

Straight-line motion with graphs and equations

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These problems train you to move between words, graphs and equations for motion in a straight line. You will find velocities and accelerations from graphs, choose the right constant-acceleration equation, and handle signs in free fall. They match AP Physics 1 unit 1 and the first topics of an algebra-based mechanics course.

Level 1 problems check definitions, level 2 problems combine two steps, and level 3 problems mirror AP free-response tasks: experimental design, paragraph arguments and multi-stage motion. Use $g = 9.81 \text{ m/s}^2$ and keep one sign convention per problem.

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

Problem 1 Distance and displacement (easy)

Bilal walks 40 m east along a school corridor, then turns and walks 25 m west. The whole walk takes 50 s. Take east as positive.

1. Calculate the distance he walked.
2. Calculate his displacement.
3. Calculate his average speed and his average velocity.

Problem 2 Scalar or vector (easy)

Classify each quantity as a scalar or a vector, then state what the sign of a vector tells you in a one-dimensional problem. The quantities are: distance, displacement, speed, velocity, acceleration, time.

Problem 3 Train between two stations (easy)

Emma in Leeds notes that her train moves from the position $x = +2.0 \text{ km}$ to $x = +14.0 \text{ km}$ in 8.0 min along a straight track.

1. Calculate the displacement in metres.
2. Convert 8.0 min to seconds.
3. Calculate the average velocity in m/s and in km/h.

Problem 4 Motorbike pulling away (easy)

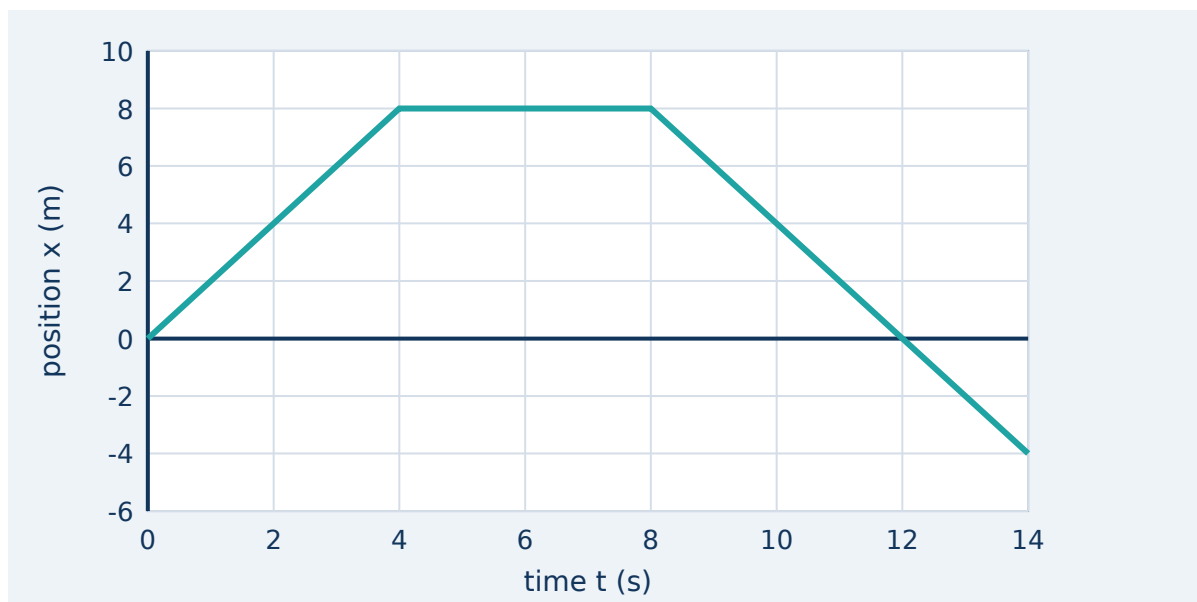
A motorbike in Mumbai speeds up from 5.0 m/s to 23 m/s in 6.0 s along a straight road.

1. Calculate the average acceleration.

- If the acceleration stays constant, find the speed 4.0 s later.

Problem 5 Reading a position-time graph (medium)

The graph shows the position of a toy cart on a straight track.

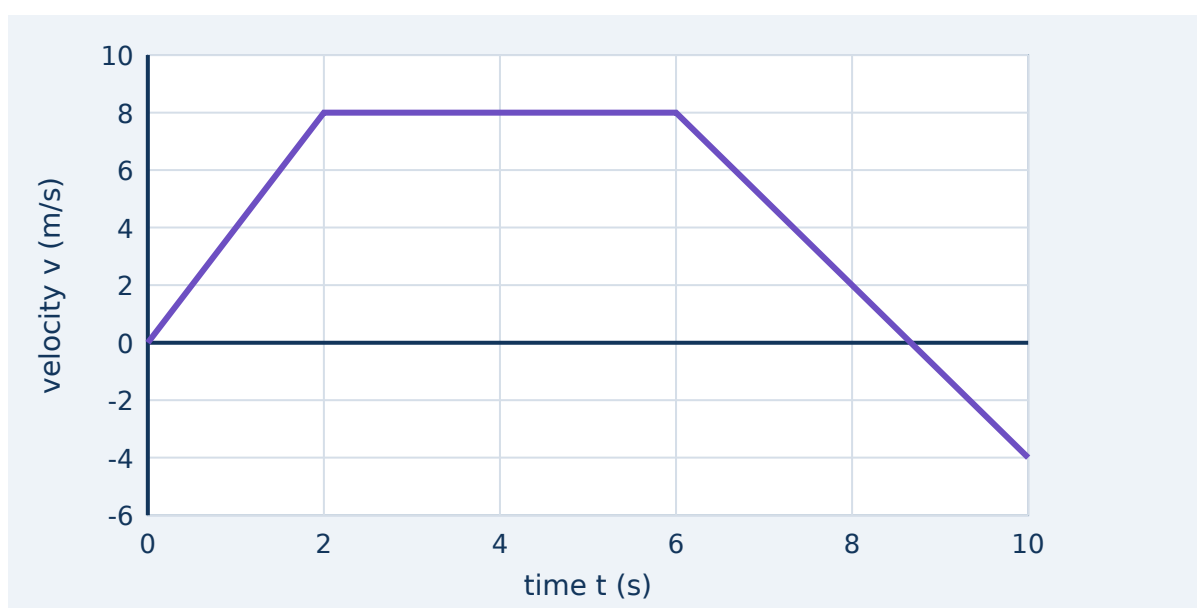


Position of the cart against time.

- Calculate the velocity of the cart in each of the three stages.
- Calculate the total distance travelled and the displacement from $t = 0$ to $t = 14$ s.
- Calculate the average velocity and the average speed for the whole 14 s.

Problem 6 Reading a velocity-time graph (medium)

The graph shows the velocity of a cart that starts at $x = 0$.



Velocity of the cart against time.

- Calculate the acceleration in each stage.

2. Calculate the displacement from 0 to 6 s.
3. Find the time at which the cart momentarily stops.
4. Calculate the position of the cart at $t = 10$ s.

Problem 7 Skateboard on a ramp (medium)

Chiamaka in Lagos releases a skateboard from rest at the top of a ramp. It travels 6.0 m in 2.0 s with constant acceleration.

1. Name the kinematic equation you will use and explain why.
2. Calculate the acceleration.
3. Calculate the speed at the bottom.

Problem 8 Metro train braking (medium)

A metro train slows from 20 m/s to 8.0 m/s while covering 168 m on a straight section.

1. Calculate the acceleration.
2. Calculate the time taken.

Problem 9 Falling coconut (medium)

Kofi in Accra watches a coconut fall from rest from a palm 12.0 m above the ground. Ignore air resistance and use $g = 9.81 \text{ m/s}^2$.

1. Calculate the time of fall.
2. Calculate the speed on impact in two different ways.

Problem 10 Velocity table of a thrown ball (medium)

Diego tosses a ball vertically upward at 9.0 m/s from his hand. Take up as positive and ignore air resistance.

1. Calculate the velocity at $t = 0.50$ s, 1.00 s, 1.50 s and 2.00 s.
2. Find the time at which the ball reaches its highest point.
3. Calculate the greatest height above his hand.

Problem 11 Signs of velocity and acceleration (medium)

A cart moves on a track with the positive x direction to the right. For each case say whether the cart is speeding up or slowing down and give the direction of its motion.

1. $v = +3 \text{ m/s}$, $a = +2 \text{ m/s}^2$
2. $v = +3 \text{ m/s}$, $a = -2 \text{ m/s}^2$
3. $v = -3 \text{ m/s}$, $a = -2 \text{ m/s}^2$
4. $v = -3 \text{ m/s}$, $a = +2 \text{ m/s}^2$

Problem 12 Matatu sprint (medium)

Wanjiru's matatu in Nairobi speeds up uniformly from rest to 108 km/h in 7.5 s.

1. Convert 108 km/h to m/s.
2. Calculate the acceleration.
3. Calculate the distance covered in this time.

Problem 13 Spot the sign error (medium)

A student drops a ball from rest and chooses down as the positive direction. She writes $a = -9.81 \text{ m/s}^2$, finds $v = -19.6 \text{ m/s}$ after 2.0 s and concludes that the ball is moving upward.

1. Identify her mistake.
2. Give the correct acceleration and the correct velocity.

Problem 14 Scooter journey (hard)

Aarav's electric scooter starts from rest and accelerates at 1.5 m/s^2 for 8.0 s. It then moves at constant velocity for 20.0 s and finally brakes uniformly to rest in 5.0 s.

1. Calculate the speed reached after the first stage.
2. Calculate the distance covered in each stage and in total.
3. Calculate the braking acceleration and the average velocity for the whole journey.

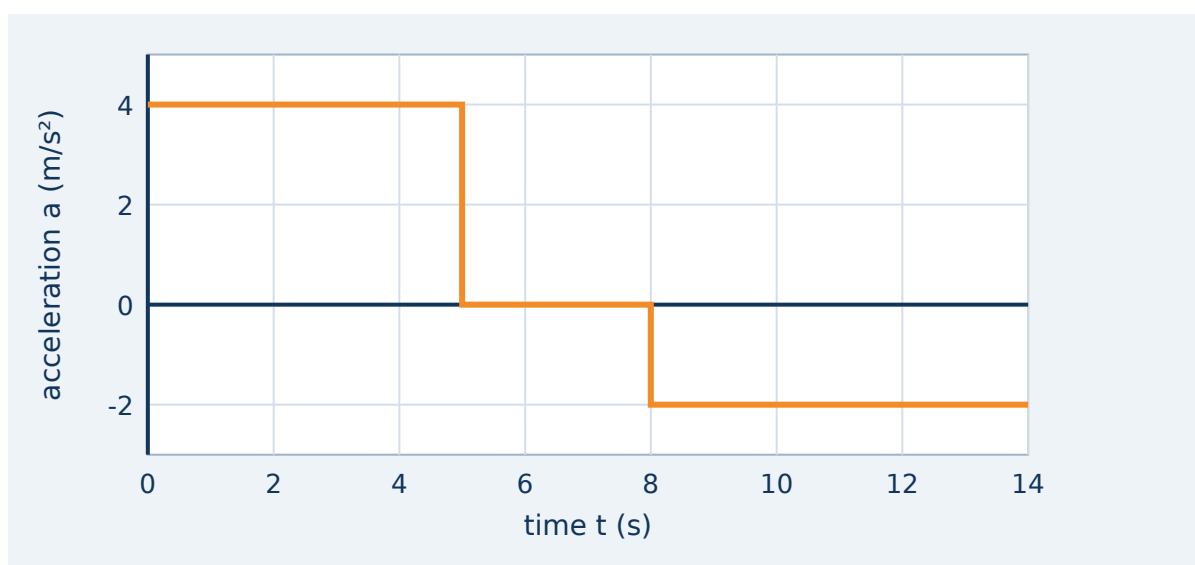
Problem 15 Doubling the speed (hard)

A car brakes with constant deceleration 5.0 m/s^2 from 15 m/s .

1. Calculate the stopping distance and stopping time.
2. Calculate both again for an initial speed of 30 m/s with the same deceleration.
3. Explain, using $v^2 = v_0^2 + 2a\Delta x$, why the distance changes by a different factor from the time.

Problem 16 Acceleration-time graph of a sled (hard)

A rocket sled starts from rest. Its acceleration is shown against time.



Acceleration of the sled against time.

1. Calculate the velocity at 5 s, 8 s and 14 s.
2. Calculate the total displacement from 0 to 14 s.
3. Describe the matching velocity-time graph in words.

Problem 17 Sandbag from a balloon (hard)

A hot-air balloon rises at a steady 4.0 m/s. When it is 60.0 m above the ground, a crew member lets go of a sandbag. Take up as positive and ignore air resistance.

1. State the initial velocity and acceleration of the sandbag.
2. Calculate how long it takes to reach the ground.
3. Calculate its velocity on impact and its greatest height above the ground.

Problem 18 Design: acceleration of a cart (hard)

Design an experiment to find the acceleration of a cart rolling down a ramp using only a metre rule and a stopwatch.

1. List the measurements and the controls.
2. State the graph you would plot and how the acceleration is found from it.
3. Explain one way to reduce the effect of timing error.

Problem 19 Argument: acceleration at the top (hard)

A student claims that at the top of its flight a ball has zero velocity and therefore zero acceleration. Strobe data for a ball thrown up at 12.0 m/s give these velocities (up positive):
 $t = 1.0 \text{ s}$: +2.19 m/s; 1.1 s : +1.21 m/s; 1.2 s : +0.23 m/s; 1.3 s : -0.75 m/s; 1.4 s : -1.73 m/s.

1. Calculate the acceleration between each pair of readings.
2. Write a short paragraph that uses the data to evaluate the student's claim.

Problem 20 Sprinter split times (hard)

Wanjiru's coach times a 60 m sprint with gates every 10 m. Times from the start: 0 s, 1.85 s, 2.87 s, 3.80 s, 4.65 s, 5.47 s, 6.29 s at 0, 10, 20, 30, 40, 50, 60 m.

1. Calculate the average velocity in each 10 m section.
2. Decide where she stops speeding up and justify it.
3. Calculate her average velocity for the whole 60 m.
4. Show that a constant acceleration cannot explain the first two sections.