Newton's 2nd Law lab   (Take home version)

This is the "take home version" of our Newton's 2nd Law lab. You will use the photos and data given below to complete your lab report just like your peers who did the hands-on version of the lab.

This lab demonstrates Newton's 2nd Law – otherwise called Newton's Law of Inertia – which is represented by the famous equation, $F = ma$. Your goal is to 'find out for yourself' if Newton's Law of Inertia is accurate – i.e. if it does indeed represent 'what happens' in a real situation.

We will set up a 2-meter aluminum track at different angles. We will accelerate an aluminum 'cart' up the track using various weights suspended from a string running through one or more pulleys. We will vary the weights and the track angle in several 'trials'. We will carefully measure in meters how far the cart travels each time, and use a stopwatch to measure the time in seconds. For each 'trial', we will compute the cart's *actual* acceleration using $\Delta x = v_1 t + \frac{1}{2}at^2$, and compare it to the *theoretical* acceleration using $F = ma$. In this way, we are comparing the cart's *observed* acceleration (what happened in reality) to its *predicted* acceleration (what should happen according to Newton's 2nd Law).

Your lab report should be professional looking and include your name, date, and title of the lab; and must contain all 5 of these elements:

1) Sketch and label all the track scenarios
2) Calculate the cart's *predicted* or *theoretical* acceleration in m/s^2 for each scenario using $F = ma$. Remember: In Physics we use meters, kilograms, and seconds in these formulas!
3) Calculate the cart's *measured* or *observed* acceleration in m/s^2 for each scenario using the formula $\Delta x = v_1 t + \frac{1}{2}t^2$
4) Compare the theoretical vs. observed acceleration for each scenario, and calculate the percent error using the formula $\%\, error = \frac{|actual - theoretical|}{theoretical}\ x\ 100$.
5) Discuss the results:
   a) Why were your measured results so different than Newton's 2nd Law predicted results (or not)?
   b) What are the sources of error in this lab?
   c) How could you improve the experiment to reduce your % error?

Below: mass of the Vernier cart in grams

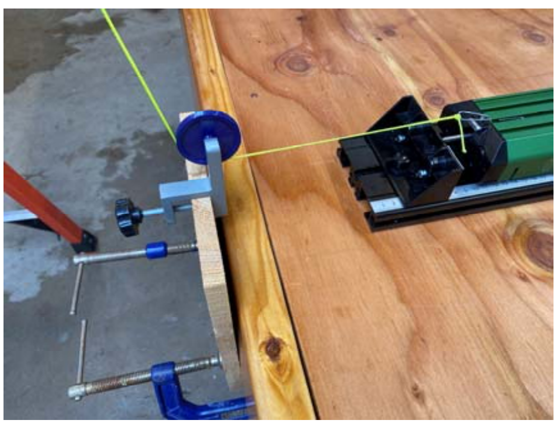
Below: mass of the carabiner clip in g

Below: mass of the black block 'cargo' in g

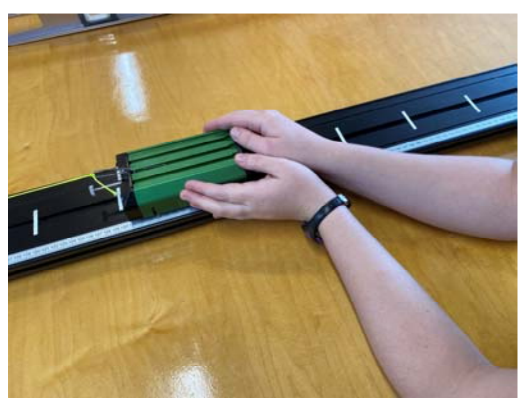
Below: mass of the paper clip 'hook' in g

Below: mass of the pulley block in g

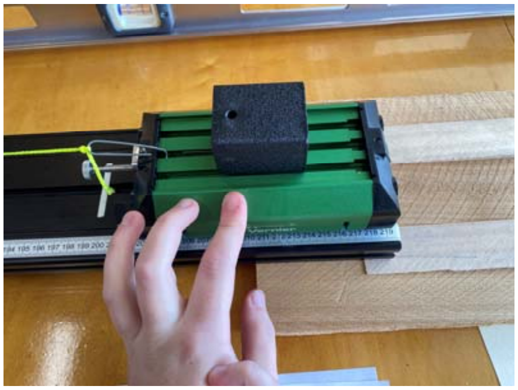
Below: showing the upper and lower pulleys



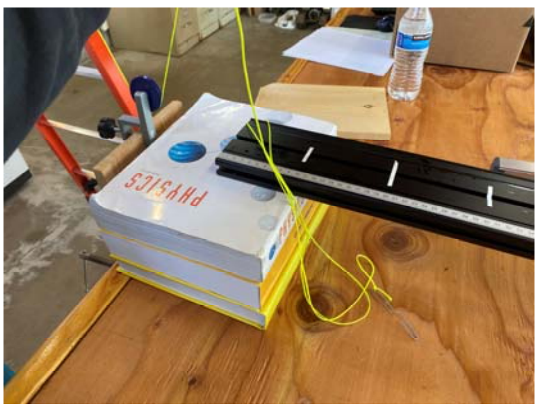
Below: showing the bubble level, and setting the cart on the track



Below: showing the black "cargo" block



Below: measuring the stack of books. Note the ruler is lined up at 10cm on the left end, and measures '22-something' cm on the right end. Again, remember, we use meters in our formulas! The books had the effect of raising one end of the track '12-something' cm over a 2.000 m stretch of track. This means the track angle was $\tan^{-1}(.0122/2.000)$, or thereabouts.



Trial 1:

In this trial, the track was set up perfectly level, with no incline (see photo with bubble level). The moving apparatus consisted of the Vernier cart itself, a paper clip hook, the string and 2 pulleys, and the carabiner clip functioning as the only weight on the other end of the string - pulling the cart forward. The masses of all these components are shown above. You will need to compute the total mass in kg of all the accelerating objects.

Results: the cart accelerated down the track for a distance of 190 cm, in the times given below. You will need to compute the average of the 3 times, and use that in your calculations.

Run	Time in seconds
1	5.10
2	5.15
3	5.30

Trial 2:

In this trial, the track was maintained perfectly level, with no incline. In this trial, the moving apparatus consisted of the Vernier cart itself with the addition of the black 'cargo' block, the paper clip hook, the string and 2 pulleys, and the same carabiner clip functioning as the only weight on the other end of the string - pulling the cart forward. The masses of all these components are shown above. You will need to re-compute the total mass in kg of all the accelerating objects.

Results: the cart accelerated down the track for a distance of 190 cm, in the times given below. You will need to compute the average of the 3 times, and use that in your calculations.

Run	Time in seconds
1	7.20
2	7.12
3	7.15

Trial 3:

In this trial, the track was elevated on one end with the stack of books shown in the pictures above. This had the effect of causing the cart to accelerate 'uphill' the whole distance. The moving apparatus consisted of the Vernier cart itself with the addition of the black 'cargo' block, the paper clip hook, the string and 2 pulleys, and this time the heavier 'pulley block' functioning as the only weight on the other end of the string - pulling the cart forward (the carabiner clip was completely removed). The masses of all these components are shown above. You will need to re-compute the total mass in kg of all the accelerating objects.

Results: the cart accelerated 'up' the track for a distance of 190 cm, in the times given below. You will need to compute the average of the 3 times, and use that in your calculations.

Run	Time in seconds
1	5.20
2	5.05
3	5.16