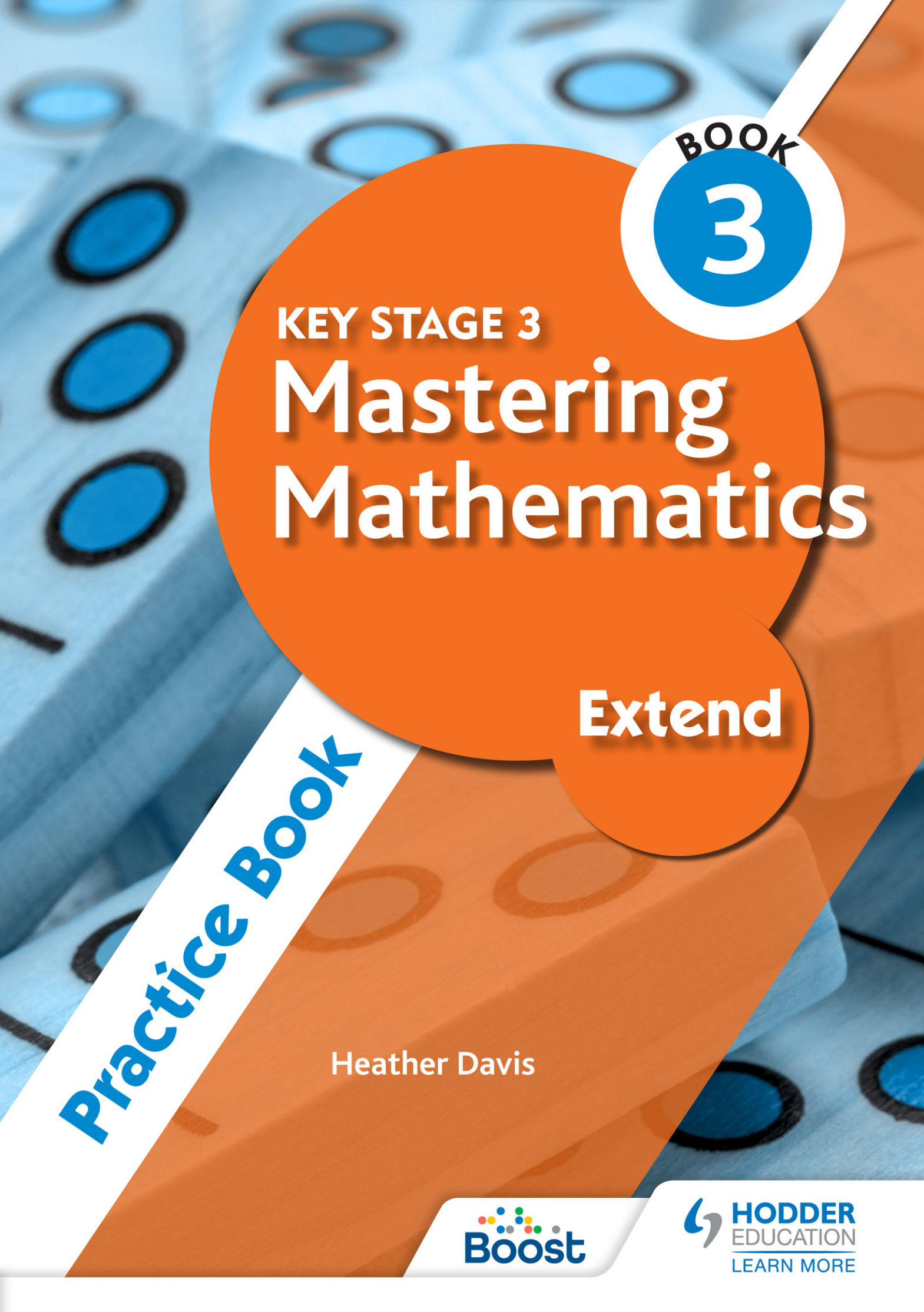
BOOK
3
KEY STAGE 3
Mastering Mathematics
Extend
Practice Book
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Contents

CHAPTER 1

Powers and indices

Fluency Reasoning Problem solving

1.1 Index notation

1 Which is larger, 3^4 or 4^3?
Justify your answer.

2 Work out, leaving your answer in index form:

a $\dfrac{2^{-5} \times 2^{11} \times 2^{-2}}{2^{-7} \times 2^{16}}$

b $\dfrac{5^5 \times 5^{-2} \times 25^2}{125^{-1} \times 5^2}$

c $\dfrac{3^3 \times 9^{-2} \times \frac{1}{3}}{27 \times 3^{-4}}$

3 Work out, leaving your answer in index form:

a $\dfrac{3^4 \times 2^3 \times 2^{-5}}{3^7 \times 2^{-2}}$ b $\dfrac{9^{-2} \times 2^{-2} \times 4^{-2}}{3^{-6} \times 8^{-2}}$

4 Write down the reciprocal of 4^{-1}.

5 Kilo means 10^3. What power of 2 is nearest to 10^3?

6 Tera means 10^{12}. What power of 2 is nearest to 10^{12}?

7 Use the numbers 3, 3, 4, 4, 5, 6, once each, and the four operations +, −, ×, ÷ as well as powers, to make the number 1000.

8 Use the digits 1 to 4, once each, in the boxes to make the largest possible answer.

□□ × □□

9 a Work out $2^{0.2} \times 2^{0.2} \times 2^{0.2} \times 2^{0.2} \times 2^{0.2}$.

b What do you call $2^{0.2}$?

The cube root of a number is the number that is raised to the power of 3 to get the original number.
e.g. $5^3 = 125$ so the cube root of 125 is 5.

10 Work out the cube root of 4^6.

11 Is it always, sometimes, or never true that $x^n = x$?
Justify your answer.

12 Use the digits 3 to 6, once each, in the boxes to make the smallest possible answer.

□□ + □□

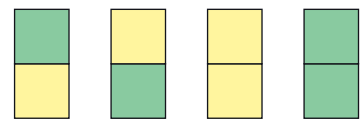
13 Use the digits 2 to 7, once each, in the boxes to make a number as close as you can to 2000.

□□ + □□ + □□

14 Use the digits 1 to 9, once each, in the boxes to make a true statement.

□□□ = □ × □ × □

15 Towers are made with yellow and green blocks.
There are 4 ways to do this for towers that are 2 blocks tall.



a How many ways can you make towers that are 3 blocks tall?

b How many ways can you make towers that are 4 blocks tall?

c How could you work out the number of ways to make towers that are 5 blocks tall?

d What difference does it make if you have blocks of 3 different colours?

1.2 Standard form

1 The distance to the nearest star from Earth, Proxima Centauri, is 40 trillion km. Ollie converts the distance to metres.
He calculates $40 \times 10^{12} \times 10^3 = 40 \times 10^{15}$.

a Explain why his answer is not in standard form.

b Write his answer in standard form.

2 The diameter of a hydrogen atom is 0.000 000 000 12 m.
Write its radius in standard form.

Remember
The circumference of a circle with radius, r, is $2\pi r$.

3 Saturn is 1.434×10^9 km from the Sun.
How far does it travel in one orbit?
Use $\pi = 3.14$ and write your answer in standard form.

4 Jack works out $(3.2 \times 10^{-3}) \div (4 \times 10^{7})$.
He says the answer is 80 000.
Explain why Jack is wrong.

5 Fill in the missing numbers.

$3 \times 10^{\square} \times \square \times 10^{12} = 4.2 \times 10^{-6}$

6 Fill in the missing numbers.

$3.6 \times 10^{\square} \div (\square \times 10^{-5}) = 7.2 \times 10^{9}$

7 There are 8×10^{8} grains of sand in a cubic metre.
A cubic metre of sand weighs 1.6×10^{3} kg.
What is the mass, in grams, of one grain of sand?

8 An adult human contains approximately 3.9×10^{13} bacteria.
The mass of an adult human is 78 kg.
Estimate how many bacteria there are in each gram of a human body.

9 The diameter of the nucleus of a cell is 5×10^{-6} m.
The cell is approximately circular in shape.
Estimate the area of the cell.
Use $\pi = 3.14$ and write your answer in standard form.

Remember
The area of a circle with radius, r, is πr^2

10 An atom has a diameter of 3.2×10^{-10} m.
A neutron has a diameter of 1.6×10^{-15} m.
How many neutrons fit in a line across one atom?

11 A drop of water has volume 0.05 cm^3.
A virus has a radius of 10^{-6} cm.
Estimate how many viruses have the same volume as a drop of water?
You may assume that the virus is spherical.
Use $\pi = 3.14$ and write your answer in standard form.

Remember
The volume of a sphere with radius, r, is $\frac{4}{3}\pi r^3$

12 The speed of light is 3×10^{8} m s^{-1}.
A light year is how far light travels in a year.
a Work out how far a light year is in kilometres.
b Draw a graph to convert light years to km from 0 to 20 light years.

13 The radius of the planet Uranus is 2.5×10^{7} m.
Work out the volume of the planet Uranus.
Use $\pi = 3.14$ and write your answer in standard form.

14 The radius of the Sun is 6.96×10^{5} km.
The Sun and Earth are modelled as spheres.
a Work out the volume of the Sun.
Use $\pi = 3.14$ and write your answer in standard form.
b The volume of the Earth is 1.08×10^{12} cubic kilometres.
Estimate how many Earths would fit in the Sun.

15 Simon draws a scale drawing of the Sun in relation to its distance from the orbit of each planet.
The distances are:

Planet	Distance from Sun in km
Mercury	5.8×10^{7}
Venus	1.1×10^{8}
Earth	1.5×10^{8}
Mars	2.2×10^{8}
Jupiter	7.8×10^{8}
Saturn	1.4×10^{9}
Uranus	2.9×10^{9}
Neptune	4.5×10^{9}

The scale drawing should fit on a piece of paper 50 cm long.
a What scale do you advise Simon to use?
b Add a column to the table to show the distances on the scale drawing.

1.3 Prime factorisation

Remember
A prime factor is a factor that is a prime number.

1 What is the smallest number with 4 different prime factors?

2 What is the smallest number with 4 prime factors?

3 **a** Write down the prime factorisation of 400.
b Split the prime factors into two identical groups.
c Multiply the numbers in one of the groups.
d What is the relationship of your answer to **c** to 400?

4 **a** Write down the prime factorisation of 5832.
b Split the prime factors into three identical groups.
c Multiply the numbers in one of the groups.
d What is the relationship of your answer to **c** to 5832?

5 Find the highest common factor of 84, 108 and 360.

6 Find the lowest common multiple of 84, 108 and 360.

7 Two numbers have a highest common factor of 3 and a lowest common multiple of 30.
The larger number is not a multiple of the smaller number.
What are the two numbers?

8 Kris has 3 sets of lights on his Christmas tree.
One set flashes every 12 seconds, another set flashes every 13 seconds, and the third set flashes every 17 seconds.
They start by all flashing together.

a How long is it before they all flash together again?

b Are there any times when only two sets flash together? If so, when are they?

9 Three numbers have a highest common factor of 4 and a lowest common multiple of 420.
None of the numbers are a multiple of any of the other numbers.
Any pair of the numbers also has 4 as the highest common factor.
Find the three numbers.

10 $12 = 2 \times 2 \times 3$.
Show how you can use the prime factorisation of 12 to find all of the factors of 12.

11 Which number, less than 100, has the greatest number of prime factors?

12 Which number, less than 100, has the greatest number of different prime factors?
Find all possible answers.

13 Which number, less than 100, has the greatest number of different factors?
Find all possible answers.

14 Use the prime factorisation of 360 to work out all of the factors of 360.

15 Liz says, '720 must have twice as many factors as 360 as it is twice as big.'
Explain why Liz is wrong.

CHAPTER 2

Fractions

Fluency | Reasoning | Problem solving

2.1 Fractions review

1 Find the missing numbers.

a $\frac{2}{3} = \frac{\square}{18}$

b $\frac{3}{5} + \frac{\square}{\square} = \frac{37}{45}$

c $\frac{\square}{4} - \frac{3}{7} = \frac{9}{28}$

d $\square \times \frac{2}{11} = \frac{10}{11}$

e $\frac{\square}{\square} \div 2 = \frac{3}{14}$

f $\frac{2}{15} \times \frac{5}{8} = \frac{1}{\square}$

g $21 \div \frac{1}{3} = \square$

h $\frac{\square}{\square} \div \frac{2}{3} = \frac{9}{8}$

2 Amelia and Ruby share some money in the ratio 2:5.

a What fraction of the money does Ruby get?

b What fraction of the amount Ruby gets, does Amelia get?

3 What fraction is halfway between $\frac{2}{7}$ and $\frac{3}{4}$?

4 Write down the missing numbers in the sequence.

$\frac{1}{3}, \frac{5}{12}, \frac{1}{2}, \frac{\square}{\square}, \frac{\square}{\square}, \frac{3}{4}$

5 Copy and complete the addition table.

The fractions in the top row and first column (in bold) are added.

The answer goes in the cell in the table corresponding to that row and column.

+	$\frac{1}{7}$			$\frac{3}{5}$
$\frac{3}{5}$			$\frac{37}{45}$	
		$\frac{11}{12}$		$\frac{17}{20}$
$\frac{1}{8}$				
	$\frac{41}{42}$	$\frac{3}{2}$		

6 a Round 2.5 to the nearest whole number.

b What is the error in the answer to **a** as a fraction?

7 A rectangle measures $\frac{3}{4}$ m by $\frac{5}{6}$ m.
Work out its area in m^2.

8 A fish weighs $\frac{3}{5}$ of its mass plus 2.4 kg.
What is the mass of the fish?

Use this set of fractions for questions 9 to 11.

$\frac{2}{3}, \frac{1}{5}, \frac{7}{9}, \frac{3}{8}, \frac{5}{6}$

9 Which fraction's reciprocal is a whole number?

10 Which two fractions have a difference of $\frac{1}{18}$?

11 Which three fractions multiply to make $\frac{5}{24}$?

12 Use the digits 1 to 9 to make a fraction equivalent to $\frac{1}{9}$.

13 Rudi says, 'I have $\frac{2}{3}$ of the votes cast in this election.'
There are 36 000 votes altogether.
How many votes does Rudi have?

14 What number, added to the numerator and denominator, makes $\frac{5}{13}$ equivalent to $\frac{1}{2}$?

15 Which is larger? $\left(\frac{2}{3}\right)^4$ or $\left(\frac{3}{4}\right)^2$?
Justify your answer.

2.2 Mixed numbers

1 Fill in the missing numbers.

a $3\frac{\square}{5} = \frac{19}{\square}$

b $\frac{\square}{3} = 5\frac{2}{\square}$

2 $2\frac{3}{4}$ of a number is 66.
What is the number?

3 Joe and Poppy share a pizza in the ratio 3 : 5.

a What fraction of the pizza does Joe get?

b What fraction of Joe's share is Poppy's share?

4 Write down the next two terms in this sequence.

$1\frac{1}{6}, 2\frac{1}{3}, 3\frac{1}{2}, 4\frac{2}{3}, \ldots$

5 Work out the missing terms in the sequence:

$-\frac{3}{4}$, $-\frac{1}{8}$, $\frac{\square}{\square}$, $\frac{\square}{\square}$, $1\frac{3}{4}$

6 What fraction is halfway between $2\frac{1}{6}$ and $5\frac{2}{5}$?

7 Copy and complete the addition table.

+		$\frac{2}{5}$	$3\frac{2}{3}$	
		$1\frac{4}{5}$		2
$\frac{3}{4}$	$1\frac{11}{12}$			
			$8\frac{19}{24}$	
$\frac{5}{6}$				$1\frac{13}{30}$

Use the following fractions for questions 8 to 11.

$1\frac{3}{4}$, $\frac{25}{16}$, $4\frac{1}{3}$, $2\frac{4}{5}$, $\frac{17}{7}$

8 Which fraction has a reciprocal with the digits 1, 3 and 3?

9 Which two fractions have a total that is closest to 5?

10 Which pair of fractions has the smallest difference?

11 Which fraction is third when the fractions are arranged in order?

12 A rectangle measures $2\frac{2}{3}$ m wide and has perimeter $13\frac{2}{3}$ m.
Find the length of the rectangle.

A proper fraction is smaller than 1.

13 Use the digits 1 to 6, once each, to make the largest total.
The fractional parts must be proper fractions.

$\square\ \frac{\square}{\square} + \square\ \frac{\square}{\square}$

14 Use the digits 1, 3, 4, 5, 8, 9, once each, to make a true statement.

$\square\ \frac{\square}{\square} = \frac{\square\ \square}{\square}$

15 Use the numbers $1\frac{3}{4}$, $5\frac{1}{8}$, $\frac{1}{2}$, $\frac{3}{8}$, $2\frac{7}{8}$ and the operations +, − to make $3\frac{1}{2}$.
You may only use each number once.

2.3 Multiplying and dividing mixed numbers

1 Ariel works out $\left(4\frac{1}{3}\right)^2 = 16\frac{1}{9}$.
Explain why Ariel is wrong.

2 Write down the square root of $1\frac{7}{9}$.

Use the following fractions for questions 3 to 6.

$2\frac{1}{4}$, $\frac{21}{8}$, $3\frac{1}{5}$, $2\frac{2}{3}$, $\frac{12}{5}$

3 Which two fractions multiply to make 7?

4 Which two fractions divide to make $\frac{3}{4}$?

5 Which three fractions multiply to make $14\frac{2}{5}$?

6 Which one of the fractions has an exact square root?

7 Write down the missing term in this sequence.

$\frac{3}{5}$, $\frac{4}{5}$, $1\frac{1}{15}$, $\frac{\square}{\square}$, $1\frac{121}{135}$, ...

8 Find the coordinates of the point that is $\frac{1}{4}$ of the way from $\left(1\frac{2}{3}, \frac{5}{6}\right)$ to $\left(3\frac{1}{2}, 2\right)$.

9 Use the numbers $2\frac{3}{4}$, $4\frac{2}{5}$, $\frac{1}{3}$, $\frac{3}{7}$, $1\frac{1}{8}$ and the operations +, −, ×, ÷ to make $1\frac{1}{2}$.
You may use each number only once.

10 $4\frac{5}{7} : N = 3 : 11$. Find N.

11 A rectangle is $3\frac{1}{8}$ m long and $2\frac{1}{5}$ m wide.
Find its area.

12 A rectangle has area 4 m^2.
One of its sides is $1\frac{3}{4}$ m long.
Find the length of the other side.

A product is the result when numbers are multiplied.

13 Use the digits 1 to 6, once each, to make the largest product.
The fractional parts must be proper fractions.

$\square\ \frac{\square}{\square} \times \square\ \frac{\square}{\square}$

14 A triangle has a base that is $6\frac{3}{4}$ cm long and height 6 cm.
A square has the same area as the triangle.
Find the length of the sides of the square.

15 Use the digits 1 to 6, once each, to make the answer $\frac{23}{26}$.

The fractional parts must be proper fractions.

$$\square\ \frac{\square}{\square} \div \square\ \frac{\square}{\square}$$

CHAPTER 3

Accuracy

Fluency Reasoning Problem solving

3.1 Significant figures

Remember

The first non-zero digit in a number is the first **significant figure**.

The first digit after the decimal point is in the first **decimal place**.

1 Use the numbers 3, 4, 5, 6 once each, with one integer in each of the boxes, to make a number that rounds to 7000 to 1 significant figure.
Give both possible answers.

2 Amanda rounds 26 873 to 2 significant figures.
She says the answer is 27.
Explain why Amanda is wrong.

3 **a** Copy and complete by placing 450, 499, 539, 550, 475, 504, in the correct places in the table.

	Numbers that round to 500 to 1 significant figure	Numbers that do **not** round to 500 to 1 significant figure
Numbers that round to 500 to 2 significant figures		
Numbers that do **not** round to 500 to 2 significant figures		

b Explain why one of the cells in the table is empty.

4 Use the numbers 2, 3, 4, 5 once each, in the boxes, to make a number that rounds to 4.3 to 2 significant figures. Give both possible answers.

5 The distance to the nearest star apart from the Sun, Proxima Centauri, is 4.014×10^{10} km.
Write this number correct to 1 significant figure

a in standard form **b** as a number.

6 The distance to the Moon from Earth is 384 400 km.

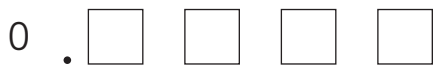
a Round the distance to the Moon to the nearest 10 000 km.

b How many significant figures is the answer to **a** correct to?

7 Is it always, sometimes, or never true that an answer rounded to the nearest million is correct to 1 significant figure?
Justify your answer.

8 Use the numbers 0, 2, 4, 6 once each, in the boxes, to make a number that rounds to 6.0 to 2 significant figures. Give both possible answers.

9 Use the numbers 0, 3, 6, 9 once each, in the boxes, to make a number that rounds to 0.09 to 1 significant figure.



10 The width of a human hair is 5.36×10^{-5} m.
Write this number correct to 2 significant figures

a in standard form

b as a number.

11 **a** Give an example of a number that rounds to 0.0 to 1 decimal place.

b Explain why there is no number that rounds to 0.0 to 1 significant figure.

12 Is it always, sometimes, or never true that an answer rounded to 1 decimal place is correct to 2 significant figures?
Justify your answer.

13 I am a 3-digit number.
When I am rounded to 1 significant figure, I am larger by 9.
When I am rounded to 2 significant figures, my digits add to 11.
What number am I?

14 Jake says, '0.0607 has 2 significant figures.'
Explain why Jake is wrong.

15 I am a number between 0.01 and 0.02 with 3 non-zero digits.
When I am rounded to 2 significant figures, I am 0.001 smaller than when I am rounded to 1 significant figure.
My digits add to 15.
What number am I?

3.2 Approximating

1. John looks at the results of a local election.
He says the percentage of the vote awarded to each candidate is 38%, 39% and 12%.
John declares there has been a mistake as the percentages do not add up to 100.
Why might John be wrong?

2. A rectangle measures 12.84 m by 5.07 m.
Abi thinks the area is 651 m^2.
Use estimation to show that she must be wrong.

3. Estimate the answer to $6.13 \times \sqrt{150} \div 0.834$.

4. Gordon estimates the answer to
$\frac{5}{7} \times \sqrt{200} \times 3.14$ to be 30.
Write out the calculation he did.

5. A kilogram is roughly the same as 2 pounds (lbs).
Estimate how many grams there are in a pound (lb) of jam.

A light year is the distance light travels in one year.

6. The star, Betelgeuse, in the constellation of Orion, is 6.079×10^{15} km from Earth.
A light year is 9.46×10^{12} km.
Estimate how many light years it is from Earth to Betelgeuse.
Give your answer correct to 1 significant figure.

Percentage error is always calculated as a percentage of the true amount when that is possible.

7. The mass of a fish is 3.68 kg.
It is rounded to 1 significant figure.
What is the percentage error in using the rounded figure?
Give your answer to 3 significant figures.

8. An approximate conversion is that there are 4.5 litres in a gallon.
Estimate how many gallons there are in 1000 litres of water.

Remember
Area of a triangle, base b, and height h, is $\frac{1}{2}bh$.

9. The area of a triangle is 1159 cm^2.
Its base is 23.7 cm.
Estimate the height of the triangle, giving your answer correct to 1 significant figure.

Remember
The area of a circle with radius r, is πr^2.

10. A blood cell has diameter 6.73×10^{-6} m.
Estimate the area of the blood cell.

11. A cuboid has sides with length 2.3 cm, 4.8 cm, and 1.9 cm.
   a. Estimate its volume by rounding the side lengths to 1 significant figure.
   b. What is the percentage error in the estimated volume?

The volume of a sphere with radius r, is $\frac{4}{3}\pi r^3$.

12. The radius of the planet Venus is 6.052×10^6 m.
Estimate its volume.

13. The radius of a circular lake is 8.28 km.
   a. Estimate its area in square metres.
   Give your answer in standard form, correct to 1 significant figure.
   b. Is your estimate an under-estimate or an over-estimate?

14. The radius of a hydrogen atom is 5.29×10^{-11} m.
Assume the atom is spherical and estimate its volume.
Give your answer in m^3 and standard form, correct to 1 significant figure.

15. The Romans used 3 as the ratio of the circumference of a circle to its diameter.
What percentage error does this give in calculating the area of a circle?

3.3 Accuracy

1. A number is rounded to 3.04 to 3 significant figures.
Write down the lower and upper bounds for the number.

2. A number is rounded to 65 to the nearest 5.
Use inequality notation to show the range of possible values for the number.

3. Kamala says that 0.9 recurring is the same as 1.
Use the fact that $\frac{1}{3} = 0.3$ recurring to show that she is right.

4. $p = 3$ and $q = 4$ and both have been rounded to 1 significant figure.
   a. Write down the lower and upper bounds for p and q.
   b. Find the lower and upper bounds for $q + p$.
   c. Find the lower and upper bounds for $q - p$.

BOOK 3

KEY STAGE 3

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