

Projectile Motion



Projectile motion is a common topic in physics that involves the study of the motion of objects thrown or projected into the air, subject to only the acceleration of gravity. Here are some key points and formulas related to projectile motion:

Key Concepts of Projectile Motion:

1. **Projectile:** An object thrown into space upon which the only acting force is gravity.
2. **Trajectory:** The path followed by a projectile.
3. **Horizontal and Vertical Components:** The motion of a projectile can be analyzed in two parts – horizontal and vertical.
4. **Initial Velocity (u):** The velocity at which the projectile is launched, which has both horizontal (u_x) and vertical (u_y) components.
5. **Time of Flight (T):** The total time the projectile remains in the air.
6. **Maximum Height (H):** The highest vertical position reached by the projectile.
7. **Range (R):** The horizontal distance traveled by the projectile.

Equations of Projectile Motion:

1. **Horizontal Motion:**
 - Horizontal Velocity (constant): $u_x = u \cos(\theta)$
 - Horizontal Distance: $x = u_x t = u \cos(\theta)t$
2. **Vertical Motion:**
 - Vertical Velocity: $u_y = u \sin(\theta)$
 - Vertical Distance (displacement): $y = u_y t - \frac{1}{2}gt^2$
 - Final Vertical Velocity: $v_y = u_y - gt$
3. **Time of Flight:**
 - $T = \frac{2u \sin(\theta)}{g}$
4. **Maximum Height:**
 - $H = \frac{u^2 \sin^2(\theta)}{2g}$
5. **Range:**
 - $R = \frac{u^2 \sin(2\theta)}{g}$

Detailed Breakdown:

1. **Launch Angle (θ):** The angle at which the projectile is launched. It determines the initial velocity components:
 - $u_x = u \cos(\theta)$
 - $u_y = u \sin(\theta)$
2. **Horizontal Motion:**
 - The horizontal component of velocity remains constant because there is no acceleration in the horizontal direction (assuming air resistance is negligible).
 - Horizontal displacement after time t : $x = u \cos(\theta)t$
3. **Vertical Motion:**

- The vertical component of velocity changes due to the acceleration due to gravity ($g = 9.8 \text{ m/s}^2$).
- The vertical displacement is given by: $y = u \sin(\theta)t - \frac{1}{2}gt^2$

4. Time of Flight:

- The total time the projectile is in the air depends on the vertical component of the initial velocity and gravity.
- $T = \frac{2u \sin(\theta)}{g}$

5. Maximum Height:

- This is the highest point the projectile reaches in its trajectory.
- $H = \frac{u^2 \sin^2(\theta)}{2g}$

6. Range:

- The horizontal distance the projectile covers during its flight.
- $R = \frac{u^2 \sin(2\theta)}{g}$

Example Problem:

Problem: A projectile is launched with an initial velocity of 20 m/s at an angle of 30° above the horizontal. Calculate the time of flight, maximum height, and range.

Solution:

1. Initial Velocity Components:

- $u_x = 20 \cos(30^\circ) = 20 \times \frac{\sqrt{3}}{2} = 10\sqrt{3} \approx 17.32 \text{ m/s}$
- $u_y = 20 \sin(30^\circ) = 20 \times \frac{1}{2} = 10 \text{ m/s}$

2. Time of Flight:

- $T = \frac{2u \sin(\theta)}{g} = \frac{2 \times 10}{9.8} \approx 2.04 \text{ seconds}$

3. Maximum Height:

- $H = \frac{u^2 \sin^2(\theta)}{2g} = \frac{20^2 \times (\frac{1}{2})^2}{2 \times 9.8} = \frac{400 \times 0.25}{19.6} \approx 5.1 \text{ meters}$

4. Range:

- $R = \frac{u^2 \sin(2\theta)}{g} = \frac{20^2 \sin(60^\circ)}{9.8} = \frac{400 \times \frac{\sqrt{3}}{2}}{9.8} \approx 35.3 \text{ meters}$

This summary should help you understand and solve basic problems related to projectile motion. If you need further detailed explanations or more example problems, please let me know!