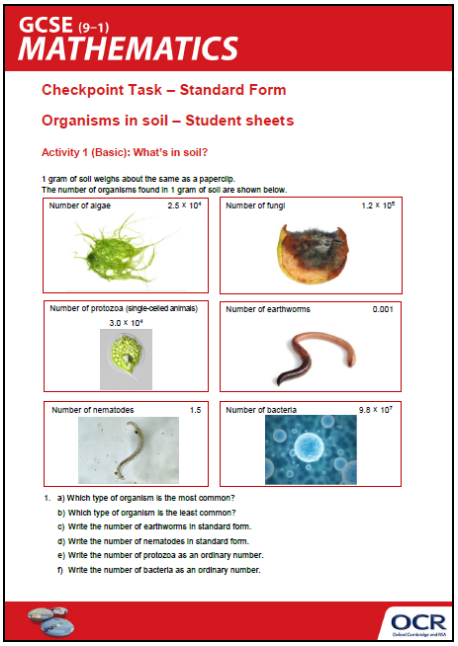
This Checkpoint Task should be used in conjunction with the KS3–KS4 Transition Guide – Standard Form

Checkpoint Task – Standard Form

Organisms in soil

Instructions and answers for teachers

***These instructions should accompany the OCR resource 'Organisms in soil' activity** which supports OCR GCSE (9–1) Mathematics*


GCSE (9–1)
MATHEMATICS

Checkpoint Task – Standard Form

Organisms in soil – Student sheets

Activity 1 (Basic): What's in soil?

1 gram of soil weighs about the same as a paperclip.
The number of organisms found in 1 gram of soil are shown below.

Number of algae 2.5×10^1

Number of fungi 1.2×10^6

Number of protozoa (single-celled animals) 3.0×10^4

Number of earthworms 0.001

Number of nematodes 1.5

Number of bacteria 9.8×10^7

1. a) Which type of organism is the most common?
   b) Which type of organism is the least common?
   c) Write the number of earthworms in standard form.
   d) Write the number of nematodes in standard form.
   e) Write the number of protozoa as an ordinary number.
   f) Write the number of bacteria as an ordinary number.

OCR

This activity offers an opportunity for English skills development.

This activity offers an opportunity for maths skills development.

Associated materials:
'Organisms in soil' Checkpoint Task activity sheet.

Answers

Activity 1 (Basic): What's in soil?

Aim:

To assess a basic understanding of numbers in standard form.

This activity is appropriate for higher achieving students at KS3 or Foundation tier students at KS4.

The mathematics covered in this activity:

Conversion of numbers in standard form to ordinary numbers and vice versa.

Ordering numbers in standard form.

Solving a problem with one number written in standard form.

Interpreting a calculator display.

Activity guidance:

Students would need to be confident in converting large and small numbers into standard form and vice versa. They would need to have developed an understanding or ability to interpret numbers written in standard form.

This investigative activity could be given to students in groups, pairs or individually.

The numbers of organisms in question 1 could be given additionally as individual cards.

If required, a page of blank tables is included at the end of this document, which can be printed out and distributed to students to stick in exercise books for completing question 2.

For further work students could be encouraged to find their own data on the internet such as particle sizes in gravel, sand, silt and clay, or other organisms in soil, etc. and write the numbers in standard form giving the units. This could promote a discussion of the need for a standard unit of measurement, e.g. metres, to enable comparison and further discuss on how to change the number into a particular unit. Working in groups, they could be asked to design a game to match standard form with ordinary numbers, produce a poster, or place pictures and corresponding numbers in standard form on a large number line, i.e. sorting the items in order as a class activity.

Suggested questions:

- What do you know?
- How can you compare the numbers?
- What does the number mean?
- Is the number large or small?
- How do you multiply by 10?
- How do you divide by 10?
- What does the negative power of 10 mean?

1 gram of soil weighs about the same as a paperclip.
The number of organisms found in 1 gram of soil are shown below.

Number of algae 2.5×10^4

Number of fungi 1.2×10^5

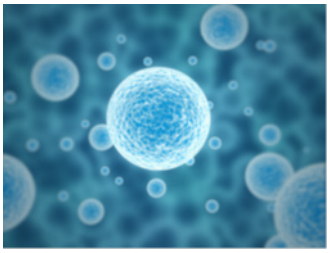
Number of protozoa (single-celled animals)

3.0×10^4

Number of earthworms 0.001

Number of nematodes 1.5

Number of bacteria 9.8×10^7



1. a) Which type of organism is the most common? Bacteria
   b) Which type of organism is the least common? Earthworms
   c) Write the number of earthworms in standard form. 1.0×10^{-3}

d) Write the number of nematodes in standard form. 1.5×10^0

e) Write the number of protozoa as an ordinary number. 3.0×10^4

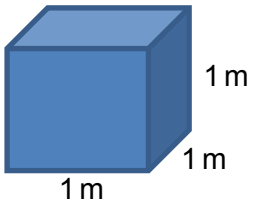
f) Write the number of bacteria as an ordinary number. 98 000 000

2. a) Write these six organisms in order giving the largest number first.
Put your results in the table below.

Name	Number in standard form
Bacteria	9.8×10^7
Fungi	1.2×10^5
Protozoa	3.0×10^4
Algae	2.5×10^4
Nematodes	1.5×10^0
Earthworms	1.0×10^{-3}

b) A scientist says these values should be given as dry weights.
In a cubic metre of soil the dry weight of the organisms are:

algae	3.2×10^1 g
bacteria	160 g
earthworms	80 g
fungi	2.0×10^2 g
nematodes	12 g
protozoa	3.8×10^1 g



(i) Which organism has the highest dry weight? Fungi

(ii) Which organism has the lowest dry weight? Nematodes

3. Earthworms can eat up to 5×10^3 bacteria in one minute.
If an earthworm ate constantly, what is the maximum number of bacteria it could eat in 24 hours?
Write your answer in standard form.

$5 \times 10^3 \times 60 \times 24$

$= 7.2 \times 10^6$

Activity 2 (Understanding indices): The farmer's field

Aim:

To assess the understanding of indices and the order of operations.

This task is appropriate for higher achieving students at KS3 or Foundation tier students at KS4.

The mathematics covered in this activity:

Addition, subtraction and multiplication of numbers in standard form.

Calculating with positive powers of 10.

Factorising.

Using the laws of indices.

Solving problems (areas and perimeters of rectangles) with numbers in standard form.

Interpreting a calculator display.

Using the correct units.

Activity guidance:

This task could be given to individual students or pairs.

Although students can use a calculator for these questions they should be able to work through a given solution and have an understanding of how expressions can be manipulated, including the method of adding expressions with different powers of 10.

In question 3, students should show the steps in their working i.e. the numbers they are multiplying on the calculator. Students should not be converting the number to an ordinary form before calculating.

More able students could be provided with more difficult areas to calculate, e.g. trapezium, circle.

Suggested questions:

- What do you know about adding numbers in standard form?
- How can you get the powers the same?
- What do you do with the indices when you multiply?
- How do you find the area?
- How do you find the perimeter?
- Is there another way to find the perimeter?
- How do you decide which number is bigger?

1. Sarah and Toby want to calculate $8 \times 10^6 + 7 \times 10^6$.

Sarah writes

$8 \times 10^6 + 7 \times 10^6$

$= 15 \times 10^{12}$

$= 1.5 \times 10^1 \times 10^{12}$

$= 1.5 \times 10^{13}$

Toby writes

$8 \times 10^6 + 7 \times 10^6$

$= (8 + 7) \times 10^6$ factorising

$= 15 \times 10^6$

a) What did Sarah do wrong?

She added the indices.

b) What did Toby forget to do?

Write the answer in standard form.

c) Write out the correct answer.

1.5×10^7

2. Sarah and Toby now want to calculate $5 \times 10^{16} - 8 \times 10^{14}$.

Toby writes

$5 \times 10^{16} - 8 \times 10^{14}$

$= 5 \times 10^2 \times 10^{14} - 8 \times 10^{14}$

$= (5 \times 10^2 - 8) \times 10^{14}$ factorising

$= (5 \times 100 - 8) \times 10^{14}$

Sarah says that Toby is right so far.

Sarah says:
Work out the brackets.
Write the answer in standard form.

Finish the calculation.

$= 492 \times 10^{14}$

$= 4.92 \times 10^{16}$

3. Write your answers to this question in standard form.

a) The length of Field A = 7×10^2 m.

The width of Field A = 5×10^2 m.

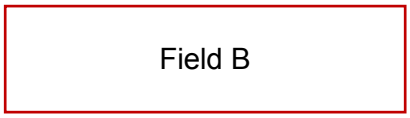
Not to scale

(i) Find the area of Field A. 3.5×10^5 m^2

(ii) Find the perimeter of Field A. 2.4×10^3 m

b) The length of Field B = 9×10^2 m.

The width of Field B = 2×10^1 m.



Not to scale

(i) Find the area of Field B. 1.8×10^4 m^2

(ii) Find the perimeter of Field B. 1.84×10^3 m^2

c) Which field, A or B, has the bigger area and by how much?

Field A has the bigger area by 3.32×10^5 m^2

Activity 3 (Challenge): How small are bacteria?

Aim:

To understand relative sizes of very small objects.

The mathematics covered in this activity:

Estimating the length of an object from a given scale.

Calculating with negative powers of 10.

Substituting into a given formula.

Order of operations.

Removing brackets from an expression.

Interpreting a calculator display.

Problem solving.

Writing to a suitable degree of accuracy.

Activity guidance:

This activity could be given to individual students or pairs. It could be extended by students researching other microscopic organisms and comparing the lengths and/or volumes.

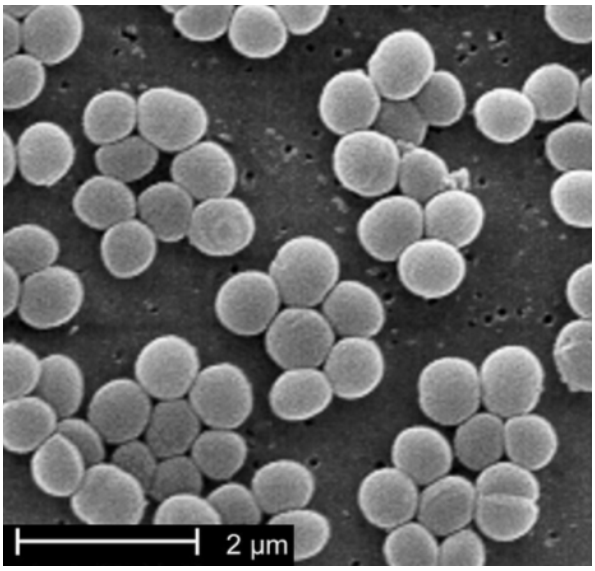
This activity is intended for more able groups of students, familiar with using formulae to find volumes and is therefore suitable for Higher tier KS4 students. Students should be asked to show all the steps in their working, ensuring that answers are given to a suitable degree of accuracy and give the correct units in their answer.

Suggested questions:

- What information does the photograph give?
- How would you use the scale?
- What degree of accuracy will you use?
- What do you know about the radius and diameter of a sphere?
- What does r cubed mean?
- How would you simplify your expression for r^3?
- How can you remove the bracket?
- What units are you working in?
- How do you find the volume of a cube?
- How many millimetres in a metre?
- What is 1 mm in metres?

- What do you do with the indices when you subtract?
- How do you subtract a negative number?
- Which is easier to read, a large or small number in standard form or a large or small ordinary number?

1.



These spherical staphylococcus bacteria can be found in the soil. Most are harmless.

The scale on the picture gives 2 µm which is equal to 2×10^{-6} metres.

a) Find the diameter and radius of one spherical staphylococcus.

$$\text{Diameter} = \frac{2 \times 10^{-6}}{3}$$
$$= 0.667 \times 10^{-6}$$
$$= 6.67 \times 10^{-1} \times 10^{-6}$$
$$= 6.67 \times 10^{-7}\ \text{m}$$
$$\text{Radius} = \frac{6.67 \times 10^{-7}}{2}$$
$$= 3.33 \times 10^{-7}\ \text{m}$$

b) Use the formula below to find the volume of one spherical staphylococcus.

$$\text{Volume} = \frac{4}{3}\pi r^3$$

Hint:
The formula can be written

$$\text{Volume} = \frac{4}{3}\pi \times r^3 \text{ where } \pi = \frac{22}{7}$$

$$\text{Volume} = \frac{4}{3}\pi r^3$$

$$= \frac{4}{3} \times \frac{22}{7} \times (3.33 \times 10^{-7})^3$$

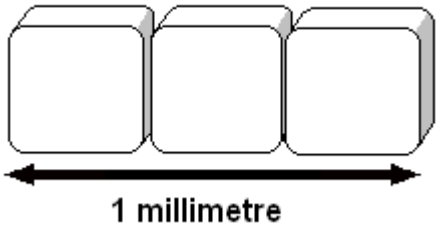
$$= 155 \times 10^{-21}$$

$$= 1.55 \times 10^{2} \times 10^{-21}$$

$$= 1.55 \times 10^{-19}\,\text{m}^3 \text{ (3sf)}$$

2. The diagram shows three grains of salt.

Each grain of salt is a cube.



a) What is the length of one grain of salt in metres?

$$1\,\text{mm} = 1 \times 10^{-3}\,\text{m}$$

$$\text{So length of one grain} = \frac{1 \times 10^{-3}}{3}\,\text{m}$$

$$= 0.333 \times 10^{-3}$$

$$= 3.33 \times 10^{-1} \times 10^{-3}$$

$$= 3.33 \times 10^{-4}\,\text{m (3sf)}$$

b) What is the volume of one grain of salt in cubic metres?

$$\text{Volume} = (3.33 \times 10^{-4})^3$$

$$= 3.33^3 \times 10^{-12}$$

$$= 36.9 \times 10^{-12}$$

$$= 3.69 \times 10^{1} \times 10^{-12}$$

$$= 3.69 \times 10^{-11}\,\text{m}^3 \text{ (3sf)}$$

4. How many staphylococcus bacteria would make up a volume equal to the volume of one grain of salt?

$$\frac{3.69 \times 10^{-11}}{1.55 \times 10^{-19}}$$

$$= 2.38 \times 10^{-11+19}$$

$$= 2.38 \times 10^{8} \text{ bacteria}$$

Task 4 (Research): Soil and worm-casts

Aim:

To apply the use of standard form in the solving of problems.

The mathematics covered in this activity:

Using standard form with positive indices.

Using information given to solve a problem.

Using measures in terms of weight, area, volume and time.

Using the laws of indices.

Problem solving.

Activity guidance:

This activity is intended for Higher tier KS4 students.

This activity could run into two lessons.

There are alternative ways to approach this activity.

One possible approach is to allow students to work through the worksheet in pairs and in so doing evaluate their methodology, after which the results and methods could be discussed as a class group, particularly for the final question part.

The final answer to the activity is clearly an overestimate.

Ask questions such as:

• Do you really think there are 360 earthworms in one square metre of soil?

• What other assumptions have been made that may have caused this overestimate?

Students should be asked to research the answers to the questions discussed. This could be set for homework or be a computer room activity, then the results of their investigation discussed as a group/class and values agreed on.

Students can then write out the solution individually using the values that they have chosen. The solution should be clearly presented with method, units and degree of accuracy clearly shown.

The websites used to obtain the information for the activity are shown below; these could be provided to individual groups via a document on the network. Students should be encouraged to search for alternative sites.

What is the approximate weight of soil?
http://www.engineeringtoolbox.com/earth-soil-weight-d_1349.html

How many earthworms can be found in the soil?
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/health/biology/?cid=nrcs142p2_053863
The information is not easily found, look under the heading Abundance and Distribution of Earthworms.

Do you need to convert square yards into square metres?
http://www.asknumbers.com/square-yard-to-square-meter.aspx

What is the weight of one average worm-cast?
http://animals.nationalgeographic.com/animals/invertebrates/earthworm/

Suggested questions:

- What units are you using?
- Are the units you are using consistent?
- What degree of accuracy are you using?
- Which part of the expression will you work out first?
- Is your answer sensible?
- What assumptions could be wrong?

1. Earthworms bring soil to the surface, forming worm-casts. If this soil could be spread evenly over the surface, what would the increase in height of the surface be in 500 years? Let's look at the problem in stages for an area of 1 hectare …

   a) There is an average of 3.6×10^2 earthworms in 1 square metre of grassland soil.
   How many earthworms are there in 1 hectare?

   1 hectare = 10^4 square metres

   Worms in 1 hectare $= 3.6 \times 10^2 \times 10^4$
   $= 3.6 \times 10^6$

b) What is the weight of soil brought to the surface in 1 hectare, by these earthworms?

Give your answer in kilograms and in standard form.

The record weight of an earthworm is 11.2 g! However, the average weight is roughly 5 g.

An earthworm can bring its own weight of soil to the surface every 24 hours.

Weight of soil $= \frac{3.6 \times 10^6 \times 5}{10^3}$

$= 1.8 \times 10^4$ kg

c) Change this weight into cubic metres, to give the volume of soil brought to the surface in 1 hectare.

$1\,m^3$ of soil weighs 1.6×10^3 kg.

Volume of soil brought to the surface

$= \frac{1.8 \times 10^4}{1.6 \times 10^3}$

$= 1.125 \times 10^1\,m^3$

d) Use this formula and solve by rearranging to find the increase in the depth of the soil in 24 hours.

Volume of a hectare of soil = area of the surface of 1 hectare × depth

Substituting into the formula gives

$1.125 \times 10^1\,m^3 = 10^4\,m^2 \times$ depth

Rearranging gives

$\text{depth} = \frac{1.125 \times 10^1}{10^4}$

$= 1.1 \times 10^{-3}$ m (2sf)

or $= 1.1$ mm (2sf)

e) Use your answer to find what the increase in depth of the soil would be in

(i) 1 year,

In 1 year the depth of the soil would be $1.1 \times 10^{-3} \times 365$

$= 4.0 \times 10^{-1}$ m

$= 0.4$ m

$= 40$ cm

(ii) 500 years.

In 500 years the depth of the soil would be $4.0 \times 10^{-1} \times 500$

$= 200\,\text{m}$

f) Your answers to part e) are significantly overestimated. Why?

- Are there really 360 worms in a square metre of grassland soil?
- The depth of the soil brought to the surface is continuously eroded by the weather, wind, rain, flood etc.
- What is the rate of erosion?
- What is the average weight of a worm?
- What is the weight of grassland soil?
- Soil would be compacted by the weight of the soil above.

Blank tables for Activity 1 (basic): What's in soil? question 2.

Name	Number in standard form

Name	Number in standard form

Name	Number in standard form

Name	Number in standard form

Name	Number in standard form

Name	Number in standard form

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