Experiment No.7
Atwood Machine

OBJECTIVE:

To study the relation between force, mass, and acceleration using an Atwood Machine and to determine acceleration due to gravity

METHOD:

Consider the Atwood machine shown in Fig. 1. A pulley is mounted on a support a certain distance above the floor. A string with loops on both ends is threaded through the pulley and different masses are hung from both ends. The smaller mass is placed near the floor and the larger mass near the pulley (the pulley can be adjusted to the appropriate height). The masses are then released and the time for them to exchange places is measured.

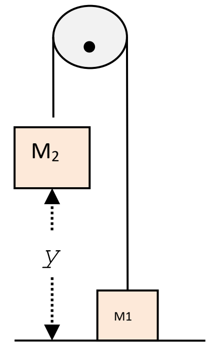

Figure 1

APPARATUS:

Pulley, loads with a stopwatch, string, and meter stick.

METHOD:

Consider the Atwood machine shown in Fig. 1. A pulley is mounted on a support a certain distance above the floor. A string with loops on both ends is threaded through the pulley and different masses are hung from both ends. The smaller mass M1 is placed near the floor and the larger mass M2 near the pulley (the pulley can be adjusted to the appropriate height). The masses are then released and the time for them to exchange places is measured.

THEORY:

Consider the larger mass, M_2. Two forces are acting on it. One is the force of gravity, $W_2 = M_2 g$, pulling it downward. The other force is the tension in the string, T_2, which is pulling it upward. Taking up to be the positive direction, Newton's 2nd Law gives, For (M_2), ($T_2 < M_2 g$)

$$\sum F_y = M_2 g - T_2 = M_2 a_2, \qquad (1)$$

Now consider the smaller mass, M_1. Again two forces are acting on it. One is the force of gravity pulling it downward. The other force is the tension in the string pulling it upward. Thus, Newton's 2nd Law gives ($T_1 > M_1 g$)

$$\sum F_y = T_1 - M_1 g = M_1 a_1, \qquad (2)$$

Because the string is attached to both masses, $a_2 = -a_1 = a$. We now assume that the string's mass is much less than either of the hanging masses and that the pulley does not rotate as the masses move. This allows us to say that $T_1 = T_2 = T$. (In reality, the pulley does rotate and the tensions can't be equal if it rotates. However, we assume that the pulley's motion takes very little energy from the system so we can approximate it as being stationary. Another way to put this approximation is that we are using a "massless" pulley and a "massless" string.) With this assumption, adding the 2 equations to get

$$M_2 g - M_1 g = M_2 a + M_1 a \quad \Rightarrow (M_2 - M_1) \cdot g = (M_2 + M_1) \cdot a$$

The net force on the system

$$F_{net} = (M_2 - M_1)g = (M_1 + M_2)a \,.$$

The theoretical acceleration is (a), then is

$$a_{th} = \frac{M_2 - M_1}{M_2 + M_1} g_{th}, \quad g_{th} = 9.8 m/s^2 = 980 cm/s^2 \qquad (3)$$

When M_2 falls with acceleration from rest then, the fall distance y is given by:

$$y = \frac{1}{2} a_{exp} t^2 \;, \quad a_{exp} = \frac{2y}{t^2} \qquad (4)$$

The experimental acceleration a_{exp} is to be determined by measuring the average time of fall for some trials of different masses.

Experimentally, we have to determine the acceleration due to gravity using

$$a_{exp} = \frac{M_2 - M_1}{M_2 + M_1} g,$$

A plot of a_{exp} versus $\frac{M_2 - M_1}{M_2 + M_1}$ gives a straight line with slope g.

Procedure:

(1) Mount a clamp to the edge of the table. Place the smart Pulley in the clamp so that the smart pulley's rod is horizontal.

(2) Use a piece of thread about 10 cm longer than the distance from the top of the pulley to the floor. Place the thread in the groove of the pulley. Fasten mass hangers to each and end of the thread.

(3) Place about 100 grams of mass on one mass hanger and record the total mass as M_1. Be sure to include the 50 grams from the mass hanger in the total mass. Place lightly more than 100 grams on the other hanger. Record this total mass as M_2.

(4) Move the heavier of the two masses upward until the lighter mass almost touches the floor. Hold the heavier mass to keep it from falling. Measure the time it takes the heavier mass to reach the floor three times.

(5) Use the distance and the average time square to calculate the experimental acceleration (a_{exp})

(6) Change the mass on the hangers each trial and try to make the difference between them small compared to the total mass.

(Fill the tab in the lab report and find g from your slope of $\mathbf{a_{exp}}$ vs. $(M_2-M_1)/(M_2+M_1)$).

Exp. No. 7

Atwood's Machine

Name: ……………………………...…………….….….……… Grade: …………………………….….

Student's No.: ……………………………………….........Day and Date: …………………………..…

Partner's Names: ……………………………………………………Sec: …….……….……..…..

(1) Fill the table below

	M_1 (g)	M_2 (g)	$t_1(s)$	$t_2(s)$	$t_3(s)$	$\bar{t}$ (s)	$\bar{t}^2$	Y(m)	a_{th}	F_{net}	a_{exp}	$\frac{M_2 - M_1}{M_2 + M_1}$
Run1												
Run2												
Run3												
Run4												
Run5												
Run6												

(2) Plot $\mathbf{a_{exp}}$ versus $\frac{M_2 - M_1}{M_2 + M_1}$ find the slope.

Slope =S= ……………………………...

g = ………..………………………

Δg = …………………………………

<u>Questions:</u>

(1) Suppose there is an Atwood machine with M_1=0.5 kg and M_2=1 kg.
What is the acceleration of such a system if the friction is negligible (g = 10 m/s^2)?

(2) What is the net force in an Atwood machine if M_1=1 kg and M_2=2 kg?