Experiment 5: Newton's Second Law Part 1

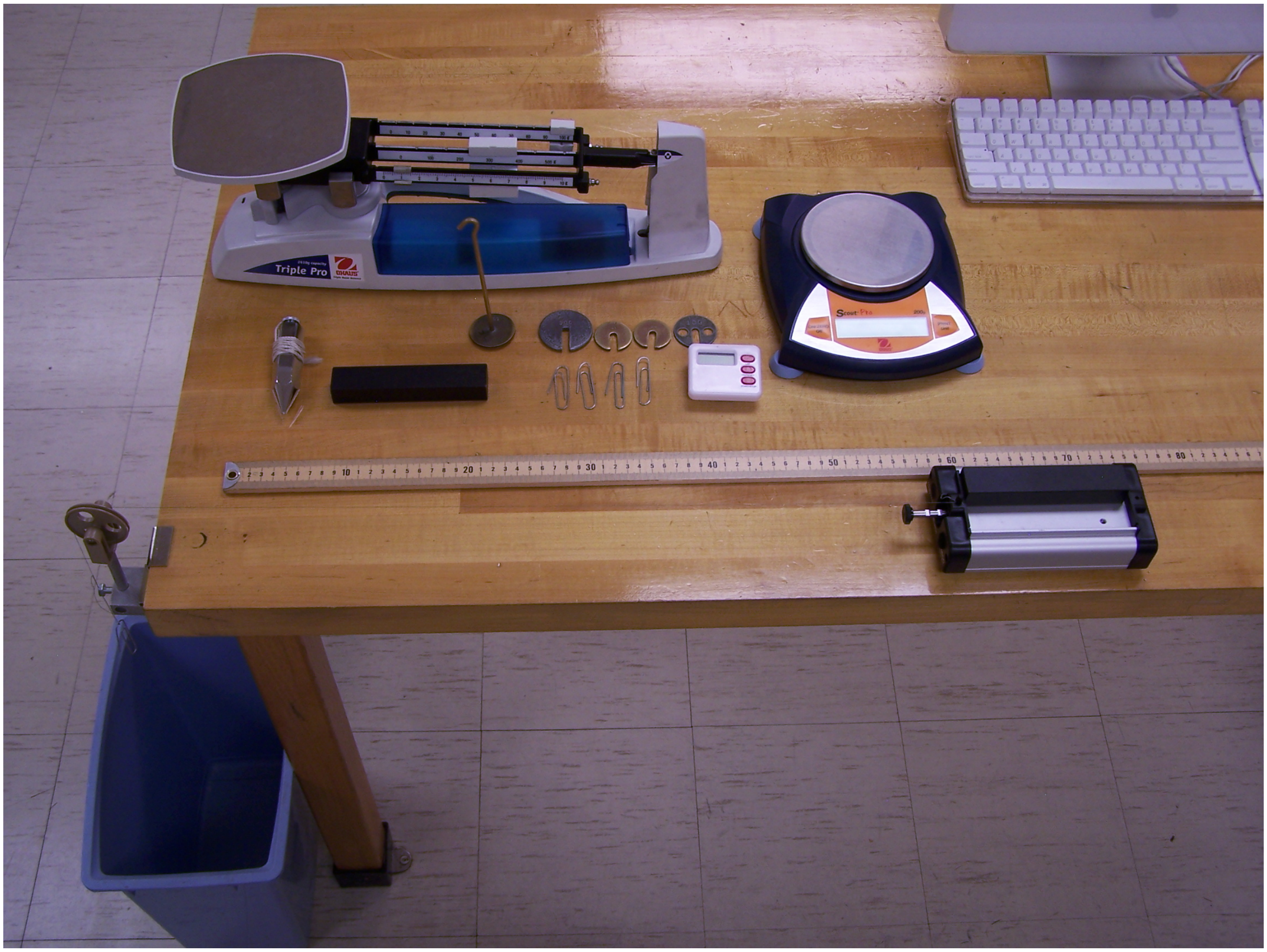

Figure 5.1: Newton's Second Law Setup

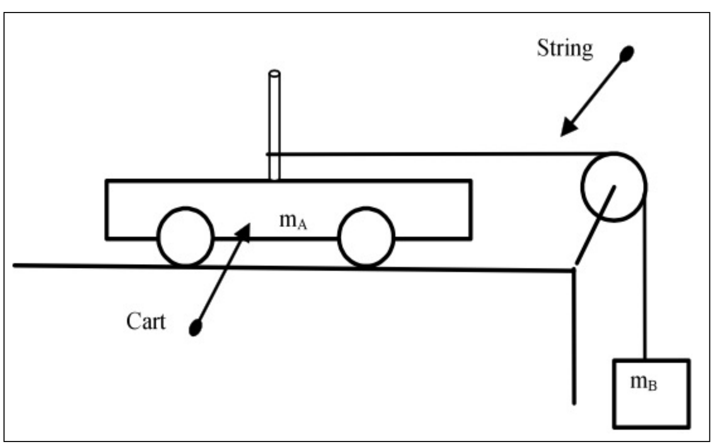

Figure 5.2: Note: String from cart to pulley must be horizontal and aligned with the pulley.

EQUIPMENT

Low-Friction Cart
Pulley and String
Triple-Beam Balance
Digital Balance
Stopwatch
Meter Stick
Mass Hanger
(1) 10 g Mass
(2) 20 g Masses
(1) 50 g Mass
Paper Clips (small masses)
Plumb Bob
Wastebasket

Advance Reading

Text: Newton's Second Law, acceleration, velocity, displacement, vectors.

Objective

The objective of this lab is to explore and analyze the relationship between force, mass, and acceleration.

Theory

According to Newton's Second Law, the acceleration, $\vec{\mathbf{a}}$, of a body is directly proportional to the vector sum of the forces, $\Sigma\vec{\mathbf{F}}$, applied to the body:

$$\Sigma\vec{\mathbf{F}} = m\vec{\mathbf{a}} \tag{5.1}$$

where m is the mass of the body.

A force T (tension) will be applied to the cart, m_A, by means of a string with an attached mass, m_B. If one can ignore the force of friction acting on the cart, then if the unbalanced force acting on the system is increased while the mass of the accelerating system is held constant, the acceleration of the system will increase proportionately.

This analysis assumes a frictionless environment.

The added mass, m_B, exerts a force equal to its weight on the cart/mass system.

When the cart is accelerating, deriving a of the cart is found with the following equation:

$$a = \frac{m_B \cdot g}{m_A + m_B} \tag{5.2}$$

We will compare this calculated acceleration to the acceleration obtained from the kinematic equations for constant acceleration.

In this experiment, acceleration will be found experimentally tracking the cart's motion across a set distance. The time of travel will be carefully measured using a stopwatch.

Note that since the cart and m_B are connected, their acceleration, velocity, and distance traveled are equal at all times. Thus, the horizontal distance the cart travels, Δx, is equal to the vertical drop of the attached mass, Δy.

$$x = x_0 + v_{0_x} t + \frac{1}{2} a_x t^2 \tag{5.3}$$

We now define calculated and measured accelerations as $a_{Theo.}$ and $a_{Meas.}$:

$a_{Theo.}$ is determined by Eq 6.2;
$a_{Meas.}$ is determined by Eq 6.3.