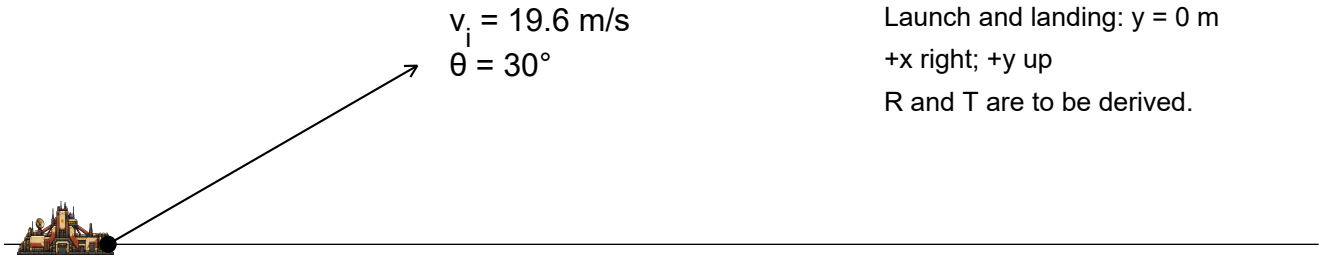
EARTH RANGE PRELAB / SIX-STAGE TEACHER DEMONSTRATION

Derive the range

Name: _____ Class: _____ Date: _____

Use one flight to connect components, time and horizontal displacement. Follow the animated demonstration, then explain the model in your own words.

A stationary launcher fires a point projectile to the right and upward. Launch and landing are both y = 0 m. Earth g = 9.8 m/s^2; a_x = 0. No wind, drag or earlier obstacle collision. The yellow point defines the trajectory; artwork is illustrative.



Given launch conditions only; diagram not to scale.

Before the reveal

Predict what determines the flight time and horizontal range. Keep this first prediction; add a correction beside it after observing.

Working conventions

g is a positive magnitude; a_y = -g = -9.8 m/s^2. Use degree mode. T means the later return time; t means elapsed time. For these rightward shots, R = Δx is positive horizontal displacement. Keep full precision until your final answer.

Page 2: follow the derivation. Pages 3-5: questions P1-P6, with supplied evidence for use without a device. Paper responses do not require an account.

MATCHES ANIMATION STAGES 1-6 / RECORD YOUR ALGEBRA

Build it one equality at a time

Use the baseline on page 1. Fill the missing expressions as the teacher reveals each step. The double-angle identity is supplied; memorizing it is not assessed.

1 / Resolve the launch

v_{ix} = _____ v_{iy} = _____

2 / Use equal elevations

$\Delta y = v_{iy}\, t - \frac{1}{2}gt^2$

0 = _____

3 / Factor; keep both roots

0 = t(_____)

t = 0 means: _____ T = _____

4 / Share the same time

$R = v_{ix}\, T$

Why can both directions use T? _____

5 / Substitute and simplify

R = (_____)(_____)

$R = 2v_i^2 \sin\theta \cos\theta / g$

Given $\sin(2\theta) = 2 \sin\theta \cos\theta$, R = _____

6 / Predict, then compare

Record P4 before observing doubled speed.

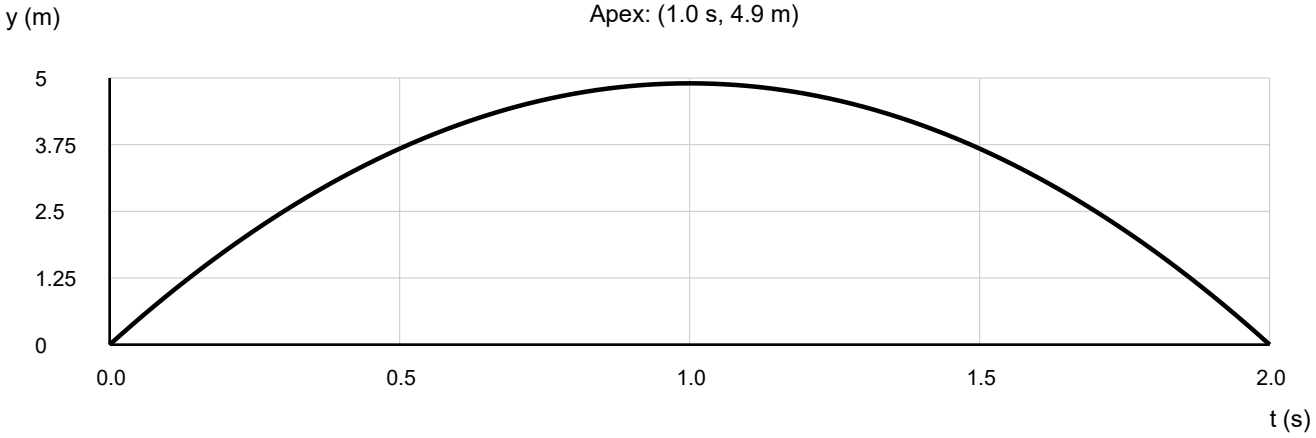
Keep angle, g, launch height and landing height fixed.

Revisit the first equality that changes when a model assumption changes. Use P5 and P6 to explain the limits of the shortcut.

P1-P2 / VERTICAL EVIDENCE

Two roots, one complete flight

Shared evidence: baseline v_i = 19.6 m/s, θ = 30°, g = 9.8 m/s^2. The supplied ideal graph begins and ends at y = 0 m. It records the same point projectile throughout.



P1 / Explain what Δy = 0 means in this derivation. Does it mean the projectile never moved upward?

P2 / Explain why t = 0 is not the landing time sought. Identify the physical event represented by each time solution.

P3-P4 / HORIZONTAL EVIDENCE AND SPEED COMPARISON

Time connects both directions

Shared evidence: the baseline has v_{ix} = 16.974 m/s, T = 2.000 s and R = 33.948 m. A second trial uses 39.2 m/s at the same 30° angle. Both start and land at y = 0 m with g = 9.8 m/s^2 and no drag or wind.

Reference equations: $T = 2v_i \sin\theta / g$; $R = v_{ix} T = v_i^2 \sin(2\theta) / g$. The baseline v_x-t graph is a horizontal line at 16.974 m/s from t = 0 to 2 s; its rectangle area is 33.948 m.

P3 / Why can the time found from vertical motion be used in the horizontal equation? Connect your explanation to the two synchronized graphs.

P4 / Keeping angle and gravity fixed, predict how doubling initial speed changes range and flight time. Support the range prediction using the equation, then compare with the observed trials.

First prediction (preserve): _____

Givens	**U**nknowns	**E**quation	**S**ubstitute	**S**olve

After observation: doubled-speed T = _____ s; R = _____ m.

Explain any revision beside your original prediction:

P5-P6 / EQUATIONS AND ASSUMPTIONS

Know where the shortcut ends

Shared evidence: the derivation uses these equalities in order. These questions change one assumption at a time; you do not need to calculate a new trajectory.

Line	Original model
A	$\Delta y = v_{iy}\, t - \frac{1}{2} g t^2$
B	$0 = v_i \sin\theta \times t - \frac{1}{2} g t^2$
C	$R = v_{ix}\, T$
D	$R = v_i^2 \sin(2\theta) / g$

General constant-acceleration rule in any direction: displacement = initial velocity × time + ½ × acceleration × time^2. Keep the sign of each component.

P5 / Which first equality must change when landing elevation differs from launch elevation? Write the vertical equation that remains valid and explain why the range shortcut no longer follows.

P6 / Which horizontal-motion equation must change if constant horizontal acceleration is introduced? Write its replacement and identify the added term.