

Projectiles and relative motion in a plane

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train you to split vectors into components, apply the horizontal and vertical equations of a projectile, and add velocities in relative motion. They start with recall and one-step calculations and end with AP-style multi-step and experiment-design tasks.

The level matches AP Physics 1 unit 1. Use $g = 9.81 \text{ m/s}^2$ unless told otherwise, take up as positive, and write each result with its unit.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 1

Problem 1 Components of a bat strike (easy)

A cricket ball leaves the bat at 30 m/s, 20° above the horizontal.

1. Calculate the horizontal component of the velocity.
2. Calculate the vertical component.
3. State which component stays the same during the flight.

Problem 2 True or false at the top (easy)

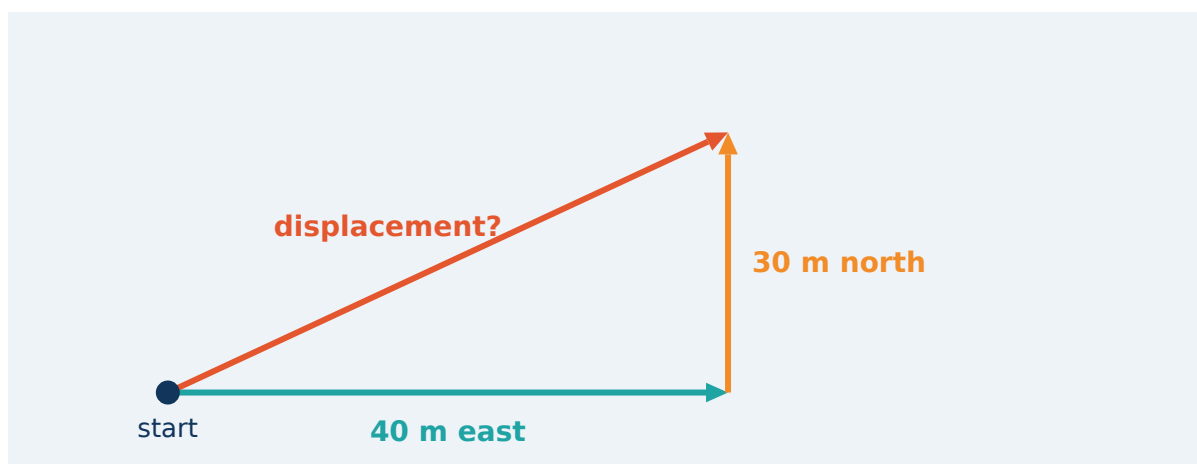
A ball is at the highest point of its path. State whether each statement is true or false.

1. The vertical velocity is zero.
2. The horizontal velocity is zero.
3. The acceleration is zero.
4. The acceleration is 9.81 m/s^2 downward.

Problem 3 Walk across a field (easy)

Chiamaka walks 40 m east and then 30 m north (see the figure).

1. Calculate the distance she walked.
2. Calculate the magnitude of her displacement.
3. Calculate the angle of the displacement north of east.



Two legs of a walk across a school field.

Problem 4 Marble leaving a table (easy)

A marble rolls off a table 0.80 m high with a horizontal speed of 1.5 m/s.

1. Calculate the time to reach the floor.
2. Calculate the horizontal distance from the table edge to the landing point.

Problem 5 Dropped or launched (easy)

Ahmed drops one ball from the top of a wall. At the same instant Bilal launches a second ball horizontally from the same height.

1. State which ball lands first, or whether they land together.
2. Explain your answer using the vertical motion only.

Problem 6 Football over level ground (medium)

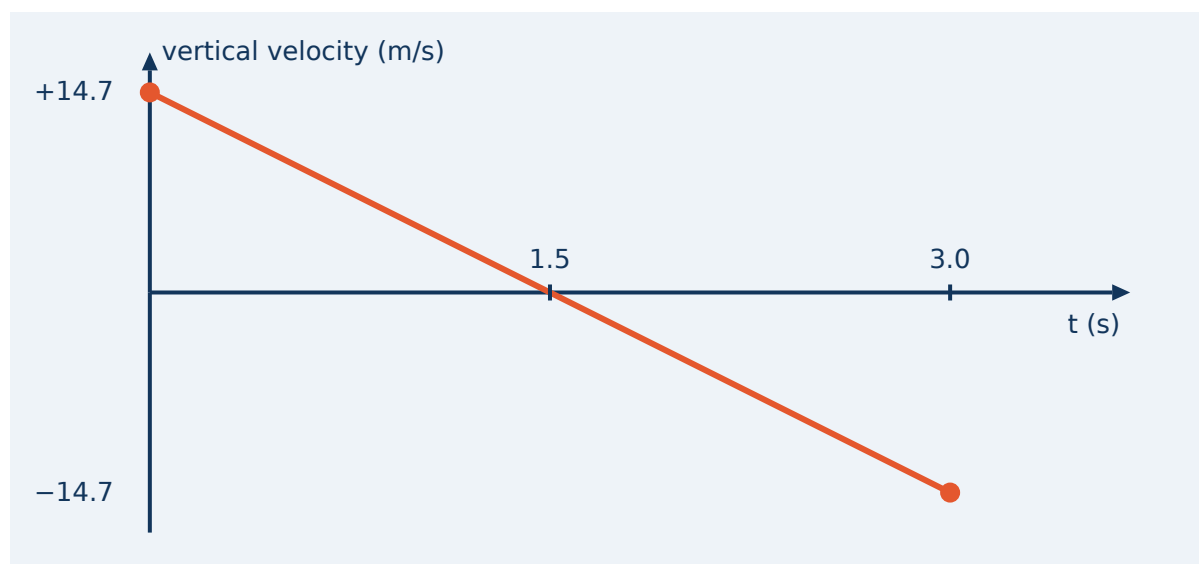
A football is kicked at 25 m/s, 40° above the horizontal, from level ground.

1. Calculate the horizontal and vertical components of the initial velocity.
2. Calculate the time of flight.
3. Calculate the range.
4. Calculate the maximum height.

Problem 7 Reading a velocity graph (medium)

The figure shows the vertical velocity of a ball thrown upward from the ground.

1. State the time at which the ball is at its highest point.
2. Calculate the gradient of the line and state what it represents.
3. Use the area under the graph from 0 to 1.5 s to find the maximum height.
4. State the time of landing.



Vertical velocity of a ball thrown upward from the ground.

Problem 8 Stone thrown from a cliff (medium)

Kofi throws a stone horizontally at 8.0 m/s from a cliff 45 m above the sea.

1. Calculate the time of fall.
2. Calculate the horizontal distance travelled.
3. Calculate the speed on impact.
4. Calculate the angle of the velocity below the horizontal on impact.

Problem 9 Moving walkway (medium)

At an airport Diego walks at 1.4 m/s relative to a 66 m long walkway that moves at 0.80 m/s.

1. Calculate his speed relative to the ground when he walks with the walkway.
2. Calculate the time to travel 66 m in that case.
3. Calculate his speed relative to the ground if he walks against the walkway.

Problem 10 Spot the error (medium)

Emma launches a ball at 20 m/s, 60° above the horizontal. Her friend says: at the top the speed is zero.

1. Calculate the horizontal component of the velocity.
2. State the speed of the ball at the top.
3. Explain the error in the friend's statement.

Problem 11 Free kick and crossbar (medium)

A free kick is taken 20 m from the goal. The ball leaves the ground at 18 m/s, 35° above the horizontal. The crossbar is 2.44 m high.

1. Calculate the time to reach the goal line.
2. Calculate the height of the ball at the goal line.

3. State whether the ball passes over the bar.

Problem 12 Same speed, different angles (medium)

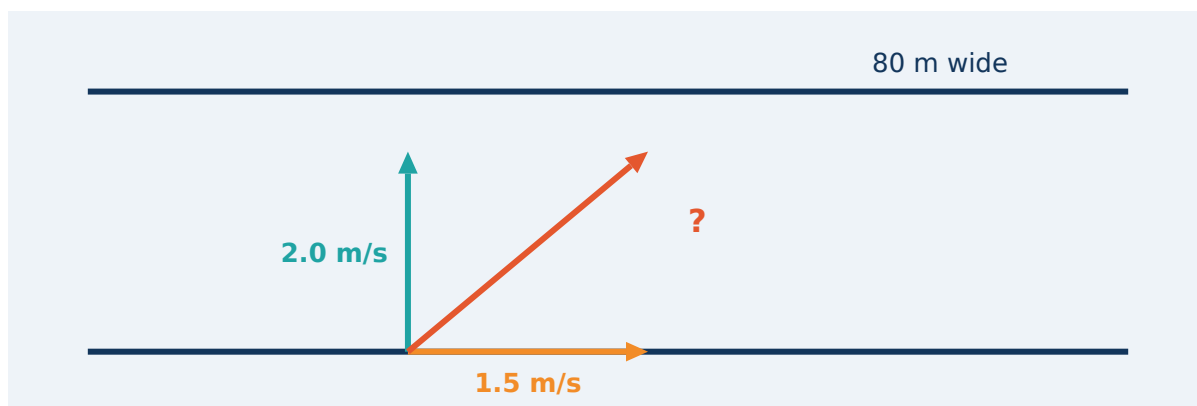
A javelin thrower releases a training ball at 15 m/s from ground level. Use $R = v^2 \sin 2\theta \div g$.

1. Calculate the range at 45° .
2. Calculate the range at 30° .
3. Calculate the range at 60° and comment on the result in 2.

Problem 13 River crossing (medium)

A boat points straight across a river 80 m wide at 2.0 m/s relative to the water. The current is 1.5 m/s (see the figure).

1. Calculate the crossing time.
2. Calculate how far downstream the boat lands.
3. Calculate the speed of the boat relative to the ground.

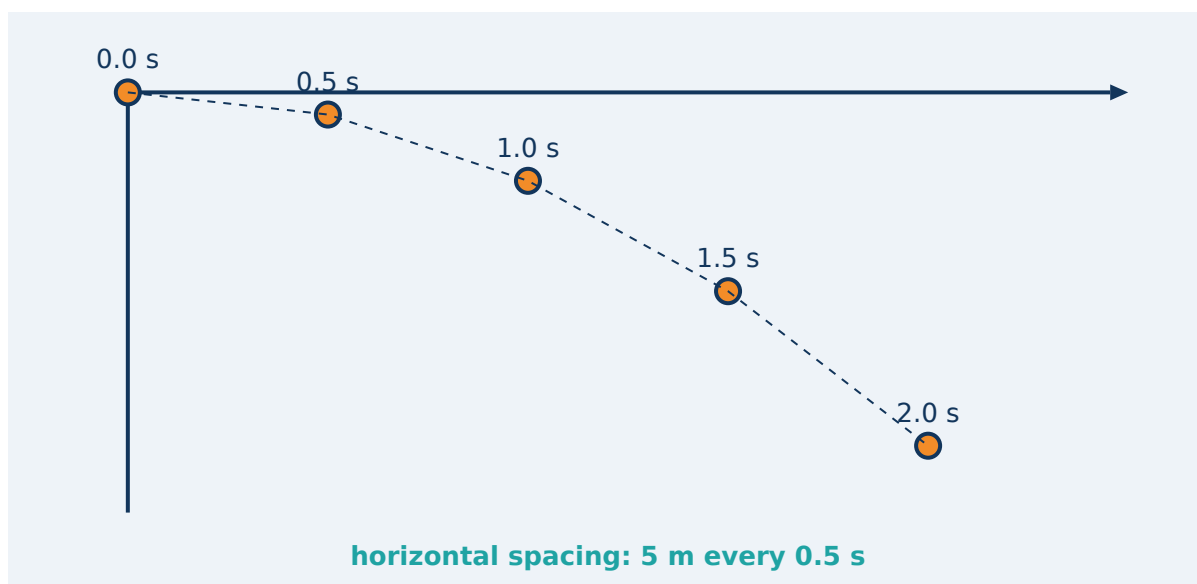


Boat heading and current for a river crossing.

Problem 14 Reading a strobe diagram (medium)

The figure shows a ball launched horizontally at 10 m/s, photographed every 0.5 s.

1. Explain why the horizontal spacing of the dots is constant.
2. Verify the vertical drop at $t = 1.0$ s using $y = \frac{1}{2}gt^2$.
3. Predict the vertical drop at $t = 2.5$ s.



Positions of a launched ball every 0.5 s (vertical scale compressed).

Problem 15 Ball hitting a wall (hard)

A ball is thrown from the ground at 20 m/s, 50° above the horizontal, towards a wall 18 m away.

1. Calculate the time taken to reach the wall.
2. Calculate the height at which it hits the wall.
3. Determine whether the ball is rising or falling at that moment.

Problem 16 Stone thrown from a bridge (hard)

A stone is thrown at 15 m/s, 30° above the horizontal, from a bridge 12 m above a lake.

1. Calculate the time to reach the water.
2. Calculate the horizontal distance travelled.
3. Calculate the speed and direction of the velocity on impact.

Problem 17 Heading into the wind (hard)

A small plane has an airspeed of 60 m/s. A steady wind blows towards the east at 15 m/s.

1. The pilot points the plane due north. Calculate the ground speed and the direction of travel.
2. The pilot wants to travel due north over the ground. Calculate the angle west of north the plane must point.
3. Calculate the ground speed in that case.

Problem 18 Basketball from its peak (hard)

A basketball thrown at 60° above the horizontal rises 3.2 m above the release point.

1. Calculate the initial vertical velocity.
2. Calculate the launch speed.

3. Calculate the horizontal range back at release height.

Problem 19 Analysing tracking data (hard)

A tracking system records a ball launched from the ground at $t = 0$.

Time (s): 0, 0.2, 0.4, 0.6, 0.8

x (m): 0, 2.4, 4.8, 7.2, 9.6

y (m): 0, 1.60, 2.82, 3.63, 4.06

1. Calculate the horizontal velocity.
2. Calculate $y \div t$ for each time and use the values to estimate the initial vertical velocity.
3. Calculate the launch speed and angle.
4. Calculate the time to reach the top.

Problem 20 Planning a launcher test (hard)

A spring launcher fires a steel ball horizontally from the edge of a bench. You have a metre rule, carbon paper, white paper and a plumb line.

1. Describe a procedure to find the launch speed.
2. State the equation you would use and which measurements go into it.
3. Suggest two ways to reduce random error in the range.
4. Explain how the result would change if the bench were twice as high and the launcher unchanged.