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David Sang

# Cambridge IGCSE®
# Combined and Co-ordinated Sciences
## Physics Workbook



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David Sang

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# Combined and Co-ordinated Sciences

## Physics Workbook

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# Contents

# Introduction

This workbook covers two syllabuses: Cambridge IGCSE Combined Science (0653) and Cambridge IGCSE Co-ordinated Sciences (0654). Before you start using this workbook, check with your teacher which syllabus you are studying and which papers you will take. You will sit either the Core paper or the Extended paper for your syllabus. If you are sitting the Extended paper, you will study the Core material and the Supplement material for your syllabus.

Once you know which paper you will be sitting, you can use the exercises in this workbook to help develop the skills you need and prepare for your examination.

The examination tests three different Assessment Objectives, or AOs for short. These are:

**AO1** Knowledge with understanding

**AO2** Handling information and problem solving

**AO3** Experimental skills and investigations.

In the examination, about 50% of the marks are for AO1, 30% for AO2 and 20% for AO3. Just learning your work and remembering it is therefore not enough to make sure that you get the best possible grade in the exam. Half of all the marks are for AO2 and AO3. You need to be able to use what you've learned in unfamiliar contexts (AO2) and to demonstrate your experimental skills (AO3).

There are lots of activities in your coursebook which will help you to develop your experimental skills by doing practical work. This workbook contains exercises to help you to develop AO2 and AO3 further. There are some questions that just involve remembering things you have been taught (AO1), but most of the questions require you to use what you've learned to work out, for example, what a set of data means, or to suggest how an experiment might be improved.

These exercises are not intended to be exactly like the questions you will get on your exam papers. This is because they are meant to help you to develop your skills, rather than testing you on them.

There's an introduction at the start of each exercise that tells you the purpose of it – which skills you will be working with as you answer the questions.

There are sidebars in the margins of the book to show which material relates to each syllabus and paper. If there is no sidebar, it means that everyone will study this material.

Use this table to ensure that you study the right material for your syllabus and paper:

| Cambridge IGCSE Combined Science (0653) | | Cambridge IGCSE Co-ordinated Sciences (0654) | |
|---|---|---|---|
| **Core** | **Supplement** | **Core** | **Supplement** |
| *You will study the material:*<br>Without a sidebar | *You will study the material:*<br>Without a sidebar<br>With a double grey sidebar<br>With a double black sidebar | *You will study the material:*<br>Without a sidebar<br>With a single grey sidebar<br>With a double grey sidebar | *You will study* ***everything****.*<br>*This includes the material:*<br>Without a sidebar<br>With a single grey sidebar<br>With a double grey sidebar<br>With a single black sidebar<br>With a double black sidebar |

## Safety

A few practical exercises have been included. These could be carried out at home using simple materials that you are likely to have available to you. (There are many more practical activities on the CD-ROM that accompanies your coursebook.)

While carrying out such experiments, it is your responsibility to think about your own safety, and the safety of others. If you work sensibly and assess any risks before starting, you should come to no harm. If you are in doubt, discuss what you are going to do with your teacher before you start.

# Chapter P1
# Making measurements

**KEY TERMS**

**density:** the ratio of mass to volume for a substance

**USEFUL EQUATIONS**

$$\textbf{density} = \frac{\textbf{mass}}{\textbf{volume}}$$

## Exercise P1.01 The SI system of units

**To be part of the international community of scientists, you need to use the SI units (Le Système International d'Unités).**

**a** Give the SI units (name and symbol) of the following quantities:

length

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volume

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**b** Give the name in words and the symbol for the following:

one thousand metres

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one-thousandth of a metre

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**c** How many

centimetres are there in a metre? ..........................

litres are there in a cubic metre? ..........................

**d** List as many non-SI units of length as you can.

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**e** Give a reason why it is important for scientists to have a system of units that is agreed between all countries.

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**f** Name some more professions that make use of the SI system of units.

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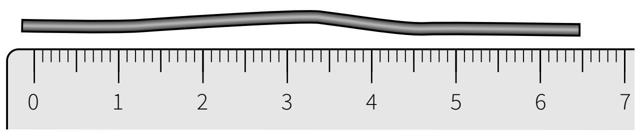
## Exercise P1.02 Accurate measurements

**To measure a length accurately, it is essential to have a careful technique. This exercise will test your ability to measure lengths.**

**a** The diagram shows how a student attempted to measure the length of a piece of wire.




From the diagram, estimate the length of the wire. ..........................

State **three** ways in which the student could have improved his technique for measuring the wire.

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**b** Find a rectangular sheet of paper, at least as big as the pages of this book. A sheet of newspaper is ideal.

Your task is to use a ruler to measure three lengths: the short side, the long side and the diagonal.

For lengths that are longer than your ruler, you will need to devise a careful technique.

**c** Describe the method you have used for measuring the length of the diagonal. It may help to include a diagram.

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**d** Record your results (in centimetres) in Table 1.01.

| Measurement | Length / cm | Length$^2$ / cm$^2$ |
|---|---|---|
| short side | | |
| long side | | |
| diagonal | | |

**Table 1.01**

**e** Now you can use Pythagoras' theorem to test your results. In the third column of the table, calculate and write down the square of each length.

Then calculate:

(short side)$^2$ + (long side)$^2$ = .........................

This should be equal to (diagonal)$^2$.

**f** Round off your values to the nearest cm$^2$. How close are your two answers? Write a comment below.

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## Exercise P1.03 Density data

**This exercise presents some data for you to interpret and use.**

Some data about the density of various solids and liquids are shown in Table 1.02.

| Material | State / type | Density / kg/m$^3$ | Density / g/cm$^3$ |
|---|---|---|---|
| water | liquid / non-metal | 1000 | 1.000 |
| ethanol | liquid / non-metal | 800 | 0.800 |
| olive oil | liquid / non-metal | 920 | |
| mercury | liquid / metal | 13 500 | |
| ice | solid / non-metal | 920 | |
| diamond | solid / non-metal | 3500 | |
| cork | solid / non-metal | 250 | |
| chalk | solid / non-metal | 2700 | |
| iron | solid / metal | 7900 | |
| tungsten | solid / metal | 19 300 | |
| aluminium | solid / metal | 2700 | |
| gold | solid / metal | 19 300 | |

**Table 1.02**

Two units are used for the densities, kg/m$^3$ and g/cm$^3$.

**a** Complete the fourth column by converting each density in kg/m$^3$ to the equivalent value in g/cm$^3$. The first two have been done for you.

**b** Ice floats on water because its density is less than that of water. Name another solid material shown in the table which will float in water.

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**c** A cook mixes equal volumes of water and olive oil in a jar. The two liquids separate. Complete the drawing of the jar to show how the liquids will appear. Label them.



**d** A student wrote: “These data show that metals are denser than non-metals.” Do you agree? Explain your answer.

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**e** Calculate the mass of a block of gold that measures 20 cm × 15 cm × 10 cm. Give your answer in kg.

**f** A metalworker finds a block of silvery metal. He weighs it and he measures its volume. Here are his results:

mass of block = 0.270 kg

volume of block = 14.0 $cm^3$

Calculate the density of the block.

Suggest what metal this might be. ..........................

## Exercise P1.04 Testing your body clock

**How good would your pulse be as a means of measuring time intervals?**

Galileo used the regular pulse of his heart as a means of measuring intervals of time until he noticed that a swinging pendulum was more reliable.

In this exercise, you need to be able to measure the pulse in your wrist. Place two fingers of one hand gently on the inside of the opposite wrist. Press gently at different points until you find the pulse. (Alternatively, press two fingers gently under your jawbone on either side of your neck.)

You will also need a clock or watch that will allow you to measure intervals of time in seconds.

**a** Start by timing 10 pulses. (Remember to start counting from zero: 0, 1, 2, 3, …, 9, 10.) Repeat this several times and record your results in a table in the space provided.

**b** Comment on your results. How much do they vary? Is the problem that it is difficult to time them, or is your heart rate varying?

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**c** Use your results to calculate the average time for one pulse.

**d** Repeat the above, but now count 50 pulses. Record your results in a table in the space provided. Calculate the average time for one pulse.



**e** Now investigate how your pulse changes if you take some gentle exercise – for example, by walking briskly, or by walking up and down stairs.

Write up your investigation in the lined space. Use the following as a guide.

- Briefly describe your gentle exercise.
- Give the measurements of pulse rate that you have made.
- Comment on whether you agree with Galileo that a pendulum is a better time-measuring instrument than your pulse.

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# Chapter P2
# Describing motion

**KEY TERMS**

**speed:** the distance travelled by an object in unit time

**acceleration:** the rate of change of an object's velocity

**USEFUL EQUATIONS**

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time taken}}$$

**speed = gradient of distance–time graph**

**acceleration = gradient of speed–time graph**

**distance = area under speed–time graph**

## Exercise P2.01 Measuring speed

**This exercise is about how we can measure the speed of a moving object.**

**a** One way to find the speed of an object is to measure the time it takes to travel a measured distance. Table 2.01 shows the three quantities involved.

Complete the table as follows:

- In the second column, give the SI unit for each quantity (name and symbol).
- In the third column, give some other, non-SI, units for these quantities.
- In the fourth column, name suitable measuring instruments for distance and time.

| Quantity | SI unit (name and symbol) | Non-SI units | Measuring instrument |
|---|---|---|---|
| distance | | | |
| time | | | |
| speed | | | |

**Table 2.01**

**b** In the laboratory, the speed of a moving trolley can be found using two light gates. A timer measures the time taken for a trolley to travel from one light gate to the other.

What other quantity must be measured to determine the trolley's speed?

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Write down the equation used to calculate the speed of the trolley

A trolley takes 0.80 s to travel between two light gates, which are separated by 2.24 m. Calculate its average speed.

**c** The speed of moving vehicles is sometimes measured using detectors buried in the road. The two detectors are about 1 m apart. As a vehicle passes over the first detector, an electronic timer starts. As it passes over the second detector, the timer stops.

Explain how the vehicle's speed can then be calculated.

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On one stretch of road, any vehicle travelling faster than 25 m/s is breaking the speed limit. The detectors are placed 1.2 m apart. Calculate the speed of a car that takes 0.050 s to travel this distance. Is it breaking the speed limit?

Calculate the shortest time that a car can take to cross the detectors if it is not to break the speed limit.

**d** Describe briefly how such a speed-detection system could be used to light up a warning light whenever a speeding car goes past.

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## Exercise P2.02 Speed calculations

**Use the equation for speed to solve some numerical problems.**

**a** The table shows the time taken for each of three cars to travel 100 m. Circle the name of the fastest car. Complete Table 2.02 by calculating the speed of each car. Give your answers in m/s and to one decimal place.

| Car | Time taken / s | Speed / m/s |
|---|---|---|
| red car | 4.2 | |
| green car | 3.8 | |
| yellow car | 4.7 | |

**Table 2.02**

**b** A jet aircraft travels 1200 km in 1 h 20 min.

How many metres does it travel? ..........................

For how many minutes does it travel? ..........................

And for how many seconds? ..........................

Calculate its average speed during its flight.

**c** A stone falls 20 m in 2.0 s. Calculate its average speed as it falls.

The stone falls a further 25 m in the next 1.0 s of its fall. Calculate the stone's average speed during the 3 s of its fall.

Explain why we can only calculate the stone's **average** speed during its fall.

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## Exercise P2.03 More speed calculations

**In these problems, you will have to rearrange the equation for speed.**



**a** A car is moving at 22 m/s. How far will it travel in 35 s?

**b** A swallow can fly at 25 m/s. How long will it take to fly 1.0 km?

**c** A high-speed train is 180 m long and is travelling at 50 m/s. How long will it take to pass a person standing at a level crossing?

How long will it take to pass completely through a station whose platforms are 220 m in length?

**d** In a 100 m race, the winner crosses the finishing line in 10.00 s. The runner-up takes 10.20 s. Estimate the distance between the winner and the runner-up as the winner crosses the line. Show your method of working.

Explain why your answer can only be an estimate.

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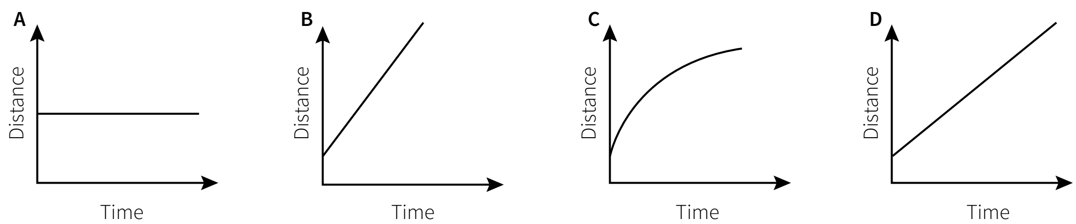
## Exercise P2.04 Distance–time graphs

**In this exercise, you draw and interpret some distance–time graphs. You can calculate the speed of an object from the gradient (slope) of the graph.**

**a** The diagrams **A**–**D** show distance–time graphs for four moving objects. Complete Table 2.03 by indicating (in the second column) the graph or graphs that represent the motion described in the first column.




| Description of motion | Graph(s) |
|---|---|
| moving at a steady speed | |
| stationary (not moving) | |
| moving fastest | |
| changing speed | |

**Table 2.03**

**b** Table 2.04 shows the distance travelled by a runner during a 100 m race. Use the data to draw a distance–time graph on the graph paper grid provided.

| **Distance / m** | 0 | 10.0 | 25.0 | 45.0 | 65.0 | 85.0 | 105.0 |
|---|---|---|---|---|---|---|---|
| **Time / s** | 0.0 | 2.0 | 4.0 | 6.0 | 8.0 | 10.0 | 12.0 |

**Table 2.04**



Now use your graph to answer these questions:

How far did the runner travel in the first 9.0 s? ..........................

How long did the runner take to run the first 50.0 m? ..........................

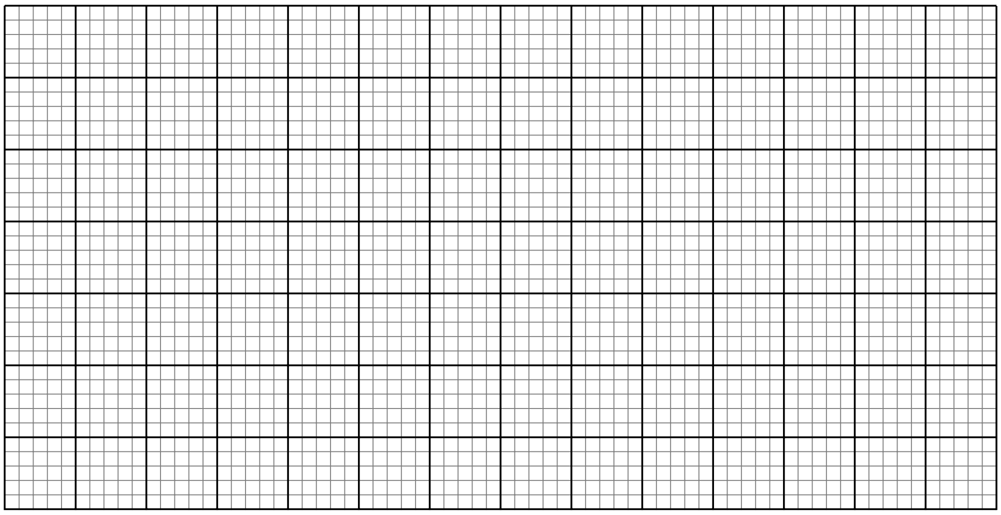
How long did the runner take to complete the 100 m? ..........................

Use the gradient of your graph to determine the runner's average speed between 4.0 s and 10.0 s. On your graph, show the triangle that you use.

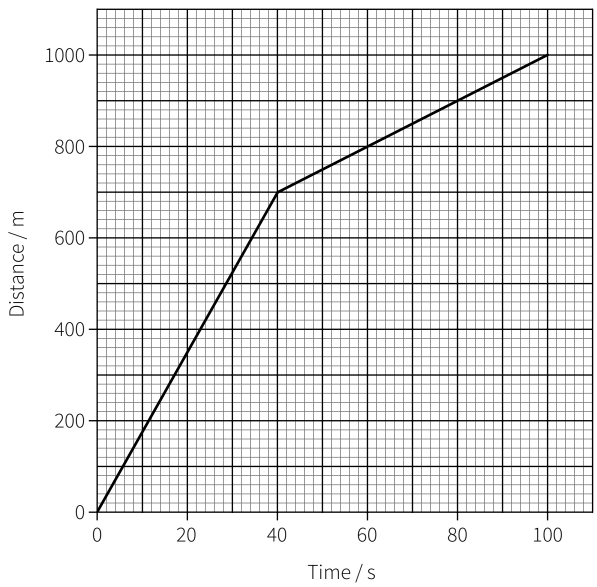
**c** On the graph paper grid provided, sketch a distance–time graph for the car whose journey is described here:

- The car set off at a slow, steady speed for 20 s.
- Then it moved for 40 s at a faster speed.

- Then it stopped at traffic lights for 20 s before setting off again at a slow, steady speed.



**d** The graph represents the motion of a bus for part of a journey.




On the graph, mark the section of the journey where the bus was moving faster.

From the graph, calculate the following:

- the speed of the bus when it was moving faster

- the average speed of the bus.

## Exercise P2.05 Acceleration

**When an object changes speed, we say that it accelerates. Its acceleration is the rate at which its speed increases.**

**a** In an advertisement, a car is described like this:

"It can accelerate from 0 km/h to 80 km/h in 10 s."

By how much does its speed increase in each second (on average)? ............................

**b** A cyclist is travelling at 4.0 m/s. She speeds up to 16 m/s in a time of 5.6 s. Calculate her acceleration.



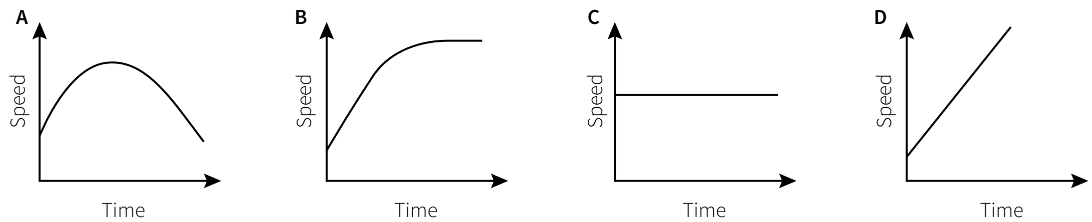
**c** A stone falls with an acceleration of 10.0 m/s$^2$. Calculate its speed after falling for 3.5 s.

**d** On the Moon, gravity is weaker than on Earth. A stone falls with an acceleration of 1.6 m/s$^2$. How long will it take to reach a speed of 10 m/s?

## Exercise P2.06 Speed–time graphs

**In this exercise, you draw and interpret some speed–time graphs. You can calculate the acceleration of an object from the gradient (slope) of the graph. You can calculate the distance travelled from the area under the graph.**

**a** The diagrams **A**–**D** show speed–time graphs for four moving objects. Complete Table 2.05 by indicating (in the second column) the graph or graphs that represent the motion described in the first column.

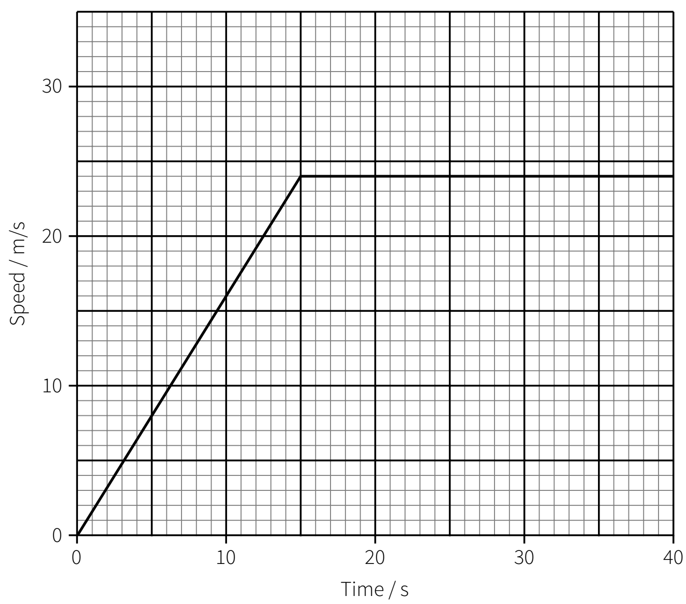



| Description of motion | Graph(s) |
|---|---|
| moving at a steady speed | |
| speeding up, then slowing down | |
| moving with constant acceleration | |
| accelerating to a steady speed | |

**Table 2.05**



**b** The graph represents the motion of a car that accelerates from rest and then travels at a steady speed.



From the graph, determine the acceleration of the car in the first part of its journey.

On the graph, shade in the area that represents the distance travelled by the car while accelerating. Label this area **A**.

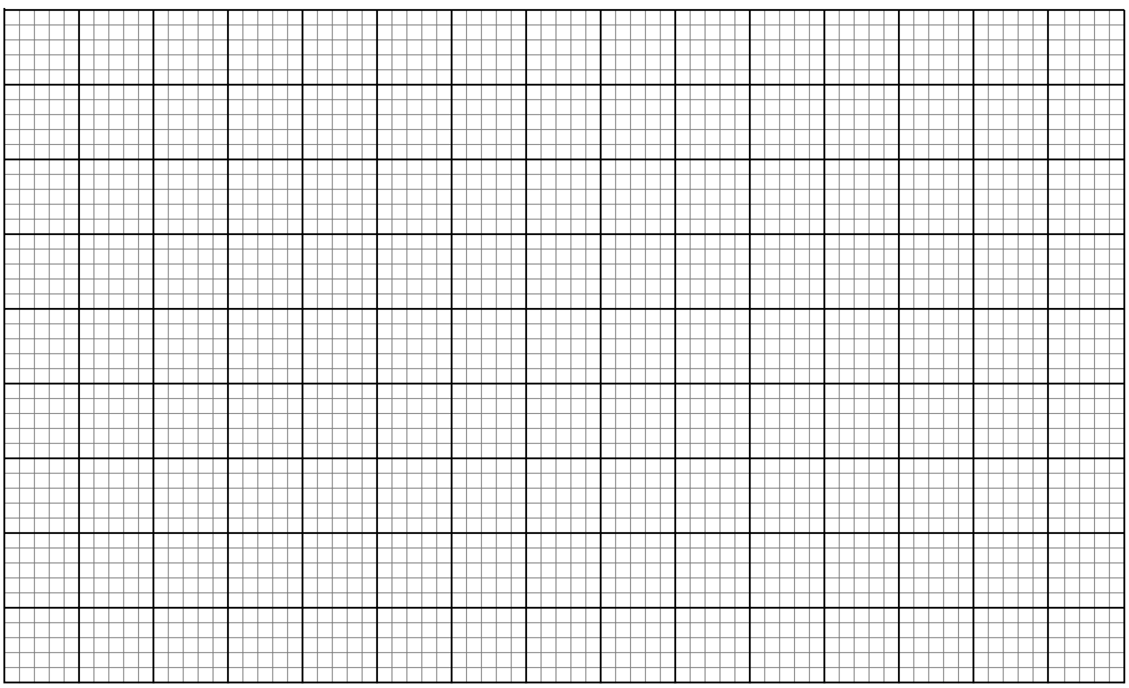
Shade the area that represents the distance travelled by the car at a steady speed. Label this area **B**.

Calculate each of these distances and the total distance travelled by the car.

[Note: area of a triangle = $\frac{1}{2}$ × base × height.]

**c** On the graph paper grid, sketch a speed–time graph for the car whose journey is described here:

- The car set off at a slow, steady speed for 20 s.
- Then, during a time of 10 s, it accelerated to a faster speed.
- It travelled at this steady speed for 20 s.
- Then it rapidly decelerated and came to a halt after 10 s.



# Chapter P3
# Forces and motion

**KEY TERMS**

**force:** the action of one body on a second body that causes its velocity to change

**resultant force:** the single force that has the same effect on a body as two or more forces

**mass:** the property of an object that causes it to resist changes in its motion

**weight:** the downward force of gravity that acts on an object because of its mass

**USEFUL EQUATIONS**

**Force = mass × acceleration**

$F = ma$

## Exercise P3.01 Identifying forces

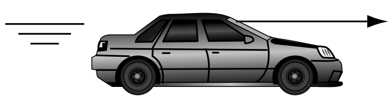
**Forces are invisible (although we can often see their effects). Being able to identify forces is an important skill for physicists.**

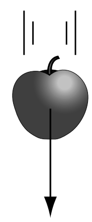
The pictures show some bodies. Your task is to add at least one force arrow to each body, showing a force acting on it. (Two force arrows are already shown.)

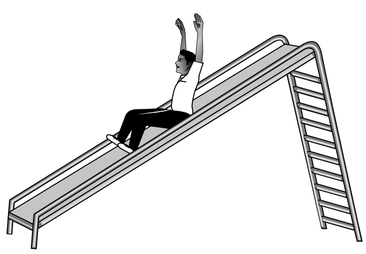
Each force arrow should be labelled to indicate the following:

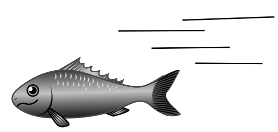
- the type of force (contact, drag/air resistance, weight/gravitational, push/pull, friction, magnetic)
- the body causing the force
- the body acted on by the force.

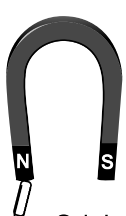
For example: the gravitational force of the Earth on the apple.

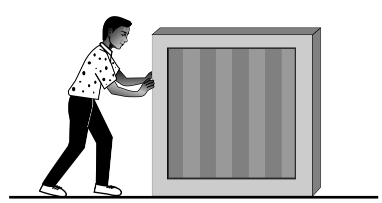








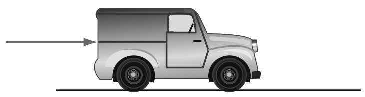


## Exercise P3.02 The effects of forces

**A force can change how a body moves, or it may change its shape.**

**a** Each diagram shows a body with a single force acting on it. For each, say what effect the force will have.



**A** ..........................................................

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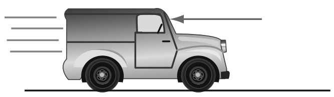

**B** ..........................................................

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**C** ..........................................................

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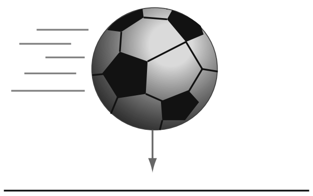

**D** ..........................................................

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**b** A boy slides down a sloping ramp. In the space below, draw a diagram of the boy on the ramp and add a labelled arrow to show the force of friction that acts on him.

What effect will the force have on the boy's movement?

..........................................................................................................................

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## Exercise P3.03 Combining forces

**When two or more forces act on a body, we can replace them by a single resultant force that has the same effect.**

**a** In Table 3.01, the left-hand column shows four objects acted on by different forces. For the same objects in the right-hand column, add a force arrow to show the resultant force acting on it in each case.

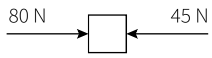
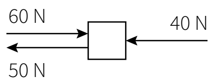
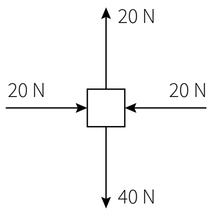
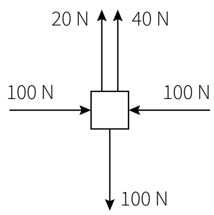
| Forces on object | Resultant force |
|---|---|
|   | |
|   | |
|   | |
|   | |

**Table 3.01**

**b** In the space below, draw a diagram showing a body with four forces acting on it. Their resultant must be 4 N acting vertically downwards.

## Exercise P3.04 Mass and weight

**Mass and weight are two quantities that can easily be confused.**

How well do you understand the difference between mass and weight? In the second column of Table 3.02, write 'mass' or 'weight' (or 'both'), as appropriate.

| Description | Mass or weight or both? |
|---|---|
| a force | |
| measured in kilograms | |
| measured in newtons | |
| decreases if you go to the Moon | |
| a measure of how difficult it is to accelerate a body | |
| caused by the attraction of another body | |
| increases if more atoms are added to a body | |
| balanced by the contact force of the floor when you are standing | |
| used in calculating the acceleration of a body when a force acts on it | |
| makes it difficult to change the direction of a body as it moves | |
| decreases to zero as a body moves far from the Earth or any other object | |

**Table 3.02**



## Exercise P3.05 Force, mass and acceleration

**Here you practise using the relationship $F = ma$.**

**a** The equation $F = ma$ relates three quantities. Complete Table 3.03 to show the names of these quantities and their SI units.

| Quantity | Symbol | SI unit |
|---|---|---|
| | $F$ | |
| | $m$ | |
| | $a$ | |

**Table 3.03**

**b** Rearrange the equation $F = ma$ to change its subject:

$m =$ $a =$

**c** Calculate the force needed to give a mass of 20 kg an acceleration of 0.72 m/s$^2$.

**d** A car of mass 450 kg is acted on by a resultant force of 1575 N. Calculate its acceleration.

**e** One way to find the mass of an object is to apply a force to it and measure its acceleration. An astronaut pushes on a spacecraft with a force of 200 N. The spacecraft accelerates at 0.12 $m/s^2$. What is the mass of the spacecraft?



**f** In the space below, draw a falling stone with the following forces acting on it:

- its weight, 8.0 N
- air resistance, 2.4 N.

**g** Calculate the stone's acceleration. (Its mass is 0.80 kg.)

# Answers

Example answers and all questions were written by the author.

## Chapter P1 Making measurements

### Exercise P1.01 The SI system of units

**a** metre (m)

cubic metre ($m^3$)

**b** kilometre (km)

millimetre (mm)

**c** 100

1000

**d** For example: inch, foot, yard, mile, furlong, etc.

**e** For example: to make it easier to compare measurements; to make it easier to share data

**f** For example: medicine (doctors, nurses), engineering, architecture and surveying, etc.

### Exercise P1.02 Accurate measurements

**a** 6.7 cm

Align end with zero; place next to ruler; straighten it out.

**b–e** *Answers will depend on the piece of paper selected by the student.*

*For example, the table should resemble the following (see Table A1.01):*

| Measurement | Length / cm | Length$^2$ / cm$^2$ |
|---|---|---|
| short side | 12.5 | 156 |
| long side | 17.3 | 299 |
| diagonal | 21.3 | 454 |

**Table A1.01**

(short side)$^2$ + (long side)$^2$ = 156 + 299 = 455

**f** *Comments will vary.*

### Exercise P1.03 Density data

**a** see Table A1.02

**b** cork

**c**


| Material | State / type | Density / kg/m$^3$ | Density / g/cm$^3$ |
|---|---|---|---|
| water | liquid / non-metal | 1 000 | 1.000 |
| ethanol | liquid / non-metal | 800 | 0.800 |
| olive oil | liquid / non-metal | 920 | 0.920 |
| mercury | liquid / metal | 13 500 | 13.500 |
| ice | solid / non-metal | 920 | 0.920 |
| diamond | solid / non-metal | 3 500 | 3.500 |
| cork | solid / non-metal | 250 | 0.250 |
| chalk | solid / non-metal | 2 700 | 2.700 |
| iron | solid / metal | 7 900 | 7.900 |
| tungsten | solid / metal | 19 300 | 19.300 |
| aluminium | solid / metal | 2 700 | 2.700 |
| gold | solid / metal | 19 300 | 19.300 |

**Table A1.02**

| Quantity | SI unit (name and symbol) | Non-SI units | Measuring instrument |
|---|---|---|---|
| distance | metre (m) | mile, etc. | tape measure, rule |
| time | second (s) | hour, etc. | clock, stopwatch |
| speed | metre per second (m/s) | mile per hour, etc. | |

**Table A2.01**

**d** Disagree. Aluminium (metal) is less dense than diamond (non-metal). But it is true that, for the table, most metals are more dense than most non-metals.

**e** 57.9 kg

**f** 19 300 kg/m$^3$

possibly tungsten

### Exercise P1.04 Testing your body clock

*Answers will vary.*

Students should recognise that measuring 50 pulses is better than measuring 10 (provided that the pulse rate is not changing). Also they should appreciate that pulse rate can change, and that this makes it less reliable than using a pendulum.

## Chapter P2 Describing motion

### Exercise P2.1 Measuring speed

**a** see Table A2.01

**b** distance travelled

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

2.8 m/s

**c** Knowing the distance between the detectors,

calculate $\frac{\text{distance}}{\text{time}}$

24 m/s; within the speed limit

0.048 s

**d** If the time taken by a vehicle is equal to or less than 0.048 s, the warning lights are shown.

### Exercise P2.02 Speed calculations

**a** The green car should be circled as the fastest in Table A2.02

| Car | Time taken / s | Speed / m/s |
|---|---|---|
| red car | 4.2 | 23.8 |
| green car | 3.8 | 26.3 |
| yellow car | 4.7 | 21.3 |

**Table A2.02**

**b** 1 200 000 m

80 min

4800 s

250 m/s

**c** 10 m/s

15 m/s

It is speeding up (accelerating).

### Exercise P2.03 More speed calculations

**a** 770 m

**b** 40 s

**c** 3.60 s

8.0 s

**d** 2.0 m

Their speeds might change during the race.

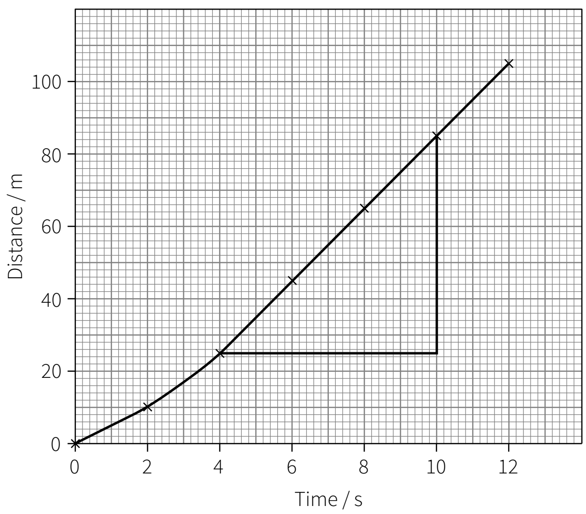
## Exercise P2.04 Distance–time graphs

**a** see Table A2.03

| Description of motion | Graph(s) |
|---|---|
| moving at a steady speed | B, D |
| stationary (not moving) | A |
| moving fastest | B |
| changing speed | C |

**Table A2.03**

**b**



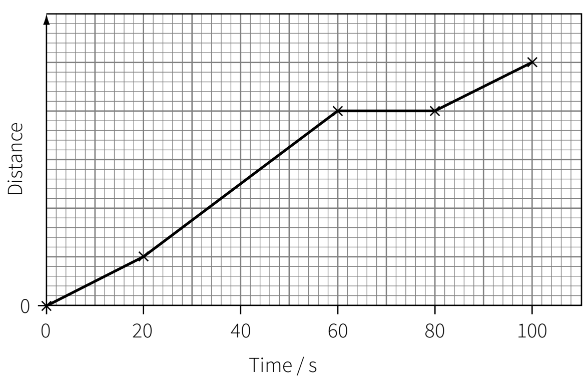

75.0 m

6.5 s

11.5 s

10.0 m/s

**c**




**d** first section marked as faster

17.5 m/s

10.0 m/s

## Exercise P2.05 Acceleration

**a** 8 km/h

**b** 2.1 m/s$^2$

**c** 35 m/s

**d** 6.25 s

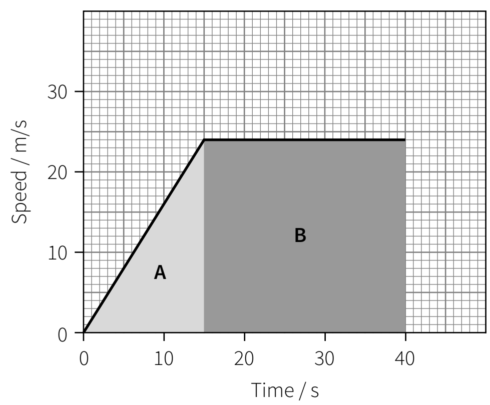
## Exercise P2.06 Speed–time graphs

**a** see Table A2.04

| Description of motion | Graph(s) |
|---|---|
| moving at a steady speed | C |
| speeding up, then slowing down | A |
| moving with constant acceleration | D |
| accelerating to a steady speed | B |

**Table A2.04**

**b** 1.6 m/s$^2$

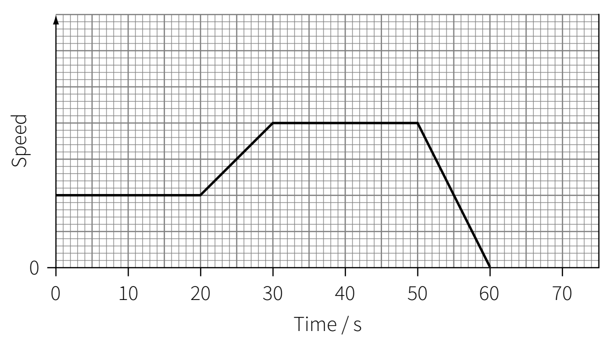



**A** $= \frac{1}{2} \times 15 \times 24 = 180$ m

**B** $= 25 \times 24 = 600$ m

total distance = 780 m

**c**



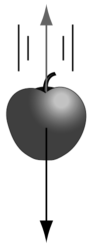
# Chapter P3 Forces and motion

## Exercise P3.01 Identifying forces

Forces and labels should be as follows:

*Apple*: (up) air resistance of air on apple;

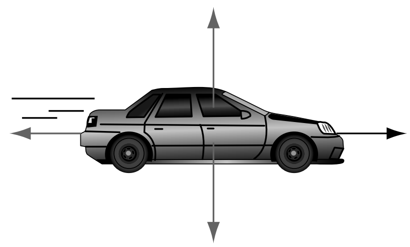
(down) gravitational force of Earth on apple



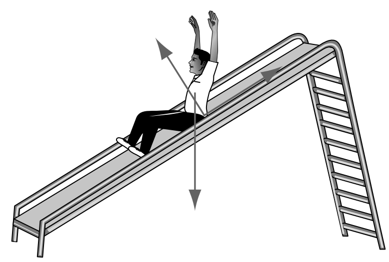
*Car*: (up) contact force of road on car;

(down) gravitational force of Earth on car;

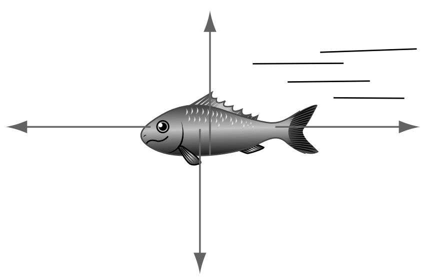
(back) air resistance of air on car; (forwards) push of engine on car



*Person on slide*: (down) gravitational force of Earth on person; (up slope) frictional force of slide on person; (normal to slope) contact force of slide on person

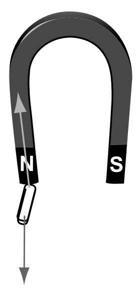


*Fish*: (down) gravitational force of Earth on fish; (up) upthrust of water on fish; (back) drag of water on fish; (forwards) thrust caused by fish's movements, acting on fish

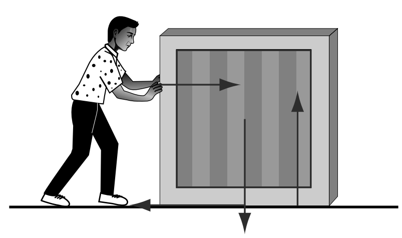


*Paperclip*: (down) gravitational force of Earth on clip;

(up) magnetic force of magnet on clip




*Box*: (down) gravitational force of Earth on box; (up) contact force of floor on box; (to right) push of person on box; (to left ) frictional force of ground on box



## Exercise P3.02 The effects of forces

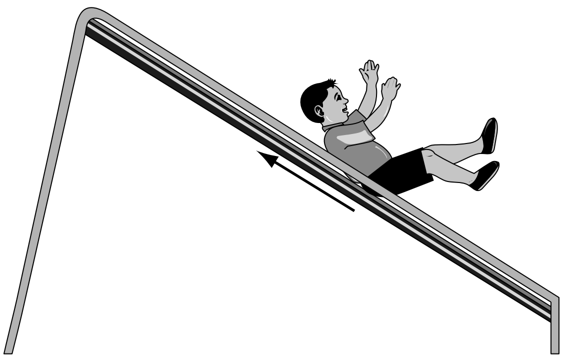
**a** **A** Van will accelerate / speed up

**B** Van will decelerate / slow down

**C** Tree will bend over to right

**D** Ball will accelerate downwards (but follow a curved path)

**b**



Friction will make him go slower (*better*: … reduce his acceleration).



## Exercise P3.03 Combining forces

**a** see Table A3.01

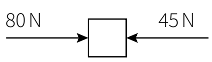
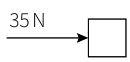
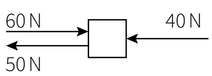
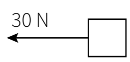
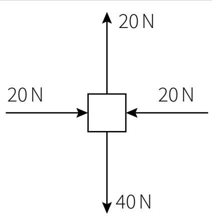
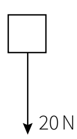
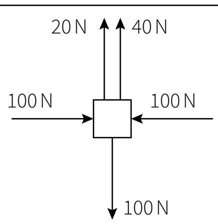
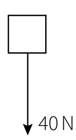
| Forces on object | Resultant force |
|---|---|
|   |   |
|   |   |
|   |   |
|   |   |

**Table A3.01**

**b** *Diagrams will vary; but must show a body with four forces acting on it with resultant 4 N acting vertically downwards.*

## Exercise P3.04 Mass and weight

See Table A3.02

| Description | Mass or weight or both? |
|---|---|
| a force | weight |
| measured in kilograms | mass |
| measured in newtons | weight |
| decreases if you go to the Moon | weight |
| a measure of how difficult it is to accelerate a body | mass |
| caused by the attraction of another body | weight |
| increases if more atoms are added to a body | both |
| balanced by the contact force of the floor when you are standing | weight |
| used in calculating the acceleration of a body when a force acts on it | mass |
| makes it difficult to change the direction of a body as it moves | mass |
| decreases to zero as a body moves far from the Earth or any other object | weight |

**Table A3.02**

## Exercise P3.05 Force, mass and acceleration

**a** see Table A3.03

| Quantity | Symbol | SI unit |
|---|---|---|
| force | $F$ | newton (N) |
| mass | $m$ | kilogram (kg) |
| acceleration | $a$ | metre per second squared (m/s$^2$) |

**Table A3.03**

**b** $m = \dfrac{F}{a}$

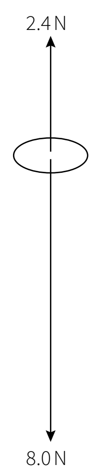
$a = \dfrac{F}{m}$

**c** 14.4 N

**d** 3.5 m/s$^2$

**e** 1667 kg (1670 kg)

**f** see diagram on right side.




**g** 7.0 m/s$^2$