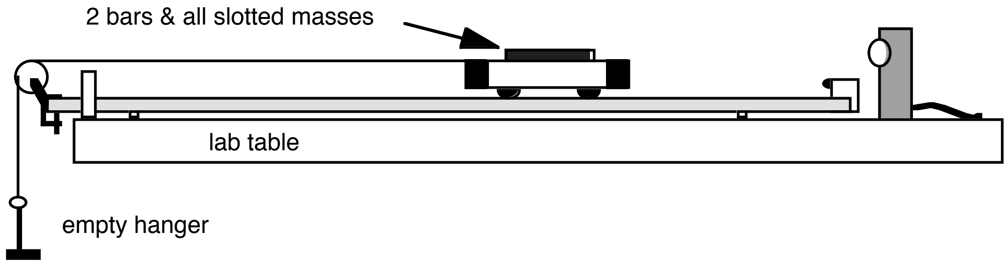
Lab 5-1: Newton's Second Law

Purpose:
1. To determine an equation that describes the relationship between acceleration and applied force for an object of constant mass.
2. To determine an equation that describes relationship between acceleration and mass for an object undergoing a constant applied force.
3. To determine the general relationship between force, mass, and acceleration.

Materials:
- 3 (three) 100 gram slotted masses
- 1 (one) 50 gram slotted mass
- 1 hanger
- 1 cart
- 2 extra 500 gram masses (bars)
- 1 string (~75 cm)
- 1 pulley system

Procedure:

1. Set up the track, cart, pulley, hanger and motion detector as shown in the diagram below.



2. Record the mass of the cart, string and hanger on the other side of this sheet.
3. Make sure the track is level. The cart should not be rolling in either direction. Also, make sure that the string is attached to the pulley horizontally.
4. Put the cart on the track. Place the two extra 500 gram masses on the cart. Place all the slotted masses on the cart. Secure the slotted masses with some masking tape. (Just enough so that the masses stay in place.)

Part I: Determining the effect of force on acceleration (with constant mass)

6. Pull the cart back to the middle of the track and hold it. Make sure that there is about 20 cm between the cart and the motion detector. Also, make sure that the hanger just reaches the ground as the cart reaches the end of the track; shorten the string if necessary. (Once the hanger hits the ground, there will no longer be an accelerating force.)
7. Start timing. When you hear the motion detector, release the cart. **Don't let the cart slam into the end of the track!**
8. To determine the acceleration of the cart, measure the slope of the best fit line of the velocity graph. Do this 3 times.
9. Repeat steps **6** to **8** above for seven more trials. For each new trial, transfer 50 grams from the cart to the hanger. If there are only 100 gram masses on the cart, switch a 100 gram from the cart with the 50 gram on the hanger After computing the best fits, simply record the results in the data table for Part I. **Do not add any new masses to the system!** The total mass that is being moved must remain constant for every trial.

Part II: Determining the effect of mass on acceleration (with constant force)

10. Put the empty cart on the track, and remove any extra masses from the hanger.
11. Start timing. When you hear the motion detector, release the cart.
12. To determine the acceleration of the cart, measure the slope of the best fit line of the velocity graph
13. Repeat steps **10** to **12** above for six more trials. For each new trial, add 250 grams (0.25 kg) to the cart. **Do not add masses to the hanger!** (The applied force must remain constant.) If needed, use masking tape to secure loose masses. After determining the slopes of the best fit lines, simply record the results in the data table for Part II.

Part III: Analyzing results.

14. Make the following graphs: Acceleration vs. Force from part 1 and Acceleration vs. Mass from part 2. If they are not linear, linearize them. Make sure that the graphs have the regression lines, equations and everything is labeled. Print out your results.

Lab 5-1: Newton's Second Law

Data for Part I:

Mass of cart, hanger, string, extra masses and all slotted masses: _________ kg

NOTE: To calculate Applied Force, use the ratio of 9.8 N for each kilogram (Also remember that 1 kg is 1000 grams.)

Mass Suspended (grams)	Applied Force (N)	Acceleration (m/s^2)
50 (just hanger)	.49	
100 (hanger + 50)		
150		
200		
250		
300		
350		
400		

Data for Part II:

Applied force exerted by the 50 gram hanger: **0.49** **N**

Mass accelerated (kg)	Acceleration (m/s^2)
cart + hanger	
cart + hanger + .25	
cart + hanger + 0.5	

Lab 5-1: Newton's Second Law

Questions:

Part I:

1. What is the equation that describes the relationship between acceleration and applied force for your data? (Remember: slopes have units.)

2. Qualitatively, describe the relationship between acceleration and force for a given mass.

Part II:

3. What is the equation that describes the relationship between acceleration and mass for your data? (Remember: slopes have units.).

4. Qualitatively, describe the relationship between mass and acceleration for a given force.

Conclusion:

1. What is the relationship between force, mass, and acceleration for any body? (Combine your results from the two parts of this lab.)

2. In Part I, why did you have to move masses from the cart to the hanger to increase the force? Why could you not just take some extra masses that were lying on the table and put them on the hanger?

3. What is a *Newton*?

4. What does the slope of the Acceleration vs. Force graph physically represent? (Simplify the units first.)

5. What does the slope of the Acceleration vs. Inverse Mass graph physically represent? ? (Simplify the units first.)