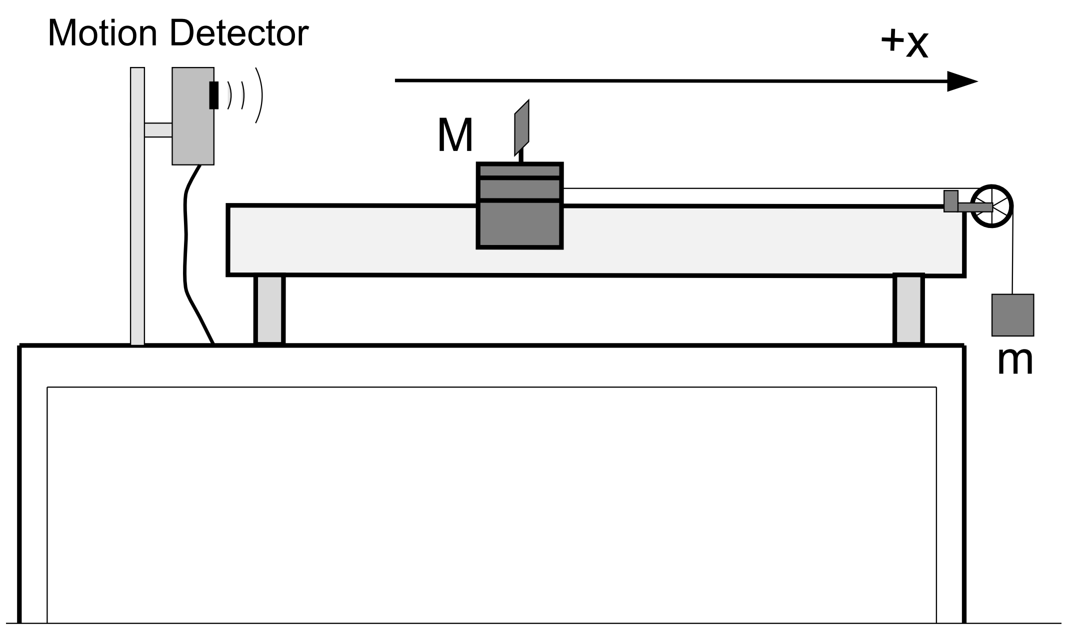
Newton's 2nd Law

This lab is a bit different than other labs this semester; we want you to try something new. This is why it's especially important to complete the pre-lab questions before coming to lab and read through the rest of the instructions to be familiar with the overall experiment.

Often, we need to rely on indirect measurements to determine a value in an experiment. Your goal is to design and carry out an experiment that determines the mass of your air-track glider without using the scale to weigh it directly or even taking it off the track. But we want you to make use of ideas you are learning in your physics class, putting Newton's laws to work.

You have at your disposal the air-track system and motion sensor used in an earlier lab, the glider whose mass you are to find, and a variety of known masses.



This manual guides you through some things to consider in the process of designing your experiment and analyzing your data. You will work out the details of your method with your lab team in lab.

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Pre-lab Questions

A glider sits on a level track. It's pulled along the track by a hanging mass, mass m, as shown in the picture earlier. In lab, the air-track provides a very low friction surface for the glider to move on. And, let's consider just the case where $m < M$.

1. The glider is initially held in place, and is then released. Once it's released, does the hanging mass fall? Does it fall with constant speed or does it accelerate? If it accelerates, is the acceleration of the hanging mass $a < g$, $a = g$, or $a > g$? You must explain why your answer makes sense.

2. Draw a free-body diagram for the hanging mass. What force(s) are acting on the hanging mass? If there is more than one force, rank the forces from greatest to least by order of magnitude.

3. Is your answer to the previous question consistent with your answer to question 1? If not, resolve the inconsistency.

4. Draw a free-body diagram for the glider. What force(s) are acting on the glider? If there is more than one force, rank the forces from greatest to least by order of magnitude

5. Based on your free-body diagrams and your understanding of Newton's Laws, determine an expression for the acceleration of the hanging mass as a function of m, g, and M.

6. If your glider is 200g, and the hanging mass is 10g, what's the acceleration?

7. What if the hanging mass were 20g instead of 10g? Does the acceleration double? Explain why your answer makes sense.

Procedure

1. (10 minutes) Discuss your pre-lab answers with your lab partners. Check with the TA for guidance or to check your results. Write down (in your lab notebook) your understanding of the relationship between acceleration, *a*, of the hanging mass and the mass of the cart *M*, mass of the hanging mass, *m*, and *g*.

2. (about 15 minutes) Come up with a strategy to determine the mass of the glider. Some things to consider:
    1. How will your experiment determine the the mass of the glider?
    2. What sources of uncertainty do you think there are? How important do you consider each source of uncertainty? In other words, how good do you think your measurement of the mass of the glider might be?
    3. Is there anything you can do to reduce a source of uncertainty, OR better quantify it?
    4. Be prepared to briefly summarize your group's plan to determine the mass of the glider during a discussion. You should choose a spokesperson for your group to give a summary during the discussion. Take some notes in your lab notebook describing your plan.

3. (5-10 minutes) Class discussion: use this time to explain your plan for measurement of the glider. You might hear ideas from other groups that you could be interested in implementing in your own procedure; take notes of good ideas that you hear. And, please offer constructive feedback to other groups.

4. (about 30 minutes) Take your data. If you're using software, don't forget to save the data so that you can find it later. Take some notes in your lab notebook so that you can remember details of your experiments. If you have important graphs, include printed copies in your notebook.

5. Is your measurement reproducible? That is, if you make the same measurement more than one time, do you get the exact same result? If not, is it still possible to quantify your result?

6. Are there parameters in your experiment you could vary to get a sense of how reliable your measurement might be? If so, try it out.

Analysis

1. (about 30 minutes) Use your data to determine the mass of the glider, and a numerical estimate how confident you are in your value. **You must report your final result for the mass of the glider to the TA.**

2. Once you have reported your result to the TA, measure the mass of the glider on the scale in the lab. Do the results agree? If they don't agree, consider possible reasons why they might not agree, and make a note of those in your lab notebook.

Some Miscellaneous Logger Pro notes:

The motion sensor connects to one of the DIG ports on the LabQuest Mini interface. If the LED on the LabQuest Mini is red or orange, unplug momentarily the cable between it and the PC. The LED should turn green after its plugged in again

Motion sensors generally have trouble reliably detecting anything less than 40-50 cm away. Data collection can be started with the green button or the space bar.

You may adjust the rate at which data is collected under Experiment - Data Collection - Sampling Rate, and also set the total duration of data collection.

New calculated data columns are created via Data - New Calculated Column … Provide a meaningful name and short name, and then enter a formula for the definition of the column. Keep in mind that you must enclose existing variables (columns) in double quotes e.g. “Time” and this is done easily by picking the column from the drop-down list presented when you click on the ‘Variable (Columns)’ button.