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Newton’s second law of motion

Spreadsheet: lab5 spreadsheet

Learning objectives

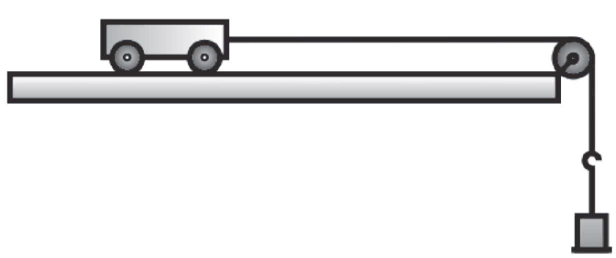
- Observe the relation between the net force and acceleration
- Use spreadsheets to record and analyze data.
- Design and execute an experiment
- Compare models and experiments.

Materials

- data/sensor interface
- Dynamic cart with force sensor
- Dynamic track
- Pulley
- String
- masses

Setup

1. Set up the experiment as demonstrated by the instructor.



2. **Measure and record the mass of the cart as mc.**

249.1g

3. Attach one end of a length of string to the cart's *force sensor.* Attach the other end to a hanging mass. Record the mass of the hanging mass as m1. Be sure the measure and cut enough length of a string such that, when passed over the pulley, m1 will be able to fall from the pulley all the way to the ground
50.0g

4. Zero out the force sensor by removing any tension in the string.

Experiment 1

Hold the cart stationary and start recording on capstone. Release the cart from rest. Stop the recording before the cart hits the bumper. Your velocity versus time plot should look flat at first and constantly increasing after the time of the release. Your force versus time graph should have two flat sections, with the first section having a larger magnitude compared to the section after the time of the release.

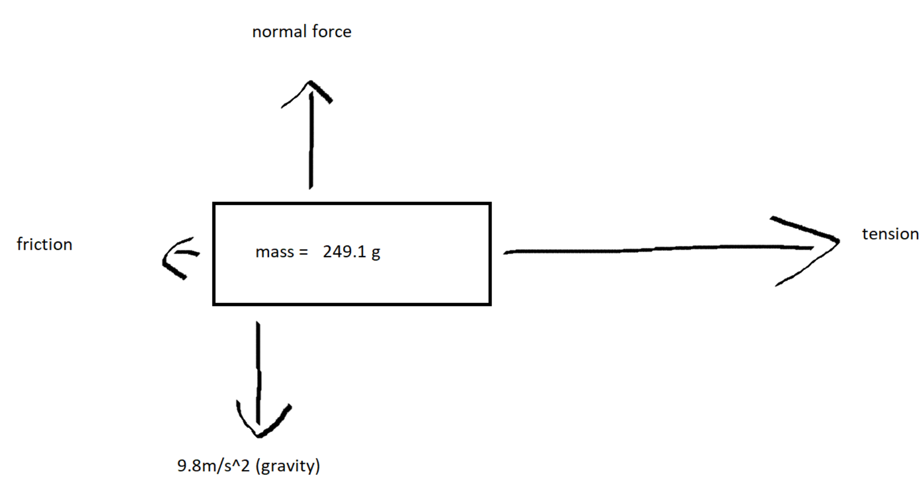
In a spreadsheet, record the weight of m1, aka m1*g, which you can read off your plot as the average magnitude of the force on the cart before the release.

Record F1 (the force on the cart after the release) and a (the acceleration, aka slope of the velocity curve after the time of release) in a spreadsheet.

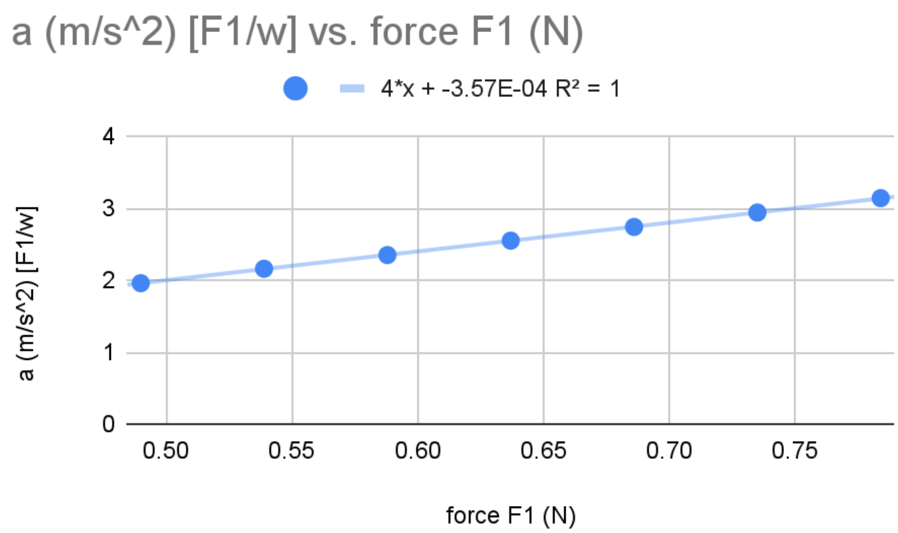
Increase the mass of m1, repeat the experiment at least 7 times (with a different mass of m1 each time). **Each time, record m1*g, F1 and, a in the spreadsheet.**

Analysis

Draw a free-body diagram of the cart.



Plot a vs F1.



What kind of curve best describe this relationship?

As seen in the graph, the line of best fit shows that the R^2 is 1, meaning that this graph is perfectly linear, otherwise know as a Linear Curve

Is this what you'd expect from Newton's second law of motion?

Newtons Second Law: F = m*a
Yes, this is what we would expect as these values are directly proportional as shown by our linear graph, where the force is proportional to the acceleration

What is the equation of the best-fit straight line?

The equation of our line of best fit is: 4x + -3.57E - 04m/s^2
(R^2 = 1)

What physical quantity is represented by the slope? (Hint: look at the units or remember Newton's second law)
1/mass

Compare the value of the slope to the actual value of the physical quantity it represents.

The slope of the graph is 4m/s^2, also, when we do 1/m we get a number that is very very near 4, or rounds to four. Meaning that the values are the same.

Based on the best-fit straight line, what is the value of the acceleration when F1=0? If the acceleration is non-zero when F1=0, what is this evidence of?

When F1=0, the acceleration is -3.57E-04m/s^2. This means that the cart is slowing down.

Based on the best-fit straight line, what is the value of the F1 when a=0? If it is non-zero, why not?
3.57E-04/4 N is the force value at a=0. This means the cart is going at a constant speed.

Based on your results, is friction negligible in this experiment? If not, what is your best estimate for the value of the friction force?
Yes, the value of friction is very low on this specific surface that friction can be counted as negligible.

Revise your FBD if needed. Based on this FBD, what is the net force acting on the cart? (Express your answer in term of F1 and f, the friction)

We do not need to revise our FBD. The one above still applies.

Apply Newton's second law to write the cart's equation of motion in terms of mc, F1. f, and a.

F_{net}=ma -> F_{net}=(m1a)-f -> T-f = ma

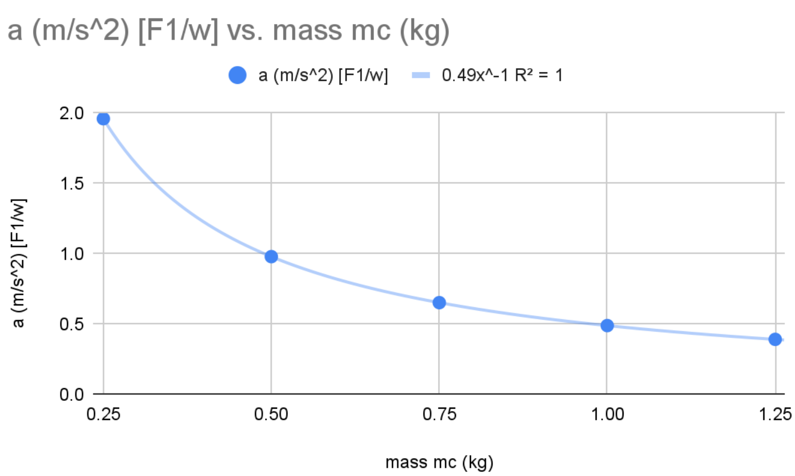
Is F1 equal to m1*g? If not, explain. (Hint: a FBD of the hanging mass could help.)
Yes, in both our experiments, and if we check mathematically, we are able to find that F1, and m1*g give us the same values consistently meaning the two are equal.

Experiment 2

Design and execute an experiment that shows that the acceleration is inversely proportional to its mass.

While keeping the hanging mass at a constant, we adjusted the mass of the cart by an increasing 250g per trial to record a change in acceleration related to the change in mass.

Use the data generated by your experiment to plot a vs m and find a best-fit equation.



What kind of curve best fit a vs m?

The curve that was the best fit was a power series. This resulted in us getting R^2 equal to 1

What physical quantity is represented by the proportionality constant?
The physical quantity that is represented by the proportionality constant is the Force.

Compare the value of the proportionality constant to the value of the physical quantity it represents.

The force as the proportionality constant is .49N and maintains itself with the physical quantity.