Lab 112: Newton's Second Law

Name: Sundeep Singh Group Number: 1
Student ID: 31454831
Date of Experiment: 9/25/2018 Date of Report Submission: 10/2/2018
Course & section number: Physics 111A-025 Instructor's Name: Mr. Binjie
Partner's names: Marchello Caruso, Muhammad Rana, Antonios Stathopoulos, and Shawn Wahi

1. OBJECTIVE AND BACKGROUND

The objective of Lab 112 is to verify Newton's Second Law in one-dimensional motion system in which a glider of a given mass on a frictionless air track is accelerated by a falling object connected to the glider with a string. Another objective of this lab is to learn how to construct free body diagrams used to show all forces with magnitude and direction acting on an object in the one-dimensional system mentioned above. The final objective of this lab is to understand how to derive the equation for theoretical acceleration from the free body diagrams in the system and to compare the theoretical value of the acceleration to experimental one. Also, we need to keep in mind the relationship between force, mass, and acceleration as given by the formula $a = \frac{\sum F}{m}$, which is written as $\sum F = ma$.

2. EXPERIMENTAL PROCEDURE

This lab experiment has many steps to it, but it is crucial that all of them are done correctly. Before starting anything, the equipment and tools should be checked in order to verify that everything needed for the lab is there. The first step is to secure the string onto the glider and to place weights on the end of the hanging side of the string. The second step would be to log into the computer and open up the correct software under "Lab 112 Dimensional Motion" file on their computer while carefully measuring as well as inputting the length of the flag located on top of the glider into the software. Then measure the mass M of the glider and the distance between the two photogates. Before the lab begins, the photogates have to be plugged into the computer and set up in the right position. Once this is complete, students have to perform step one of the lab. Students will bring the glider to its initial position, which is 15 centimeters ahead of photogate 1, and then let it go, observing the recorded measurements of time and velocity on the computer. Furthermore, students will perform this 2 more times, while adding on mass to the glider in order to study the changes that will be made to acceleration if mass changes. This is repeated two times, both times with different mass and after this is complete, part 2 begins where the track is raised at an incline. To measure the incline, the protractor is used. After the incline is measured, the glider, without any additional mass on it is releases 15 centimeters in front of photo gate one. Similar to part 1, the glider is released 3 times, each time with increasing weights on the glider while the data is being recorded on the computer. Now that velocity at photogate 1 and 2 are given, along with the time it took to get from photo gate 1 to photogate 2, students cause use this information to find the theoretical acceleration.

3. **RESULTS:** CALCULATION

Part 1:

Experimental Acceleration:

A= $\frac{V_{photogate\ 2}-V_{photogate\ 1}}{time} = \frac{1.5154\frac{m}{s}-0.8234\frac{m}{s}}{0.4266\ s}$ = 1.6221 m/s^2

Theoretical Acceleration:

m = hanging mass = 40 g

M_g = mass of glider = 179.4 g

A= $\frac{m-M_g sin\emptyset}{M_g+m} * g$ = $\frac{40\ g-(179.4\ g)*\sin(0)}{179.4\ g+40\ g} * 9.8\ m/s^2$ = 1.7867 m/s^2

Error Analysis:

Percent error= $\left|\frac{Theoretical\ Value-Experimental\ Value}{Theoretical\ Value}\right| * 100$

Percent error= $\left|\frac{1.7867\frac{m}{s^2}-1.6221\frac{m}{s^2}}{1.7867\frac{m}{s^2}}\right| * 100$ = 9.21 %

Part 2: $\emptyset = 3.0°$

Experimental Acceleration:

A= $\frac{V_{photogate\ 2}-V_{photogate\ 1}}{time} = \frac{1.3298\frac{m}{s}-0.7309\frac{m}{s}}{0.4825\ s}$ = 1.2412 m/s^2

Theoretical Acceleration:

m = hanging mass = 40 g

M_g = mass of glider = 179.4 g

$\emptyset = 3.0°$

A= $\frac{m-M_g sin\emptyset}{M_g+m} * g$ = $\frac{40\ g-(179.4\ g)*\sin(3.0)}{179.4\ g+40\ g} * 9.8\ m/s^2$ = 1.3673 m/s^2

Error Analysis:

Percent error= $\left|\frac{Theoretical\ Value-Experimental\ Value}{Theoretical\ Value}\right| * 100$

Percent error= $\left|\frac{1.3673\frac{m}{s^2}-1.2412\frac{m}{s^2}}{1.3673\frac{m}{s^2}}\right| * 100$ = 9.22 %

4. Discussion

Throughout this lab, my group was exposed to many different physics theories and principles in real life. The primary principles/theories we learned in this lab ware Newton's Second Law and how to solve the magnitude and direction acting on an object. Newton's second law was the core of this lab and without it, we could not have solved for the theoretical acceleration. When the lab was done, the percent error calculated by myself was 9.21% for part 1 and a very similar 9.22% for part 2 and this error could have been due to countless reasons. For one, we had a ruler to measure our items instead of a dial caliper. Another possible error in play could have been machine error of the photogates and the motion sensor which seem to be only incremental, but they can have a large effect in the whole experiment. Some of the other tools such as the accuracy of the protractor used. Above all, human error could have been one of the largest errors, but to try to minimize these errors, we took repeated measurements and averaged them. However, as mentioned in the lab manual, there seems to be a very valid question as to whether the linear density of the cord may affect the experiment and I think that it does not. Because the string has a linear density, the mass of the string is spread evenly, thus not posing a huge influence on the affect of the experiment. With that being said, I do believe that imperfections in the string, such as knots and bumps, may hinder the experiment by causing discrepancies and non-continuities. Another assumption that we made is that the table is leveled, but just to comprehend how drastic a change it would have been if the angle was off by 1, the theoretical acceleration could be as far off as 6 % and that is a very considerable change. With all of these possible errors, we were still able to get a moderately low percent error of 9.21% for part 1 and 9.22% for part 2 because the measured acceleration was mostly consistent with the theoretical value.

5. Conclusions

Overall, a tremendous amount has been learned from this lab experiment. For one, I learned that a small variation in angle measurement can lead to a huge error. Adding onto that, it was also learned that the tension in the rope where the mass is hanging is the same tension in the rope connected to the glider. However, there are somethings that I learned need to be improved with this design. One thing that can be improved in the design of the experiment is newer and more efficient measuring tools such as the ruler and compass which have much more accurate counterparts. Another thing that can also be improved is the motion sensor due to the fact that it was giving us inconsistent results for some of the trials.

6. Reference

"Newton's Second Law." *The Physics Classroom*,

www.physicsclassroom.com/class/newtlaws/Lesson-3/Newton-s-Second-Law.

"Double Trouble in 2 Dimensions." *The Physics Classroom*,

www.physicsclassroom.com/class/vectors/Lesson-3/Double-Trouble-in-2-Dimensions.

7. Attachment of Raw Data

Table I:

Total Glider Mass (kg)	Hanging Mass M (kg)	Type	Acceleration (m/s^2)	Time to travel distance L (s)	Velocity at gate 1 V1 (m/s)	Velocity at gate 2 V2(m/s)
Mg	0.04	Theoretical	1.7867			
		Experimental	1.6221	0.4266	0.8234	1.5154
Mg + 2M1	0.04	Theoretical	1.2234			
		Experimental	1.1167	0.5089	0.6937	1.262
Mg + 4M1	0.04	Theoretical	0.9302			
		Experimental	0.8728	0.5829	0.6012	1.11

Table II:

Total Glider Mass (kg)	Hanging Mass M (kg)	Type	Acceleration (m/s^2)	Time to travel distance L (s)	Velocity at gate 1 V1 (m/s)	Velocity at gate 2 V2(m/s)
Mg	0.04	Theoretical	1.3673			
		Experimental	1.2412	0.4825	0.7309	1.3298
Mg + 2M1	0.04	Theoretical	0.7746			
		Experimental	0.7674	0.6269	0.5651	1.0462
Mg + 4M1	0.04	Theoretical	0.4660			
		Experimental	0.4543	0.7966	0.4445	0.8064