

Acceleration and velocity-time graphs

Name: _____ Class: _____ Date: _____

Start here

0-5 minutes

Today: Read velocity-time gradients, explain signs and find final speed from uniform-acceleration data.

You need: Pen, a different-coloured pen, ruler and calculator with square-root key. Graph is supplied.

Work from memory and show working. Write directly in this booklet.

1. Velocity increases from 4.0 m/s to 10 m/s east in 3.0 s. Calculate average acceleration.

Working and acceleration:

2. An object keeps moving at 6.0 m/s east. State its acceleration and whether it is stationary.

3. A calculation gives $v^2 = 49 \text{ m}^2/\text{s}^2$. What is the final speed v ?

Stop for check 1. Wait for your teacher before moving on.

Try again A

Only if directed. Use the first 2 reading minutes, then continue on page 2.

Help: Use page 2: change in velocity divided by elapsed time; a flat velocity line means zero acceleration; take the square root of v^2 for speed.

(a) Velocity rises from 2 to 14 m/s in 4 s. Find acceleration. (b) At constant velocity 7 m/s east, state acceleration and whether motion stops. (c) If $v^2=81 \text{ m}^2/\text{s}^2$, find speed.

When your teacher says, turn to page 2.

Read the methods and models

5-15 minutes

Velocity is speed in a stated direction. With east positive, a positive velocity means eastward travel. Acceleration is change in velocity per second, not velocity itself. A velocity-time gradient gives acceleration. A horizontal section means constant velocity; it is stationary only when velocity is zero.

Find or explain	Method / meaning
Acceleration, a (m/s^2)	$a = (\text{final velocity} - \text{initial velocity}) / \text{elapsed time}$.
Graph section	$a = (\text{later velocity} - \text{earlier velocity}) / (\text{later time} - \text{earlier time})$. Use both changes.
Motion direction	Use the sign of velocity. Positive velocity with negative acceleration can mean slowing eastward.
Uniform forward acceleration	$v^2 - u^2 = 2as$; rearrange to $v^2 = u^2 + 2as$. Square u first, then take the square root for final speed.
Symbols / units	u initial velocity, v final velocity (m/s); a acceleration (m/s^2); s displacement along the chosen line (m).

Worked models from the revision notes

A velocity changes uniformly from 4.0 to 16 m/s in 6.0 s. Find acceleration. In a separate straight-line test, $u=2.0$ m/s, $a=1.5$ m/s² and $s=4.0$ m, with uniform acceleration forward. Find final speed.

Acceleration = $(16-4.0)/6.0 = 2.0$ m/s². Separate test: $v^2 = u^2 + 2as = 2.0^2 + 2 \times 1.5 \times 4.0 = 16$ m²/s². Final speed $v = \sqrt{16} = 4.0$ m/s. Take the square root after calculating v^2 .

Choose the right method

Given a velocity change and time? Use $a = \Delta v / \Delta t$. Given u , a and s for uniform straight-line acceleration? Use $v^2 = u^2 + 2as$, then $v = \sqrt{u^2 + 2as}$ for the forward speed here. The squared-speed value is not a speed. Do not use the equation across a changing-acceleration interval.

Adapted from PhysicsUK Motion Graphs, Speed and Acceleration: shared section 3, section 5 and brief scalar/vector support from section 1. Online reading is optional. Optional online reading.

Turn to page 3 for question 4.

Check signed gradient and direction

15-20 minutes

4. A straight velocity-time section joins (2.0 s, +8.0 m/s) to (6.0 s, +2.0 m/s), with east positive. Choose the correct signed acceleration and motion description. Show both changes.

- A. -1.5 m/s^2 ; moving east and slowing
- B. $+0.33 \text{ m/s}^2$; moving east and speeding up
- C. -1.5 m/s^2 ; moving west
- D. $+1.5 \text{ m/s}^2$; moving east and speeding up

Velocity change = _____ m/s; time change = _____ s

Signed acceleration and chosen letter: _____

Motion direction and reason: _____

Stop for check 2. Wait for your teacher before moving on.

Try again B

Only if directed. Complete this instead of questions 5-6, then answer questions 7-9 on page 4.

Help: Use both endpoint differences on page 2. Positive velocity sets eastward motion even when its gradient is negative.

A new east-positive velocity-time section joins (3 s, +10 m/s) to (7 s, +2 m/s). Calculate signed acceleration and describe the motion.

If B was used, Figure 2 may remain unfinished: all remaining questions use 0-20 s. Otherwise complete its missing final section in question 5.

At 20 minutes begin the graph questions. The graph represents a new test, not question 4.

Turn to page 4 for Figure 2 and questions 5-9.

Complete and read the velocity graph

20-30 minutes

A delivery robot moves only east or is stationary. East is positive. Use the same Figure 2 for questions 5-9 and 11-14.

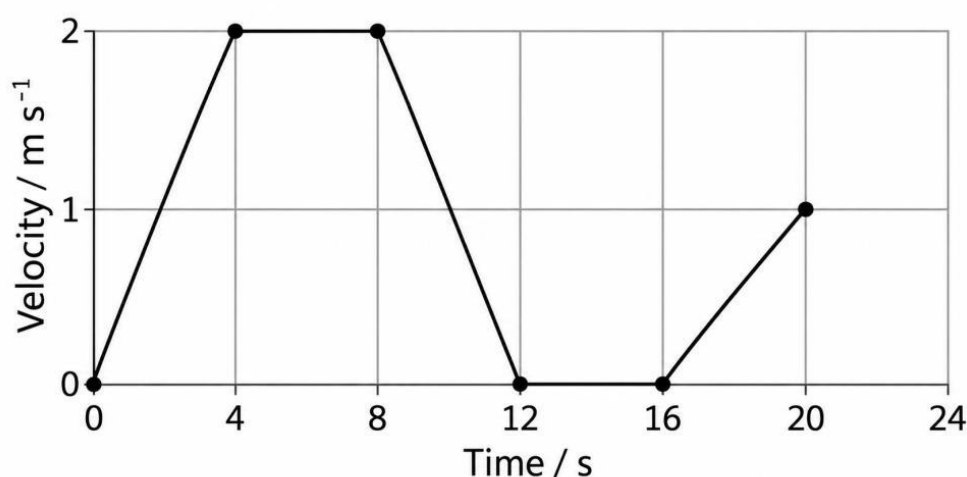


Figure 2: robot motion, east positive. From 20-24 s velocity remains +1.0 m/s; draw that missing section for question 5.

5. Complete Figure 2 from 20-24 s. Its velocity stays at 1.0 m/s east throughout that interval. Draw directly on the graph.

6. State the velocity at 6.0 s in Figure 2, including direction.

7. Calculate the acceleration from 0-4.0 s in Figure 2.

Changes and division:

Acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$ m/s²

8. Calculate the signed acceleration from 8-12 s in Figure 2. East is positive.

Changes and division:

Signed acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$ m/s²

9. Describe velocity and acceleration from 4-8 s in Figure 2.

Velocity:

Acceleration and reason:

At about 30 minutes turn to page 5 for the independent check.

Pause, then identify rest

30-33 minutes; then continue practice

10. A new cart's velocity increases uniformly from +3.0 to +9.0 m/s in 4.0 s, then remains at +9.0 m/s for 2.0 s. Calculate acceleration during the increase. State acceleration during the flat section and whether the cart is stationary there.

Increasing-stage acceleration - working and unit:

Flat-stage acceleration:

Is the cart stationary? Reason:

Stop for check 3. Wait for your teacher before moving on.

Try again C

Only if directed. Complete this instead of questions 11-12, then continue with questions 13-16.

Help: Subtract the initial velocity before dividing. Constant velocity means no velocity change, not no motion; use page 2.

A separate cart increases velocity uniformly from 5 to 11 m/s in 3 s, then keeps velocity 11 m/s. Find acceleration in each stage and state whether it stops during the constant stage.

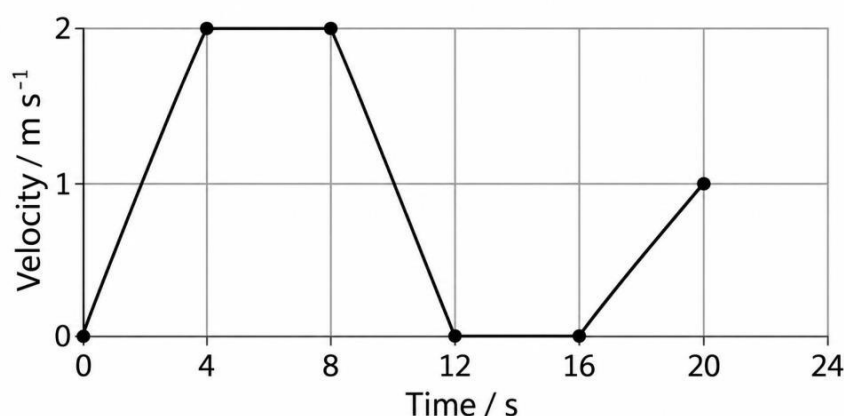


Figure 2: robot motion, east positive. From 20-24 s velocity remains +1.0 m/s; draw that missing section for question 5.

11. State the time interval when the robot is stationary in Figure 2.

Continue the graph explanations on page 6.

Describe the quantities precisely

33-45 minutes - continue practice

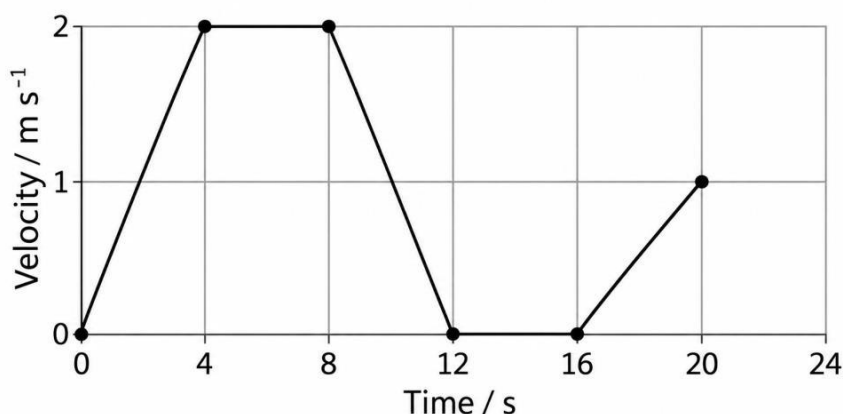


Figure 2: robot motion, east positive. From 20-24 s velocity remains +1.0 m/s; draw that missing section for question 5.

12. Describe how velocity changes from 16-20 s in Figure 2 and state whether acceleration is constant.

Velocity change:

Is acceleration constant? Reason:

Acceleration, if calculated:

13. A trainee writes: “the velocity is accelerating at 0.50 m/s^2 from 0-4 s.” Rewrite this using correct quantities and language.

14. A pupil says the falling line from 8-12 s in Figure 2 means the robot is moving west. Explain the error.

Finish practice with the two applications on page 7.

Apply the two calculation methods

Finish practice by 45 minutes

These are separate tests, adapted from the revision note's original practice questions 1 and 5. Use the methods on page 2.

15. Velocity increases uniformly from 3.0 m/s to 15 m/s in 6.0 s. Calculate acceleration.

Equation and substitution:

Acceleration = m/s²

16. A conveyor package has initial speed 1.0 m/s and accelerates uniformly forward at 2.0 m/s² along a straight line for 6.0 m. Calculate final speed. Use $v^2 - u^2 = 2as$ and show the squared-speed stage and square root.

Equation and rearrangement:

Substitution for v^2 :

Squared-speed value = m²/s²

Square root and final speed = m/s

Check your result

Acceleration needs m/s²; final speed needs m/s. Check that uniform forward acceleration has increased the speed. A squared-speed result still needs its square root.

At 45 minutes turn to page 8 to review, then complete the final check.

Review, then show what you can do

45-55 minutes review; 55-60 minutes independent exit

17. Correct practice in a different colour and explain one correction using a gradient, quantity/sign or equation step. If all answers were correct, use Figure 2 to explain how negative acceleration can coexist with eastward motion.

Independent exit - only when your teacher says

Cover earlier pages and previous answers. Complete question 18 independently.

18. In a new east-positive velocity-time section, points are (1.0 s, +12 m/s) and (5.0 s, +4.0 m/s). (a) Find signed acceleration and describe motion. (b) A different cart has $u=2.0$ m/s and accelerates uniformly forward at 2.0 m/s² for 8.0 m. Find v using $v^2-u^2=2as$. (c) An eastward velocity stays at 4.0 m/s: state acceleration and whether it is stationary.

(a) Both changes and signed acceleration:

Motion description and reason:

(b) Squared-speed calculation:

Final speed and unit:

(c) Acceleration and stationary/moving reason:

Stop for check 4. Wait for your teacher before moving on.

Write your name on page 1. Hand in all pages with working and corrections.

Try again D - next lesson

Leave this today. Your usual teacher may direct it next lesson.

Help: Next lesson revisit page 2's endpoint, direction and squared-speed methods. Cover that reading before the fresh attempt.

Next lesson: an east-positive velocity-time section joins (2 s, +15 m/s) to (7 s, +5 m/s). Find signed acceleration and describe motion. A different cart has $u=1$ m/s, uniform forward $a=1$ m/s² and $s=12$ m: find v using $v^2-u^2=2as$. At constant velocity 3 m/s, is acceleration zero and is the cart stationary?

Hand your complete booklet to your teacher.