Projectile Motion Experiment

I. INTRODUCTION

1.1. Projectile Motion

Anyone who has observed a baseball in motion (or, for that matter, any other object thrown into the air) has observed projectile motion. The ball moves in a curved path, and its motion is simple to analyze if we make two assumptions: (1) the free-fall acceleration **g** is constant over the range of motion and is directed downward, and (2) the effect of air resistance is negligible. With these assumptions, we find that the path of a projectile, which we call its *trajectory,* is *always* a parabola.

To show that the trajectory of a projectile is a parabola, let us choose our reference frame such that the *y* direction is vertical and positive is upward. Because air resistance is neglected, we know that $a_y = -g$ (as in one-dimensional free fall) and that $a_x = 0$. Furthermore, let us assume that at *t* 0, the projectile leaves the origin ($x_i = y_i = 0$) with speed v_i, and the vector $\mathbf{v}_i$ makes an angle θ_i with the horizontal, where θ_i is the angle at which the projectile leaves the origin. From the definitions of the cosine and sine functions we have

$$y = (\tan\theta_i)\,x - \left(\frac{g}{2v_i^2\cos^2\theta_i}\right)x^2$$

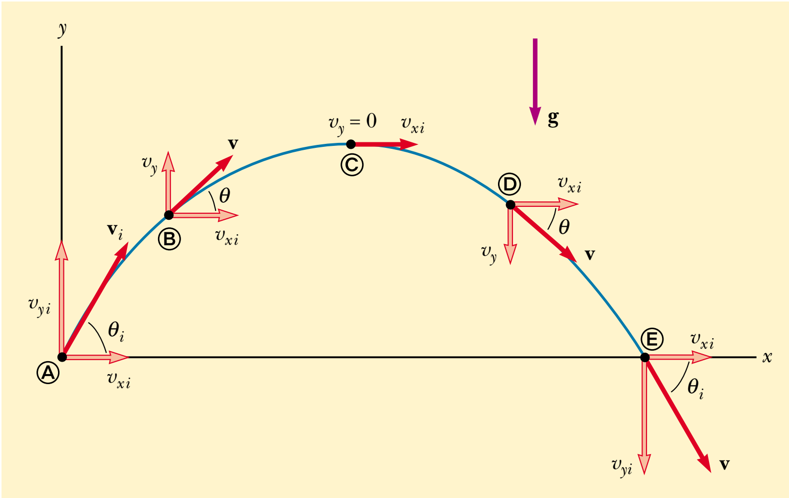

Figure 1. Projectile motion

Suppose that at time $t = 0$, the particle is at the point (x_0, y_0) and at this time its velocity components have the initial v_{0x} and v_{0y}. Since the velocity of **horizontal motion** in the projectile motion is constant, we find:

$$a_x = 0$$

$$v_x = v_{0x}$$

$$x = x_0 + v_x t$$

If we take the initial position $(at\ t = 0)$ as the origin, then: $x_0 = y_0 = 0$

the equation of motion along the x axis as:

$$\boxed{x = v_x t}$$

For the motion along the $y\ axis$, the velocity (v_y) at the later time, t becomes:

$$v_y = at$$

$$\boxed{y = \frac{1}{2}at^2}$$

The dots produced on the data sheet will look like the figure as shown in the Figure-(**2**). Here, note that the intervals between the dots of the *x*- projections in the horizontal direction are equal.

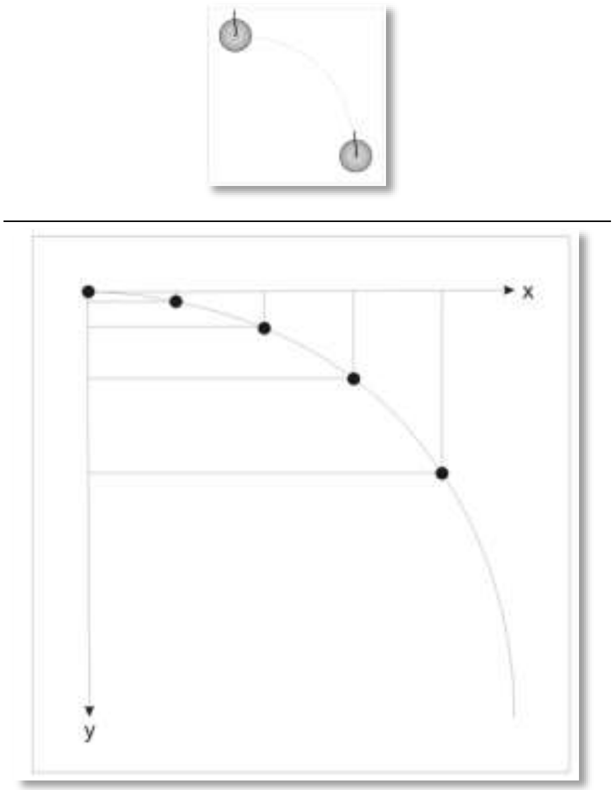

Figure 2. Schematic diagram of the horizontally projected motion of the puck on an inclined air table.

II. APPARATUS

Air Table set.

III. EXPERIMENTAL PROCEDURE

1. Place the foot leveling block at the upper leg of the air table to give the plane an inclination angle of $\theta = 9^0$.

2. Adjust the frequency of the spark timer, $f = 20Hz$.

3. Keep one of the pucks stationary on a folded piece of data sheet paper and carbon paper at the lower corner of the plane.

4. Attach the shooter to the upper left side of the table with 0^0 (zero degrees) shooting angle to give horizontal shooting.

5. Make test shootings to find the best tension of the rubber to give a convenient trajectory.

6. First activate the compressor pedal and as you release the puck from the shooter also start the spark timer by pressing its pedal. Stop pressing both pedals when pucks reach the bottom of the plane. These dots are the data points of the trajectory- A .

7. Now, place the puck opposite to the shooter without tension of shooter (note that the puck must be outside the shooter). Then activate both compressor pedal and spark timer pedal in the same time and then let it slide freely down on the inclined plane. The dots will give trajectory- A .

8. Remove the data sheet and examine the dots of trajectory. If the data points are inconvenient to analyze, repeat the experiment and get new data.

9. Select a clear dot on the path as the initial position of the motion as $y = 0$ and $t = 0$.

   . 9.1. Circle and number the data points (dots starting from the first dot as 0) as 0, 1, 2, 3, 4, 5...10 as shown in the Figure-(3).

   . 9.2. Consider the downward trajectory as positive *y axis* and horizontal projectionaspositive *x axis*.

10. Draw perpendicular lines from dots to *x and y axis* for the trajectory- B by taking the first dot (dot 0) as the origin (0, 0) . This origin is the initial position of the projectile motion.

11. Measure the horizontal x (m) and vertical y (m) displacements from the initial position (0, 0) and then record in the experimental data tables.

12. Determine the time (t) for each of these dots. The time interval between two dots is given by 1/ f which is equal to 1/20 seconds. Then, calculate total time of flight (t_f) corresponding to the total horizontal displacement (x_R) of a projectile.

13. Calculate and record the horizontal velocity (v_x) by using the time of flight (t_f) and the total horizontal distance traveled during the motion (x_R) . Complete the data Table-(1).

14. Starting from dot "0" of the trajectory-B, measure the distances of the y projections (y-axis) of the first 10 data points (dots). Determine also the times corresponding to each of these dots. 14.1. Fill the measurements in the trajectory-B columns in the experimental data Table-(2).

15. Similarly, by starting from dot "0" of the trajectory-A, measure the distances of the y-projections of the first 10 data points (dots).

    . 15.1. Calculate the times corresponding to each of the dots for trajectory-A.

    . 15.2. Record your data values in the trajectory-A columns in the T able-(5).

16. Using the equation $y=1/2\ at^2$, find the accelerations a_A and a_B of the vertical motions for both trajectory-A and B. In the calculations, take displacement- y as the total distance of the first 10 dots starting from the dot-0 on the y *axis* .

17. Compare these two accelerations of both trajectories and also compare them with the acceleration found in the previous experiment (Part-A).

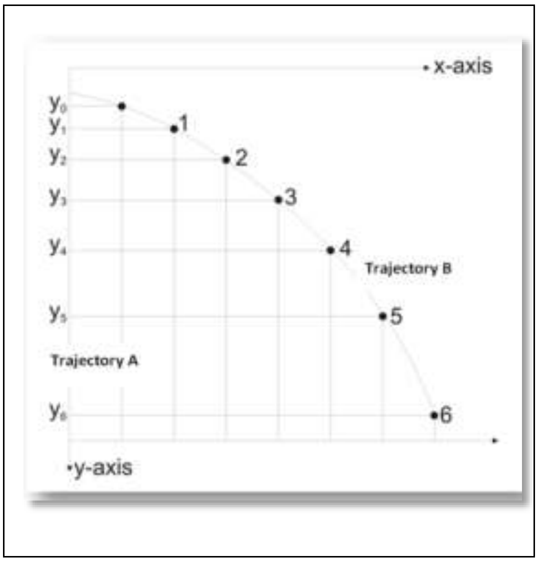

Figure 3. The dots as data points produced by the puck on the data sheet.

Table 1 Horizontal velocity of the projectile motion.						
Frequency f(Hz)	Dot number		Measured value			
20		x(m)	t(s)	x_R(m)	t_f(s)	v_x(m/s)
		measured	measured	calculated	calculated	calculated
	0	0	0			
	1					
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					

Table 2. The measurements of accelerations for the trajectory-A and trajectory-B

Dot number	**Trajectory-A**		**Trajectory-B**		**Trajectory-A**		**Trajectory-B**	
	(Vertical Motion)		(Vertical Motion)		(By the slope)		(By the slope)	
	y(m)	t(s)	y(m)	t(s)	a_A=(m/s^2)		a_B=(m/s^2)	
0	0	0	0	0	0		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.