GCSE Biology

Student maths skills worksheet

Name .... Class .... Date ....

Use of significant figures

Learning outcomes

After completing this activity, you should be able to:

- use an appropriate number of significant figures to display an answer
- calculate a value to the same number of significant figures as the data it is derived from.

Aims

It is not always necessary to know a value to an exact figure. Sometimes it is good enough to have an approximation to this exact number. For example, the population of Manchester in mid-2014 was 520 215. Whilst some people (e.g., health professionals) may need to know the exact figure, for many people a value of 520 000 or even 500 000 would be good enough to get a feel for the size of the population.

When you round a value in this way, you are making a decision about how many significant figures to display in an answer. Scientists often work to the following rules:

- write your answer to three significant figures
- or, if lower, write your answer based on the lowest number of significant figures from a set of data.

Worked example

Choosing an appropriate number of significant figures

1 Look at the data an answer is based upon, and note the number of significant figures the data is quoted to.

2 Perform any required calculation(s).

3 Write your answer to:

  a the number of significant figures noted in (1) above, or

  b 3 significant figures

  depending on whichever of (a) and (b) gives the lowest number of significant figures.

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Worked example 1

A group of students measured the height of five seedlings. Their results are shown below:

44 mm 48 mm 32 mm 38 mm 36 mm

What was the mean height of the seedlings?

Look at the data an answer is based upon, and note the number of significant figures the data is quoted to:

Each of the values is quoted to two significant figures.

Perform any required calculation(s):

$$\text{mean value} = \frac{\text{sum of values}}{\text{number of values}}$$

$$\text{mean value} = \frac{44 + 48 + 32 + 38 + 36}{5}$$

$$\text{mean value} = \frac{198}{5}$$

mean value = 39.6 mm

Write your answer to an appropriate number of significant figures:

The data in this question is quoted to two significant figures, so this is how your answer should be expressed.

39.6 mm = 40 mm (to two significant figures)

The mean value is 40 mm.

Tip – To round a value, select the place value to which you are going to round. Look at the next digit. If the value is < 5, round down; if the value is ≥ 5, round up.

Worked example 2

A student measures the time taken for *Elodea* pondweed to produce 2 cm^3 of oxygen gas at different light intensities. Her results are shown below:

Relative light intensity	Time in s
1	48
2	24
3	16
4	12
5	10

Calculate the rate of photosynthesis for each value, using the formula:

$$\text{rate of photosynthesis (/s)} = \frac{1}{\text{time (s)}}$$

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Look at the data an answer is based upon, and note the number of significant figures the data is quoted to:

Each of the values is quoted to two significant figures

Perform any required calculation(s):

Relative light intensity	Time in s	Calculated rate /s	Rate /s
1	48	0.020833	0.021
2	24	0.041667	0.042
3	16	0.0625	0.063
4	12	0.083333	0.083
5	10	0.1	0.010

Note that each rate value has been calculated to two significant figures, because the original data (time in s) is also quoted to two significant figures.

Tip – You would not usually include the calculated rate column; this has been shown here for reference only.

Tip – Remember that when considering a decimal value, the first digit counting as a significant figure must be a non-zero value.

Questions

1 Write the following values to three significant figures:

a 8316

.... (*1 mark*)

b 25642

.... (*1 mark*)

c 3.29582

.... (*1 mark*)

d 0.04626

.... (*1 mark*)

2 Write the following values to two significant figures:

a 8316

.... (*1 mark*)

b 25642

.... (*1 mark*)

c 3.29582

.... (*1 mark*)

d 0.04626

.... (*1 mark*)

3 Calculation the mean of the following values:

62.5 s 68.2 s 59.7 s 60.4 s 65.5 s 62.1 s

....

.... (*2 marks*)

4 A group of students investigated how wind speed affects the rate of transpiration. They attached a cutting to a potometer and measured the distance travelled by an air bubble in 3 minutes. Their results are shown below:

Wind speed in m/s	Distance moved in cm			
	Repeat 1	Repeat 2	Repeat 3	Mean
2	1.10	1.20	1.15	
4	3.35	3.45	3.45	
6	4.20	4.20	4.30	
8	6.75	6.80	6.85	
10	10.45	10.40	10.30	

Complete the students' results table by calculating the mean distance travelled for each wind speed result. (*5 marks*)

Exam-style question

5 A student was looking for a link between the number of species present in an area of their school field, and whether the land was trampled or not. They performed a series of random samples using a quadrat of area 1 m^2. The results collected by the student are shown below.

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Land type sampled	Number of different species identified					
	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Mean
untrampled	13	11	15	15	10	
partially trampled	10	8	8	6	8	8
trampled	3	5	5	3	4	4

a Explain what is meant by a random sample.

.... (*1 mark*)

b Calculate the mean number of species identified in the untrampled land.

.... (*1 mark*)

c Suggest an explanation for the student's results.

....

.... (*2 marks*)

d In the partially trampled land, the student counted an average of seven dandelions in each quadrat area.

i Calculate the total number of dandelions counted by the student.

.... (*1 mark*)

ii The region of land on the school field that the student classified as partially trampled measured 140 m × 82 m. Estimate the total number of dandelions on the partially trampled land. Express your answer to an appropriate number of significant figures.

....

....

.... (*3 marks*)

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Student maths skills worksheet

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Standard form and order of magnitude

Learning outcomes

After completing this activity, you should be able to:

- use standard form where appropriate
- make order of magnitude estimates.

Aims

Some numbers in Biology are very large, like the human population. Other numbers are very small, such as the size of a virus. Scientists normally write very large or very small numbers in standard form.

It is sometimes accurate enough to have an idea about the size of something. For example, you could say that a virus is around 10^{-7} m in size. This type of approximation is known as an order of magnitude estimate.

In this activity you will practise converting numbers into standard form and making order of magnitude estimates.

Worked examples

How to convert a value >1 to standard form

1. State the value to be converted.
2. State the first part of the number as a decimal number, with one digit (not zero) in front of the decimal place, and 2 digits after the decimal place. Round the original value as appropriate.
3. State the second part of the number, which multiplies the number by the appropriate power of 10.

   A positive power in a standard form value tells you how many times to multiply the value by 10.
4. Add the unit (if required).

Student maths skills worksheet

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Worked example

The human population was 7 400 000 000 in February 2016. Convert this value to standard form.

Write the value to be converted:

Value = 7 400 000 000

State the first part of the number as a decimal number:

7.40

State the second part, which multiplies the number by the appropriate power of 10:

10^9 (this is because there are 9 digits after the number 7).

Add the unit:

There is no unit for population size

The conversion is therefore:

$7\,400\,000\,000 = 7.40 \times 10^9$

How to convert a value <1 to standard form

1. State the value to be converted.
2. State the first part of the number as a decimal number, with one digit (not zero) in front of the decimal place, and 2 digits after the decimal place. Round the original value as appropriate.
3. State the second part of the number, which multiplies the number by the appropriate power of 10.

   A negative power tells you how many times to divide the value by 10.
4. Add the unit (if required).

Worked example

A virus is measured by an electron microscope to be 0.000 000 2 m in size. Convert this value to standard form.

Write the value to be converted:

Value = 0.000 000 2 m

State the first part of the number as a decimal number:

2.00

State the second part, which multiplies the number by the appropriate power of 10:

10^{-7} (this is because there are 7 zeroes before the number 2).

Add the unit:

m

The conversion is therefore:

$0.000\,000\,2\text{ m} = 2.00 \times 10^{-7}\text{ m}$

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How to make an order of magnitude estimate

1. State the value to be approximated in standard form.
2. Round up to 10 if it is ≥ 5; round down to 1 if it is < 5.
3. State the number to the appropriate power of 10.

Worked example 1

State the human population (7.40×10^9 in February 2016) to the nearest order of magnitude.

State the value to be approximated

7.40×10^9

Round up to 10 if it is ≥ 5; round down to 1 if it is < 5

Round up to 10×10^9

State the number to the appropriate power of 10

$10 \times 10^9 = 10^{10}$

The human population is of the order of magnitude 10^{10} in size

Worked example 2

State the size of a virus (measured as 0.000 000 2 m) to the nearest order of magnitude.

State the value to be approximated in standard form

2.00×10^{-7} m

Round up to 10 if it is ≥ 5; round down to 1 if it is < 5

Round down to 1×10^{-7} m

State the number to the appropriate power of 10

1×10^{-7} m $= 10^{-7}$ m

A virus is of the order of magnitude 10^{-7} m in size.

Questions

1 Convert the following numbers to standard form:

a 34 000

.... (*1 mark*)

b 728 900 999

.... (*1 mark*)

c 0.004

.... (*1 mark*)

d 0.000 081 48

.... (*1 mark*)

2 Convert the following standard form numbers to a value:

a 4.29×10^{3}

.... (*1 mark*)

b 8.30×10^{6}

.... (*1 mark*)

c 7.52×10^{-3}

.... (*1 mark*)

d 3.01×10^{-5}

.... (*1 mark*)

3 State the nearest order of magnitude to each of the following values:

a 1.49×10^{5}

.... (*1 mark*)

b 67 845

.... (*1 mark*)

c 3.56×10^{-3}

.... (*1 mark*)

d 0.000 895

.... (*1 mark*)

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4 State the range of values which would be covered by each of the following order of magnitude estimates:

a 10^4

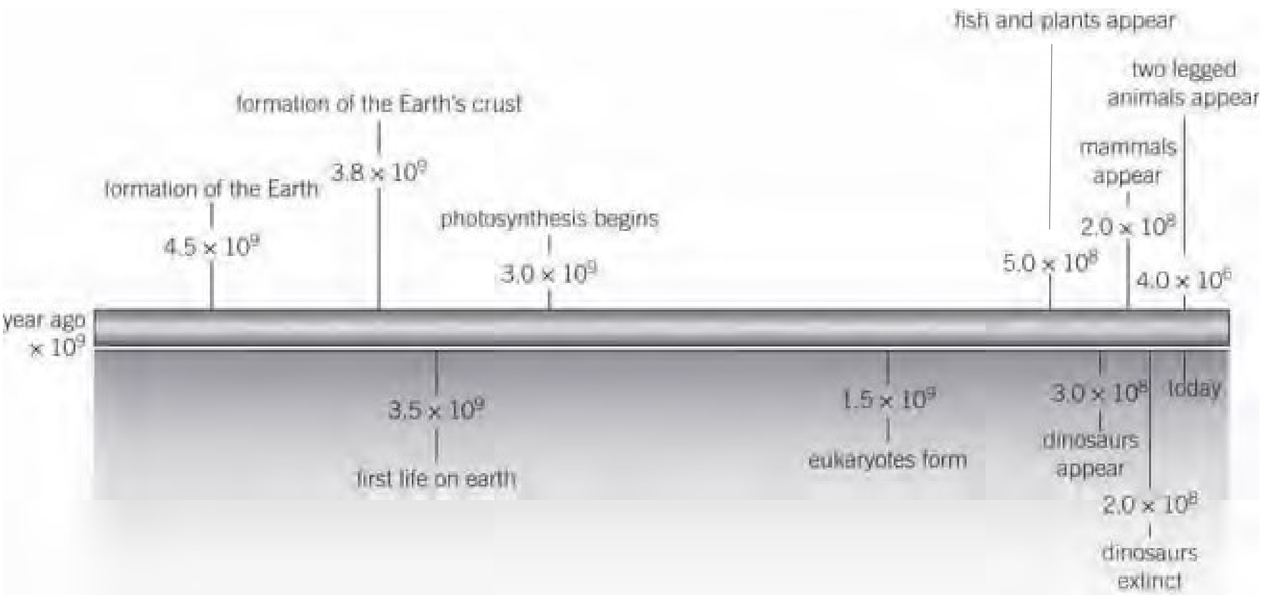
.... (*1 mark*)

b 10^{-3}

.... (*1 mark*)

Exam-style question

5 The following diagram represents some events in the evolution of the Earth:



a Complete this sentence by circling the correct word:

The Earth is approximately 4.5 **thousand / million / billion** years old. (*1 mark*)

b How much time elapsed between the first life appearing on Earth and the evolution of organisms able to photosynthesise?

....

.... (*2 marks*)

c State and explain the effect on the Earth's atmosphere of the evolution of organisms able to photosynthesise.

....

....

.... (*3 marks*)

d The Cambrian geological period is defined as running between 485 and 541 million years ago. Label these times on the timeline. (*1 mark*)

e To the nearest order of magnitude, how long ago did mammals first appear?

.... (*1 mark*)

f How long ago did dinosaurs appear, as a fraction of the time since eukaryotes formed?

....

....

.... (*3 marks*)