Introduction

In this topic students define speed and calculate it using measurements of distance and time. The concept of speed is used in Section 3 when students learn about wave motion. They plot and interpret graphs of motion (speed–time and distance–time graphs). They learn about acceleration as rate of change of speed. This is essential knowledge for study of Newton's second law in Topic 1.5 *Forces*. They learn about the acceleration of free fall near to the Earth.

Links to other topics

Sections	Essential background knowledge	Useful links
1 General physics	1.1 Length and time	1.3 Mass and weight
		1.4 Density
		1.5 Forces
		1.6 Momentum
		1.7 Energy, work and power
		1.8 Pressure
3 Properties of waves		3.1 General wave properties

Topic overview

P1.2a	**Speed and graphs of motion**
	In this activity students learn how to calculate speed using speed = distance/time. They learn about using graphs to describe motion and carry out a practical activity to draw a distance–time graph.
P1.2b	**Acceleration**
	In this activity students learn about acceleration. They learn how to find distance travelled using a velocity–time graph. They carry out a practical activity to measure acceleration.
P1.2c	**Falling objects**
	In this activity students learn about falling objects. There are two suggested practicals in this activity.
P1.2d	**Consolidation and summary**
	This activity provides an opportunity for a quick recap on the ideas encountered in the topic as well as time for the students to answer the End of topic questions in the Student Book.

Activity P1.2a Speed and graphs of motion

Learning objectives

- Know how to define speed and calculate average speed from total distance/total time.
- **Extended** Be able to distinguish between speed and velocity.
- Be able to plot and interpret a speed–time graph or a distance–time graph.
- Know how to recognise from the shape of a speed–time graph when a body is at rest, moving with constant speed or moving with changing speed.

Learning outcomes

- How to define speed and calculate speed from total distance–total time.
- How to plot and interpret a speed–time graph or a distance–time graph.
- How to recognise from the shape of a speed–time graph when a body is:
  - at rest
  - moving with constant speed
  - moving with changing speed.
- **Extended** Be able to distinguish between speed and velocity.

Common misconceptions

Lower-ability students may need to be shown how to follow the line of a distance–time graph from left to right in real time, being aware of the variable plotted on the vertical axis.

Extended Make sure that students know that speed is not associated with a direction, but velocity is.

Resources

Student Book pages 17–20

Worksheet P1.2a.1 Distance–time data

Worksheet P1.2a.2 Distance–time graphs

Files on CD–ROM: P1.2a.1_worksheet; P1.2a.2_worksheet; P1.2a.1_tech_notes

Resources for class practicals (see Technician's notes, following)

Approach

Introduce the activity

Note for the teacher: distance measured from a fixed point is called displacement. Average velocity is total displacement divided by total time taken, so that the average velocity for a journey which starts and ends at the same point must be zero as the total displacement is zero. The gradient of the displacement time graph provides the velocity because the gradient can be positive or negative depending on which way the object is moving. The gradient of a distance time graph only gives the speed because the gradient of a distance time graph can only be positive. Total distance for a journey can only increase, it can never decrease.

Ask the students what they understand by the word *speed*. Where do they come across this concept in everyday life? Draw a large set of labelled distance–time axes on the board. Don't bother to put scales on the axes. Ask a student to describe their journey from home to school that morning. Sketch a graph on the axes to summarise the journey.

Develop the activity

Introduce the equation relating speed, distance and time. Study the worked examples on pages 17–18 of the Student Book by setting students the problem to attempt in pairs (without the solution). After a given time, bring the class back together to compare students' solutions with the given answer.

Extended Students need to be aware of the difference between speed and velocity. Use page 18 of the Student Book to help with this.

Move on to discuss how graphs can be used to describe motion. The practical on Worksheet P1.2a.1 could be carried out at this point. Students will line up along a long corridor, playing field, quadrangle or hall.

Each pair of students will have a stopclock and will work out their distance from the start of the line.

At a signal from you, all students start their clocks together.

They note the times at which you are in front of them.

You should start from 0 m and walk–run–stand along the line for about a minute.

After the practical is complete, a computer and data projector will simplify data sharing so that students can draw the distance–time graph. They can plot the points for their own graph as they are entered – they do not need to wait until all of the data have been entered.

Students can attempt Worksheet P1.2a.2 after they have completed the practical activity. Note that the tasks on the worksheet become progressively more demanding. In task 3, students may need some guidance about how to calculate the speed from the graph.

Finish the activity

Sketch a distance–time graph on the board and challenge a student to act out the journey that it represents. Allow their peers to criticise/approve the student's interpretation. Repeat as time permits.

Students should answer the questions on page 20 of the Student Book.

Technician's notes

Be sure to check the latest safety notes on these resources before proceeding.

The following resources are needed for the class practical P1.2a.1:

The activity will need to take place in a long corridor, hall, playing field or quadrangle.

stopclock for each pair of students
metre rule for each pair
data projector
computer running Excel spreadsheet
graph paper

Answers

Pages 18−19

1. a) The cars move along the road in the same direction, a constant distance apart.

   b) If they are moving towards each other, they will collide head on. If they are moving apart, they will continue to move apart.

   c) The cars will move along the road a constant distance apart and both in the opposite direction to a).

2. The average velocity for the journey is zero because the person ends up back at the start point meaning that the total distance travelled from the start point is zero, so that the average velocity is zero. Note that the average speed is not zero.

3. 10 000/15 × 60 = 10 000/900 = 11.1 m/s

4. 1.5 × 15 = 22.5 m

5. 3000 s = 50 minutes

Page 20

1. If the distance is measured from a fixed point then the line will have a positive gradient for moving away, and a negative gradient for moving towards.

2. A graph will have axes that are labelled properly with a scale, plotted data points and the best line. A sketch graph is drawn to illustrate the main shape of the line. Only key values, such as where the line changes direction, will be given on the axes.

3. Note that a graph of distance against time can only increase with time. The average speed for a journey can then be worked out from the total distance divided by the time taken. Distance from a fixed point is called displacement and if this is plotted against time it is possible to know which way the object is moving. The gradient of the displacement time graph gives the velocity and the total displacement divided by time taken gives the average velocity.

Your graph is likely to be a curve, as shown in Fig. 1.9 for the first 20 seconds.

4. a) 16 m/40 s = 0.4 m/s   b) 16 m/30 s = 0.5 m/s   c) 0 m/s

Worksheet P1.2a.2

1. A –setting off, B – walking, C – short stop, D – long stop, E – running, F – strolling and G – arriving back.

2.a)

b)

c)
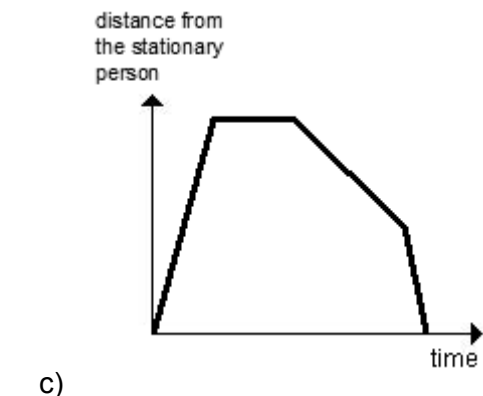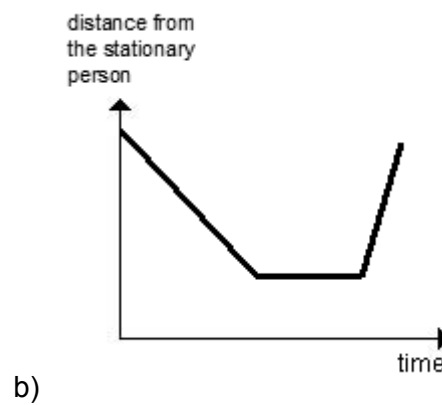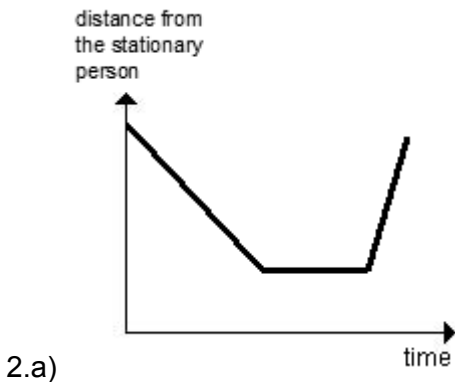
3. a) 80 km/h   b) 60 km/h   c) 130 km/h   d) 0 km/h   e) 300/5 = 60 km/h.

P1.2a.1 Distance–time data

Apparatus

stopclock

metre rule

notepad

pencil

Method

1. Stand in a line with your partner.

2. Find out what number you are in the line. The first person is 0, the next is 1, and so on.

3. Use the metre rule to make sure that you are 2.0 m away from the people on either side.

4. Work out your distance from the start of the line.

5. When the teacher gives the sign, start your stopclock.

6. Dictate the time to the nearest second to your partner each time that the teacher is in front of you.

Handling experimental observations and data

7. Share your data with the rest of the group.

8. Use the data to draw a distance–time graph for the teacher.

9. Use the graph to write about the teacher's journey.

P1.2a.2 Distance–time graphs

1. This graph is for a journey made to the shops and back.
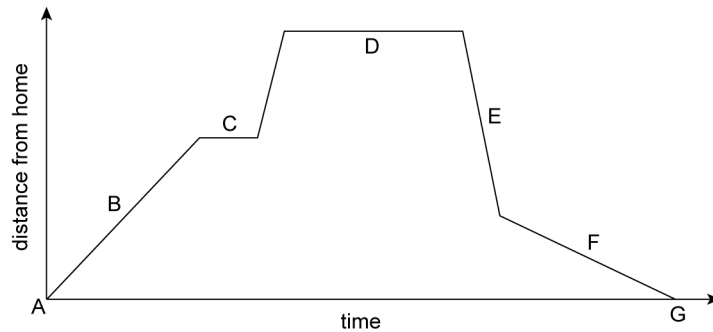
Describe what is happening at each of the letters on the graph.

2. Here are some descriptions of journeys. Sketch a distance–time graph for each journey. Assume that the distance is measured from the person who doesn't move.

   a) Alice stands next to Bill for a while. She then walks away from him, pauses and then runs back again.

   b) Carla starts off a long way from Dave. She walks towards him. When she gets halfway, she stops and then runs back to where she started.

   c) Erica starts off next to Faisal. She runs away immediately. After a short stop to catch her breath she slowly walks back, but halfway there, she runs back to him.

3. Here is the distance–time graph for a car journey.
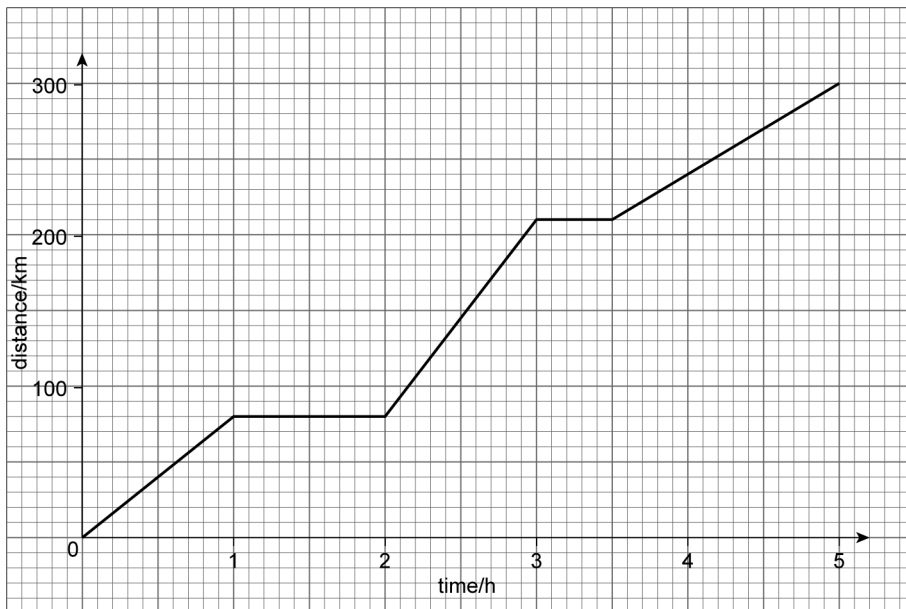
Use it to calculate:

   a) the speed for the first hour

   b) the speed for the last hour

   c) the greatest speed

   d) the lowest speed

   e) the average speed of the car for the whole journey.

Activity P1.2b Acceleration

Learning objectives

- Calculate the area under a speed–time graph to work out the distance travelled for motion with constant acceleration.
- Understand that acceleration and deceleration are related to changing speed, including qualitative analysis of the gradient of a speed–time graph.
- **Extended** Define and calculate acceleration using change of velocity/time.
- **Extended** Calculate speed from the gradient of a speed–time graph.
- **Extended** Calculate acceleration from the gradient of a speed–time graph.
- **Extended** Know how to recognise linear motion for which the acceleration is constant and calculate the acceleration.
- **Extended** Know how to recognise motion for which the acceleration is not constant.
- **Extended** Understand deceleration as a negative acceleration.

Learning outcomes

- Be able to work out the distance travelled from a speed–time graph by calculating the area under the speed–time graph for motion with constant acceleration.
- Demonstrate understanding that acceleration is related to changing speed and know how to analyse speed–time graphs.
- **Extended** Be able to define and calculate acceleration using change of velocity/time.
- **Extended** Be able to calculate speed from the gradient of a speed–time graph.
- **Extended** Be able to calculate acceleration from the gradient of a speed–time graph.
- **Extended** Be able to recognise linear motion for which the acceleration is constant and calculate the acceleration.
- **Extended** Be able to recognise motion for which the acceleration is not constant.
- **Extended** Know that deceleration is a negative acceleration.

Common misconceptions

This may be students' first introduction to a vector quantity – one that has both a value and a direction – so it is worth making sure that they understand that the positive direction must always be defined for vectors in one dimension.

Students may need reminding that the beam of infra-red light passing through a light gate is invisible.

Resources

Student Book pages 20–26

Worksheet P1.2b.1 Finding the speed of a moving object

Worksheet P1.2b.2 Acceleration calculations

Files on CD–ROM: P1.2b.1_worksheet; P1.2b.2_worksheet; P1.2b_tech_notes

Resources for demonstration and class practical (see Technician's notes, following)

Approach

Introduce the activity

Talk about a car's speedometer reading 50 km/h and then a few seconds later it displays 70 km/h, and explain that this means the car has *accelerated*. Demonstrate the use of a light gate to measure the speed of a small object passing through it, such as a book.

Ask students to calculate the speed of the book from its length and the time recorded by the software. If a data projector is used, you could also teach the class how to use the software. Do not show them how to use the software to calculate speed.

Stand on a stepladder and hold a white golf ball in the air. Release it. Ask students to describe its motion as it falls, bounces and rises back towards your hand. Help them along with the ideas of acceleration and positive and negative velocities.

Develop the activity

Discuss the section 'What is acceleration?' on page 20 of the Student Book.

`Extended` Students should try the worked example on page 21 of the Student Book, without the solution, and then compare their answers to the given solution and discuss any differences. The questions at the top of page 22 give further practice.

Students can then carry out the practical on Worksheet P1.2b.1 in small groups. Although the light gate software can calculate a value for *v* directly, it is good for the students to do this themselves.

SAFETY INFORMATION: If this experiment is carried out on a bench or desk, beware of a trolley running off the end of the slope onto the floor or someone's foot!

The next part of the activity focuses on velocity–time graphs. Discuss the section on pages 22–23 of the Student Book before students answer the questions on page 24. Make sure that they understand how to find distance from a velocity–time graph and then ask them to complete Worksheet P1.2b.2.

The questions in the Developing investigative skills box could be done by students working in pairs. Discussion of the questions is a useful learning tool.

Finish the activity

Stand on a chair and drop a golf ball towards the floor. Ask students to sketch velocity–time graphs for the ball as it falls. Once they have all done a sketch, you could show them again and ask them to draw an acceleration–time graph (constant negative value with a positive spike where it hits the floor, if up is positive).

Run a short test to see if students can recall the meanings and units of the symbols *u*, *v*, *a* and *t* and the acceleration equation itself.

Technician's notes

Be sure to check the latest safety notes on these resources before proceeding.

The following resources are needed for the acceleration demonstration:

light gate, computer running associated software (to record time object takes to pass through the light gate) and data projector (if available)
book
stepladder
golf ball

The following resources are needed for the class practical P1.2b.1, per group:

track and trolley
clamp , sticky tape, card, 30 cm ruler and stopclock
light gate and block
computer

Answers

Page 22, top

1. 10 m/s^2 2. –15 m/s^2

Page 22, bottom

1. a) athlete: 8 m/s; fun runner: 6.25 m/s   b) athlete: horizontal line at 8 m/s, starting at 0 s and finishing at 50 s; fun runner: horizontal line at 6.25 m/s, starting at 0 s and finishing at 64 s

Page 24

1. The acceleration is the gradient of the graph.

2. The distance travelled is the area under the graph.

3. a) athlete A: 8 m/s; athlete B: 6.25 m/s   b) athlete A: horizontal line at 8 m/s, starting at 0 s and finishing at 50 s; fun runner: horizontal line at 6.25 m/s, starting at 0 s and finishing at 64 s

4. The area under the speed–time graph is the same, i.e. 8 m/s $\times$ 50 s = 6.25 m/s $\times$ 64 s.

5. 45 m

Developing Investigative Skills, page 26

1. Extra friction provided by pulling the tape along/through the ticker timer would reduce the acceleration (and the trolley may reach a constant speed if the drag was enough to balance the force pulling the trolley down the slope).

2. An alternative approach could be to video the trolley rolling down the ramp and then measure the position frame by frame on playback. This would need a scale to be attached alongside the ramp for measurements. Using light gates would be more difficult, as a lot would be needed if the motion of the trolley was to be studied all the way down the ramp.

3. Table completed with student's results.   4. Graph starts at the origin and curves upwards, indicating an increase in speed as the trolley moved down the ramp.

5. Table completed.   6. Graph starts at the origin and provides a (reasonably) straight line indicating a (reasonably) steady increase in speed.

7. The data point for 0.6 s looks to be incorrectly calculated as it is significantly above the pattern of the other points on the speed–time graph.

8. If yes – would allow averages to be taken, ironing out some of the random friction effects of pulling the tape through. If no – not possible to repeat exactly as the friction from the tape/path of the trolley would be slightly different each time.

Worksheet P1.2b.2

1. a) +5 m/s^2 b) –4 m/s^2 c) +5 m/s^2 d) +10 m/s^2
2. a) 75 m   b) +0.5 m/s^2 c) 268.75 m   d) back the way she came   e) 187.5 m   f) 0.5 s
g) –10 m/s.

P1.2b.1 Finding the speed of a moving object

You are going to find the speed of a moving object and then calculate its acceleration.

Apparatus

track

block

trolley

light gate, computer, card, ruler, clamp and sticky tape (OR ticker tape and ticker timer)

stopclock

SAFETY INFORMATION

If this experiment is carried out on a bench or desk, beware of a trolley running off the end of the slope onto the floor or someone's foot!

Method

1. Place the track on the bench with the block under one end so that it slopes gently.

2. Place the trolley on the track and fasten the length of card to the top.

3. Clamp the light gate near the lower end of the track, such that the card breaks the infra-red light beam when the trolley passes by.

4. Set up the software so that it measures the time it takes the card to pass through the light gate. Measure the length of the card.

5. Place the trolley at the top of the track. Release it, starting the stopclock at the same time.

6. Stop the clock when the card is halfway through the light gate. Write the value for the acceleration time into the results table below.

7. Use the time for the light gate and the length of the card to calculate a value for the final velocity v of the trolley.

8. The initial velocity u of the trolley is zero. Calculate the acceleration a of the trolley from the values of u, v and t (the stopclock reading).

9. Repeat steps 5 to 8 three times.

Handling experimental observations and data

10. Record your results in a table like the one below.

11. Calculate an average value for the acceleration.

| Length of card/m	Light gate time/s	Final velocity/m/s	Acceleration time/s	Acceleration/m/s^2
			Average value	

P1.2b.2 Acceleration calculations

1. All of these questions assume that objects moving to the right have a positive velocity. Calculate the average acceleration of each these objects. Don't forget to include its sign (+ or –) as well as its value.

   a) A car moves to the right from rest, reaching a speed of 40 m/s in a time of 8 s.

   b) An athlete starts from rest and after 2.5 s is moving to the left with a speed of 10 m/s.

   c) An airplane touches the landing strip at a speed of 60 m/s to the right. It comes to a stop 12 s later.

   d) A snooker ball rolls to the left at a speed of 5 m/s, to be hit by the table edge for a time of 0.2 s, leaving it rolling to the right at a speed of 3 m/s.

2. The graph is for a motorcyclist on a long straight track. The motorcyclist starts moving at 0 s.

Use data from the graph to answer these questions.

   a) How far did the motorcyclist move between 0 s and 10 s?

   b) What was her acceleration between 10 s and 20 s?

   c) How far did she move altogether before she stopped for a rest at 30 s?

   d) Which way was she moving from 35 s onwards?

   e) How far was she from the starting point at 50 s?

   f) Her acceleration at 35 s was –25 m/s^2. For how long did she accelerate?

   g) At 50 s she applies the brakes for 0.5 s. If the brakes provide an acceleration of +5 m/s^2, what is her velocity when the brakes are released?
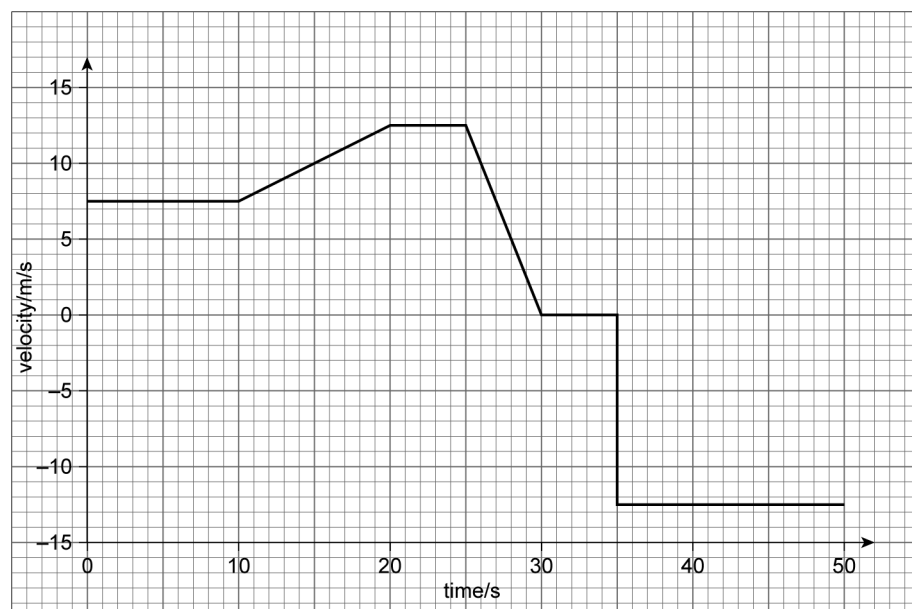
Activity P1.2c Falling objects

Learning objectives

* State that the acceleration of free fall for a body near to the Earth is constant.
* Extended Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity).

Learning outcomes

* Know that the acceleration of free fall for a body near to the Earth is constant.
* Extended Be able to describe the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity).

Common misconceptions

Students expect falling objects to speed up as they drop, so they are always surprised to come across objects that appear to float down at a steady speed. Friction due to air resistance is a difficult concept for many students to accept because air is so insubstantial.

Students also find it hard to believe that weight is independent of velocity. They may insist that things reach a terminal velocity because they are moving fast enough to switch off gravity.

Resources

Student Book pages 27–29

Worksheet P1.2c.1 Falling cupcake cases 1

Worksheet P1.2c.2 Falling cupcake cases 2

Files on CD–ROM: P1.2c.1_worksheet; P1.2c.2_worksheet; P1.2c.1_tech_notes

Resources for demonstration and class practicals (see Technician's notes, following)

Approach

Introduce the activity

Demonstrate the steady fall of a cupcake case. Then crumple it into a ball and let students try to explain why this makes such a difference to the way it falls.

Space students around the room. Give each student a piece of A4 paper. Show them how to fold it into a fan and tell them to fan themselves vigorously. Draw their attention to the increase of effort required to move the fan more quickly. Introduce the idea of air resistance.

Develop the activity

Discuss the text on page 27 of the Student Book.

Extended Make sure that students can describe the motion of a falling skydiver.

Students can then try the first of the two practicals on Worksheet P1.2c.1 in pairs. The practical requires good hand–eye coordination from the student who does the timing.

Extended Students can then work on the Developing investigative skills box. As in the previous activity, this can be done in pairs.

Students can then answer the questions on page 29 of the Student Book. Higher-ability students can also try the Extended question on page 29 and go on to the second experiment on worksheet 1.2c2.

Finish the activity

If students have done the second practical on Worksheet P1.2c.2, you could ask each group to read out their evaluation for constructive criticism by their peers.

Students should work in pairs to produce a summary of the main points of the activity in a form of their choice.

Technician's notes

Be sure to check the latest safety notes on these resources before proceeding.

The following resources are needed for class demonstrations:

paper cupcake cases
A4 sheets of paper to make paper fans

The following resources are needed for class practicals P1.2c.1 and P1.2c.2, per group:

three 1 metre rules for Worksheet P1.2c.1, one 1 metre rule for P1.2c.2
clamp, stand, bos and stopclock
paper cupcake cases

The size of the case is not very important. Larger ones are easier for less dexterous students to handle.

Cases that are not unfolded by students can be reused.

Answers

Developing Investigative Skills, page 28

1. The experiment only takes a matter of seconds. Watching the ball, observing its position (preferably by keeping your eyeline level with the ball to avoid parallax errors), looking at the clock, noting down the times and then refocusing on the ball would be very difficult for one person to do.

2. The students should use the same ball for repeat measurements. They should also keep the temperature of the wallpaper paste constant, as changes in viscosity will affect the terminal velocity.

3. Graph drawn. Should be a smooth curve, beginning at the origin and flattening off at terminal velocity of 6.4 cm/s.

4. Should indicate the point where the line just becomes flat.

5. If the paste is not too dark in colour, it might be possible to set a series of light gates at specific points alongside the tube to do the timing and/or calculate speeds. Also, could record on video and measure off frame-by-frame playback (taking care not to introduce parallax errors through the fixed position of the camera).

Page 29

1. The velocity that an object, such as a skydiver, has when the forces are balanced so that the object travels at a maximum constant speed.

2. 10 m/s   3. 15 N upwards

4. 585 N downwards

5. a) Velocity   b) Acceleration The velocity graph decreases from initial zero until it reaches a constant value, which is the terminal velocity. The force graph includes the constant weight (the drag), which increases with time and then becomes constant; and the resultant, which is found by adding the weight and the drag. The acceleration graph increases initially and then reaches zero because the velocity has reached terminal velocity, which is not changing, so there is no acceleration.

P1.2c.1 Falling cupcake cases 1

Apparatus

metre rules

clamp, stand and boss

stopclock

paper cupcake case

Method

Work in pairs for this practical.

1. Clamp the metre rule so that it is upright, with one end on the ground.

2. Hold the cupcake case with its base 0.50 m above the ground.

3. Release the case and start the clock at the same time.

4. Stop the clock when the case hits the ground.

5. Repeat the process twice more to check the repeatability of your results.

6. Repeat steps 3 to 5 for heights of 1.00 m, 1.50 m, 2.00 m and 2.50 m above the ground.
You will need to put the clamp stand on the bench for some of these.
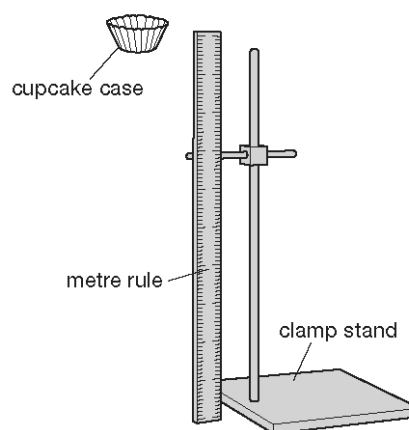
7. Enter your results into a table like this one.

Height/m	Time of fall/s			Average time/s	Average speed/m/s
0.50					
1.00					
1.50					
2.00					
2.50					

Handling experimental observations and data

8. Use your results to plot a graph showing how the average speed depends on how long the case has been falling.

9. Try to explain the shape of the graph.

Planning and evaluating investigations

10. Why was it important to know the height of the case above the ground at the start?

11. Did the same person release the case and start the clock each time? Does this matter?

P1.2c.2 Falling cupcake cases 2

Apparatus

metre rule

clamp, stand and boss

stopclock

paper cupcake cases

Method

1. Clamp the metre rule so that it is upright, with one end on the ground.

2. Hold the cupcake case with its base 1.00 m above the ground.

3. Release the case and start the clock at the same time.

4. Stop the clock when the case hits the ground.

5. Repeat the process twice more to establish the reliability of your results.

6. Repeat steps 2 to 5 for two, three, four and five cases nested in each other.

7. Enter your results into a table like this one.
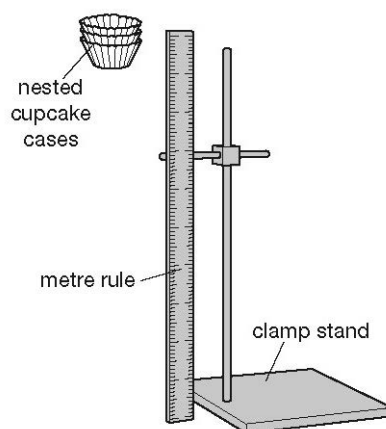
Handling experimental observations and data

Number of cases	Time of fall/s			Average time/s	Average speed/m/s
1					
2					
3					
4					
5					

8. Use your results to plot a graph showing how the average speed depends on the number of cases.

9. Does your graph agree with your hypothesis?

Planning and evaluating investigations

10. Why do your results give an average speed?

11. How could you check your results?

Activity P1.2d Consolidation and summary

Learning objectives

- To review the learning points of the topic.
- To test understanding through answering questions.

Learning outcomes

- Be familiar with the knowledge and understanding summarised in the End of Topic Checklist.
- Be able to apply this knowledge and understanding by answering End of Topic Questions in the Student Book.

Resources

Student Book pages 30–32

Approach

Introduce the activity

Ask students to work with a partner to make a list of key words from this topic. They could then work together to produce a spider diagram showing how the different concepts are linked. They could compare their list with the list of key words given on page 30 of the Student Book. Discuss the Checklist on page 30 and ask questions to find out how much of the content students are comfortable with.

Develop the activity

Ask students to work individually through the End of topic questions on pages 31–32 of the Student Book without looking at the text. As they work, walk around the classroom observing their answers and questioning them as necessary to find out which questions are causing difficulties.

In question 7, students need to work out the total distance by adding the 200 m and the 160 m together. Work out the total time by adding up the time for each section – they may forget to include the time waiting at the junction.

It may be helpful to discuss with students how to tackle question 10. In this sort of question, the first thing to do is to decide which forces will be acting on the object. The next thing is to decide whether the forces are balanced or unbalanced. If they are unbalanced the skydiver will be either accelerating or decelerating. If they are balanced the skydiver will either be travelling at constant speed or not moving. In stage 2 the skydiver will have reached the terminal velocity and because the forces are balanced will not accelerate or decelerate.

Bring the activity together

After a set period, ask the students to stop working and discuss any areas of difficulty you observed as you walked round the class. Students should complete any unanswered questions for homework, but you should stress that they should attempt the questions without looking at the text, so that they can see how much they have remembered.

Answers

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	0.36 km/minute	1 mark
2 a)	5 m/s	1 mark
2 b)	–6 m/s	1 mark
	+4 m/s	1 mark
3	1.25 m/s^2	1 mark
4 a)	10 km/h per second	1 mark
4 b)	2.78 m/s^2	1 mark
5 a)	That something is stationary.	1 mark
	The distance does not change as time increases.	1 mark
5 b)	A straight line.	1 mark
	Positive gradient for moving away, negative gradient for moving towards.	1 mark
6 a)	Speed describes how far an object travels in a unit of time.	1 mark
	Velocity is numerically identical to speed, but it also includes a statement of the direction of the travel.	1 mark
6 b)	The sign of a velocity indicates a direction.	1 mark
	'Positive' and 'negative' velocities are in opposite directions to each other.	1 mark
	(We still need to explain which direction we are taking to be positive – this will change depending on the motion we are studying. For example, if we are looking at the motion of objects acting under the force of gravity, we might say upwards is the positive direction, so that downwards becomes the negative direction.)	
6 c)	acceleration = (change in velocity)/(time taken)	1 mark
	= rate of change of velocity.	1 mark
6 d)	deceleration, or retardation	1 mark
6 e)	Work out the total area	1 mark
	under the line on the graph,	1 mark
	multiplying distance by time.	1 mark
7 a)	speed = distance/time	1 mark
	= 200 m/20 s	1 mark
	= 10 m/s	1 mark
7 b)	distance = speed × time	1 mark
	= 8 m/s × 20 s	
	= 160 m	1 mark

Question	Correct answer	Marks
7 c)	average speed = total distance/total time	1 mark
	= 360 m/50 s	
	= 7.2 m/s	1 mark
8 a)	The speed remained constant.	1 mark
	If the line on a distance–time graph has a constant gradient, then the speed is constant.	1 mark
8 b)	Read off the graph: after 20 s the car had travelled 200 m;	1 mark
	after 60 s it had travelled 800 m;	1 mark
	so the distance travelled is: 800 – 200 = 600 m.	1 mark
8 c)	speed = distance/time	1 mark
	v = 600/40	1 mark
	= 15 m/s	1 mark
8 d)	It stopped.	1 mark
	The line is horizontal during this time, indicating that the car was not moving (no distance was travelled).	1 mark
9 a)	total distance = area under the line	1 mark
	= ($\frac{1}{2}$ × 1.5 × 3.0)	1 mark
	= 2.25 m (Note: the tractor showed constant acceleration from A to B and then constant deceleration from B to C.)	1 mark
9 b)	1.5/0.75 = 2 m/s^2	1 mark
9 c)	1.5/3 – 0.75 = $\frac{1}{2}$ m/s^2	1 mark
10 a)	Stage 1 – the skydiver is accelerating.	1 mark
	The downward weight is greater than the upward force caused by air resistance.	1 mark
	Stage 2 – the skydiver is travelling at constant speed.	1 mark
	The weight and air resistance are balanced.	1 mark
	Stage 3 – the skydiver is slowing down.	1 mark
	The force caused by the air resistance is greater than the weight.	1 mark
	Stage 4 – the skydiver is travelling at a constant speed.	1 mark
	The forces are balanced again.	1 mark
	Stage 5 – the skydiver is stationary on the ground.	1 mark
	The forces are balanced.	1 mark
10 b)	The weight is balanced	1 mark
	by the upward force of the ground on the skydiver.	1 mark
	Total:	55 marks