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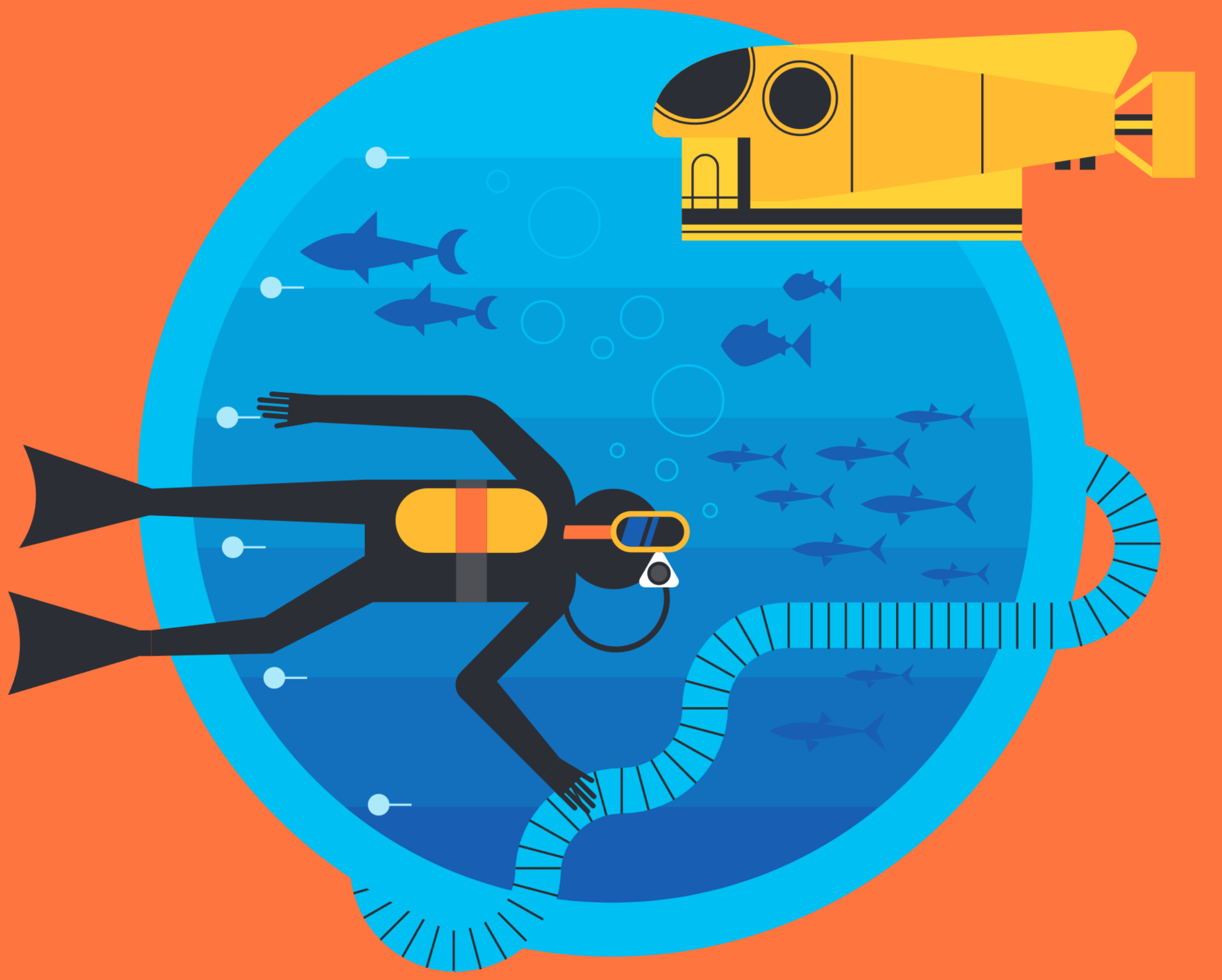
8

Maths

Student Book



Lower Secondary

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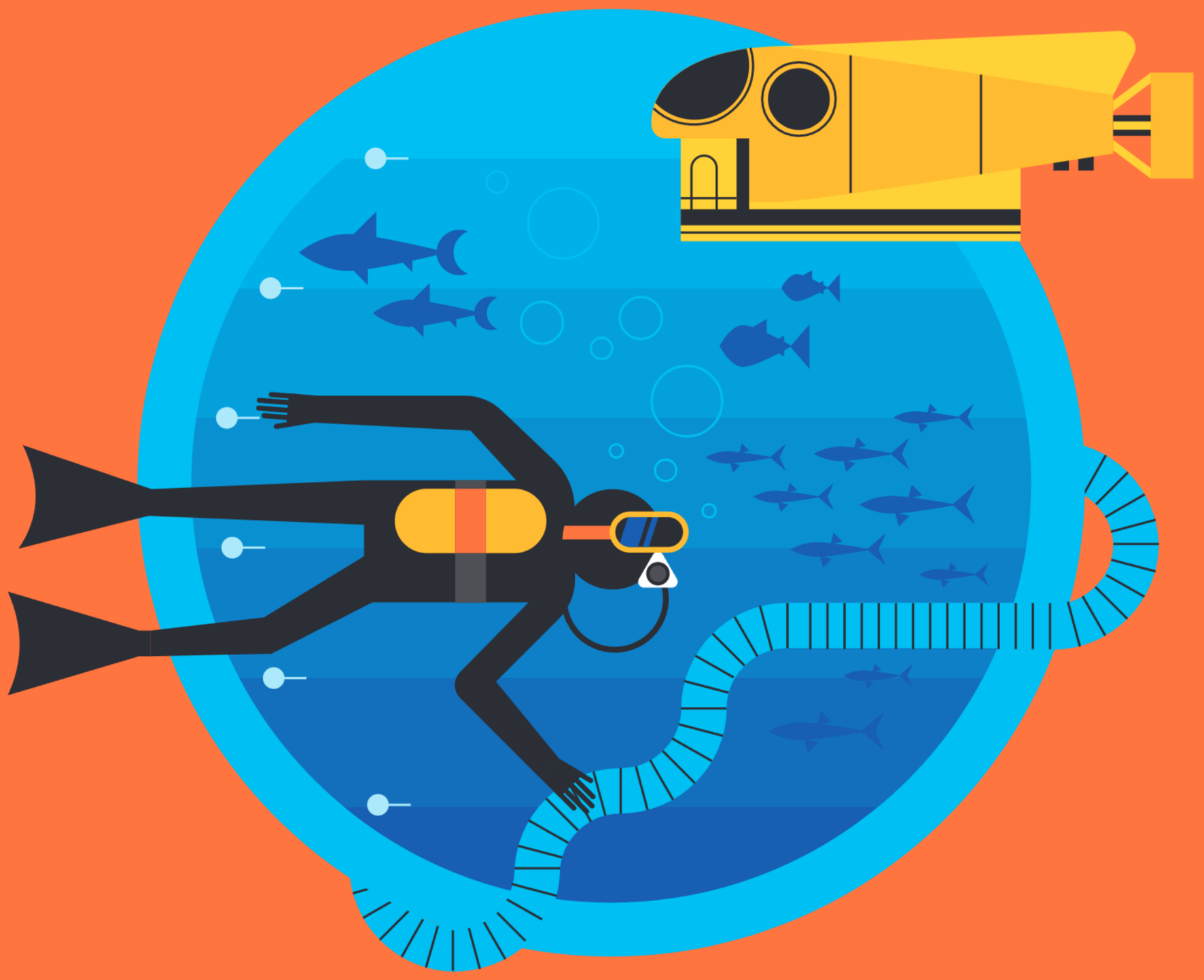

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Contents

How to use this book

Each topic begins with a set of learning objectives. These tell you what you will be able to do by the end of the lesson.

Key idea

The key idea summarizes the main points of each topic in a few sentences.

Key words

The key words for each topic are highlighted in **bold** in the text. They are also included in order of appearance in this box. You can also find them in the Glossary at the back of your Student Book.

Fluency questions

These questions check your understanding of a topic before moving on to the next.

Stretch zone

This icon shows you where you will need to think in a different way. It is OK if you find the 'stretch zone' questions difficult. Instead of giving up, keep thinking and trying. You will get there – doing challenging work is the exercise your brain needs!

Welcome to your Student Book

This introduction shows you all the different features *Oxford International Maths* has to support you on your journey through Lower Secondary Maths.

Being a mathematician (someone who studies maths) is great fun. As you work through this Student Book, you will learn how to work mathematically and become confident (or even more confident!) in your maths skills.

Each chapter in this book covers a few topics. With plenty of worked examples and practice questions, you will study these topics for a few weeks to make sure you have time to learn them properly.

Learning maths is like building a house: you cannot add a new layer of bricks if some of the bricks below are missing. To be successful with a new topic in maths, you need to build on things you learned previously, in *Oxford International Maths 7.*

Literacy skills

These boxes tell you more about the history and use of key vocabulary to put the new words you learn in context.

Stretch zone

These boxes suggest ideas for how to take your learning further and discover something more than what is in the pages of your Student Book.

Calculator skills

These boxes help you get to know your calculator and use it effectively.

Some of the topics in this book would be almost impossible without a calculator. In other topics, your calculator will be useful for doing lots of calculations quickly or for checking answers.

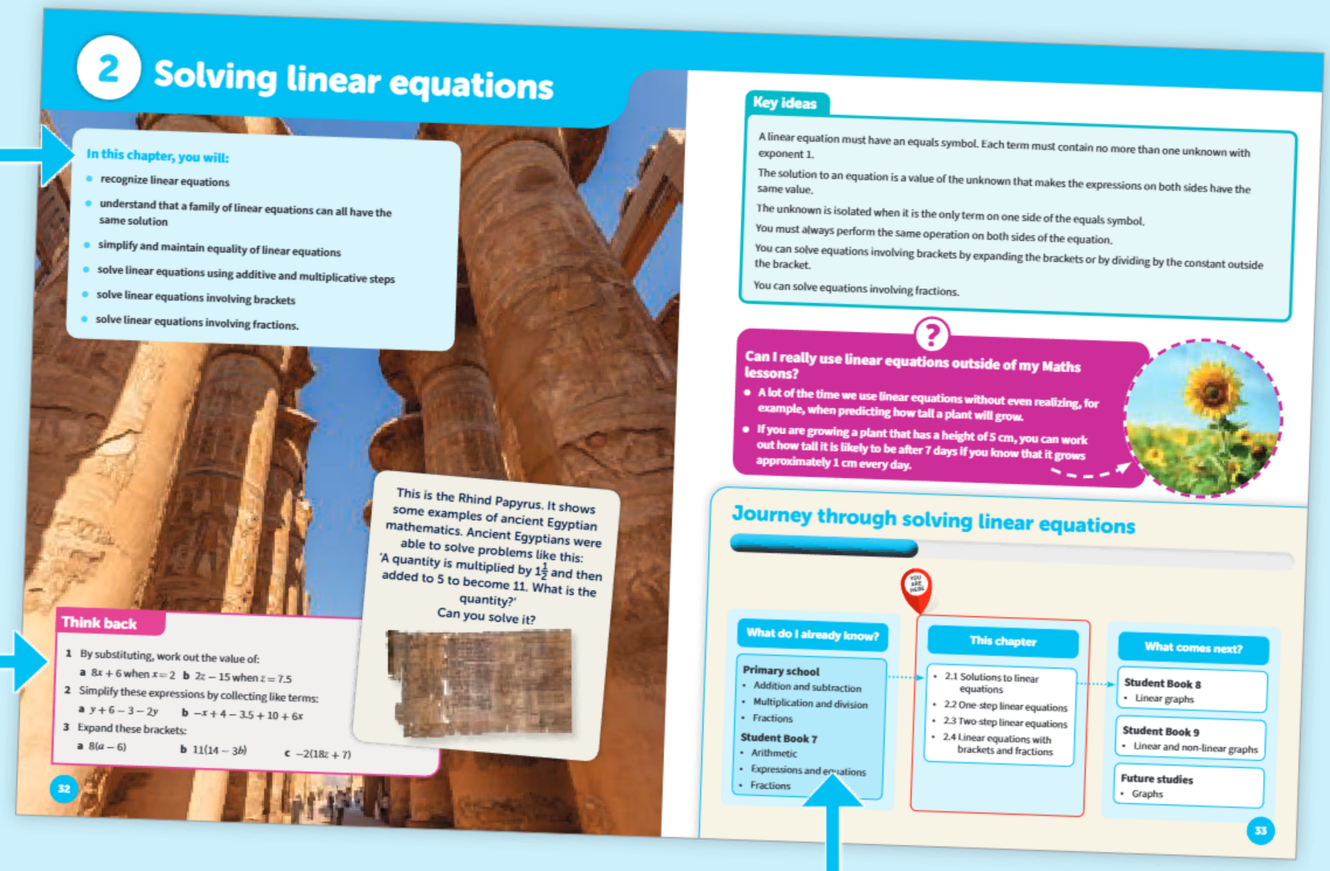
Do not use your calculator for all your maths. You should still be confident to carry out calculations, both in your head and by using written methods. Your teacher will tell you when to use a calculator and when they want you to work out a maths problem without one.

Chapter opener

Each chapter begins with an introduction. This reminds you what you already know and shows you what is coming up in the chapter.

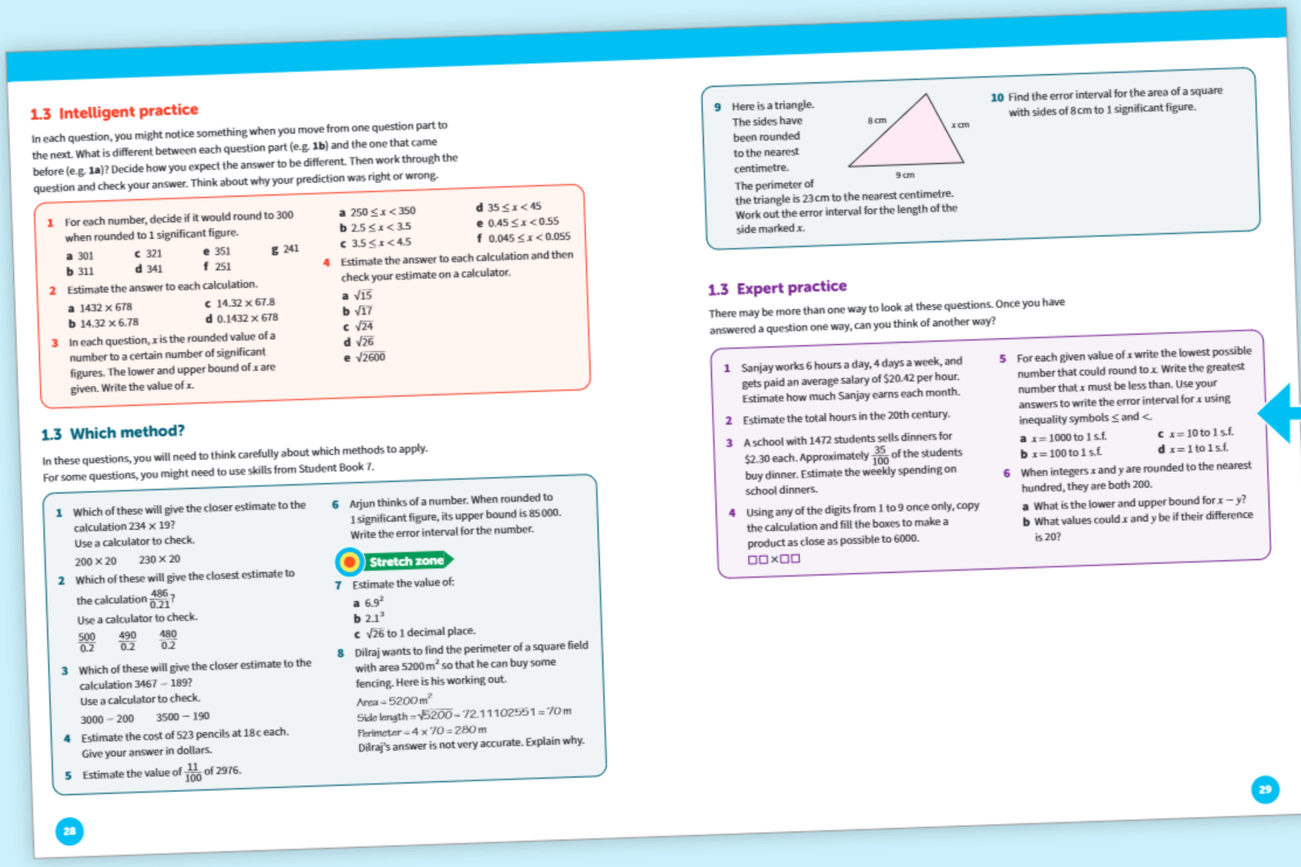
Think back

These quick questions help you recall the maths you already know. To be successful with a new topic in maths, you need to build on your existing knowledge and fill in any gaps before carrying on.



Chapter map

This map shows clearly what maths you already know, the new topics you will study in this chapter, and the next steps in your maths learning.



Become an expert at each topic

There are three different ways to practise maths at the end of every section:

1 Intelligent practice

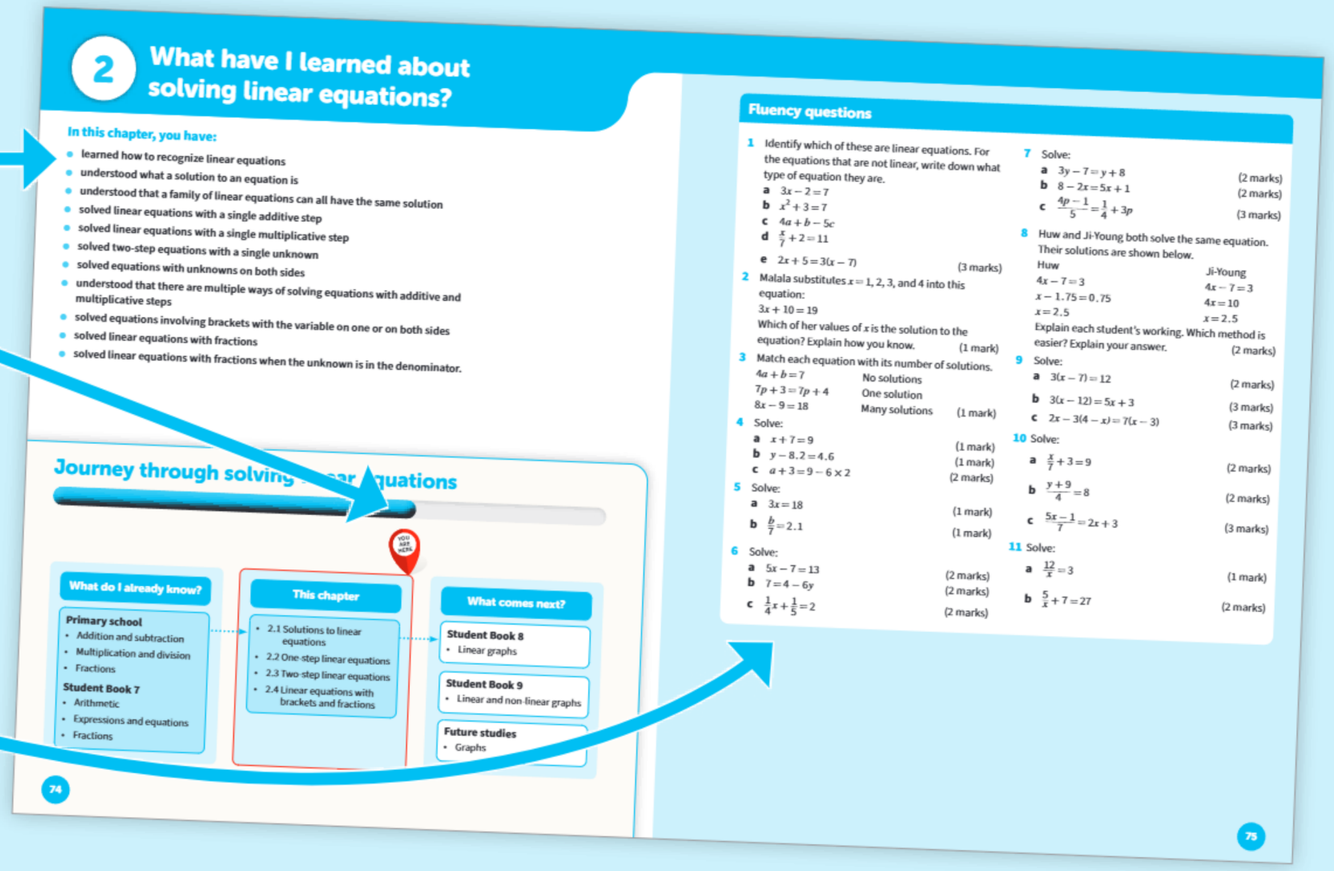
2 Which method?

3 Expert practice

Each exercise works in a particular way to help your brain make connections, remember the topic, and recognize when to use it.

Chapter summary

This summarizes what you have learned so far and shows your progress through the unit.



Fluency questions

You can use these exam-style questions to test how well you know the topics in the chapter.

How to use example-problem pairs

Example-problem pair (EPP) grids are a special type of worked example that help you understand what you are doing at each step and why.

There are lots of different ways you can use the example-problem pairs. Here is one possible way:

1 Start with the **Worked example** on the left.

2 Think about each line of working using the questions in the **Thinking** column.

Worked example	Thinking	Your turn!
Estimate the value of 29×482 and say if your estimate will be greater or less than the exact answer.	*How can we round each number to make the calculation easier?* I could round both numbers to 1 significant figure.	**Estimate the value of 31×712 and say if your estimate will be greater or less than the exact answer.**
$29 \times 482 \approx 30 \times 500 = 15\,000$	*Have we rounded up or down? What effect will this have on the estimate?* I rounded both numbers up, so my estimate will be bigger than the real answer.	
Since both numbers have been rounded up, this is an overestimate.		

3 Try to predict what the next line of working will be before you look at it.

4 Once you have thought about the example on the left, move to the **Your turn!** question on the right. This question will be very similar to the example you have just studied.

You can use the same thinking ideas to answer this question one step at a time.

The questions in the **Thinking** column help you think more generally about the example, so that you understand how to think about a different question.

The **Your turn!** question lets you apply the new idea with some support, so that you can be confident in what you need to do before you move on to the **Fluency** questions.

How to use Reflect, Expect, Check, Explain

For the **Intelligent practice** questions, use the Reflect, Expect, Check, Explain (RECE) method. This means you think about the question you are about to do, compare it to the one you have just done, and predict how the answer will be different. This is a great technique for developing your reasoning skills – plus it gives you an opportunity to discuss things with your partner, or as a class, which helps you become more confident talking about maths.

1. **Reflect**: Read the question. What has changed in this question compared to the previous one? What has stayed the same?
2. **Expect**: Using your reflection from Step 1 and the answer to the previous question, what do you think the answer will be? Can you explain why you think that?
3. **Check** your expectation by carrying out the usual method to answer the question.
4. **Explain**: Was your expectation in Step 2 correct? If the answer surprises you, can you explain why? If the answer is what you expected, how could you explain your reasoning to someone else? If you were not able to make a prediction in Step 2, can you explain the relationship now?

Look at the example below.

Question 2a

Estimate the answer to 1432×678.

$1432 \times 678 \approx 1000 \times 700 = 700\,000$

Question 2b

Estimate the answer to 14.32×6.78.

Reflect: This question is like **2a**, except both numbers have been divided by 100.

Expect: I think the answer will be $700\,000 \div 100 = 7000$.

Check: $14.32 \times 6.78 \approx 10 \times 7 = 70$

Explain: I was wrong! Because both numbers have been divided by 100, the calculation has in fact been divided by 100 twice, or by 10 000.

You can also use this method when you are working through the **Your turn!** question in an example-problem pair.

1 Estimation and rounding

In this chapter, you will:

- round integers to powers of 10
- round numbers to decimal places (d.p.)
- understand sensible degrees of accuracy and round numbers to significant figures (s.f.)
- estimate calculations
- work out if a rounded calculation is an underestimate or an overestimate
- understand and show rounding errors using inequalities.

This photograph shows the total amount of money raised for a charity event on television. News headlines the next day stated that the charity had raised $20 million.
Why might the headlines have said $20 million instead of $20 309 747?

Think back

1 In the number 1 945 382 067 write which digit represents the number of:
a thousands **b** hundred millions **c** tens.

2 In the number 14.659 8273 write which digit represents the number of:
a hundred-thousandths **b** hundredths **c** ten-thousandths.

3 Work out:
a $3 + 49 \div 7$ **b** $28 + 6 \times 0.5$ **c** $3 \times 8^2 - (5 \times 40)$ **d** $4.5 + (11 - 6)^2$

Key ideas

When rounding a number, you always check the digit in the column to the right of the digit that stands for the degree of accuracy you need.

Significant figures start at the first non-zero digit.

When you round numbers to estimate calculations, you need to make the calculation easier to work out but still as accurate as possible.

An error interval is written $a \leq x < b$, where x is the rounded value, a is its lower bound, and b is its upper bound.

When do we use estimation and rounding in everyday life?

- When you go shopping, it is useful to estimate the total cost of the items you are buying so you do not spend too much money.
- You need to know when it is important to know an exact number and when an estimate is good enough. This depends on what you are using the data for.

Journey through estimation and rounding

What do I already know?

Primary school
- Number and place value

Student Book 7
- Place value
- Properties of numbers
- Arithmetic

This chapter

- 1.1 Rounding to decimal places
- 1.2 Rounding to significant figures
- 1.3 Estimation

What comes next?

Student Book 9
- Standard form

Future studies
- Standard form
- Limits of accuracy

1.1 Rounding to decimal places

1.1.1 Round integers to the nearest 10, 100, 1000, and higher

After this topic, you will be able to:

- round integers to a given power of 10.

Key idea

To round to any power of ten, always look at the next column to the right of the one given to decide whether to round up or down.

Literacy skills

'Degree of accuracy' means how accurately you write a number. For example, you might round the number to the nearest hundred, or to one decimal place.

Key words

approximate, round, degree of accuracy, rounded, halfway

Sometimes it can be helpful to use **approximate** numbers.

One way of approximating numbers is to **round** them. Rounding is the process of taking a number and picking another number close to it, depending on the **degree of accuracy** you need.

For example, if the size of the crowd at a sports event was 34 951, you could round the number and say it was 35 000 *to the nearest thousand*. Here you have chosen 'the nearest thousand' as the degree of accuracy.

Here are the integers 34 951 and 34 206 on a number line:

You can see that 34 206 is closer to 34 000 than to 35 000, so 34 206 rounds to 34 000 to the nearest thousand. You can write statements like this:

34 206 ≈ 34 000 (to the nearest thousand)

34 951 ≈ 35 000 (to the nearest thousand)

The symbol ≈ means 'is approximately equal to', and you can use it when estimating and rounding.

34 500 is exactly **halfway** between 34 000 and 35 000. In this case, you always round up instead of down.

If you are rounding to the nearest ten, always look at the ones column to help you to see how to round. If the digit in the ones column is below 5, round down. If it is 5 or above, round up.

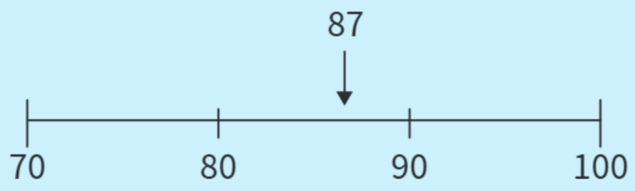
Worked example	Thinking	Your turn!
Round 795 602 to the nearest 10 000.	*Which digit do we look at when rounding?* I think about the degree of accuracy needed and look one digit to the right.	**Round 5 457 901 to the nearest 10 000.**
79(5)602 ≈ 800 000 (to the nearest 10 000)	*What does this digit tell us to do?* 5 is the halfway digit, so I round up.	

Sometimes you may be given a **rounded** number and asked to work out how big or how small the original number could be. For example, 8000 votes to the nearest thousand could be as few as 7500 votes, because 7500 is the smallest number that rounds up to 8000, but not as many as 8500 votes, because 8500 rounds up to 9000.

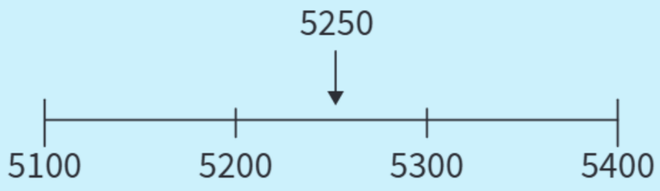
Fluency questions

1 Use the number lines to round:

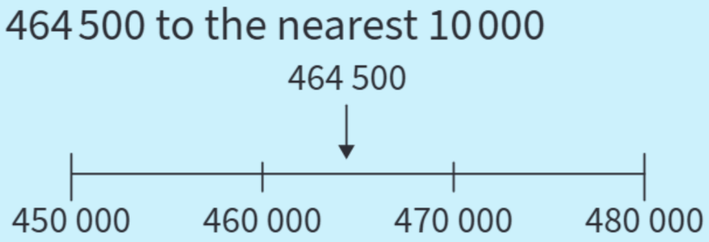
a 87 to the nearest 10



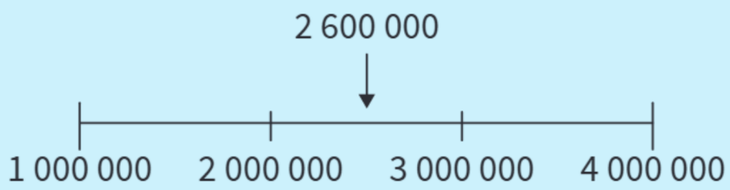
b 5250 to the nearest 100



c 464 500 to the nearest 10 000



d 2 600 000 to the nearest million.



2 Round each integer to the nearest 10.

a 104 **b** 85 **c** 6555

3 Round each integer to the nearest 100.

a 950 **b** 83 550 **c** 904 675 501

4 Round each integer to the nearest 1000.

a 5420 **b** 13 459 **c** 134 914 501

5 Round:

a 793 400 to the nearest 10 000

b 9 560 000 to the nearest 100 000

c 23 490 000 to the nearest million.

Stretch zone

6 An integer is given as 3600 rounded to the nearest 100.
Write the smallest integer it could be.

7 An integer is given as 46 000 rounded to the nearest 1000.
Write the smallest integer it could be.

8 A number is given as 6000 rounded to the nearest 10.
Write the smallest integer it could be.

1.1.2 Rounding numbers to decimal places

After this topic, you will be able to:

- round numbers to any number of decimal places (d.p.).

Key idea

When rounding, you always check the digit in the column to the right of the digit that stands for the degree of accuracy you are rounding to.

Key word

decimal place

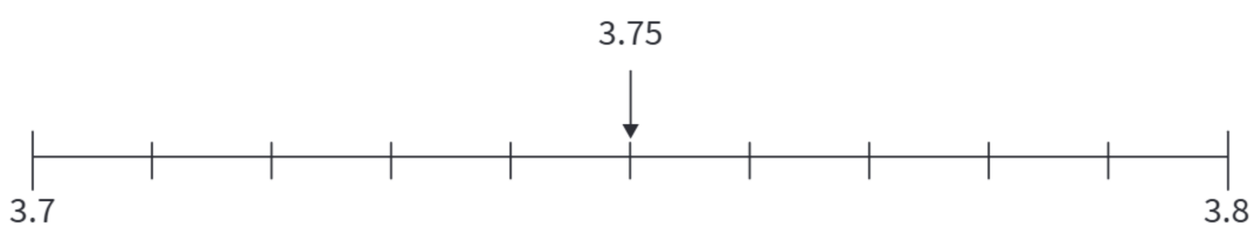
When you are using decimals, you can round to a given number of **decimal places**. Here are the numbers 3.72 and 3.765 on a number line:

You can see that 3.72 is closer to 3.7 than to 3.8, so 3.72 rounds to 3.7 to one decimal place. You can also see that 3.765 is closer to 3.8 than to 3.7, so 3.765 rounds to 3.8 to one decimal place. You can write statements like this:

$3.72 \approx 3.7$ (to 1 d.p.) and $3.765 \approx 3.8$ (to 1 d.p.)

where 'd.p.' stands for 'decimal places'.

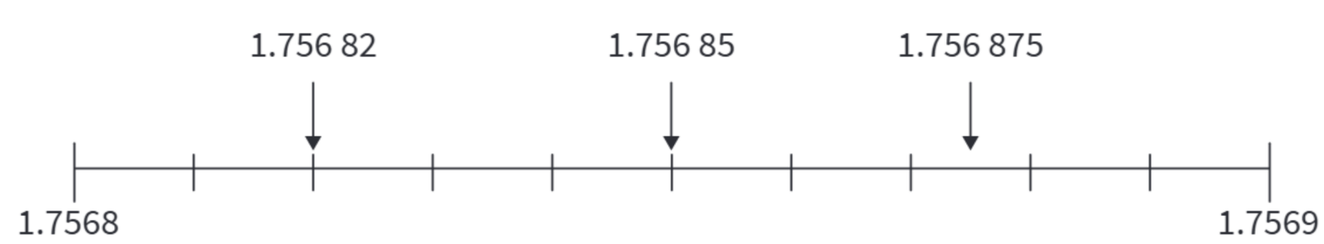
You can see that 3.75 is exactly halfway between 3.7 and 3.8.



In this case, you always round up instead of down, so 3.75 rounds to 3.8 to one decimal place:

$3.75 \approx 3.8$ (to 1 d.p.)

To think about how rounding works with more decimal places, zoom in to the number line from 1.7568 to 1.7569.



All the numbers in this interval begin with the digits 1.7568, so all of them will either round to 1.7568 or 1.7569 to four decimal places. The number at the halfway mark is 1.756 85 and this is the first number that rounds up. The digit immediately after the fourth decimal place shows you whether the number is closer to 1.7568 or 1.7569.

Do not ignore zeros when you round. To round 1.230 045 to four decimal places you write 1.2300 (to 4 d.p.). You must write the final zeros as you need to write four decimal places.

Worked example	Thinking	Your turn!
Round 0.0158 62 to 4 decimal places.	*Which column do we look at to decide whether to round up or down?* I have to look at the fifth decimal place.	**Round 0.023 579 8 to 4 decimal places.**
0.015 8⑥2 ≈ 0.0159 (to 4 d.p.)		

You can round decimals to the nearest integer by looking at the first decimal place.

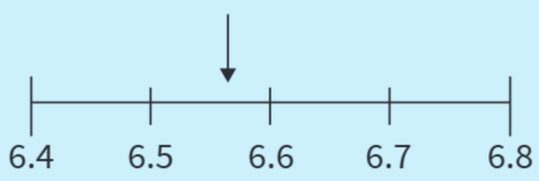
Worked example	Thinking	Your turn!
Round 16.53 to the nearest integer.	*Which digit tells us how to round to the nearest integer?* I need to look at the digit in the first decimal place. It is a 5, so I round up.	**Round 340.06 to the nearest integer.**
16.⑤3 ≈ 17 (to the nearest integer)		

Context can also help you to make decisions about rounding. For example, when buying tins of paint, you always need to round up to the next whole tin.

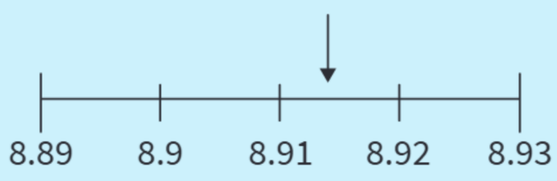
Fluency questions

1 Use the number lines to round each number to the given number of decimal places.

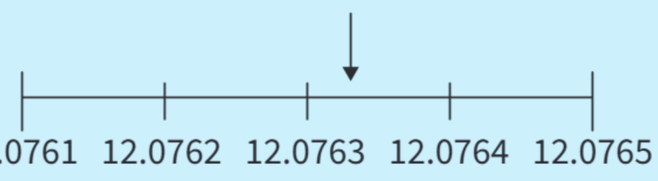
a 6.57 (1 d.p.)



b 8.914 (2 d.p.)



c 12.076 32 (4 d.p.)



2 Round each number to the given number of decimal places.

a 7.15 (1 d.p.)
b 9.245 (2 d.p.)
c 82.1645 (3 d.p.)
d 12.95 (1 d.p.)
e 143.6455 (3 d.p.)
f 0.099 995 (5 d.p.)

Stretch zone

3 A number is given as 0.786 rounded to 3 decimal places.
Write the smallest number it could be.

4 A number is given as 3.1875 rounded to 4 decimal places.
Which of these numbers could it be?

0.187 54 3.187 49 3.1870 3.187 55
3.1879 0.187 51 3.018 75 3.187 549

1.1 Intelligent practice

In each question, you might notice something when you move from one question part to the next. What is different between each question part (e.g. **1b**) and the one that came before (e.g. **1a**)? Decide how you expect the answer to be different. Then work through the question and check your answer. Think about why your prediction was right or wrong.

1 Copy the table and round each number to complete it.

		To nearest 10	To nearest 100	To nearest 1000
a	853 902			
b	85 390			
c	8539			
d	853			
e	85			
f	8			

2 Copy the table and round each number to complete it.

		To 1 decimal place	To 2 decimal places	To 3 decimal places
a	2.1032			
b	2.2143			
c	2.3254			
d	2.4365			
e	2.5476			
f	2.6587			
g	2.7698			

3 Round each number to the nearest integer.

a 1.2 **b** 1.3 **c** 1.5 **d** 1.56 **e** 15.6 **f** 0.156

4 Round each number to the degree of accuracy given.

a 0.9 (to the nearest integer)
b 0.99 (1 decimal place)
c 0.999 (2 decimal places)
d 0.9999 (3 decimal places)
e 0.999 99 (4 decimal places)
f 0.999 999 (5 decimal places)
g 1.000 0001 (6 decimal places)

5 Round 3521.53 to:

a 1 decimal place
b the nearest integer
c the nearest 10
d the nearest 100
e the nearest 1000.

6 What is the least number that rounds to 2 000 000 to:

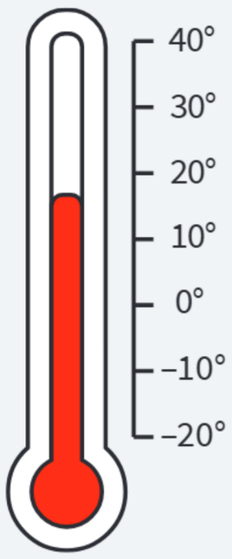
a the nearest million
b the nearest hundred thousand
c the nearest 10^4
d the nearest 100
e the nearest integer?

7 **a** What is 3.75 to 1 decimal place?
b What is 3.75 to the nearest integer?
c Kurt needs 3.75 kg flour to bake cakes for a party. Flour comes in 1 kg bags. How many bags should he buy?

1.1 Which method?

In these questions, you will need to think carefully about which methods to apply.
For some questions, you might need to use skills from Student Book 7.

1 Here is a thermometer. Round the temperature to the nearest 10 degrees.



2 Work out the area of the rectangle and give your answer to one decimal place.

3 Write five different numbers that:

a are greater than 1.2 and round to 1.2 to 1 decimal place

b are less than 1.2 and round to 1.2 to 1 decimal place.

4 A restaurant bill comes to $62.49. Stefan shares the bill between himself and his two friends.

a How much does each person have to pay?

b If they round each share to the nearest dollar, by how much will they overpay in total?

5 Round 2 h 40 min to the nearest hour.

6 The population of France in January 2023 was reported to be 68.04 million. Round this to

a the nearest million

b the nearest hundred thousand.

Stretch zone

7 Freja needs 1272 cm of fences to go all the way around her garden. Fence sections are 1 m wide. How many fence sections should she buy?

8 Meena thinks of a number. She rounds it to the nearest 1000 and gets 8000.

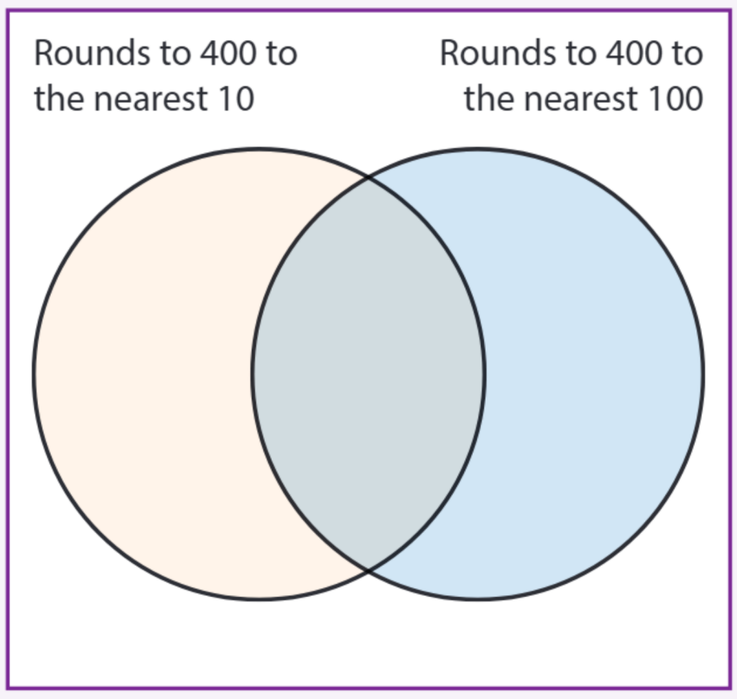
a Write three possible numbers Meena could have thought of.

b What is the smallest number Meena could have thought of?

1.1 Expert practice

There may be more than one way to look at these questions. Once you have answered a question one way, can you think of another way?

1 Copy and complete the Venn diagram with a number that fits each section. If any section is impossible to fill, explain why.



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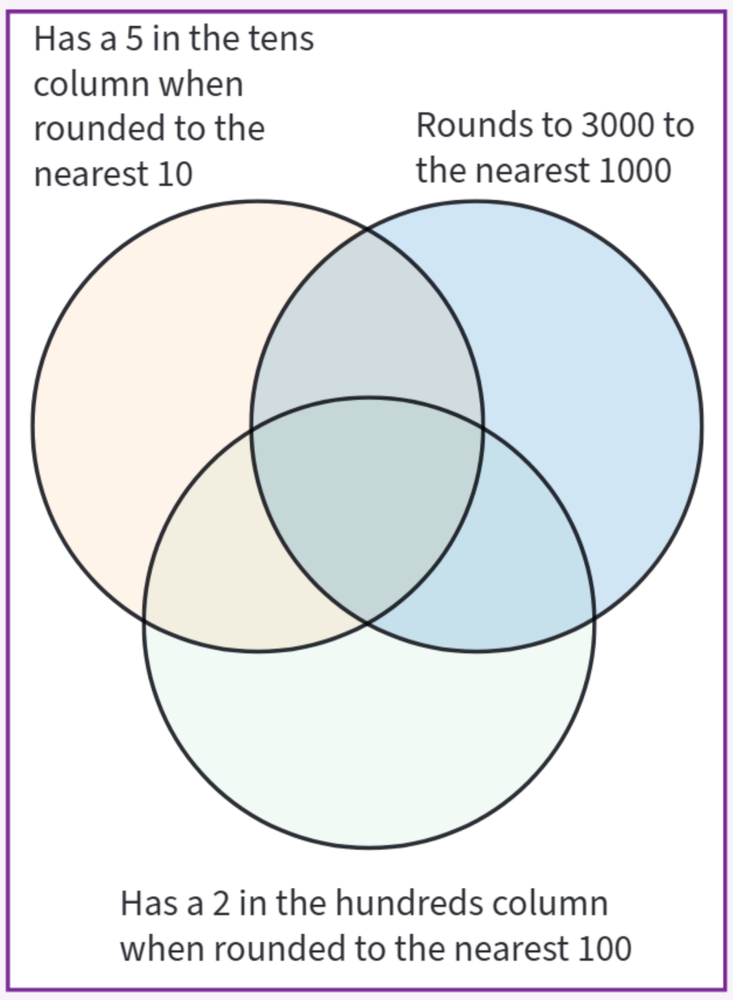


3 A survey shows that $\frac{48}{100}$ of people in a school have brown hair. Ava writes a report for the school newspaper which says, 'Around half of people in the school have brown hair.'
Do you agree?

4 Drink A contains 12.23 g of fruit. Drink B contains 11.9 g of fruit. Derek tells his friend that they both contain about the same amount of fruit. How has Derek reached this conclusion?

5 Write a number that:

a when rounded to the nearest 10 and to the nearest 100, gives the same answer
b when rounded to the nearest 10, to the nearest 100, and to the nearest 1000, gives the same answer
c when rounded to the nearest 100 is ten more than when rounded to the nearest 10.

6 Round 1260.1 to the degree of accuracy given.

a nearest even number
b nearest odd number
c nearest 5
d nearest 10
e nearest 500
f nearest 5000

7 There are different ways to round negative numbers. One way is called 'symmetric rounding'. In this type of rounding, 1.5 rounds up to 2, but −1.5 rounds down to −2, so what happens to positive numbers is the mirror image of what happens for negative numbers.

Round these numbers to the nearest integer using symmetric rounding.

a −3.1 **c** −7.5 **e** −0.8

b −10.9 **d** −0.3

Stretch zone

8 Write a word problem about a context where it only makes sense to round down. Explain why this is the case.

1.2 Rounding to significant figures

1.2.1 What is a significant figure?

After this topic, you will be able to:

- understand significant figures.

Key idea

Significant figures start at the first non-zero digit.

Key words

non-zero, significant figure, placeholder

The first **non-zero** digit in a number is called its first **significant figure**. In each of these numbers, the first significant figure is circled.

②546	③40	0.⑨2	0.000①75	①2.0348
The first non-zero digit is 2. Its value is 2000.	The first non-zero digit is 3. Its value is 300.	The first non-zero digit is 9. Its value is 0.9.	The first non-zero digit is 1. Its value is 0.0001.	The first non-zero digit is 1. Its value is 10.

You can see that the value of the first significant figure can be different, depending on the size of the number. With some decimals, there are zeros before the first significant figure. They keep the first significant figure in the correct column. For example, the number 'three hundredths' needs the digit 3 in the second decimal place, 0.03. Without the zeros in the ones and tenths columns, the 3 would have a different value.

Worked example	Thinking	Your turn!
Copy each number and circle the first significant figure. Write the value of the significant figure. **a** 38 024 **b** 0.007 91		**Copy each number and circle the first significant figure. Write the value of the significant figure.** **a** 260 512 **b** 0.000 104
a ③8 024 The value of the 3 is **30 000**.	*Where is the first non-zero digit in the number?* I can see that in this integer it is the first digit.	

Worked example	Thinking	Your turn!
b 0.00(7)91 The value of the 7 is 0.007.	*Where is the first non-zero digit in this decimal number?* I can see that the first non-zero digit is in the thousandths place.	

In a decimal number, once the significant figures have started, all digits are significant, including zeros. This number has four significant figures:

Stretch zone

Zero is the reason we can write numbers efficiently. Investigate Roman numerals, Arabic numerals, and the history of zero to find out more about this incredibly useful digit.

Worked example	Thinking	Your turn!
How many significant figures are there in each number? **a** 0.004 795 **b** 0.010 503	*Which digits are significant, and which are **placeholders**?* I know that the first non-zero digit is the first significant figure. All the zeros before that are placeholders.	**How many significant figures are there in each number?** **a** 0.0103 **b** 0.0069
a There are 4 significant figures: 4, 7, 9, and 5.		
b There are 5 significant figures: 1, 0, 5, 0, and 3.		

Fluency questions

1 Copy each number and circle the first significant figure.

a 1002
b 20 305
c 0.5024
d 1.0031
e 542
f 0.004 005 006

2 How many significant figures are there in each of these numbers?

a 604
b 101 207
c 1.204
d 0.045 789
e 0.006
f 0.020 04

Stretch zone

3 Copy each number and underline the zeros that count as significant figures.

a 3051
b 500 401
c 0.0204
d 0.003 008
e 0.100 000 000 002

1.2.2 Rounding integers to significant figures

After this topic, you will be able to:

- round integers using significant figures.

Key idea

Depending on the value of the digits, rounding to a number of significant figures can be the same as rounding to the nearest 1, 10, 100, 1000 or more.

Significant figures allow us to round different numbers to the same degree of accuracy without losing an idea of the size of those numbers. For example:

- If you round 3700 and 420 both to the nearest thousand, you get 4000 and 0.
- However, if you round 3700 and 420 both to one significant figure, you get 4000 and 400. It is now easier to compare their size.

In the number 1285, the first significant figure is '1', worth 1000. To round to one significant figure, use the digit in the next column. The digit is less than 5, so round down and write $1285 \approx 1000$ (to 1 s.f.) where 's.f.' stands for 'significant figure'.

You need to write the three zeros to make sure that the 1 stays in the thousands column. This means that the zeros are placeholders and are not significant figures.

To round 1285 to two significant figures, look at the first two significant figures. Then use the 8 in the tens column to round up, giving $1285 \approx 1300$ (to 2 s.f.).

To three significant figures, you have $1285 \approx 1290$, since the 5 in the ones column tells you to round up.

Worked example	**Thinking**	**Your turn!**
Round: **a** **45 680 to 2 significant figures** **b** **987 to 1 significant figure.**	*What are the first two significant figures and what is their value?* They are 4 and 5, and their values are 40 000 and 5000.	**Round:** **a** **8397 to 2 significant figures** **b** **96 420 to 1 significant figure.**
a $45\,680 \approx 46\,000$ (to 2 s.f.)	*How do we decide whether to round up or down?* I look at the next digit. It is 6, so I round up.	

Worked example	Thinking	Your turn!
b 987 ≈ 1000 (to 1 s.f.)	*What is the first significant figure and what does the next figure tell us?* It is 9 with a value of 900. The next figure, 8, is more than 5 so I need to round up. *How many placeholders will we need?* Rounding up takes me to 1000, with three placeholders.	

If you are given a rounded number ending with a zero, and you know the degree of accuracy, you can say which digits are significant and which are just placeholders.

Worked example	Thinking	Your turn!
A number is rounded to give 6000 to 3 s.f. **Which digits are not significant figures?**	*How many digits are significant and what does that leave us with?* The number was rounded to 3 s.f., so the first three digits are significant. That leaves me with one zero placeholder.	**A number is rounded to give 30 000 to 3 s.f.** **Which digits are not significant figures?**
600Ⓞ		

As you can see from the worked example, you cannot always tell how many significant figures a number has unless you know the degree of accuracy of the rounding.

Fluency questions

1 Round each number to the given number of significant figures.

a 427 (1 s.f.)
b 6325 (2 s.f.)
c 12 478 (4 s.f.)
d 854 362 (2 s.f.)
e 7891 (1 s.f.)
f 78 532 (2 s.f.)
g 432 576 (3 s.f.)
h 1 697 431 (5 s.f.)

2 Round each number to the given number of significant figures.

a 309 (2 s.f.)
b 4099 (2 s.f.)
c 5099 (3 s.f.)
d 70 999 (2 s.f.)
e 810 999 (4 s.f.)
f 709 900 (3 s.f.)
g 1 909 999 (1 s.f.)
h 32 999 990 (5 s.f.)

Stretch zone

3 A number has been rounded to 750.

How many significant figures were used?

4 A number has been rounded to 8500.

Ben says that the number has been rounded to 2 significant figures.
Anushka says that the number has been rounded to 3 significant figures.
Give examples of numbers to show that both Ben and Anushka could be correct.

1.2.3 Rounding decimals to significant figures

After this topic, you will be able to:

- round decimals using significant figures.

Key idea

Depending on the value of the digits, rounding to a number of significant figures can be the same as rounding to the nearest 0.1, 0.01, 0.001, or smaller.

As with integers, rounding decimals to significant figures can mean different things depending on the size of the number. If the first significant figure is in the tenths column, then rounding to one significant figure will be the same as rounding to one decimal place. If the first significant figure is in the thousandths column, it will be the same as rounding to three decimal places.

To round 0.004 502 to one significant figure, find the first significant figure, which is 4. Then look in the next column and round up or down using the normal rules of rounding. Since the digit in the next column is 5, round up to get $0.004\,502 \approx 0.005$ (to 1 s.f.).

To round to three significant figures, find the first three significant figures, which are 4, 5, and 0. The next digit is 2, which tells you to round down, giving $0.004\,502 \approx 0.004\,50$ (to 3 s.f.).

You must write the final 0, as you need to write three significant figures.

Worked example	Thinking	Your turn!
a Round 0.003 712 to 1 significant figure.	*What is the first significant figure?* The first significant figure is 3.	**a Round 0.000 0724 to 1 significant figure.**
$0.003\,712 \approx 0.004$ (to 1 s.f.)	*Do we need to round it up or down?* Since it is followed by a 7, I need to round it up.	
b Round 0.080 25 to 2 significant figures.	*How many significant figures do we need to write in our answer?* I need to write two significant figures. They will be 8 and 0.	**b Round 0.001 042 to 2 significant figures.**
$0.080\,25 \approx 0.080$ (to 2 s.f.)		

You can work out what a number could have been before it was rounded.
For example:
If you are given 0.7 as a number that has been rounded to one significant figure, the least that the unrounded number could have been is 0.65, as 0.65 is the least number that rounds up to 0.7. The unrounded number could not have been as great as 0.75, because 0.75 is the least number that rounds up to 0.8.

Worked example	Thinking	Your turn!
A number is rounded to 0.0023 to 2 significant figures. **What is the least the number could have been?**	*What numbers would round up to 0.0023?* I know that any number from 0.002 25 to 0.0023 would round up to 0.0023.	**A number is rounded to 0.08 to 1 significant figure.** **What is the least the number could have been?**
The least number that rounds up to 0.0023 to 2 s.f. is 0.002 25.	*What numbers would round down to 0.0022?* Any number below 0.002 25 would round down to 0.0022.	

Fluency questions

1 Round each number to 1 significant figure.

a 0.084
b 0.006 410
c 5.987 21
d 0.000 002 912
e 5.785
f 15.9032
g 1300.058
h 29 614

2 Round each number to the given number of significant figures.

a 0.0157 (2 s.f.)
b 0.007 849 (3 s.f.)
c 1.087 546 (2 s.f.)
d 145.097 (4 s.f.)
e 0.010 005 00 (2 s.f.)
f 1200.078 (3 s.f.)
g 19 043.521 (5 s.f.)
h 430 510.55 (3 s.f.)

Stretch zone

3 A decimal is rounded to 3 significant figures to give 0.0645.
What could the starting decimal have been?
Give an example with 5 decimal places.

1.2 Intelligent practice

In each question, you might notice something when you move from one question part to the next. What is different between each question part (e.g. **1b**) and the one that came before (e.g. **1a**)? Decide how you expect the answer to be different. Then work through the question and check your answer. Think about why your prediction was right or wrong.

1 Round each number to 1 significant figure.

a 24 320
b 2432
c 243.2
d 24.32
e 27.32
f 2.732
g 0.2732
h 0.20732
i 0.020732
j 0.0020732

2 Copy and complete the table by rounding each number to 1, 2, and 3 significant figures.

When you have rounded, underline the significant figures in the answer.

		To 1 s.f.	To 2 s.f.	To 3 s.f.
a	5227			
b	5727			
c	5927			
d	6927			
e	8927			
f	9927			
g	9997			

3 Copy and complete the table by rounding each number to 1, 2, and 3 significant figures.

When you have rounded, underline the significant figures in the answer.

		To 1 s.f.	To 2 s.f.	To 3 s.f.
a	0.5227			
b	0.057 27			
c	0.005 927			
d	0.000 6927			
e	0.000 089 27			
f	0.000 009 927			
g	0.000 000 9997			

4 Round each number to the degree of accuracy given.

a 0.99 (to 1 s.f.)
b 0.999 (to 2 s.f.)
c 0.9999 (to 3 s.f.)
d 0.999 99 (to 4 s.f.)
e 0.099 999 (to 4 s.f.)
f 0.099 97 (to 3 s.f.)
g 0.0995 (to 2 s.f.)
h 0.093 (to 1 s.f.)

5 A number has been rounded to 900 000.
What is the smallest number it could be if the rounding is to:

a 1 significant figure
b 2 significant figures
c 3 significant figures
d 4 significant figures
e 5 significant figures?

1.2 Which method?

In these questions, you will need to think carefully about which methods to apply.
For some questions, you might need to use skills from Student Book 7.

1 Round each number to the degree of accuracy given.

- **a** 493 (to the nearest 10)
- **b** 493 (to the nearest 100)
- **c** 493 (to 1 significant figure)
- **d** 0.057 65 (to 1 significant figure)
- **e** 0.057 65 (to the nearest hundredth)
- **f** 0.057 65 (to 4 decimal places)

2 **a** Round 4560 to

- **i** the nearest 1000
- **ii** 1 significant figure.

b Explain why your answers are the same.

3 **a** Round 0.0623 to

- **i** 1 decimal place
- **ii** 1 significant figure.

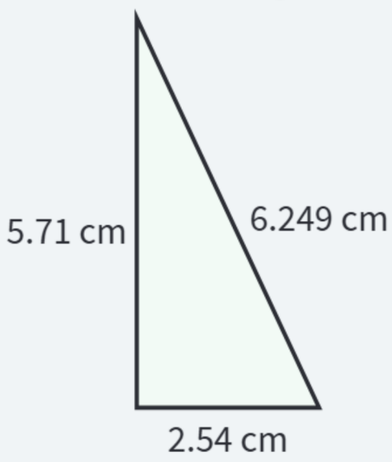
b Explain why your answers are different.

4 The Burj Khalifa tower in Dubai is 829.8 m tall.

- **a** Round 829.8 m to 1 significant figure.
- **b** Round 829.8 m to 2 significant figures.
- **c** Which is the most suitable approximation for the height of the Burj Khalifa: 1 significant figure or 2 significant figures? Explain your reasoning.

5 Martha measures the length of a tiny insect as 0.0352 cm. If she wants to approximate this number, should she round it to 1 decimal place or 1 significant figure? Explain your reasoning.

6 Here is a triangle.



Work out the perimeter of the triangle. Give your answer to 2 significant figures.

7 Round fifty-six thousand two hundred and three to 3 significant figures.

8 Underline the placeholders that are not significant figures in each number.

- **a** A number is rounded to 1 significant figure to get 40 000.
- **b** A number is rounded to 2 significant figures to get 40 000.
- **c** A number is rounded to 3 significant figures to get 8700.
- **d** A number is rounded to 2 significant figures to get 0.0037.
- **e** A number is rounded to 3 significant figures to get 0.0562.
- **f** A number is rounded to 3 significant figures to get 0.470.

Stretch zone

9 Write the smallest number that would round to 450 000 to:

- **a** 2 significant figures
- **b** the nearest 10
- **c** 3 significant figures
- **d** the nearest integer.

1.2 Expert practice

There may be more than one way to look at these questions. Once you have answered a question one way, can you think of another way?

1 Write a number that works in each question.

a When rounded to the nearest 10 and to 1 significant figure, the answer is the same.

b When rounded to the nearest 10 and to 2 significant figures, the answer is the same.

c When rounded to 1 decimal place and to 2 significant figures, the answer is the same.

d When rounded to 2 significant figures and to 1 significant figure, the answer is the same.

2 **a** Give an example of a number that when rounded to the nearest 100 and to 2 significant figures, the answer is the same.

b Give another example.

c Give an interesting example.

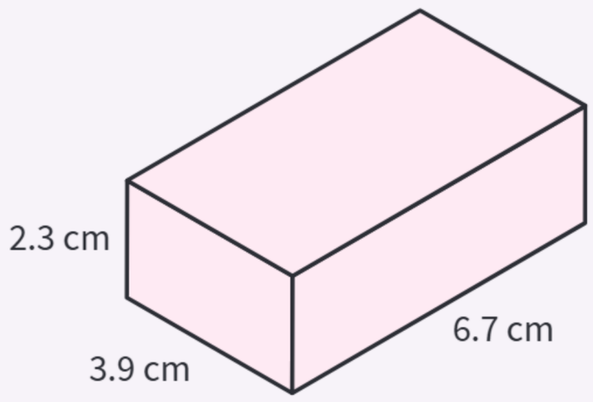
d Give a number that someone might think gives the same answer when rounded to the nearest 100 and to 2 significant figures, but you know it does not.

3 A newspaper says that the population of a town is 45 000. The actual population has been rounded to 2 significant figures to give this.

a What is the smallest possible number of people in the town?

b What is the largest possible number of people in the town?

4 Here is a cuboid.

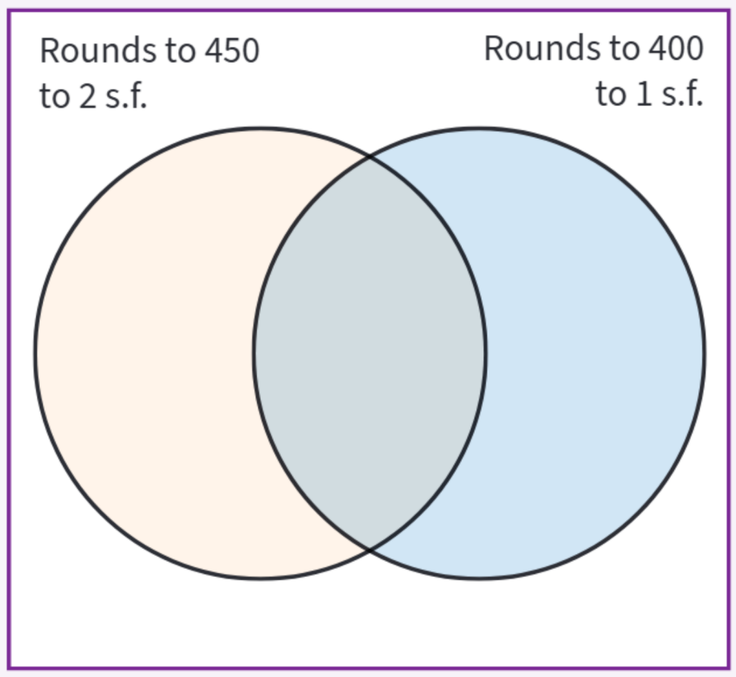


Work out the volume of the cuboid by multiplying together the length, width, and height. Round your answer to a degree of accuracy that you think is sensible, and explain why you chose this rounding.

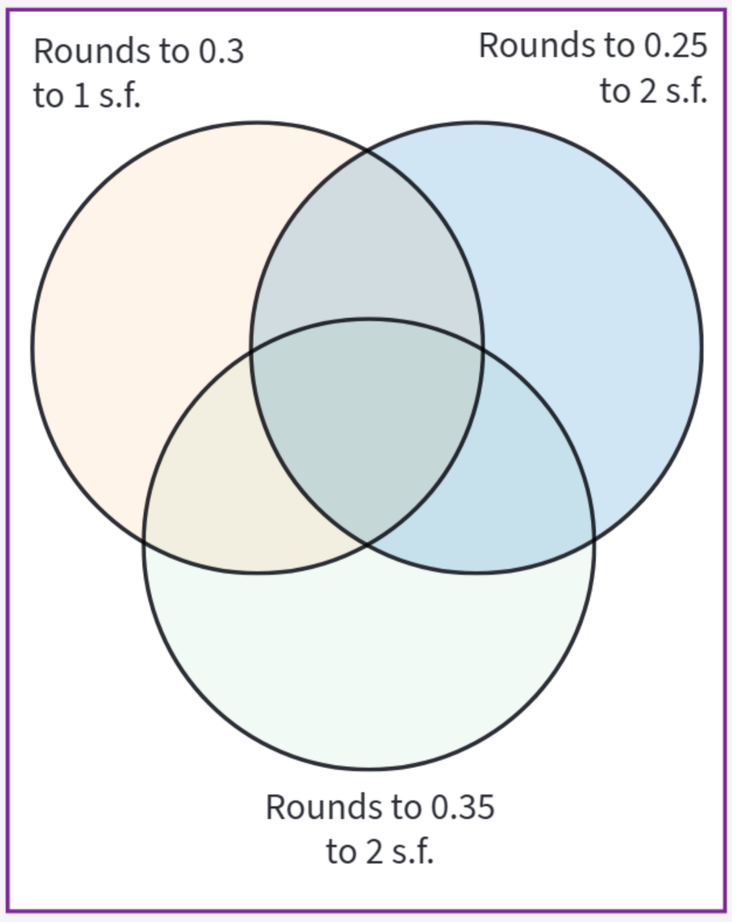
5 Write the product of 54 and 3.6 to 2 significant figures.

6 Write the quotient of 35 and 12.2 to 3 significant figures.

7 Copy and complete the Venn diagram with a number that fits each section. If any section is impossible to fill, explain why.



8 Copy and complete the Venn diagram with a number that fits each section. If any section is impossible to fill, explain why.



9 A tin contains 250 g of beans, correct to 2 significant figures. Which of these amounts could the tin actually contain?

247.2 g	254.1 g	244.9 g
255 g	260 g	245.5 g

1.3 Estimation

1.3.1 Estimating calculations

After this topic, you will be able to:

- understand what is meant by a sensible degree of accuracy
- estimate calculations.

Key idea

A sensible degree of accuracy is a value that is accurate enough for what you need. This depends on what you are trying to communicate or calculate.

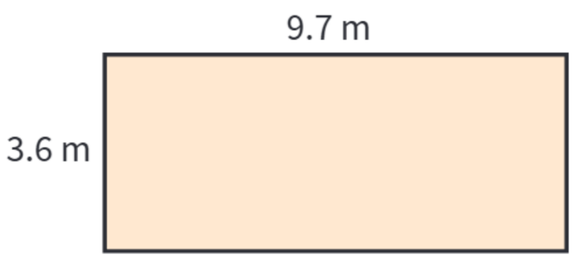
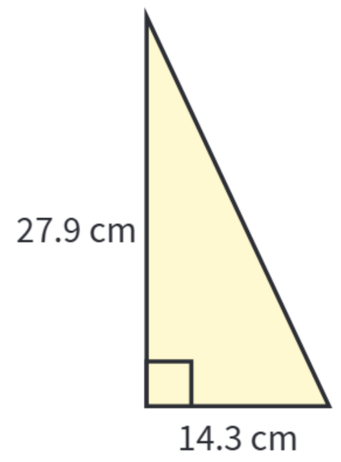
When you measure a person's height, the nearest centimetre is sensible as there is no need to go into millimetres. The nearest metre would not work, as anyone from 50 cm to under 150 cm would be recorded as 1 m tall!

If you are reporting the distance from London to Edinburgh, about 648.24 km, two significant figures, or 650 km, is sensible. If you want to describe the width of an average atom, you could round to one significant figure: 0.3 nanometres.

If you are asked to give the answer to a **calculation** to a 'sensible degree of accuracy' use the numbers in the question as a guide. If they contain two significant figures, write your answer to two significant figures as well.

Key word

calculation

Worked example	Thinking	Your turn!
Calculate the area of this rectangular classroom floor. Give your answer to a sensible degree of accuracy.  	*How do we calculate the area?* I multiply the length and width because it is a rectangle.	**Calculate the area of this triangle. Give your answer to a sensible degree of accuracy.** 
Area $= 3.6 \times 9.7 = 34.92$	*How do we decide how accurate to make our answer?* The numbers in the question have 1 d.p. or 2 s.f. so I could choose either of these.	
$\approx 35\,m^2$ (to 2 s.f.)		