Straight Line Motion with Constant Velocity Experiment

I. INTRODUCTION

1.1.Motion

If a particle is moving, we can easily determine its change in position. **The displacement of a particle is defined as its change in position.** As it moves from an initial position x_i to a final position x_f, its displacement is given by x_f x_i. We use the Greek letter delta ( ) to denote the *change* in a quantity. Therefore, we write the displacement, or change in position, of the particle as

$$\Delta x \equiv x_f - x_i$$

The average velocity v_x of a particle is defined as the particle's displacement *x* divided by the time interval *t* during which that displacement occurred:

$$\overline{v}_x \equiv \frac{\Delta x}{\Delta t}$$

where the subscript *x* indicates motion along the *x* axis. From this definition we see that average velocity has dimensions of length divided by time (L/T) — meters per second in SI units.

For a displacement along the x-axis, the average velocity (v_{av}) of the object is equal to the slope of a line connecting the corresponding points on the graph of position versus time (*x t graph*). The average velocity depends only on the total displacement (x) that occurs during the motion time(t). The position, $x(t)$ of an object moving in a straight line with constant velocity is given as a function of time as:

$$x(t) = x_0 + vt$$

If the object is at the origin with the initial position x_0 0, the equation of the motion becomes at any time;

$$x(t) = vt$$

So, the object travels equal distance in the equal time intervals along a straight line.

1.2. Purpose:

The main purpose of this experiment is to study and analyze:

I. The position and velocity of the motion with **constant velocity**,

II. The acceleration of a straight-line motion with **constant acceleration**,

III. Horizontal **projectile** (two-dimensional) motion of an object moving on an inclined air table,

IV. Conservation of **linear momentum**.

II. APPARATUS

2.1. Introduction to the Air Table

The air table consists of four main components: the flat plane, spark timer, pucks and compressor (Figure at top).

1. **The Flat Plane:** With a very smooth surface. Black carbon paper and white recording paper are placed on it (55x55 cm).

2. **Spark Timer:** It produces sparks with frequencies of 10,20,30,40 and 50Hz. In the experiments we select the frequency 10 or 20 Hz. This gives the best results.

3. **Pucks:** They are rigid heavy metal disks with very smooth surfaces. A hole is drilled at the center through which the pressured air flows. When the compressor is operated by pressing the pedal, the air with pressure flows through the holes of the puck and forms an air cushion between the two smooth surfaces: the plate of air

table and smooth surface of the puck. Thus the pucks slide on the surface almost without any friction.

There is also an electrode at the bottom of the puck. When the spark timer is operated by pressing its switches, then high voltage produces sparks which causes dark spots on the white paper with equal time intervals.

If we place a piece of paper under the puck, we can record its trajectory by use of a spark apparatus, which leaves a trail of dots on the paper. The study of these dots enables us to measure the position as a function of time for the moving pucks.

4. **Compressor**: The compressor provides an air-flow through the cables to the pucks on the air table. When the compressor is switched on, an air-flow through the cables is produced from the compressor towards the pucks. The compressed air flowing through the bottom surface of the pucks reduces the friction between the pucks and the air table, and so the pucks move almost freely on the table

	Flat Plane of the Air Table
	Spark Timer
	Compressor
	Foot Switches
	Shooter
	The Pucks
	Foot Leveler

Figure 1. Air table components

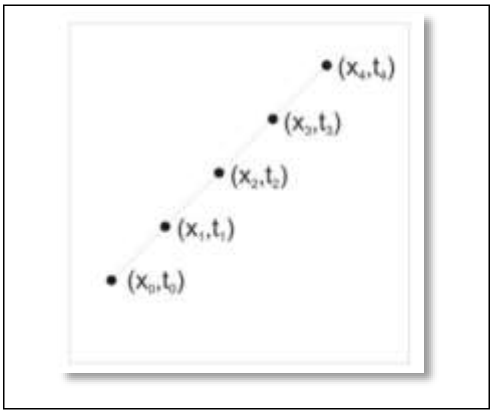

Figure 2. The produced data

To study air table experiments, first a sheet of carbon paper and then a sheet of white paper (as **experiment paper**) are placed on the air table. The puck moving on the surface of the air table will be considered as the particle. The pucks in the experiment are connected to the spark timer by conducting wires and then placed on the experiment paper on the air table. The spark timer works by means of a foot switch. While you are pressing the foot switch to start spark timer, sparks are produced continuously between the pucks and the carbon paper at a frequency (f) adjusted on the spark timer.

Each spark produces a dot on the experiment paper, and the motion of the pucks in any experiment can be examined using the path of these dots on the experiment paper. For example, if the frequency is set to $f\ 20Hz$, each puck on the table marks 20 dots on the experiment paper in one second and the time interval t between successive dots is given by $T\ 1/20\ 0.05$ second.

III. EXPERIMENTAL PROCEDURE

1. Level the air table glass plate **horizontally** by using the adjustable legs.

2. Place the black carbon paper (50x50 cm) which is semiconducting on the glass plate. The carbon paper should be flat and on the air table given by the experimental set-up .

3. Place white recording paper as data sheet on the flat carbon paper.

4. Place two pucks on white paper. Keep one of the pucks stationary on a folded piece of data sheet at one corner of the air table.

5. For **the alignment** of the air table, adjust the legs of the air table so that the puck will come to rest about the center of the table.

6. Test both two switches for the compressor and spark timer operations. With the puck pedal, the single puck should move easily, almost without friction when compressor works. When the spark timer foot switch is pressed, black dots on white paper should be observed (on the side that faces the carbon paper).

7. Set the spark timer to $f\ 20Hz$.

8. Now again, test the compressor only by pressing the puck footswitch. Make sure that the puck is moving freely on the air table. By activating both the puck pedal and spark timer pedal (**foot switches**) in the same time, test also the spark timer and observe the black dots on the recording paper.

9. Place the puck at the edge of the table then press both compressor and spark timer pedals as you push the puck on the surface of air table. It will move along the whole diagonal distance across the air table in a straight line with constant velocity. Then, stop the pedals.

10. Remove the white recording paper from air table. The dots on the data sheet will look like those given in the Figure 2.

11. Measure the distances of the dots starting from first dot by using a ruler.

12. Find also the time corresponding to each dot. The time between two dots is 1/20 seconds since the spark timer frequency was set to $f\ 20Hz$.

13. Number and **encircle** the dots starting from 0 at position x_0 (starting point) to avoid errors in calculations.

14. Measure the distances of the first 10 dots starting from dot “**0**”. And then, find the time corresponding to each dot. Record the data values in the Table-(**1**). The time **interval between two dots** is given by 1/ *f* which is equal to 1/20 seconds.

15. Using the data points in Table-**(1**), plot the*x t graph*. The graph must show a linear function.

16. Draw the best line that fits a linear graph. Then, calculate the velocity of the puck by using the slope of the line.

17. From the values in Table-(**1**), calculate the position and time corresponding to each **dot interval** and then fill in your data in the Table-(**2**).

18. Calculate the average velocity (v_{av}) from the table for each dot interval and then compare with the value which is obtained from the graph.

Table 1 Data values

Dot number	Position x±Δx(m)	Time t (s)	V_{avg}(m/s)
0	0	0	Slope
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Table 2 Experimental values

Interval number (n)	x_n(m)	x_{n+1}(m)	x_{n+1}(m)-x_n(m)	t_n(s)	t_{n+1}(s)	t_{n+1}(s)-t_n(s)	v(m/s)
0-1							
1-2							
2-3							
3-4							
4-5							
5-6							
6-7							
7-8							
8-9							
9-10							

3.1 Conclusions

Compare the average velocity found from the graph with the velocity calculated for the each time interval?

Discuss the difference in the velocity values calculated from the table and the values found from the graph. Is the difference approximately the same?.

What are the sources of error in the experiment?

Write your comments related to the experiment.

Ref.

1) Serway, R, Beichner,R. Physics for Scientists ans engineers with modern physics, Fifth edition. 2000.

2) Rentech.Air Table Experimental Set, student guide. 2013.