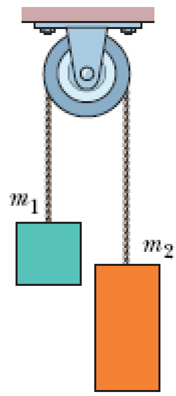
PHYSICS **Reiner, Hutchison, Vourgourakis**

Lab 3-1: Newton's 2^{nd} Law

In this experiment, you will use something called an Atwood's machine (shown below) to test the relationship between net force, mass, and acceleration that is Newton's second law.



Each lab station is equipped with a *smart pulley* and a piece of string tied to two mass hangers. Different masses placed on each of the hangers will cause the system to accelerate at different rates.

As the system accelerates, the smart pulley spins, alternately blocking and unblocking the *photogate* beam. The photogate is connected to a Lab-Pro unit, which is in turn connected to your TI calculator. A calculator program called *ACCEL* will calculate the accelerations for you from the sequential time intervals for which the photogate beam was block by the pulley spokes.

The net force which causes this system to accelerate is related to the difference in mass on each side of the Atwood machine. This net force has to accelerate the entire system, which consists of both sets of added masses as well as the hangers themselves (we ignore the masses of the pulley and string).

You will conduct this experiment in two parts, first **keeping the net force constant and varying the system mass**, then **keeping the system mass constant and varying the net force** acting on the system. Instructions for running the *ACCEL* program are provided below.

1. Plug the Lab-Pro into the electrical outlet and plug the calculator into the Lab-Pro using the link cord.
2. Call up the program called ACCEL and press enter.
3. When asked for the length of the experiment, use either **1 or 2 seconds**.
4. When asked for the number of revolutions, use either **1 or 2**.
5. Get your hanging masses in place and press enter just as or just after you release them.
6. Look at the v-t graph to make sure it is linear.
7. Press enter and ask to calculate acceleration. Assuming that the R^2 value looks good, write down the acceleration (the accelerations given by the calculator are in units of m/s^2).

Part I: For this part, you will keep the difference in mass between the two hangers constant and vary the total system mass. The difference in mass should be relatively small (50 grams at the most), so that the accelerations are not out of control. For each trial you will record the masses and the acceleration. Conduct at least five trials and record your data in a table such as the one on the other side of the page:

DATA TABLE PART I

M_1 (kg)	M_2 (kg)	M_{system} (kg)	ΔM (kg)	F_{net} (N)	a (m/s^2)

(NOTE: M_1 and M_2 should include the hanger mass)

Part II: In this part of the experiment, you will keep the total system mass constant and vary the difference in mass between the two sides of the pulley. Choose a total system mass which is convenient (larger is better, since that will slow the accelerations down) and begin with a difference in mass of 10 grams. Then sequentially add mass to one side of the pulley while subtracting an equal mass from the other side so that the sum of the two masses stays constant. Conduct at least five trials and record your data in a table such as the one below:

DATA TABLE PART II

M_1 (kg)	M_2 (kg)	M_{system} (kg)	ΔM (kg)	F_{net} (N)	a (m/s^2)

The report for this assignment should include:

- Data tables for both parts of the experiment
- Graphs along with appropriate best fit equations of
    - I. acceleration vs. system mass for part I of the experiment
    - II. acceleration vs. net force for part II of the experiment
- A conclusion in which you discuss/explain your results as they relate to Newton's 2nd law. Think about which of the three quantities in $F_{net} = ma$ we kept constant in each part and what that means about the expected shape of your graph. Is your graph linear or curved? What does that mean about the relationship between the two quantities graphed? Does that confirm what Newton wrote in his 2nd law?