Newton's Second Law Lab

Please read all directions before starting. Do everything in your lab notebook – it will be checked later for a grade but you will not be turning anything else in. THIS IS A CLASS COPY. DO NOT TAKE IT WITH YOU. IT IS ONLINE.

Purpose: Find the mass of an object using the relationship between acceleration and mass of another object.

Background: We have already learned that the acceleration of an object can be described with Newton's Second Law:

$$a = \frac{\Sigma F}{m}$$

So if we vary the mass of an object and measure the resulting accelerations, we could make a graph of acceleration vs. 1/m. The slope of such a graph would be the net force on the object. If the net force was provided by the weight of a second object, we could find the mass of that second object since:

$$weight = force\ of\ gravity = mg$$

So we are going to hang some random object by a string that goes over a pulley to pull on a cart whose acceleration we will measure as we vary its mass. Woot!

Since we can't measure acceleration directly, we'll have to calculate it using kinematics. Starting from:

$$x = x_o + v_o t + (1/2)at^2$$

Assuming that the cart starts from rest ($v_o = 0$) and that $x_o = 0$, this rearranges to:

$$a = \frac{2x}{t^2}$$

Which means we will have to measure how far (x) the cart moves in a time t to later calculate the constant acceleration. It is very important that the net force (and therefore acceleration) is constant the entire distance the cart moves.

Materials:

String	Various masses	Cart Masking Tape	Random object less than 200g
Pulley	Meter stick	Stopwatch (cell phone)	Digital scale

See the diagram on the whiteboard for the setup of materials.

Procedure

1. Choose an object to be your "pulling object." The object MUST be less than 200 g. Write a description of the object, find, and record its mass with the digital scale. Tie or tape this "pulling object" to the end of the hanging string.
2. Mark out a known distance on the desk. The cart needs to have free movement over this distance. Record the distance in meters. Do not change this distance later.
3. Place a known amount of mass on the cart. Record the total mass of the cart in kilograms (cart alone has mass = 1 kg). Be sure to place the masses near the front of the cart so that they can't slide forward when you stop it later.
4. Pull the cart back to the beginning of the marked distance and release it from rest. Record the time it takes to travel the marked distance. Make sure you stop it before it hits the pulley but after it has travelled the whole marked distance. Make sure the object hanging off the string does not hit the ground before the cart is done with its run.
5. Repeat step 4 until you have at least 5 recorded times for this cart mass.
6. Repeat steps 3-5 for at least 8 different cart masses. If you run out of masses to use, use the digital scale to find the mass of random objects to add to your cart (the scale only goes to 0.2 kg, though, so be careful).

Analysis:

1. Find the average time for each set of trials. Add to data table.
2. Calculate the acceleration of the cart for each set of trials using the average time for t. Add these to your data table.
3. Graph acceleration vs. 1/mass and create a best-fit line for your data. Remember to label your axes and title your graph.
4. Find the slope of your best fit line.
5. Use the slope to calculate the MASS of the "pulling object."
6. Find the percent error of your calculated value for the mass of the "pulling object" by comparing it to the value you found with the digital scale.

Analysis Questions

1. Did your graph have a non-zero y-intercept? Should it have? Why or why not? If your intercept does not correspond with what you think it should have been, what do you think caused your data to deviate?
2. Name one more thing (DIFFERENT from anything mentioned in #1) that could have affected your answer. How did it affect your answer? That is, did it make your calculated mass too high or too low? I am looking for a mathematical analysis here, so trace this

error all the way from your time measurements, through the equations used, to your answer for mass.