Force – Mass – Acceleration
Newton's 2nd Law of Motion

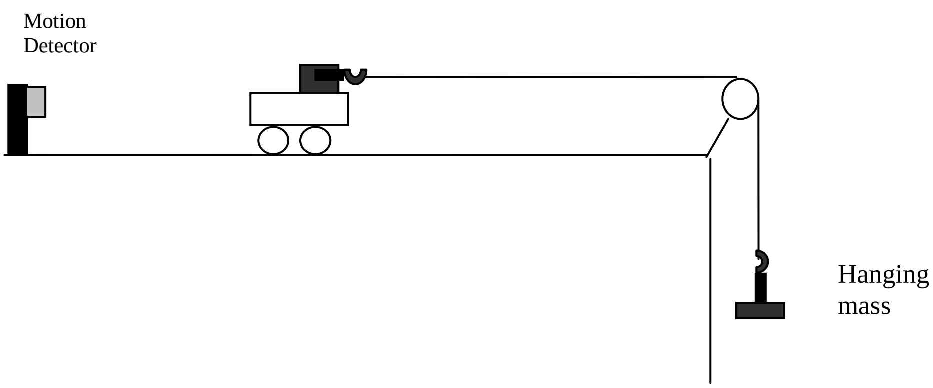
In this lab you are going to investigate

1. the relationship between the acceleration of a cart and the net force applied to it;
2. the relationship between the acceleration of a cart and its mass while the net force on the cart stays constant.

Materials

PASCO cart and track
Motion detector
Force Probe (set to 10N)
Triple beam balance
Mass hanger
Assortment of hanging masses
Pulley and String

Experiment File (Additional Physics→Real Time Physics→Mechanics→L03A2-2)



Acceleration and Net Force

Procedure

1. **Prediction 1:** Suppose that you pull the cart with a constant force away from the motion detector on a frictionless track. Predict the graphs of net force vs time, velocity vs time, and acceleration vs time.
   To test your prediction, set up the apparatus as shown above. Set the button on the force probe to 10N. Zero the force probe with no force applied to its hook (Do this by clicking on the blue "**0**" button at the top of the screen, and then checking only the force probe). Then test your prediction with a hanging mass of 45g and comment on your results. Include the actual graphs in your report.

2. Now, we will try to find out how the acceleration changes as we change the magnitude of the force applied to the cart. Use the values indicated in the <u>Data Table 1</u> for the hanging mass. Be sure to include the mass of the hanger. In each case, on the acceleration graph, highlight the section where acceleration is constant. Use the statistics feature of LoggerPro, , to determine the force and the acceleration for the cart only during the time interval when the force and acceleration are nearly constant. Repeat each measurement three times. Find the average of the three measurements and the associated uncertainty.

3. Construct a graph of average force vs average acceleration. Include uncertainties as error bars on your graph. Draw two lines, one with maximum slope and the other with minimum slope going through the error bars. Use these lines to find the range of values for the combined mass of the cart and the force sensor.

4. Directly measure the mass of the cart and the force sensor, and compare the two values.

Acceleration and Mass

Procedure

1. **Prediction:** If you pull the cart with a constant force it will accelerate. What type of relationship (quadratic, linear, inverse, etc.) do you expect to get between the acceleration of the cart and its mass? Explain.

2. Measure the mass of the cart and the force probe.

3. Zero the force probe with no force applied to its hook. Begin with the empty cart. Use a hanging mass of 100g. Release the cart and collect data.

4. Notice the tension force measured by the force sensor drops as soon as the cart is released. Clearly explain why this happens.

5. Using the statistics feature of LoggerPro, 

, determine the tension force and the acceleration during the time interval when they are nearly constant. Record the data in Data Table 2.

6. Place 100g in the cart. **Adjust the hanging mass to maintain the tension force applied to the cart by the string constant**. Record the tension force and the acceleration of the cart. Repeat with 200g, 300g, and 500g placed in the cart. Use the Vernier 500g block that can be safely secured to the cart.

5. On the computer, plot a graph of average acceleration vs total mass (with constant tension force). Include the uncertainties as error bars on the graph. Use the curve fit feature of LoggerPro to fit the data points. Does the shape of the graph agree with your prediction? Explain.

6. What shape do you expect to get if you plotted acceleration vs (1/mass)? Is there any way to determine the net force on the cart from this graph? Explain.

7. Plot the graph of acceleration vs (1/mass) and test your prediction. Include uncertainties as error bars. Draw two lines, one with maximum slope and the other with minimum slope going through the error bars. Use these lines to find the range of values for the tension force. Clearly explain your reasoning.

8. In the conclusion, in addition to reporting your numerical results, explain how these two experiments support Newton's Second Law of Motion.

<u>Data Table 1</u>

<u>Net Force and Acceleration</u>

Hanging Mass	**Acceleration(m/s^2)**	**Force(N)**
35g		
Average ± unc.		
45g		
Average ± unc.		
65g		
Average ± unc.		
85g		
Average ± unc.		

Data Table 2

Mass and Acceleration

Hanging Mass(g)	Tension Force (N)	Mass of Cart, force probe and additional mass (g)	Acceleration (m/s^2)
100g			
Average ± Uncertainty			
Average ± Uncertainty			
Average ± Uncertainty			
Average ± Uncertainty			
Average ± Uncertainty			

Average Tension ± Uncertainty	