Experiment No: M3

Experiment Name: Newtons's Second Law of Motion

Objective:

1. Investigation of one dimensional motion under constant force, plotting displacement vs. time, velocity vs. time.
2. Observing Newton's second law of motion, plotting force vs. acceleration.

Keywords: Velocity, acceleration, force, Newton's law

Theoretical Information:

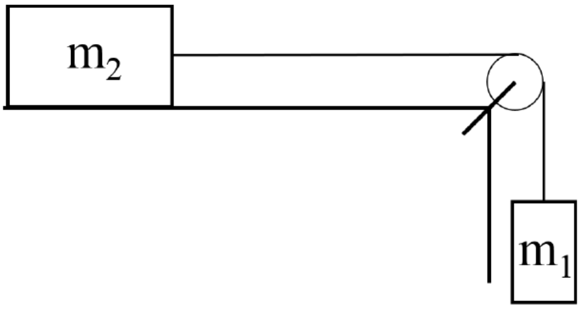

Figure 3.1: A physical model for the experimental set-up

The experiment can be studied by the help of the simple model depicted in Figure 3.1. To investigate the motion of m_1 and m_2, one should draw the "free body diagrams" of the two masses. These diagrams are shown in Figure 3.2.

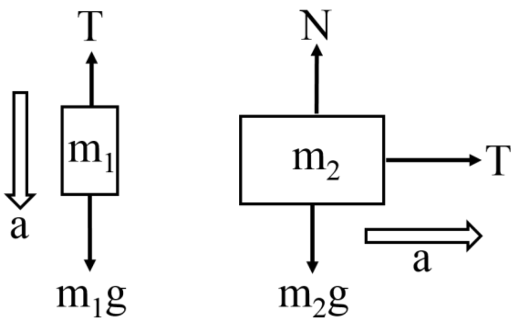

Figure 3.2: Free body diagrams showing the forces acting on two bodies and their accelerations.

Using $\vec{F} = m\vec{a}$.(Newton's second law of motion) we can write the following equations for the bodies.

$$m_1 g - T = m_1 a \quad 3.1$$

$$N - m_2 g = 0 \quad 3.2$$

$$T = m_2 a \quad 3.3$$

If we add equations [3.1] and [3.3] we get the following expression $m_1 g = (m_1 + m_2)a$. We can easily pull out as follows:

$$a = \frac{m_1 g}{m_1 + m_2} \quad 3.4$$

As one can see from equation [3.4] the acceleration of the system depends on m_1 and m_2. Given that the masses remain constant during one set of measurement the acceleration is also expected to stay constant. So in this system m_1 is expected to make a motion with constant acceleration in the vertical direction while m_2 is expected to make the same in the horizontal.

In the experimental set-up we will investigate the motion of the body with mass m_2 in the horizontal direction. The definition of the acceleration is given as $a = dv/dt$. We can rewrite this equation as follows: $dv = a \cdot dt$. We have already argued that a is expected to be constant during the motion in the previous paragraph. So if we integrate both sides of this equation under that condition we reach the following equation which expresses the dependence of the velocity to the time.

$$v = v_0 + at \quad 3.5$$

Here v_0 is the initial velocity of the body.

Now if use the definition of the velocity which is $v = dx/dt$ and substitute it in the equation [3.5] and pass the denominator of the left side to the right we can rearrange the equation as follows:
$dx = (v_0 + at)dt$. Integrating both sides we can easily deduce the following equation:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2 \quad 3.6$$

Here x_0 represents the initial position of the body. The equations [3.5] and [3.6] are called the kinematics equations of the motion with constant acceleration.