Cambridge University Press
978-1-107-58948-3 — Cambridge International AS and A Level Physics Workbook with CD-ROM
David Sang , Graham Jones
Excerpt
More Information

Chapter 1:
Kinematics – describing motion

Chapter outline

- define and use distance, displacement, speed and velocity
- describe laboratory methods for determining speed
- draw and interpret displacement–time graphs
- distinguish between scalar and vector quantities, and give examples
- add and subtract vector quantities

KEY TERMS

displacement: the distance travelled in a particular direction

scalar: a quantity with magnitude only

vector: a quantity with both magnitude and direction

Equations: $\text{average speed} = \dfrac{\text{distance travelled}}{\text{time taken}}$

$$\text{average speed} = \frac{\Delta d}{\Delta t}$$

$$\text{velocity} = \frac{\text{change in displacement}}{\text{time taken}}$$

$$\text{velocity} = \frac{\Delta s}{\Delta t}$$

Exercise 1.1 Speed calculations

These questions will help you to revise calculations involving speed, distance and time. You will also practise converting units. The SI unit of time is the second (s). It is usually best to work in seconds and convert to minutes or hours as the last step in a calculation. The correct scientific notation for metres per second is m s^{-1}.

1 A train travels 4000 m in 125 s. Calculate its average speed.

2 A spacecraft is orbiting the Earth with a constant speed of 8100 m s^{-1}. The radius of its orbit is 6750 km.

- **a** Explain what is meant by the term *constant speed*.
- **b** Calculate how far it will travel in 1.0 hour.
- **c** Calculate how long it will take to complete one orbit of the Earth. Give your answer in minutes.

3 A police patrol driver sees a car that seems to be travelling too fast on a motorway (freeway). He times the car over a distance of 3.0 km. The car takes 96 s to travel this distance.

- **a** The speed limit on the motorway is 120 km h^{-1}. Calculate the distance a car would travel at 120 km h^{-1} in one minute.
- **b** Calculate the distance a car would travel at 120 km h^{-1} in 1 s.
- **c** Calculate the average speed of the car, in m s^{-1}.
- **d** Compare the car's actual speed with the speed limit. Was the car travelling above or below the speed limit?

Cambridge University Press
978-1-107-58948-3 — Cambridge International AS and A Level Physics Workbook with CD-ROM
David Sang , Graham Jones
Excerpt
More Information

4 It is useful to be able to compare the speeds of different objects. To do this, the speeds must all be given in the same units.

a Calculate the speed, in m s^{-1}, of the objects in each scenario, i-vi. Give your answers in standard form (also known as *scientific notation*), with one figure before the decimal point.

i Light travels at 300 000 000 m s^{-1} in empty space.

ii A spacecraft travelling to the Moon moves at 11 km s^{-1}.

iii An athlete runs 100 m in 10.41 s.

iv An alpha-particle travels 5.0 cm in 0.043×10^{-6} s.

v The Earth's speed in its orbit around the Sun is 107 000 km h^{-1}.

vi A truck travels 150 km along a motorway in 1.75 h.

b List the objects in order, from slowest to fastest.

Exercise 1.2 Measuring speed in the laboratory

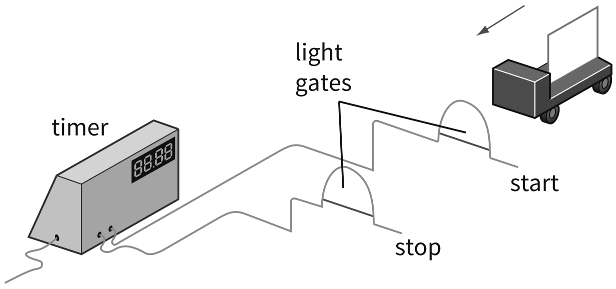
You can measure the speed of a moving trolley in the laboratory using a ruler and a stopwatch. However, you are likely to get better results using light gates and an electronic timer. In this exercise, you will compare data from these different methods and practise analysing it.

1 A student used a stopwatch to measure the time taken by a trolley to travel a measured distance of 1.0 m.

a Explain why it can be difficult to obtain an accurate measurement of time in this way.

b Explain why the problem is more likely to be greater if the trolley is moving more quickly.

2 This diagram shows how the speed of a trolley can be measured using two light gates connected to an electronic timer. An interrupt card is fixed to the trolley:



a Describe what happens as the trolley passes through the light gates.

b Name the quantity shown on the timer.

c What other measurement must be made to determine the trolley's speed? Describe how you would make this measurement.

d Explain how you would calculate the trolley's speed from these measurements.

e Explain why this method gives the trolley's *average* speed.

3 It is possible to determine the average speed of a trolley using a single light gate.

a Draw a diagram to show how you would do this.

b Describe what happens as the trolley passes through the light gate.

c Explain how you would find the trolley's average speed using this arrangement.

Cambridge University Press
978-1-107-58948-3 — Cambridge International AS and A Level Physics Workbook with CD-ROM
David Sang , Graham Jones
Excerpt
More Information

TIP
When using ticker-tape timers, think about whether to count the dots or the spaces between the dots.

4 A ticker-timer can also be used to record the movement of a trolley. The ticker-timer makes marks (dots) on paper tape at equal intervals of time.

a Sketch the pattern of dots you would expect to see for a trolley travelling at constant speed.

b A ticker-timer makes 50 dots each second on a paper tape. State the time interval between consecutive dots.

c A student measures a section of tape. The distance from the first dot to the sixth dot is 12 cm. Calculate the trolley's average speed in this time interval. Give your answer in m s^{-1}.

Exercise 1.3 Displacement–time graphs

A displacement–time graph is used to represent an object's motion. The gradient of the graph is the object's velocity. These questions provide practice in drawing, interpreting and using data from displacement–time graphs.

1 Velocity is defined by the equation:

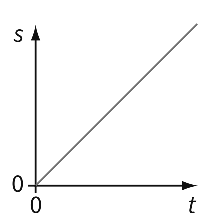
$$\text{velocity} = \frac{\Delta s}{\Delta t}$$

a State what the symbols *s* and *t* stand for.

b State what the symbols Δs and Δt stand for.

c Sketch a straight-line displacement–time graph and indicate how you would find Δs and Δt from this graph. Remember to label your graph axes with the correct quantities.

2 This sketch graph represents the motion of a car:

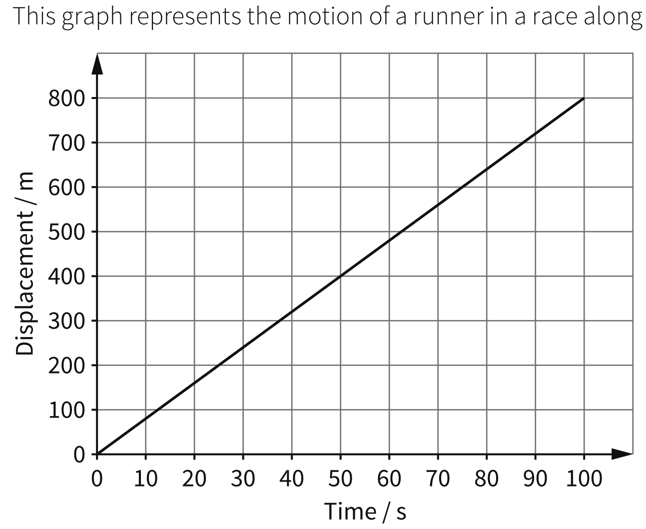


a Explain how you can tell that the car was moving with constant velocity.

b Copy the sketch graph and add a second line to the graph representing the motion of a car moving with a higher constant velocity. Label this 'faster'.

c On your graph, add a third line representing the motion of a car which is stationary. Label this 'stationary'.

3 This graph represents the motion of a runner in a race along a long, straight road:



Cambridge University Press
978-1-107-58948-3 — Cambridge International AS and A Level Physics Workbook with CD-ROM
David Sang , Graham Jones
Excerpt
More Information

Use the graph to deduce:

a the displacement of the runner after 75 s

b the time taken by the runner to complete the first 200 m of the race

c the runner's velocity.

4 This table gives values of displacement and time during a short cycle journey:

Displacement / m	0	80	240	400	560	680
Time / s	0	10	20	30	40	50

a Draw a displacement–time graph for the journey.

b From your graph, deduce the cyclist's greatest speed during the journey.

Exercise 1.4 Adding vectors

These questions involve thinking about displacement and velocity. These are vector quantities – they have direction as well as magnitude. Every quantity in physics can be classified as either a scalar or a vector quantity. A vector quantity can be represented by an arrow.

1 A scalar quantity has magnitude only.

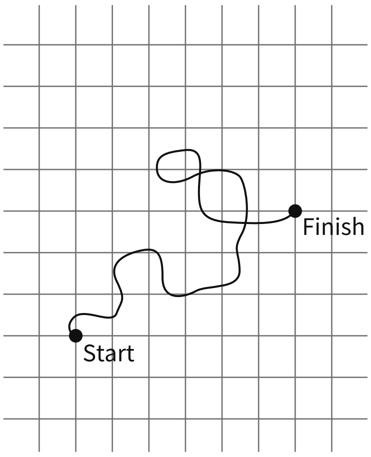
a Name the scalar quantity that corresponds to displacement.

b Name the scalar quantity that corresponds to velocity.

c For each of the following quantities, state whether it is a scalar or a vector quantity:

mass, force, acceleration, density, energy, weight

2 This drawing shows a piece of squared paper. Each square measures 1 cm × 1 cm. The track shows the movement of a spider that ran around on the paper for a short while:



a How many squares did the spider move *to the right*, from start to finish?

b How many squares did the spider move *up the paper*?

c Calculate the spider's displacement between start and finish.
Make sure that you give the distance (in cm) and the angle of its displacement relative to the horizontal.

d Estimate the distance travelled by the spider. Describe your method.

Cambridge University Press
978-1-107-58948-3 — Cambridge International AS and A Level Physics Workbook with CD-ROM
David Sang , Graham Jones
Excerpt
More Information

3 A yacht sails 20 km due north. It then turns 45° to the west and travels a further 12 km.

a Calculate the distance, in km, travelled by the yacht.

b Draw a scale diagram of the yacht's journey. Include a note of the scale you are using.

c By measuring the diagram, determine the yacht's displacement relative to its starting point.

4 A passenger jet aircraft can fly at 950 km h^{-1} relative to the air it is flying through. In still air it will therefore fly at 950 km h^{-1} relative to the ground.

a A wind of speed 100 km h^{-1} blows head-on to the aircraft, slowing it down. What will its speed relative to the ground be?

b If the aircraft was flying in the opposite direction, what would its speed be relative to the ground?

c The aircraft flies in a direction such that the wind is blowing at it sideways (in other words, at 90°).

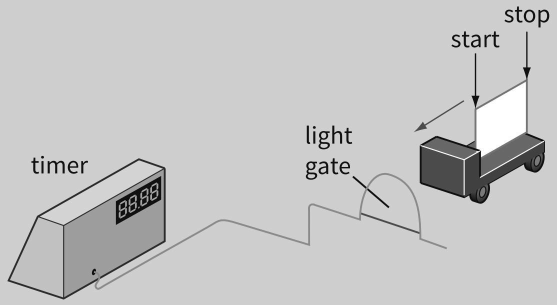
i Draw a diagram to show how these two velocities add together to give the resultant velocity of the aircraft.

ii Calculate the aircraft's speed relative to the ground.

Exam-style questions

1 **a** Define 'speed'. [1]

This diagram shows a laboratory trolley with an interrupt card mounted on it. The trolley will pass through a single light gate:



b Explain how the card causes the timer to start and stop. [3]

c The card is 10 cm wide. The timer indicates a time of 0.76 s. Calculate the average speed of the trolley. [2]

d Explain why the speed you calculated in **c** is the trolley's *average* speed. [1]

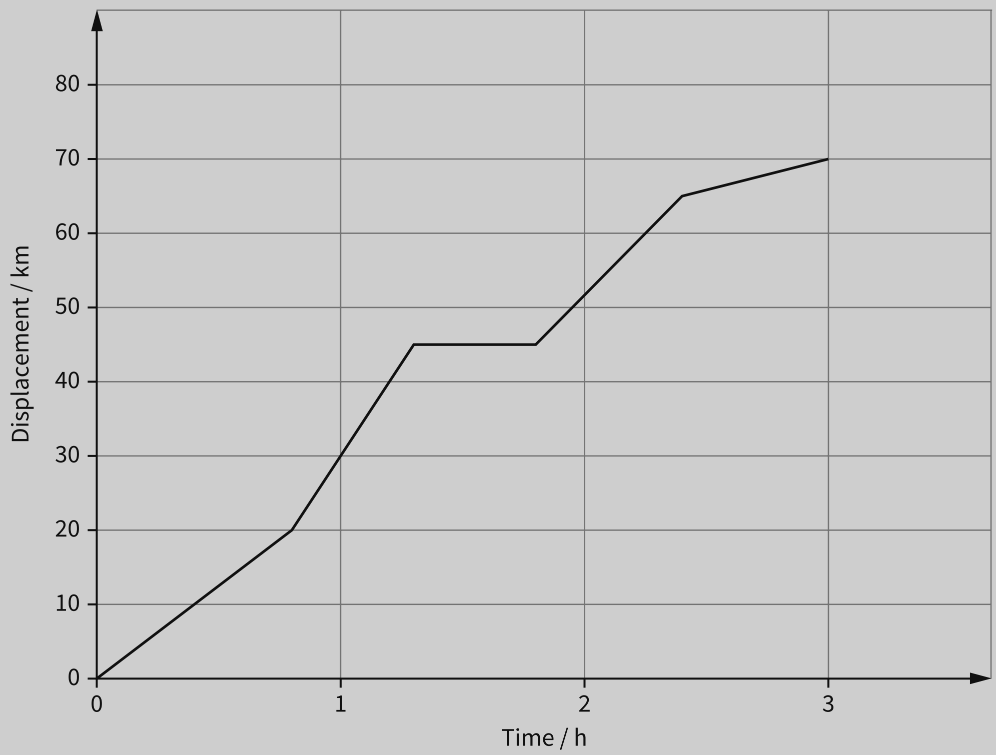
2 A slow goods train is travelling at a speed of 50 km h^{-1} along a track. A passenger express train that travels at 120 km h^{-1} sets off along the same track two hours after the goods train.

a Draw a displacement–time graph to represent the motion of the two trains. [4]

b Use your graph to determine the time at which the express train will catch up with the goods train. [1]

Cambridge University Press
978-1-107-58948-3 — Cambridge International AS and A Level Physics Workbook with CD-ROM
David Sang , Graham Jones
Excerpt
More Information

3 This graph represents the motion of a car along a straight road:



From the graph, deduce the following:

a the time taken for the car's journey [1]

b the distance travelled by the car during its journey [1]

c the car's average speed during its journey [1]

d the car's greatest speed during its journey [1]

e the amount of time the car spent travelling at the speed you calculated in **d** [1]

f the distance it travelled at this speed. [1]

4 A physical quantity can be described as either 'scalar' or 'vector'.

a State the difference between a *scalar quantity* and a *vector quantity*. [2]

b Define *displacement*. [1]

A light aircraft flies due east at 80 km h^{-1} for 1.5 h. It then flies due north at 90 km h^{-1} for 0.8 h.

c Calculate the distance travelled by the aircraft in each stage of its journey. [2]

d Draw a scale diagram to represent the aircraft's journey. [2]

e Use your diagram to determine the aircraft's final displacement relative to its starting point. [2]