Physics Laboratory Report

Lab number and Title: Lab 106 – Static and Kinetic Friction

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Date of Experiment: 09/14/2023 **Date of Report Submission: 09/21/2023**

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

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

1. INTRODUCTION

1.1 Objectives

This lab, Lab 106, is about understanding and using static and kinetic frictions, which are prevalent in our everyday lives. In our previous labs, we had ignored the use of friction in favor of simpler forces, but now we are subject to understanding how to put friction in as well. Our objective is to pull objects of different weight and determine how the coefficients of static and kinetic friction change. From this, we can reinforce the idea taught in class that the force of friction (which is in the x vector) is dependent on the normal force (which is in the y vector).

1.2 Theoretical background

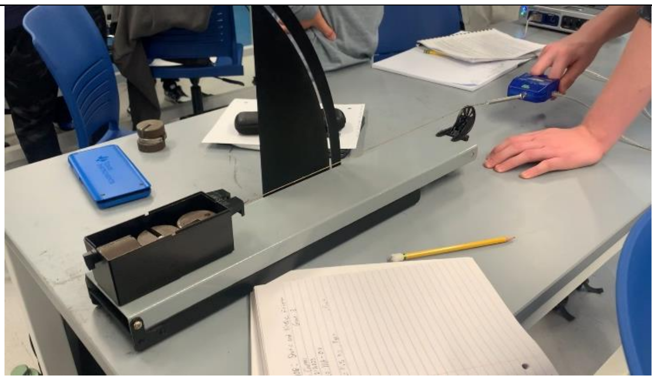
We are already familiar with F = ma for both the x and y components, having used it in our previous labs. However, this time for the x vector we will have to include the force of friction, which runs opposite of the applied force. Furthermore, in class we were taught that the force of friction is equal to mu(s/k) *Fn, where mu(s/k) represents the coefficient of static or kinetic friction, and Fn represents the normal force calculated through the y vector.

When at a horizontal plane (0 degrees incline), the Fn is simply equal to Fg (or mg), but in the later experiment we raised the platform to see changes in the force of friction.

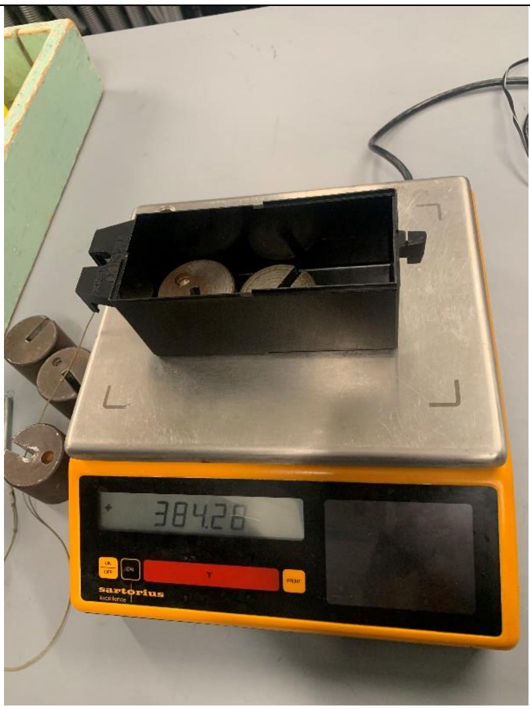
2 EXPERIMENTAL PROCEDURE

Experiment One

Our group followed the directions in the lab manual. In summary, it involved us doing 5 experiments, one of each at a different weight, where we pulled the mass using a string to find the static and kinetic frictions. The platform was at 0 degrees.

Trial #	Actual Weight	Experiment Setup
#1 1500g	 1582.66g	 Mass is connected through string over a pully to a sensor. Sensor calculates values on the computer. 0-degree incline, mass shown on left.

#2 1200g	 1283.28g	 Mass is connected through string over a pully to a sensor. Sensor calculates values on the computer. 0-degree incline, mass shown on left.
#3 900g	 983.65g	 Mass is connected through string over a pully to a sensor. Sensor calculates values on the computer. 0-degree incline, mass shown on left.

#4 600g	 683.90g	 Mass is connected through string over a pully to a sensor. Sensor calculates values on the computer. 0-degree incline, mass shown on left.
#5 300g	 384.26g	 Mass is connected through string over a pully to a sensor. Sensor calculates values on the computer. 0-degree incline, mass shown on left.

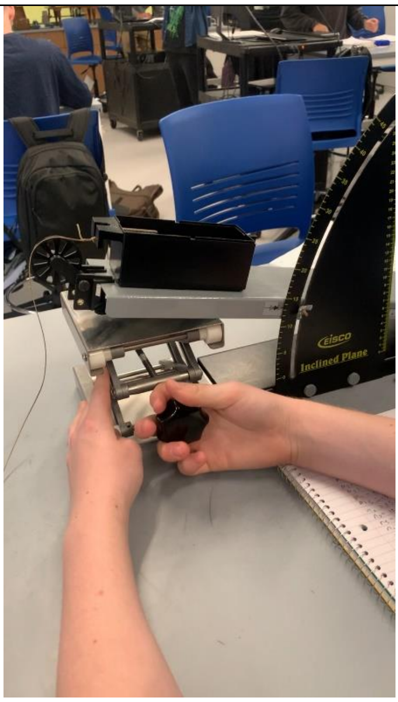
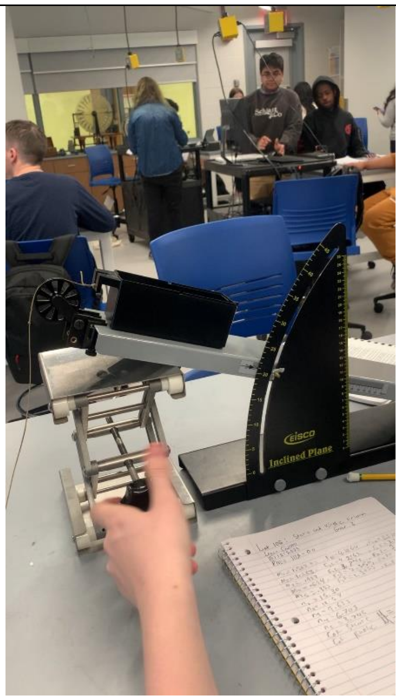
Variables

- Mass of Weight (m)
- Gravity (g)
- Coefficient of static friction (Ms)
- Coefficient of kinetic friction (Mk)

Experiment Two

Experiment two was split into two parts. The first part had us test for the angle of theta where the mass begins sliding without having to be pushed. We did this three times and found an average. The second part gave us set variables for which we had to run similar trials as in experiment one (pull the string up the incline) and recognize the difference.

Part One

	
Setup of Experiment	Highest Point for Trial 1

Variables

- Angle (Θ)
- Mass (m)
- Acceleration due to gravity (g)

Part Two

Theta = 10-degrees

Setup of Part Two

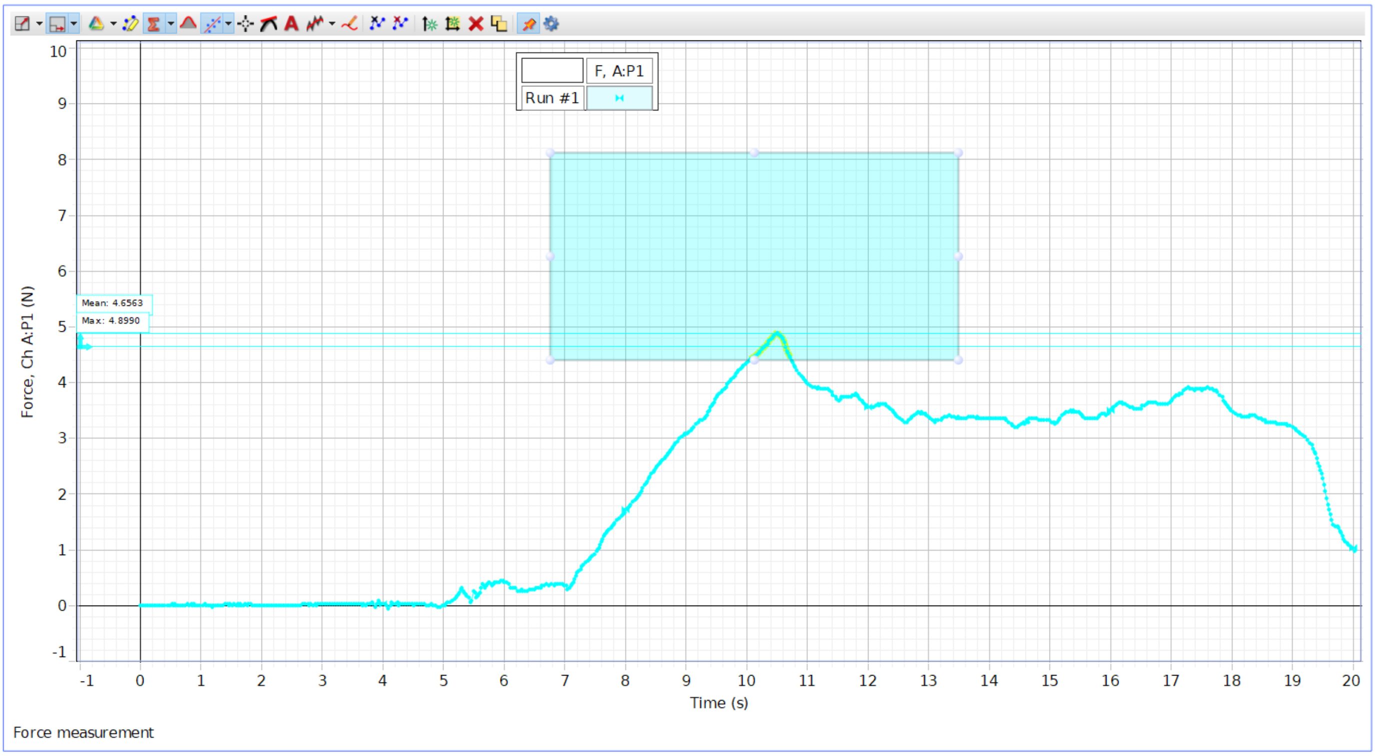
Variables

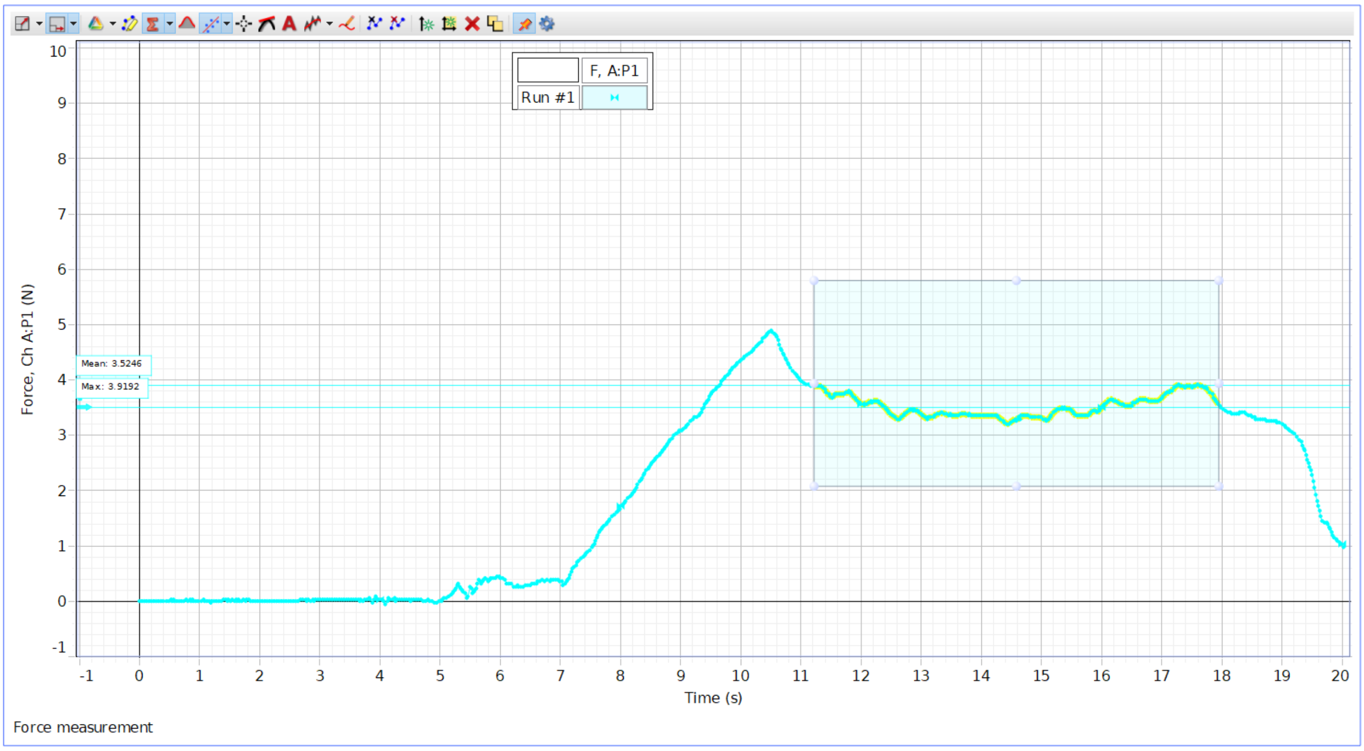
- Angle (Θ)
- Mass (m)
- Acceleration due to gravity (g)

3 RESULTS

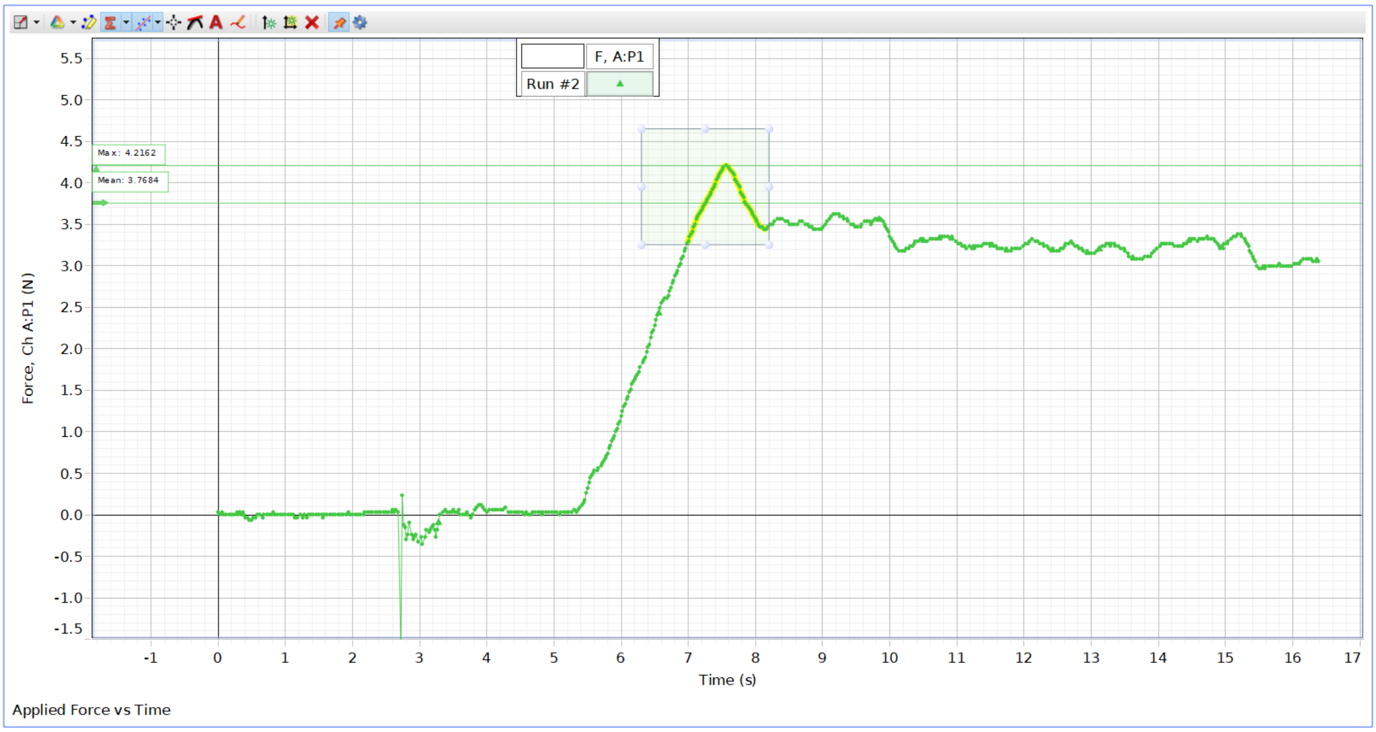
Experiment One

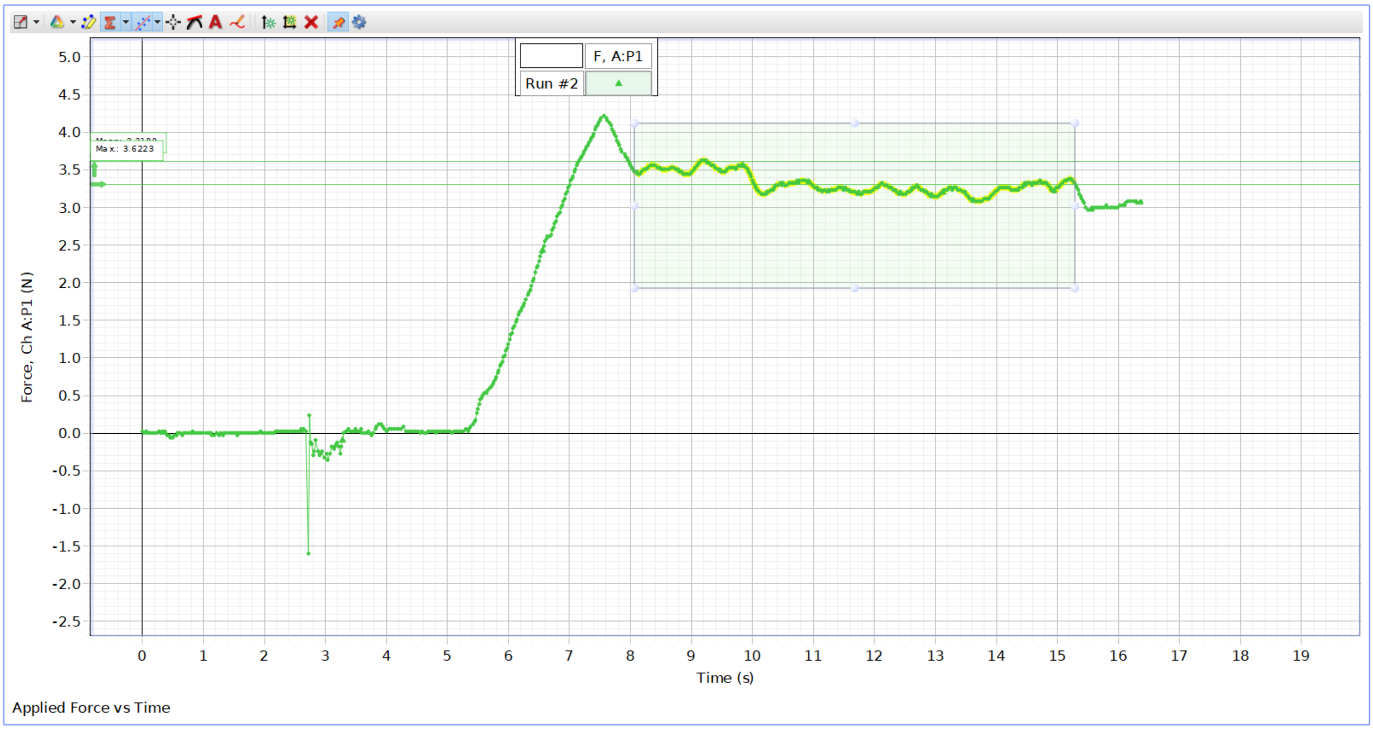
1500g Weight



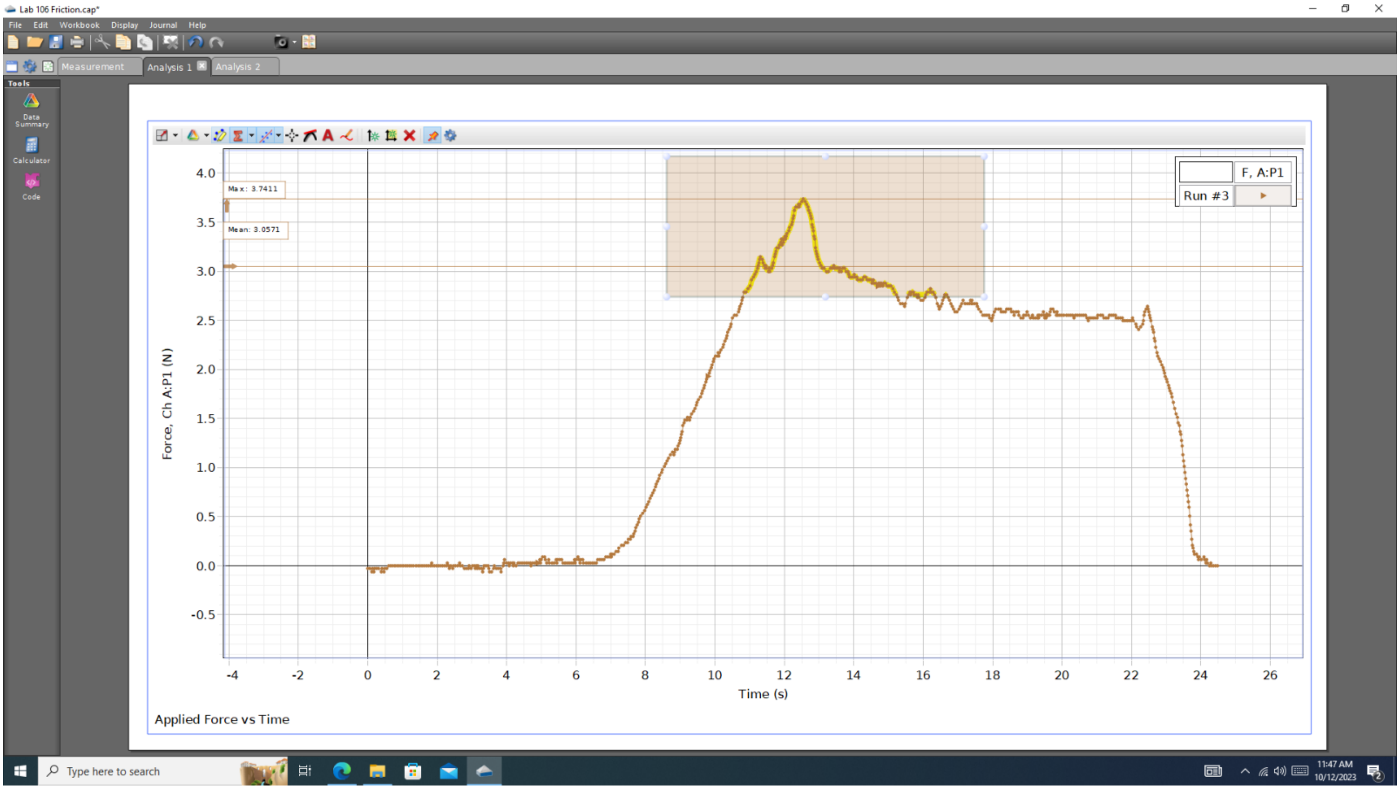


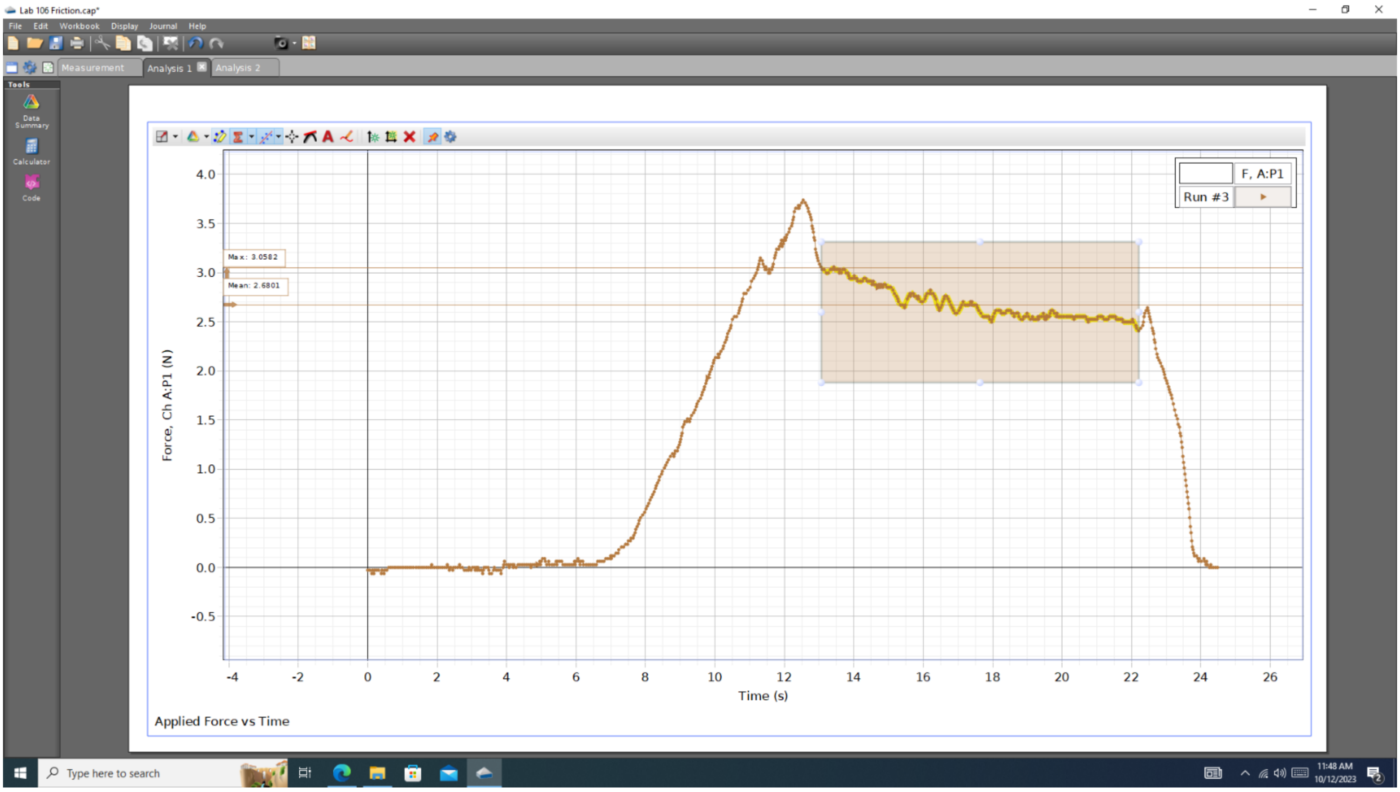
1200g


F, A:P1
Run #2
Max: 4.2162
Mean: 3.7684
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time

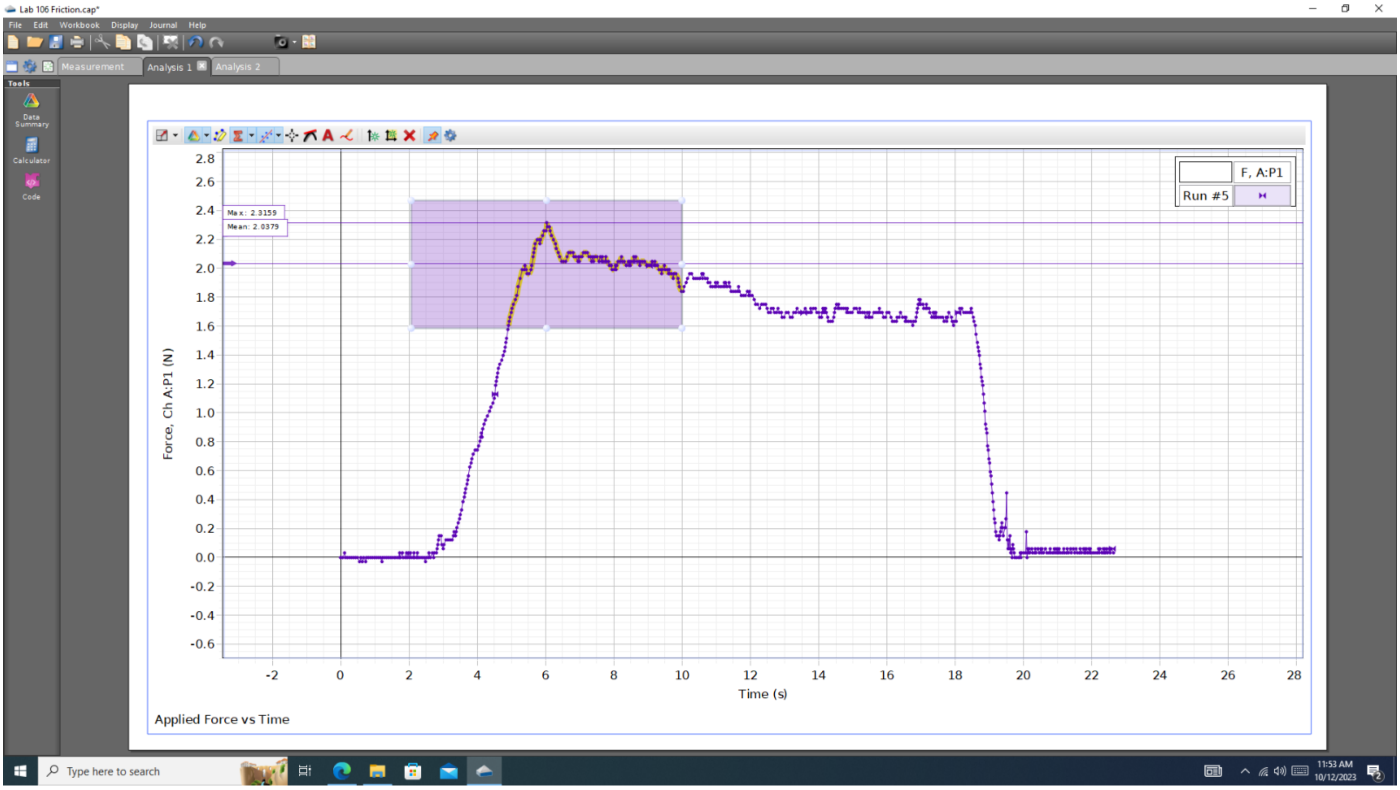

F, A:P1
Run #2
Max: 3.6223
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time

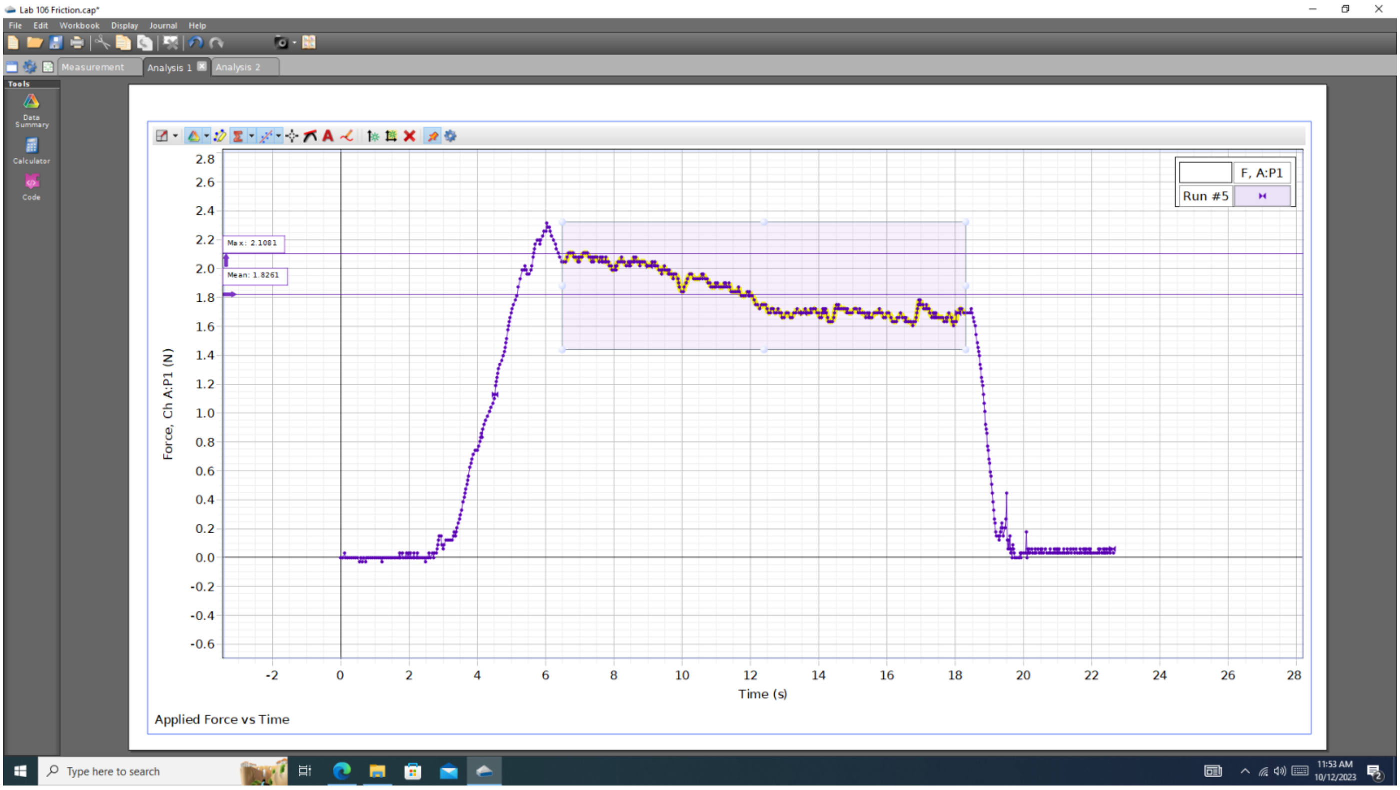
900g


Lab 106 Friction.cap*
File Edit Workbook Display Journal Help
Measurement
Analysis 1
Analysis 2
Tools
Data Summary
Calculator
Code
Max: 3.7411
Mean: 3.0571
F, A:P1
Run #3
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time
Type here to search
11:47 AM
10/12/2023

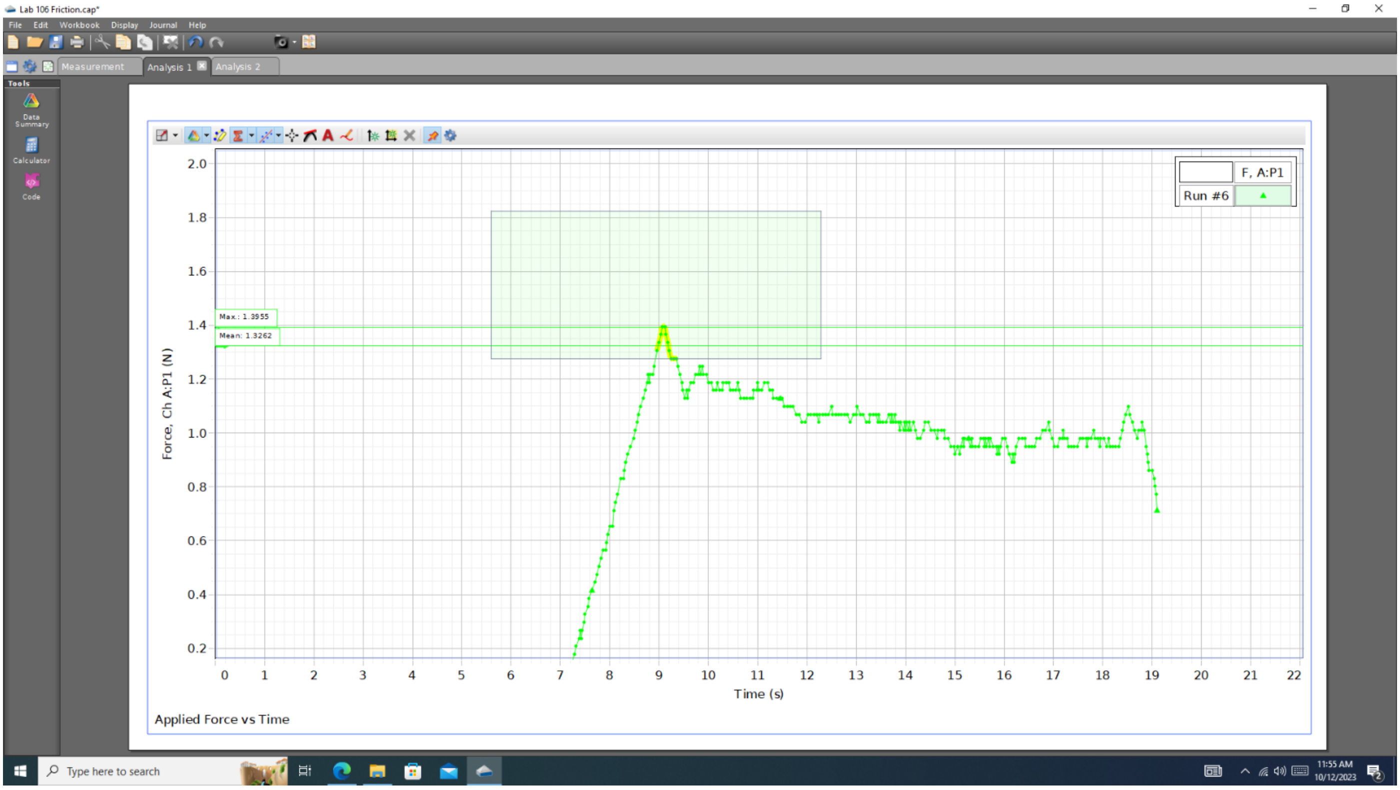

Lab 106 Friction.cap*
File Edit Workbook Display Journal Help
Measurement
Analysis 1
Analysis 2
Tools
Data Summary
Calculator
Code
Max: 3.0582
Mean: 2.6801
F, A:P1
Run #3
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time
Type here to search
11:48 AM
10/12/2023

600g


Lab 106 Friction.cap*
File Edit Workbook Display Journal Help
Measurement
Analysis 1
Analysis 2
Tools
Data Summary
Calculator
Code
F, A:P1
Run #5
Max: 2.3159
Mean: 2.0379
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time
Type here to search
11:53 AM
10/12/2023


Lab 106 Friction.cap*
File Edit Workbook Display Journal Help
Measurement
Analysis 1
Analysis 2
Tools
Data Summary
Calculator
Code
F, A:P1
Run #5
Max: 2.1081
Mean: 1.8261
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time
Type here to search
11:53 AM
10/12/2023

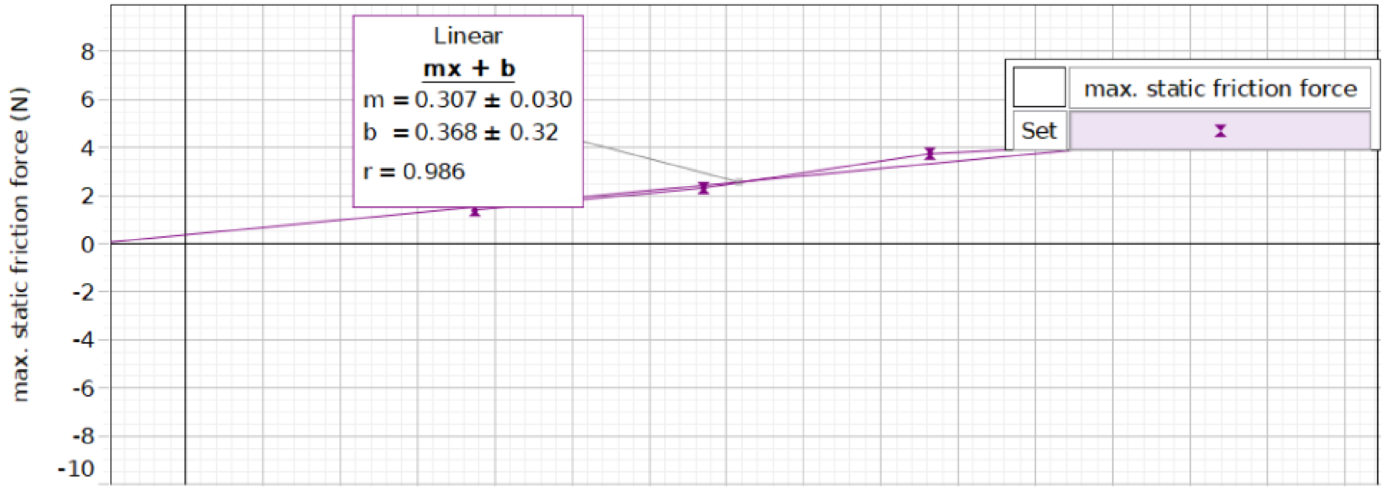
300g



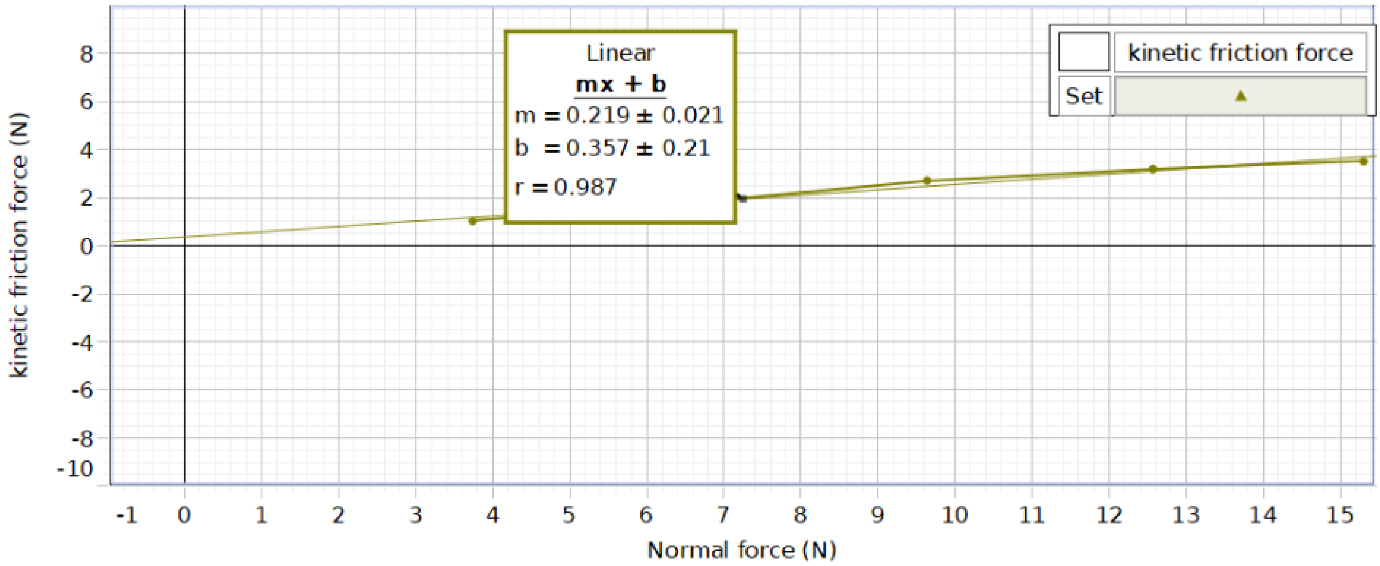
Mass	Static and Kinetic Friction
1500g	S: 4.885N, K: 3.525N
1200g	S: 4.216N, K: 3.180N
900g	S: 3.741N, K: 2.689N
600g	S: 2.316N, K:1.826N

300g	S: 1.395N, K: 1.042N

For the calculated frictional force, I used the value of μs and μk to plug into the equation.



Coefficient of Static Friction: 0.307



Friction Force vs. Normal Force

Coefficient of Kinetic Friction: 0.219

No calculations are needed for part one since this was done just by the experiment and collecting data.

Experiment Two

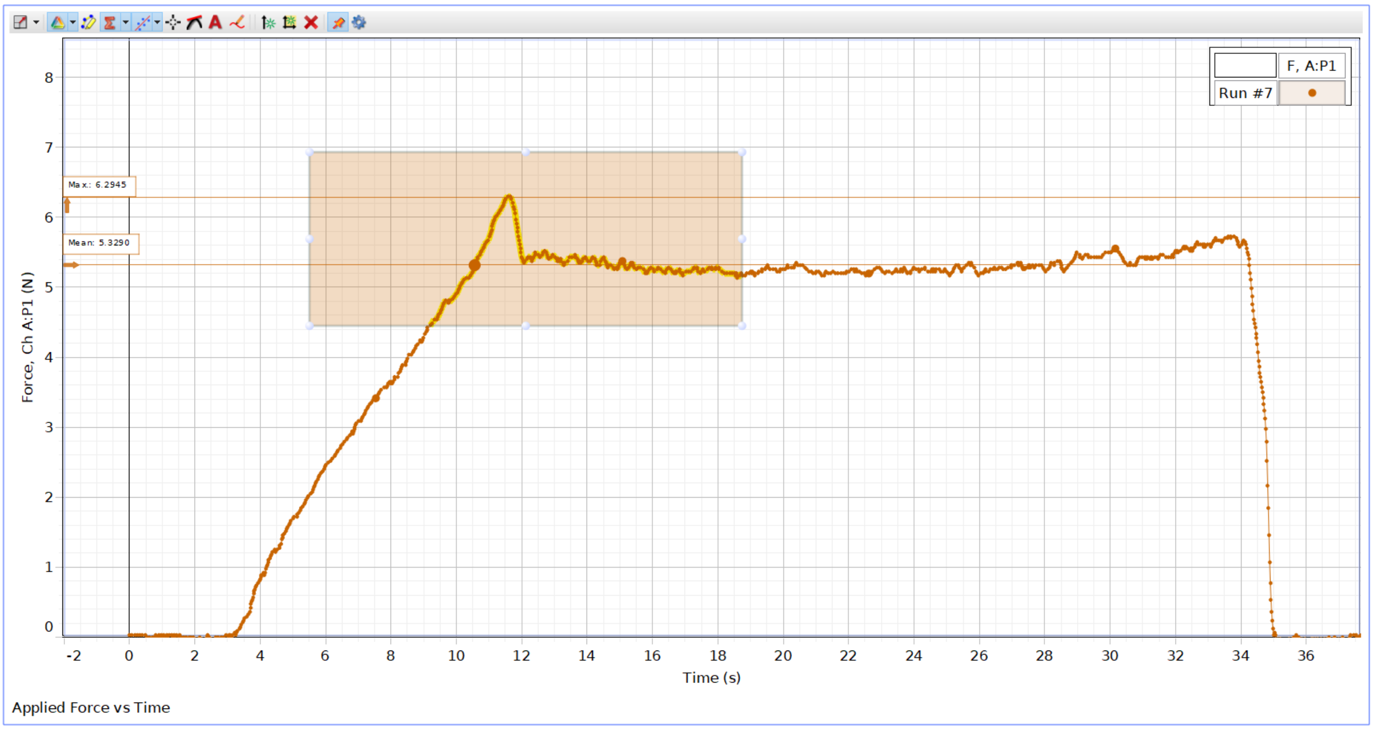
Part One

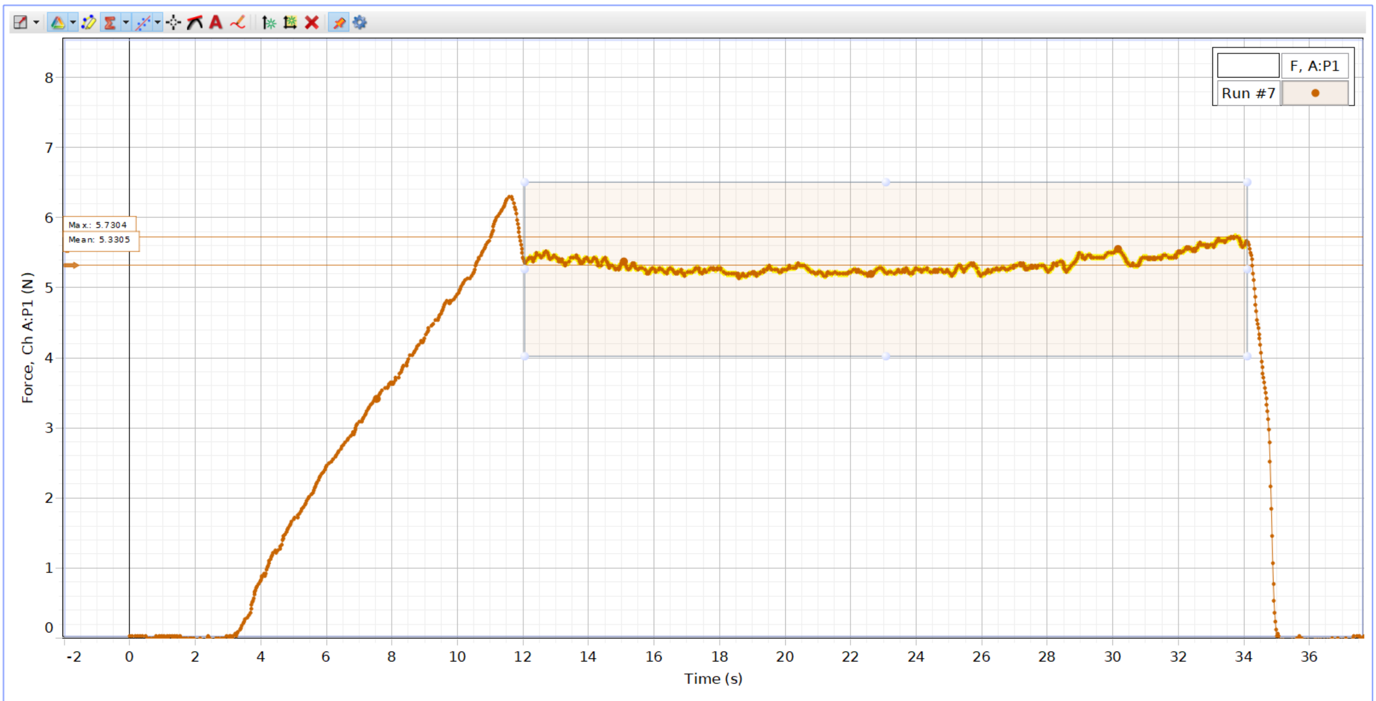
Trial	Angle
#1	21°
#2	22°
#3	22.5°
Average	21.8 OR 22 (in significant figures)

No calculations are needed for part one since this was done just by the experiment and collecting data.

Part Two

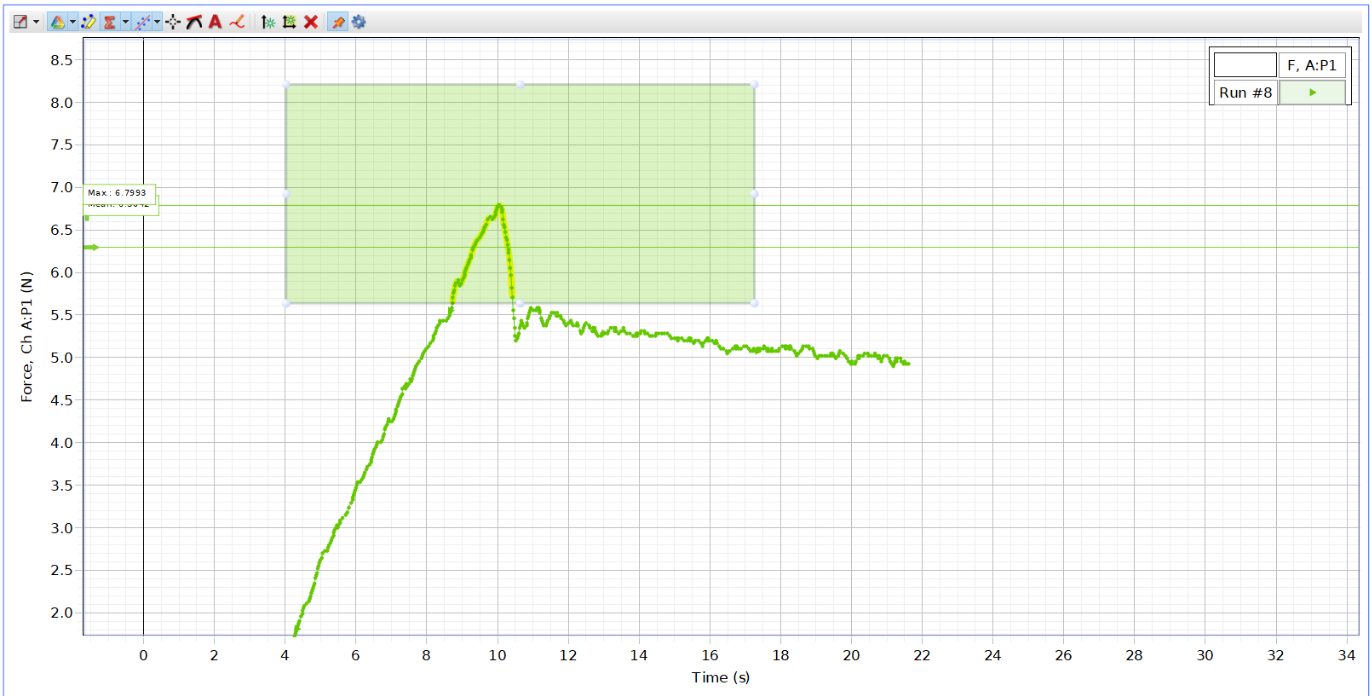
Trial One



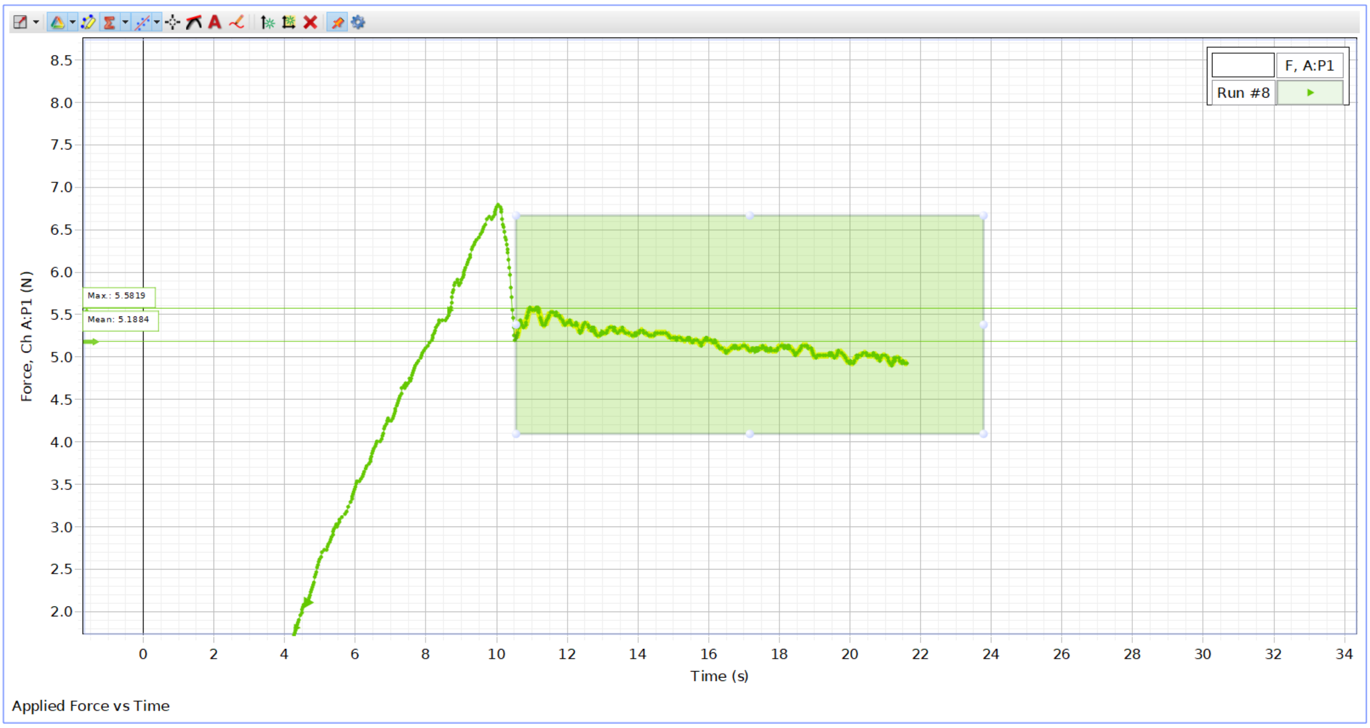


Applied Force vs Time

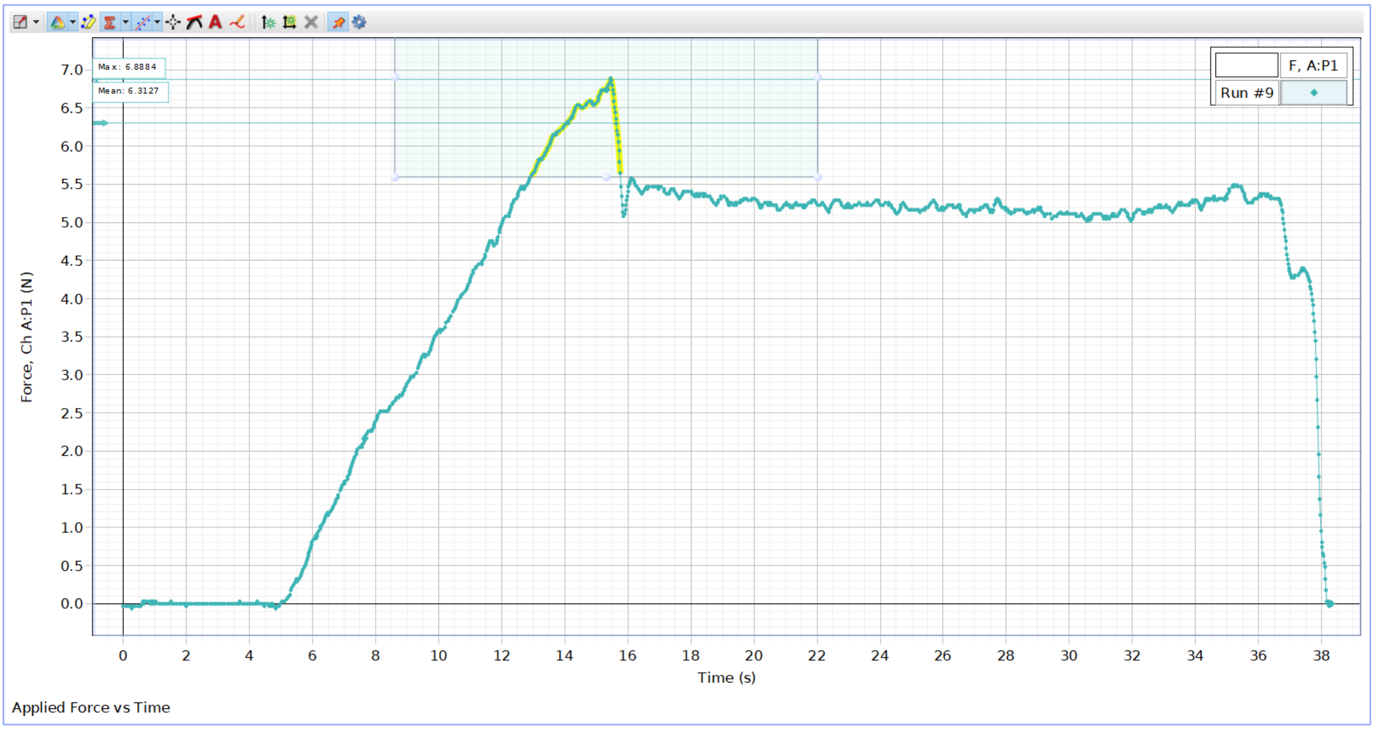
Trial Two

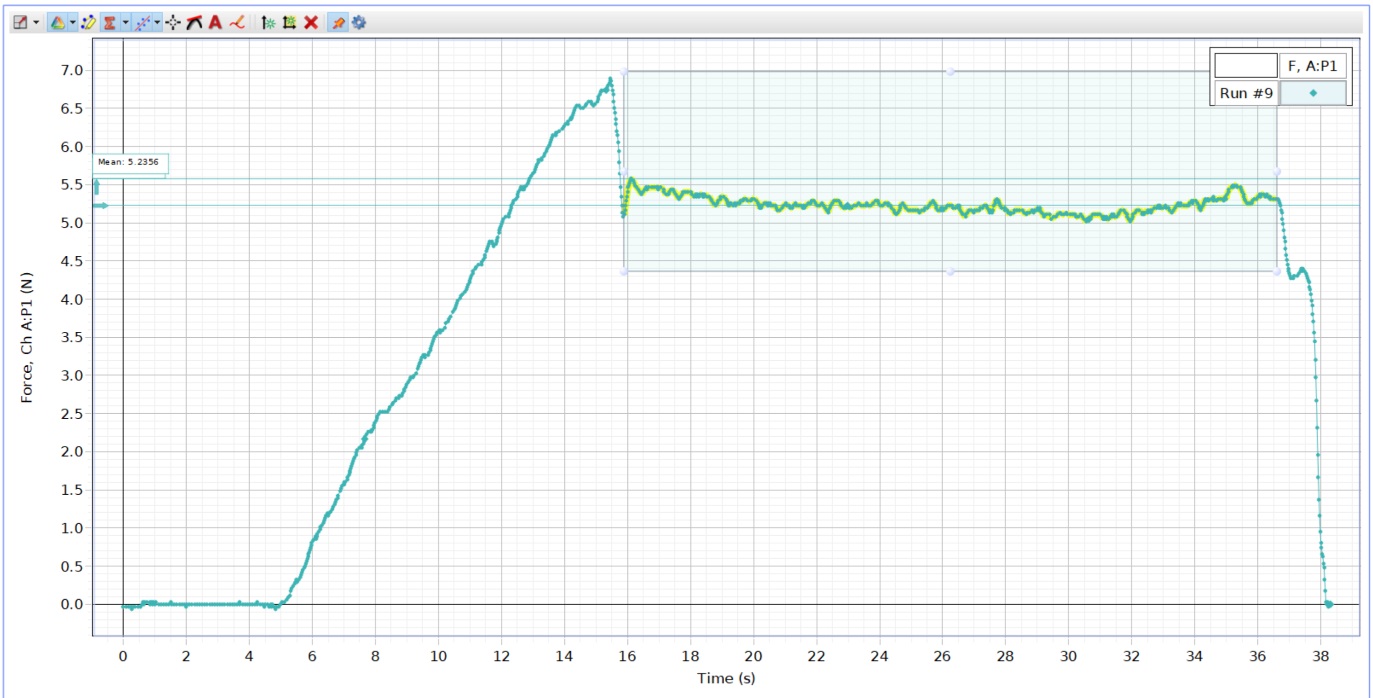


Applied Force vs Time


F, A:P1
Run #8
Max: 5.5819
Mean: 5.1884
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time

Trial Three


F, A:P1
Run #9
Max: 6.8884
Mean: 6.3127
Force, Ch A:P1 (N)
Time (s)
Applied Force vs Time



Applied Force vs Time

Lab 106

Calculations

$\mu_s = 0.307$, $\mu_k = 0.219$ (taken from exp 1)

$F_{sf} = \mu_s F_n \cos(\theta)$ $\quad$ $F_{sf} = (0.307)(12.57N)(\cos 10^\circ)$

$F_{sf} = 3.80N$

$F_{kf} = \mu_k F_n \cos(\theta)$ $\quad$ $F_{kf} = (0.209)(12.57N)(\cos 10^\circ)$

$F_{kf} = 2.71N$

$\Sigma F_y = 0 \rightarrow F_n - mg = 0$ $\quad$ $F_n = mg$

$F_n = (1.283kg)(9.8 m/s^2)$ $\quad$ $F_n = 12.57N$

	Theoretical	Measured
Static Friction	3.80N	6.6607N (EP: 75.3%)
Kinetic Friction	2.71N	5.2515N (EP: 94.5%)

Used the formula |(Measured – Theoretical / Theoretical| * 100

4 ANALYSIS and DISCUSSION

The two formulas that were used during the calculation of the theoretical values were the use of Newton's Second Law (ΣF = ma) and the definition of Force of Friction (Ff = μ(s/k)Fn). Fn can be solved using Newton's Second Law in the y vector, and then substituted within the force of friction formula to get what we are looking for. There were no calculations for this part in order to find μs and μk because the values can not be solved. This is because the value of Force of Friction and μf (for both s and k) were unknown, which means we wouldn't be able to solve for the equation. However, when solving Ff after knowing μf, we were able to match that up and reach a near value to the value that the computer provided.

For experiment two, part one, we did not have calculations, and it was simply testing. We just ran the experiment three times and jotted down the values and evaluated. The result was that the force of friction decreases as the angle increases, and at some point, the value of friction becomes lower than the value of cos(ϴ)mg, or the force of gravity. For part two, we were given set values, and had to calculate for the answer. This experiment however had one major problem; the error percentage was very high. The values for these are close to 100%, which would mean that one of the two values is highly inaccurate. Alternatively, I believe that the reason the error percentage is so high is due to rounding error and perhaps the unforeseen factors that may affect the experiment. Also having used the muk and mus from the first experiment was possibly not correct, as the values dramatically shifted between experiments one and two. However, this still satisfies the objective of the experiment.

There were three questions within the lab manual. Question one, referring to the graph in the manual, asks about the motion at the different points. At A, the acceleration is increasing. At B, acceleration has reached its maximum but has stopped increasing. At this point the acceleration is constant but not for long. At point C, the acceleration begins decreasing, thus making the force value decreasing. Lastly at point D, the force is constant, so the acceleration is constantly being applied. The next question asks if the normal force affects the coefficient of friction, and the answer is no. The coefficient is dependant on the type of materials that are interacting with one another, and Fn is calculated separately to get force of Friction. Last question asks about trends between the coefficient of kinetic and static friction. Simply put, static is always higher than kinetic coefficients.

5 CONCLUSIONS

We learned how to solve problems using Newton's second law and the definition of the force of friction to solve for the problems displayed in the labs. We were able to go back and force between the x and y vector (during experiment two) to calculate for these values and get a better understanding of how friction works. This experiment had me questioning how this would change if we used a different surface with a higher coefficient of friction, because our lab cut short the different materials and how they affect the situation. A change I would propose to the experiment is that we use different values of. Overall, it was an enjoyable lab with many learned experiences.