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Strand 2 Using our number system

- Unit 1 Band c: Working with whole numbers
- Unit 2 Band d: Understanding decimals
- Unit 4 Band e: Understanding negative numbers
- Unit 3 Band e: Multiplying and dividing decimals by 10, 100, etc.
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Outside the maths classroom

Measuring space

How many stars are there in our galaxy?

Toolbox

Adding or subtracting numbers in standard form is straightforward if the multiple of ten is the same.

Five million added to three million is eight million, which can be written as $5 \times 10^6 + 3 \times 10^6 = 8 \times 10^6$.

If the powers of ten are not equal rewrite them so they are.

Then the same strategy can be used.

$$6 \times 10^9 + 5 \times 10^8 = 60 \times 10^8 + 5 \times 10^8$$

$$= 65 \times 10^8$$

$$= 6.5 \times 10^9.$$  

When multiplying (or dividing) two numbers in standard form, work with each part of the number separately.

$$5 \times 10^7 \times 3 \times 10^4 = 5 \times 3 \times 10^7 \times 10^3$$

$$= 15 \times 10^{10}$$

$$= 1.5 \times 10^{11}.$$  

Note: This is not standard form.

The number must be between 1 and 10.
Example – Multiplying large and small numbers

A grain of sand weighs around $3.5 \times 10^{-10}$ kg.
It is thought that there are around $7.5 \times 10^{18}$ grains of sand on the Earth.
Use the figures above to calculate the weight of all of the sand on Earth. Give your answer in
standard form.

Solution

$$3.5 \times 10^{-10} \times 7.5 \times 10^{18} = 26.25 \times 10^8$$

$$= 2.625 \times 10^9 \text{kg}$$

Example – Subtraction and division of small numbers

A loaf of bread contains $5 \times 10^{-3}$ kg of yeast and $1 \times 10^{-2}$ kg of salt.

a How much do the salt and yeast weigh in total?

b How much greater is the weight of the salt than the yeast in kg?

c How many times is the weight of salt greater than the yeast?

Solution

a $1 \times 10^{-2} + 5 \times 10^{-3} = 10 \times 10^{-3} + 5 \times 10^{-3}$

$= 1.5 \times 10^{-2}$ kg

b $1 \times 10^{-2} - 5 \times 10^{-3} = 10 \times 10^{-3} - 5 \times 10^{-3}$

$= 5 \times 10^{-3}$ kg

The salt weighs $5 \times 10^{-3}$ kg more than the yeast.

c $\frac{\text{weight of salt}}{\text{weight of yeast}} = \frac{1 \times 10^{-2}}{5 \times 10^{-3}}$

$= 0.2 \times 10^{-2-(-3)}$

$= 0.2 \times 10^{1}$

$= 2 \times 10^0$

There is twice as much salt as yeast.

Do the questions in this unit without a calculator first. Use your calculator to check your answers.

Practising skills

1 Work out the values of the following, giving your answers in standard form.

a $3.2 \times 10^5 + 4.6 \times 10^5$

d $6.4 \times 10^3 + 2000$

b $6.8 \times 10^{-2} - 5.1 \times 10^{-2}$

e $1.8 \times 10^{-3} + 2.2 \times 10^{-3}$

f $6.4 \times 10^{-2} - 0.033$

c $8000 + 700$

g $7.2 \times 10^5 + 4.6 \times 10^5$

2 Work out the following, giving your answers in standard form.

a $7.2 \times 10^5 + 4.6 \times 10^5$

d $7.2 \times 10^5 - 4.6 \times 10^5$

b $7.2 \times 10^5 + 4.6 \times 10^4$

e $7.2 \times 10^6 - 4.6 \times 10^5$

f $7.2 \times 10^5 - 4.6 \times 10^6$

c $7.2 \times 10^5 + 4.6 \times 10^6$

f $7.2 \times 10^5 - 4.6 \times 10^6$
Strand 2 Using our number system

3. Without using a calculator work out the value of the following. Give your answers in standard form.
   a. \(3 \times 10^5 \times 2 \times 10^7\)
   b. \(2 \times 10^3 \times 4 \times 10^6\)
   c. \(2 \times 10^5 \times 5 \times 10^2\)
   d. \(3 \times 10^{-5} \times 3 \times 10^7\)
   e. \(5 \times 10^{-7} \times 2 \times 10^5\)
   f. \(9 \times 10^{-6} \times 7 \times 10^{-4}\)

4. Without using a calculator work out the value of these calculations.
   a. \(6 \times 10^5 \div 2 \times 10^3\)
   b. \(8 \times 10^9 \div 4 \times 10^8\)
   c. \(6 \times 10^5 \div 2 \times 10^3\)
   d. \(3 \times 10^7 \div 2 \times 10^3\)
   e. \(2 \times 10^5 \div 4 \times 10^3\)
   f. \(2 \times 10^6 \div 8 \times 10^8\)

5. Using standard form, write down a number that is between:
   a. \(6 \times 10^5\) and \(6 \times 10^4\)
   b. \(6 \times 10^{-3}\) and \(6 \times 10^{-2}\)
   c. \(7.1 \times 10^2\) and \(7.1 \times 10^3\)
   d. \(7.1 \times 10^{-6}\) and \(7.1 \times 10^{-7}\)

6. Coley says:

   When you’re multiplying numbers in standard form you have to multiply the two numbers at the front together and write down what that comes to, then write ‘\(\times 10\)’ and finally add the two powers together and write that down.

   Explain why Coley’s method won’t always give the correct answer in standard form.

Developing fluency

1. Work out the following, giving your answers in standard form.
   a. \(3.204 \times 10^2 + 4 \times 10^{-1}\)
   b. \(3.204 \times 10^2 - 4 \times 10^{-1}\)
   c. \(3.204 \times 10^2 \times 4 \times 10^{-1}\)
   d. \(3.204 \times 10^2 \div 4 \times 10^{-1}\)

2. The speed of light is \(3 \times 10^8\) metres per second and there are roughly \(3 \times 10^7\) seconds in a year. A light year is the distance travelled by light in one year. Approximately how many metres is a light year? Give your answer in standard form.

3. The masses of some of the planets in our Solar System are:
   - Jupiter: \(1.9 \times 10^{27}\) kg
   - Saturn: \(5.7 \times 10^{26}\) kg
   - Mercury: \(3.3 \times 10^{23}\) kg
   - Earth: \(6 \times 10^{24}\) kg.
   a. Place the planets in order of mass.
   b. How many times greater than the mass of the Earth is the mass of Jupiter?
   c. How many times greater than the mass of Mercury is the mass of Jupiter?
   d. How many time greater than the mass of Mercury is the mass of the Earth?
Some approximate masses are:
caffeine molecule $3.2 \times 10^{-25}$ kg
eyebrow hair $7 \times 10^{-8}$ kg
average human cell $1 \times 10^{-12}$ kg
water molecule $3 \times 10^{-26}$ kg.

a How many water molecules weigh the same as an eyebrow hair?
b How many water molecules weigh the same as one caffeine molecule?
c How many times greater than the mass of a water molecule is the mass of an eyebrow hair?

A hydrogen atom weighs $1.67 \times 10^{-27}$ kg.
An oxygen atom weighs $2.67 \times 10^{-26}$ kg.
What is the mass of a molecule of water?

Problem solving

1. The mass of a spacecraft is $7.8 \times 10^4$ kg.
The spacecraft is carrying equipment with a total mass of $2.4 \times 10^3$ kg.
The spacecraft docks with a space station.
The mass of the space station is $4.62 \times 10^5$ kg.
The commander of the space station does not want the total mass on docking to be greater than $5.43 \times 10^5$ kg.
Is the total mass within this limit?

2. Jenny is making a scale model of the Solar System.
She wants the distance from Earth to Saturn to be 20 cm on her scale model.
The real distance from the Earth to Saturn is $1.25 \times 10^9$ kilometres.
a Find the scale of the model in the form $1:n$ where $n$ is written in standard form.
Jenny wants to put the position of a spacecraft on the scale model.
The real distance of the spacecraft from Earth is $8.5 \times 10^8$ kilometres, correct to 2 significant figures.
b Work out the distance of the spacecraft from Earth on the scale model.

3. Karim is trying to find out the thickness of a piece of paper.
He has a box of paper which contains 3000 sheets of paper positioned on top of each other.
The height of the paper is 0.3 m.
a Work out the thickness of each sheet of paper.
Give your answer in metres, in standard form.
Karim also wants to know the weight of each sheet of paper.
He weighs the box containing the paper, then he weighs the box when it is empty.
The weight of the box and paper is 54 kg.
The weight of the empty box is 500 g.
b Work out the weight of each piece of paper.
Give your answer in kilograms, in standard form.
Elaine is estimating how far away a thunderstorm is from her home.

The speed of sound is estimated at $3.3 \times 10^2$ metres per second.
The speed of light is estimated at $3.0 \times 10^8$ metres per second.

a) The thunderstorm is 6 km away and Elaine sees a flash of lightning.

She hears the clap of thunder $x$ seconds later.

Work out the value of $x$.

Give your answer to the nearest whole number.

b) The length of time between seeing the next flash of lightning and hearing the clap of thunder is 3 seconds.

How far away is the thunderstorm now?

State any assumptions that you have made.

Lynn is carrying out a survey on the living space per person in five different countries.
The table shows the information that she has collected.

<table>
<thead>
<tr>
<th>Country</th>
<th>Area (in km²)</th>
<th>Population</th>
<th>Area (in km²) per person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>$3.0 \times 10^6$</td>
<td>$2.2 \times 10^7$</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>$8.5 \times 10^6$</td>
<td>$2.0 \times 10^8$</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>$9.6 \times 10^6$</td>
<td>$1.4 \times 10^9$</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>$3.6 \times 10^5$</td>
<td>$8.3 \times 10^7$</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>$2.4 \times 10^5$</td>
<td>$6.4 \times 10^7$</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>$9.8 \times 10^6$</td>
<td>$3.2 \times 10^8$</td>
<td></td>
</tr>
</tbody>
</table>

She wants to find out which country has the greatest land area per person.
Complete the table and compare the five countries.

Rod is a keen physicist interested in the wavelengths of sound waves.

Rod wants to find the difference between the wavelength of his favourite radio station to the wavelength of his dad’s favourite radio station.

Rod listens to FM Capital Radio which has a frequency of 102 MHz.
Rod’s dad listens to AM Radio 5 Live which has a frequency of 909 kHz.

$1 \text{ MHz} = 10^6 \text{ waves per second}$.$1 \text{ kHz} = 10^3 \text{ waves per second}$.

To find the wavelength (in m), Rod uses the formula:

\[
\text{wavelength} = \frac{3 \times 10^8}{\text{frequency (in waves per second)}}
\]

Work out the difference between the wavelength of Rod’s favourite radio station and the wavelength of his dad’s favourite radio station.
Reviewing skills

1. Work out
   a. $8.48 \times 10^4 + 8.4 \times 10^3 - 3 \times 10^2$
      Give your answer in standard form.
   b. Write the following as ordinary numbers.
      i. $8.48 \times 10^4$
      ii. $8.4 \times 10^3$
      iii. $3 \times 10^2$
   c. Use your answers to part b to check your answer to part a.

2. Work out the following, giving your answers in standard form.
   a. $6000 \times 1.5 \times 10^9$
   b. $1.6 \times 10^{-4} \times 2 \times 10^{-3}$
   c. $2.3 \times 10^6 + 3 \text{ million}$
   d. $0.0052 - 3.2 \times 10^{-3}$
   e. $7.6 \times 10^2 \times 2 \times 10^{-1}$
   f. $7.6 \times 10^2 \div 2 \times 10^{-1}$

3. A human body contains roughly $1 \times 10^{12}$ bacteria and there are about $7 \times 10^9$ people on the planet.
   How many bacteria are there in total within all of the people?
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