Sometimes it is necessary to work with very large numbers and very small numbers. Here are two examples.

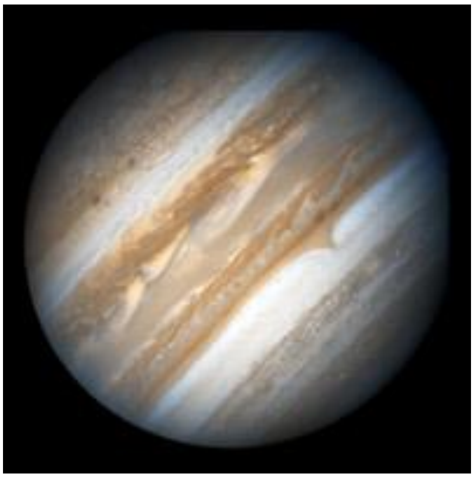


Image of Jupiter produced by STScI for NASA from http://hubblesite.org/

Jupiter's surface area

Jupiter's surface area is equal to $4\pi r^2$
where Jupiter's radius r = 71 492 000 metres.

Think about…

- how to work out Jupiter's surface area.

Atomic particles

The mass of a proton is
0.000 000 000 000 000 000 000 001 673 g.

This is 1836 times as heavy as an electron.

Think about…

- how to work out the mass of an electron
- how to work out the number of protons needed to make a mass of 1 kg.

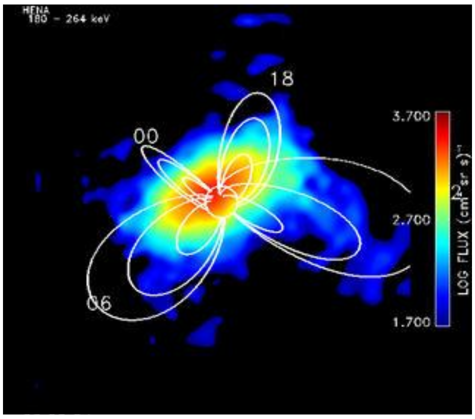


Image of an oxygen atom produced by the NASA/Goddard Space Flight Center Scientific Visualization Studio from http://www.nasa.gov

This activity shows how to use standard form to work out the answers to questions like these.

Information sheet

A Powers of 10

10^3	10^2	10^1	10^0	10^1	10^{-2}	10^{-3}
↓	↓	↓	↓	↓	↓	↓
1000	100	10	1	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1000}$

Other examples are 10^6 = 1 000 000 and $10^{-9} = \dfrac{1}{1\ 000\ 000\ 000}$

Think of a negative in the power as 'one over'.

Think about…

Any number to the power zero has a value of 1, so $1\ 000\ 000^0 = 1$ and $4^0 = 1$
Can you explain why this is so?

B Calculating with standard form

Numbers written in standard form have two parts
$a \times 10^n$, where a is between 1 and 10 and n is a positive or negative integer

Examples: $7.3 \times 10^5 = 730\,000$ or $3.681 \times 10^{-7} = 0.000\,000\,3681$

Calculators have a variety of ways of entering numbers in standard form:

Using [EXP] key: For 4.5×10^3 enter 4.5 [EXP] 3
and for 7.1×10^{-5} enter 7.1 [EXP] [(–)] 5

Using [EE] key: For 4.5×10^3 enter 4.5 [EE] 3
and for 7.1×10^{-5} enter 7.1 [EE] [(–)] 5

Using [10^x] key: For 4.5×10^3 enter 4.5 [10^x] 3
and for 7.1×10^{-5} enter 7.1 [10^x] [(–)] 5

Note: Not all calculators have a separate [(–)] key.
If your calculator does not have this, enter (– 5) using brackets.

Use your calculator to work out the following examples, and check that you get the same answers:

1 $(4 \times 10^{-3}) + (8 \times 10^{-5}) = 4.08 \times 10^{-3}$ or 0.00408

2 $(7 \times 10^5) - (9 \times 10^4) = 6.1 \times 10^5$ or 610 000

3 $(4 \times 10^3) \times (2 \times 10^6) = 8 \times 10^9$ or 8 000 000 000

4 $(8 \times 10^9) \div (2 \times 10^6) = 4 \times 10^3$ or 4000

C Using standard form in real situations

Jupiter's surface area

Jupiter's radius r = 71 492 000 metres. In standard form this is 7.1492×10^7.

The surface area is $4\pi r^2 = 4\pi \times (7.1492 \times 10^7)^2$

Work this out on your calculator. You should get 6.4228×10^{16} m^2

Think about…

What is this as an ordinary number?

Atomic particles

The mass of a proton is 0.000 000 000 000 000 000 000 001 673 g.
In standard form this is 1.673×10^{-24}

This is 1836 times as heavy as an electron.

Think about…

- how to work out the mass of an electron

> If you find this difficult, think of an easier problem:
>
> A father weighs 84 kg. This is 3 times as heavy as his daughter.
> How would you work out how much his daughter weighed?

The mass of an electron = $(1.673 \times 10^{-24}) \div 1836$

Work this out on your calculator. You should get 9.112×10^{-28} g
What is this as an ordinary number?

Think about…

- how to work out the number of protons needed to make 1 kg

> If you find this difficult, think of an easier problem.
>
> Satsumas weigh on average 40 g each.
> How do you work out how many would weigh 1 kg?

The number of protons that weigh 1 kg = $1000 \div (1.673 \times 10^{-24})$

Work this out on your calculator. You should get 5.977×10^{26}
What is this as an ordinary number?

Try these

1 Write these in standard form:

a three million	**b** £12.6 million	**c** eighty thousand
d five billion	**e** £3.25 billion	**f** ten and a half billion

g seven million, five hundred and twenty thousand

h four hundred and fifty million and sixty-eight thousand

2 Write these as ordinary numbers.

a 2.4×10^{6}	**b** 2.4×10^{-6}	**c** 3×10^{9}
d 3×10^{-9}	**e** 7.14×10^{5}	**f** 7.14×10^{-5}

3 Write these numbers in standard form.

a 36 000 000	**b** 482 000	**c** 900 000 000
d 0.000 25	**e** 0.000 007	**f** 0.003 456

Think about…

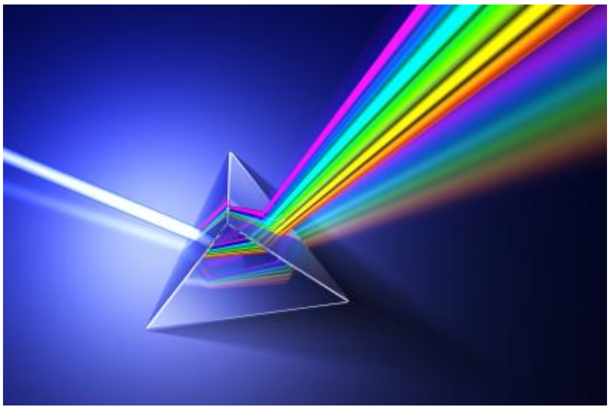
In the following problems, if you are not sure what calculation you need, make up a situation with easy numbers to help you to see what to do.

4 At the end of 2009 there were 6.4×10^{8} mobile broadband subscriptions and 4.9×10^{8} fixed broadband subscriptions in the world.
What was the total number of broadband subscriptions?

5 The Earth is 1.5×10^{11} metres from the Sun.
Light travels at about 3×10^{8} metres per second.

Use the formula: $\text{time} = \dfrac{\text{distance}}{\text{speed}}$ to estimate the time taken for sunlight to reach the Earth.

6 The wavelength of red light is 7×10^{-7} metres and that of violet light is 4×10^{-7} metres.
What is the difference between these wavelengths?



7 A bacterium measures 1×10^{-6} metres and a virus measures 2×10^{-7} metres.
How many times bigger is the bacterium than the virus?

8 A flea is 9.5×10^{-4} metres long and a dust mite is 2.3×10^{-3} metres long.
Which of these is longer and by how much?

9 The surface area of the Earth is approximately 5.1×10^{8} square kilometres.
The area of Europe is about 9.9×10^{6} square kilometres.
Approximately what % of the Earth's area is Europe?

10 Each locust in a swarm eats about 2.3×10^{-3} kilograms of food in a day and there are about 3×10^{4} locusts in the swarm.

Roughly how much does the whole swarm eat in a day?

11 You may know that Saturn has rings. It also has moons.
The table gives information about six of Saturn's moons.

Moon	Distance from Saturn (m)	Volume (m^3)	Mass (kg)
Dione	3.77×10^{8}	7.36×10^{17}	1.05×10^{21}
Enceladus	2.38×10^{8}	6.54×10^{16}	8.40×10^{19}
Iapetus	3.56×10^{9}	1.63×10^{18}	1.88×10^{21}
Rhea	5.27×10^{8}	1.88×10^{18}	2.49×10^{21}
Tethys	2.95×10^{8}	6.24×10^{17}	7.55×10^{20}
Titan	1.22×10^{9}	7.15×10^{19}	1.35×10^{23}

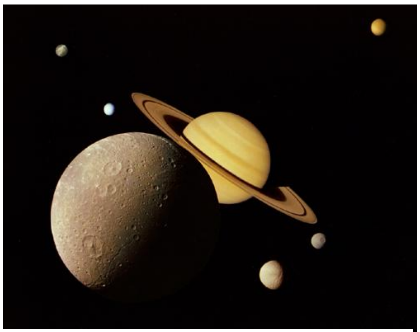


Image from http://www.nasa.gov

a List the moons in the order of their distance from Saturn. Start with the nearest.

b List the moons in the order of their volumes. Start with the largest moon.

c List these moons in the order of their masses. Start with the heaviest.

d Use the formula: $\text{density} = \frac{\text{mass}}{\text{volume}}$ to find the density of each moon.

12 The table gives the atomic masses of carbon, hydrogen, oxygen and nitrogen.

Element	Atomic Mass (kg)
Carbon	1.99×10^{-26}
Hydrogen	1.67×10^{-27}
Oxygen	2.66×10^{-26}
Nitrogen	2.33×10^{-26}

a List the elements in the order of their masses. Start with the lightest.

b Molecules of other substances are made from combinations of atoms. Find the mass of each of the following molecules:

i carbon monoxide (CO) made from one atom of carbon plus one of oxygen

ii carbon dioxide (CO_2) made from one atom of carbon plus two of oxygen

iii water (H_2O) made from two atoms of hydrogen plus one of oxygen

c i Which is heavier, a molecule of acetic acid ($C_2H_4O_2$) or nitric acid (HNO_3)?

ii What is the difference in their masses?

13 It has been said that "Unravel your DNA and it would stretch from here to the Moon". (http://hypertextbook.com/facts/1998/StevenChen.shtml). Check whether this is true.

You can assume that:

- there are about 10^{13} cells in the body; each cell contains about 3 billion base pairs, where each base pair is 3.4×10^{-10} metres long.
- the distance between the Earth and the Moon is 3.8×10^{8} metres.

At the end of the activity

Can you explain why:

a $2.42 \times 10^{4} = 24\ 200$

b $2.42 \times 10^{-4} = 0.000242$.

c $0.000\ 056 = 5.6 \times 10^{-5}$

d $1\ 250\ 000\ 000 = 1.25 \times 10^{9}$

How do you enter a number like 5.6×10^{-5} into your calculator?

What are the advantages of working in standard form?

Are there any disadvantages?