Experimental No. (3)
Newton's Second Law

Objective:

To verify Newton's second law, by:

1. **Investigating the dependence of acceleration of a body on its mass, when the net force is kept constant and,**

2. **Investigating the dependence of acceleration of a body on the net force, when its mass is kept constant.**

Apparatus:

Air track, Glider, Hanger, 2 Photogates, 5g, 10g,15g, 20g and 25g masses

Theory:

Newton's second law states that the acceleration of a body is proportional to the force acting on the body and inversely proportional to its mass:

$$\overrightarrow{F} = m\overrightarrow{a} \tag{23}$$

Figure(9) is a sketch of the apparatus used in the experiment. In this experiment a low friction air track will be used to test the validity of Newtons Second Law. A hanging mass will be attached to a glider placed on the air track by means of a light (negligible mass) string. By varying the amount of mass that is hanging we will vary the net force acting on this two body system. While doing this we will make sure to keep the total mass of the two body system constant by moving mass from the glider to the hanger. With the air track turned

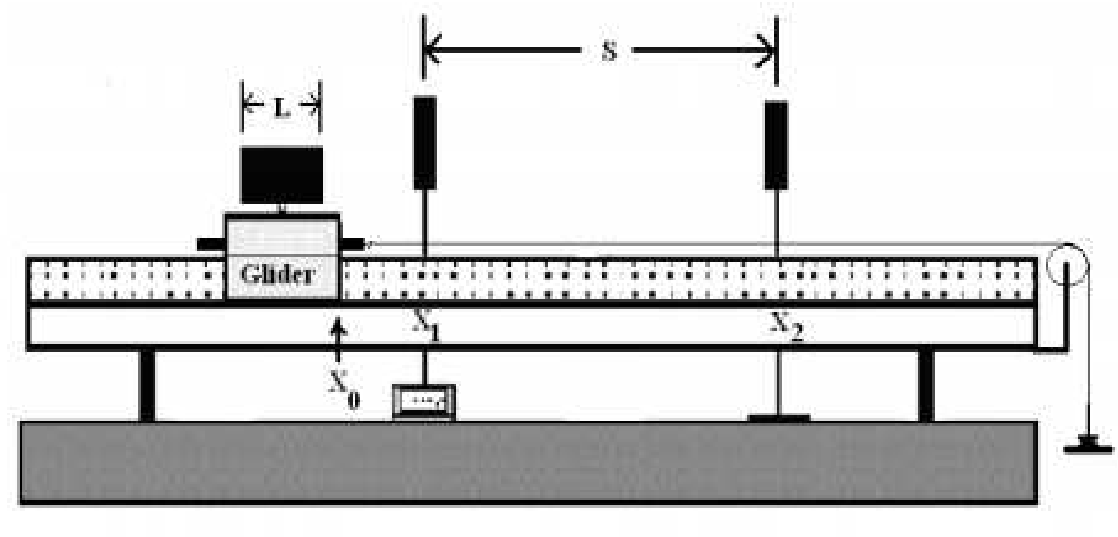

Figure 9:

on, the hanging mass will be released and the glider will pass through two photogate timers. The photogate timers will be used to measure two velocities Recall that $v = \frac{\triangle x}{\triangle t}$. In our case$\triangle x$ will be the length of a fin placed on top of the glider($= 5cm$). If you know the separation between the two photogate timers, you can use the following equation to determine the acceleration of the glider:

$$v_2^2 = v_1^2 + 2 * a * S \tag{24}$$

$$a = \frac{v_2^2 - v_1^2}{2S} \tag{25}$$

where v_2 is the velocity measured with the second photogate, v_1 is the velocity measured with the first photogate, a is the acceleration and S is the distance between the two photogate timers. Applying Newtons Second Law to the glider in the horizontal direction and using to the right as the positive direction yields:

$$M_H * g - T = M_H * a \tag{26}$$

$$T = M_G * a \tag{27}$$

$$afteraddtion \quad M_H * g = F_H = (M_H + M_G) * a \tag{28}$$

Where T is the tension in the string; $F_G = M_G * g$ is the weight of the glider; and $F_H = M_H * g$ is the weight of the hanging mass where g is the acceleration due to gravity.

Procedure:

I. Dependence of acceleration on mass at constant force.

1. **Set up the air track as shown in Figure (9). With the hanging mass disconnected from the glider and the air supply on, level the air track by carefully adjusting the air track leveling feet. The glider should sit on the track without accelerating in either direction. There may be some small movement due to unequal air flow beneath the glider, but it should not accelerate steadily in either direction.**

2. **Measure the length (L) of the fin on top of the glider and record it in your spreadsheet. See the Figure for a definition of various lengths that will be used throughout this experiment.**

3. **Measure the mass of the glider (M_{G0}) and empty hanger (M_{H0}) and record these masses in your spreadsheet.**

4. **Using the 5, 10 and/or 20 gram masses, place mass on the glider. Make sure to distribute the masses symmetrically so that the glider is balanced on the track and not tipping to one side. record this in your spreadsheet in the column labeled M_1.**

5. **increase the mass on the glider up to five values and record the other quantities in the table 1.**

6. **Plot the inverse of the acceleration** $(\frac{1}{a})$ **against the added mass to the hanger** M_1**.**

II. Dependence of acceleration on Force at constant mass.

1. **Note that the total mass of your system** $(M_G + M_H)$ **should remain constant throughout the experiment and always be equal to the value entered next to Total system mass** $(M_{H0} + M_{G0} + 50)$**. You are just redistributing 50 grams of mass between the glider and the hanger during the experiment.**

2. **Let the glider accelerate with all the 50 grams on the glider and the hanger empty. Tabulate your data and calculations in table (2).**

3. **Repeat step 2 by removing weights from the glider 10 grams and add them to the driving load(hanger) keeping the same total mass of the system. and tabulate your data and calculations in table (2).**

4. **plot** $F = (M_{Ho} + M_1)$***g Vs. a.**

Name:................. Grade:......... **Data and Calculation**

$M_{Go} = ...gm,$ $M_{Ho} = ...gm.$

Table 1:

M_1	t_1	t_2	t_3	V_1	V_2	**a**	$\frac{1}{a}$
(gm)	**(sec)**	**(sec)**	**(sec)**	(cm/sec)	(cm/sec)	(cm/sec^2)	(sec^2/cm)

measured M_{Go}	from graph M_{Go}	$\frac{\Delta M_{Go}}{M_{GO}}\%$	accepted g	from graph g	$\frac{\Delta g}{g}\%$
(gm)	(gm)		(cm/sec^2)	(cm/sec^2)	

$$total\ mass = M_{Go} + M_{Ho} + ...gm$$

Table 2:

Net force F_H (dyne)	t_1 (sec)	t_2 (sec)	t_3 (sec)	V_1 (cm/sec)	V_2 (cm/sec)	a (cm/sec^2)

slope=total mass (gm)	(m_{Ho} from slope) (gm)	$\frac{\Delta m_{H0}}{m_{H0}}\%$

Experimental No. (4)
Friction

Objective:

- **To determine the Coefficient of Static Friction and kinetic Friction**

Apparatus:

- **Horizontal plane (of variable angle to be Incline plane), Frictionless pulley, Wooden block, String, Mass holder and various masses.**

Theory:

Friction is a resisting force that acts along the tangent to the two surfaces in contact when one body slides or attempt to slide across another. The direction of the fractional force on each body is to oppose that body's motion. It is an experimental observation that frictional forces depend upon the nature of the materials in contact, including their composition and roughness, and the normal force N between the surfaces. Normal force is the force that each body exerts on the other body, and it acts 90 to each surface. The frictional force is directly proportional to the normal force. To a good approximation, the frictional force seems to be independent of the apparent area of contact of the two surfaces. There are two different kinds of friction:
Static friction Occurs when two surfaces are still at rest with respect to each other, but an attempt is being made to cause one of them to slide over the other one. Static friction force fs arises to oppose any force trying to cause motion tangent to the surfaces. It increases in response to such applied forces up to some maximum value f_s^{max} that is determined by a constant characteristic of the two surfaces. This is