Experiment 5 (M 7)

NEWTON'S LAW OF MOTION

1- Purpose

To investigate the factors of motion and observe the Newton's second law of motion using an Atwood's machine that placed on inclined plane.

2- Apparatus

Air table set, pulley, string, wooden block, ruler.

3- Theory

In 1686, Sir Isaac Newton first presented his three laws of motion in the "Principia Mathematica Philosophiae Naturalis".

Newton's first law states that every object will remain at rest or in uniform motion in a straight line unless compelled to change its state by the action of an external force. This is normally taken as the definition of inertia. If all the external forces cancel each other out (this means there is no net force acting on an object) then the object will maintain a constant velocity. If that velocity is zero, then the object remains at rest. If an external force is applied, the velocity will change because of the force.

The second law explains how the velocity of an object changes when it is subjected to an external force. The law defines a force to be equal to change in momentum (mass times velocity) per change in time. For an object with a constant mass m, the second law states that the force F is the product of an object's mass and its acceleration $\vec{a}$:

$$\vec{F} = \mathrm{m} \cdot \vec{a}$$

One may study Newton's second law using a device known as **Atwood's machine**, shown below (Figure 6.1). It consists of pulley and two hanging masses, m_1 and m_2.

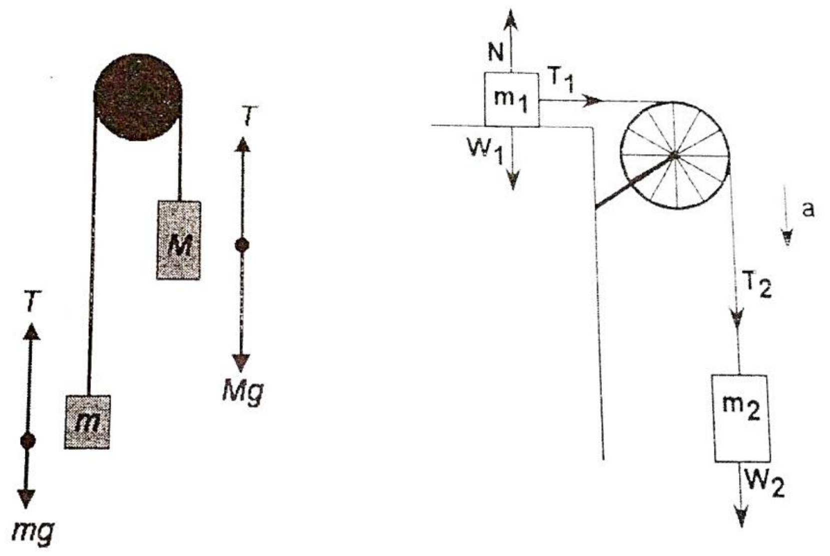

Figure 6.1. Atwood's machine and the forces acting on m_1 and m_2.

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 accalerated downward and the lighter mass is accelerated upward. The acceleration is constant during the motion and the distance y;

$$y = \vartheta_o \cdot t + \frac{1}{2}\alpha \cdot t^2, \vartheta_0 = 0$$

can be written.

One may set up a system shown below (Figure 6.2) to set an Atwood's machine.

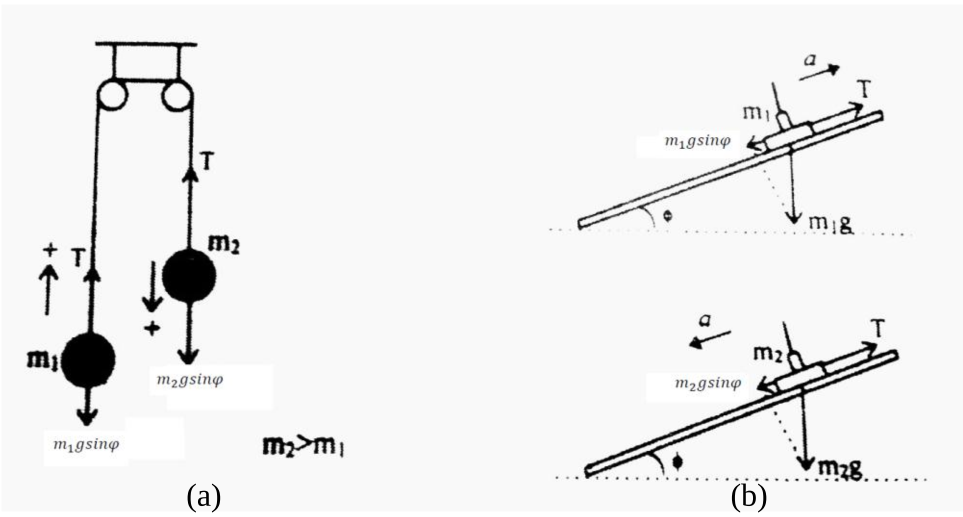

Figure 6.2. (a) Atwood's machine on the air table (b) the motion of masses m_1 and m_2.

Two forces act on mass m_2 as shown in Figure 6.2. These are tensile force on the rope T and vertical component of gravity force $m_2 g sin\varphi$. The net force on mass m_2, $F_{net} = m_2 \alpha$;

So Newton's Second Law predicts theoretically;

$$a = \frac{(m_2 - m_1)}{m_1 + m_2} g sin\varphi$$

Tensile force on the rope;

$$T = \frac{2m_1 m_2}{m_1 + m_2} g sin\varphi$$

can be written.

4- Procedure

- Operate air compressor and balance the air table.
- Locate the wooden block to the back leg of the air table and find the slope of the air table.
- Locate the pulleys upper part of the air table as shown in figure . Roll the rope up pulley and tie the discs.
- Put the light dics at the lowest position and the heavy one at the highest position. Operate the air compressor and see the motion of masses (discs), heavy disc go downward and light one go upward. Repeat this step until you are ready.
- Adjust spark timer (generator) to a proper frequency or period.
- Operate again air compressor and spark timer (generator) pedal also.
- Check out your data if it is proper.
- Give numbers to your data points 0,1,…,5 starting from first data point. Choose the first point as zero (this is the point of origin).
- Starting from zero point show the displacements on y – axis (use dimensioning rules). Record them into table.
- Determine the accelerations of two masses plotting y – t^2 graph, seperately.
- Compare these result with teoretical one, 980 cm/s^2.
- Calculate the tensile force, T.

5- Data

	m_1=…….g	m_2=…….g		
#	y±Δy (cm)	y±Δy (cm)	t±Δt (s)	t^2 ±Δt^2(s^2)
0				
1				
2				
3				
4				
5				

Table 6.1 Distance-time data for m_1 and m_2

6. Questions

1. *Analyse the motion in y- axes. Which type of motion does the disc follow?*
2. *Calculate the system accelerate and tensile force of string for Atwood's*