# Projectile Motion Equations Worksheet

Level: A-Level / AP Physics 1 / IB | Difficulty: Advanced | Topic: Mechanics

Practice projectile motion with 10 problems covering horizontal launches, angled trajectories, time of flight, maximum height, and range. Resolving into x and y components is the key skill.

## Equations you will need

| | |
|---|---|
| **x = (u cos theta) t** | Horizontal displacement |
| **y = (u sin theta) t - 1/2gt^2** | Vertical displacement |
| **vx = u cos theta** | Horizontal velocity (constant) |
| **vy = u sin theta - gt** | Vertical velocity at time t |
| **R = u^2 sin(2theta) / g** | Range on level ground |
| **t_flight = 2u sin theta / g** | Total time of flight |
| **H = u^2 sin^2theta / (2g)** | Maximum height |

## Symbol key

| Symbol | Quantity | Unit |
|---|---|---|
| u | launch speed | m/s |
| theta | launch angle | degrees |
| g | gravitational acceleration | 9.8 m/s^2 |
| R | horizontal range | m |
| H | maximum height | m |
| t | time | s |

## Practice problems

1. A ball is launched horizontally at 20 m/s from a 45 m high cliff. Find time to hit ground. (g = 9.8 m/s^2)

2. Same ball: how far from the base does it land?

3. A projectile is launched at 30 m/s at 60deg above horizontal. Find the time of flight.

4. Same projectile: find the maximum height.

5. Same projectile: find the horizontal range.

6. A ball kicked at 25 m/s at 40deg above horizontal. Find horizontal range.

7. A stone thrown horizontally at 15 m/s lands 30 m away. Find the launch height.

8. A projectile launched at 20 m/s at angle theta has range 35 m. Find theta.

9. Find the vertical velocity of a ball 2 s after launch at 40 m/s at 30deg.

10. A projectile launched at 50 m/s at 45deg. Find the speed when it lands at the same height.

# Answer key

Full worked solutions for each problem.

1. 45 = 1/2(9.8)t^2 -> t = 3.03 s
2. x = 20 x 3.03 = 60.6 m
3. t = 2(30)sin60deg / 9.8 = 5.30 s
4. H = (30^2 x sin^260deg)/(2x9.8) = 34.4 m
5. R = (30^2 x sin120deg)/9.8 = 79.5 m
6. R = (25^2 x sin80deg)/9.8 = 62.8 m
7. t = 30/15 = 2 s; h = 1/2(9.8)(4) = 19.6 m
8. sin(2theta) = (35)(9.8)/400 = 0.8575 -> 2theta ? 59.0deg -> theta ? 29.5deg
9. vy = 40 sin30deg - 9.8(2) = 20 - 19.6 = 0.4 m/s
10. By symmetry, lands at 50 m/s (energy conserved)