Kuwait University	Course 125 Phys. Lab. I
Physics Department	Experiment 9: Newton's 2^{nd} Law

Objectives

- To study the Newton's Second Law for one dimentional motion using an *air track* setup.

Equipment to be used

- Experimental setup: 2 m air track with glider, stops, pulley, hanger, mass pieces (Figure 1)
- Measuring devices:

  meter scale (on the airtrack, for measuring position and displacement)

  photogate timer with memory and two photogates (for measuring time intervals)
- PC for getting the slope of straight lines in the graphs
- balance (only for checking the given masses of the glider and of the hanger)

References :

R. A. Serway, Physics for Scientists and Engineers,
Chapter 3- Sections(1,2,3,4),Chapter 5-Section 5.

D.Halliday, R. Resnick and J.Walker, Fundamentals of Physics,
Chapter 2-Section(3,4,5,6),Chapter 5-Section 5.

Theory

Newton's Second Law of motion states that : *a force acting on a mass causes it to accelerate in the direction of the force. The amount of acceleration is directly proportional to the force, and inversely proportional to the mass.* If there are n number of unbalanced forces acting on the same body of mass m and causing it to accelerate then the mathimatical notation of newton's second law will be:

$$\sum_{i=1}^{n} \mathbf{F} \;=\; m\mathbf{a} \tag{1}$$

In this experiment you will study Newton's Second Law by examining the one-dimensional motion of an air track glider under the action of a constant force F. This force is supplied by the weight of a hanging mass. The direction of the force is changed to the horizontal by the pulley (assumed to be frictionsless) and the mass is used to pull the glider. By varying the mass of the hanger (*heavy mass*) and of the glider (*inertial mass*), and measuring the acceleration of the glider, you'll be able to verify Newton's Second Law.

Procedure

1. Set up the air track as shown in Figure 1. **Level** the air track very carefully by adjusting the *air track levelling feet*. A glider should sit on the air track without accelerating in either direction.There may be some movement of the glider due to unequal air flow beneath the glider, but it should not accelerate steadily in either direction.

2. Measure the length L of the glider and record it in Table 1.

3. Add mass pieces with a total mass of 100 g to the glider. Be sure that the masses are distributed symmetrically so the glider is balanced. **Determine** the total mass of your glider plus the mass pieces and record the total as m in Table 1.

4. Place a mass of 10 g on the hanger. Record the total mass m_a of the hanger plus added mass pieces. The mass of the empty glider is normally

(180 ± 1) g and the mass of the hanger is 10 g.

5. Set the photogate timer to *GATE* mode with memory switched "ON".

6. Choose a starting point $x_o = 10$ cm for the glider, near to the end of the track.

7. Press the *RESET* button, **switch on** the Air Supply.

8. Hold the glider steady at x_o, then release it. Record t_1, that is displayed on the timer which represent the time it took the glider to pass through the first photogate. Push the memory switch that was originally in the "ON" position to "READ" position and take the displayed time as t. Now subtract (t-t_1) and you will get t_2 which represent the time it took for the glider to pass through the second photogate. **Repeat** this measurement two more times and take the average of your measured t_1 and t_2.

9. Again **start** the glider from x_o with the photogate timer switched to PULSE mode. Measure and record t_3,which represent the time it took the glider to pass between the photogates. **Repeat** this measurement two more times and record the average of t_3.

10. Vary m_a by moving masses from the hanger to the glider (thus keeping the total mass $m + m_a$ constant). Record m and m_a in Table 1 and repeat steps 5 through 10. Try at least 4 different values for m_a.

11. Now leave m_a constant at previously used value. Vary m by adding or removing mass pieces from the glieder. Repeat steps 5 through 9. Try at least four different values for m. Record the data in Table 2.

Processing the experimental data

For each set of the experimental conditions:

12. Use the length of the glider and the average times to **determine** v_1 and v_2, the average glider velocity as it passed through each photogate.

13. Use the equation

$$a = \frac{v_2 - v_1}{\bar{t}_3} \tag{2}$$

to **determine** the average acceleration of the glider as it passed between the two photogates.

14. Plot the following graphs

1. the average acceleration as a function of the applied force,F_a,
for Table 1.

2. the average acceleration as a function of the total mass, $m + m_a$
for Table 2.

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Laboratory Assignment

1. What direction of the coordinate axis x should be selected in Figure 1? Will the results depend upon the assignment?

2. What are the units of the physical quantities *velocity, acceleration, force*?

3. List measuring devices for velocity, force, length.

4. Which quantity can you get from the slope of the curve at a given point

a) in a plot of displacement versus time,

b) in a plot of velocity versus time,

c) in a plot of the acceleration versus applied force?

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Worksheet for Experiment 9

Glider length $l =$ mass of the glider = mass of the hanger =

Table 1:

m	m_a	$\bar{t}_1$	$\bar{t}_2$	$\bar{t}_3$	$v_1 = l/\bar{t}_1$	$v_2 = l/\bar{t}_2$	a	$F_a = m_a a$
260	40							
240	60							
220	80							
200	100							
180	120							

Table 2:

m	m_a	$\bar{t}_1$	$\bar{t}_2$	$\bar{t}_3$	$v_1 = l/\bar{t}_1$	$v_2 = l/\bar{t}_2$	a	$F_a = m_a a$
200	120							
240	120							
280	120							
320	120							
360	120							

Discussion:

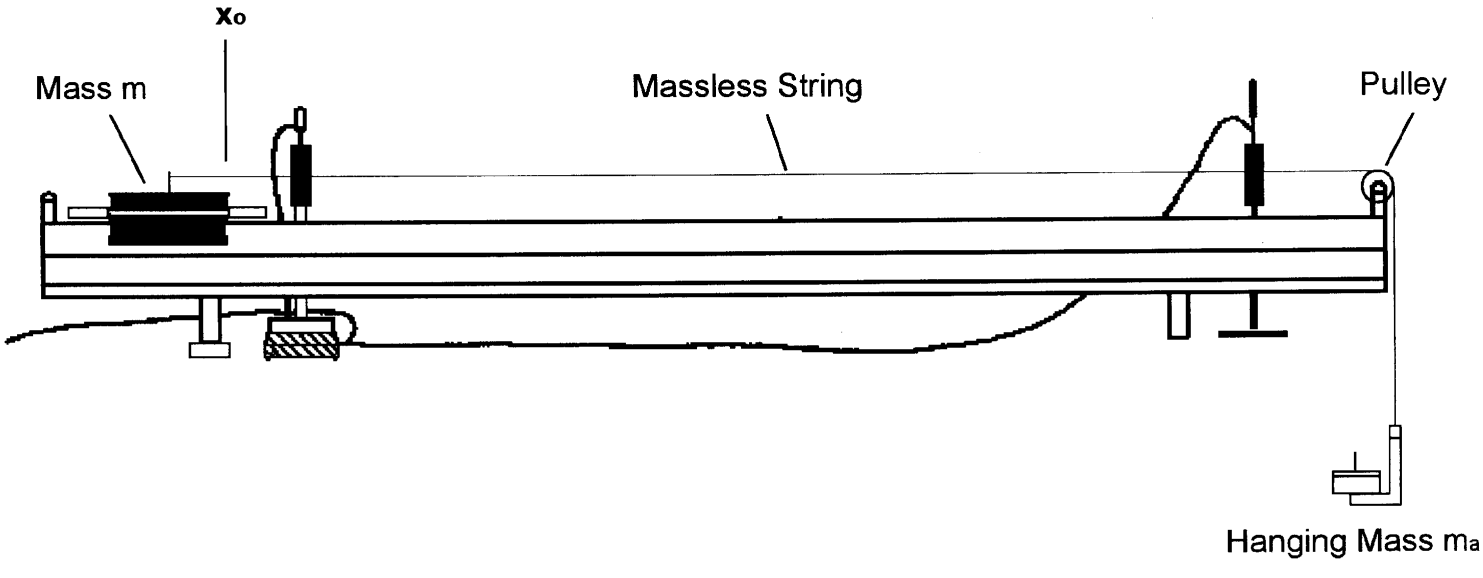

Figure 9 : Experimental Setup for Part B " Newton's Second Law"