Name: _____ AP PHYSICS 1 Date: _____

KINEMATICS DAY 10: PROJECTILES — ANGLED LAUNCH

WARMUP **Day 9 Review**

A ball is launched horizontally from a fixed-height cliff. If its launch speed doubles, what happens?

□ **A.** Fall time doubles; range stays the same
□ **B.** Fall time stays the same; range doubles
□ **C.** Both fall time and range double
□ **D.** Both fall time and range stay the same

Check one → convince your neighbor in one sentence.

Physics in the Wild — Why Nobody Punts at 45°: In a vacuum, 45° gives maximum range. Real punters kick closer to 50–55° — they're buying *hang time* so the coverage team can get downfield, trading distance for the bigger v_y. Once you can split a launch into components, trade-offs like that are one line of algebra.

ANGLED LAUNCH = DAY 8 + DAY 9

Step 1 — resolve: $v_{0x} = v_0 \cos\theta$ (stays constant), $v_{0y} = v_0 \sin\theta$ (then free-falls).

Step 2 — fly (level ground, up positive):

- Time to top: $t = v_{0y}/g$ · Total flight: $T = 2v_{0y}/g$
- Max height: $H = v_{0y}^2/(2g)$ — *units: $(m/s)^2/(m/s^2) = m$ ✓*
- Range: $R = v_{0x} \cdot T$

At the top: $v_y = 0$ but v_x is still going — the projectile is never at rest.

WE DO **Exercise 1: The Full Flight**

A soccer ball is kicked at 20 m/s at 37° above horizontal from level ground. Find **(a)** the components, **(b)** the total flight time, **(c)** the maximum height, and **(d)** the range.

YOUR TURN

YOU DO Exercise 2: Steeper Kick

A ball is launched at 25 m/s at 53° above horizontal from level ground. Find the total flight time, maximum height, and range.

Resolve once, at the start. After Step 1, the launch speed v_0 should never appear in your equations again — only v_{0x} and v_{0y}. Mixing v_0 into a vertical equation is the #1 angled-launch error.

YOU DO Exercise 3: Complementary Angles

Two identical balls are kicked at 20 m/s — one at 30°, one at 60°. For each, find the flight time and range. What do you notice about the ranges? Which ball wins on hang time?

USE THE SYMMETRY

SYMMETRY FACTS (LEVEL GROUND, NO AIR RESISTANCE)

- Time up = time down; the trajectory is a mirror image about the peak
- Landing speed = launch speed; landing angle = launch angle (below horizontal)
- Complementary launch angles (30°/60°, 37°/53°) give equal ranges
- 45° maximizes range — it splits v_0 evenly between distance (v_x) and airtime (v_y)

CHALLENGE **Exercise 4: No Calculator Needed**

A ball launched at 26 m/s at 40° lands on level ground. **(a)** What is its landing speed? **(b)** What other launch angle at 26 m/s would land in the same spot? **(c)** Justify both answers in one sentence each — no computation allowed.

PAPER PRACTICE

PRACTICE PROBLEMS

P1 Vertical Component

Find the initial vertical velocity component of a launch at 30 m/s at 53° above horizontal.

P2 Hang Time

A projectile is launched with v_{0y} = 9.8 m/s on level ground. How long is it airborne?

P3 Full Analysis

A ball is launched at 19.6 m/s at 30° above horizontal on level ground. Find the flight time, maximum height, and range.

P4 Best Angle

In one or two sentences: why does 45° give the maximum range on level ground? Frame your answer as a trade-off between the two components.