Verifying Newton's Law

Prelab

1. When a net force accelerates an object and you compare that acceleration to that of an object experiencing the same net force but possessing twice the mass, what will the ratio of the two objects be?
2. When you have an object of mass m and it is being accelerated by a net force that causes a certain acceleration a, what will the acceleration of mass m be?
3. If a force is exerted on an object the object will always accelerate. Is this a true statement?
4. When an object slides down an incline and accelerates due to gravity, is the acceleration 9.81 m/s^2? If it is not that, is the acceleration more or less than g? *Ignore friction*

Experiment ~ Quantitative Analysis of Newton's 2nd Law

Purpose of Experiment

We study in which way the cause for change in motion, force, is proportional to a property of an object, mass. The three Newton Laws describe how forces act to change the motion of a body:

$$\sum \vec{F} = 0$$

$$\sum \vec{F} = m\vec{a}$$

$$\vec{F}_{A\to B} = -\vec{F}_{A\to B}$$

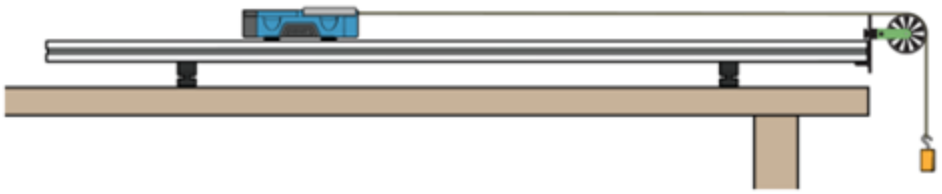
Our objective is to confirm that

- For a given force the change in motion (acceleration) scales with the mass of the object.
- For a given mass of an object the change of motion scales with the applied force.

Activity 1 ~ Varying the mass M of an object

General Procedure

1. Set up the cart, weights, string and motion detector as shown below. Determine the mass of your cart.



Procedure

1. Open a new logger pro file. You will need a graph that will allow you to identify the acceleration of your cart at a specific time.
2. Modify the mass of the cart by adding 0, 1, 2, or 3 metal bars to its bed.
3. Find the mass M of the cart in each case.
4. Use a light pulling weight at the end of the string, preferably less than 10% of the mass of the cart.
5. Complete the following table with your data in excel.

Pulling Weight 1	**Load 1 _____g**	**Load 2 _____g**	**Load 3 _____g**	**Load 4 _____g**
Run 1 ~ Accel				
Run 2 ~ Accel				
Run 3 ~ Accel				
Run 4 ~ Accel				
Run 5 ~ Accel				
Mean				
Std dev.				

Activity 2 ~ Constant cart mass M

Procedure

1. Open a new logger pro file. You will need a graph that will allow you to identify the acceleration of your cart at a specific time.
2. Modify the pulling weights, use light weights and record their mass in the data table.
3. Find the mass M of the cart, use at least 2 weights in the cart.
4. Complete the following table with your data.

Load 1	**Weight 1 _____g**	**Weight 2 _____g**	**Weight 3 _____g**	**Weight 4 _____g**
Run 1 ~ Accel				
Run 2 ~ Accel				
Run 3 ~ Accel				
Run 4 ~ Accel				
Run 5 ~ Accel				
Mean				
Std dev.				

Analysis

1. Did you notice an impact of friction? If so, what was the impact friction in the experiments?
2. Graph the results from activity 1 as acceleration vs. 1/M. (using excel)
    a. Fit the graph with a straight line that passes through the origin. The plot should be linear with a slope F. Is it linear?
    b. What value of F do you obtain from the fitted line?
    c. Relate the value of F to the pulling weight.
3. Graph the results from activity 2 as acceleration vs. F. (using excel)
    a. Fit the graph with a straight line that passes through the origin. The plot should be linear with a slope of 1/M. Is it linear?
    b. What value of M do you obtain from the fitted line?
    c. Relate the value of M to the mass of the cart.
4. Assuming the cart is perfectly level and frictionless, that the pulley is massless and frictionless, and that the string is massless, perfectly flexible, and not stretchable, obtain a symbolic expression for the acceleration a of the cart in terms of cart mass M, hanging weight mass m, and gravitational acceleration g. Include a FBD of the mass m.
5. From the symbolic expression you obtained in question 4, would you expect a perfectly straight line in a vs 1/M and a vs. F plots? What approximation(s) is (are) implicit in claiming the plots "should" be linear?
6. How could the experiments be conducted to make the plots theoretically linear, or at least for their deviations from linearity to be undetectable?
7. Perform your error analysis of the data.
8. Evaluate your prelab answers and correct them here if necessary.

Experiment Extension – Meet a Specific Acceleration

Procedure

1. Produce a specific acceleration on your system by measuring the cart mass, hanging mass, and calculating the acceleration. The instructor will give you an acceleration value.