

Projectile Motion

TOPICS AND FILES

Mechanics Topics

Projectile motion with different initial speeds

Projectile motion with different launch angles

Capstone Files

13A Projectile Motion 1.cap

13B Projectile Motion 1.cap

EQUIPMENT LIST

Qty	Items	Part Numbers
1	PASCO Interface (for three sensors)	
2	Photogate Head	ME-9498
1	Time-of-Flight Accessory	ME-6810
1	Photogate Mounting Bracket	ME-6821
1	Projectile Launcher	ME-6800
1	Metric Measuring Tape, 30 m	SE-8712
1	Extension Cord, 6 m	PI-8117
1	C-clamp, large	SE-7285

INTRODUCTION

This lab has two parts.

The purpose of Experiment 1 is to compare the time of flight of a projectile for different values of initial speed when a launcher is aimed horizontally. Use photogates and a time-of-flight pad to measure the initial speed and the time of flight of a projectile. Use *Capstone* to record the motion. Compare the time of flight for the projectile when it is launched horizontally at different initial speeds.

The purpose of Experiment 2 is to compare the time of flight of a projectile for different values of the launch angle above horizontal. Use photogates and a time-of-flight pad to measure the initial speed and the time of flight of a projectile. Use *Capstone* to record the motion. Predict the range of a projectile based on the initial speed, vertical height, and launch angle.

BACKGROUND

These equations are used to describe the “ x ” and “ y ” components of projectile motion. You will use these equations later in this exploration.

$$\begin{aligned}
x - x_0 &= v_0 \cos \theta_0 t \\
y - y_0 &= v_0 \sin \theta_0 t - \frac{1}{2}gt^2 \\
v_y &= v_0 \sin \theta_0 - gt \\
v_y^2 &= (v_0 \sin \theta_0)^2 - 2g(y - y_0)
\end{aligned} \tag{1}$$

Projectile motion is a kind of two-dimensional motion that occurs when the moving object (the projectile) experiences only the acceleration due to gravity, which acts in the vertical direction. The acceleration of the projectile has no horizontal component if the effects of air resistance are ignored. The vertical component of the acceleration equals the acceleration due to gravity, g .

The vertical motion of a freely falling ball launched horizontally off a table of height d is independent of any horizontal motion the ball may have. Thus the time for a ball to fall to the ground is independent of its horizontal speed. The distance d a ball falls from rest as a function of the time of fall t is given by the next equation where g is the acceleration in free fall.

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

Thus the time for a ball to fall straight down a distance d from rest to the ground is given by the following.

$$t = \sqrt{\frac{2d}{g}} \tag{3}$$

If a ball launched horizontally with a non-zero initial speed takes the same amount of time to reach the ground as a ball that drops from rest from the same height, this equation also gives the time of flight for any ball launched horizontally regardless of the initial speed of the ball.

The horizontal ‘range’ of the projectile depends on its horizontal speed, and the total time that it is in the air. The time of flight for a projectile launched at angle θ above the horizontal is determined by the initial speed in the vertical direction, v_{0y} , and the acceleration due to gravity. The time up and down for a projectile is given by the next equation.

$$t = \frac{2v_0 \sin \theta}{g} \tag{4}$$

Note that this formula assumes that the object returns to the same vertical position it had when it was launched. The ‘range’, R , is the horizontal speed multiplied by the time of flight.

$$R = v_{0x}t = v_0 \cos \theta \left(\frac{2v_0 \sin \theta}{g} \right) \tag{5}$$

SAFETY REMINDER

- Wear safety goggles when using the projectile launcher.
- Follow directions for using the equipment.

THINK SAFETY, ACT SAFELY, BE SAFE!