Online Lab: Atwood's Machine

Name: ______ Date: ______

Instructor: ______ Section: ______

Objective:

For this lab you will be working with a simulated pulley arrangement. You will study the relationships between mass and acceleration using an Atwood's Machine apparatus. Though we do not consider it in todays analysis, an ideal two pulley arrangement does have friction and a nonzero mass.

Theory:

Newton's second law (F_{net} = ma) can be experimentally tested with an apparatus known as an "Atwood's Machine." Figure 1 below illustrates an idealized version of the Atwood's Machine. Here, two objects, connected by a massless thread, are draped over a frictionless, massless pulley, as shown in the Figure 1. For clarity, we assume the object on the left is object 1, and the object on the right is object 2. If the mass m_1 of object 1 is greater than the mass m_2 of object 2, object 1 accelerates downward, and object 2 accelerates upward. Since the objects are connected, the magnitude of the acceleration is the same for each object. Since the pulley is frictionless and massless, and the string is massless, the tension on each side of the pulley has the same magnitude (i.e., $T_1 = T_2$). Given these assumptions, the freebody diagrams for the two objects are shown below:

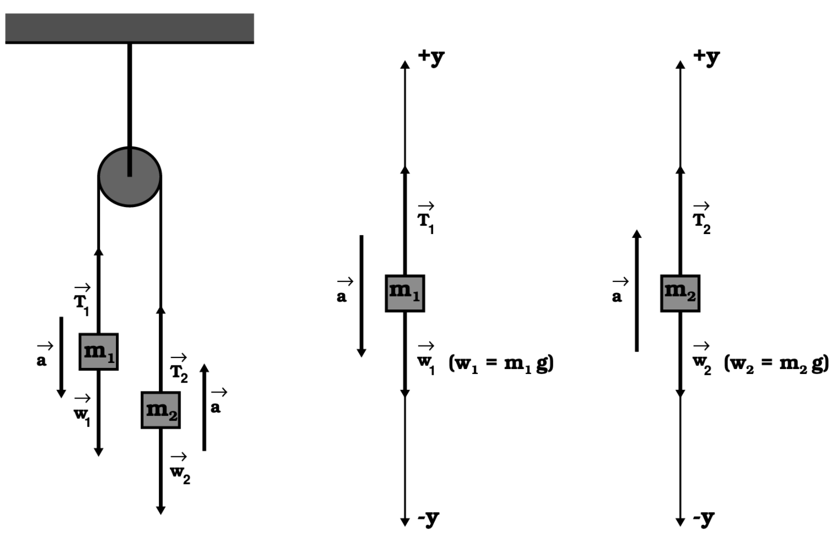


Figure 1: An idealized Atwood Machine with Free-Body Diagrams

Applying Newton's 2nd Law, $F_{net,y} = \mathrm{m}a_y$ to each object, we write

$$T - m_1 g = -m_1 a \tag{1}$$

and

$$T - m_2 g = m_2 a. \tag{2}$$

If we eliminate the tension T, we can obtain the following expression for the magnitude of the acceleration:

$$a = \frac{(m_1 - m_2)g}{m_1 + m_2}. \tag{3}$$

The numerator is the net force causing the system to accelerate, and the denominator is the total mass being accelerated. We will call this the theoretical expression for the acceleration, ath, which can also be written as

$$a_{theory} = \frac{F_{net}}{m_{tot}}, \tag{4}$$

where F_{net} = (m_1 - m_2)g and $m_{tot} = m_1 + m_2$.

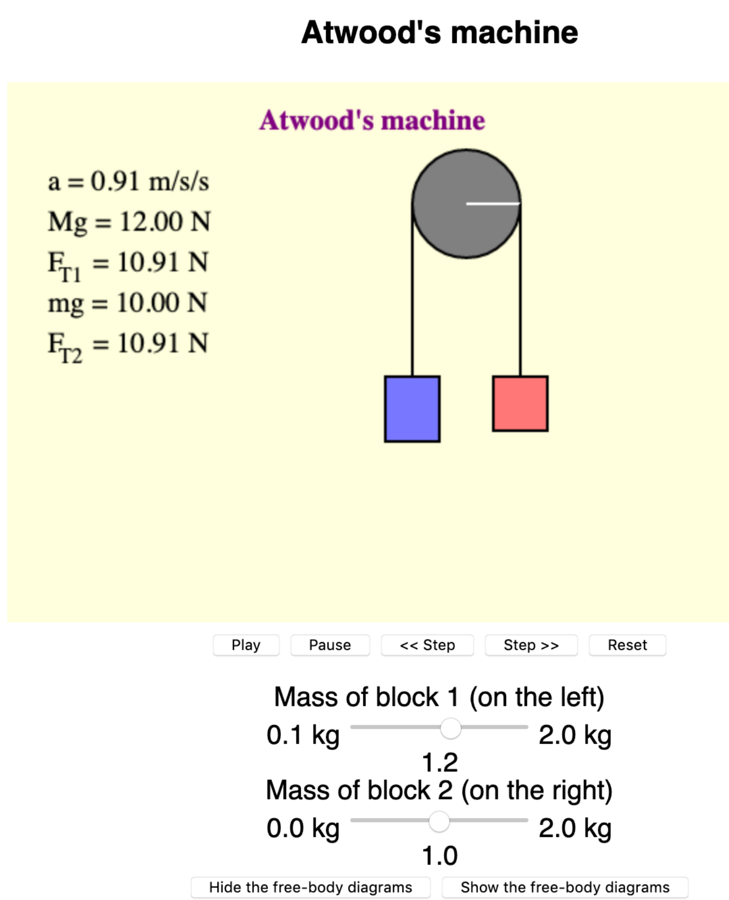


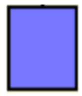
Figure 2: Initial Configuration after opening the Atwood's Machine Simulator

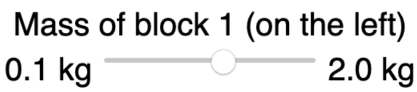
Online Atwood's Machine Experiment Instructions:

1. Go to the following website:
   http://physics.bu.edu/ duffy/HTML5/Atwoods_machine.html

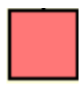
2. Figure 2 shows an example of what you should see on your screen.

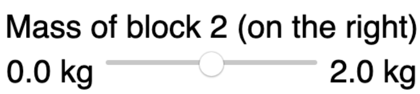
3. Description of the Buttons used during the Experiment is given below:

   (a) The blue block on the left,  represents Mass 1.

   (b) 

   Allows you to adjust the mass of block 1.

   (c) The blue block on the left,  represents Mass 2.

   (d) 

   Allows you to adjust the mass of block 2.

   (e) a = 0.91 m/s/s
   Mg = 12.00 N
   F_{T1} = 10.91 N
   mg = 10.00 N
   F_{T2} = 10.91 N
   The upper right of the simulation provides a number of experimental values. For this lab, we are only interested in the top most value, the experimental acceleration, a_{exp} or as shown here ($\mathbf{a = 0.91\ m/s/s}$).

Procedure: Atwood's Machine

1. Set the mass of Block 1, m_1 to 1.0 kg and the mass of Block 2, m_2 to 1.0 kg.
2. What do you observe?

3. Set the mass of Block 1, m_1 to 1.1 kg and the mass of Block 2, m_2 to 0.9 kg.
4. Click **Play and Observe the simulation**.
   Record the acceleration in the upper left of the simulator in the a_{exp} column of Table 1.
5. **Repeat Steps 3-4** for each of the m_1 and m_2 sets in Table 1.

Table 1: Acceleration Data

m_1 (kg)	m_2 (kg)	Δm	a_{exp} (m/s^2)	a_{theory} (m/s^2)	$\%_{error}$
1.1	0.9				
1.2	0.8				
1.3	0.7				
1.4	0.6				
1.5	0.5				
1.6	0.4				
1.7	0.3				
1.8	0.2				
1.9	0.1				

6. **Calculate** the mass difference, Δ_m for each mass set using $\Delta_m = m_1$ - m_2.
   Record these values in column 3 of Table 1.
7. **Calculate** the theoretical acceleration, a_{theory} for each mass set using the equation:
   Recall the acceleration due to gravity $g = 9.8\ m/s^2$.

$$a_{theory} = \frac{F_{net}}{m_{total}} = \frac{(m_1 - m_2)g}{m_1 + m_2}$$

   Record these values in column 5 of Table 1.

8. **Compare** your experimental acceleration, a_{exp} with the theoretical acceleration, a_{theory}:

$$\%_{error} = \frac{a_{exp} - a_{theory}}{a_{theory}} \times 100\%$$

Record these values in column 6 of Table 1.

Conclusions:

1. How well do your experimental acceleration values a_{exp} and theoretical acceleration, a_{theory} values agree?

2. What can you conclude about Newton's Second Law from this experiment?