We can use this pattern to simplify the writing of very large and very small numbers.

For example,     $5\,000\,000$     and     $0.000\,003$
$$= 5 \times 1\,000\,000 \qquad\qquad = \frac{3}{1\,000\,000}$$
$$= 5 \times 10^6 \qquad\qquad\qquad = 3 \times \frac{1}{1\,000\,000}$$
$$= 3 \times 10^{-6}$$

> **Scientific notation** involves writing any given number as *a number between* 1 *inclusive and* 10, multiplied by a *power of* 10. The result has the form
> $$a \times 10^k \quad \text{where} \quad 1 \leqslant a < 10 \quad \text{and } k \text{ is an integer.}$$

### Example 6 ◄) Self Tutor

Write in scientific notation:

**a**   $23\,600\,000$              **b**   $0.000\,023\,6$

**a**       $23\,600\,000$         **b**       $0.000\,023\,6$
$\quad = 2.36 \times 10^7$          $\quad = 2.36 \times 10^{-5}$

### Example 7 ◄) Self Tutor

Write as an ordinary decimal number:

**a**   $2.57 \times 10^4$              **b**   $7.853 \times 10^{-3}$

**a**     $2.57 \times 10^4$         **b**     $7.853 \times 10^{-3}$
$\quad = 2.5700 \times 10\,000$       $\quad = 0007.853 \div 10^3$
$\quad = 25\,700$                       $\quad = 0.007\,853$

> Remember that
> $10^{-3} = \dfrac{1}{10^3}.$

## EXERCISE 1C

**1**   Write using scientific notation:

**a**   230          **b**   53 900          **c**   0.0361          **d**   0.006 80

**e**   3.26          **f**   0.5821          **g**   361 000 000          **h**   0.000 001 674

**2**   Write as an ordinary decimal number:

**a**   $2.3 \times 10^3$          **b**   $2.3 \times 10^{-2}$          **c**   $5.64 \times 10^5$          **d**   $7.931 \times 10^{-4}$

**e**   $9.97 \times 10^0$          **f**   $6.04 \times 10^7$          **g**   $4.215 \times 10^{-1}$          **h**   $3.621 \times 10^{-8}$

**3**   Express the following quantities using scientific notation:

**a**   There are approximately 4 million red blood cells in a drop of blood.

**b**   The thickness of a coin is about 0.0008 m.

**c**   Earth's radius is about 6.38 million metres.

**d**   A Rubik's Cube has approximately $43\,252\,000\,000\,000\,000\,000$ possible arrangements.

**4** Express the following quantities as ordinary decimal numbers:

   **a** The Amazon River is approximately $6.99 \times 10^6$ m long.

   **b** A piece of paper is about $1.8 \times 10^{-2}$ cm thick.

   **c** A test tube holds $3.2 \times 10^7$ bacteria.

   **d** A mushroom weighs $8.2 \times 10^{-6}$ tonnes.

---

**Example 8**                                                    🔊 **Self Tutor**

Simplify, writing your answer in scientific notation:

   **a** $(3 \times 10^4) \times (8 \times 10^3)$        **b** $\dfrac{2 \times 10^{-3}}{5 \times 10^{-8}}$

  **a** $\quad (3 \times 10^4) \times (8 \times 10^3)$

     $= 24 \times 10^{4+3}$

     $= (2.4 \times 10^1) \times 10^7$

     $= 2.4 \times 10^8$

  **b** $\dfrac{2 \times 10^{-3}}{5 \times 10^{-8}}$

     $= \frac{2}{5} \times 10^{-3-(-8)}$

     $= 0.4 \times 10^5$

     $= (4 \times 10^{-1}) \times 10^5$

     $= 4 \times 10^4$

---

**5** Simplify the following, writing your answers in scientific notation:

   **a** $(3 \times 10^3) \times (2 \times 10^7)$       **b** $(4 \times 10^3) \times (7 \times 10^5)$

   **c** $(8 \times 10^{-4}) \times (7 \times 10^{-5})$      **d** $(9 \times 10^{-5}) \times (6 \times 10^{-2})$

   **e** $(3 \times 10^5)^2$               **f** $(4 \times 10^7)^2$

   **g** $(2 \times 10^{-3})^4$            **h** $(5 \times 10^{-3})^3$

   **i** $(6 \times 10^{-1}) \times (4 \times 10^3) \times (5 \times 10^{-4})$   **j** $(6 \times 10^{-3})^2 \times (8 \times 10^{11})$

   **k** $(4 \times 10^3)^{-1}$            **l** $(5 \times 10^{-4})^{-2}$

**6** Simplify the following, writing your answers in scientific notation:

   **a** $\dfrac{8 \times 10^6}{4 \times 10^3}$      **b** $\dfrac{9 \times 10^{-3}}{3 \times 10^{-1}}$      **c** $\dfrac{4 \times 10^6}{2 \times 10^{-2}}$

   **d** $\dfrac{2.5 \times 10^{-4}}{(5 \times 10^7)^2}$    **e** $\dfrac{(8 \times 10^{-2})^2}{2 \times 10^{-6}}$    **f** $\dfrac{(5 \times 10^{-3})^{-2}}{(2 \times 10^4)^{-1}}$

**7**  **a** How many times larger is $3 \times 10^{11}$ than $3 \times 10^8$ ?

   **b**  **i** Which is smaller, $5 \times 10^{-16}$ or $5 \times 10^{-21}$ ?

      **ii** By how many times is it smaller than the other number?

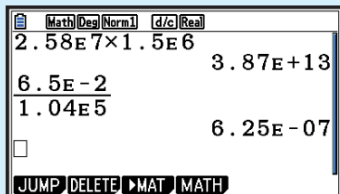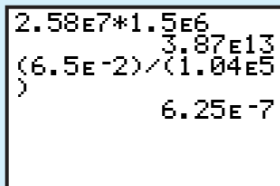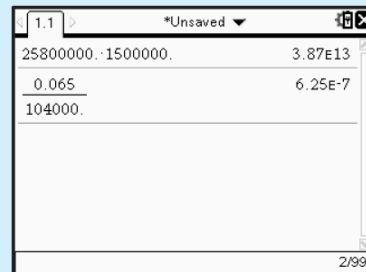   **c** How many times larger is $4 \times 10^6$ than $8 \times 10^{-5}$ ?

**Example 9**

Use your calculator to find:

a $(2.58 \times 10^7) \times (1.5 \times 10^6)$

b $\dfrac{6.5 \times 10^{-2}}{1.04 \times 10^5}$

**GRAPHICS CALCULATOR INSTRUCTIONS**

**Casio fx-CG20**

```
Math Deg Norm1 d/c Real
2.58E7×1.5E6
                3.87E+13
6.5E-2
1.04E5
                6.25E-07
□
JUMP DELETE ▶MAT MATH
```

**TI-84 Plus**

```
2.58E7*1.5E6
                3.87E13
(6.5E-2)/(1.04E5
)
                6.25E-7
```

**TI-nspire**

```
1.1      *Unsaved ▼
25800000.·1500000.        3.87E13
  0.065                   6.25E-7
104000.
                              2/99
```

a $(2.58 \times 10^7) \times (1.5 \times 10^6) = 3.87 \times 10^{13}$

b $\dfrac{6.5 \times 10^{-2}}{1.04 \times 10^5} = 6.25 \times 10^{-7}$

8 Calculate the following, giving each answer in scientific notation. The decimal part should be rounded to 3 significant figures.

a $(4.7 \times 10^5) \times (8.53 \times 10^7)$

b $(2.7 \times 10^{-3}) \times (9.6 \times 10^{14})$

c $\dfrac{3.4 \times 10^7}{4.8 \times 10^{15}}$

d $\dfrac{7.3 \times 10^{-7}}{1.5 \times 10^4}$

e $(2.83 \times 10^3)^2$

f $(5.96 \times 10^{-5})^2$

g $\dfrac{(3.56 \times 10^4)^2}{8.05 \times 10^{-5}}$

h $\dfrac{2.9 \times 10^2}{(7.62 \times 10^7)^3}$

9 Answer the **Opening Problem** on page **14**.

10 Use your calculator to answer the following:

a A rocket travels in space at $4 \times 10^5$ km h$^{-1}$. Assuming 1 year $\approx 365.25$ days, how far will it travel in:

i 30 days ii 20 years?

b A bullet travelling at an average speed of $2 \times 10^3$ km h$^{-1}$ hits a target 500 m away. Find the time of the bullet's flight, in seconds.

c Mars has volume $1.31 \times 10^{21}$ m$^3$ whereas Pluto has volume $4.93 \times 10^{19}$ m$^3$.
How many times bigger is Mars than Pluto?

d Microbe C has mass $2.63 \times 10^{-5}$ grams whereas microbe D has mass $8 \times 10^{-7}$ grams.

i Which microbe is heavier?

ii How many times heavier is it, than the other microbe?