

Show equations, substitutions, units, and vector directions. Explain your reasoning. Use sensible rounding.

Answers appear below each question beside a vertical bar. Equivalent correct reasoning is acceptable.

Constants	1 km = 1000 m 1 h = 3600 s
Equations	$\Delta x = x_f - x_i$ $v_{avg} = \Delta x / \Delta t$ average speed = distance / Δt $a = (v_f - v_i) / t$ $v_f = v_i + at$ $\Delta x = v_i t + \frac{1}{2}at^2$ $v_f^2 = v_i^2 + 2a\Delta x$ $\Delta x = \frac{1}{2}(v_i + v_f)t$

Use constant-acceleration equations only when acceleration is constant.

1.1 Graphing Relationships

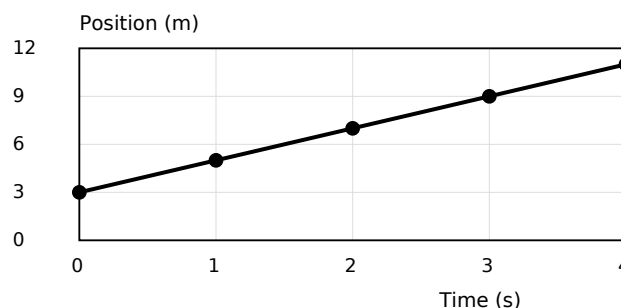
1. A student changes the time a cart rolls and measures its position. Identify the independent and dependent variables, their graph axes, and two conditions to keep constant.

Independent: elapsed time on the horizontal axis. Dependent: position on the vertical axis. Keep the cart and track slope/surface the same. Other reasonable controlled conditions are acceptable.

2. The data below describe a cart. Plot position versus time on the grid. Draw a best-fit line. Find its slope and equation, then predict the position at 7.0 s. Explain the assumption in that prediction.

t (s)	0	1	2	3	4
x (m)	3	5	7	9	11

Use the grid to plot the data.



The points lie on $x = (2.0 \text{ m/s})t + 3.0 \text{ m}$. Slope = $(11.0 - 3.0) / (4.0 - 0) = 2.0 \text{ m/s}$. At 7.0 s, $x = 17 \text{ m}$. This extrapolation assumes the same constant velocity continues.

1.2 Distance and Displacement

3. A student starts at $x = +2.0 \text{ m}$, walks to $+14.0 \text{ m}$, then returns to -4.0 m . Find the total distance and displacement. Classify each quantity as scalar or vector.

Distance = $12.0 + 18.0 = 30.0 \text{ m}$, a scalar. Displacement = $-4.0 - 2.0 = -6.0 \text{ m}$, a vector pointing in the negative direction.

1.3 Speed and Velocity

4. The walk in Question 3 takes 12.0 s. Find average speed and average velocity. Explain how a moving person can have a nonzero average speed but zero average velocity.

Average speed = $30.0 / 12.0 = 2.50 \text{ m/s}$. Average velocity = $-6.0 / 12.0 = -0.50 \text{ m/s}$. A round trip has positive distance but zero displacement, so its average velocity is zero.

ANSWER KEY

1.4 Position-Time Graphs

5. Use the position-time graph. Find the velocity during each interval: 0–2 s, 2–4 s, and 4–6 s. When is the object at rest? Find its total distance and displacement.

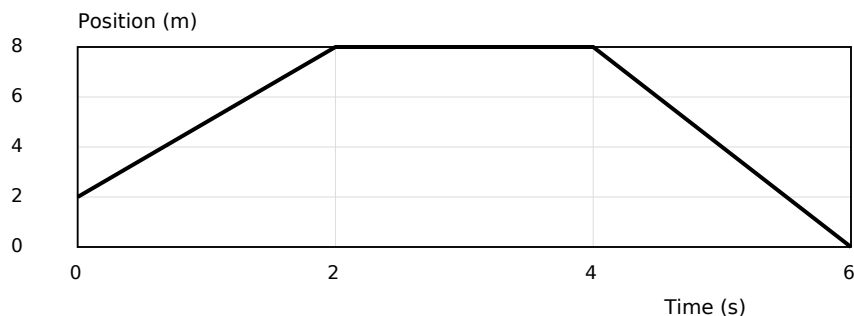
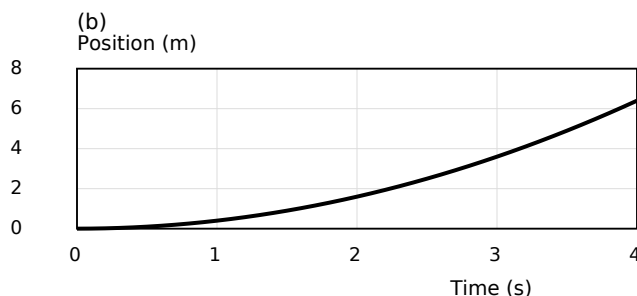
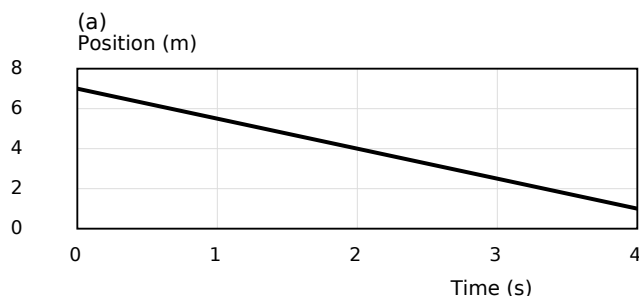


Diagram not to physical scale.

Slopes: $(8 - 2)/2 = +3$ m/s, 0 m/s, and $(0 - 8)/2 = -4$ m/s. It rests from 2 to 4 s. Distance = $6 + 8 = 14$ m. Displacement = $0 - 2 = -2$ m.

6. Sketch position-time graphs for (a) constant negative velocity and (b) motion in the positive direction that speeds up. Label both axes. Explain how each graph shows the motion.



(a) A straight line with negative slope. (b) An increasing curve that gets steeper with time. Position-time slope is velocity, so increasing positive slope means increasing speed.

1.5 Acceleration

7. A cyclist moving east slows from 18.0 m/s to 6.0 m/s in 4.0 s. Take east as positive. Calculate acceleration and explain why its sign differs from the velocity sign.

$a = (6.0 - 18.0)/4.0 = -3.0$ m/s², or 3.0 m/s² west. The cyclist moves east but loses eastward velocity. Opposite velocity and acceleration directions mean slowing down.

8. For each pair of signs, state whether speed increases or decreases: (a) v positive, a positive, (b) v positive, a negative, (c) v negative, a positive, (d) v negative, a negative.

(a) Increases. (b) Decreases. (c) Decreases. (d) Increases. Matching signs increase speed. Opposite signs decrease speed until the object reaches zero velocity.

ANSWER KEY

1.6 Velocity-Time Graphs

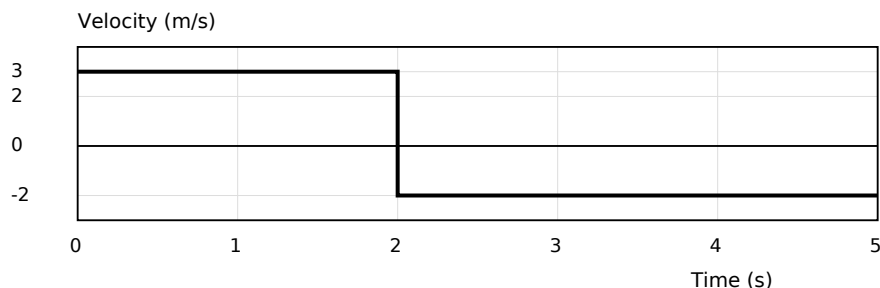
9. Use the velocity-time graph. Calculate the acceleration in each interval and the total displacement from 0 to 6 s.



Diagram not to physical scale.

From 0–2 s: $a = 4/2 = +2 \text{ m/s}^2$. From 2–4 s: $a = 0$. From 4–6 s: $a = -4/2 = -2 \text{ m/s}^2$. Displacement = $\frac{1}{2}(2)(4) + (2)(4) + \frac{1}{2}(2)(4) = 16 \text{ m}$.

10. A cart travels at $+3.0 \text{ m/s}$ for 2.0 s , then at -2.0 m/s for 3.0 s . Treat the reversal as instantaneous. Sketch its velocity-time graph. Find displacement and distance using areas.



Draw horizontal segments at $+3.0 \text{ m/s}$ from 0–2 s and -2.0 m/s from 2–5 s. Signed area = $6.0 - 6.0 = 0 \text{ m}$ displacement. Sum of area magnitudes = 12 m distance.

1.7 Kinematic Equations

11. A cart starts from rest and accelerates at $+2.4 \text{ m/s}^2$ for 5.0 s . Find its final velocity and displacement. Show an equation for each result.

$v_f = 0 + (2.4)(5.0) = +12 \text{ m/s}$. $\Delta x = 0 + \frac{1}{2}(2.4)(5.0)^2 = +30 \text{ m}$.

12. A car moving at $+24.0 \text{ m/s}$ brakes with constant acceleration -4.0 m/s^2 . Find its stopping time and stopping distance.

$t = (0 - 24.0)/(-4.0) = 6.0 \text{ s}$. $0 = (24.0)^2 + 2(-4.0)\Delta x$, so $\Delta x = 72 \text{ m}$.

ANSWER KEY**Unit 1 Review**

13. A train increases its velocity from +8.0 m/s to +20.0 m/s over 84 m with constant acceleration. Find its acceleration and elapsed time.

| $a = (20.0^2 - 8.0^2)/(2 \times 84) = +2.0 \text{ m/s}^2$. $t = (20.0 - 8.0)/2.0 = 6.0 \text{ s}$.

14. A car moves at 72 km/h. Convert this speed to m/s. Find the distance it travels at this speed in 15 s.

| $72 \text{ km/h} \times (1000 \text{ m}/1 \text{ km}) \times (1 \text{ h}/3600 \text{ s}) = 20 \text{ m/s}$. Distance = $(20)(15) = 300 \text{ m}$.

15. Correct each claim: (a) A horizontal line always means an object is at rest. (b) Negative acceleration always means slowing down. (c) The area under a position-time graph gives displacement.

| (a) A horizontal position-time line means rest, but a horizontal velocity-time line means constant velocity. (b) Negative acceleration means acceleration in the negative direction. (c) Signed area under a velocity-time graph gives displacement.

16. A runner starts from rest, accelerates uniformly to 6.0 m/s in 3.0 s, then maintains that speed for 5.0 s. Find total distance and average speed over all 8.0 s.

| First interval: $\Delta x = \frac{1}{2}(0 + 6.0)(3.0) = 9.0 \text{ m}$. Second: $\Delta x = (6.0)(5.0) = 30 \text{ m}$. Total = 39 m. Average speed = $39/8.0 = 4.9 \text{ m/s}$.