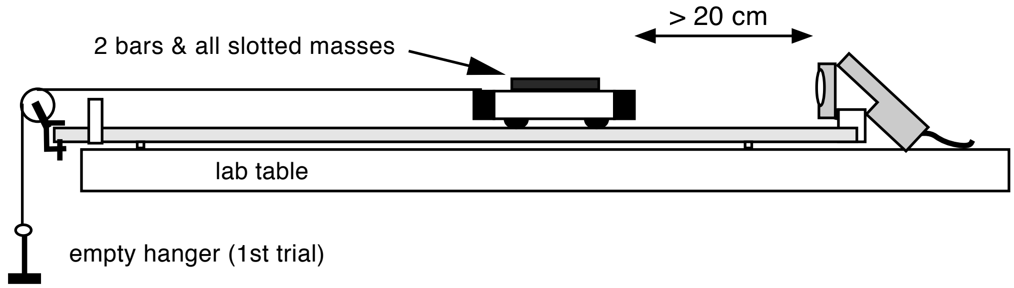
Lab 5-2: Newton's Second Law

Purpose: To determine an equation that describes the relationship between acceleration and applied force for an object of constant mass.

Materials:
1 (one) 200 gram slotted mass
1 (one) 100 gram slotted mass
1 (one) 50 gram slotted mass
2 black bars (500 grams each)
1 string (~75 cm)
1 pulley
1 hanger (50 grams)
1 cart (500 grams)

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. (This means the string is over the end bar of the track.)
4. Start *LoggerPro*. Open up the file "02 Cart.cmbl". Make sure the bottom graph is velocity vs. time.
5. 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.)
6. Pull the cart back and hold it. Make sure that there is at least 20 cm between the cart and the motion detector. Start collecting data. When you hear the motion detector, release the cart. **Don't let the cart slam into the end of the track!**
7. To determine the acceleration of the cart, measure the slope of the best fit line of the velocity graph. You will have to highlight the portion of the graph that shows the cart speeding up.
8. Repeat steps **6** and **7** above for seven more trials. For each new trial, transfer 50 grams from the cart to the hanger and measure the resulting acceleration. (If there are only 100 gram masses on the cart, switch a 100 gram from the cart with the 50 gram on the hanger.) **Do not add any new masses to the system!** The total mass that is being moved must remain constant for every trial.

Analyzing Results

9. Since the force causing the system to accelerate is the weight of the hanger, fill in the column marked "Force" by calculating the weight of the "Total Hanger Mass" as follows:
   a. First calculate the column "Total Hanger Mass" by adding the mass of the hanger to the extra mass you have put on the hanger. Convert your mass to kg, and record in the table.
   b. Now that you know the total mass of the hanger in kg, calculate the weight of the hanger and extra masses and record this in the column "Force."
10. Make a graph of Force vs. Acceleration from your data. Make sure you title the graph, include labels & units, and include the linear fit to find the slope of your graphed data. Either print the graph or sketch it (including labels and slopes) below.

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Data: Mass of cart, hanger, 2 black bars and all slotted masses: _________ kg

NOTE: The Force is equal to the weight of the Total Hanger Mass. $F_w = mg$ & $g = 10\ m/s^2$

Extra Mass on Hanger (grams)	*Total Hanger Mass (kg)*	*Force (N)*	*Acceleration (m/s²)*
0	*empty hanger =* 0.05 kg	.50	
50	*hanger + 50 grams =* 0.100 kg		
100			
150			
200			
250			
300			
350			

Questions:

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

2. If 1 N = 1 kg•m/s² show that the units of the slope reduce to kg.

3. What is the physical significance of the slope of your Force vs Acceleration graph?

4. Why did you have to transfer the mass between the cart and the hanger? Why couldn't you just add masses to the hanger to increase the applied force?

5. a. If you double the force on an object what will happen to its acceleration?

   b. If you triple the force on an object what will happen to its acceleration?

   c. If you halve the force on an object what will happen to its acceleration?

   d. If you wanted to get 5 times the acceleration on an object, how much force would you need?