Name: _____ Partner's Name: _____

Newton's Second Law

In this experiment, you will examine Newton's Second Law.

OBJECT:

To find the acceleration of a system given the masses and the acting forces.

APPARATUS:

- air track with glider, masses and hanger.
- balance, photogate timer, meter stick.
- support blocks, pulley assembly.

The system consists of two masses connected by a string. One of the masses, M_1, is a glider which glides on an air track with almost no friction. The other, M_2, consists of a hanger and various additional masses suspended from the string. The system is acted upon by only one external unbalanced force, namely the gravitational force. The project will be to determine the acceleration of the system as a function of the masses M_1 and M_2.

The (constant) acceleration of the M_1 glider will be determined by measuring the time required for the glider to travel the distance between the photogate timers when released from rest at timer A.

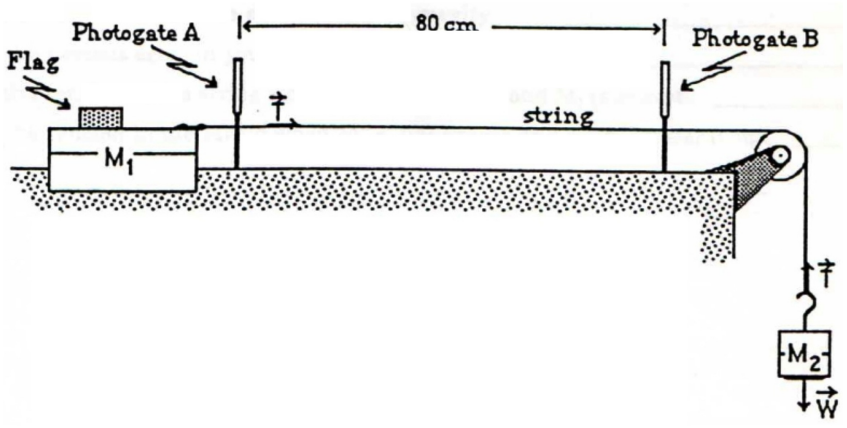

Figure 1: Experimental Setup.

SET UP ADJUSTMENTS:

1. Turn on the air supply and carefully place your glider on the air track. The glider should float without friction and will probably drift toward one end of the track or the other.

2. To level the track, loosen the wing nut on the single leveling screw under the track and twist the leveling screw until the glider floats near the middle of the track. The floating glider is very sensitive to the slightest tilt from the horizontal. When the glider floats consistently near the center of the track, tighten the locking wing nut. It is important that the track be level, since if $M_2 = 0$ we expect that $x = 0$, which won't be the case if the track is tilted.

PROCEDURE:

1. Measure the mass of your glider

   $$M_1 =$$

   Then tie a long string to the eye at the top of the glider. Place the glider on the track and adjust your pulley system so that the **string runs parallel** to the top edge of the track and does not rub against the sides of the slot in the bumper mount at the end of the track.

2. Set up the photogate timers to be $d = 80$ cm apart, with enough space between photogate B and the track bumper so that you can stop the glider after it passes through gate B.

3. To determine the acceleration a of the glider, you will measure the time Δt that it takes for the glider to travel a distance $d = 80$ cm, starting from rest. What equation will allow you to find a from Δt and d?

   (1)

4. If you have a red glider use masses of

   $$M_2 = 30,\ 50,\ 75,\ 100,\ 125\ \textit{and}\ 150\ \text{gm}.$$

   successively. The 30 gram mass ($20 + 5 + 5$ grams) can be tied directly on the string. Use the weight hanger for masses of 50 grams and up. Tie the hanger (or masses) to the string, allowing enough string so that the glider is *just in front of photogate A* when the weights are up at the pulley and so that the weights do not hit the floor until after the glider passes photogate B.

5. Push the glider to the end of the track just past photogate A. Turn the photogates to the **PULSE** position and press the **RESET** button. Hold the glider at rest just before it intercepts photogate A. Release the glider, being careful to let it start from rest without any push. Catch the glider so that it does not bounce back through photogate B. The timer will count during the entire time of travel of the glider between the photogates. The glider must be caught so that it does not bounce back through the timer and so that it does not slam into the end bumper and disturb the leveling of the track. Try this a few times for practice.

6. Measure the time Δt for three runs for each value of M_2 and average the times. Record your data in Table 1.

7. Perform an analysis of your setup (see Fig. 1) using Newton's second law ($\Sigma F = ma$) to derive an equation for a in terms of M_1, M_2 and g.

$$a = g \cdot \left(\qquad\qquad \right) \tag{2}$$

8. Based upon your Eq. (2) above, use Excel to draw a graph of a so that the graph is a straight line with slope=g. (The fit line should go through the origin if you managed to keep the track level).

   Find the slope = _____

   Find the y-intercept = _____

QUESTIONS:

1. From your graph trendline, calculate the acceleration of gravity.

2. Calculate the percent error in your value of g.

3. What is the potential significance of your y-intercept value? If the track *were* tilted at a small angle ϕ what would be the relation between the y-intercept and ϕ?

4. Calculate the tension in the string when $M_2 = 100$ gms and M_1 is at rest.

5. Calculate the tension in the string when $M_2 = 100$ gms and M_1 is accelerating.

Table 1

M_2	Δt	Δt_{avg}	a	$M_2/(M_1 + M_2)$

DUE NEXT WEEK...

1. Completed data Table.
2. This lab handout with all questions answered.
3. Excel graph of a with a data fit line.

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Newton's 2'nd Law