STEM: Powers of 10

Guided

1 Complete the place-value table showing the powers of 10.

$\div 10$ $\div 10$ $\div 10$ $\div 10$ $\div 10$ $\div 10$

....	100	10	1	.	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1000}$	$\frac{1}{10000}$	....
....	$10 \cdots$	$10 \cdots$	10^0	.	10^{-1}	$10 \cdots$	$10 \cdots$	$10 \cdots$	....

$\div 10$ $\div 10$ $\div 10$ $\div 10$ $\div 10$ $\div 10$

> Each of the headings in the place-value table is a power of 10. This is because we have a decimal system (*dec* = 10).

2 a The tables show the prefixes for powers of 10. Complete the tables.

Prefix	Letter	Power	Number
tera	T		1 000 000 000 000
giga	G	10^9	1 000 000 000
mega	M		1 000 000
kilo	k	10^3	
deci	d	10^{-1}	0.1

Prefix	Letter	Power	Number
centi	c	10^{-2}	
milli	m		0.001
micro	µ	10^{-6}	
nano	n		0.000 000 001
pico	p	10^{-12}	

b How many times bigger is

i a gigawatt than a megawatt ....

ii a megametre than a metre ....

iii a kilometre than a decimetre ....

iv a centimetre than a nanometre? ....

> Some powers of 10 have a name called a prefix. Each prefix is represented by a letter. The prefix for 10^6 is mega (M) as in megabyte (MB).

Literacy hint

The prefix for micro is the Greek letter µ, pronounced 'mu'.

3 STEM The table shows information about different planets.

Guided

Name of planet	Diameter of planet (km)	Average distance from Sun (km)
Earth	$1.28 \times 10^4 = 12\ 800$	$1.5 \times 10^8 = $ ....
Mars	$6.8 \times 10^3 = $	$2.28 \times 10^8 = $ ....
Jupiter	$1.43 \times 10^5 = $	$7.79 \times 10^8 = $ ....

a Complete the table, writing the distances as ordinary numbers.

b Which of these planets has the greatest diameter? ....

c Which of these planets is closest to the Sun? ....

> First write 10^4 as an ordinary number.
> $1.28 \times 10^4 =$
> $1.28 \times 10\ 000 = \square$

4 STEM / Problem-solving A jumbo jet has a maximum take-off mass of 3.3×10^5 kg. How many tonnes is this?

> 1 tonne = 1000 kg

5 STEM / Reasoning Mycoplasma are the smallest living cells yet discovered. They can be as small as 1.5 micrometres in diameter. What is this diameter in millimetres?

Check Tick each box as your **confidence** in this topic improves. ☹ 😐 ☺

Need extra help? Go to page 6 and tick the box next to Q1. Then try it once you've finished 1.1–1.5.

1

Guided

1 Evaluate (work out the value of) these.

a $\dfrac{2 \times 5^6}{5^4} = 2 \times 5^{\cdots} = 2 \times \ldots\ldots = \ldots\ldots$

> Simplify the powers of 5, then multiply by 2.

> You can simplify expressions containing powers to make calculations easier.

b $\dfrac{2^3 \times 4^9}{4^8}$ .... c ....

2 **Problem-solving** Work out $\dfrac{8 \times 2^{10} \times 5 \times 32}{2^6 \times 16 \times 2^7}$

> **Strategy hint**
>
> Write as many numbers as possible as powers of 2.

3 Sort these cards into matching pairs.

| $19 + 3^2$ | $19 - 3^2$ | $19 + (-3)^2$ | $19 - (-3)^2$ |

| $34 - 5^2 - 4^2$ | $34 - (-5)^2 + 4^2$ | $34 - 5^2 + (-4)^2$ | $34 - (-5)^2 - 4^2$ |

4 Round these numbers to the given number of significant figures.

Guided

a 52.5381 (4 s.f.)

52.54

> When the next digit is 5 or above, round the previous digit up. Here the fifth significant figure is an 8, so round the 3 up to 4.

> You can round numbers to a given number of significant figures (s.f.). The first significant figure is the one with the highest place value. It is the first non-zero digit in the number, counting from the left.

b 0.004 721 (3 s.f.)

> The fourth significant figure is 1, so leave the third digit as 2.

c 85 739 (2 s.f.)

> The third significant figure is 7.

$50 \times 300 = \square$

5 Estimate the answer to each calculation by rounding each number to 1 significant figure.

a 54 × 279 .... b 4268 × 37 .... c 487 ÷ 18 ....

6 Estimate the answer to each calculation by rounding each number to 1 significant figure.

a $\dfrac{(3.4 + 5.8)^2}{2.3^3}$

b $\dfrac{(34 - 17)^2}{6.7^2}$

c $\dfrac{5.2 \times 4.7}{(1.8 + 3.4)^2}$

> $\dfrac{(3.4 + 5.8)^2}{2.3^3} \approx \dfrac{(3 + 6)^2}{2^3} = \dfrac{9^2}{8}$
> What number is a multiple of 8 and close to 9^2? Use this to estimate the final answer.

7 **Problem-solving** Prem starts with a whole number.
He rounds it to 2 significant figures. His answer is 430.
Write down the largest and smallest numbers he could have started with.

8 **Real** The table shows the capacities of five football stadiums.

Stadium	Old Trafford	Anfield	Deva	Emirates	Cardiff City
Capacity	75 731	45 522	5376	60 362	26 828

a In the last row in the table, round each capacity correct to 1 s.f.

b Work out an estimate of the range in capacities.

Check Tick each box as your **confidence** in this topic improves.

😟 😐 🙂

□ □ □

Need extra help? Go to page 6 and tick the boxes next to Q2 and 3. Then try them once you've finished 1.1–1.5.

Guided

1 Complete

a $5^{-2} = \dfrac{1}{5^2}$ **b** $\dfrac{1}{2} = 2^{\cdots}$ **c** $7^{\cdots} = \dfrac{1}{49}$

d $\ldots^{-2} = \dfrac{1}{121}$ **e** $3^{-3} = \ldots$ **f** $2^{-5} = \ldots$

g $8^{-1} = \ldots$ **h** $\dfrac{1}{16} = 4^{\cdots} = 2^{\cdots}$ **i** $\dfrac{1}{625} = 25^{\cdots} = 5^{\cdots}$

> A number raised to a negative power is the same as the reciprocal of that number to the power.

2 Write each calculation as a single power.

a $10^7 \times 10^{-4}$ **b** $6^3 \times 6^{-5}$ **c** $3^{-2} \times 3^{-4}$

     $= 10^3$ — $\boxed{10^7 \times 10^{-4} = 10^{7+(-4)}}$

d $5^{-2} \div 5^3$ **e** $9^{-8} \div 9^{-3}$ **f** $(11^{-3})^4$ **g** $(4^{-6})^2$

> The laws of indices still apply with negative numbers.
> $a^m \times a^n = a^{m+n}$
> $a^m \div a^n = a^{m-n}$
> $(a^m)^n = a^{mn}$

3 Write each calculation as

   i a single power

   ii an integer or a fraction.

a $6^5 \times 6^{-3} \times 6^{-4}$ **b** $3^{-5} \times 3^{-1} \div 3^{-9}$ **c** $\dfrac{5^{-4} \times 5^{-7}}{5^{-8}}$

   i ....   **i** ....   **i** ....

   ii ....   **ii** ....   **ii** ....

> **Worked example**

4 Write each calculation as a fraction.

a $\dfrac{1}{5} \times \dfrac{1}{5}$ **b** $\left(\dfrac{5}{8}\right)^2$ **c** $\left(\dfrac{3}{10}\right)^3$

> The brackets show that the whole fraction (the numerator and denominator) is squared or cubed.

5 Write each number as a fraction raised to a power.

a $\dfrac{25}{49}$ **b** $\dfrac{64}{144}$ **c** $\dfrac{81}{100}$

d $\dfrac{9}{121}$ **e** $\dfrac{8}{27}$ **f** $\dfrac{1}{125}$

6 **Problem-solving** Jai eats half a pizza, his dad eats half of what is left and his mum eats half of what is then left. How much pizza remains?
Write your answer

a as a fraction

b as a fraction raised to a power.

Standard form

1 Circle the numbers that are written in standard form.

3.5×10^8 $\qquad$ 2×10^7 $\qquad$ 0.6×10^4

9.9×10 $\qquad$ 73×10^{-8} $\qquad$ 4.306×10^{-9}

> A number written in **standard form** is a number between 1 and 10 multiplied by a power of 10.
> 4.2×10^6 is written in standard form. Using algebra, standard form is $A \times 10^n$ where $1 \leqslant A < 10$ and n is an integer.

2 These numbers are written in standard form.
Write them as ordinary numbers.

a 5×10^3 $\qquad$ **b** 3.7×10^{-4} $\qquad$ **c** 4.9×10^7 $\qquad$ **d** 2.09×10^{-6}

> $5 \times 10^3 = 5 \times 1000 = \square$

3 Write each number in standard form.

Guided

a 35 700
$= 3.57 \times 10^4$

> 3.57 lies between 1 and 10. Multiply by the power of 10 needed to give the original number
> 3.5   7   0   0

b 498

> 1.8 lies between 1 and 10. Multiply by the power of 10 needed to give the original number. The number is less than 1 so the power is negative. This is the same as dividing by a power of 10.

c 7 100 000

d 0.0018
$= 1.8 \times 10^{-3}$

e 0.000 006 35

f 0.000 000 04

> 0.0   0   1   8

4 STEM

a Write each of the distances in the table in standard form.

Object	Average distance from Earth (km)	Average distance from Earth in standard form (km)
Mars	225 000 000	
Our Moon	384 400	
Saturn	1 300 000 000	

Worked example

b Jupiter is at an average distance of 7.87×10^8 km from Earth. Is it closer to Earth than Saturn?

5 Put each set of numbers in order, from smallest to largest.

a 6.4×10^3 $\qquad$ 7.8×10^2 $\qquad$ 2.1×10^4 $\qquad$ 8.52×10^2 $\qquad$ 3.51×10^4

> Write each number in full to help you order them.

b 1.4×10^{-4} $\qquad$ 9.27×10^{-6} $\qquad$ 5.31×10^{-5} $\qquad$ 6.8×10^{-4} $\qquad$ 2.67×10^{-3}

6 STEM Write these sub-atomic particles in order of their mass, largest first.

Particle	electron	neutron	proton
Mass (g)	9.11×10^{-28}	1.675×10^{-24}	1.673×10^{-24}

7 STEM Write the following measurements as ordinary numbers

i in metres $\qquad$ **ii** in millimetres.

> There are 1000 mm in 1 m, so multiply by $10^{\square}$.

a The diameter of a human hair: 1×10^{-4} m $\qquad$ **i** ……………… $\qquad$ **ii** ………………

b The width of a cheek cell nucleus: 5.1×10^{-6} m $\qquad$ **i** ……………… $\qquad$ **ii** ………………

Check Tick each box as your **confidence** in this topic improves.

Need extra help? Go to page 6 and tick the boxes next to Q6–10. Then try them once you've finished 1.1–1.5.

1 Work out each calculation.
Give your answer in standard form.

Guided

a $(1.3 \times 10^4) \times (8 \times 10^5)$

$= 1.3 \times 8 \times 10^4 \times 10^5$

$= 10.4 \times 10^9$

$= 1.04 \times 10 \times 10^9$

$= 1.04 \times 10^{10}$

> Rearrange so that the numbers are together and the powers of 10 are together.

> Calculate the product of the numbers and use laws of indices to simplify the powers of 10.

> Rewrite the answer in standard form, if necessary: $10.4 = 1.04 \times 10^1$

b $(2.85 \times 10^6) \times (4 \times 10)$ **c** $(4.2 \times 10^3) \times (6 \times 10^7)$ **d** $(1.5 \times 10^4)^2$

2 Work out each calculation. Give your answers in standard form.

a $\dfrac{8 \times 10^6}{4 \times 10^2}$ **b** $\dfrac{9 \times 10^7}{3 \times 10^4}$ **c** $\dfrac{1.8 \times 10^5}{6 \times 10}$

> Divide the number parts. Use the laws of indices to divide the powers of 10.

3 Use a calculator to work out

a $(3.58 \times 10^2) \times (7.25 \times 10^5)$ **b** $\dfrac{1.457 \times 10^{12}}{3.1 \times 10^7}$

> **Worked example**

4 **STEM** An optical microscope magnifies objects 1000 times.
A red blood cell has a diameter of 1×10^{-5} m.
How large will it appear in the microscope?
Give your answer in millimetres.

5 Work out each calculation. Give your answers in standard form.

a $3.2 \times 10^5 + 2.47 \times 10^5$ **b** $4.5 \times 10^4 + 2.7 \times 10^3$

c $5.8 \times 10^{-6} - 1.4 \times 10^{-6}$ **d** $2.9 \times 10^{-5} - 6.5 \times 10^{-7}$

> Both numbers need to have the same power of 10 before you can add or subtract them. Alternatively, you can convert from standard form to ordinary numbers first.

6 **STEM** Viruses vary in size from the smallest at 1.7×10^{-9} m to the largest at 1×10^{-6} m.
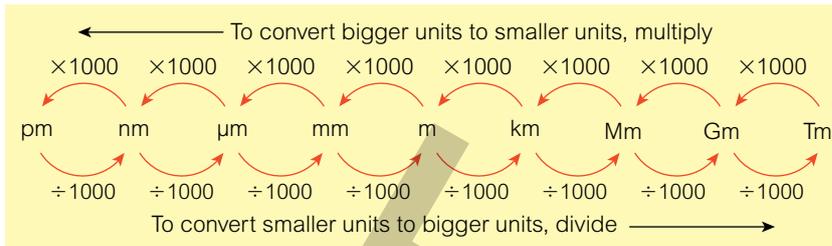What is the range in the sizes of viruses?

Check Tick each box as your **confidence** in this topic improves.

Need extra help? Go to page 6 and tick the box next to Q11. Then try it once you've finished 1.1–1.5.

Powers of 10

☐ **1** Convert

To convert bigger units to smaller units, multiply

×1000 ×1000 ×1000 ×1000 ×1000 ×1000 ×1000 ×1000

pm   nm   μm   mm   m   km   Mm   Gm   Tm

÷1000 ÷1000 ÷1000 ÷1000 ÷1000 ÷1000 ÷1000 ÷1000

To convert smaller units to bigger units, divide →

    a 4.7 Gm to km ....

    b 0.000 53 mm to nm ....

    c 829 000 μm to km ....

    d 0.043 μm to pm ....

Calculating and estimating

☐ **2** Round each number to 1 significant figure.

    a 47.23 ....

    Circle the first significant figure. It's in the 10s column, so round to the nearest 10.

    c 55 500 ....

    b 0.73 ....

    d 0.0184 ....

☐ **3** Estimate the answer to each calculation by rounding each number to 1 significant figure.

    a 365×45 ....

    b $5631 \div 23$ ....

Indices

☐ **4 a i** $4^3 \div 4^8 = 4^{\cdots}$

Guided

    ii $4^3 \div 4^8 = \dfrac{4^3}{4^8} = \dfrac{\cancel{4} \times \cancel{4} \times \cancel{4}}{\cancel{4} \times \cancel{4} \times \cancel{4} \times 4 \times 4 \times 4 \times 4 \times 4} = \dfrac{\square}{\square}$

Which index rule can you use?

Worked example

    iii Use your answers to copy and complete: $4^{-5} = \dfrac{1}{4^{\cdots}}$

    b Complete

    i $5^{-2} = \dfrac{1}{5^{\cdots}}$ **ii** $3^{-4} = \dfrac{1}{3^{\cdots}}$ **iii** $8^{-7} = \dfrac{1}{8^{\cdots}}$ **iv** $7^{-3} = \dfrac{1}{7^{\cdots}}$

☐ **5** Write each calculation as a single power.

Guided

    a $5^3 \times 5^{-7} = 5^{3+(-7)} = 5^{\cdots}$

    b $4^{-2} \times 4^5 = 4^{\cdots + \cdots} = 4^{\cdots}$

    c 7×7^{-6} ....

    d $3^4 \div 3^9 = 3^{\cdots - \cdots} = 3^{\cdots}$

    e $\dfrac{9^2}{9^{-5}}$ ....

    f $(6^{-3})7 = 6^{\cdots \times \cdots} = 6^{\cdots}$

Standard form

☐ **6** Work out

$\overset{\frown}{5.2}$

5 2 0 0

5.2×10^3 means multiply 5.2 by 10 three times.

    a 5.2×10^3 ....

    b 3.8×10^4 ....

    c 9.1×10^2 ....

    d 4.7×10^6 ....

7 Work out

   a 6.5×10^{-3} ....

   b 2.7×10^{-4} ....

   c 8.3×10^{-2} ....

   d 9.4×10^{-6} ....

> 6.5
> 0   0   0   6   5
> 6.5×10^{-3} means divide 6.5 by 10 three times.

8 A number written in standard form looks like this:

$$A \times 10^{n}$$

number between 1 and 10   times sign   power of 10

Guided

Write each number using standard form.

   a $4900 = 4.9 \times 10^{......}$

   b 730 000 ....

   c 51 000 000 000 ....

9 Write each number using standard form.

Guided

   a $0.000\,83 = 8.3 \times 10^{......}$

> 8.3
> 0   0   0   0   8   3
> 8.3 lies between 1 and 10.

   b 0.000 009 7 ....

   c 0.005 ....

   d 0.000 000 004 6 ....

10 Jamila thinks that 3 000 000 000 is more than 3×10^{9}.

   Is she correct? Explain your reasoning.

....

Calculating with standard form

11 Work out each calculation. Give your answers in standard form.

Guided

   a $(2.4 \times 10^{2}) \times (3 \times 10^{5})$

     $= 2.4 \times 3 \times 10^{2} \times 10^{5}$

     $= \ldots\ldots\ldots \times 10^{...}$

   b $(1.8 \times 10^{4}) \times (4 \times 10^{3})$

   c $(5 \times 10^{7}) \times (3.1 \times 10^{2})$

Worked example

   d $\dfrac{8.4 \times 10^{7}}{2.1 \times 10^{2}}$

     $= \dfrac{8.4}{2.1} \times \dfrac{10^{7}}{10^{2}}$

     $= \ldots\ldots\ldots \times 10^{...}$

   e $\dfrac{7.2 \times 10^{5}}{6 \times 10^{8}}$

   f $\dfrac{4 \times 10^{11}}{5 \times 10^{7}}$

1 a 1.03 cm = ... m

  b 3.35 g = ... mg

  c 72.6 ml = ... l

2 In this spider diagram, the four calculations give the answer in the middle.
Work out the missing numbers and complete the diagram.

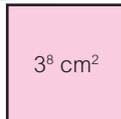7.34×10^3

.... $\div 10^2$

....

$0.0734 \times 10^{\cdots}$

$7\,340\,000 \div 10^{\cdots}$
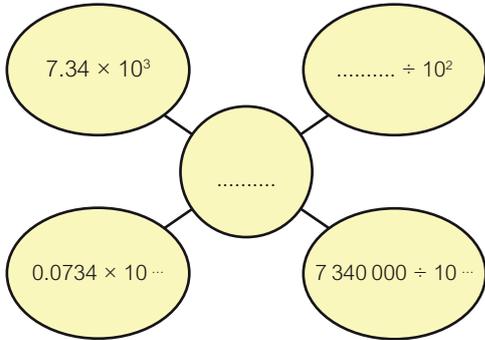
3 By rounding to 1 significant figure, estimate

  a 329 ÷ 96 = ...

  b 57 632 × 208 = ...

  c $\dfrac{62 \times 29}{196}$ = ...

4 Evaluate

  a $16(-2 + 4) + 3(6 - 9)^2$ = ...

  b $\dfrac{8(3)^7}{5 - 3} + 5^2$ = ...

  c $14 - \dfrac{9}{(-2 - 1)^2} + 3 \times 15$ = ...

5 Reasoning The area of a square is 3^8 cm^2.
What is the length of one side?
Write your answer as a power of 3.

3^8 cm^2

....

6 Reasoning

  a Circle the numbers with the same value?

  $(0.2)^3$ $\left(\dfrac{1}{2}\right)^3$ 5^{-3} $\left(\dfrac{1}{5}\right)^3$ 25^{-2}

  b Write $\dfrac{1}{100}$ in as many different ways as you can.

  ....

7 Problem-solving Write these numbers in order, from smallest to largest.

3.17×10^{-4} 0.31×10^{-3} $0.000\,315$ 3106×10^{-7} $\dfrac{6.2 \times 10^{-9}}{2 \times 10^{-5}}$

Strategy hint

Write each number
in standard form first.

8 Work out the reciprocals of these numbers. Give your answers in standard form.

a 2×10^7 **b** 5×10^6 **c** 8×10^{-4} **d** 2.5×10^{-6}

9 Real The populations of Austria, France, Italy, Switzerland and the UK are shown in the table.

a Write these countries in order of population size, from smallest to largest.

Country	Population in 2014
Austria	8.53×10^6
France	6.605×10^7
Italy	6.078×10^7
Switzerland	8.18×10^6
UK	6.41×10^7

b What is the difference between the populations of France and the UK?

c Approximately how many times larger is the population of the UK than that of Austria?

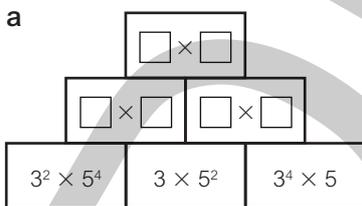**d** What is the total population of these five countries?

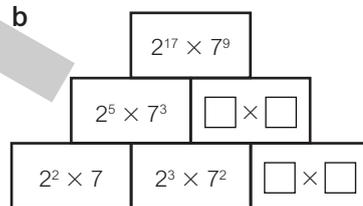The total population of Europe is 7.38×10^8.

e What proportion of Europe's population lives in the UK or France?

10 Problem-solving In these multiplication pyramids, the number in a brick is the product of the two bricks below it.
Work out the missing entries. Write each answer in index form.

a

$$\boxed{\square \times \square}$$
$$\boxed{\square \times \square} \quad \boxed{\square \times \square}$$
$$\boxed{3^2 \times 5^4} \quad \boxed{3 \times 5^2} \quad \boxed{3^4 \times 5}$$

$$\boxed{3^2 \times 5^4 \times 3 \times 5^2 = 3^3 \times 5^6}$$

b

$$\boxed{2^{17} \times 7^9}$$
$$\boxed{2^5 \times 7^3} \quad \boxed{\square \times \square}$$
$$\boxed{2^2 \times 7} \quad \boxed{2^3 \times 7^2} \quad \boxed{\square \times \square}$$

$$\boxed{2^5 \times 7^3 \times 2^{\square} \times 7^{\square} = 2^{17} \times 7^9}$$

11 Reasoning Use your answers from Q10 to help you complete these general rules.

a $a^p \times b^q \times a^r \times b^s = a^{\cdots} \times b^{\cdots}$ **b** $\dfrac{a^p \times b^q}{a^r \times b^s} = a^{\cdots} \times b^{\cdots}$

1 Complete the table using the cards.

Prefix	Letter	Power	Number

μ | nano | milli | d | 0.000 001

0.000 000 001 | m | giga | 10^{-9}

G | T | 10^{12} | deci | 10^{-6}

1 000 000 000 000 | 10^{-3} | 10^{-1} | 1 000 000 000

n | micro | 0.1 | 10^{9} | 0.001 | tera

2 Estimate the answer to these calculations by rounding each number to 1 significant figure.

   a 765×38 ....   **b** $4324 \div 53$ ....

3 Write as a single power.

   a $5^4 \times 5^{-11}$ ....   **b** $8^{-3} \times 8^{-4}$ ....   **c** $(3^{-2})^4$ ....   **d** $\dfrac{6^{-5} \div 6^{-2}}{6^{-1} \times 6^{-3}}$ ....

4 Write each number in standard form.

   a 7900 ....   **b** $0.000\ 008\ 13$ ....

5 The average distance of the Moon from the Earth is 3.84×10^5 km.

Write this distance in metres as an ordinary number.

....

6 Work out each calculation. Give your answers in standard form.

   a $\dfrac{6.3 \times 10^9}{2.1 \times 10^5}$ ....   **b** $(2.4 \times 10^5) \times (5 \times 10^{-11})$ ....

7 A bee has a mass of 1.2×10^{-4} kg. Write down the mass of the bee in grams.

8 A sheet of paper is 5×10^{-5} m thick. How many sheets of paper are there in an 801 cm tall stack of the same paper?