Newton’s Laws Lab

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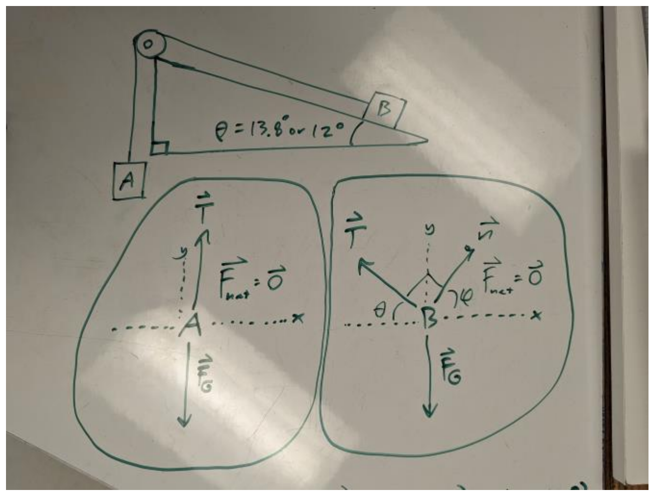
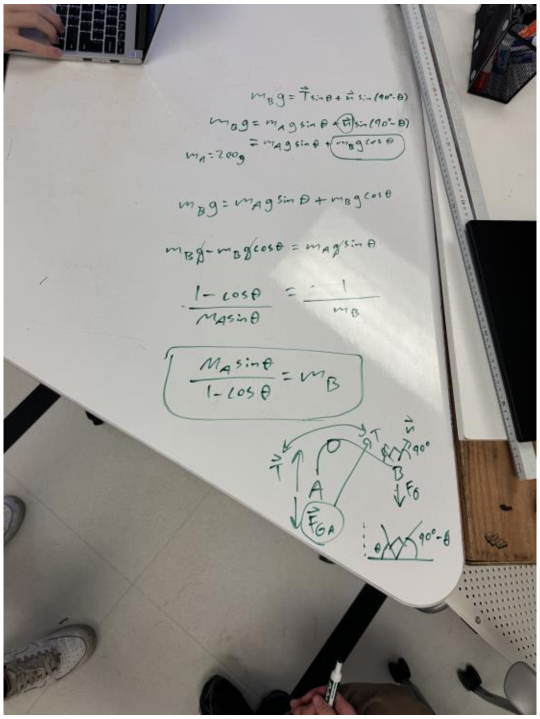
Introduction

Newtons laws are some of the most fundamental concepts to our understanding of physics. Force disturbs the state of an equilibrium and Newtons second law assumes the identity of a force and describes how an object responds to it (Randall D Knight). Through this lab we explored the concept of motion using force and learned how to apply them to real world scenarios and broaden our understanding of the *forces* at play in our daily lives.

Experiment 1: The Classic Senseless problem

In this experiment, we found ourselves tasked with estimating the mass of a cart, given a known weight, a string and an inclined plane. To do this, we would attach the weight to the cart with the string, then by moving the inclined plane around, we could find an angle at which the cart remains stationary and take our measurement, which we measured to be around 12 degrees. With all necessary forces identified, we could now draw out the problem.





Pictured above are our free-body diagrams, alongside a diagram of each component. The left box shows the forces at play on *Mass A*, our 200g weight, The right most diagram demonstrates the forces acting on the cart, Mass B. Note that for each, the net force is zero. From here, our goal of finding the mass of the cart is within grasp. Starting with the equation:

$$m_B g \ = \ T\sin(\theta)\, n\sin(90-\theta)$$

With some algebraic manipulation, the whole process is visible in the image to the left, we were finally able to derive the equation in terms of m_B.

$$\frac{m_A \sin(\theta)}{1-\cos(\theta)} = m_B$$

Our estimate, using the directly measured version of θ , ended up being approximately 962g. We believe this to be a reasonable estimate, as the cart was not very large or heavy when we were tasked with moving it around. Of course, to get a better estimate of the cart's mass, we would need to either measure it directly, or find another way to measure the mass, but without directly measuring the weight.

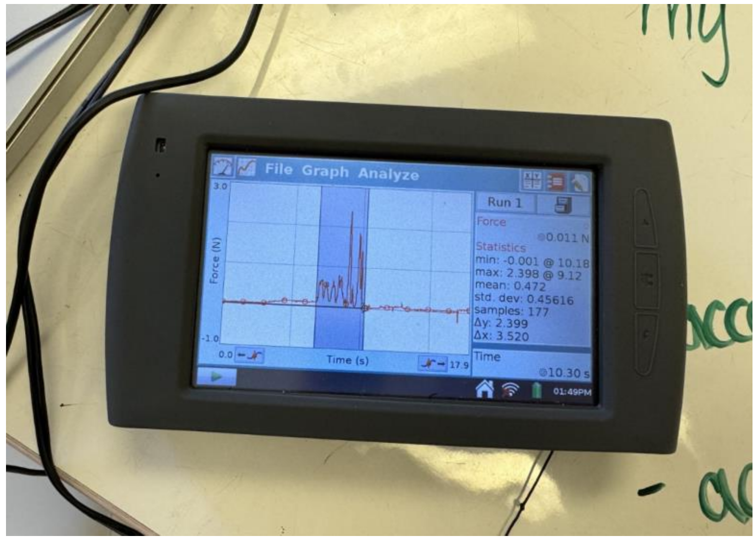
Experiment 2: Measure the mass, not the weight

Experiment 2 was focused on confirming our findings from our previous experiments; however, with the major caveat of avoiding measuring the cart's weight directly. This challenge left us with a single question; "What else can we use to measure mass?" The answer: Newtons second law, which states that force is directly related to mass & acceleration, or in more commonly known by its equation:

$$F = ma$$

Notice how the formula never interacts with gravity? This means that we have a way to get the mass of an object without calculating its weight! Fortunately, we can rearrange this equation to give us mass, in the form of: $\frac{F}{a} = m$

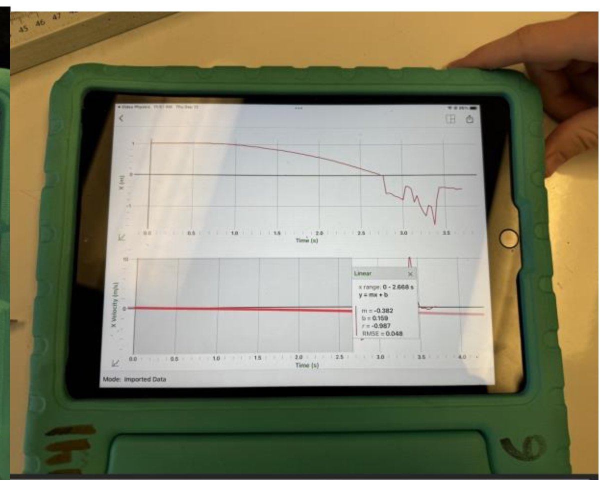
From here, we had to come up with a way to measure the force of an object, and its acceleration. We elected to use the iPad to help us find acceleration, and a force sensor to



Unfortunately, our data was less than ideal. The force sensor, as opposed to a single uniform force, tracked several sharp spikes, we normalized this by taking the average of our data, getting a force of: 0.472 N

The image on the right demonstrates the issues with our data.

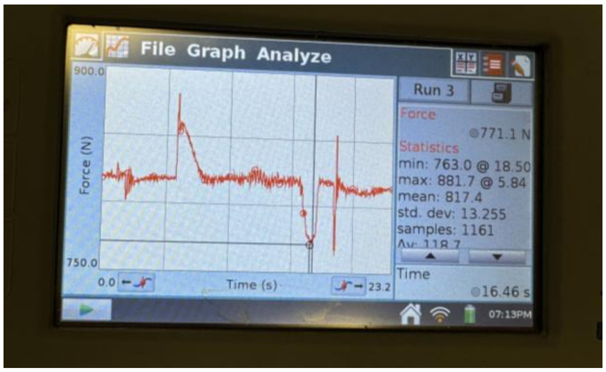
Getting the data for acceleration didn't go much smoother, where we were plagued by tracking issues, though, with persistence, we managed to extract some usable data from the mess.



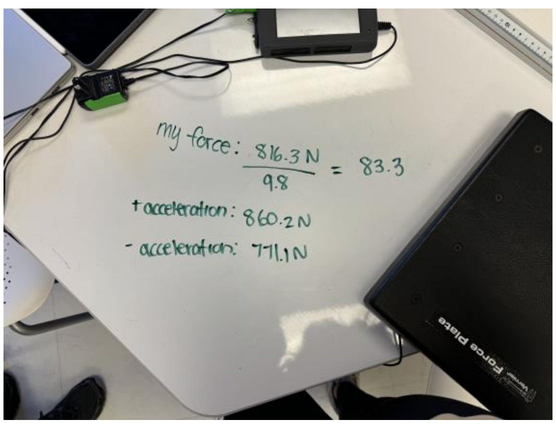
Despite the far from ideal tracking, we managed to get an acceleration value of 0.382 m/s^2 which, now that we have both force & acceleration, we plug these into our formula to get a final mass of: 1.23kg. A perfectly reasonable weight, if a bit heavy. While a fair bit heavier than our original estimate, given the data we had been working with, this is surprisingly accurate!

Experiment 3: Otis Elevators Rapid Weight Loss Program

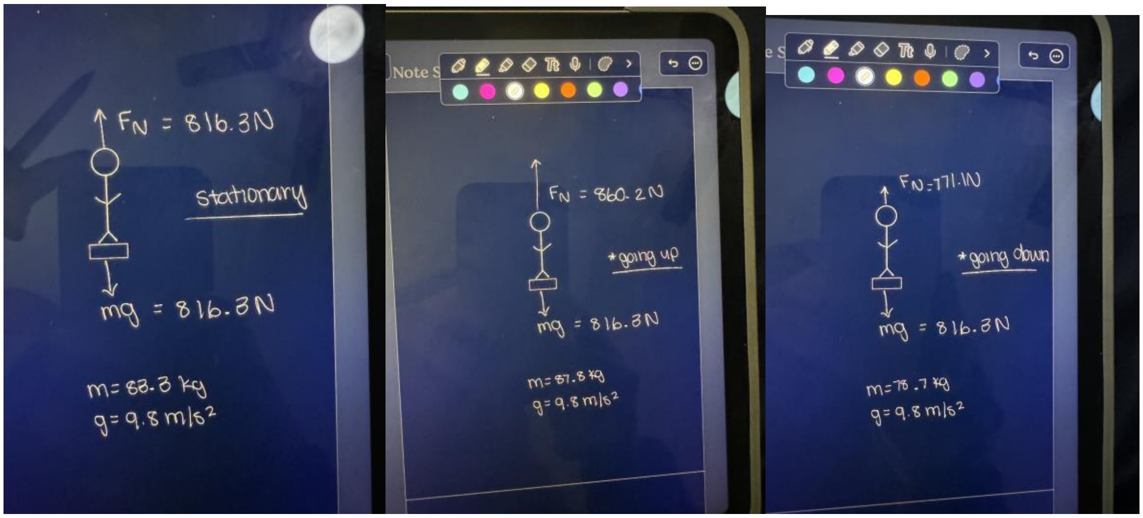
In this experiment, the objective was to calculate one's apparent weight by using a force plate on an elevator that is accelerating. The force plate was zeroed at a stationary stance using the LabQuest program and a person's force was graphed at the parameters of 50 samples/s with the duration of 60 seconds going from the basement level to the second level of the Engineering building.



This graph shows the LabQuests data of the force change as the elevator climbed to the second floor.



The average force on the person standing on the force plate was 816.3N. We know that force is equal to the product of an objects mass and gravity, so we took 816.3N and divided it by gravity (9.8m/s^2) to get 83.3 kg. The weight did change during the elevator ride as the force that was detected on the force scale increased as the elevator went up and decreased as the elevator slowed down. Using the same equation we got the results that the weight of the object (person) increased from 83.3 kg to 87.8 kg as the elevator went up and the weight decreased to 78.7 kg as the elevator went down. It is important to make the distinction between weight and apparent weight because apparent weight is due to different forces acting on an object meanwhile weight is due to the force of gravity.



Conclusion:

Throughout this lab, we toyed around with Newton's laws, using them in unique ways to solve for an unknown, while relying on some highly useful skills such as trigonometry. Through working as a group, we managed to employ each of our skillsets to complete several of the above experiments, rearranging formulas and running experiments as needed. Using the provided tools, we demonstrated how with some algebra and a bit of outside the box thinking, you can find unique ways to find properties of an object, even while lacking the traditional tools to do so.