AP Physics: Lab #5

The Atwood Machine

Name _____ Hour _____

Lab Partners _____

Purpose:

* Use Newton's 2nd Law to analyze two masses on an Atwood machine.
* Determine the force of friction acting on an Atwood machine.

Equipment:

LabQuest Mini with USB cord	Mass set
Computer with LoggerPro software	Nylon string
Photogate and Photogate cord	Ring stand
Atwood machine smart pulleys (2)	Electronic balance

Introduction:

Newton's 2nd Law states that the net force acting on a system is proportional to the acceleration of that system according to the equation: $F_{net} = m \cdot a$. In an Atwood machine, a pulley connects two unequal masses, causing one mass to accelerate upwards while the other accelerates downwards.

Consider an Atwood machine with two masses such that $m_1 > m_2$, as shown in FIGURE 1 below. The net forces accelerating these masses can be found by analyzing the free body diagrams of each mass individually. Three forces act on each mass, as shown in FIGURE 2 and FIGURE 3 below. *Weight* acts on each mass in a downwards direction, *tension* acts on each mass in an upwards direction, and *friction* acts in the direction to oppose the motion of the system. If $m_1 > m_2$, the net force on m_1 accelerates it downwards, while the net force on m_2 accelerates it upwards. Thus, friction acts upwards on m_1, but downwards on m_2.

This experiment will measure the acceleration of such a system as one mass is pulled upwards and the other mass falls downwards. The values for the tension in the string and force of friction acting on the pulley can then be determined.

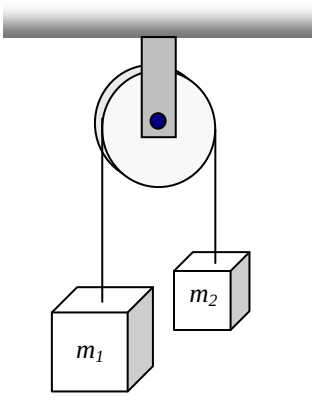


FIGURE 1

$F_{net} = W_1 - T - F_f$

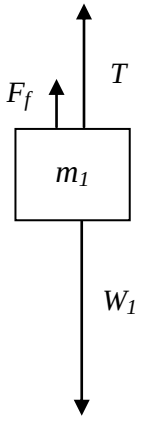


FIGURE 2

$F_{net} = T - F_f - W_2$

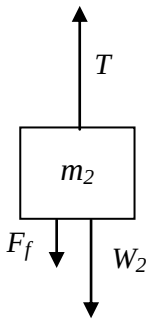
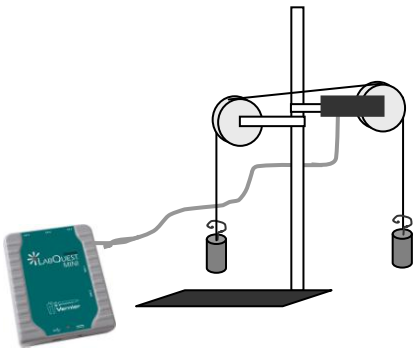


FIGURE 3

Procedures:



Securely attach the smart pulleys and photogate to a support stand, allowing the pulleys to extend over the edge of the lab table. Thread the nylon string through the smart pulleys to construct an Atwood machine. *(NOTE: Two pulleys are used to prevent the masses from striking each other; however only one pulley needs to be attached to a photogate for data collection.)*

Insert the plug of the photogate cord into the DIG I port of the LABQUEST. Use the USB cord to connect the LABQUEST to the computer. Then open the "*Lab #5 Template*" LOGGERPRO file from the class web site or Shared folder.

Attach masses to each end of the pulleys, distributing the masses so that Mass #1 is slightly greater than Mass #2. Then click the green COLLECT button on the LOGGERPRO toolbar. Carefully release the Atwood machine masses. As the pulley begins spinning in the photogate, it will trigger the LABQUEST to begin collecting data. Be sure to have a member of your lab group catch the masses before they strike the floor!

If the LABQUEST continues to collect data after the masses have stopped moving, following the instructions in the LOGGERPRO program to decrease the number of data points collected. Use the ANALYZE → AUTOSCALE commands to view the data collected. If necessary, repeat the experiment until the data collected is acceptable for analysis. Then save the LOGGERPRO file for Trial #1 on your home folder for future analysis. Repeat the experiment until you have obtained two additional data sets using the same masses that are suitable for analysis. Save the data for these trials as well, being sure not to overwrite the file containing your previous trials.

Move some of the mass from Mass #2 to Mass #1, creating a larger difference between the two masses. Repeat the experiment for 3 trials, using the new combination of masses and recording the data on Data Table B. Repeat the experiment for a third combination of masses, recording the data on Data Table C.

Calculations:

Calculate the weight W of each mass for each trial.

Use the ANALYZE → CURVEFIT command to produce an appropriate regression line to determine the acceleration of the masses for each trial. Print copies of your data, graphs and regression line from one of your trials to include in your report. *(NOTE: For best printing results, use the FILE → PAGE SETUP command to change the orientation to landscape and the FILE → PRINTING OPTIONS command to add a footer with your Name and Trial #.).*

Use a system of two equations to calculate the force of friction F_f acting on the pulley and the tension T in the string for each combination of masses.

Analysis:

To summarize the lab report, answer the application questions below in complete sentences. In addition, include a brief statement of the overall results for the lab.

- Draw a free body diagram of the forces acting on each mass during the situation in Data Table A. Include the type, amount and direction of each force.
- For the situation in Data Table A, calculate the net force acting on each mass. How do the net forces acting on the two masses compare to each other? How do the accelerations of the two masses compare to each other? Explain your answers.
- Use a system of two equations or the Short Lab 4-C *Interactive Physics* file to calculate the theoretical acceleration of the masses and tension in the string for the situation in Data Table A if friction is ignored. By what percentage do these amounts vary from . . . the actual acceleration . . . the actual tension?
- Does the tension in the string depend on the difference between the masses? If so, which case produces . . . the largest amount of tension? . . . the smallest amount of tension? Why do you think this might be so?

Data Table A:

	Mass $_1$	*Mass $_2$*	*Weight $_1$*	*Weight $_2$*	*Acceleration*
Trial 1					
Trial 2					
Trial 3					
Average					

Tension = _____ Force of Friction = _____

Data Table B:

	Mass $_1$	*Mass $_2$*	*Weight $_1$*	*Weight $_2$*	*Acceleration*
Trial 1					
Trial 2					
Trial 3					
Average					

Tension = _____ Force of Friction = _____

Data Table C:

	Mass $_1$	*Mass $_2$*	*Weight $_1$*	*Weight $_2$*	*Acceleration*
Trial 1					
Trial 2					
Trial 3					
Average					

Tension = _____ Force of Friction = _____

Lab Report:

Title Page, Objectives, & Overall Report – 5 pts
Procedures – 3 pts
Data Table – 5 pts
Calculations – 6 pts
Analysis – 12 pts