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Lab #10 – Newton's Second Law. Part 2 – Varying the Mass.

Objective: Determine the relationship between mass and acceleration.

Materials: Go Direct Cart, track, computer, string, assorted masses, super pulley, scale.

In this lab, you will vary the mass of the cart and measure the acceleration of the cart. You will check whether the Newton's 2nd Law is accurate.

The force accelerating the cart will remain constant.

Procedure:

1. Measure the mass of the cart with a string: m_c = ***0.278 kg***
2. Place the empty cart on the track with the string over the pulley so that the hook may be dropped to give the cart acceleration. Attach a hook (its mass is ***50 g***) with additional ***100 g*** mass. $\boldsymbol{m_h = 0.150}$ ***kg***.
   Do not remove it during experiments.
3. Release the cart. ***Stop the cart before it hits the pulley***.
4. Using graph ***v(t)*** choose the interval with a constant acceleration. Determine the magnitude of the cart's acceleration.
5. Repeat the procedure, adding one weight at a time (measure its mass) to the cart.

Total mass of the system M (kg)	0.428	0.553	0.678	0.803	0.928
a (m/s^2)	3.30	2.57	2.10	1.77	1.54
$\frac{1}{M}$ $(\frac{1}{kg})$	2.34	1.80	1.47	1.25	1.08

Analysis: Show all formulas and calculations for one set of masses in your report.

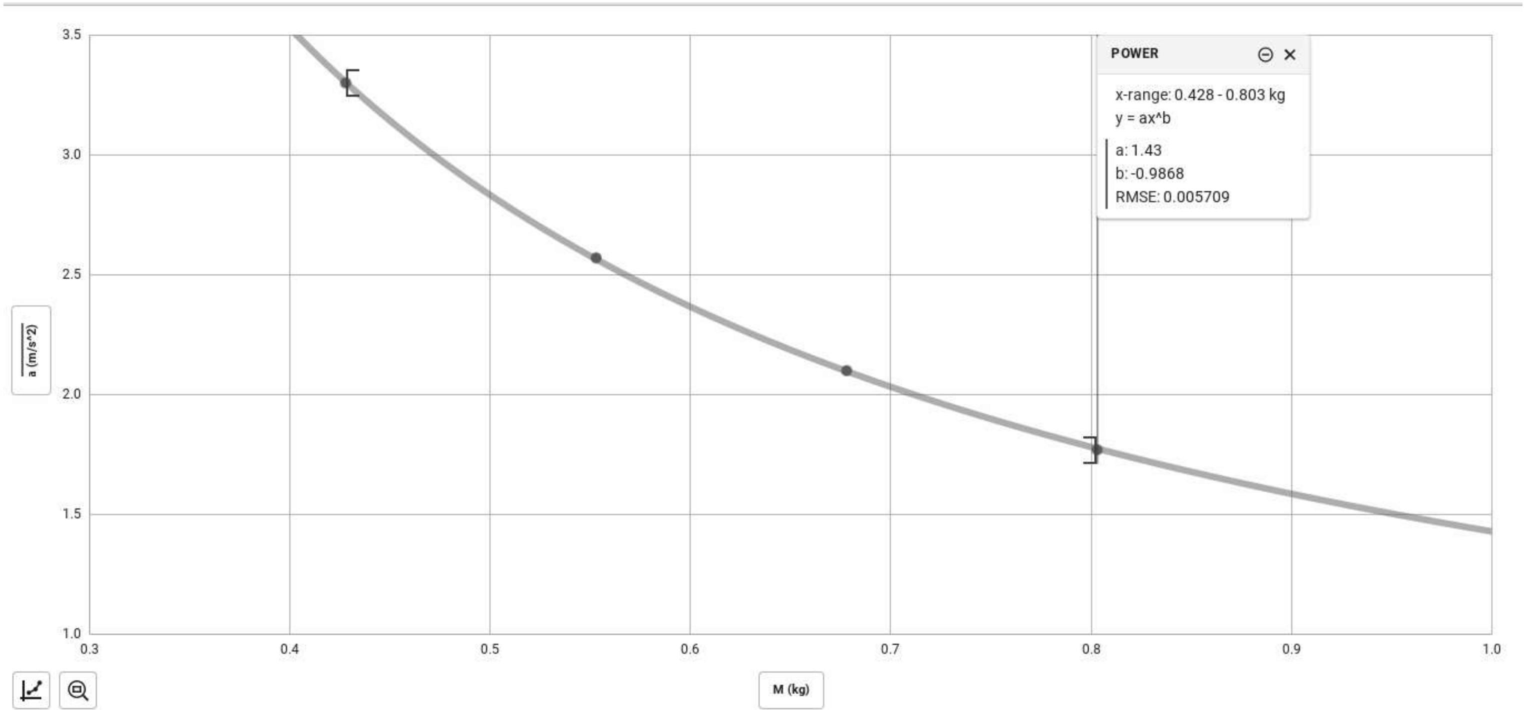
1. Calculate the net force F_{net} acting on the system. Neglect friction.

Truong, Alex

$F_{net} = m_{hook}g = 0.15 \text{ x } 10 = 1.50$ N

2. Using "Graphical Analysis", graph ***a*** **vs.** ***M***, and draw **the line of best fit.**

Loubier, Cooper



3. What shape is your graph? What shape should it be according to Newton's 2nd law?

Loubier, Cooper

The shape of my graph is hyperbolic. According to Newton's 2nd law, the shape should also be hyperbolic because the Net Force will stay the same and if the mass increases then the acceleration will decrease and vice versa.

4. What quantities should be used to make the graph linear? Calculate and add them to the table. Show one sample calculation.

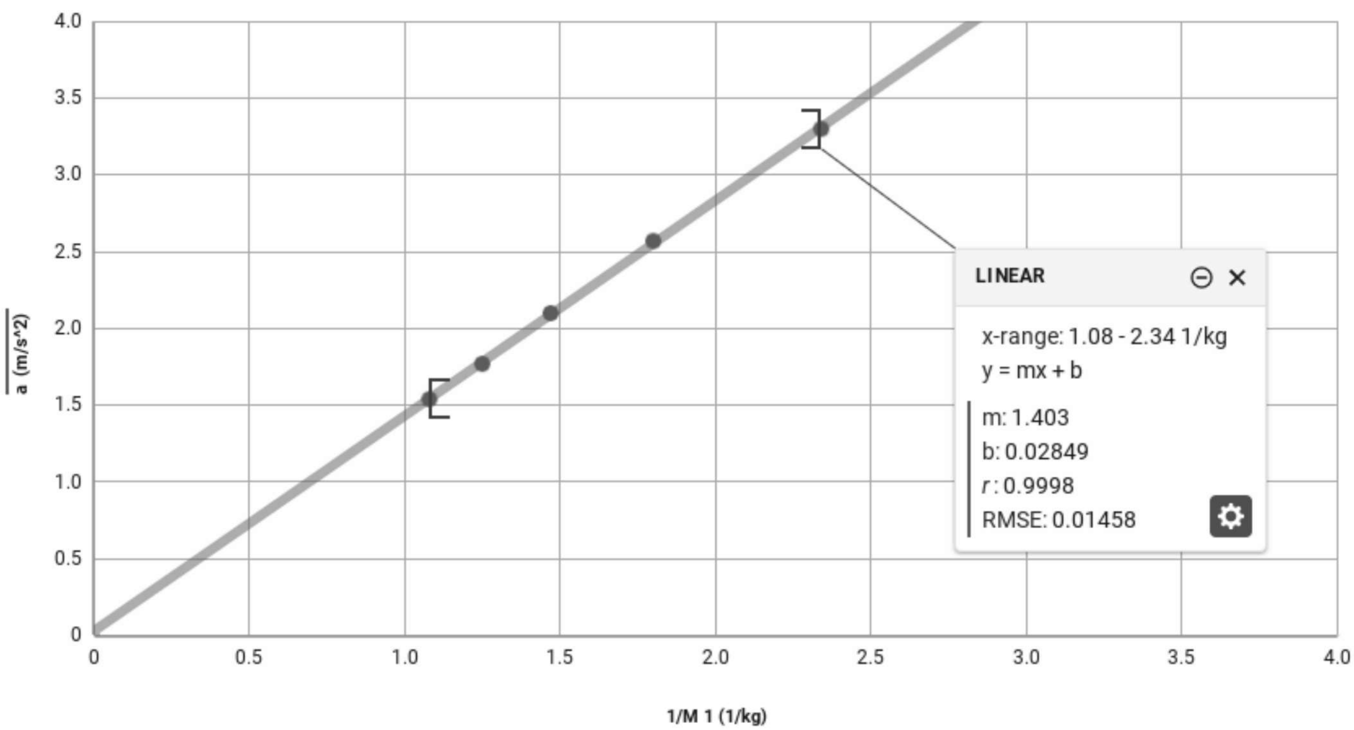
Kamal, Amjed

a vs. $\frac{1}{M}$

1/M = 1.0/0.428 = 2.34 1/kg

5. Using "Graphical Analysis", plot the new graph. Report its slope. What is the physical significance of the slope? Calculate percent error.

Kamal, Amjed



Slope = 1.40

Slope in this graph represents the net force of the system at any acceleration and mass.
%error = |(experimental-accepted)/accepted| x 100%
%error = |(1.40-1.50)/1.50| x 100% = 0.07 x 100% = 7%

6. Report and discuss the "y-intercept" for the graph.

Kamal, Amjed

The y- intercept in this graph represents the acceleration at 0 when the inverse of mass is 0.

7. Discuss the sources of error in the lab. **(Team)**

A source of human error could be the straightness of the table since it is extremely difficult for anyone to align the track perfectly on the unstable tables. Friction in the axles of the cart's wheels and the track could've decreased the acceleration of the system and f_{net}.One of the weights were slightly lighter than the required weight which could've also decreased mass of the system and f_{net}.

8. Give conceptually different examples (one for each student) of real-world situations where such kinds of measurements and calculations are important. Explain your examples in clear coherent arguments (one paragraph for each student).

Arcaro, Gage

This lab pertains to the relationships between two connected masses, one of which has a force applied to it. Calculating acceleration of the system can be applicable to things like freight trains because the engineer/conductor of the train needs to know how fast they must go in order to reach their destination on time. The mass of the engine car is pulling the mass of the freight behind it. Force is only applied to the engine car.

Kamal, Amjed

When constructing a skyscraper in order to bring objects, tools, and materials down or up you need a pulley system. A person may have to let go slowly of the rope so that the materials can go down. A person may also have to pull it up in order to bring up the materials they need to use. Depending on the mass of the system it may take longer to pull it down or up as acceleration decreases as mass increases.

Loubier, Cooper

Using the pulley system can be very useful and important in rock climbing. Self belaying is what some rock climbers do to get themselves down a cliff. They use the pulley system to slowly bring themselves to the bottom of the cliff. If they want to slowly bring themselves down the cliff they have to put a big mass on top of the cliff to decrease the acceleration due to gravity on the person. The person self belaying can also make their way down the cliff smoother and safer by making contact with the cliff with their feet every few seconds to induce the force of friction going upward to further reduce or possibly completely counteract the acceleration due to gravity.

Truong, Alex

Garage doors use a pulley system to extend and retract the doors smoothly. When designing an autonomous system for garage doors, measurements of the mass of the system and a desired range of net force are needed to calculate a range of acceleration fit for accuracy and safety. Without these measurements, the acceleration of the garage will be too slow, decreasing efficiency or causing the doors to not move. Or too fast which may damage the system or nearby objects and people.

9. Give an example of how you would improve this lab (better precision, more interesting, different design, etc.).

Arcaro, Gage

In order to improve this lab, instead of using the force of gravity to pull the cart, we could use another motorized cart to pull the original cart. Attaching a spring scale to the new cart can directly read the force that is being applied to the original cart. Mass can still be exchanged between carts. The observer can apply this lab to things such as a freight train.