

PROJECTILE MOTION

PURPOSE:

Predict where a horizontally projected object will land.

EQUIPMENT:

inclined plan, steel ball, stop watch

DATE _____

AUTHOR _____

PARTNER _____

PARTNER _____

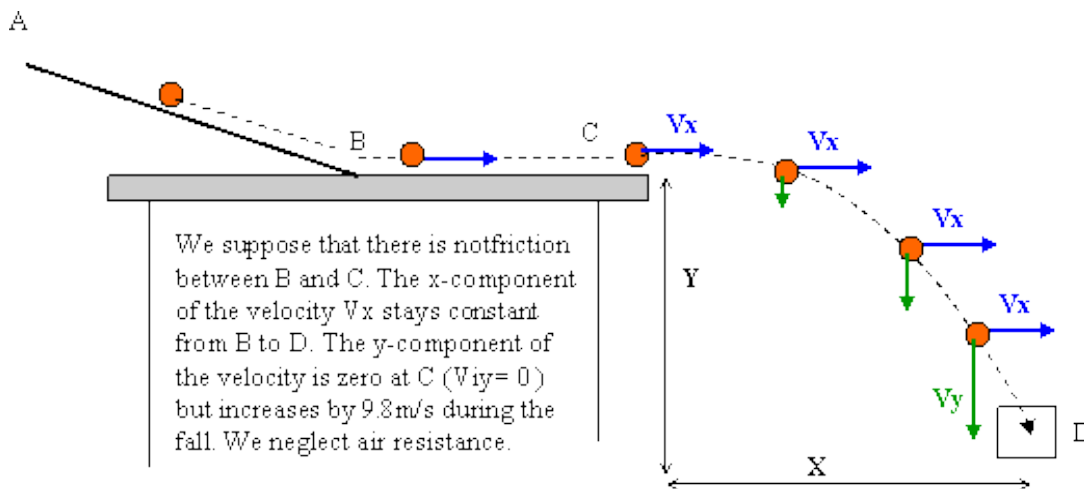
BACKGROUND

There are basically three kinds of motion: (1) the horizontal, straight-line motion of objects moving on the surface of the earth ; (2) the vertical motion of dropped objects that accelerate toward the surface of the earth; and (3) the motion of an object that is projected in the air. The third type of motion, projectile motion, could be directly upward as a vertical projectile, straight out as a horizontal projection, or at some angle between the vertical and the horizontal. Basic understanding of such compound motion is to understand that (1) gravity always acts on objects, no matter where they are, (2) the acceleration due to gravity (g) is independent of any motion that an object may have that is:

the horizontal motion is independent from the vertical motion.

As an example of projectile motion, consider the figure below. After rolling the incline AB, the ball moves across a frictionless, horizontal track BC. At C the ball leaves the track to become a projectile. While the ball is still on track BC, and ignoring air resistance, the speed of the ball on the track is constant because there are no net force acting on the ball.

After the ball leaves the track, it becomes a projectile. The motion of such projectile is easier to understand if you split the complete motion into vertical and horizontal parts. After the ball leaves the track, there is an unbalanced force (weight = mg) that accelerates the ball downward. The ball thus has an increasing downward velocity the same as that of a dropped ball that is represented by the vertical vector arrows (V_y) in the figure. Ignoring air resistance, there is no force in the horizontal direction so the horizontal velocity remains the same as shown by the arrow V_x . The combination of the vertical motion (V_y) and the horizontal motion (V_x) caused the ball to follow a curved path until it hits the floor.



The vertical distance y that a falling object moves is proportional to the square of the time it is falling vertically t . Considering the acceleration due to gravity (g) then

$$y = \frac{1}{2} g t^2$$

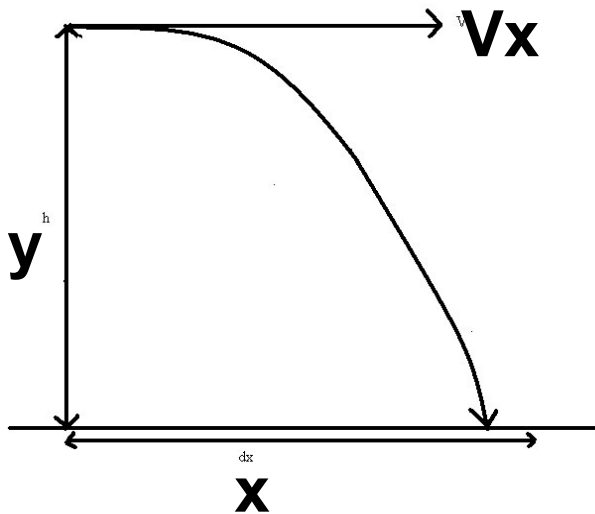
The horizontal distance x that a ball moves depends on its horizontal velocity V_x when it leaves the horizontal track. Velocity is distance per unit time so:

$$V_x = x/t \text{ and } t = x/V_x$$

Imagine what would happen if the ball had a horizontal velocity only. Without gravity there would be no increasing downward velocity and the ball would move straight out from the table. It would, however, be vertically above where it would have hit the floor (if there were a downward velocity) at the same time. You can see this if you mentally remove the V_y arrow from the figure.

The time of fall is $t = x/V_x$ you can substitute this time in $y = \frac{1}{2} g t^2$ and you get :

$y = \frac{1}{2} g (x/V_x)^2$ which now has both the vertical y and the horizontal distance x in the same relationship. See figure below.



You will predict X using the equations of motion and check your prediction. You will also use a graph to compute the flight time and then check your computation.

PROCEDURE:

STEP1: Adjust the ramp so that A is 10 cm above the table. Measure the horizontal par BC. Release the ball from A and time how long the ball takes to cross over BC. Along BC the ball has a constant velocity = V_x . We neglect frictions. Find the velocity V_x of the ball using $V_x = BC / t$. Make at least three runs and find the average velocity. Record your data in TABLE A.

TABLE A

trial	time (t) (s)	velocity (V_x) (cm/s)
1		
2		
3		
average V_x		
vertical distance Y		
calculated X		

STEP2: Measure and record Y in TABLE A.

From the equation $Y = 0.5 g (X^2/V_x^2)$. ($X = \sqrt{2 Y V_x^2 / g}$) solve for X . Then use the values of Y and V_x from TABLE A to predict X. Record in TABLE A what X should be according to your calculations.

STEP3: Place a cup or a piece of paper at the calculated distance X from the edge of the table. Roll the ball down the ramp to see if your calculated prediction was correct. Is your prediction good ?

(you can also use a piece of carbon paper on a sheet of paper for a target).

STEP4: Increase the height to the ramp to 20cm. What is happening to the distance x ?

CONCLUSION:

Was the purpose of this lab accomplished ? Why or Why not ?

(your answer to this question should show thoughtful analysis and careful, through thinking)