Atwood's Machine

Objective:

The purpose of this laboratory activity is to study the relationship between force, mass, and acceleration using an Atwood's Machine.

Apparatus:

Pulley, loads with electronic timer and meter stick.

Theory:

The acceleration of an object depends on the net applied force, and the mass. In an Atwood's Machine, the difference in weight between two hanging masses determines the net force acting on the system of both masses. This net force accelerates both of the hanging masses; the heavier mass is accelerated downward, and the lighter mass is accelerated upward.

In the free body diagram of the Atwood's machine, T is the tension in the string, M_1 is the lighter mass, M_1 is the heavier mass, and g is the acceleration due to gravity. Assuming that the pulley has no mass, the string has no mass and doesn't stretch, and that there is no friction, the net force on M1 is the difference between the tension and $M_1 g$ ($T > M_1 g$). The net force on M_2 is the difference between the tension and $M_2 g$ ($T < M_2 g$).

Solve for "a", the acceleration of the system of both masses. The theoretical acceleration is "g" times the difference in mass divided by the total mass.

$$a = g\frac{M_2 - M_1}{M_2 + M_1} \tag{33}$$

From the analysis of the force equation we see that: if we plot a graph of y versus t^2 we get a straight line whose slope is equal to $S = \frac{1}{2}a$. So
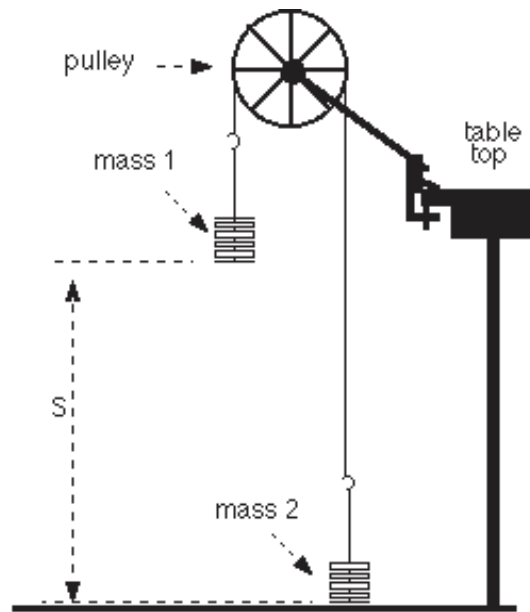
Figure 14:

by measuring the distance and time we can experimentally determine the acceleration due to gravity.

Procedure:

1. Mount a clamp to the edge of a 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

3. Fasten mass hangers to each end of the thread.

4. 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 slightly more than 100 grams on
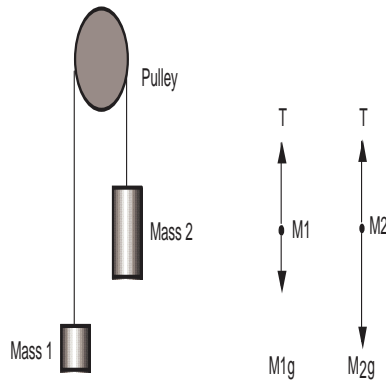
Figure 15:

the other hanger. Record this total mass as M_2.

5. 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.

6. use the distance and the average time square to calculate the experimental acceleration(a_{exp}) from the equation:

$$y = \frac{1}{2}a_{exp}t^2 \tag{34}$$

7. change the mass on the hangers each trial and try to make the deference between them is small compared to the total masses.

	M_1	M_2	t_1	t_2	t_3	$\bar{t}$	t^2	y (m)	a_{th}	F_{net}	a_{exp}
Run1											
Run2											
Run3											
Run4											
Run5											

from the graph of a_{exp} versus $\frac{M_2-M_1}{M_2+M_1}$ find the slope.

S=..............,   g=.................

calculate the error in g.

....

Questions:

1. Suppose there is an Atwood's machine with $M_1 = 0.5$ kg, $M_2 = 1.0$ kg. What is the acceleration of such a system if the friction is negligible $(g = 10m/s^2)$?

2. What is the net force in an Atwood's machine if $M_1 = 1$ kg and $M_2 = 2$ kg?

Conservation of Energy

Objective:

Verification of the conservation of energy law.

Apparatus:

Flex-track, balls, ruler, and carbon paper.

Theory:

If a ball of mass m is released from point A on the track AB, then the conservation of energy gives:

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 + work\,done\,against\,friction. \tag{35}$$

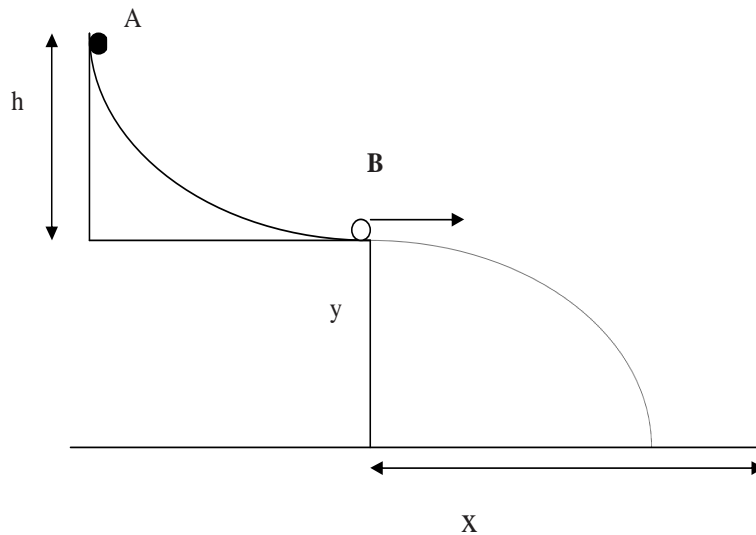where mgh is the potential energy of the ball relative to point B on

Figure 16:

the track (see fig. 1)

$\frac{1}{2}mv^2$ is the transitional kinetic energy of the ball at point B.

$\frac{1}{2}I\omega^2$ is the rotational kinetic energy of the ball at point B.