You will learn to:
• Use and understand powers of 10.
• Use the prefixes associated with powers of 10.
• Understand the effect of multiplying and dividing by any integer power of 10.

**Why learn this?**
A byte is a unit of digital information stored on a computer. A megabyte is $10^6$ bytes and a gigabyte is $10^9$ bytes.

**Exercise 1.1**

1 Match each value in the top row to the equivalent value from the bottom row.

<table>
<thead>
<tr>
<th>$10^2$</th>
<th>$10^4$</th>
<th>$10^3$</th>
<th>$10^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>100000</td>
<td>100</td>
<td>10000</td>
</tr>
</tbody>
</table>

2 Work out
   a $4.5 \times 10$
   b $2.36 \times 1000$
   c $0.843 \times 100$
   d $1.45 \times 10000$
   e $270 \div 10$
   f $4685 \div 1000$
   g $35 \div 100$
   h $450 \div 10000$

3 Copy and complete this place-value table.

<table>
<thead>
<tr>
<th>...</th>
<th>10000</th>
<th>1000</th>
<th>100</th>
<th>10</th>
<th>$\frac{1}{10}$</th>
<th>$\frac{1}{100}$</th>
<th>$\frac{1}{1000}$</th>
<th>$\frac{1}{10000}$</th>
<th>...</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td>$\Box$</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>1000</td>
<td>100</td>
<td>10</td>
<td>10</td>
<td>...</td>
</tr>
</tbody>
</table>
This table shows the prefixes for powers of 10.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Letter</th>
<th>Power</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>tera</td>
<td>T</td>
<td>$10^{12}$</td>
<td>1 000 000 000 000</td>
</tr>
<tr>
<td>giga</td>
<td>G</td>
<td>$10^9$</td>
<td>1 000 000 000</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>$10^6$</td>
<td>1 000 000</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^3$</td>
<td>1 000</td>
</tr>
<tr>
<td>deci</td>
<td>d</td>
<td>$10^{-1}$</td>
<td>0.1</td>
</tr>
<tr>
<td>centi</td>
<td>c</td>
<td>$10^{-2}$</td>
<td>0.01</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
<td>0.001</td>
</tr>
<tr>
<td>micro</td>
<td>μ</td>
<td>$10^{-6}$</td>
<td>0.000 001</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
<td>0.000 000 001</td>
</tr>
<tr>
<td>pico</td>
<td>p</td>
<td>$10^{-12}$</td>
<td>0.000 000 000 001</td>
</tr>
</tbody>
</table>

a. Add the prefixes to your place-value table in Q3.
b. A gram (g) is a unit of mass. How many grams are in a kilogram (kg)?
c. A joule (J) is a unit of energy. How many joules are in a megajoule (MJ)?
d. A watt (W) is a unit of power. How many watts are in a gigawatt (GW)?

5 STEM  Convert
   a. 4 kg to g
   b. 2.4 MJ to J
   c. 12.5 GW to W.

6 STEM  How many times bigger is
   a. a millimetre than a nanometre
   b. a gigawatt than a megawatt
   c. a kilojoule than a joule
   d. a megagram than a kilogram?

Discussion  What other name do we use for a megagram?

Worked example
The average distance of Venus from the Sun is $1.08 \times 10^8$ km.
Write this distance as an ordinary number.

$$1.08 \times 10^8 = 1.08 \times 100000000 = 108\,000\,000 \text{ km}$$

First write $10^8$ as an ordinary number.

7 STEM  The table shows information about some planets.

<table>
<thead>
<tr>
<th>Name of planet</th>
<th>Diameter of planet (km)</th>
<th>Average distance from Sun (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>$4.9 \times 10^3$</td>
<td>$5.79 \times 10^7$</td>
</tr>
<tr>
<td>Earth</td>
<td>$1.28 \times 10^4$</td>
<td>$1.5 \times 10^8$</td>
</tr>
<tr>
<td>Saturn</td>
<td>$1.2 \times 10^5$</td>
<td>$1.427 \times 10^9$</td>
</tr>
</tbody>
</table>

a. Copy the table. Write all the distances as ordinary numbers.
b. Which planet has the greatest diameter?
c. Which planet is closest to the Sun?

Discussion  How can you answer parts b and c without writing the distances as ordinary numbers?
8 STEM / Problem-solving The Space Shuttle had a lift-off mass of $1.1 \times 10^5$ kg. How many tonnes is this?

9 STEM The table shows the dimensions of some small organisms.

<table>
<thead>
<tr>
<th>Name of organism</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>dust mite</td>
<td>0.42 mm</td>
<td>0.25 mm</td>
</tr>
<tr>
<td>bacteria</td>
<td>2 µm</td>
<td>0.5 µm</td>
</tr>
<tr>
<td>virus</td>
<td>0.3 nm</td>
<td>15 nm</td>
</tr>
</tbody>
</table>

a Write all the dimensions in metres.
b Which organism has the greatest length?
c Which organism has the smallest width?

Discussion How can you answer parts b and c without writing the dimensions as ordinary numbers?

10 STEM / Reasoning An atom is the smallest object that you can see with an electron microscope. The width of an atom is about 0.1 nanometres. What is this distance in millimetres?

11 Explore How many photographs can you store on a 1 terabyte server?

What have you learned in this lesson to help you to answer this question?

What other information do you need?

12 Reflect After this lesson Jaina says, ‘I understood this lesson well because it’s all about place value.’ Look back at the work you have done in this lesson.

How has place value helped you?

What other maths skills have you used in this lesson?
1.2 Calculating and estimating

You will learn to:
• Calculate with powers.
• Round to a number of significant figures.

Why learn this?
The organisers of sporting events often round the number of spectators to estimate the income from ticket sales.

Exercise 1.2

1. Simplify
   a. \(5^2 \times 5^4\)
   b. \(8^2 / 8^3\)
   c. \(7^4 \times 7^6 / 7\)

2. Work out
   a. \(-4 \times -4\)
   b. \(-7 \times -7\)
   c. \((-3)^2\)
   d. \((-10)^2\)

3. Use rounding to estimate the answers.
   a. \(97 \div 4\)
   b. \(12.3 \times 10.2\)
   c. \(18.6 \div 5\)

4. Evaluate \(\frac{2 \times 3^9}{3^7}\)
   \[\frac{2 \times 3^9}{3^7} = 2 \times 3^{9-7} = 2 \times 3^2 = 2 \times 9 = 18\]

5. Work out
   a. \(\frac{5 \times 2^{12}}{2^5}\)
   b. \(\frac{3^2 \times 4^4}{4^3}\)
   c. \(\frac{2 \times 5^3 \times 5^5}{5^4}\)
   d. \(\frac{6^{15} \times 10}{6^7 \times 6^9}\)

6. Problem-solving
   Work out \(\frac{2^8 \times 16 \times 32 \times 7}{8 \times 2^{10}}\).

7. Reasoning
   Sarka and Rasheed both work out the same calculation. Here is what they write.

   **Sarka**
   \[
   32 - (-5)^2 = 32 - 25 = 32 + 25 = 57
   \]

   **Rasheed**
   \[
   32 - (-5)^2 = 32 + 25 = 32 - 25 = 7
   \]

   Who is correct? Explain the mistake that the other one has made.
8  Sort these cards into matching pairs.

\[
\begin{align*}
14 + 4^2 & \quad 14 - 4^2 & \quad 14 + (-4)^2 & \quad 14 - (-4)^2 \\
25 - 2^2 - 6^2 & \quad 25 - (-2)^2 + 6^2 & \quad 25 - 2^2 + (-6)^2 & \quad 25 - 2^2 - (-6)^2
\end{align*}
\]

Discussion  What method did you use?

Investigation

1  a  Work out  i  \( (2 \times 5)^2 \) ii  \( 2^2 \times 5^2 \)

b  Work out  i  \( (2 \times 5)^3 \) ii  \( 2^3 \times 5^3 \)

2  What do you notice about your answers to Q1?

3  a  Write a rule for calculating the power of the product of two numbers.

b  Will this same rule work for three or more numbers?

4  a  Work out  i  \( (10 + 2)^2 \) ii  \( 10^2 + 2^2 \)

b  What do you notice about your answers to part a?

5  Write a rule for calculating the power of the quotient of two numbers.

Reasoning

Investigation Q5 hint

Make sure that the second number divides exactly into the first, and that the power is greater than 2.

Investigation Q9 hint

\[
\frac{(3 \times 4)^2 \times 3}{2^2 \times 3} = \frac{3 \times 4^2 \times 3^3}{2^2 \times 3^3} = \frac{(2 \times 4)^3}{2^2 \times 3} = \ldots
\]

6  a  Work out  i  \( (3 + 4)^2 \) ii  \( 3^2 + 4^2 \)

b  What do you notice about your answers to part a?

Discussion  Is there a rule for calculating the power of the sum or difference of two numbers?

9  Work out

a  \( \frac{(3 \times 4)^2}{2^2 \times 3} \)

b  \( \frac{(3 \times 4)^3}{2^2 \times 9} \)

c  \( \frac{32 \times 5^3}{(5 \times 4)^2} \)

9  Work out  d  \( \frac{(6 \times 2 \times 8)^2}{4^2 \times 3} \)

Worked example

Round these numbers to the given number of significant figures.

a  42.038 (4 s.f.)

b  0.05713 (3 s.f.)

c  21,561 (2 s.f.)

\begin{align*}
a & \quad 42.04 \\
b & \quad 0.0571 \\
c & \quad 22,000
\end{align*}

b  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 a 4.

\begin{align*}
a & \quad 42.04 \\
b & \quad 0.0571 \\
c & \quad 22,000
\end{align*}

b  The fourth significant figure is 3, so leave the third digit as 1.

\begin{align*}
a & \quad 42.04 \\
b & \quad 0.0571 \\
c & \quad 22,000
\end{align*}

b  2 and 1 are the first 2 significant figures. The third is 5, so round the 1 up to 2.

Key point

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.

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

a  47.368 (4 s.f.)

b  0.00662 (1 s.f.)

b  579,452 (2 s.f.)

Topic links: Negative numbers, Volume, Range, Order of operations

Subject links: Science (Q15)
11 Estimate the answer to each calculation by rounding each number to 1 significant figure.
   a) $37 \times 492$
   b) $6230 \times 26$
   c) $897 \div 28$
   d) $45239 \div 183$

12 Estimate the answer to each calculation by rounding each number to 1 significant figure.
   a) $(1.2 + 3.5)^2$
   b) $(27 - 14)^3$
   c) $(3.32 \times 2) / (2.3 + 4.2)^2$
   d) $(786 - 529)^2 / 7.4^2$

13 The diagram shows a cuboid.

   ![Diagram of a cuboid with dimensions 8.23 m, 3.75 m, 1.42 m]

   Work out the volume of the cuboid.
   Give your answer in m$^3$ correct to 3 significant figures.

14 Problem-solving Sarita starts with a whole number. She rounds it to 2 significant figures. Her answer is 670.
   a) Write down two different numbers she could have started with.
   b) What is the largest number she could have started with?
   c) What is the smallest number she could have started with?

15 STEM The table shows the diameters of five planets.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mercury</th>
<th>Venus</th>
<th>Earth</th>
<th>Mars</th>
<th>Uranus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (km)</td>
<td>4878</td>
<td>12104</td>
<td>12756</td>
<td>6794</td>
<td>51118</td>
</tr>
</tbody>
</table>

   a) Round each diameter correct to 1 significant figure.
   b) Work out an estimate of the range in diameters.

16 Real A football stadium seats 42,785.
   The average price of a ticket is £32.
   Estimate the total money taken from ticket sales for one match.

17 Explore When is it a good idea to round numbers?
   When is it not a good idea?
   Look back at the maths you have learned in this lesson.
   How can you use it to answer this question?

18 Reflect Look back at Q12.
   Use a calculator to work out the exact answer to each part.
   How can your estimate help you to check your calculator answer?
### 1.3 Indices

**You will learn to:**
- Use negative indices.
- Work out powers of fractions.

**Why learn this?**
Carbon dating uses negative indices to describe the decay of carbon-14.

**Exercise 1.3**

1. Write as a single power.
   - **a** $3^4 \times 3^5$
   - **b** $7^9 \div 7^5$
   - **c** $4^{13} \div 4^{10}$
   - **d** $(2^4)^3$
   - **e** $(11^7)^3$
   - **f** $3^5 \times 81$
   - **g** $8 \times 2^6$
   - **h** $5^{10} \div 125$

**Investigation**

1. Copy and complete the sequence of powers. Write your numbers as integers or fractions of 10.
2. Repeat part 1 for powers of 2.
3. Copy and complete.
   - **a** $10^{-2} = \frac{1}{10^2}$
   - **b** $2^{-3} = \frac{1}{2^3}$
   - **c** $2^{-5} = \frac{1}{2^5}$
   - **d** The reciprocal of $10^4$ is $\frac{1}{10^4}$
4. Copy and complete the rules.
   - $2^{-n} = \frac{1}{2^n}$
   - $10^{-n} = \frac{1}{10^n}$
5. Write down the value of $5^{-2}$ as a decimal. Check your answer with a calculator.

**Q1 hint**
To multiply powers, add the indices. To divide powers, subtract the indices. To work out the power of a power, multiply the indices.

**Reasoning**

<table>
<thead>
<tr>
<th>$10^5$</th>
<th>$10^4$</th>
<th>$10^3$</th>
<th>$10^2$</th>
<th>$10^1$</th>
<th>$10^0$</th>
<th>$10^{-1}$</th>
<th>$10^{-2}$</th>
<th>$10^{-3}$</th>
<th>$10^{-4}$</th>
<th>$10^{-5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$100000$</td>
<td>$10000$</td>
<td>$1000$</td>
<td>$100$</td>
<td>$10$</td>
<td>$1$</td>
<td>$\frac{1}{10}$</td>
<td>$\frac{1}{100}$</td>
<td>$\frac{1}{1000}$</td>
<td>$\frac{1}{10000}$</td>
<td>$\frac{1}{100000}$</td>
</tr>
</tbody>
</table>

**Discussion**
What is the value of any number raised to the power 0?

**Key point**
A number raised to a negative power is the same as the reciprocal of that number to the power.

**Topic links:** Calculations with fractions, Laws of indices
3 Write each calculation as a single power.
   a \(10^5 \times 10^{-2}\)  
   b \(4^3 \times 4^{-1}\)  
   c \(11^{-2} \times 11^{-5}\)  
   d \(7^2 \div 7^{-5}\)  
   e \(6^{-2} \div 6^4\)  
   f \(8^{-7} \div 8^{-3}\)  
   g \((9^{-2})^5\)  
   h \((12^{-4})^{-2}\)  

4 Write each calculation as
   i a single power
   ii an integer or a fraction.
   a \(3^2 \times 3^{-1} \times 3^{-4}\)  
   b \(4^2 \times 4^{-1} \div 4^{-2}\)  
   c \(5^{-3} \div 5 \div 5^{-2}\)  
   d \(2^{-3} \times 2^{-6} \div 2^{-4}\)  

5 Write each calculation as a fraction.
   a \(\frac{1}{3} \times \frac{1}{3}\)  
   b \(\left(\frac{3}{4}\right)^2\)  
   c \(\left(\frac{3}{5}\right)^3\)  
   d \(\left(\frac{2}{3}\right)^4\)  

6 Write each number as a fraction raised to a power.
   a \(\frac{16}{100}\)  
   b \(\frac{9}{49}\)  
   c \(\frac{25}{64}\)  
   d \(\frac{8}{64}\)  
   e \(\frac{16}{625}\)  
   f \(\frac{1}{27}\)  

7 Problem-solving Jamal eats half a cheesecake, his brother eats half of what is left and his sister eats half of what is then left. How much cheesecake remains?
   Write your answer
   a as a fraction
   b as a fraction raised to a power.

8 Explore Does raising a number to a power always make the number bigger?
   Choose some sensible numbers to help you explore this situation.
   Then use what you’ve learned in this lesson to help you to answer the question.

9 Reflect Rhiannon says, ‘Mathematics is often about spotting patterns’.
   Do you agree? Explain.
   When else have you used pattern spotting in maths?
1.4 Standard form

You will learn to:
• Write numbers using standard form.
• Order numbers written in standard form.

Why learn this?
Scientists describing the universe need to write down very large numbers in a way that is easy to read.

Exercise 1.4

1. Work out
   a. \(2.5 \times 100\)
   b. \(7.3 \times 0.01\)
   c. \(4.06 \times 10^{-1}\)
   d. \(9.55 \times 10^{-3}\)

2. Copy and complete.
   a. \(23.4 \times 10^3 = \underline{23,400}\)
   b. \(2.35 \times 10^2 = \underline{235}\)
   c. \(34 \times 10^3 = \underline{34,000}\)
   d. \(0.067 \times 10^2 = \underline{6.7}\)

3. Which of these numbers are written in standard form?
   a. \(2.8 \times 10^3\)
   b. \(7 \times 10^5\)
   c. \(0.2 \times 10^2\)
   d. \(27 \times 10^{-5}\)
   e. \(3.3 \times 10\)
   f. \(5.022 \times 10^{-6}\)

4. These numbers are written in standard form. Write them as ordinary numbers.
   a. \(7 \times 10^2\)
   b. \(2.5 \times 10^{-5}\)
   c. \(5.4 \times 10^6\)
   d. \(3.04 \times 10^{-3}\)

Key point
A number written in standard form is a number between 1 and 10 multiplied by a power of 10.

4.2 \times 10^6 is written in standard form.
Using algebra, standard form is \(A \times 10^n\), where 1 \(\leq A < 10\) and \(n\) is an integer.

Q4 hint
\(7 \times 10^2 = 7 \times 100 = \underline{700}\)

Worked example
Write each number using standard form.

a. 41 000
b. 0.003 94

\(41 000 = 4.1 \times 10^4\)
\(0.003 94 = 3.94 \times 10^{-3}\)

Topic links: Powers, Laws of indices, Priority of operations
Subject links: Science (Explore, Q6, Q8–10)
5 Write each number in standard form.
   a 23 500  
   b 315  
   c 12 000 000  
   d 0.04  
   e 0.000 35  
   f 0.000 000 090 1

6 STEM The distance light travels in a year is called a light-year.
   a Write each of the distances in the table in standard form.

<table>
<thead>
<tr>
<th>Object</th>
<th>Distance from Earth (light-years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre of our galaxy</td>
<td>26 000</td>
</tr>
<tr>
<td>Andromeda (a neighbouring galaxy)</td>
<td>2 500 000</td>
</tr>
<tr>
<td>Betelgeuse (a star of Orion)</td>
<td>600</td>
</tr>
</tbody>
</table>

b The Triangulum Galaxy is the furthest galaxy you can see without a telescope. It is \(3 \times 10^6\) light-years away. Is it closer to Earth than Betelgeuse?

7 Put these sets of numbers in order, from smallest to largest.
   a \(9.87 \times 10^2\)  
   \(8.65 \times 10^4\)  
   \(1.9 \times 10^3\)  
   \(3.59 \times 10^2\)  
   \(1.95 \times 10^4\)
   b \(5.3 \times 10^{-3}\)  
   \(4.8 \times 10^{-2}\)  
   \(3.99 \times 10^{-5}\)  
   \(8.05 \times 10^{-6}\)  
   \(8.76 \times 10^{-3}\)
   c \(3.22 \times 10^{-2}\)  
   \(3.02 \times 10^{2}\)  
   \(3.2 \times 10^{-3}\)  
   \(3.22 \times 10^{2}\)  
   \(3.22 \times 10^{-3}\)

8 STEM / Problem-solving The table shows the masses of the planets in our Solar System.
   a Rewrite each mass in standard form (some already are).

<table>
<thead>
<tr>
<th>Planet</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>(5.97 \times 10^{24})kg</td>
</tr>
<tr>
<td>Jupiter</td>
<td>(1899 \times 10^{24})kg</td>
</tr>
<tr>
<td>Mars</td>
<td>(0.642 \times 10^{24})kg</td>
</tr>
<tr>
<td>Mercury</td>
<td>(0.33 \times 10^{24})kg</td>
</tr>
<tr>
<td>Neptune</td>
<td>(102 \times 10^{24})kg</td>
</tr>
<tr>
<td>Saturn</td>
<td>(568.5 \times 10^{24})kg</td>
</tr>
<tr>
<td>Uranus</td>
<td>(86.8 \times 10^{24})kg</td>
</tr>
<tr>
<td>Venus</td>
<td>(4.87 \times 10^{24})kg</td>
</tr>
</tbody>
</table>

b Approximately how many times heavier is Earth than Mars?

c Which planet is approximately 1000 times heavier than Mars?

9 STEM Write these atoms in order of the size of their nucleus, largest first.

<table>
<thead>
<tr>
<th>Atom</th>
<th>Size of nucleus (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>gold</td>
<td>(1.4 \times 10^{-14})m</td>
</tr>
<tr>
<td>helium</td>
<td>(3.8 \times 10^{-15})m</td>
</tr>
<tr>
<td>aluminum</td>
<td>(7.2 \times 10^{-15})m</td>
</tr>
</tbody>
</table>

10 STEM Write the following measurements as ordinary numbers
   i in metres  
   ii in millimetres.
   a The diameter of the core in an optical fibre: \(6.25 \times 10^{-5}\)m  
   b The line width on a microprocessor: \(1.8 \times 10^{-7}\)m

11 Explore What units are used to measure distances in the Universe?
   Is it easier to explore this question now that you have completed the lesson?
   What further information do you need to be able to answer this?

12 Reflect Look back at your answer to Q7. You could answer this using ordinary numbers or standard form. Which method did you choose? Explain your choice.
1.5 STEM: Calculating with standard form

You will learn to:
• Calculate with numbers written in standard form.

Why learn this?
Scientists exploring nanotechnology need to describe very small numbers in a way that is easy to read.

Exercise 1.5: Orders of magnitude

1 Write each number in standard form.
   a 59 000
   b 0.0601
   c 0.000 000 072
   d 5323

2 Write as a single power of 10
   a $10^{-3} \times 10^2$
   b $10^{-3} \times 10^{-2}$
   c $10^3 \div 10^{-1}$
   d $10^{-1} \div 10^2$

Worked example

Write $(2.7 \times 10^3) \times (4 \times 10^2)$ in standard form.

$(2.7 \times 10^3) \times (4 \times 10^2) = 2.7 \times 4 \times 10^3 \times 10^2$

$= 10.8 \times 10^5$

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: $10.8 = 1.08 \times 10^1$

3 Work out each calculation. Give your answers in standard form.
   a $(1.2 \times 10^2) \times (3 \times 10^3)$
   b $(1.5 \times 10^5) \times (5 \times 10^3)$
   c $(4 \times 10^4) \times (6.25 \times 10)$
   d $(1.2 \times 10^3)^2$

4 Work out each calculation. Give your answers in standard form.
   a $\frac{6 \times 10^8}{3 \times 10^2}$
   b $\frac{8 \times 10^5}{2 \times 10^3}$
   c $\frac{1.2 \times 10^6}{3 \times 10}$
   d $\frac{2 \times 10^5}{1.25 \times 10^4}$

Q4 hint
Divide the number parts. Use the laws of indices to divide the powers of 10.

Topic links: Ratio, Enlargement

Subject links: Science (Q6–15, Q18)
5 Use a calculator to work out
\[ (9.6 \times 10^7) \times (6.41 \times 10^3) \quad \text{and} \quad \frac{1.342 \times 10^{11}}{6.1 \times 10^5} \]

Discussion Which buttons do you use on your calculator? Is the answer in standard form?

6 STEM Light travels at 299792458 metres per second (m/s).
   a Write down the speed of light in km/s, correct to 1 significant figure
      i as an ordinary number    ii using standard form.
      The distance from the Sun to the Earth is 1.496 \times 10^8 km.
   b Use your answer to part a to work out how long it takes light
to travel from the Sun to the Earth. Give your answer to the
   nearest minute.

7 STEM / Problem-solving Sound travels at 3.4 \times 10^2 m/s.
   What is the ratio of the speed of light to the speed of sound?
   Give your answer in the form \( n : 1 \), to 2 decimal places.

8 STEM / Reasoning A human hair has a diameter of approximately
   1 \times 10^{-1} mm. The human eye cannot easily see anything smaller than
   a human hair without a microscope.
   An optical microscope can enlarge an image to 1000 times the size of
   the object. Is it possible to see these organisms with a microscope?
   a polio virus \( 2 \times 10^{-5} \text{mm} \)
   b human red blood cell \( 1 \times 10^{-2} \text{mm} \)
   c staphylococcus \( 5 \times 10^{-4} \text{mm} \)

9 STEM / Modelling The table gives the sizes of eggs from
different animals.

<table>
<thead>
<tr>
<th>Object</th>
<th>Approximate diameter (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extinct elephant bird</td>
<td>2.5 \times 10^{-1}</td>
</tr>
<tr>
<td>Ostrich</td>
<td>1.5 \times 10^{-1}</td>
</tr>
<tr>
<td>Hummingbird</td>
<td>1 \times 10^{-2}</td>
</tr>
<tr>
<td>Sea star</td>
<td>9 \times 10^{-4}</td>
</tr>
<tr>
<td>Human</td>
<td>1.2 \times 10^{-4}</td>
</tr>
</tbody>
</table>

A model of an ostrich egg is built for an exhibition. Its diameter is 10 m.
   The same scale is used to build models of the other objects.
   a Work out the length of each model. Choose an appropriate unit of
      length for each answer.
   b Is this a good scale to use? Would you be able to hold each model
      in your hand?

10 STEM A 3D electron microscope magnifies objects 1 000 000 times.
     A water molecule has a diameter of 2 \times 10^{-10} m.
     How large will it appear in the microscope?
     Give your answer in millimetres.

11 STEM Graphite is made up of layers of graphene sheets. Each
   sheet of graphene is one atom thick. There are 3 \times 10^6 layers of
   graphene in 1 mm thickness of graphite. If you ignore the thickness
   of the layers, what is the gap between the layers? Give your answer
   in standard form.

Q7 hint Use the speed of light given in Q6.

Q8c Literacy hint
Staphylococcus is a bacteria that
causes food poisoning.

Q11 hint Layers of graphene are so thin, about
1.4 \times 10^{-10} \text{m} thick, that they can be
ignored in this calculation.
12 STEM Here are some wavelengths in the electromagnetic spectrum.

- Gamma ray: $1 \times 10^{-12}$ m
- Red light: $6.8 \times 10^{-7}$ m
- Microwave: $1.22 \times 10^{-1}$ m
- VHF radio wave: 3 m
- Low frequency radio wave: 10 km

a. How many gamma ray wavelengths fit into the length of one red light wave?
b. How many times larger are low frequency radio waves than microwaves?
c. Which is longer: $10^2$ VHF radio waves or $3 \times 10^{10}$ red light rays?

13 STEM / Problem-solving The mass of a proton is about 2000 times larger than the mass of an electron.

Copy and complete this sentence, using standard form.
The mass of an electron = the mass of a proton $\times 2 \times 10^5$

14 Real / STEM Sunglasses are coated with very thin layers to cut out ultraviolet radiation. These layers are about $4 \times 10^2$ nm thick. Give the thickness in metres.

15 Real Your fingernail grows about 1 nm per second. How much could your fingernail grow in 4 weeks? Give your answer in millimetres.

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

- $5.1 \times 10^8 + 1.45 \times 10^8$
- $6.75 \times 10^{-4} + 4.25 \times 10^{-4}$
- $6.5 \times 10^{-4} + 2.07 \times 10^{-3}$
- $9.05 \times 10^8 + 7.8 \times 10^5$
- $3.9 \times 10^7 + 4.2 \times 10^8$
- $5.6 \times 10^{-4} + 2.07 \times 10^{-3}$

17 Work out

- $9.6 \times 10^{-7} - 6.3 \times 10^{-7}$
- $5.33 \times 10^8 - 2.8 \times 10^5$
- $8.88 \times 10^4 - 8.37 \times 10^4$
- $7.02 \times 10^{-3} - 6.1 \times 10^{-4}$

18 STEM The wavelengths in the visible light spectrum extend from $3.8 \times 10^{-7}$ m to $7.5 \times 10^{-7}$ m.

What is the range of wavelengths in the visible light spectrum?

19 Explore What is the smallest organism you can see?

Is it easier to explore this question now that you have completed the lesson?

What further information do you need to be able to answer this?

20 Reflect The title of this lesson is ‘Orders of magnitude’. Why do you think scientists find it useful to know about orders of magnitude?
Powers of 10

1. a Complete this table of prefixes.

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Power of 10</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>giga</td>
<td>$10^9$</td>
<td></td>
</tr>
<tr>
<td>mega</td>
<td>$10^6$</td>
<td></td>
</tr>
<tr>
<td>kilo</td>
<td>$10^3$</td>
<td>1000</td>
</tr>
<tr>
<td>deci</td>
<td>$10^{-1}$</td>
<td></td>
</tr>
<tr>
<td>centi</td>
<td>$10^{-2}$</td>
<td></td>
</tr>
<tr>
<td>milli</td>
<td>$10^{-3}$</td>
<td>0.001</td>
</tr>
<tr>
<td>micro</td>
<td>$10^{-6}$</td>
<td></td>
</tr>
</tbody>
</table>

b Match the cards that show the same value.

- 50 000 milligrams
- 50 000 milligrams
- 0.005 kilograms
- 50 000 milligrams
- 0.005 kilograms
- 500 decigrams
- 500 decigrams
- 500 decigrams
- 500 decigrams
- 500 decigrams

2. Write these numbers in order of size, starting with the smallest.

$4.6 \times 10^4$, $8.9 \div 10^5$, $2.1 \times 10^5$, $2.4 \div 10^7$

Calculating and estimating

3. Use rounding to estimate the answers to

   a $13.3 \times 12.8$
   b $24.8 \div 5.2$

4. Evaluate

   a $\frac{3^3 \times 5}{2}$
   b $\frac{4^2 \times 3}{2^3}$

Indices

5. Write each of these numbers as a fraction.

   a $5^{-3}$
   b $6^{-1}$
   c $2^{-4}$

6. Write as a single power.

   a $10^3 \times 10^{-4}$
   b $3^{-2} \div 3$
   c $(3^{-2})^3$
   d $7^{-5} \div 7^{-2}$
Standard form

7 Write each number in standard form.
   a 345
   c 34.5 \times 10^3
   d 0.005 \times 10^6

8 Write 0.007 231 in standard form.

9 Write these numbers in order, from smallest to largest.
   \(3.1 \times 10^{-2} \quad 3.2 \times 10^{-3} \quad 3.22 \times 10^3 \quad 3.022 \times 10^4 \quad 3.2 \times 10^{-5}\)

Calculating with standard form

10 Work out each calculation. Give your answers in standard form.
   a \((4.1 \times 10^{-6}) \times (2 \times 10^3)\)
   b \frac{6 \times 10^3}{1.5 \times 10^2}

11 Work out each calculation. Give your answers
   i in standard form
   ii as ordinary numbers.
   a \frac{23.31 \times 10^5}{3.7 \times 10^7}
   b (7.09 \times 10^2) \times (6.3 \times 10^3)

12 Real The mass of iron in planet Earth is \(2.090 \times 10^{24}\) kg.
   Given that the Earth has a mass of \(5.972 \times 10^{24}\) kg, find the
   percentage of the Earth's mass that is iron.

13 How sure are you of your answers? Were you mostly
   😞 Just guessing   😞 Feeling doubtful   😊 Confident
   What next? Use your results to decide whether to strengthen or
   extend your learning.

Challenge

14 \(a = 2.3 \times 10^6\) and \(b = 2.3 \times 10^{-3}\)
   Calculate
   a \(a^2\)   b \(b^3\)
   c \(a^3 b^4\)   d \(\frac{a}{b^5}\)
   Give your answers in standard form.
1 Strengthen

You will:
- Strengthen your understanding with practice.

Powers of 10

1 Copy and complete
   a kilo (k) = $10^3 = 1000$
   b mega (M) = $10^6 = \square$
   c giga (G) = $10^9 = \square$

Key point

- To convert bigger units to smaller units, multiply
  - pm $\times 1000$  
  - nm $\times 1000$  
  - μm $\times 1000$  
  - mm $\times 1000$  
  - m $\times 1000$  
  - km $\times 1000$  
  - Mm $\times 1000$  
  - Gm $\times 1000$  
  - Tm
- To convert smaller units to bigger units, divide

2 Convert
   a 6.5 Tm to km
   b 0.014 m to nm
   c 50,000 nm to mm
   d 2200 km to Mm
   e 0.000 0006 Gm to mm

3 Convert
   a 5 kilojoules (kJ) to joules (J)
   b 0.021 megawatts (MW) to watts (W)
   c 270 000 l to ml
   d 720 μg to mg

4 STEM
   a Safia’s computer processor has a speed of 6.1 megahertz (MHz). What is its speed in kilohertz (kHz)?
   b The wavelength of a red light is 690 nm. Convert this length to μm.

Calculating and estimating

1 Copy these numbers. Circle the first significant figure. Write down its value.
   a 32.45  
   b 0.64  
   c 25 800  
   d 0.0782

2 Write the numbers in Q1 to 1 significant figure.

3 Round these numbers to the given number of significant figures.
   a 53 876 (2 s.f.)  
   b 0.735 (2 s.f.)  
   c 56.554 (3 s.f.)  
   d 0.002 410 6 (3 s.f.)

Q2a hint

6.5 × 1000 × 1000 × 1000 = \square

Q3a hint

Circle the second significant figure. What place-value column is it in?
4. Round each number in these calculations to 1 significant figure. Then estimate the answer to each calculation.
   \[a \quad 44 \times 273 \quad b \quad 67 \times 534 \quad c \quad 421 \div 18 \quad d \quad (585 \div 33)^2\]

Indices

1. a i \[3^2 \div 3^5 = 3\]  
   ii \[3^2 \div 3^5 = \frac{1}{2} \times \frac{3^2}{3^5} = \frac{3}{3^3} = \frac{1}{3}\]  
   iii Use your answers to copy and complete: \(3^{-3} = \frac{1}{3}\)

b Copy and complete.
   \[i \quad 7^{-2} = \frac{1}{7}\]  
   ii \(4^{-5} = \frac{1}{4^5}\)  
   iii \(\frac{1}{9^3} = 9^-\)  
   iv \(\frac{1}{5^2} = 5^-\)

2. Write each calculation as a single power.
   a \[7^2 \times 7^{-4} = 7^{2+(-4)} = 7^-\]
   b \[3^{-1} \times 3^5 = 3^0 = 1\]
   c \[5^{-4} \times 5\]
   d \[8^2 \div 8^6 = 8^2 \div 8^6 = 8^-\]
   e \[4^{-3} \div 4^{-5}\]
   f \[\frac{10^3}{10^7}\]
   g \((5^{-2})^3 = 5^{-2\times3} = 5^-\)
   h \((6^5)^{-4}\)

3. Which calculations in Q2 have answers that are less than 1?

Standard form

1. Work out
   a \[3.7 \times 10^3\]
   b \[2.5 \times 10^4\]
   c \[8.1 \times 10^2\]
   d \[5.4 \times 10^7\]

2. Work out
   a \[9.3 \times 10^{-3}\]
   b \[7.3 \times 10^{-2}\]
   c \[1.5 \times 10^{-4}\]
   d \[4.9 \times 10^{-6}\]

3. A number written using standard form looks like this:
   \[A \times 10^n\]

Write each number using standard form.
   a \[3100 = 3.1 \times 10^3\]  
   b \[29000\]  
   c \[7 150 000\]  
   d \[69 000 000 000\]
4 Write each number using standard form.
   a $0.0064 = 6.4 \times 10^{-3}$
   b $0.072$
   c $0.000004$
   d $0.00000021$

5 Write the numbers in each list in order, from smallest to largest.
   a $1.8 \times 10^5$  $3.7 \times 10^{-2}$  $9.4 \times 10^{2}$  $6.9 \times 10^{-7}$
   b $4 \times 10^{-1}$  $4.2 \times 10^{-2}$  $4.22 \times 10^{2}$  $2.4 \times 10^{2}$  $2.44 \times 10^{-1}$

Calculating with standard form

1 Work out each calculation. Give your answers in standard form.
   a $(3 \times 10^4) \times (2.6 \times 10^5) = 3 \times 2.6 \times 10^4 \times 10^5 = \square \times 10^\square$
   b $(1.7 \times 10^5) \times (2 \times 10^3)$
   c $(5 \times 10^3) \times (2.5 \times 10^8)$
   d $\frac{6.6 \times 10^6}{2.2 \times 10^2} = \frac{6.6 \times 10^6}{2.2 \times 10^3} = \square \times 10^\square$
   e $7.8 \times 10^3$
   f $2 \times 10^9$
   g $8 \times 10^5$

2 Work out each calculation. Give your answers in standard form.
   a $(6.41 \times 10^5) \times (1.8 \times 10^{-7})$
   b $(3.7 \times 10^{-3}) \times (9.3 \times 10^{10})$
   c $55.8 \times 10^9$
   d $6.2 \times 10^2$
   e $2.136 \times 10^3$
   f $3.56 \times 10^8$

3 The average distance from the Sun to the Earth is approximately $1.5 \times 10^8$ km.
Light travels at $3 \times 10^8$ ms$^{-1}$.
Find the time taken for light to travel from the Sun to the Earth.

4 Problem-solving How thick is a single page in this book?
Follow these steps to find out.
   a Find out how many sheets of paper are in the book.
   b Use a ruler to measure the total thickness of the pages in the book (in mm).
   c Use your calculator to find the thickness of one sheet in mm.
      Write the answer in standard form.
   d Convert your answer in part c to nanometres (nm). Give your answer to 1 decimal place.
5 Real Write these countries in order of population size, from smallest to largest.

<table>
<thead>
<tr>
<th>Country</th>
<th>Population (July 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>$6.411 \times 10^7$</td>
</tr>
<tr>
<td>New Zealand</td>
<td>$4.540 \times 10^6$</td>
</tr>
<tr>
<td>Iceland</td>
<td>$3.263 \times 10^5$</td>
</tr>
<tr>
<td>Japan</td>
<td>$1.271 \times 10^8$</td>
</tr>
<tr>
<td>St Lucia</td>
<td>$1.8 \times 10^5$</td>
</tr>
<tr>
<td>Brazil</td>
<td>$2.028 \times 10^8$</td>
</tr>
</tbody>
</table>

6 Real Use the information in the table in Q6 to answer these questions.

a Write the population of Iceland as an ordinary number.

b Calculate the total population of all the countries in the table.

c How many times bigger is the population of the UK than the population of St Lucia?

7 STEM An electron has a mass of $9.109 \times 10^{-31}$ kg.

a How many electrons are there in 1 kg of electrons?

A proton has a mass of $1.673 \times 10^{-27}$ kg.

b How many electrons are equivalent to one proton?

Enrichment

8 On Earth, the oceans cover an area of $3.62 \times 10^8$ km² with a mean depth of $3.68 \times 10^4$ m.

Use this information to estimate the volume of water in the oceans of the Earth. Give your answer in standard form in m³.

9 Reflect Nandini says, ‘Working with indices, powers and roots is all about adding, subtracting, multiplying and dividing’.

Look back at the questions you answered in these Strengthen lessons. Describe when you had to:

- add
- subtract
- multiply
- divide.

Do you agree with Nandini statement? Give some examples to explain why.

Subject link: Geography (Q5 and 6), Science (Q3, 7 and 8)
1 Extend

You will:
• Extend your understanding with problem-solving.

1 a Match each prefix to its correct power of 10.

- centi $10^{-2}$
- micro $10^{-6}$
- giga $10^9$
- pico $10^{-12}$
- kilo $10^3$

b Write the prefixes for the remaining powers of 10.

2 Work out these conversions.
   a 1 kilogram (kg) = □ g
   b 1 megajoule (MJ) = □ J
   c 1 gigatonne (Gt) = □ t
   d 1 terawatt (TW) = □ W
   e 1 decilitre (dL) = □ l

3 The diagram shows a cuboid.

What is the surface area of the cuboid?
Give your answer to 3 significant figures.

4 Write as a single power.
   a $11^7 \times 11^{-3} \div 11^{-2}$
   b $3^{-13} \times 3^4 \div 3^{-5} \div 3^2$
   c $7^{-7} \times 7^{-2} \div 7^{-1} \div 7^8$
   d $5^{-3} \div 5^3 \times 5^{-10} \times 5^{-3}$

5 Work out
   a $3^{-3} \times 2^{-2} \times 2^{-1} \times 3^4$
   b $(\frac{1}{2})^{-3} \times (\frac{1}{3})^{-1} \times (\frac{1}{2})^2 \times (\frac{1}{3})^{-1}$
   c $(\frac{1}{2})^{-2} \times (\frac{1}{3})^3 \times (\frac{1}{2})^{-3} \times (\frac{1}{3})^{-2}$
   d $(\frac{1}{2})^{-3} \times (\frac{1}{2})^3$

6 Real / STEM Scientists often use units written with negative indices. For example, 30 m/s = 30 ms$^{-1}$.
Write these units using negative indices.
   a km/h
   b m/s$^2$
   c kg/m$^3$
   d mi/h

7 STEM There are 100 trillion microorganisms in the human intestines. This is 10 times the number of cells in a human body. Write the number of cells in a human body, in standard form.

8 Problem-solving Write these numbers in order, from smallest to largest.
   $1.26 \times 10^{-3}$ $0.12 \times 10^{-2}$ $0.00124$ $1205 \times 10^{-6}$ $\frac{1}{8 \times 10^2}$

Q2e hint
1 decimetre = 0.1 m

Q7 Literacy hint
1 trillion = 1 000 000 000 000

Q8 Strategy hint
Write each number in standard form first.
9 **Real** The table shows how people accessed information about a football tournament.

<table>
<thead>
<tr>
<th>Number of people (to 3 s.f.)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected with the official site</td>
<td>$1.12 \times 10^8$</td>
</tr>
<tr>
<td>Apps downloaded</td>
<td>$2.20 \times 10^7$</td>
</tr>
<tr>
<td>Facebook users</td>
<td>$4.55 \times 10^8$</td>
</tr>
<tr>
<td>Tweets during the match</td>
<td>$3.66 \times 10^7$</td>
</tr>
</tbody>
</table>

Use the data to work out the missing number in each sentence.

**a** There were roughly ______ times more Facebook users than people connected to the official site.

**b** There were roughly ______ times more Facebook users than tweets in the match.

**c** There were roughly ______ times more tweets in the match than people who downloaded apps.

10 Put the answers to these calculations in order, from smallest to largest.

A $(2.3 \times 10^{-3}) \times (7.4 \times 10^{-2})$

B $(1.3 \times 10^{-2})^2$

C $(5.3 \times 10^{-2}) \div (3.2 \times 10^2)$

D $(1.091 \times 10^{-4}) + (6 \times 10^{-5})$

E $(1.8 \times 10^{-4}) - (1.8 \times 10^{-5})$

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

**a** $2 \times 10^9$  
**b** $8 \times 10^7$  
**c** $4 \times 10^{-5}$  
**d** $1.6 \times 10^{-4}$

12 **Real** The number of app downloads in July 2008 was $1.0 \times 10^7$. There were 10 times as many in September 2008 and 10 times as many again in April 2009. In June 2014 there were $7.5 \times 10^{10}$ app downloads.

**a** How many downloads were there in April 2009?  
**b** What was the increase from July 2008 to June 2014?

13 **STEM / Reasoning** The smallest size the human eye can see is $10^{-4}$ m. The diameter of a virus particle is 170 nm. Could you see a group of 1 million virus particles with the naked eye? Explain your answer.

14 **STEM** The formula for working out the frequency of a wave in the electromagnetic spectrum is $f = \frac{c}{\lambda}$ where $c$ is the speed of light and $\lambda$ is the wavelength. $c = 3 \times 10^8$ m/s

Work out the frequency of

**a** red light with wavelength $6.9 \times 10^{-7}$ m  
**b** blue light with wavelength $4.65 \times 10^{-7}$ m.

Give your answers in standard form to 2 significant figures.

Q14 Literacy hint

$\lambda$ is the Greek letter lambda. It is sometimes used instead of a letter from our alphabet. The unit for frequency is hertz (Hz).
15 **Reasoning**  
**a** Which of these numbers have the same value?

\[
(0.5)^3 \quad 8^{-2} \quad \left(\frac{1}{4}\right)^2 \quad \left(\frac{1}{2}\right)^3 \quad 2^{-3} \quad \left(\frac{1}{64}\right)^{\frac{3}{2}}
\]

**b** In how many different ways can you write \(\frac{1}{9}\)?

16 **Real**  
The populations of Bangladesh, China, India and Pakistan in 2014 are shown in the table.

<table>
<thead>
<tr>
<th>Country</th>
<th>Population in 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>(1.566 \times 10^8)</td>
</tr>
<tr>
<td>China</td>
<td>(1.366 \times 10^9)</td>
</tr>
<tr>
<td>India</td>
<td>(1.247 \times 10^9)</td>
</tr>
<tr>
<td>Pakistan</td>
<td>(1.880 \times 10^8)</td>
</tr>
</tbody>
</table>

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

**b** What is the difference between the population of India and China?

**c** How many times larger is the population of India than that of Pakistan?

**d** What is the total population of these four countries?
The world population is \(7.183 \times 10^9\).

**e** What proportion of the world’s population lives in China or India?

---

**Challenge**

17 **Real / STEM / Modelling**  
A science museum wants to make a scale model of the Solar System.

The diagram shows the real distances between the Earth, Moon and Sun.  
In the model the Earth and the Moon are 10 cm apart.  
How far away from the Earth will the Sun need to be?

**Discussion**  
Is this a good scale for the model? Suggest some distances that might work better.

---

**Investigation**

The speed of light is \(3 \times 10^8\) m/s.

**a** How many kilometres does light travel in one year? (Assume 1 year to be 365 days).

Neptune is approximately 4.5 billion km from the Sun.

**b** Work out how long it takes light from the Sun to reach Neptune.

---

18 **Reflect**  
In this unit you have learned a lot of new vocabulary.  
Write a list of all the new vocabulary you have used.  
Write, in your own words, a definition for each one.  
Compare your definitions with those of your classmates.  
Did you all learn the same thing?

---

**Q18 hint**

A light year is the distance travelled by light in one year.
1 Unit test

1 Real The stadium that will host the 2020 Superbowl seats 98,025 people. The average price of a ticket is $120. Estimate the total money taken from ticket sales for the Superbowl.

2 Work out
   a \( \frac{4 + 3 \times 6 - 4}{3^2 - 4} \)
   b \( 25 \left(3^3 + 2\right) \div 5 \times 3 \)

3 Use rounding to one significant figure to estimate
   a \( 1875 \times 5.36 \)
   b \( \frac{285 \times 3.16}{11.2} \)

4 Write each number in standard form.
   a \( 820 \)
   b \( 0.000\ 091\ 5 \)

5 Put these numbers in order, from smallest to largest.
   \( 1.24 \times 10^{-2} \)
   \( 1.21 \times 10^{-4} \)
   \( 1.2 \times 10^2 \)
   \( 1.23 \times 10^3 \)
   \( 1.24 \times 10 \)

6 Work out each calculation. Give your answers in standard form.
   a \( 8.8 \times 10^8 \)
     \( 2.2 \times 10^3 \)
   b \( (2.5 \times 10^4) \times (5 \times 10^{-7}) \)

7 Work out each calculation. Give your answers in standard form.
   a \( (1.505 \times 10^{-5}) \times (8.3 \times 10^4) \)
   b \( \frac{48.96 \times 10^3}{5.1 \times 10^{-3}} \)

8 Write as a single power.
   a \( 6^3 \times 6^{-4} \)
   b \( 3^{-4} \div 3^{-2} \)
   c \( (7^{-3})^2 \)
   d \( 4^{-4} \div 4^{-2} \)
     \( 4^{-1} \times 4^{-1} \)
9 a Arrange these cards into their correct groups. Each group must have one card of each colour.

b Convert
   i 9 GJ to joules
   ii 13 kW to watts
   iii 8.5 Ms to seconds.

10 An African elephant weighs about 6 tonnes. The Earth weighs $5.97 \times 10^{24}$ kg.
   a How many kg are in a tonne?
   b How many tonnes does the Earth weigh?
   c What is the mass of the Earth, measured in elephants?
      Give your answer in standard form.
   d Look back at the data in Exercise 1.4 Q8.
      How many elephants do you need to make the mass of each planet?

Challenge

11 Problem-solving A publisher prints $1.25 \times 10^7$ copies of a newspaper.
   Each newspaper consists of 16 sheets of paper.
   a Calculate the number of sheets of paper needed to print all the newspapers. Give your answer in standard form.
   To make the newspapers, the sheets of paper are folded in half.
   b The height of a pile of newspapers is 125 cm. The pile contains 420 newspapers.
      Calculate the thickness of one sheet of paper. Give your answer in metres in standard form.

12 Reflect Which of the questions in this unit test:
   • took the shortest time to answer? Why?
   • took the longest time to answer? Why?
   • were the most thought-provoking? Why?