



CBSE Physics - Problem of the day

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Projectile motion from unequal heights is a classic CBSE Class XI concept that appears every year in board exams and is a favourite for JEE and NEET tricky questions. Unlike the standard ground-to-ground case, here the launch and landing heights differ, which means you cannot use the shortcut range formula. You must apply the equations of motion separately for horizontal and vertical directions.

Concepts Tested

- Resolution of velocity
- Equations of motion
- Time of flight
- Maximum height
- Horizontal range

Problem Statement

A cricketer hits a ball with an initial velocity of 25 m/s at an angle of 60° above the horizontal from ground level. The ball is caught by a fielder standing on a platform 2.0 m above the point of projection.

Calculate:

- a. The maximum height reached by the ball
- b. The time for which the ball remains in air until caught
- c. The horizontal distance between the striker and the fielder

Take $g = 9.8 \text{ m/s}^2$



Think First Do not use $R = u^2 \sin 2\theta / g$, because the landing height is not zero. For vertical motion, take upward as positive, so displacement at catch is $+2.0$ m, not zero. You will get a quadratic equation for time, that gives two roots.

Step-by-Step Solutions

Solution for (a) Maximum Height

Step 1: Resolve velocity

$$u_x = u \cos 60^\circ = 25 \times 0.5 = 12.5 \text{ m/s}$$

$$u_y = u \sin 60^\circ = 25 \times 0.866 = 21.65 \text{ m/s}$$

Step 2: At max height $v_y = 0$, use $v_y^2 = u_y^2 - 2gH$

Step 3: $H = u_y^2 / (2g) = (21.65)^2 / (2 \times 9.8) = 468.7 / 19.6 = 23.91 \text{ m}$

Answer (a): Maximum height = 23.9 m above ground (approx 24 m)

Solution for (b) Time of Flight

Step 1: Use $y = u_y t - \frac{1}{2}gt^2$, set $y = 2.0$ m at the catch point

Step 2: $2 = 21.65t - 4.9t^2 \Rightarrow 4.9t^2 - 21.65t + 2 = 0$

Step 3: Solve quadratic

$$t = [21.65 \pm \sqrt{(21.65)^2 - 4 \times 4.9 \times 2}] / 9.8$$

$$t = [21.65 \pm \sqrt{468.72 - 39.2}] / 9.8$$

$$t = [21.65 \pm \sqrt{429.52}] / 9.8$$

Step 4: $t = [21.65 \pm 20.73] / 9.8 \Rightarrow t_1 = 0.094 \text{ s (ascending)}, t_2 = 4.32 \text{ s (descending)}$

Answer (b): Choose $t = 4.32$ s, the ball is caught on its way down.



Solution for (c) Horizontal Range

Step 1: Horizontal velocity is constant (no air resistance)

Step 2: $R = u_x \times t = 12.5 \times 4.324 = 54.05 \text{ m}$

Answer (c): Horizontal distance $\approx 54.1 \text{ m}$

Key Takeaways

- Maximum height depends only on vertical component $u \sin\theta$, not on landing height.
- When launch and landing heights differ, always use $y = u_y t - \frac{1}{2}gt^2$, never the standard time-of-flight formula.
- The quadratic gives two times, the smaller is while going up, the larger is while coming down.
- Horizontal range = $u \cos\theta \times$ total time, because horizontal motion is uniform.

Common Mistakes

- Using $R = \frac{u^2 \sin 2\theta}{g}$, this is valid only for same-level projection.
- Taking $g = 10 \text{ m/s}^2$ in CBSE numericals, use 9.8 unless specified.
- Forgetting the +2 m displacement and setting $y = 0$.
- Choosing the smaller root 0.094 s as time of flight.

Your Turn

Try the same problem with $u = 25 \text{ m/s}$, angle = 45° , and catch height = 1.5 m. Find (a) maximum height, (b) time of flight, (c) range. Post your answers in the comments. Hint: u_y will be smaller, so expect less height and shorter flight time.



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