Accelerating Atwood Machines

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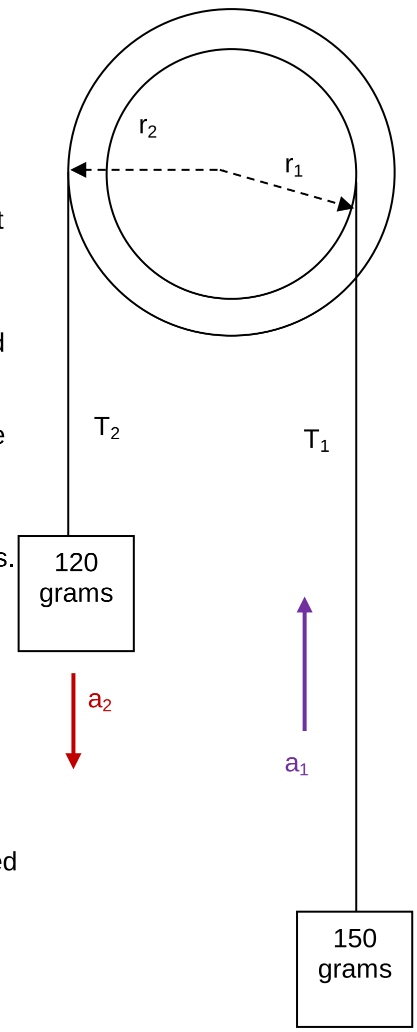
OBJECTIVE: To learn how to apply Newton's 2nd Law to a system having both rotating and translating components. Specifically the use of both $\sum \tau = I\alpha$ and $\sum F = ma$ must be coupled together to solve for the acceleration of a system.

MATERIALS: You may (but do not have to) use any of the following:

- A lab-stand with a mounted Atwood Machine.
- Two 50-g mass hangers connected to different radii of the Atwood Machine.
- Two masses of approximately 120 and 150 grams.
- A meter stick.
- A stopwatch.
- String.
- Scissors
- Two spring scales.



PROCEDURE:

1. **Determine the moment of inertia for the Atwood Machine**. The Atwood is not a hoop nor a disk. There is no special formula like mr^2 with which to find its moment of inertia. We must therefore find it experimentally. (Suggested procedure: Partner #1 unwind your string and apply a known force with a spring scale while Partner #2 applies a constant force to a second spring scale attached to the second string. This second string must be wrapped so that it will unwind. Partner #3 should hold the Atwood wheel stationary while the other two partners apply their forces in opposite directions. In effect, Partner #1 is applying a torque in the opposite direction of Partner #2. When Partner #3 releases the wheel, Partner #1 moves towards the Atwood machine while Partner #2 moves away from the Atwood machine, both attempting to maintain a constant force. Partner #3 times how long is required for the Atwood to make a given number of rotations. Partner's #1 and #2 may need to adjust their forces so that they move in the proper direction and so Partner #3 can obtain a good time measurement. What net torque do your two constant applied forces exert on the wheel? $\sum \tau = I\alpha$
   Use a stopwatch and what you know about uniform accelerated motion to determine α. It may be wise to do several trials and average your times required to produce each angular displacement (θ) that you measure. Once you have α then determine I for your machine. This moment of inertia you will now use for the rest of the lab for it is an intrinsic characteristic of your Atwood machine and would only change if the Atwood physically changes or if its axis of rotation moved from its center.

2. Next, predict the downward linear acceleration (a_2) of the 120-g mass as shown by using the following steps:
   a) Use $\sum F = m_1 a_1$ to develop a relationship for the 150-g mass. You will need to introduce a variable for the tension in this string -- call it T_1.
   b) Use $\sum F = m_2 a_2$ to develop a 2nd relationship for the 120-g mass. You will need to introduce a second variable for the tension in this string -- call it T_2.
   c) Use $\sum \tau = I\alpha$ to develop a 3rd relationship for the spinning wheel of the Atwood Machine.
   d) You now have three equations and four unknowns (a_1, a_2, T_1, and T_2). What final relationship can you use between the four unknowns to give you a solvable set of 4-equations in four unknowns? (Hint: how do the two accelerations, a_1 and a_2, relate to the angular acceleration α of the wheel?)
   e) Solve your four equations for a_2. What will the units of a_2 be?

3. Using the provided masses, and the Atwood apparatus experimentally check your theoretical value for a_2. There are a couple of different ways to go about this. Explain what you did to verify the acceleration. It would be wise to perform several trials in order to average out errors that might occur from a single trial.

4. Did your theoretical value match your measured value? Discuss differences that you observe and at least **three** possible sources of error that might have produce them. To receive credit for this, for each error you must fully explain how your error supports the variation you observe between your theoretical and experimental accelerations. You must show why your suggested error supports the fact that your experimental number is too high or too low.

WRITE-UP:

- You should do an individual write-up. You may need to have a relatively l4arge 410g1rou2p12 1of2 1p0eople121052055165365 when collecting initial data since there are a limited number of Atwood Machines.
- Each write-up should show your work (neatly) for each of the steps listed above. Label each part of your write-up with the appropriate number (1, 2a-2d, 3, 4) so that they can be easily identified on your paper.
- Make sure you clearly differentiate between **initial measurements**, **calculated predictions**, and **verifying measurements**.
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