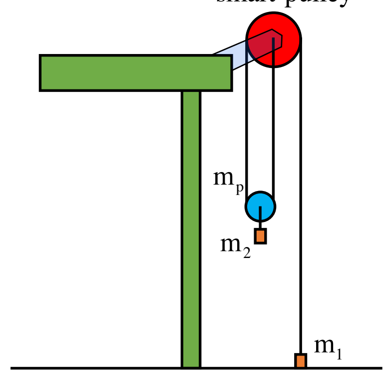
LAB: The DOUBLE ATWOOD MACHINE (L-6)

The best way to become comfortable with drawing free body diagrams, then using writing out Newton's Second Law from what you see in the free body diagram, is to deal with a truly strange configuration. That is what you will have the opportunity to do in this lab.

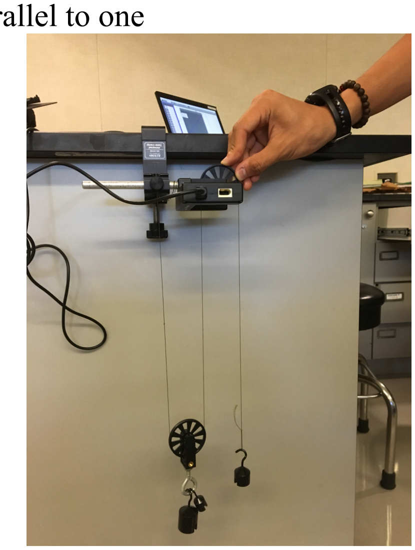
Object: To derive the acceleration of a mass in a double Atwood machine set-up.

Equipment:
1 Smart Pulley
1 pulley clamp
1 secondary (hanging) pulley
1 100 gram mass and a 60 gram mass (or a 50 gram and 10 gram mass)
1 string long enough to accommodate the system
1 some way to video the acceleration of the system, OR
1 Logger Pro set-up attached to a computer running Lab Pro



Procedure:

A mass m_1 (60 grams) sitting on the floor is attached to a string that is threaded up and over a Smart Pulley. The string runs down the other side to and a secondary, massive hanging pulley (mass m_p --you'll have to measure this value) to which is attached a mass m_2 (100 grams), threads through that pulley, then runs back up to the Smart Pulley where it rigidly attaches to any support that is handy. All the strings should be parallel to one another. When released, the m_1 moves upward with some acceleration. It is that acceleration you are trying to determine. Note that a set-up that is comparable but easier to work with is shown to the right.



Data to be Taken:

1.) If you are in class, measure all the masses (m_1, $m_{2+pulley}$). Set up the system, then use the Logger Pro system to generate a *Velocity vs Time* graph on the computer. Put in a regression line and take its slope to get the acceleration of the mass m_1.

2.) If you are using a video (which you are), all the information you will need, including the experimental acceleration of m_1, will be provided in the video (https://www.youtube.com/watch?v=yy1m3suwBHw&feature=youtu.be .

Calculations:

The theoretical side:

1.) Draw a f.b.d. for the forces acting on m_1. Then use N.S.L. to derive a general algebraic expression for the tension being applied to m_1. You will end up with two unknowns, the acceleration and the tension. You will need another expression in order to solve.

2.) Draw a f.b.d. for the forces acting on m_2 and m_p combined (treat them as one object). Be very careful with the tensions. Remember, if a pulley is massless, which this one is (what gives it substantial mass is the frame that is holding it, not the pulley itself), all it will do is re-direct the line of tension in the string. Use N.S.L. to derive a general algebraic expression for the tension acting on these masses. Notice that m_1 and m_2 (plus the pulley) have different accelerations (we should have talked about this in class). In this N.S.L. expression, write the acceleration in terms of m_1's acceleration (it's going to look like $.5a_1$ or $2a_1$ or something like that . . .). If you do all of this correctly, you will end up with two unknowns—the same tension and the same acceleration terms as you had in the previous expression.

3.) Rewrite the two expressions derived above, then solve for the acceleration of m_1.

The experimental side:

4.) If you are using a Logger Pro, you know the acceleration of m_1. State it here. If you are using a video, use the Tracker software and a Google Sheet to determine m_1's acceleration.

Comparison:

5.) The hope is that the theoretically expected acceleration of m_1 will be the same, or at least close to the experimentally observed acceleration of that mass. Do a % error between the two values. The equation for % error is different than that for % comparison we used previously. A % error is calculated between a theoretical/"correct" value (here, your derived acceleration) and a measured value (here, your value from Logger Pro or your video). To find % error, use the equation:

$$\% \, error = \frac{|actual - theoretical|}{theoretical} x100$$

6.) Comment on the validity of the N.S.L. approach in this lab. If your % error had a deviation larger than 10 %, explain where you think error may have crept into your work.