Physics Laboratory Report

Lab number and Title: Lab 111 – Projectile Motion

Name: Arsh Bhamla **Group ID: 3**

Date of Experiment: 09/28/2023 **Date of Report Submission: 10/05/2023**

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

Partners' Names: Logan Chappel, Jose Tabuena, Connor Nguyen

1. INTRODUCTION (10 points)

This experiment had us review two-dimensional motion in order to track the trajectory of a ball. The purpose was to have us determine the unknown variables of the five we learned in class (velocity, acceleration, direction (theta), change in x (Δx) and change in y (Δy)). We were able to do so by applying the kinematics formulas and using both parts of the vectors (the x and y values) to solve for our variables. The experiment is split into two important parts. The first part had us set a horizontal trajectory and determine two catchers, while part two had us put the ball at a 60-degree trajectory and use our previously learned knowledge to apply.

We are already familiar with one dimensional motion, and the formulas for velocity and position. As we learned in class, we are able to apply the same formulas into two dimensional vectors so long as we separate the x and y component. Furthermore, we can solve for a value in a one-dimensional equation so long as we have at least three of the values given to us. However, using two-dimensional vectors, we can plug information back and forth to figure out the answer despite only be given two values (rather than three). Lastly, when dealing with objects shot at an angle from a height, we learned that we could split the project between the start to when it levels again, and then the rest of it. That way we can apply our understanding on a better filled set of data points to solve for our problem.

1 EXPERIMENTAL PROCEDURE (10 points)

Part One

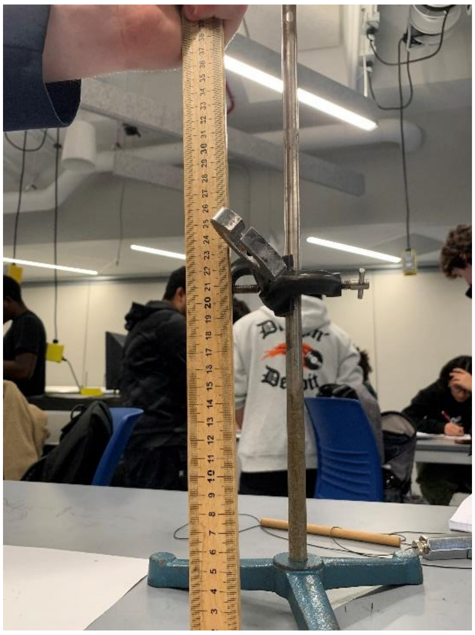
The full procedure is described in the manual and in the instructions provided in class. In summary, we set up a mini launcher with no angle at the end of the table and launched a small metal ball to find the initial velocity. We took data of the average distance, determined time, and from that found the initial velocity of the ball. We then used that velocity to determine the distance of two catchers, which the ball is meant to go through.

Givens:

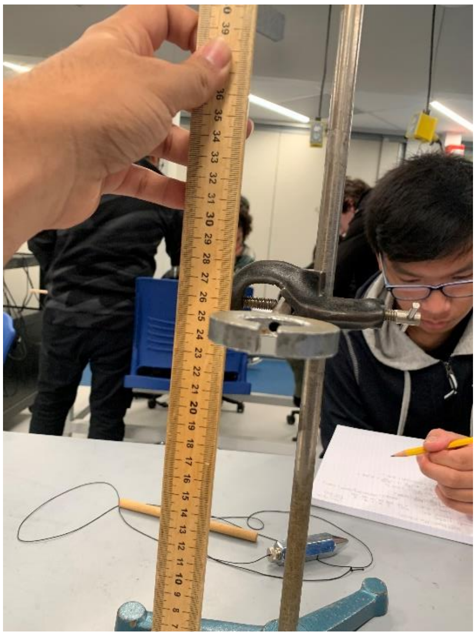
- Height of launcher (Y initial)
- Height of Catcher 1 (Y1)
- Height of Catcher 2 (Y2)
- X total (xf)
    - This was measured in our experiment by taking an average of 5 trials.

Angle of launcher (0 degrees)

Height of launcher (0.5m)



Height of Catcher 1 (0.2m)



Height of Catcher 2 (0.25m)

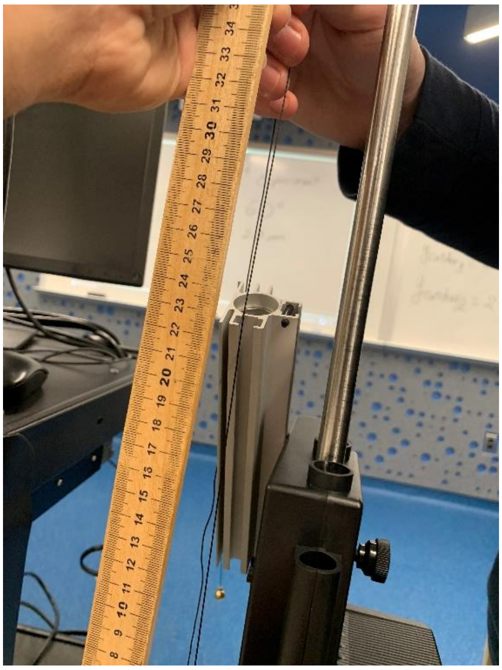
Was adjusted after photo was taken

Part Two

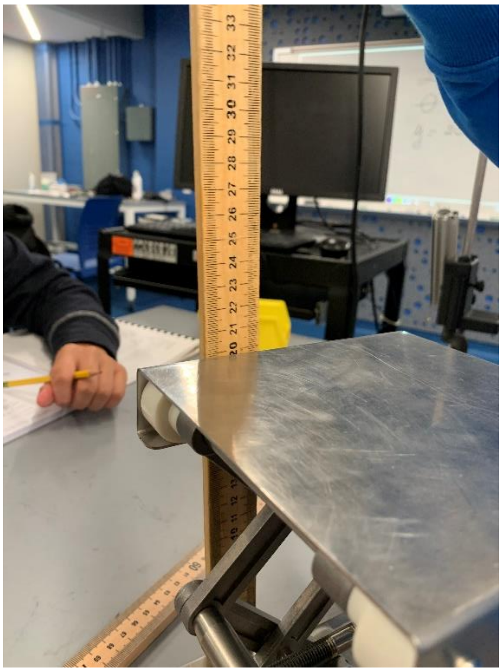
The procedure for part two is also in the manual. In summary, the launcher was set at an angle with the end having a 20cm platform (which is equal to the height of the ball launcher) to determine the initial velocity of the object. We had to apply our understanding of trigonometry to utilize the vector's components (this uses cosine and sine to represent x and y, respectively).

Givens:

- Height of launcher (Y initial)
- Height of platform 1 (Y1)
- Direction of launcher (ϴ)
- X total (xf)
    - This was measured in our experiment by taking an average of 5 trials.



Height of Launcher (0.2m)



Height of Platform (0.2m)

Angle of Launcher (60 degrees)

2 RESULTS (30 points in total)

Part One

Trial	1	2	3	4	5	Average
Value of x	1.006m	1.011m	1.019m	1.035m	1.036m	1.024m

Variables	How to Get Them	Value
Y_0 (Height of Launcher)	Given	0.50m
Y_1 (Height of Catcher 1)	Given	0.20m
Y_2 (Height of Catcher 2)	Given	0.25m
X_{total} (Distance of ball)	Measured in experiment	1.024m (chart above)
T_{total} (Time)	Calculated	0.319s
V_0 (Initial velocity of the ball)	Calculated	3.20 m/s
T_1 (Time to get to catcher 1)	Calculated	0.247s
X_1 (Distance of catcher 1)	Calculated	0.790m
T_2 (Time to get to catcher 2)	Calculated	0.226s
X_2 (Distance of catcher 2)	Calculated	0.723m

Lab III

Calculations

Part 1

Trial	1	2	3	4	5
Value of x in meters	1.006m	1.011m	1.019m	1.035m	1.036 m

$X_{avg} = 1.024$ meters or 1,024 mm

$y_0 = 0.5$ m, $V_{0x} = ?$, $t = ?$

$\cancel{y} = y_0 + \cancel{V_{0y}t} + \frac{1}{2}gt^2 \rightarrow 0 = y_0 + \frac{1}{2}gt^2$

$\rightarrow -y_0 = \frac{1}{2}gt^2 \rightarrow \sqrt{\frac{-2y_0}{g}} = t \rightarrow t = \sqrt{\frac{-2(0.5)}{-9.8}}$

$t = 0.319$ s

$x = \cancel{x_0} + V_{0x}t + \cancel{\frac{1}{2}at^2} \rightarrow x = V_{0x}t \longrightarrow V_{0x} = x/t$

$V_{0x} = \frac{1.024}{0.319} \rightarrow \boxed{V_{0x} = 3.20 \text{ m/s}}$

Part 2

$y_0 = 0.5$ m, $y_1 = 0.2$ m, $y_2 = 0.25$ m

Catcher 1

$y_1 = y_0 + \cancel{V_0t} + \frac{1}{2}gt^2$

$t = \sqrt{\frac{2(y_1 - y_0)}{g}}$ $t = 0.247$ s

$x = \cancel{x_0} + V_0t + \cancel{\frac{1}{2}at^2}$

$x = (3.20)(0.247)$

$\boxed{x_1 = 0.790 \text{ m}}$

Catcher 2

$y_2 = y_0 + \cancel{V_0t} + \frac{1}{2}gt^2$

$t = \sqrt{\frac{2(0.25 - 0.5)}{-9.8}}$ $t = 0.226$ s

$x_2 = \cancel{x_0} + V_0t + \cancel{\frac{1}{2}at^2}$

$x_2 = (3.20)(0.226)$

$\boxed{x_2 = 0.723 \text{ m}}$

Part one and two in the image represent the two portions of experiment 1. They involve the horizontal ball. Experiment 2 is in the section below.

Part Two

Trial	1	2	3	4	5	Average
Value of x	0.983m	0.986m	0.989m	0.991m	0.999m	0.99m

Variables	How to Get Them	Value
Y_0 (Height of Launcher)	Given	0.20m
Y_1 (Height of Platform)	Given	0.20m
Ɵ (Angle of Launcher)	Given	60°
X_r (Distance to platform)	Measured in experiment	0.99m
T_r (Time to platform)	Calculated	0.35s
X_{total} (Distance of ball)	Calculated	2.43m
T_{total} (Time to land)	Calculated	0.475s
V_0 (Initial velocity of the ball)	Calculated	5.14 m/s

Lab III

Calculations

Trial	1	2	3	4	5
Value of x in m	0.983m	0.986m	0.989m	0.991	0.999

$x_{avg} = 0.99m$ (to platform)

0.475
1.220m

$x = x_0 + V_0\cos(\theta)t + \tfrac{1}{2}at^2$ $\quad y = y_0 + V_0\sin(\theta)t + \tfrac{1}{2}gt^2$

$\cancel{y} = \cancel{y_0} + V_0\sin(\theta)t + \tfrac{1}{2}gt^2$, $V_0 = \dfrac{\tfrac{1}{2}gt^2}{\sin(\theta)t}$

$x = \cancel{x_0} + V_0\cos(\theta)t + \cancel{\tfrac{1}{2}at^2}$

$x = \dfrac{gt^2\cos(\theta)\cancel{t}}{2\sin(\theta)\cancel{t}} \rightarrow x = \dfrac{gt^2\cos(\theta)}{2\sin(\theta)}$

$\left(t = \sqrt{\dfrac{x\cdot\sin(\theta)2}{g\cos(\theta)}}\right) \rightarrow t = \sqrt{\dfrac{.99\sin(60°)}{9.8\cos(60°)}}$

$t_r = 0.349944959\ s$

$x = \cancel{x_0} + V_0\cos(\theta)t + \cancel{\tfrac{1}{2}at^2} \rightarrow x = V_0\cos(\theta)t$

$V_0 = \dfrac{x}{\cos(\theta)t} \rightarrow V_0 = \dfrac{0.99}{\cos(60°)(.349944959)} \rightarrow \boxed{V_0 = 5.14\ m/s}$

$y = \cancel{y_0} + V_0\sin(\theta)t + \tfrac{1}{2}at^2$

$y - V_0\sin(\theta)t = \tfrac{1}{2}at^2 \rightarrow y - V_0\sin(\theta) = \tfrac{1}{2}at$

$\rightarrow \dfrac{2(y - V_0\sin(\theta))}{a} = t \rightarrow t = \left(\dfrac{2(-0.2 - 5.14\sin(60°))}{-9.8}\right)$

$t_{max} = 0.9498\ s \quad x = \cancel{x_0} + V_0\cos(\theta)t + \cancel{\tfrac{1}{2}at^2}$

$x = 5.14\cos(60)(.9498) = 2.439m$

3 ANALYSIS and DISCUSSION (20 points)

For experiment one, we used our recently learned understanding of the projectile formulas to solve the equation. The object was shot horizontally (and therefore had no vertical initial velocity), allowing it to simplify the vector's components from the singular formula. We first solved for the time it took to hit the ground, and using that, we could solve for the initial velocity. In the follow up question for the same experiment, we had to find out the distance of the catchers from the launcher so that it would be able to land through the middle ring. We were given the height of these catchers, so the location had to be precise, or the ball would either bounce off, or miss completely. My group determined that it would be smart to solve for time using the y component, then plug that time into the x component to get the distance.

For experiment two, we were given a slightly altered experiment. The launcher was set up at an angle, which required us to then use sine and cosine to solve. From the y component I solved for V initial, and then plugged the new set of values into the x component (since V initial in both are the same). Afterwards I solved for time, then used that to solve for the initial velocity of the ball. This was able to be done since the height of the platform was the same as the launcher, so we could assume that y initial and y final were 0 (in respect to one another).

Determining the error percentage is difficult considering some of the values were only taken in the measured factor, without any theoretical value. This applies to both part one and two of the experiment for the x value we we calculated in the trials. However, there was around 1-2 millimeters variations where we just rounded the value. This comes to 0.001*100% = 0.1% error percentage on those values. The values in the calculations too were also rounded to the thousandths place, meaning that the error percentage was also in the millimeter level. Therefore the highest error percentage was from the height of the platform/catcher 1, which was 0.5%. Averaged out, this leaves us with a 0.3% error percentage.

4 CONCLUSIONS (10 points)

We learned how to solve for problems by utilizing both components of a vector quantity, and how we can alter formulas to make sure we do not have more than two unknown vectors at a time. Even though we started with not a lot of information, we were able to derive things using our understanding of physics. The experiment had me questioning how we could do this on a three-dimensional plane considering that we only used the x and y components. Another change to see is to include air resistance since we did not calculatre for it in our lab. Overall, it was an enjoyable lab with many learned experiences.