Straight Line Motion with Constant Acceleration Experiment

I. INTRODUCTION

1.1.Motion with constant velocity

If the acceleration of a particle varies in time, its motion can be complex and difficult to analyze. However, a very common and simple type of one-dimensional motion is that in which the acceleration is constant. When this is the case, the average acceleration over any time interval equals the instantaneous acceleration at any instant within the interval, and the velocity changes at the same rate throughout the motion.

$$v_{xf} = v_{xi} + a_x t \qquad \text{(for constant } a_x\text{)}$$

This powerful expression enables us to determine an object's velocity at *any* time *t* if we know the object's initial velocity and its (constant) acceleration. A velocity–time graph for this constant-acceleration motion is shown in Figure 1. The graph is a straight line, the (constant) slope of which is the acceleration a_x ; this is consistent with the fact that a_x dv_x/dt is a constant. Note that the slope is positive; this indicates a positive acceleration. If the acceleration were negative, then the slope of the line in Figure 1 would be negative.

1.2.Purpose:

In this part of the experiment, you will examine straight-line motion of an object (puck) with constant acceleration on an inclined frictionless air table. By plotting the experimental data, you will find the acceleration of the puck sliding down on an inclined air table.

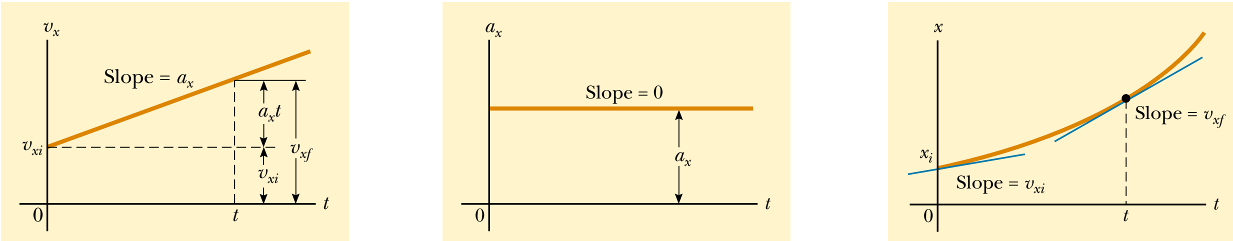

Figure 1. Constant acceleration graphs

When a particle slides straight down a frictionless inclined plane, its acceleration is constant, and it will move in a straight line down the plane. The magnitude of the acceleration depends on the angle at which the plane is inclined. If the inclination angle is 90^0, the object will slide down with an acceleration which is equal to the Earth's **gravitational acceleration** *g* with the magnitude of 9.8 m/s^2.

In this experiment, we will observe the motion of a puck moving in a straight line with a velocity changing uniformly. The back side of the air table is raised to form an inclined plane on the air table. The air table is inclined at an angle of with the horizontal plane as shown in the Figure-(**2**).

If you put the puck at the top of the inclined air table and let it slide down the plane, it will move downwards on a straight line but with increasing velocity. The rate of change of the velocity is the acceleration of the puck. If at time t_1 , the puck is at the point x_1 with a velocity of v_1 , then at a later time t_2, it will be at a point of x_2 with a velocity v_2 .

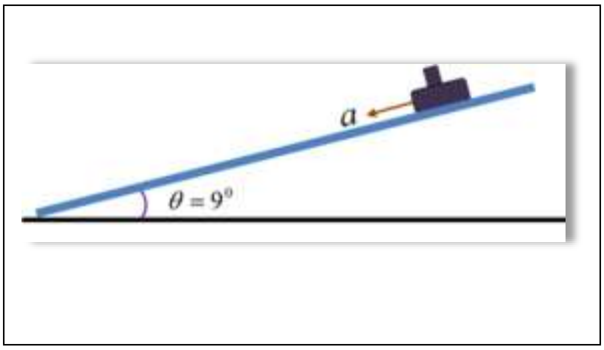

Figure 2. Inclided air table.

The average acceleration of the puck in this time interval $\Delta t = t_2 - t_1$ is defined as:

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

Suppose that at an initial time t_1 0 , the puck is at the position of x_0 and has a velocity of $v_1 = v_0$. At a later time $t_2 = t$, it is in position x and has a velocity of $v_2 = v$. Then, the average acceleration will be equal to:

$$a_{av} = \frac{v - v_0}{t - 0}$$

Then, the velocity of the puck will be:

$$v = v_0 + at$$

III. EXPERIMENTAL PROCEDURE

1. To perform this experiment, first place a sheet of carbon paper and then a sheet of white paper on the air table.
2. Place the foot leveler to the upper leg of the air table to give an inclination angle (the angle with the horizontal plane) as θ=9° . Use an angle finder to measure the inclination angle.
3. Put the puck at the top of the inclined plane and press the compressor pedal and check if the puck is falling freely.
4. Set the spark timer frequency to *f* 20*Hz*.
5. Put the puck at the top of the inclined plane to start the experiment. Press both puck and spark timer switches simultaneously and stop pressing when the puck reaches the bottom part of the inclined plane.
6. Remove the data recording paper from air table and examine the dots produced on it. Number and circle the dots from 0 to 10.

6.1.Take the first dot as your initial data point ($x_0 = 0, t_0 = 0$) and **the positive** *x axis* as direction of the puck's motion.
6.2.Measure and record the time *t* and the positions *x* of the first 10 dots starting from "**0**". Record the data values in the data Table-(**1**) with respect to your initial point.

6.3. Calculate and record also t^2 values in the Table-(**1**).

7. Plot *x* versus t^2. Then, draw the best line that fits your data points and using the slope of this line.

8. Determine the acceleration, *a*, of the puck. Show these calculations on your graph paper clearly.

Table 1 Experimental values

			x(m)	t(s)	$t^2(s^2)$	a (m/s²)
Inclination angle	Frequency	Dot number	Measured value			
			x_0=0	t_0=0	0	by slope
		0				
		1				
		2				
		3				
		4				
		5				
		6				
		7				
		8				
		9				
		10				

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.