Newton's Second Law Virtual Lab

Objectives:

- To investigate the relationship between acceleration and force at a constant mass
- To investigate the relationship between acceleration and mass at a constant force
- To verify Newton's Second Law, F=ma

Download Instructions: (For Internet Explorer)

Click on the link to open the virtual lab home page.

Once the page has opened, read the system requirements, then scroll down to the **GO TO DOWNLOAD PAGE** link.

Scroll down to **SIMLAB2001--PHYSICS LAB SIMULATOR** and then click on **SIMLAB LITE** at the bottom in the middle column. **[Make sure you are in the Windows download section (near top of page) or, if appropriate for you, in the MAC download section (towards bottom of page).]**

Choose **SAVE** and click **OK** and then choose a place to save it to on your hard drive.

(This download will give all the simulations needed for the rest of this course)

Once the download is complete, go to the place where you have stored the file and double-click on the icon to open the file. It will have to be unzipped, so click on the prompt to unzip the file and tell it where to placed the unzipped files.

Go to the folder labeled **SIMLAB LITE** and open it. There will be more folders for different experiments inside. Open the folder that is labeled **AIRTRACKS**. Click on the icon that says **TRUE BASIC SIMLAB_AIRTRACKS**.

Click on **START THE PROGRAM**.

Click on **F=ma**.

Click on I**NSTRUCTIONS**. Read through this information about the experiment.

Click **EXIT**.

Procedure: Constant Mass:

1) Set the mass of the hanger between 5 and 50 grams. Record.

2) Set the mass of the cart between 300 and 600 grams. Record.

3) Launch the cart. Record the time.

4) Repeat four more times, more if there is an outlier.

5) Keep the mass of the cart constant and vary the mass of the hanger.

6) Repeat Steps 3 and 4. Record all data. Repeat this procedure an additional three times. This will give you five different hanger masses and hence, five different forces.

Procedure: Constant Force

1) Keep the mass of the hanger constant (the force) and vary the mass of the cart.

2) Launch the cart and record the time. Repeat four more times, more if there is an outlier. Record all data.

3) You should have data for five different cart masses.

Calculations:

Since $v_0 = 0$ when the timer starts and the distance between the photogates is known, you can solve for acceleration using the equation

$$x = v_o t + \frac{1}{2} at^2$$

Make sure that all variables are in SI units before calculating.

Show at least one of these calculations in your report. Record the final accelerations in an Analysis table.

Change all hanger masses to forces by using W = mg, where m is in kg and g is 9.8 m/s^2.

Graphs:

Using the program Graphical Analysis found in the Introductory Unit make two graphs:

1) acceleration (in m/s^2) versus force (in Newtons)

2) acceleration (in m/s^2) versus mass of cart (in kg)

Analysis of "a vs. F" graph:

- This should produce a straight line with a direct relationship. Use the regression key (R=) on the navigation bar of the program to produce the best-fit straight line. Think about what the slope should indicate for this graph.

Analysis of "a vs. m" graph:

- This should not produce a straight line, but rather a curve fit. Use the f(x) button to select a curve fit that works. Try the inverse fit…does it work? It should. Think about why this is an inverse relationship.

Error Analysis of "a vs. F" graph:

- Find the reciprocal of the slope. Compare this value to the constant mass of the cart for this part of the lab. Find the percent error using the equation:

$$\% \text{ error} = \frac{|\text{Experimental value} - \text{Theoretical value}|}{\text{Theoretical value}} \times 100$$

In this case, the mass of the cart is theoretical and the inverse slope is the experimental value. Report your findings in the error section of the lab report.

Error Analysis of "a vs. m" graph:

- Choose several points on the graph (not data points) and multiply them together. Do you get the same value each time? Does this represent an inverse relationship? Compare the average of two of these values to the constant force applied in this procedure.
- Find the percentage error of the two forces using the formula from above. Report this in the error section of the lab report.