SHS Physics
2-D Motion
Projectile Motion Lab

Name ______________________________

Date ______________________________

Purpose:
Investigate the path of a projectile and verify equations of projectile motion.

Materials:

Steel ball	board	textbook support
1 sheet lined paper	grooved metric ruler	
Tape	carbon paper	

Concept and Skill Check:
An object that is launched into the air and then comes under the influence of gravity moves in two dimensions and is called a projectile. If the frictional force due to air resistance is disregarded, the horizontal component of velocity will remain constant during the projectile's entire path. The vertical component of velocity is the same as the motion of an object in free fall. The force due to the gravity accelerates the projectile downward at the rate of 9.8 m/s^2 . The equation for vertical displacement of an object falling with constant acceleration, "a" is described by the following:

$$S_y = V_o t + \frac{1}{2} at^2$$

Where "S_y" is the vertical displacement, "V_o" is the initial vertical velocity, "t" is the elapsed time, and "a" is the acceleration due to gravity. The equation for the horizontal displacement of an object is described by the following:

$$S_x = V_x t$$

Where "x" is the horizontal displacement, V_x is the initial horizontal velocity, and "t" is the elapsed time.

In the apparatus shown in Figure 1, A steel ball is projected horizontally From the bottom of the raised ruler And rolls down an inclined plane (the board or tray) across the paper. The acceleration of the steel ball is The component of the acceleration of gravity that acts parallel to the direction of the inclined plane. The projectile's horizontal velocity remains nearly constant since the frictional effects of the steel ball on the smooth paper are negligible.

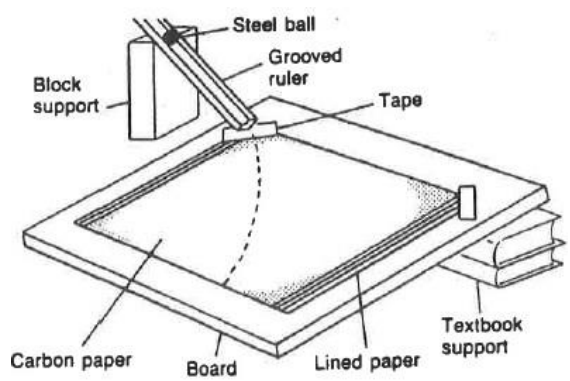

Figure 1. The path of the steel ball will be marked on the lined paper in a pattern similar to the one shown by the dashed line above.

Procedure:

1. Set up the apparatus as shown in Figure 1. Lay the lined paper on the board. Position it so that the groove in the raised ruler is perpendicular to the vertical lines and tape the corners of the paper to the board. Adjust the height of the ruler so that the steel ball will begin its path across

the paper at the upper left-hand corner and travel most of the way across the paper. Secure the ruler and block with tape when the ball rolls the proper distance. Practice placing the sphere at different heights on the raised ruler, until you have found the best location for releasing the steel ball and obtaining the desired result.

2. Place the carbon paper over the lined sheet with the carbon side down and tape the top corners to hold it in place. As the steel ball moves across the carbon paper, it will trace it path on the lined paper.

3. Roll the steel ball down the grooved ruler, allowing the ball to move across the carbon paper. Lift the carbon paper and check to see that the carbon paper left a trace of the ball's path. Remove the carbon paper and the lined paper from the board. With a pencil, retrace the ball's path if it is difficult to see.

4. Because the horizontal velocity of the ball was constant, it took the ball the same time to travel each of the horizontal distances between adjacent vertical lines on the paper. Therefore, each width of a section on the paper can represent successive intervals of equal time. Draw a horizontal line, as shown in Figure 2, across the paper from point where the projectile's path starts to the opposite side of the paper. Label this line **AB**, as indicated in Figure 2. Beginning at the first vertical line where the ball's path is visible, label this line 0. Number each successive vertical line across the paper as 1,2,3,4,5, … and so on, if not already done.

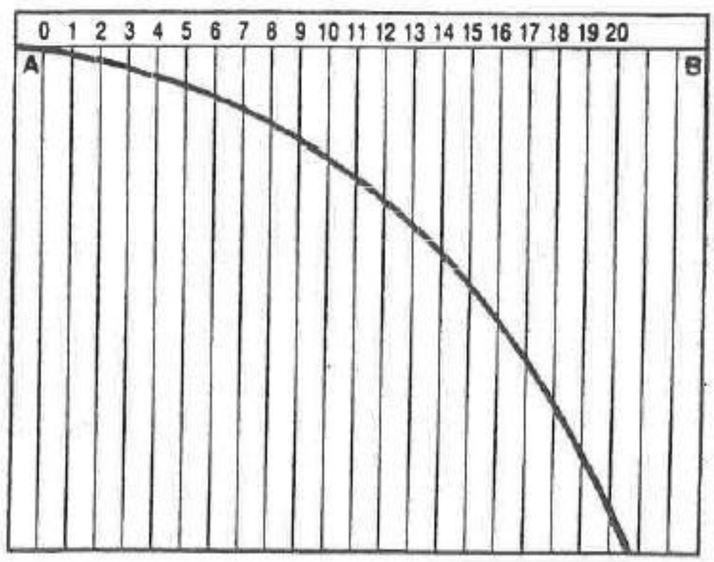

Figure 2. Draw line AB so that point A is where the path of the projectile crosses the first vertical line.

5. Measure in centimeters the vertical distance along each line from the horizontal line AB to the path of the ball. Record each of these distances in Table 1.

6. Determine the distance the ball traveled down the incline during each time interval. Using the values for vertical distance, subtract the length on the previous vertical line from the length on the current vertical line to determine the distance the ball traveled. The distance the ball traveled during each interval represents its average vertical velocity. Record each value for average vertical velocity in Table 1.

Table 1: Observations and data

Time Interval Number	Total horizontal distance (cm)	Total vertical distance (cm)	Ave vertical velocity (cm/interval)	Ave Vertical Accel. ($cm/interval^2$)
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Post-lab Analysis:

1. Obtain graph paper and plot a graph of the horizontal distance versus time, with horizontal distance on the y-axis and time on the x-axis. Draw a "Line of Best Fit".
   a. What is the slope of this graph?

   b. What does the slope tell you about the objects motion?

2. Obtain graph paper and plot a graph of the vertical distance versus time, with vertical distance on the y-axis and time on the x-axis. Draw a "Line of Best Fit".

   a. Describe the slope of this graph.

   b. What does the slope tell you about the objects motion?

3. What other data do you have that shows the path of the steel ball from question #2.

4. Obtain another sheet of graph paper, and plot a graph of vertical velocity versus time, with vertical velocity on the y-axis and time on the x-axis.
   a. What does this graph indicate about the projectile's motion?

   b. What type of motion does this graph demonstrate?

<u>Application:</u>

A rifleman raises his gun and aims it at a tin can target on a shelf in the shooting range. If the barrel of the gun is pointed straight at the can, under what conditions will the bullet hit the tin can?

_______ 10 data
_______ 10 graphs
_______ 30 questions
_______ 50 Total