EXPERIMENT 1

Atwood's Machine

GOAL

- To set up the Atwood's Machine
- To analyze and study the motions generated in the system of the Atwood's pulley machine.

THEORY

The Atwood machine was invented in 1784 by English mathematician George Atwood (1745 – 1807). The purpose of this invention was to study the mechanical motion with constant acceleration and verify relating mechanical laws. Atwood's machine is also a convenient system to demonstrate principles of classical mechanics.
Atwood's machine consists of a pulley and two hanging masses. The difference in weight between the two hanging masses determines the net force acting on the system. This net force accelerates both of the hanging masses; the heavier mass is accelerated downward, and the lighter mass is accelerated upward. By varying the masses, we can control the motion of the system, making it faster or slower.

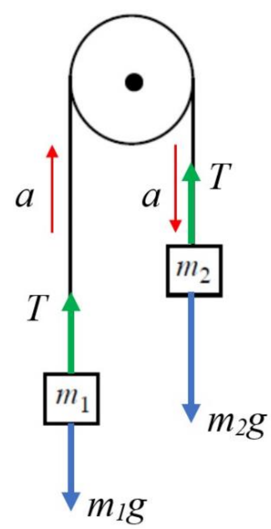

Fig. 1. The free body diagram of the Atwood's machine

Fig. 1 represents a free body diagram of an Atwood's machine. In our theoretical explanations and in process of driving working formulae, we will consider that m_1 is less than m_2, which makes m_1 to accelerate upward and m_2 to accelerate downward when the system is released. Let's apply Newton's Second Law to both of masses:

$$m_1 g - T = m_1 a \qquad (1)$$

$$-m_2 g + T = m_2 a \qquad (2)$$

where T is the tension force, g is the local gravitational acceleration, a is the acceleration of the system.

Adding equations (1) and (2) side-by-side, we can eliminate T:

$$m_1 g - m_2 g = m_1 a + m_2 a \qquad (3)$$

The local gravitational acceleration can be determined from equation (3):

$$g = \frac{(m_1 + m_2)a}{m_1 - m_2} \qquad (4)$$

PROCEDURE

Acceleration of system

As one can see from formula (4), we have to measure the acceleration of the system in order to determine the local gravitational acceleration of Earth. In this experiment, we will determine the acceleration ***a*** experimentally for various combinations of m_1 and m_2, by measuring the time t required for m_2 to "fall" a distance h, and using the familiar constant-acceleration equation

$$h = \frac{1}{2} a t^2 \qquad (5)$$

The acceleration a can be obtained from equation (5):

$$a = \frac{2h}{t^2} \qquad (6)$$

Measurements

1. Set up the Atwood's machine for two different masses, m_1 and m_2.
2. Bring the mass m_1 down until it touches the desk and measure the distance h between the desk and the bottom of mass m_2.
3. Release mass m_1 simultaneously starting the timer and measure the time until the mass m_2 touches the desk.
4. Repeat step 3 five times and complete the Table 1.

Table 1

m_1 (kg)	m_2 (kg)	h (m)	t (s)	a (m/s^2)	g (m/s^2)

5. Determine the gravitational acceleration by evaluating the average of the experimental data from the last column of Table 1.