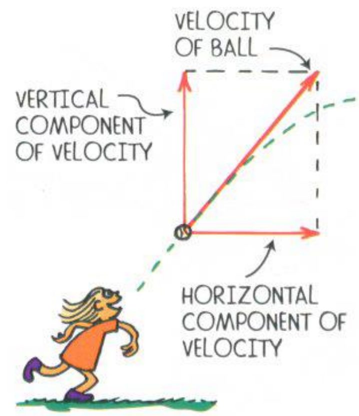
Name ____ Date _______________ Period ______

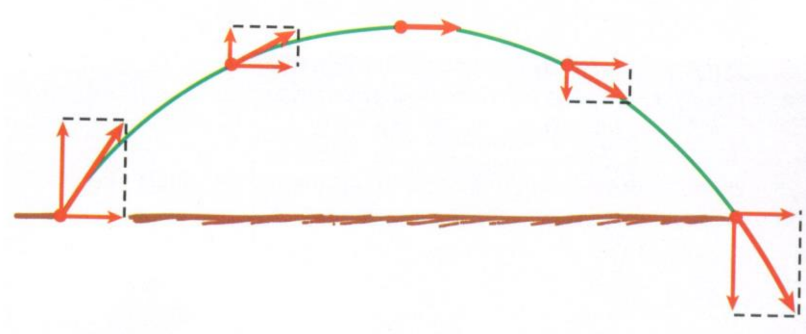
Lab: Independence of Motion

CONCEPTUAL PHYSICS: UNIT 2



INTRODUCTION: A cannonball shot from a cannon, a stone thrown into the air, a ball rolling off the edge of a table, a spacecraft circling the Earth- all of these are examples of projectiles. A **projectile** is any object that moves through the air or space, acted on only by gravity (and air resistance, if any). Projectiles near the surface of the Earth follow a curved path that at first seems rather complicated. However, these paths are surprisingly simple when we look at the horizontal and vertical components of motion separately.

The **horizontal component** of motion for a projectile is just like the horizontal motion of a ball rolling freely along a level surface without friction. When friction is negligible, a rolling ball moves at constant velocity. The ball covers equal distances in equal intervals of time. With no horizontal force acting on the ball there is no horizontal acceleration. The same is true for the projectile- when no horizontal force acts on the projectile, the horizontal component of velocity remains constant (look at the horizontal component of in the diagram below).



The **vertical component** of a projectile's velocity is like the motion of a freely falling object. Gravity acts vertically downward. Like a ball dropped in midair, a projectile accelerates downward as shown on the diagram to the right. Its vertical component of velocity changes with time. The increasing speed in the vertical direction as it falls causes a greater distance to be covered in each successive equal time interval. Or, if the ball is projected upward, the vertical distances of travel decrease with time on the way up.

OBJECTIVES: Using time, distance, g, and vector analysis, you will determine the velocity of ball thrown into air and its maximum height.

MATERIALS:

- Softball (or tennis ball)
- Stopwatch
- Football field.
- Lab handout

PROCEEDURE:

1. Form teams of 4 students each (NOTE: Each "team" has 1 thrower, 2 timers, and one spotter).
2. Find a spot on the football field away from other groups (watch where you throw your ball).

3. **Trial #1:** Throw the ball 10 to 20 meters to maximize "hang time". (At about a 45 degree angle)
- Measure the total time the ball remained in the air to the nearest 0.1 seconds (average the time for the two timers) Record in Data Table #1
- Measure and record the total distance covered in Data Table #1

4. **Trial #2:** Repeat throwing the ball, but this time throw it at a much higher angle (At about 75 degrees)
- Measure the total time the ball remained in the air to the nearest 0.1 seconds (average the time for the two timers) Record in Data Table #1
- Measure and record the total distance covered in Data Table #1

5. Calculate the horizontal velocity using the equation below and enter into Data Table #1. (Show your work here. Round off answer to the one decimal place)

$$v = \frac{d}{t}$$

6. Once you have completed data table, complete Conclusion questions.

DATA TABLE #1			
Trial	Total time in the air (s)	Total distance (m)	Horizontal velocity (m/s)
Trial #1			
Trial #2			

CONCLUSION QUESTIONS:

1. If we neglect air resistance, what can you say about a projectiles <u>horizontal</u> component of motion as it travels through the air?

2. If we neglect air resistance, what is the only force acting on a projectile?

3. Which of the projectiles velocity-components is affected by the force you mentioned above? (horizontal or vertical)

4. What is the balls vertical velocity when it reaches the peak of its trajectory?

5. At what two points during its trajectory will the balls vertical speed components be equal?

6. Calculate the time your ball traveling in an upward direction and downward direction for each trial. (Remember that if we neglect air resistance, you can simply divide total time in half)

Trial #1 upward- **Trial #1 downward-**

Trial #2 upward- **Trial #2 downward-**

7. Using the times you calculated above, determine the maximum height your ball attained. Use the following equation. **d** = distance traveled in meters, **g** = 9.8 m/s^2, and **t** = time in seconds *(show your work below)*

$$d = \frac{1}{2}gt^2$$

Trial #1 Maximum Height in meters=

Trial #2 Maximum Height in meters=

8. Now that you know the time the object remained in the air, you can also calculate the balls maximum vertical-velocity component for each trial using the equation below. Remember this will be the point at which the ball was released as well as the point at which it returns to the ground……..having a positive value on the way up and a negative value on the way down. *(show your work below)*

v = final velocity

$\mathbf{v_0}$ = initial velocity (use the vertical velocity of the ball at the top of its trajectory)

g = 9.8 m/s^2

t = time in seconds for the ball to make its downward motion (from question 6)

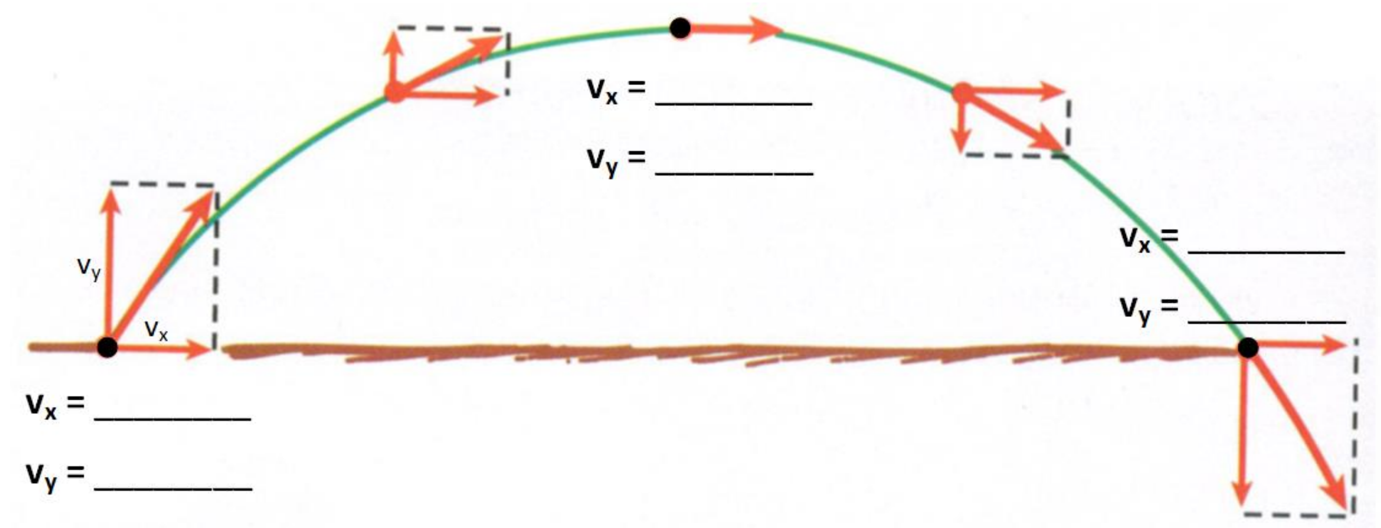
$$v = v_0 + gt$$

Trial #1 =

Trial #2 =

9. If you threw the ball with equal force, at what angle do you think it would travel the greatest horizontal distance?

10. Complete the diagram below showing values for both horizontal and vertical velocity components for Trial #1.



11. What can you say about the value of "**g**" at each of the points in the diagram above?

12. What is meant by "independence of motion" when we refer to a projectile?

13. Why does the actual path of a projectile never travel as far as its ideal path?

14. Which velocity components would be affected by air resistance? (explain)

15. How does the downward component of the motion of a projectile compare with the motion of free fall?

16. Using graphical vector analysis, draw to scale the **vertical velocity component** and the **horizontal velocity component** (stretch your “numbers” to make the graph as large as possible. This will yield a more accurate calculation). Using the parallelogram technique we used in class, draw the **resultant vector** that would describe the balls release velocity. You can now use a metric ruler and protractor to determine the balls release velocity and the angle at which the ball was thrown.

Release velocity =

Angle ball thrown =