



ÇANAKKALE ONSEKİZ MART UNIVERSITY

DEPARTMENT OF PHYSICS

**GENERAL PHYSICS
LABORATORY MANUAL
AND
WORKBOOK**

EXPERIMENT 1

MOTION WITH CONSTANT VELOCITY

PURPOSE

The purpose of this experiment is to verify that an object moving under the influence of no net force moves in a straight line with constant velocity and to calculate this velocity.

THEORY

Motion is a continuous change of position in time. There are different types of motion. The simplest of these is the motion in a straight line with constant velocity. In this type of motion, the moving object travels equal distances in equal time intervals along a straight line. Newton's first law states that an object at rest will remain at rest, and an object moving in a straight line with constant velocity will remain so unless a net force acts on the object. Therefore, an object moving in a straight line with constant velocity experiences no net force.

To describe the motion of the object, the object is modeled by a point particle. A vector \vec{r} known as the **position vector** is introduced to give the position of the moving object with respect to a given origin of the coordinates. Obviously, this position vector will be a function of time; $\vec{r} = \vec{r}(t)$. This is because a moving particle, that is changing its position with time, will be at $\vec{r}_1(t_1)$ in the instant t_1 and in another instant t_2 at $\vec{r}_2(t_2)$. This explicit form of the dependence of position on time will be determined by the specific type of motion of the particle. The **average velocity** \vec{v}_{avg} , of the particle is defined as the average change in the position vector of this particle in a given time interval.

$$\vec{v}_{avg} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta \vec{r}}{\Delta t} \quad (1.1)$$

Where Δ means the difference. The **instantaneous velocity** is defined as:

$$\vec{v}_{ins} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt} \quad (1.2)$$

So the instantaneous velocity is just the derivative of $\vec{r}(t)$ with respect to time and obviously, it is a vector quantity.

In the straight-line motion, things are a bit simpler. Since this is a one-dimensional motion then by taking the x-axis to be in the direction of the motion, $\vec{r}(t)$ reduces to $\vec{x}(t)$, which is the displacement of the particle along the x-axis. In this case, the average velocity will be

$$v_{avg} = \frac{\Delta x}{\Delta t} \quad (1.3)$$

And the instantaneous velocity will be

$$v_{int} = \frac{dx}{dt} \quad (1.4)$$

In this motion $\frac{dx}{dt}$ must be constant. Therefore, the general form of $x(t)$ will be:

$$x(t) = bt + c \quad (1.5)$$

where b and c are constants. Clearly, the constant 'b' is the instantaneous velocity and the constant 'c' is the initial position that is

$$x(t = 0) = x(0) = c \quad (1.6)$$

Finally, the displacement $x(t)$ of a particle moving in a straight line with constant velocity will be given as a function of time in the form

$$x(t) = vt + x_0 \quad (1.7)$$

If at $t=0$, the initial position is the origin ($x_0 = 0$), then

$$x(t) = vt \quad (1.8)$$

From the above relation, It is obvious that for a particle moving in a straight line with constant velocity, if one makes different measurements of position x at different instants of time, and tabulates them as $(x_1, t_1), (x_2, t_2), (x_3, t_3), \dots$ etc., the plot of a graph of x versus t using these data points, will be a straight line (see Figure 1-1).

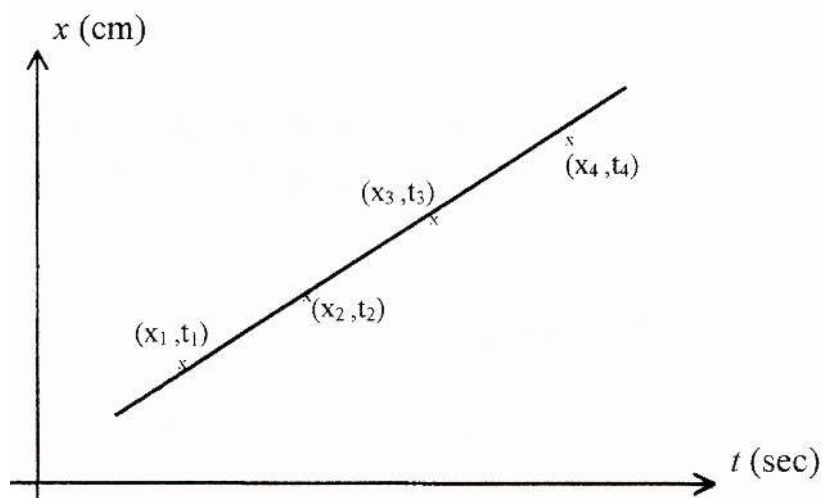


FIGURE 1.1 The x versus t graph of an object moving in a straight line with constant velocity.

In this experiment, you are going to study, analyze and calculate the velocity of an object moving in a straight line with constant velocity. The puck that is moving on the surface of the air table, will be considered as a particle. A puck released to move freely on a horizontal (leveled off) air table can be considered as experiencing no net force since the air table is horizontal and the friction is almost eliminated. Therefore if you push a puck on the surface of the air table, it will move in a straight line with constant velocity at the moment you release it. The x and t record of the position will be provided by the dots on the datasheet (see Figure 1.2). The displacement x of the given dot, the first dot, second dot and so on for instance, can be measured

directly using a ruler. The time elapsed to travel this displacement can be determined by counting the intervals from the reference dot and multiplying by the time intervals between two successive dots which is just $1/f$, where f is the frequency of the spark timer.

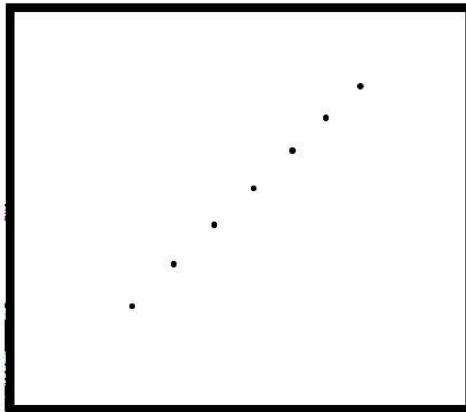


FIGURE 1.2 The dots produced by the puck on the datasheet.

EQUIPMENT

Air table, ruler, millimetric graph paper.

PROCEDURE

1. Level off the air table.
2. Place the conductive carbon paper and the datasheet on the glass plate of the air table.
3. Keep one of the pucks stationary by placing it at one corner of the air table and putting a folded piece of paper under it. In this experiment, only one puck will be used.
4. Set the spark timer frequency to 20 Hz.
5. Activate the footswitch (P) and push the puck diagonally across the surface of the air table at the moment you released the puck, activate the footswitch (S) to start the spark timer. Let the puck travel the whole diagonal distance across the air table, and then remove your feet off the (S) and (P) switches.
6. Remove the datasheet from the air table. Number the dots as 0,1,2,... etc. The first dot can be taken as dot 0. Measure the distance of five dots from dot 0 (see figure 1.3) and finding the time corresponding to each dot, fill in Table 1.1. The x and t measurements in this table should be filled together with their corresponding errors.

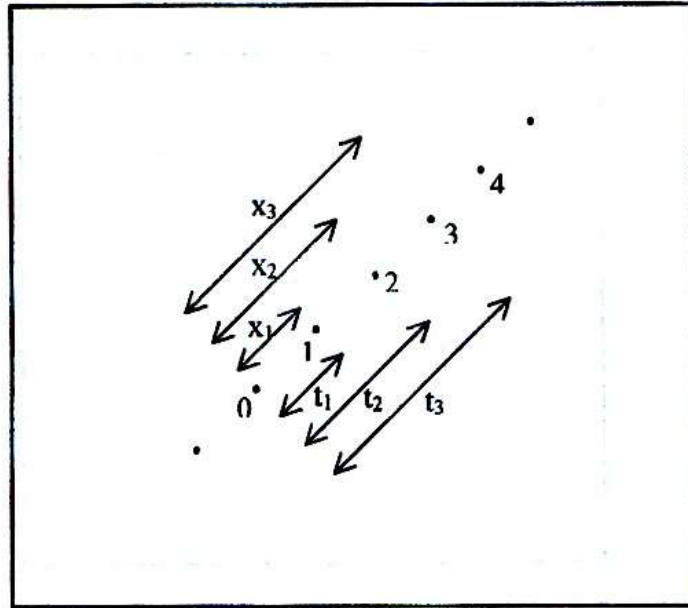


FIGURE 1.3 Analysis of the data points.

7. Using the data points in Table 1.1, plot the graph of the position x versus t on linear graph paper. Plot the position in centimeters along the vertical axis and the time in seconds along the horizontal axis. Label the axes, and write down the corresponding unit on each axis. Plot the data points along with the error bars. Note that the distribution of the data points suggests a straight line fitting. Is this an expected result? Draw the best and worst straight lines for your data.
8. Find the slopes of the best line m_b and the worst line m_w . Calculate the error in the slope $\Delta m = |m_b - m_w|$. From these slopes find $v \pm \Delta v$.
9. Using the data in Table 1.1 construct Table 1.2. Find the average velocity for each interval and fill in the table with the correct number of significant figures.



Course Name: ENV-1021 – General Physics Laboratory
EXPERIMENT 1: MOTION WITH CONSTANT VELOCITY EXPERIMENT REPORT

INSTRUCTOR'S NAME & TITLE:						SIGNATURE:		EXAM DATE:
STUDENT'S NAME/SURNAME:						SIGNATURE:		EXAM DURATION:
STUDENT ID #:								
Question								TOTAL POINT:
Point								
Prog. Outcomes	PO1,2							

REPORT OF
EXPERIMENT 1: MOTION WITH CONSTANT VELOCITY

Name-Surname:

Student No:

Group:

Laboratory and Examination Rules:

- 1- The most important thing in the laboratory is your safety. The dangers mostly result from a lack of knowledge of the equipment and procedures.
- 2- Personal safety rules must be obeyed with extreme discipline.
- 3- When you enter the laboratory never play with the equipment until it has been explained and the instructor has given permission.
- 4- Keep your experimental equipment and tabletop clean.
- 5- Report any accident to your instructor immediately.
- 6- Most of the equipment used in the laboratory is expensive and some of them are delicate. Even after you are familiar with the equipment, always have your experimental setup checked and approved by the instructor before putting it into operation.
- 7- If any of the equipment is broken or does not function properly, report it to the instructor.
- 8- Read and study the experiments before you come to the laboratory.
- 9- It is forbidden to share the questions and answers of this assignment on the internet or in another environment.
- 10- Students must answer the assignment by themselves. It is forbidden to do the assignment with others or to get help from others.
- 11- Write your name and surname and student number and sign your signature on the top right of each answer page.

RESULTS AND DISCUSSION

1. Write your x and t measurements with the corresponding errors in Table 1.1.

TABLE 1.1

Dot number	$x \pm \Delta x$ (cm)	$t \pm \Delta t$ (sec)
0	0	0
1		
2		
3		
4		
5		

2. Are the data points on the datasheet evenly spaced? Is this an expected result? Why?

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3. Show how to find the error Δt for only one time measurement below.

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4. $m_b = \dots\dots\dots \text{cm/sec}$

$m_w = \dots\dots\dots \text{cm/sec}$

$\Delta m = |m_b - m_w| = \dots\dots\dots \text{cm/sec}$

5. $v \pm \Delta v = \dots\dots\dots \text{cm/sn}$

6. Using Table 1.1, construct Table 1.2 below.

TABLE 1.2

	$x_i \pm \Delta x_i$ (cm)	$x_{i+1} \pm \Delta x_{i+1}$ (cm)	$x_{i+1} - x_i \pm \Delta(x_{i+1} - x_i)$ (cm)	$t_i \pm \Delta t_i$ (s)	$t_{i+1} \pm \Delta t_{i+1}$ (s)	$t_{i+1} - t_i \pm \Delta(t_{i+1} - t_i)$ (s)	$v_{av} \pm \Delta v_{av}$ ($\text{cm} \cdot \text{s}^{-1}$)
0 - 1							
1 - 2							
2 - 3							
3 - 4							
4 - 5							

6. Explain the calculation of v_{avg} and the error Δv_{avg} for any intervals (one interval is sufficient).

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7. Compare the average velocity for each interval in Table 1.2 with the velocity calculated from the graph.

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8. Write down the comments related to the experiment and/or elaborate on and discuss any points.

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Good luck