# Newton's 2nd Law and Atwood Machine

## *Part 1: Ideal Atwood machine*

In this part use the small plastic pulley.

1. Look at the device in front of you. This device consisting of a pulley and two suspended weights is called the Atwood machine. What are the forces acting on each weight?

2. Make one of the weights larger than the other. What will happen? What do you think are the factors that affect the motion of the Atwood machine?

3. Try to apply Newton's 2nd law on each one of the weights and find an equation for the acceleration of the system.

4. What assumptions or approximations have you made in your answers so far?

5. Can you calculate the acceleration of the system experimentally using the devices in front of you and the equations of motion?

6. Calculate the acceleration of the system using the equation you found in step 3. Does it agree with the experimental calculation from step 5? Are your approximations valid?

## *Part 2: Non Ideal Atwood machine*

In this part use the large aluminum pulley.

7. Repeat steps 5 and 6 using the large pulley. Are your approximations valid in this case? Why? Is the equation you found in step 3 still valid?

8. Try to analyze the forces acting on the components of the system in this case and the torques acting on the pulley. Doing this would lead to the equation :

$$D = \frac{a}{g}\left(\frac{I}{R_1^2} + 2m_1\right) + \frac{\tau_f}{R_1 g} \qquad (1)$$

Where:

D is the difference in the masses $(m_2 - m_1), m_2 > m_1$

$R_1$ is the radius of string around the pulley.

$I$ is the moment of inertia of the wheel (the pulley)

And $\tau_f$ is the torque due to the friction opposing the rotation of the pulley.

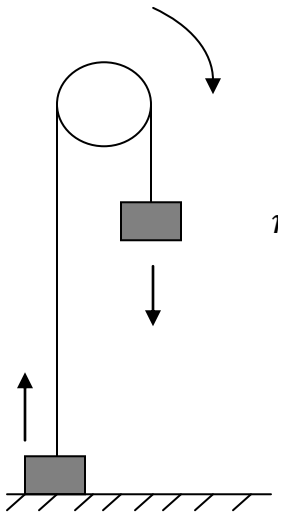

Figure 1

9. Suggest an experiment that would allow you to calculate the moment of inertia of the wheel using equation (1) and keeping $m_1$ constant. Hint see step 5 and figure 1 above.

10. Carry out the experiment, tabulate your data and draw the needed graph to calculate $I$ .

11. If you are given that the moment of inertia of a solid cylinder of mass M and radius R is given by

$$I = \frac{1}{2} M R^2$$

And that the density of aluminum is given by $\rho_{Al} = 2.7 \times 10^3 \, kg/m^3$, can you calculate the moment of the inertia of the wheel directly? Does the experimental value you found in step 10 agree with the value you got in this step?

***Bonus question:***

Can you find the frictional force opposing rotation of the pulley from the graph you made in step 10?