of tension applied on one object is equivalent to the tension force applied on the other. This gives us our equation, and the rest was simply plugging in the values. For the experiments values (measured), we used a = change in velocity divided by change in time. This comes from the definition of acceleration. We got the values of V_f, V_0, and t_L from the experiment, and it came down to us plugging in the values to get the acceleration.

For part two, there was one critical difference which came from the angle of the platform. Because of theta, we had to use sine to solve the equation. This change, as shown in the measured data, slowed the velocity and acceleration down by as much as 15 times the value (between measured acceleration of $4m_1$). There was a vector component to calculate the normal force, but since we weren't counting friction, this was ignored. Had we used friction force (for which we would have been provided μk), we would use the normal force (calculated as cos(theta) multiplied by the force of gravity ($m_g g$).

The error percentage was sizable in comparison to the other experiments done before, and this can be attributed to friction and air resistance. While in the theoretical experiment, we neglected to include Friction force and air resistance (because of their small values), these values likely played a role in the experiment. The likely reasoning behind this is because as the values get smaller (for example in run 3 of part two), the difference that air resistance and friction are having are at a greater proportion. So in larger experiments, the error percentage was around 10%, the lowest one had an upwards of 50% difference, which is a lot.

4 CONCLUSIONS

We learned how to solve problems using Newton's second law and both components to solve the problems. Even though we did not start with the acceleration, by completing the experiment we were able to solve it and determine how close the experiment came towards a theoretical value. This experiment had me questioning how this would change if we used a surface with a higher coefficient of friction, or when the glider has a higher weight. A change I would propose to the experiment is that we use different values of m_h (the suspended mass) instead of just changing m_g (the glider). Overall, it was an enjoyable lab with many learned experiences.