Kuwait University	Course 125 Phys. Lab. I
Physics Department	Experiment 7: Kinematics

Instantaneous versus average velocity

Objectives

- To study average and instantaneous velocity for one-dimensional motion using an *air track*.

Equipment to be used

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

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

  photogate timer with memory and an accessory photogate(for measuring time intervals)

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

When a moving object changes its position over a period of time, then this object is said to have a *velocity*. It is a measure of how fast this object is moving. Suppose this object is moving from its initial position (x_1) at time (t_1) to reach another position (x_2) after some time (t_2). The ratio of displacement(Δx) of this object that occures during the time interval (Δt) is known as the *Average Velocity* and it is given as:

$$\bar{v} \; = \; \frac{\Delta x}{\Delta t} \; = \; \frac{x_2 - x_1}{t_2 - t_1} \qquad (1)$$

this value $\bar{v}$ is an average value of the "velocity" during the full motion from x_1 to x_2 over the whole time interval. The term "*Instantaneous velocity*" refers to the velocity of the object at a given instant of time and it is denoted as v. The velocity of an object at any instant of time is obtained from the average velocity by decreasing the time interval Δt closer and closer to zero. As Δt decreases, the average velocity approches a limiting value which is the value of the velocity at that instant:

$$v \; = \; \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} \; = \; \frac{dx}{dt} \qquad (2)$$

In this experiment you will study the relationship between instantaneous and average velocities, and see how a series of average velocities can be used to get an instantaneous velocity. You will also study one-dimensional motion of a glider along the airtrack, see Figure 8.1. Pressured air is blown between the track and the glider, thus you can assume frictionless motion. You will also use the Photogate timer and the accessory timer to measure the time intervals.
Procedure:

Average velocity

A1. Set up the airtrack as shown in Figure 1, lift one end of the track with a 1 -2 cm support.

A2. Choose a point $x_1 \approx$ **100 cm** near to the centre of the track. Measure the position x_1 on the air track scale and record this value in Table 1.

A3. Choose a starting point $x_o = 10$ cm for the glider, near the upper end of the track.

A4. Place the photogate at x_P **and the accessory photogate at** x_A at equal distance from x_1, as shown in the Figure. Adjust the photogate such that the glider will interrupt the photogate beam. Record the distance between the photogates as $D = x_A - x_P$ (displacement) in Table 1.

A5. **Set** the *slide switch* on the photogate timer to *PULSE* mode.

A6. **Press** the *RESET* button. **Switch on** the *Air supply*, **adjust** the *air output* to position 3.

A7. **Hold** the glider at the starting position and then **release** it from this position x_o. **Record** time t_1, the time shown in the photogate timer after the glider has passed through both photogates.

A8. **Repeat** steps A6 and A7 at least four times, **record** the times.

A9. Now **repeat** steps A4 trough A9 for different values of D according to Table 1.

A10. **Set** the switch on the photogate timer to *GATE* and fix the 100 mm flag on the glider. The photogate timer will measure the time when the flag interrupts the optical beam of the photogate.You can determine the velocity of the flag from this time.

A11. **Remove the accessory photogate** and place the other photogate at x_1.

A12. **Hold the glider at the starting position** x_o und then **release it** from this position x_o. Record the time t_1.

A13. **Repeat** A12 at least four times and record the time in Table 2.

Processing the experimental data

For each value of D,

A14. calculate the average time $\bar{t}$,

A15. calculate the average velocity $v_{\text{av}} = D/\bar{t}$,

A16. plot a graph of v_{av} versus D using the data in Table 1,

A17. Discuss how to get the instantaneous velocity v_{inst} from your data.

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Laboratory Assignment

1. What direction of the coordinate axis x should be selected in Figure 4.1 and Figure 4.2? 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 7

A. Instantaneous versus average velocity

Table 1 (all lengths in cm):

x_P	x_A	D	t_1	t_2	t_3	t_4	t_5	$\bar{t}$	$\bar{v} = \frac{D}{\bar{t}}$
30	170								
40	160								
50	150								
60	140								
70	130								
80	120								
90	110								

Table 2

length of flag	t_1	t_2	t_3	t_4	t_5	$\bar{t}$	$v = l/\bar{t}$
$l = 10$ cm							
$l = 5$ cm							

Discussion:

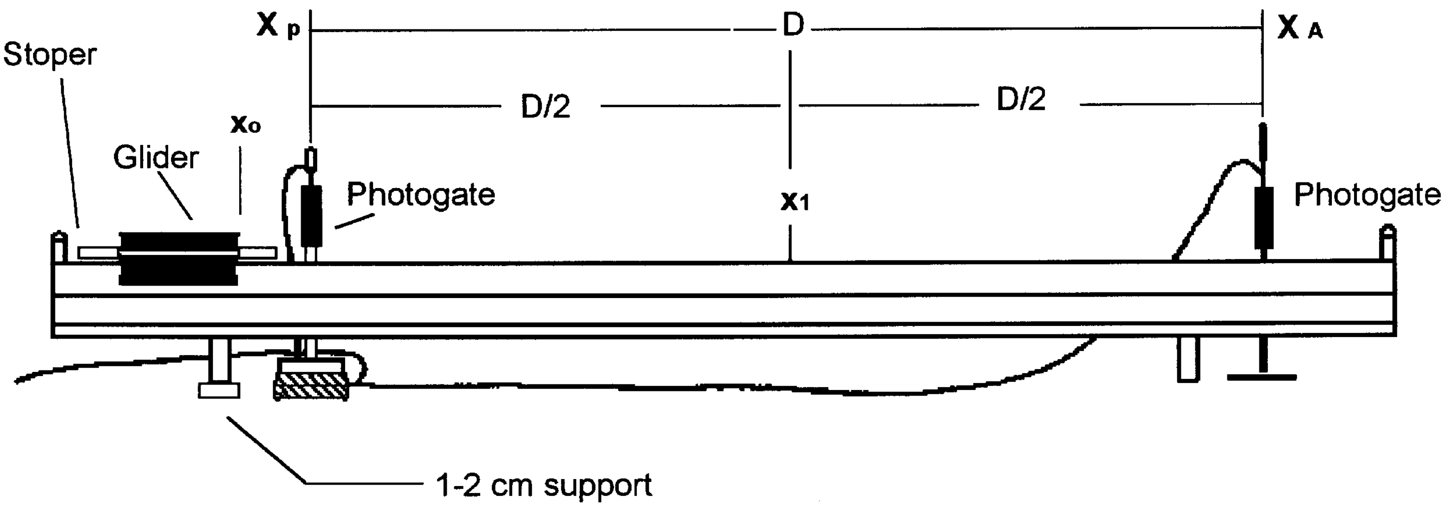

Figure 7.1A Experimental Setup of two meter Air Track Used in part A

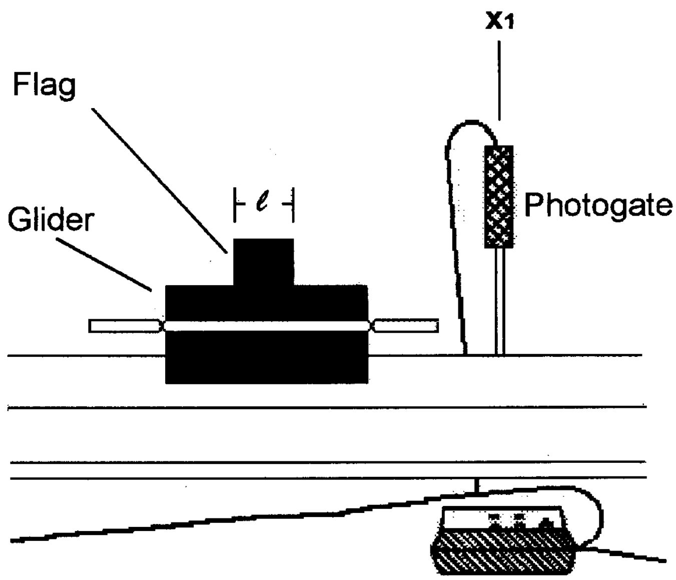

Figure 7.1b Experimental Setup of the Air Track and Glider with Flag of length ℓ