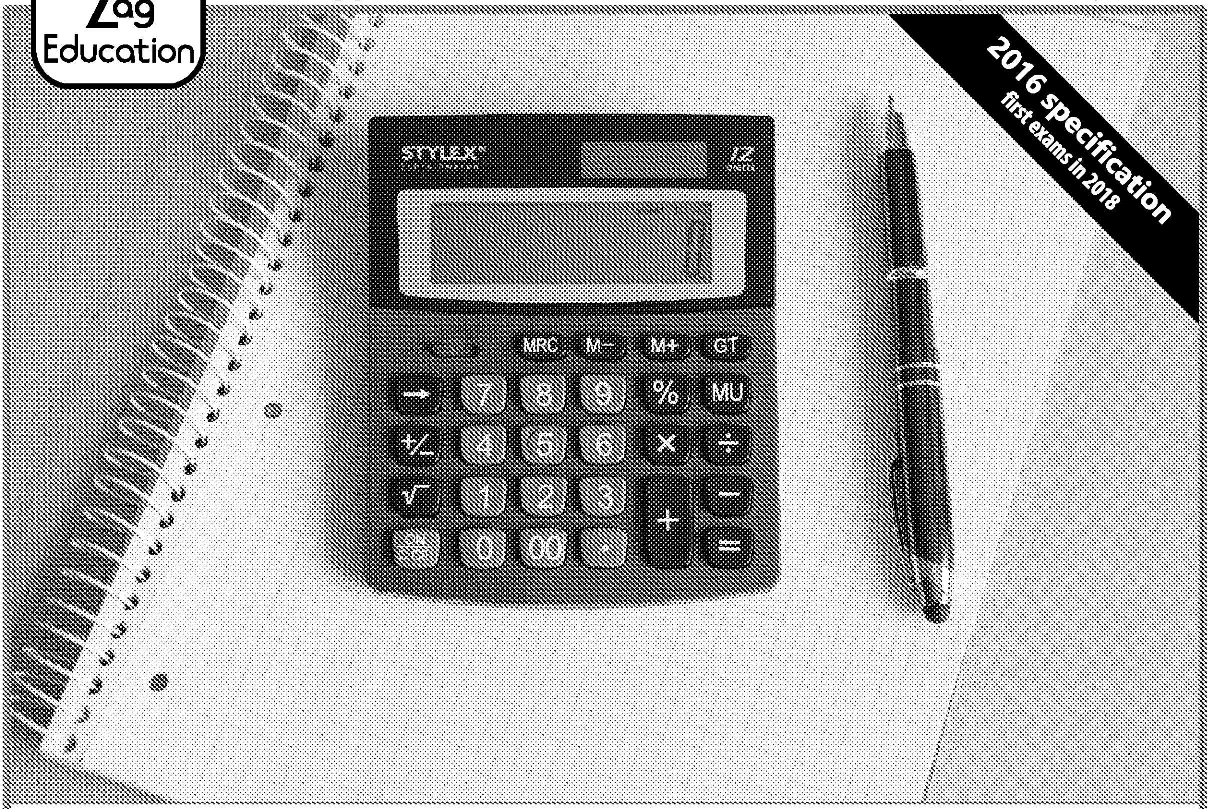
Biology GCSE (9–1) | WJEC | 3400



Maths Skills

for GCSE WJEC Biology

zigzageducation.co.uk **POD 12015**

Contents

Teacher's Introduction

Remember!

Always check the exam board website for new information, including changes to the specification and sample assessment material.

This GCSE Maths Skills pack will support students studying the WJEC GCSE Biology specification with the key mathematical skills they need to succeed in their course.

Mathematical skills pose a challenge for many students, with some finding it difficult to see how a skill learned in a Maths lesson is applied in a Biology lesson. This resource has been designed to support students in making this connection, and to build up their confidence in approaching questions that have a mathematical element.

It gives a gentle, conversational review of the skill, with worked examples, and offers students the opportunity to practise the skill in isolation and then also in the context of an examination-style question. By using these resources, students can ensure they have the skills they need for each section of the Biology course. They can work through the chapters independently, or they can be directed to them as support for skills identified in class as in need of some improvement.

There are five chapters covering all the key maths skills needed for GCSE Biology. Each chapter contains the following elements:

- **Specification overview** – this provides an overview of the skills and explains what the exam board requires students to demonstrate in the exam.
- **Topic notes** – a brief summary revising the skills and demonstrating how to apply the skills.
- **Worked examples** – one or more fully worked questions which use the relevant skill, to demonstrate how students should approach them.
- **Practice questions** – each skill is concluded with practice questions that increase in difficulty. All the Biology knowledge needed to complete the question will be provided, and the question focuses on testing students' understanding of the maths skill itself.

The chapters are:

1. Arithmetic and numerical computation
2. Handling data
3. Algebra
4. Graphs
5. Geometry and trigonometry

There are two diagnostic tests for each chapter. The first is provided at the start of the resource and is designed to be used before you work through each chapter, to highlight students' existing strengths and areas for improvement. The second is designed to be used after reviewing the chapter's content and is provided after the main content of the resource, just before the answers. The tests will allow you to identify areas for particular focus before undertaking the work, and then afterwards, to determine whether further work is needed on specific areas.

March 2023

Students' Introduction

In order to do well in your GCSE Biology course, you need to have some maths sk
questions will require some mathematics.

Many students are less confident with maths than they would like to be, and it ca
learned in a Maths lesson is applied in a Biology lesson. This resource has been d
making this connection, and to build up your confidence in approaching question
element. It gives a review of the skill needed, with worked examples, and the
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1. Arithmetic and numerical computation
2. Handling data
3. Algebra
4. Graphs
5. Geometry and trigonometry

There are two **diagnostic tests** for each chapter.

- **Test 1** should be used before you work through each chapter, to show what
  you need to improve.
- **Test 2** should be used after you have worked through the chapter's content

The tests will help you to identify areas for particular focus before undertaking th
determine whether you still need to work on specific areas.

DIAGNOSTIC TES

1.1 ARITHMETIC AND NUMERICAL COMPUTATION

1. Write 0.4 as a fraction in its simplest terms.

   ....

2. Write ⅝ as a decimal number and as a percentage.

   ....

3. Write 1[illegible]00 in standard form.

   ....

4. Write 3.5×10^{-3} as a decimal number.

   ....

5. There are 25 students in a class; seven of them have blue eyes. What percentag

   ....

   ....

6. A biscuit contains 7.5 grams of carbohydrate and 2.5 grams of fat. What is t
   the biscuit? Give your answer in its simplest terms.

   ....

   ....

7. A farmer needs to order food for her chickens. She has 48 chickens, and they
   month. Estimate how much chicken food the farmer needs to order each month

   ....

   ....

DIAGNOSTIC TES

2.1 HANDLING DATA

1. Write 25198 to three significant figures.

....

2. A gardener grew some tomato plants. She noted how many tomatoes she go

25 [illegible] 28 18 25 26 31 25

Calculate the mean number of tomatoes per plant.

....

....

3. A wildlife rescue centre kept records of the types of wild mammals that came int
for one week.

Hedgehog	Hedgehog	Fox	Hedgehog
Vole	Vole	Badger	Fox
Hedgehog	Hedgehog	Vole	Badger
Fox	Fox	Hedgehog	Vole

a) Design a frequency table for these data.

b) Display the data using a suitable chart.

4. There are 120 students in Year 11. The head of year wants to select six stu
planning committee. Suggest a method she could use to choose the students r

....

....

5. A bag contains [illegible] ball, two blue balls and five yellow balls. You pick
looking at it. [illegible] the probability that the ball will be:

a) blue? ....

b) not red? ....

6. A rectangular field is 150 m wide by 200 m long. What is the order of magn
in square metres (m^2)?

DIAGNOSTIC TES

3.1 ALGEBRA

1. The formula for the density of an object is

   density = mass / volume   d = m

   a) Calculate the density of an object that weighs 40 g and has a volume o

   ………………………………………………………………………………………………

   ………………………………………………………………………………………………

   b) What would be the units of your answer to part a)?

   ………………………………………………………………………………………………

   ………………………………………………………………………………………………

   c) A different object has a density of 0.5 kg/m^3 (kilograms per cubic metr does it weigh? Give the units of your answer.

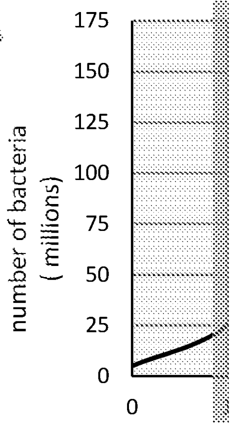
   ………………………………………………………………………………………………

   ………………………………………………………………………………………………

DIAGNOSTIC TES

4.1 GRAPHS

1. The graph shows the growth of bacteria in a nutrient solution.



a) How many bacteria were present on day 2?

....

b) Describe what happened to the population of bacteria over the five days.

....

....

....

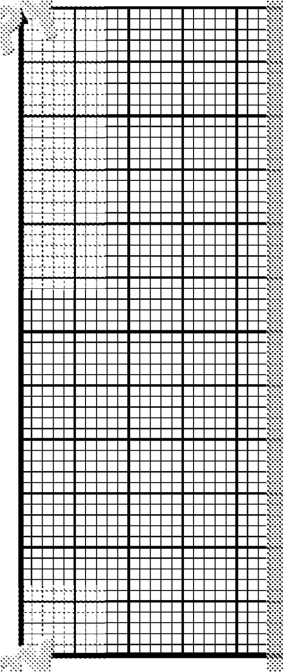
....

c) Calculate the population growth rate between day 1 and day 3, in mil

....

....

2. A wood pigeon can fly at a speed of 60 kilometres per hour. Speed = distance



a) Plot a graph of distance against time for a pigeon flying for six hours. Label both axes of the graph.

b) How far will the pigeon travel in 2.5 hours?

....

....

DIAGNOSTIC TES

5.1 GEOMETRY AND TRIGONOMETRY

1. What instrument would you use to measure angles?

2. What units do we use to measure angles?

3. Calculate the area of the following shapes:
   a) Rectangle 4 cm × 1.5 cm
   b) Triangle base 10 cm, height 4 cm
   c) Circle with radius 5 cm

4. This tank measures 2 m × 2 m × 6 m.
   Calculate the volume of the tank. Give the units of your answer.

5. This cube measures 2 cm × 2 cm × 2 cm.
   Calculate the total surface area of the cube. Give the units of your answer.

1 ARITHMETIC AND NU
COMPUTATION

SPECIFICATION OVERVIEW

Recognise and use expressions in decimal form
Recognise and use expressions in standard form
Use ratios, fractions and percentages
Make estimates of the results of simple calculations

THEORETICAL OVERVIEW

Decimals

A decimal number includes amounts which are between 0 and 1 (fractions).

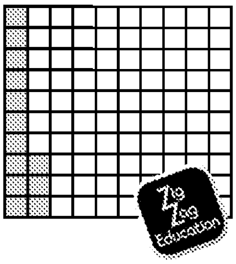
0.25 is a decimal number, and so is 9.25.

You use decimals with money; £3.62 is three pounds sixty-two pence, **or** three poi

The decimal point separates the whole numbers from the fractions, which are tenth

- **0.1** is a tenth, ${}^{1}/_{10}$
- **0.01** is a hundredth, ${}^{1}/_{100}$
- **0.001** is a thousandth, ${}^{1}/_{1000}$

Example: In **0.13**, the value of the digit 1 is one tenth, and the value of the digit 3



Tip: The large square represents 1, and it is divided
Each small square represents ${}^{1}/_{100}$.

Each column represents ${}^{1}/_{10}$, which is the same as ${}^{10}/_{1}$

Ordering decimals

Hundreds are bigger than tens, tens are bigger than units, units are bigger than te than hundredths.

When ordering numbers, you should always compare the digits on the left first; ju were putting words into alphabetical order.

WORKED EXAMPLE

Which is greater: 2.701 or 2.71?

Solution

Line up the decimal points like this:

Units		*Tenths*	*Hundredths*	*Thousandths*
2	[illegible]	[illegible]	*0*	*1*
2	*.*	*7*	*1*	*0*

Both numbers h
tenths, but 2.7
2.71 has one h
greater than 2.

Decimal places (dp)

'Decimal places' means how many digits come after the decimal point.

Examples: 3.985 has three decimal places; 78.0015 has four decimal places.

When you analyse experiment results, your calculator may give you a number wit usually need to round your answers to one or two decimal places for your table a

Rule: Count the figures after the decimal point to find the decimal place. If this is 5, it stays as it is. 5 or more, and you round it up.

3.42 = 3.4 to one decimal place (1 dp): **one decimal place** is the **first figure afte** Now look at the next number to see if it is 5 or more. It's a 2, so the 4 stays the s

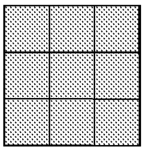
6.58 = 6.6 to 1 dp: the first figure after the decimal point is 5, but because the 5 up to a 6.

47.3942 = 47.39 to 2 dp: the 9 is the second decimal place, followed by a numbe

3.98 = 4.0 to 1 dp because the 9 is rounded up to a 10, which makes the 3 into a this occasion because you need one digit after the decimal point to have one deci

Indices and standard form

A square number is made when you multiply a number by itself.



9 is a square number.
$3 \times 3 = 9$
3×3 can also be written as 3^2 (3 squared)

The small 2 ('^{2}') is an **index number**, or **power**. It tells you how many times you h

The opposite of a square number is a **square root**. For example, the square root

The mathematical symbol for square root is √, so you would write it as $\sqrt{9} = 3$.

WORKED EXAMPLES

a) Calculate 168^2

Solution

Use the x^2 button on your calculator: $\boxed{168}\ \boxed{x^2}\ \boxed{=}$ *Or do $168 \times 168 = 28$*

b) Find the square root of 6.25

Solution

Use the √ button on your calculator: $\boxed{\sqrt{}}$ *6.25* $\boxed{=}$ *The answer is 2.5*

Indices (powers)

A power of a number shows how many times you need to multiply that number b

For example [illegible] **3 to the power of 5 = 3 × 3 × 3 × 3 × 3 = 243**

Your calculator should have a button labelled X^n. To calculate 3^5 it's $\boxed{\mathbf{3\ x^n\ 5\ =}}$

Biology application: multiplying bacteria – the 2^n rule

Bacteria are very simple organisms, and they reproduce by dividing in two.

In warm, moist conditions, such as inside the human body, bacteria can double in nu

If you started with one bacterium, then over two hours it would work like this:

	20 min	40 min	60 min	80 min	10
	× 2	× 2	× 2	× 2	×
1	2	4	8	16	3

Two hours is 120 minutes. So you would have 1 × 2 × 2 × 2 × 2 × 2 × 2 = 6

This is the same as $\mathbf{2^6}$

To work out the number of bacteria in a specified time, you need to know:

- How many there were at the start
- The time period it takes for them to divide

Then the calculation you do is **starting number × $\mathbf{2^n}$**, where n is the number of time

WORKED EXAMPLE

If you start with 1000 bacteria and they divide once every two hours, how ma

Solution

16 hours is 8 × 2 hours, so that's eight time periods (n = 8) ⇒ 1000 × 2^8

Powers of 10

Numbers such as **one hundred, ten thousand** and **1 million** are sometimes written

Power of 10	Number in figures	Number in words	Word
10^2	**100**	One hundred	
10^3	**1000**	One thousand	
10^4	**10 000**	Ten thousand	
10^5	**100 000**	One hundred thousand	
10^6	**1 000 000**	One million	
10^9	**1 000 000 000**	One billion	

★ ***Notice that the power of 10 is equal to the number of zeros.***

WORKED EXAMPLE

Write the number one hundred thousand as a power of 10.

Solution

Write the number out in figures, and then count the zeros to get the power of

100 000 = $\underline{10^5}$

Negative powers of 10

Negative powers of 10 are **fractions.** In biology we often study very small things
therefore, you need to understand very small measurements.

Very small numbers such as **thousandths** and **millionths** are usually written as neg

Power of 10	Number in figures as a fraction	Number in figures as a decimal	Number in words
10^{-1}	**1/10**	0.1	One tenth
10^{-2}	**1/100**	0.01	One hundredth
10^{-3}	**1/1000**	0.001	One thousandth
10^{-6}	**1/1 000 000**	0.000001	One millionth
10^{-9}	**1/1 000 000 000**	0.000000001	One billionth

Biology application

Cells are usually measured in micrometres. A micrometre is 10^{-6} metres, or one m
The mathematical sign for micrometre is µm.

A human red blood cell is 8 µm in diameter. In metres that's eight millionths of a m

Since 1 µm = 10^{-6} m, 8 µm is often written as 8×10^{-6} m.

Standard index form

Standard index form is also called **standard form,** and it's a way of writing very
using powers of 10. A number written in standard form is made up of:

- A number between 1 and 10, for example 2.5 multiplied by
- 10 to the power of something **10^n**, where **n** m

Very big numbers have positive powers of 10; however, small numbers have negative

The power of 10 you use is how many places you need to move the decimal point.

WORKED EXAMPLES

1. Write 253 000 000 in standard form.

Solution

Use the digits you have before the zeros start to make a number between 1 and 1
Here the digits are 253, so the number is <u>2.53</u>.

Work out the power of 10 by counting how many places you have to move the de
from 253000000 to 2.53, like this:

8 7 6 5 4 3 2 1

2 . 5 3 0 0 0 0 0 0.   So <u>253 000 000 = 2.5</u>

2. Write 0.000067 in standard form.

Solution

Use the digits you have after the zeros finish to make a number between 1 and 1
Here the digits are 67, so the number is <u>6.7</u>.

Work out the power of 10 by counting how many places you have to move the de
from 0.000067 to 6.7, like this:

1 2 3 4 5

0 . 0 0 0 0 6 . 7   So <u>0.000067 = 6.7 x 10^{-5}</u>

You will see numbers written in standard form during your Biology course, and yo
how small they are. The words for the powers of 10 will help you.

Examples: You know that 10^9 is one billion; therefore, 2.5 × 10^9 is two and a ha
10^{-3} is one thousandth; therefore, 4 × 10^{-3} seconds is four millisecond

★ ***The higher the power of 10, the higher the value of the number.***

If you need to convert a number in standard form back to an ordinary number, yo

Most scientific calculators have a button labelled $\boxed{\times 10^x}$ or $\boxed{\times 10^n}$ for this.

WORKED EXAMPLE

Write 3.75 × 10^6 as a whole number.

Solution

On your calculator it's 3.75 $\boxed{\times 10^x}$ 6 = the answer is 3 750 000

If your calculator doesn't have a standard form button, try use the x^n button instead.

3.75 × $\boxed{10}$ $\boxed{x^n}$ $\boxed{6}$ =

Alternatively, move the decimal point in the opposite direction and fill in any em
maintain the size of the number, like this:

$$\overset{1}{\longrightarrow}\ \overset{2}{\longrightarrow}\ \overset{3}{\longrightarrow}\ \overset{4}{\longrightarrow}\ \overset{5}{\longrightarrow}\ \overset{6}{\longrightarrow}$$

3 . 7 5 0 0 0 0   So <u>3.75 x 10^6 = 3 750 000</u>

Multiplying and dividing using standard form

When you multiply numbers in standard form, you **add** the powers of 10, like this:

$10^3 \times 10^5 = 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 = 10^8$

Example: 2.3×10^5 multiplied by one thousand = $\mathbf{2.3 \times 10^5 \times 10^3 = 2.3 \times 10^5}$

Where both numbers are in standard form, you multiply the numbers and add the

$2 \times 10^{-3} \times 3.4 \times 10^6$

Multiply the numbers $2 \times 3.4 = 6.8$

Add the powers of 10 $10^{-3} \times 10^6 = 10^{-3+6} = 10^3$

Put it together $\mathbf{6.8 \times 10^3}$

When you divide numbers in standard form, you **subtract** the powers of 10, like th

$$10^5 \div 10^3 = \frac{10 \times 10 \times \cancel{10 \times 10 \times 10}}{\cancel{10 \times 10 \times 10}} = 10^2$$

- ★ ***Use the*** $\boxed{\times 10^x}$ ***or*** $\boxed{x^n}$ ***button on your calculator for complicated calculations.***

WORKED EXAMPLE

Since the start of the COVID-19 pandemic, the cases of infection in the UK a $\mathbf{2.3 \times 10^7}$. The number of deaths is estimated as $\mathbf{1.82 \times 10^5}$.

Calculate the death rate as a percentage of total infections.

Solution

The calculation you need is $\dfrac{\text{deaths}}{\text{cases of infection}} \times 100$

On your calculator that's 1.82 $\boxed{\times 10^x}$ *5 ÷ 2.3* $\boxed{\times 10^x}$ *7 × 100 =* ***0.79 % to***

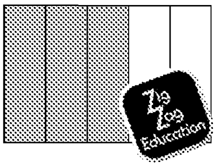
Fractions, ratios and percentages

Fractions

A **fraction** is made up of two parts: the **numerator** (on the top) and the **denomina**

- ★ ***The denominator tells you how many parts or fractions the whole amount has bee***
- ★ ***The numerator tells you how many of those fractions we're talking about right no***

Example

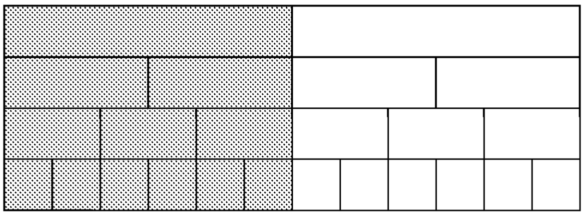


This rectangle has been divided into five parts. The p

Three parts out of five are shaded in; that's $^3/_5$

Two parts out of five are not shaded; that's $^2/_5$

Equivalent fractions



$$\frac{1}{2} = \frac{2}{4}$$

This means you can multiply or divide a fraction without changing its value if you d

numerator and the denominator.

★ ***Sometimes you can divide the top and bottom of a fraction by the same number.***

This is called **cancelling down**. It is also called **simplifying** the fraction. It's very

dealing with [illegible] numbers.

An exam question will sometimes ask you for a fraction in its simplest form.

WORKED EXAMPLE

Write $^{12}/_{16}$ in its simplest form.

Solution

12 and 16 will both divide by 4, so you cancel it down like this:

$$\frac{12}{16} \begin{matrix} \div \\ \div \end{matrix} \begin{matrix} 4 \\ 4 \end{matrix} = \frac{3}{4}$$

You can't divide it any further, so this

Writing one number as a fraction of another number

Imagine that there are 10 questions in a test and you get seven of them correct.

You would say that you got 7 out of **10**, or $^{7}/_{10}$. That means that 7 as a fraction o

In the same [illegible] as a fraction of 12 is $^{4}/_{12}$ or $^{1}/_{3}$, and 20 as a fraction of 48 i

★ ***You may need to estimate to get an approximate fraction, also called a proporti***

Example: If 293 adults in a group of 910 are obese, then the proportion of obese **about ⅓** because 293 is approximately 300 and 910 is approximately 900.

$^{300}/_{900}$ **= ⅓**

Fractions with units of measurement

These often come up, and you must be **really** careful with the units. Both amounts m

you make the fraction.

Example: Write 20p as a fraction of £2.

20p as a fraction of £2 is not $^{20}/_{2}$, it's $^{20}/_{200}$ because £2 = 200p.

$^{20}/_{200}$ = $^{1}/_{10}$, so 20p is $^{1}/_{10}$ of £2.

WORKED EXAMPLE

What frac[illegible] five metres is 30 centimetres?

Solution

There are 100 centimetres in a metre, so 5 m = 500 cm.

30 cm as a fraction of 5 m is $^{30}/_{500} = {}^{3}/_{50}$

Finding a fraction of a number or an amount

The rule is that whenever you see the word **'of'** in maths, it means that you **multipl**

Example: What is ⅜ of 24?

$\frac{3}{8} \times 24 = \frac{3 \times 24}{8} = \frac{72}{8} = \mathbf{9}$ On your calculator that's 3 ÷ 8 × 24 = 9

Multiplying fractions

Rule: When you multiply fractions, you just multiply the numerators and multiply the
the fraction if necessary.

WORKED EXAMPLE

Calculate $\frac{3}{4} \times \frac{2}{5}$

Solution

$\frac{3}{4} \times \frac{2}{5} = \frac{3 \times 2}{4 \times 5} = \frac{6}{20} = \frac{3}{10}$

Ratios

A ratio is a way to compare two or more amounts.

Recipes, for example, are sometimes given as ratios. To make pastry you usually
part butter. This means that the ratio **of flour to butter is 2 : 1**.

If pastry is two parts flour to one part butter, then there are three parts (2 + 1) al
pastry is flour and one **third** is butter.

flour	flour	butter

- ★ ***Ratios are similar to fractions; they can both be simplified by cancelling down.***
- ★ ***Always write the ratio in the order that is stated in the question. The ratio of flou***
butter to flour is 1 : 2.

Example: There are 15 women and six men working in a health centre. What is th
Give your answer in its simplest form.

The ratio of women to men is **15 : 6**. *However, both sides of this ratio will divide by 3.* Dividing by 3 gives you **5 : 2**.

So, the **simplest form** of the ratio is **5 : 2**

R
m

You may be asked to simplify a ratio to **n : 1**. In that case, just divide each side

There are two and a half times as many women as men.

WORKED EXAMPLE

Anjula is 120 cm tall. Fiona is 1.5 m tall. What is the ratio of Anjula's heig simplest form?

Solution

★ *You can't compare two amounts unless they are in the same units.*

One amount is in centimetres, the other is in metres. You must convert Fiona's

1.5 m = 150 cm

Now the ratio is 120 : 150

Both sides will divide by 10; this makes it 12 : 15

Both sides will divide by 3; this makes it 4 : 5

Therefore, the ratio is 4 : 5.

Ratios are also used when dividing up amounts.

Example: In a population of pea plants, the ratio of pink flowered plants to white many plants of each colour would you expect to find in a sample of 500?

1. Add the numbers in the ratio together. **3 + 1 = 4**

pink	pink	pink	white

2. Divide the amount by this number. **500 ÷ 4 = 125**, so *one part is* ***125 plants***
3. Multiply each of the numbers in the ratio by 125.

Pink flowered plants **3 × 125 = 375**

White flowered plants **1 × 125 = 125**

Check that the tw

Sometimes you aren't given the whole amount, and you need to work it out. The ma parts the numbers represent.

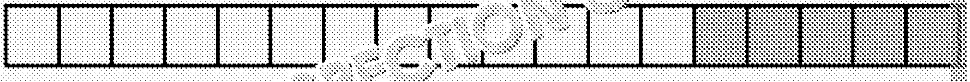
WORKED EXAMPLE

The ratio of girls to boys in a school is 13 : 12. There are 572 girls. How man school altogether?

Solution

1. *You know that there are 572 girls – that number represents 13 parts.*

   Therefore, one part = 572 ÷ 13 = 44 pupils.



2. *You already know that girls = 13 parts and boys = 12 parts, so that's 25 parts*

   44 × 25 = 1100 pupils.

Percentages and percentage change

★ *'Per cent' (%) means 'out of 100', so a percentage is a fraction with 100 as the*

★ *If 70 per cent of the population has a mobile phone, this means that 70 out of ev*

Converting fractions, decimals and percentages

Here are some conversions you should try to remember these if you can – it will make lif

fraction	decimal
$^1/_2$	0.5
$^1/_4$	0.25
$^1/_{10}$	0.1
$^1/_3$	0.3333…
$^1/_{100}$	0.01

★ ***To change a fraction to a percentage, <u>multiply it by 100</u>.***

$^2/_5$ converted to a percentage is $\frac{2}{5} \times 100 = \frac{200}{5} = 40\ \%$

★ ***To change a percentage to a fraction, put 100 as the denominator, then cancel it***

64 % expressed as a fraction is $\frac{64}{100} = \frac{32}{50} = \frac{16}{25}$

★ ***To change a decimal to a percentage, multiply by 100 on your calculator or mov the right, like this:***

0.62 expressed as a percentage is **62 %**

0.375 expressed as a percentage is **37.5 %**

★ ***To change a percentage to a decimal, divide by 100 on your calculator or move the left, like this:***

73.5 % expressed as a decimal is **0.735**

60 % expressed as a decimal is **0.60**, or just **0.6**

5 % expressed as a decimal is **0.05** – be careful with this one

Finding a percentage of an amount

A percentage is another way of writing a fraction with a bottom number of 100.

$$30\ \% = \frac{30}{100}$$

So, to find 30 % of an amount, you must work out $\frac{30}{100}$ of that amount.

Example: 30 % of 90 mm = 30 ÷ 100 × 90 = 27 mm

Writing an amount as a percentage

Test results are often written as percentages because it makes it easier to compare

Example: A student receives the following results:

English	40 out of 50
Maths	45 out of 60
History	27 out of 30

Which is the student's best subject?

To find out, change [illegible] into a percentage, like this:

$$\frac{\text{Student's m[illegible]}}{\text{Total for the [illegible]}} \times 100$$

English 40 ÷ 50 × 100 = 80 %

Maths 45 ÷ 60 × 100 = 75 %

History 27 ÷ 30 × 100 = 90 %

The percentages allow the results to be compared very easily. In this case the low
the best result.

★ ***Any units of measurement can be used to make the fraction, but they must be th***

WORKED EXAMPLE

Express 0.5 mm as a percentage of 2500 μm.

Solution

First you must make the [illegible]. To convert millimetres to micrometres

0.5 mm [illegible]

The calcul[illegible] $\frac{500}{2500} \times 100 = 20\ \%$

Percentage increase or decrease

Often in scientific experiments we are measuring a change. For example:

- **How much do plants grow with different amounts of water?**

  To investigate this, you could take five plants of the same species, give each
  each day for one or two weeks, and measure the increase in height of each

  However, it's very unlikely that your five plants would [illegible] *exactly* the same
  investigation, so then how do you compare the [illegible]

  The solution to this problem is to [illegible] **percentage change.** This will tell
  grown compared to how [illegible] the start.

  To calcul[illegible] change, whether it's an increase or a decrease, the

  $$\textbf{percen[illegible]ange} = \frac{\textbf{actual change}}{\textbf{original amount}} \times \mathbf{100}$$

- To work out the **actual change**, subtract the original amount from the new am
- A positive change is an increase; a negative change (for example -3) is a de

WORKED EXAMPLE

Three years ago Adam weighed 50 kg; now he weighs 65 kg. What is the per
Adam's weight?

Solution

1. *Work out the* **actual increase** *in his weight (kg) by subtracting the two amounts*
2. *Divide by the* **original weight** *(which is 50 kg, and then multiply by 100 to*

15 ÷ 50 × 100 = 30 % *So, Adam's weight has increas*

Estimating the results of simple calculations

You don't always need an exact value for a number, especially a very long numbe rough or an **approximate** value which gives you a good idea what the true value i

For example, if you are reporting back on an experiment to investigate whether c affects how quickly a plant makes food by photosynthesis, saying

> *The rate of photosynthesis of a plant under blue light is almost double the rate of under yellow light.*

might be more relevant than saying

> *Under blue light the rate of photosynthesis is 33.7 units, whereas under yellow l is 16.8 units.*

If you are asked to ***estimate*** an answer, they want a sensible idea of how big the your calculator.

You round off all the numbers in the problem to **one significant figure** to make 'ea do this in your head.

Example: Give an approximate answer to the calculation $\frac{\mathbf{608 \times 29}}{\mathbf{5.8}}$

Round each number to one significant figure, and then do the calculation:

$\frac{\mathbf{600 \times 30}}{\mathbf{6}} = \frac{\mathbf{18\ 000}}{\mathbf{6}} = \mathbf{3000}$, so the answer is **3000**

There is more information about significant figures in the next section.

PRACTICE QUESTIONS

1. a) Copy and complete the table; the first one has been done for you.

Amount in words
Thirteen thousand five hundred and six
Two thousand and sixty four
One million seven hundred and fifty thousand

b) Arrange the numbers from part a) in order of size, starting with the **sma**

2. Put these decimal numbers in order of size, starting with the **largest**.

0.702, 0.072, 0.72, 0.207, 0.27, 0.027

3. Write these numbers in standard form.

a) Three billion b) 250 000 000 c) 0.0015

4. Complete these statements using powers of 10.

a) A kilogram is _____ grams. b) A millimetre is ______

c) A nanosecond is _______ seconds. d) There are ________ µ

5. Calculate, giving your answer in standard form.

a) 3.6×10^4 multiplied by one million

b) 8.7×10^7 divided by 10^2

6. Bacteria species X divides every 1.5 hours. Starting with one bacterium, ho
36 hours?

7. Simplify the following ratios to n : 1.

a) 240 : 60 b) 1 metre : 10 centimetres c) 7000 : 350

8. The ratio of cats to dogs in a rescue centre is 3 : 1. If there are 60 of these c
are dogs?

9. Calculate:

a) $^{2}/_{5}$ of 600 b) $^{5}/_{9}$ of 450

10. Multiply these fractions, giving your answer in its simplest terms.

a) $\frac{3}{7} \times \frac{2}{5}$ b) $\frac{2}{5} \times \frac{10}{12}$

11. Three fifths of the trees in a wood are deciduous (lose their leaves in winter).
what is the total number of trees in the wood?

12. Copy and complete the table below. The first one has been done for you.

Fraction	Decimal
$^{1}/_{4}$	0.25
$^{3}/_{8}$	
$^{2}/_{5}$	
	0.04

13. In a school there are 800 students and 70 teachers. 15 % of the students and 2
handed. How many left-handed people are there altogether?

14. Anika is on a diet to lose weight. At the start of the diet, she weighed 85 kg.
70 kg. Calculate the percentage change in Anika's weight. Give your answe

15. Estimate an answer to the following calculation. Your estimate should be a si

$\frac{31\,009}{1926}$ $\frac{1155}{201}$

2 HANDLING DA

SPECIFICATION OVERVIEW

Use an appropriate number of significant figures
Find arithmetic means
Construct and interpret frequency tables and diagrams, bar charts and histogra
Understand the principles of sampling as applied to scientific data
Understand simple probability
Make order of magnitude calculations

THEORETICAL OVERVIEW

Significant figures (sf)

When we get a long decimal answer on a calculator, we could round it off to a ce

Another method for giving an approximated answer is to round off using **significa**

The word **significant** means important. The closer a digit is to the beginning of a n significant, it is.

In the number **368 249**, the **3** is the most significant digit because it tells us that the **thousand** and something. It follows that the 6 is the next most significant, and so o

3 6 8 2 4 9

You may be asked to round off a number using a certain number of significant fig and 3 significant figures.

The rules for rounding are:

- Find the digit you want
- If the next digit is **5 or more**, you **round up.**
- If the next digit is **4 or less**, you **do not round up.**

Use zeros to fill in spaces and to keep the value of the number.

WORKED EXAMPLE

Write the number 368 249 correct to 2 significant figures.

Solution

3 6 8 2 4 9

Identify the first two digits. They are 3 and 6; therefore, so far, we have 360 0

Look at the next digit. It is 8, so you must round the 6 up to 7.

Don't forget to put the zeros in, so that the number still has the same value.

The answer is 370 000

You can also round off very small numbers in the same way. The first digit after th

In the number **0.0058763**, the **5** is the most significant digit because it tells us that **and something**. The 8 is the next most significant, and so on.

WORKED EXAMPLE

Write the number 0.0058763 correct to 2 significant figures.

Solution

0 . 0 0 5 8 7

1. *Identify the first two numbers after the decimal point that aren't zeros. Th far, you have 0.0058.*
2. *Look at the nex[illegible] is 7, so you must round the 8 up to 9.*
3. *To [illegible] value, you need the zeros between the decimal point and the s need[illegible] ones after.*

The answer is 0.0059

Recording survey data – frequency tables, bar charts a

Categoric, discrete and continuous variables

- **Categoric** variables are described in words, and the categories are separate Examples include blood group, and species of animal.
- **Discrete** variables are measured in numbers, but only some numbers have me of children in a family is discrete because you can't have half a child.
- **Continuous** variables can cover any value within your range of accuracy. Fo values such as 153.7 centimetres or 45.3 kilograms are possible and have me

Frequency tables

A frequency table is just what it sounds like – a table that shows how often a particu

The data can be shown in a bar chart or a histogram, depending on whether or continuous

Example: Some students were investigating the species of wildflowers in their loca numbers of five plant species in a 2 m × 2 m square. Their frequency table looks

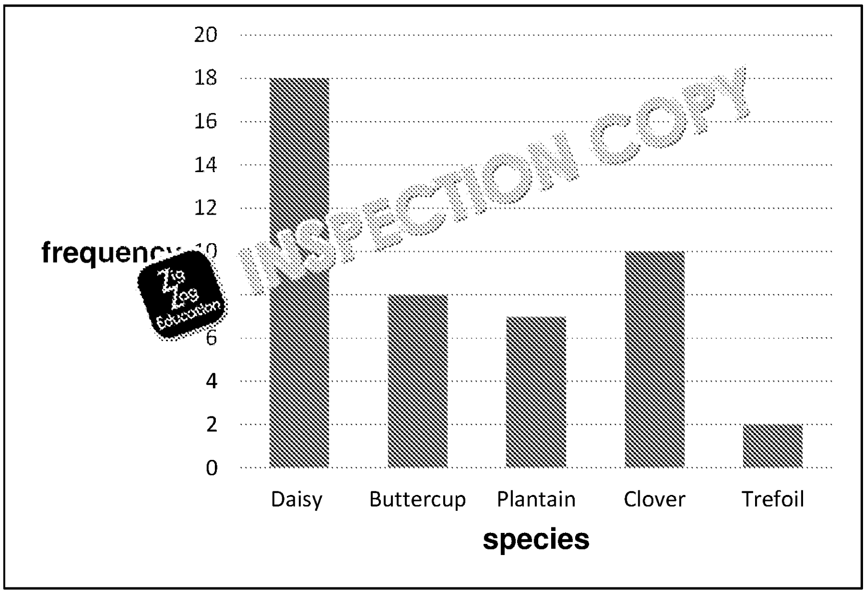
Plant species	Tally	Frequency
Daisy	𝍸𝍸𝍸 III	18
Buttercup	𝍸 III	8
Plantain	𝍸 II	7
Clover	𝍸𝍸	10
Trefoil	II	2

A set of data like thi **distribution.**

Tally marks are use groups of five, so it's

Bar charts

For data where you count the frequencies of categoric or discrete variables, you
results. The bar chart for this set of data would look like this:



Notic
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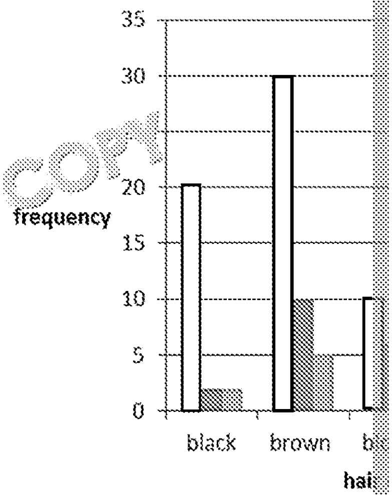
In this example, there are single bars because the researcher was counting only on

However, a slightly different type of bar chart can show more than one categoric

Example: A student collected data about the hair colour and eye colour of a grou
two-way table.

		Hair colour				
		Black	**Brown**	**Blonde**	**Red**	**Grey**
Eye colour	**Brown**	20	30	10	4	26
	Blue	2	10	6	2	15
	Green	2	5	3	6	4

The information in the two-way table can also be shown as a multiple bar chart, lik



Decide which category you are going to put on the horizontal scale – in this case it's hair colour.

Then for each hair colour you draw a bar for the numbers with brown, blue and green eyes.

Always include a key to show what each bar represents.

Anybody could look at th[illegible] conclusions. [illegible]

- Nearly everybody in the sample who has black hair also has brown eyes.
- The least common hair colour is red.

Again, notice that there is a gap between the groups of bars for each hair colour.

Continuous data

If you are counting frequencies for a continuous variable such as height or weight,

You need to group the data carefully so that every individual is counted just once.

Example: This frequency table shows the *heights* of 25 secondary school pupils.

Height (cm)	120–130	130–140	140–150	15
Frequency	[illegible]	6	10	

However, there's a problem with the table because if somebody is exactly 140 cm and, therefore, they could be counted twice.

However, you couldn't have 120–129, 130–139, etc. because it's possible for a p 129.4 cm tall or 129.99 cm tall and, therefore, not be counted at all.

A better way of representing grouped continuous data is to use **inequality signs** t

Symbol	**Meaning**
<	is less than, so 2 < 5 is a true statemen
>	is more than, so 6 > 4 is a true statemer
≤	is less than or equal to, so 2 ≤ 5 is true, and so
≥	is more than or equal to, so 6 ≥ 4 is true, and s

So, the table of results for this set of data would look like this:

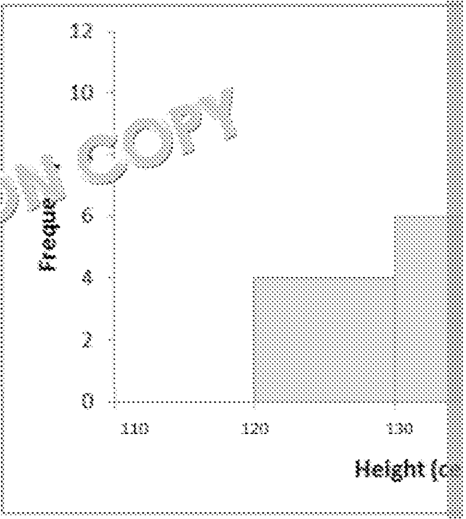
Height (cm)	**Frequency**
120 ≤ h < 130	4
130 ≤ h < 140	6
140 ≥ h < 150	10
150 ≥ h < 160	5

For example, 120 ≤ h < 130 means that

- 120 cm is **less than or equal to** the height of the people in this group, and
- the height of the people in this group is **less than** 130 cm.

People who are **exactly** 120 cm tall will come into this group because of the equals sign.

When you draw a bar chart for this frequency distribution, the bars are joined together because height is a **continuous** variable. A bar chart like this is called a **histogram**.



WORKED EXAMPLE

A farmer measured the height of 20 young fruit trees in his orchard. These

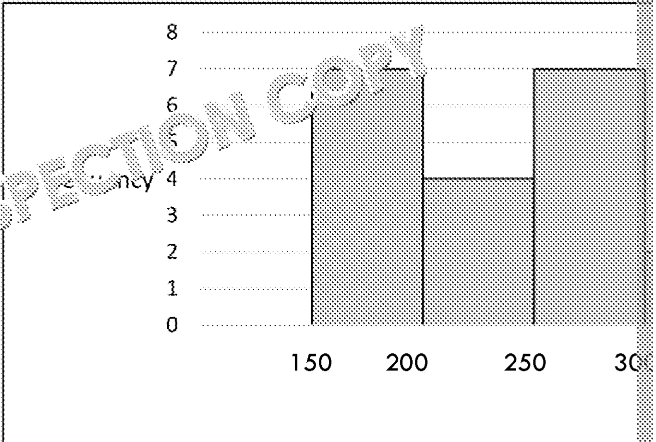
175 cm	230 cm	250 cm	18
281 cm	228 cm	160 cm	26
309 cm	286 cm	[illegible] cm	18
320 cm	210 cm	2[illegible]5 cm	19

Display these results in a grouped frequency table and in a histogram.

Solution

The smallest height is 160 cm, and the largest is 320 cm, so it would make se
like this:

Height (cm)	*Frequency*
150 ≤ h < 200	*7*
200 ≤ h < 250	*4*
250 ≤ h < 300	*7*
300 ≤ h < 350	*2*



Sampling

If researchers need to carry out a survey, it is not always possible to test a whole 'population'; for example, you couldn't count every sin[illegible] in a field, or ask e
person in the UK with heart disease about the medication they are on.

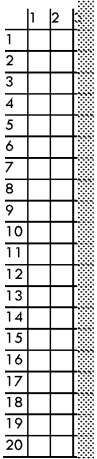
In cases such as this, a method of sampling is needed. You need a sample which **represents** the population as a whole and is not ***biased***.

Biologists sometimes need to find out what species of plants and animals live in a habitat, and to monitor their numbers to see whether they are changing.

It is usually not possible to count the entire population, so scientists take a **sample**
then use it to **estimate** the total population.

Scientists usually use **quadrats** to sample plant populations. A quadrat is usually a
The plants underneath can be identified and counted.

If you know the area of the habitat and the area under the quadrats, you can calc
numbers of organisms in the habitat.



Example: There are 12 dandelion plants inside a 1 m^2 quadrat. The whole field is 150 m^2 in area. The estimated population size of dandelions in the field would be:

$$12 \times (150 \div 1) = 12 \times 150 = 1800$$

However, it's important that the quadrats are placed **at random**. That means scientists do not choose where to place them, because they could be biased without realising it.

The best way is to measure out the habitat and divide it up into a numbered grid.

Each square on the grid will have two numbers – one horizontal and one vertical – for example, the shaded square on this grid is 4,12.

Then, you use a computer or a calculator to generate two random numbers betwe
Use these numbers as coordinates for where you place the quadrat.

- ★ ***The <u>validity</u> and <u>reproducibility</u> of the results increase the more quadrats you use***
- ★ ***Random numbers can also be used to choose people to take part in health survey***

WORKED EXAMPLE

**A doctor's surgery has 1600 patients who are on medication for high bloo
select 100 of these patients to be invited to take part in a health and lifestyl
of doing this?**

Solution

*The surgery could assign each of the 1600 patients a number, and then use a
random numbers.*

*Remember: when carrying out a **random sample**, you must make sure that eve
be chosen.*

Analysing data with the mean

When you do experiments or surveys, you are collecting results. These are called
done anything with them yet.

Once raw data has been collected, it needs to be **analysed** to see what it tells the

This is done by measuring the **average** or **mean** value.

- ★ ***<u>Mean</u> is the total of all the results divided by the number of results – this is what pe
finding the average. It's also called the <u>arithmetic mean</u> because you have to c***

Scientists usually repeat their experiments and calculate the mean of their results –
more likely the mean is to be reliable.

The **<u>mean</u>** gives you an idea of the average value, but it is not always a good me
any extreme values (those that are a lot bigger or a lot smaller than the others) a

For example, if you are trying to find the average height of a group of 10-year-old in the group who is unusually tall for their age, this will push the mean up. If you were park visit for this group, you might find that more children than you expected were t

In the case of experiment results, where there are repeats and one result is much b the others, researchers call this an anomalous result and leave it out when they cal

Finding the mean for a set of data:

WORKED EXAMPLE 1 – discrete distribution with a small number of valu

Student A took 11 tests during the term. These were her marks out of 20:

10 14 10 12 10 11 12 10

Work out the mean of Student A's results.

Solution

*To find her **mean** score, just add up all the marks and then divide by the numbe*

$$\frac{10 + 14 + 10 + 12 + 10 + 11 + 12 + 10 + 11 + 9 + 12}{11} = \frac{121}{11} = 11$$

WORKED EXAMPLE 2 – discrete distribution with a larger number of frequency table

A group of 25 adults were asked how many children they each have:

Number of children	Frequency
0	3
1	8
2	12
3	1
4	1

Three adults have no children
Eight adults have one child
Twelve adults have two childre
One adult has three children
One adult has four children

Work out the mean of these data.

Solution

*To find the mean, you need to find the mean number of **children per adult**.*

1. *Find the **total number of children**. To do this you multiply the number of c that number of children (the frequency):*

   3 adults have 0 children each   3 × 0 = 0 children

   8 adults have 1 child each   8 × 1 = 8 children

   12 adults have 2 children each   12 × 2 = 24 children

   1 adult has 3 children   1 × 3 = 3 children

   1 adult has 4 children   1 × 4 = 4 children

   39 children

2. *Find the **total number of adults**. In this case the question tells you, but if it numbers in the frequency column:* **3 + 8 + 12 + 1 + 1 = 25**

3. ***Divide** the number of children by the number of adults:* **39 ÷ 25 = 1.56**

★ ***This is the arithmetic mean, and it is a theoretical value – you can't have c***

Probability

Probability means how **likely** it is that something will happen.

It is measured on a scale between 0 and 1, or between 0 % and 100 %.

- A probability of zero means that something is **impossible.**
- A probability of 1 or 100 % means it is **definitely going to happen.**
- Unlikely events have a probability between 0 and 0.5, likely events have a pr

Probability can be written as a fraction, as a decimal, or as a percentage, like thi

0	[illegible]	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$
	0.1	0.2	0.3	0.4	0.5	0.6	0.7
	10 %	20 %	30 %	40 %	50 %	60 %	70

Calculating probabilities

When different **outcomes** of an event are equally likely to happen, you can use a probabilities of the different outcomes:

$$\text{probability of the outcome} = \frac{\text{number of ways that the o}}{\text{total number of possibl}}$$

Example: When you throw a fair dice there are **six possible outcomes**: 1, 2, 3, 4

- **What is the probability that you throw a 6?**

  There is only **one** way of throwing a 6, so the probability is $\frac{1}{6}$

- **What is the probability that you throw an odd number?**

  There are **three** odd numbers – 1, 3 and 5 – so the probability is

  $\frac{\text{number of ways of throwing an odd number}}{\text{[illegible] the possible numbers}} = \frac{3}{6} = \frac{1}{2}$ *or 0.5 or 50 %*

Finding the probability of something not happening

Any outcome is *either* going to **happen** or **not happen**, so the probability that som **100 %) minus the probability that it *will* happen.**

WORKED EXAMPLE

The probability that it will rain on any day in December is ³⁄₅. What is the pro rain on 5th December?

Solution

The probability that it will not rain is 1 − ³⁄₅ = ²⁄₅

For a set of data from a survey or an experiment, you can calculate the probabili times it occurs in the sample.

Example: If 80 trees in a wood were checked, and 20 of them were found to be [illegible] probability that a tree selected at random is diseased will be

$$\frac{\text{diseased trees}}{\text{total trees}} = \frac{20}{80} = \frac{1}{4} \text{ or 0.25 or}$$

With any data, the bigger the sample the more likely it is to reflect the general po trees would give a more reliable probability than a sample of 80 trees.

The AND/OR rule

If you are asked to find the probability that **outcome A <u>and</u> outcome B <u>both</u> hap** probabilities together.

WORKED EXAMPLE 1

Every time a baby is born, the probability that it will be a girl is ½. What is t first three children will all be girls?

Solution *Child 1* *Child 2* *Child 3*

½ × ½ × ½ = <u>⅛</u>

If you are asked to find the probability that <u>either</u> **outcome A <u>or</u> outcome B hap** probabilities together.

WORKED EXAMPLE 2

Mrs Begum buys a pack of 50 mixed flower bulbs to plant in her garden. The

Tulips	**10**
Daffodils	**10**
Snowdrops	**15**
Bluebells	**15**

She picks a bulb at random. What is the probability that it is a bluebell or a s

Solution

$$\frac{\text{bluebells + snowdrops}}{\text{total bulbs}} = \frac{15 + 15}{50} = \frac{30}{50} = \frac{3}{5}$$

Order of magnitude calculations

Order of magnitude is a way of comparing amounts to the nearest power of 10. it's good for comparing very large or very small numbers.

WORKED EXAMPLE

A cell in the human breathing passages is approximately 16 micrometres lo

A flu virus is approximately 80 nanometres long.

By how many orders of magnitude is the human cell larger than the virus?

Solution

First convert the cell size and the virus size into standard form:

Human cell: 1 micrometre (µm) = 10^{-6} m therefore, 16 µm = 16 × 10^{-}

Virus: 1 nanometre (nm) = 10^{-9} m therefore, 80 nm = 80 × 10^{-9} = 8 ×

Now do the division on your calculator: human cell ÷ virus

1.6 $\boxed{x10^x}$ −5 ÷ 8 $\boxed{x10^x}$ −8 = 200

200 = **2 × 10^2** so the human cell is two orders of magnitude larger than the vi

PRACTICE QUESTIONS

1. a) Write 47 392 to 1 significant figure.

   b) Write 0.009854 to 2 significant figures.

   c) Calculate 17.5 % of 2390. Give your answer to 2 significant figures.

2. Here are seven numbers:

   13 6 [illegible] 4 8

   Calculate the mean

3. The table shows information about the marks of 30 students in a test.

Mark	Frequency
14	2
15	10
16	2
17	3
18	13
	Total = 30

   a) Calculate the mean mark for this class.

   b) Students who scored less than the mean mark are required to retake the must retake the test?

4. A group of students counted trees of four species in their local park. They ob

beech	cherry	beech	beech
sycamore	rowan	cherry	rowan
cherry	beech	rowan	rowan
beech	cherry	beech	rowan

   a) Design a frequency table for these results.

   b) Display the data in a fully labelled bar chart.

5. The weights of 30 teenage girls were recorded in this frequency table:

Mass (kg)	Frequency
$40 < x \leq 50$	6
$50 < x \leq 60$	17
$60 < x \leq 70$	5
$70 < x \leq 80$	1
$80 < x \leq 90$	1

   a) Draw a fully labelled frequency diagram for these data.

   b) A new girl joins the group. She weighs exactly 60 kg. Which group doe

6. Some students were investigating the population of daisy plants in a field. Th
using this method:

> 1. Place 10 1 m² quadrat frames in random positions around the field.
> 2. Count the number of plants in each quadrat.
> 3. Record the results in a table and calculate the mean.
> 4. Use this to estimate the total number of plants in the field.

a) What would be the best way to [illegible] the quadrats to get a valid sampl

(i) Close their eyes and throw the quadrats.

(ii) Use [illegible] random numbers.

(iii) Distribute the quadrats evenly across the field.

b) The table below shows the students' results:

Quadrat	Number of daisy plants
1	5
2	3
3	7
4	2
5	8
6	5
7	2
8	5
9	3
10	[illegible]
Total	

Calculate the mean number of daisy plants per square metre.

c) The field has an area of 8000 m². Use your answer from part b) to esti
of daisy plants in the field.

7. Staff at an animal rescue centre recorded the colour of 20 cats in their care.

Colour	Frequency
Tabby	8
Black and white	6
Black	3
White	1
Grey	2

A cat is chosen at random. Calcul

a) White

b) Not grey

c) Tabby or black

Write each answer as a fraction,

8. The probability that [illegible] carrying *Staphylococcus aureus* bacteria on th
is about [illegible] Patients who need to go into hospital are tested to see whether

If a hospital tests 3600 patients, estimate how many will ***not*** be carriers.

9. An egg-laying chicken consumes about 120 g of food per day. Give the ord
amount of food consumed by 50 chickens in one year, in kilograms.

3 ALGEBRA

SPECIFICATION OVERVIEW

Substitute numerical values into algebraic equations using appropriate units for p

THEORETICAL OVERVIEW

Working with formulas

A formula is an equation or expression in algebra which describes the **relationshi**

Formulas are [illegible] a [illegible] science; an example is the formula for calculating spee

$$s = \frac{d}{t}$$

which means **speed = distance ÷ time.** The actual distance and the actual time c
stays the same.

Substituting numbers into equations

If you know some of the variables in a formula or an equation, you can find the ot
you know instead of the letters.

★ ***It's only possible to find one missing number at a time.***

So, in the speed formula, if you know that the distance is 180 miles and the time is

$$s = \frac{d}{t} = \frac{180}{3} = 60 \text{ miles per hour}$$

When you have found the missing value, you have [illegible] the equation.

WORKED EXAMPLF

Body mass index (BMI) is a measure of a person's weight relative to their hei
the formu[illegible] $\frac{m}{h^2}$

where m is the mass (weight) in kilograms and h is the height in metres.

Amina is 1.64 metres tall, and she weighs 60 kilograms. Calculate her BMI.

Solution

1. *Substitute 60 for m in the formula, and 1.64 for h*
2. *Now do the calculation on your calculator* $60 \div 1.64^2 = 22.3081...$

Amina's BMI is 22.3

You will often be able to work out the **units** using the information you have been g

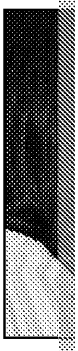
For example, the **density** of a substance is calculated using the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

If the mass is measured in grams (g) and the volume is measured in cubic centimetr
measured in grams per **cubic centimetre (g/cm³).**

★ ***Whenever you see the word <u>per</u>, it always means divide. Miles per hour is miles***

Biology application – calculating magnification



A microscope magnifies a small object to give a larger image.

You are dealing with **three** numbers:

- The **actual size** of the object (**A**)
- The **magnification** of the microscope (**M**)
- The **image size** (**I**)

Actual size × Magnification = Image size A × M = I

If you know **two** of these numbers you can always work out the other one.

There are two ways of doing this:

- Method [illegible]

  Just remember that **the image is always the big amount** because that's wha been magnified.

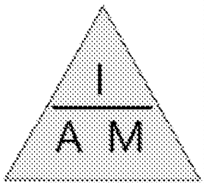
  A × M = I

  Therefore, if you are trying to find **I**, you multiply: **I = A × M**

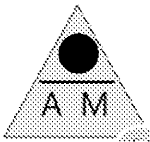
  If you know **I** and you are trying to find one of the others, you divide: **A = I ÷**

- Method 2: use the formula triangle

  Cover the value you're trying to find with your finger, and the triangle will tell you what sum to do.

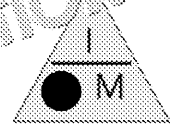


To find the **image size**



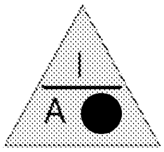
I = A × M

To find the **actual size**



A = I ÷ M

To find the **magnification**



M = I ÷ A

WORKED EXAMPLE

The image shows a cross section of a plant root tip, as seen under the micros

The image has been magnified 40×.

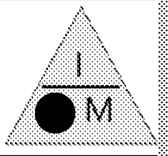
Calculate the width of the root tip.

Solution

First write down what you already know:

I = 25 mm

M = 40 so we need to find A



Actual width of root tip = I ÷ M = 25 ÷ 40 = ***0.625 mm***

PRACTICE QUESTIONS

1. The speed at which something moves can be calculated using the equation

$$s = \frac{d}{t}, \text{ or } \quad \text{speed} = \frac{\text{distance}}{\text{time}}$$

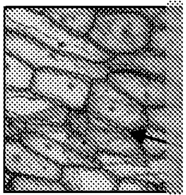
In a human reflex action, such as moving your hand away from a hot object, t
100 metres per second (m/s).

How long would the impulse take to travel 0.9 m? State the **units** of your ans

2. When you look at cells under the microscope, you see a magnified image.

Actual size × Magnification = Image size

If you know two of these, you can work out the third.



a) These onion cells have been magnified by 100×.
The distance shown on the diagram is 29 millimetres.
Calculate the actual length of the onion cell. *2 marks*

b) This cross section of a young plant root is 1.2 millimetres wide.
The distance shown on the diagram is 48 millimetres.
Calculate the magnification. *2 marks*

c) An *E. coli* bacterium is 0.6 micrometres (µm) long. It is magnified 12 000 times under an electron microscope. How long will the image be? Give your answer in ***millimetres*** for a third mark. *3 marks*

3. Medicines use very small amounts of drugs, and these are usually measured in milligrams (mg). A milligram is one thousandth of a gram.

Sometimes children need to have medicines that are usually prescribed to adu
working out the appropriate dose.

Young's rule uses this equation:

$$\text{Child dose (mg per day)} = \text{Adult dose (mg per day)} \times \frac{\text{Age of child}}{\text{Age} + 12}$$

Use this rule to work out the correct dose for an eight-year-old child, when the

4 GRAPHS

SPECIFICATION OVERVIEW

Translate information between graphical and numeric form
Plot two variables from experimental or other data
Interpret the slope of a linear graph

THEORETICAL OVERVIEW

When you carry out a scientific experiment, you are trying to answer a question a variables. For example:

What happens to a person's pulse rate when they exercise?

Do young people have faster reactions than older people?

How does light affect plant growth?

You are trying to find out how one variable affects the other. You do this by chan having the effect, and then measuring what happens to the other one.

The variable you change on purpose is called the <u>independent variable</u>. You *choo*

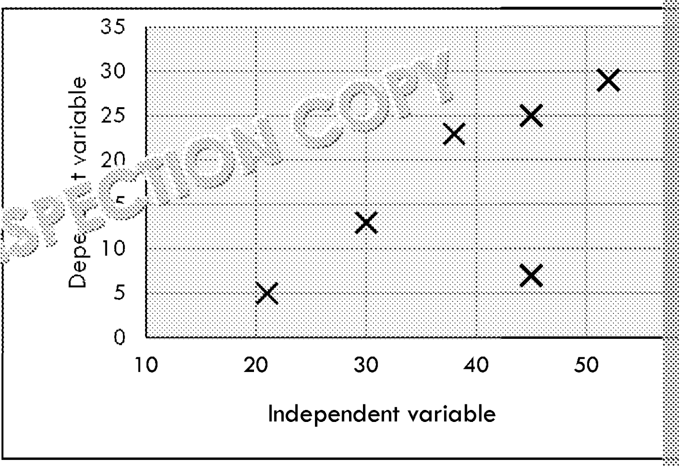
The result that you measure is called the <u>dependent variable</u>. You *measure* it for each

Designing and plotting a graph from a table of results

- The independent variable goes on the horizontal (x) axis; the dependent vari
- Label each axis and include units of measurement.
- For each axis, use a sensible scale. It doesn't always have to start from zero – for example. However, [illegible] the smallest to the largest value for each variab Decide how much each square should represent.
- Plot your points onto the graph as small crosses.
- Look for the pattern, and then draw in your line or curve of best fit. Use a sh beyond the values you are given.

- You may have a result that does not fit the pattern of the others, as shown in
- This is called an **anomalous** result.
- Check that you have plotted it correctly and, if you have, draw a circle aroun best fit through the other results.

If you can't get a line or curve of best fit at all, write **no correlation** on your graph ***random*** and do not show a relationship between the two variables.



WORKED EXAMPLE

The cell sap in plant cells contains sugar and other substances in solution. W out of cells through the cell membrane.

Some students conducted an experiment to find out what happens to potato different concentrations of sugar solution.

They cut five sticks of potato to the same size and weighed them.

Then they placed the potato sticks in beakers containing different concentrat 0 mol/dm³ (distilled water) to 1 mol/dm³ (very strong sugar solution) and le

After two hours they removed the potato sticks, dried them, and weighed th

They then calculated the percentage change in mass.

The table shows their results.

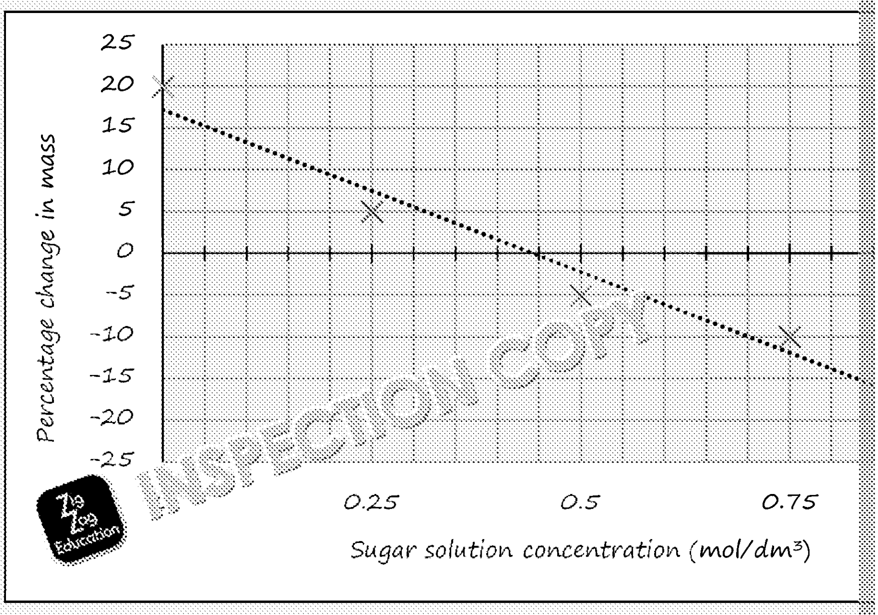
Sugar solution concentration (mol/dm³)	Mass of potato (g)		
	Starting mass	Final mass	Change in
0	2.0	2.4	+ 0.4
0.25	2.1	2.2	+ 0.1
0.5	2.1	2.0	- 0.1
0.75	2.0	1.8	- 0.2
1.0	1.9	1.5	- 0.4

a) Plot a fully labelled graph of these results.

b) Use your line of best fit to estimate the concentration of sugar solution t the mass of the potato.

Solution

a) *Your graph would look like this:*

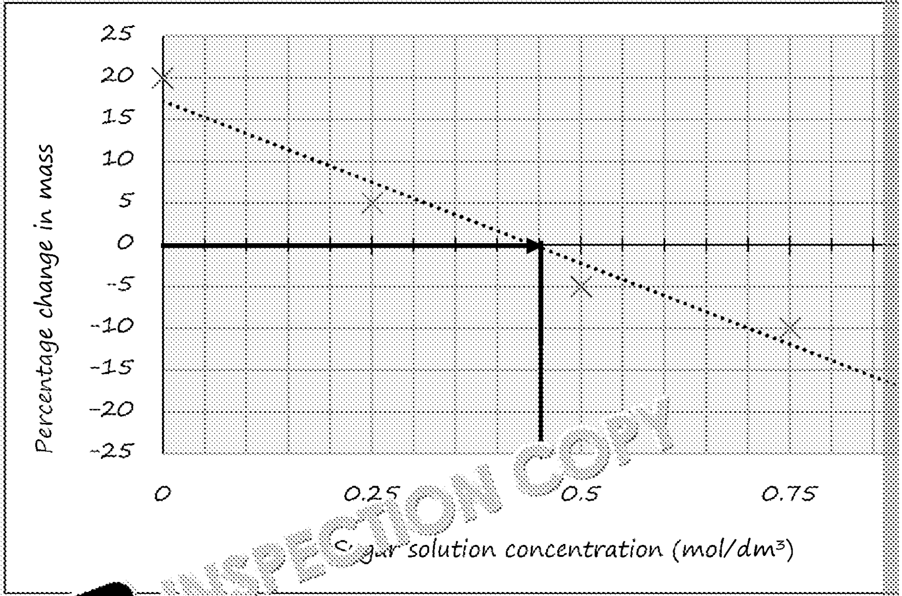


WORKED EXAMPLE (CONTINUED)

You will get marks for:

- *independent variable on x-axis, dependent variable on y-axis*
- *x-axis and y-axis labelled, with correct units*
- *even, sensible scales on both axes*
- *points plotted accurately*
- *line of best fit that goes through the middle of the results*

b) *No change in mass would be 0 % on the y-axis.*



Draw [illegible] across from 0 until it meets your line of best fit, and then draw
scale for sugar solution concentration. Read the value off the scale – it's 0.4

Translating information between graphical and numer

Reading and understanding graphs

The line on a graph tells you **what happens when you increase the value of the** it from left to right.

The steepness and direction of the line show the changes in the dependent variabl

An upward slope means an increase. The steeper the slope the faster the increase

A horizontal line means no change in the dependent variable.

A downward slope means a decrease. The steeper the slope the faster the decre

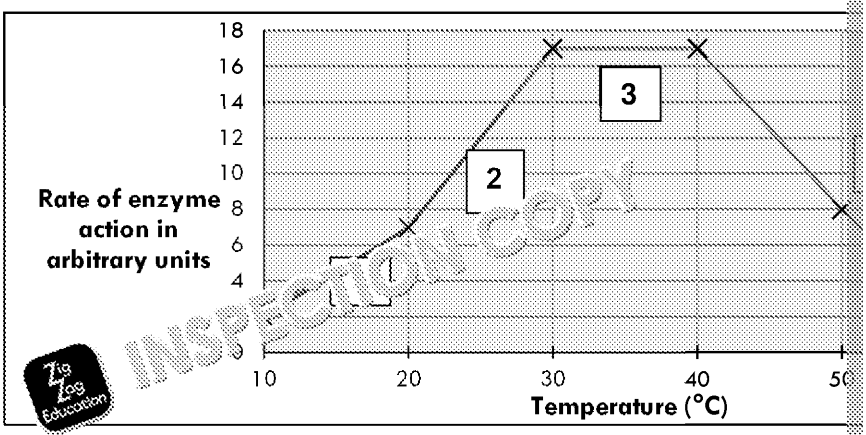
The next graph is about enzyme action.

Digestive enzymes break down large molecules in our food into small, soluble mole the bloodstream and used by the body cells.

The **rate** of enzyme action means how quickly it works, and it is affected by severa

This graph shows the rate of enzyme action at temperatures between 10 °C and 6

You can see that the line on the graph shows four definite stages.



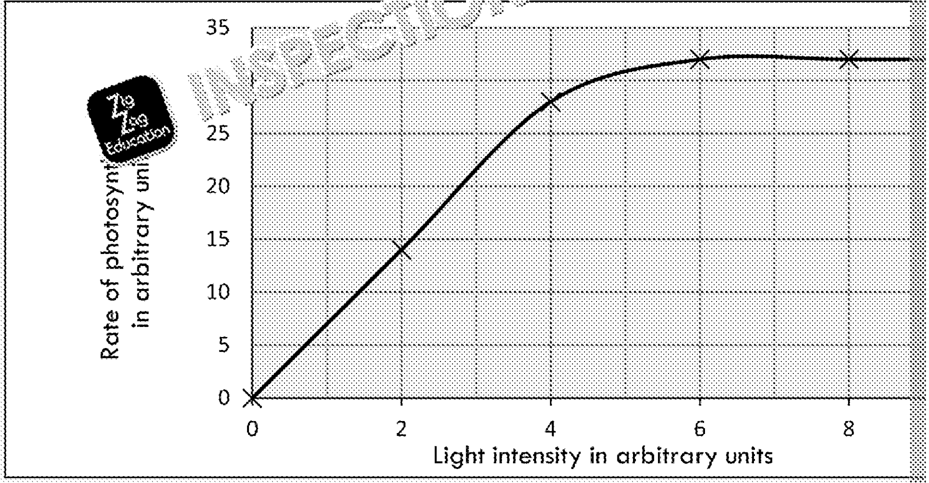
As the temperature increases:

1. from 10 to 20 degrees, the rate of enzyme action increases
2. from 20 to 30 degrees, the rate of enzyme action increases more rapidly (ste
3. from 30 to 40 degrees, enzyme action stays at a constant high rate
4. from 40 to 60 degrees, the rate of enzyme action decreases, until the enzyme

Obtaining numerical data from a graph

WORKED EXAMPLE

Plants make food by photosynthesis. They need light to do this. The graph intensity on the rate of photosynthesis.



a) Describe the effect of increasing the light intensity on the rate of photo

b) Predict the rate of photosynthesis at 14 units of light. Explain your an

Solution

a) *Just describe the line on the graph and give values of the independent var changes. Here you can see that it's an upward slope, and then the line goe go[illegible] would be:*

As the light intensity increases, the rate of photosynthesis increases up to 6 un

b) *32, because the rate of photosynthesis reached its maximum at 6 units; i this has no effect.*

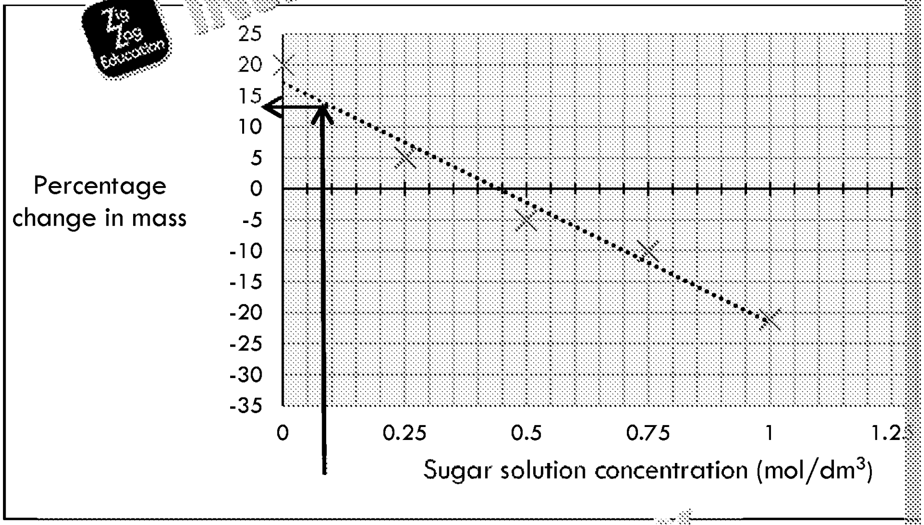
You may be asked to:

- read the graph and give data values using the line on the graph or the line o
- extend the line to predict results outside the data provided (extrapolation)
- use data from the graph for calculations

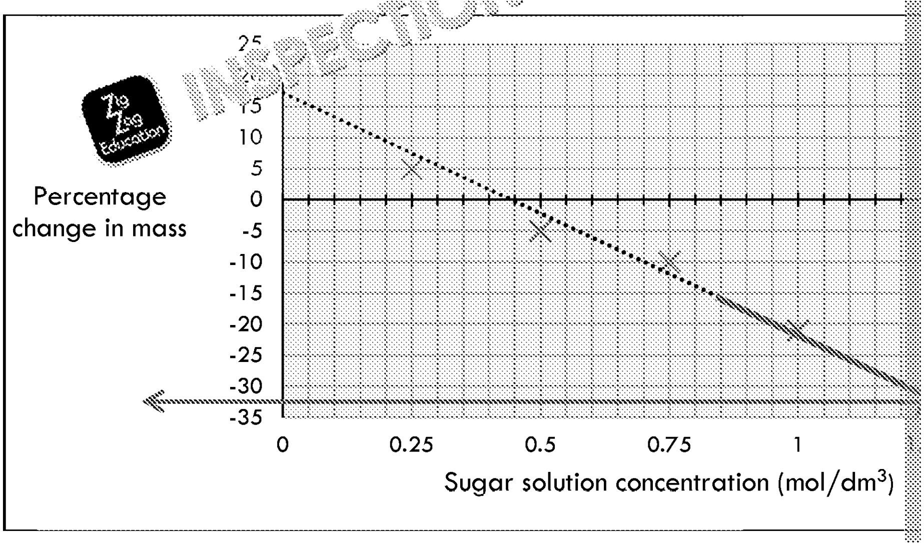
Using the graph on percentage change in mass from earlier in this chapter:

a) Use the line of best fit to estimate the percentage change in mass of a potato concentration of 0.1 mol/dm³.

Find 0.1 on the horizontal axis, then draw a line up to the line of best fit on th to the percentage change and read off the value. The answer is **13 %**.



b) Predict the percentage decrease in mass of a potato stick placed in a sugar s 1.25 mol/dm³.

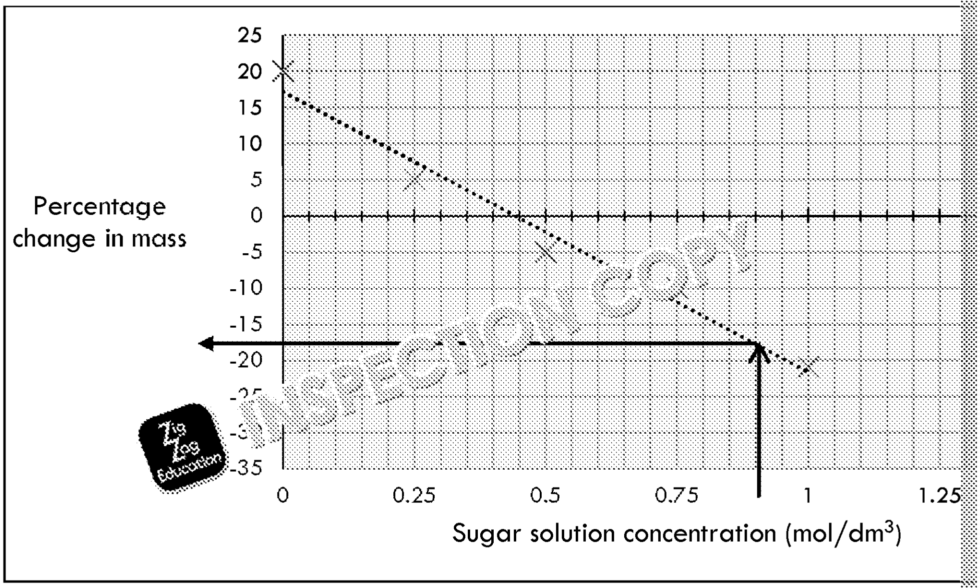


Place your ruler on the line of best fit and extend it until it gets to 1.25 on the across to the percentage change axis and read off the value. The answer is 3

★ *You don't need to write the minus sign because the question was about perc*

c) A potato stick with a mass of [illegible] g is placed in 0.9 mol/dm³ sugar solution fo estimate the mass of the potato after two hours. Give your answer to two sig

Find 0.9 on the horizontal axis, then draw a line up to the line of best fit on th to the percentage change and read off the value. The answer is **-17.5 %**.



Your prediction is that the potato will decrease in mass by 17.5 %. The origi

Work out 17.5 % of 2.5 g 17.5 ÷ 100 × 2.5 = 0.4375 g

Now subtract that from the starting weight 2.5 – 0.4375 = **2.0625**

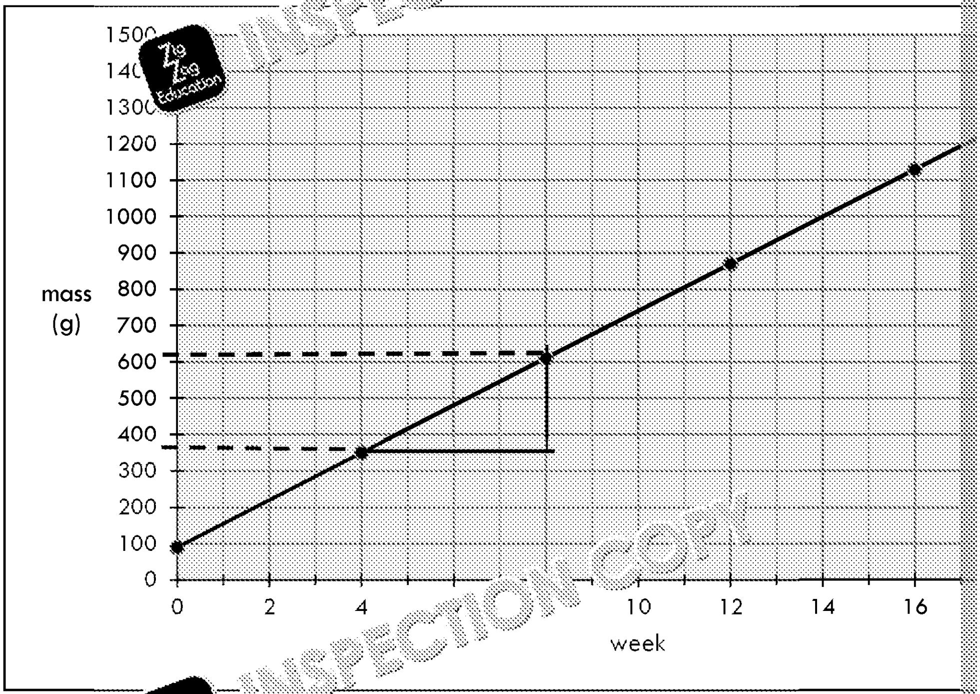
Round this answer to 2 sf 2.0625 ~ **2.1 g**

Rate calculations from graphs

With some scientific research, data is collected over a period of time; for example with measles, or the number of species that become extinct each year.

If time is on the x-axis of a graph, then the **gradient** of the graph represents the **r**

This graph shows the weight of a kitten in the first 20 weeks of its life:



To work out the kitten's growth rate in **grams per week**, find the gradient (m) like

Choose two convenient points on the line – it's best to pick ones that are easy to re the values for 4 weeks and 8 weeks.

Mass at 4 weeks = 350 g Mass at 8 weeks = 600 g Increase in mass

To calculate the growth rate, divide this by the number of weeks between the two

250 g ÷ 4 weeks = **62.5 grams per week**

★ ***Notice that the line does not start at 0; it intercepts the y-axis at 100 g. That wa***

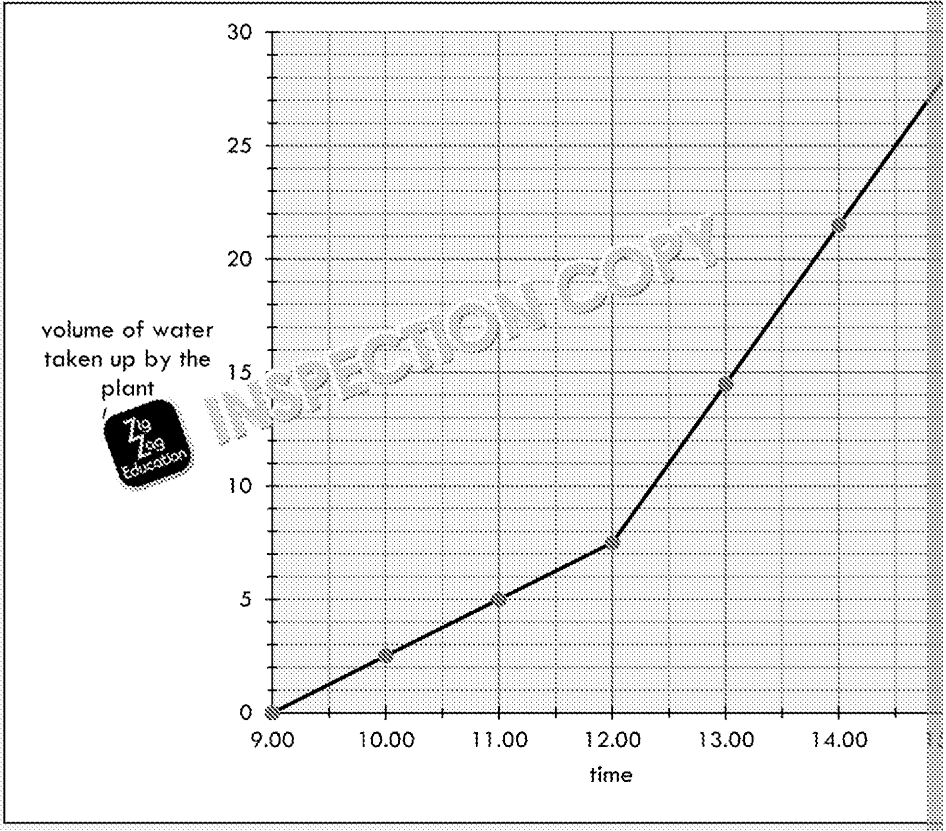
WORKED EXAMPLE

Plants lose water through their leaves in a process called transpiration. The water evaporates through [illegible] on the leaf surface called stomata.

A potometer can be used to measure the amount of water that a plant loses. A leafy shoot is placed in the potometer, and it takes up the same volume of water that evaporates through the leaves. This is then measured on a scale on the glass tube.

A student set up a potometer and recorded the reading on the scale at regular intervals for three hours. Then she switched on a fan in front of the plant and continued to take readings for a further three hours. The temperature was kept constant throughout the investigation.

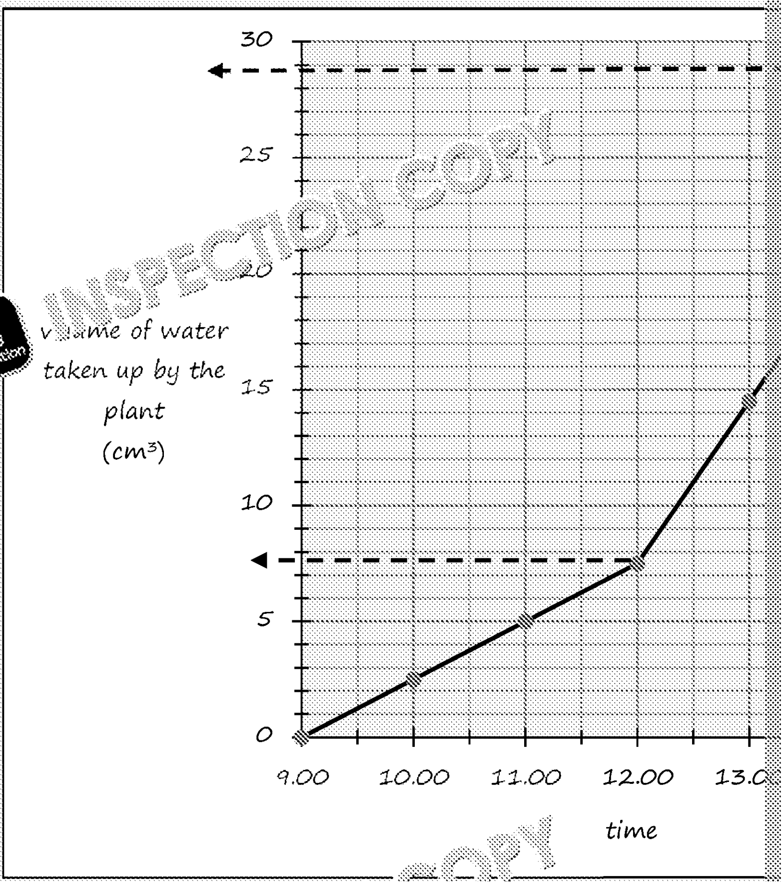
The graph below shows the student's results:



How many times faster was the rate of transpiration after the fan was switc

WORKED EXAMPLE (CONTINUED)

Solution



First work out the rate of transpiration without the fan; that's between 9.00 an

By drawing a line on the graph you can see that 7.5 cm³ of water was taken up

$\frac{7.5 - 0}{12.00 - 9.00} = \frac{7.5 \text{ cm}^3}{3 \text{ hours}} = $ **2.5 cm³ per hour**

Now work out the rate with the fan; that's 12.00 to 15.00

By drawing another line on the graph, you can see that 28.5 cm³ of water had

$\frac{28.5 - 7.5}{15.00 - 12.00} = \frac{21 \text{ cm}^3}{3 \text{ hours}} = $ **7 cm³ per hour**

To work out **how many times** faster the rate of transpiration with the fan is, yo

7 ÷ 2.5 = **2.8** times faster

★ **If the question had been '*<u>How much</u> faster is the rate of transpiration aft***
you would need to <u>subtract</u> the two values.

7 − 2.5 = 4.5 [illegible] faster

PRACTICE QUESTIONS

1. The cell sap in pumpkin cells contains sugar and other substances in solution. Som to find out what happens to pumpkin cells when they are placed in different conc

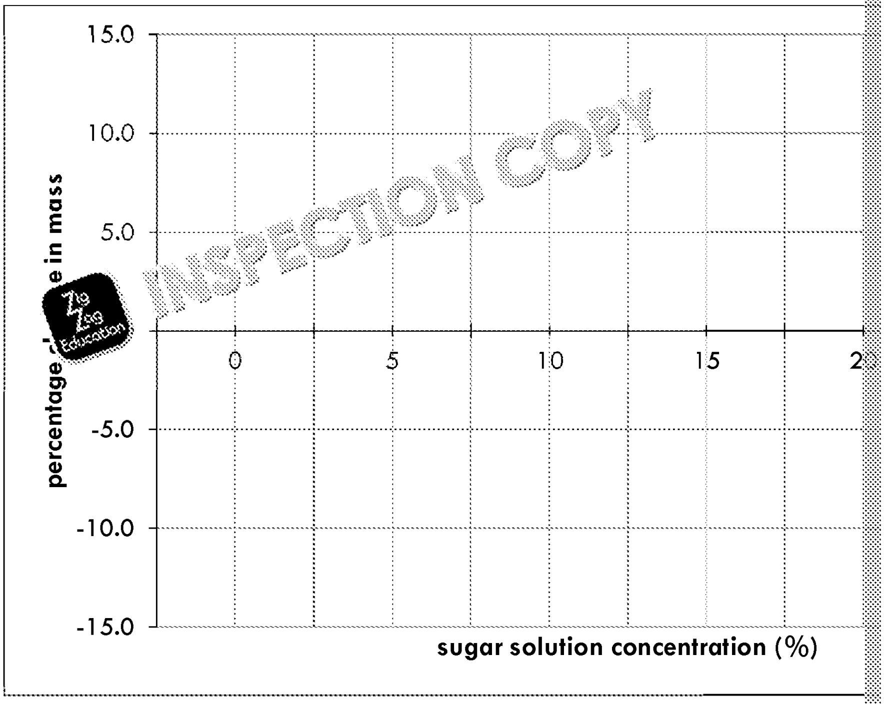
They cut sticks of pumpkin to the same size and weighed them, and then place different concentrations of sugar solution from 0 % to 25 %.

After an hour the students removed the sticks of pumpkin from the solutions, d again. The table shows their results:

Sugar solution concentration (%)	Mass of pumpkin (g)		
	Starting mass	Final mass	Cha
0 (distilled water)	5.0	5.6	
[illegible]	5.1	5.4	
10	5.1	5.0	
15	5.0	4.8	
20	4.9	4.6	
25	5.2	4.7	

a) Copy and complete the table. Give your answers to **one decimal place** positive or negative.

b) Copy these axes onto graph paper and plot the percentage change as best fit.



2. The same group of students completed another experiment. This time they we temperature on the action of amylase enzyme. Amylase is a digestive enzym molecules into sugar molecules.

   The students added 1 cm^3 of amylase solution to 10 cm^3 of starch solution at t to 65 °C.

   They tested the mixture every 30 seconds for 10 minutes and recorded the tir be broken down.

   The table shows their results:

Temperature (°C)	Time for the starch to be digested
[illegible]5	4.5
25	2.5
35	1.5
45	2.0
55	5.0
65	10.0 (experiment stopped – starch n

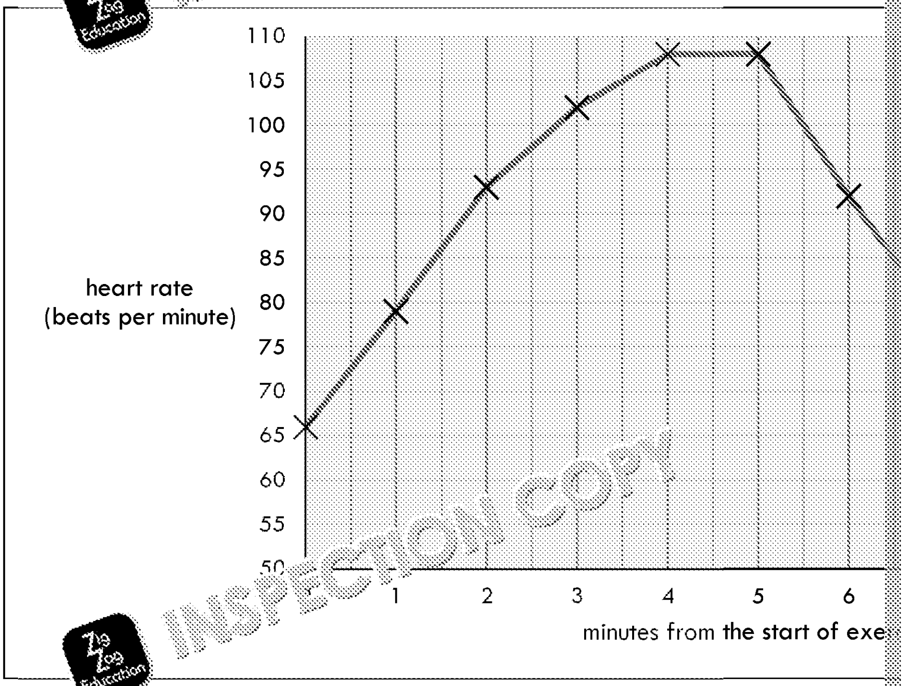
   a) On graph paper, plot a suitable graph for these results.
      (i) Label both axes, including units
      (ii) Use sensible scales on both axes
      (iii) Plot your six points accurately with small crosses
      (iv) Draw a line or curve of best fit

   b) What does your graph tell you about the effect of temperature on starc

3. A man ran on a treadmill while wearing a digital heart rate monitor.

   He measured his heart rate at the start and then every minute during the exe minutes afterwards.

   The graph shows his readings:



   a) How long did the exercise last for?

   b) What was the man's heart rate after 3.5 minutes of exercise?

   c) After he stopped exercising, how long did it take for the man's heart rat

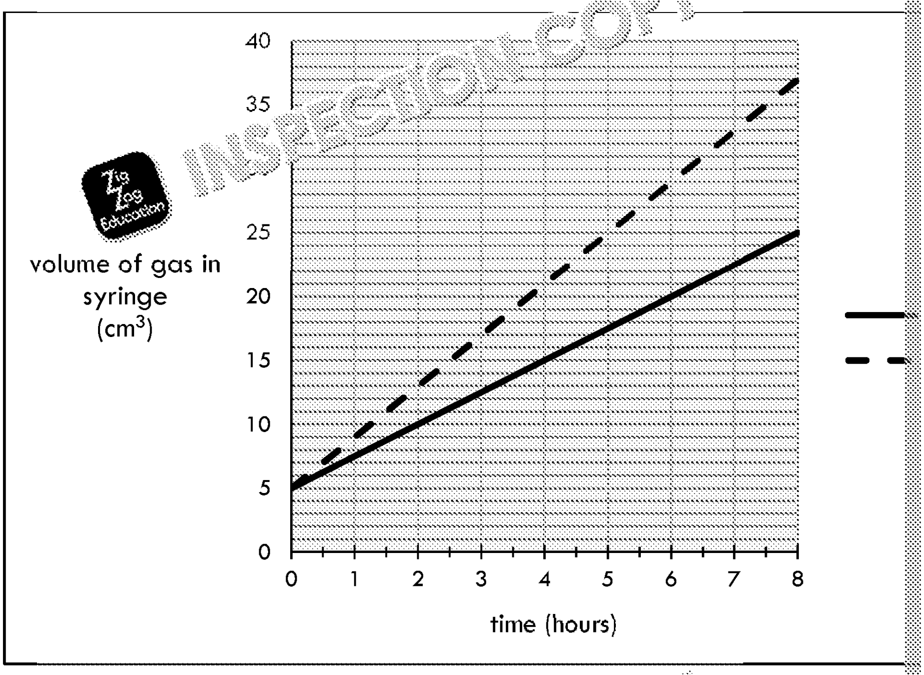
   d) Describe what happened to the man's heart rate during the 10 minutes.

4. When plants make food by photosynthesis they produce oxygen, which return

In the case of underwater plants, the oxygen appears as bubbles coming out collect the gas in a gas syringe and measure the volume that is produced.

Ali put two 15 cm pieces of pondweed in water under lights of different colo oxygen they produced in eight hours.

The graph shows his results.



a) Without doing any calculations, which colour of light leads to faster phot

b) When the experiment started, there was already some gas in the syring

c) How much gas was produced by plant 1 in six hours?

d) Calculate the rate of gas production for both plants in cm^3 per hour.

5 GEOMETRY AND TRIGO

SPECIFICATION OVERVIEW

Calculate areas of triangles and rectangles, surface areas and volumes of cubes
These notes also include area of a circle

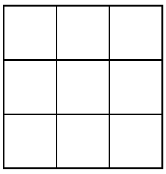
THEORETICAL OVERVIEW

Calculating area and [illegible]

Area is the amount of [illegible] taken up by a two-dimensional flat shape.

We measur[illegible] in **square units: m^2, cm^2, mm^2, nm^2**, etc. For example, 6 m^2 m

It's all about how many squares would fit into the shape, like this:

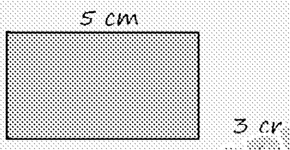


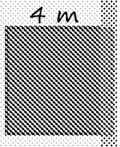
If each small square measures 1 metre long and 1 metre wide
square is 9 square metres because nine small squares will fit i

There are formulas for calculating the area of different shapes.

- **Area of a square or rectangle** = length × width or height

WORKED EXAMPLES



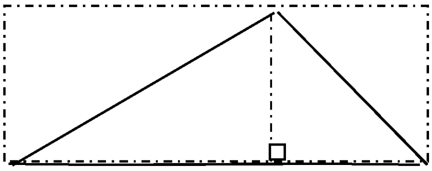


Are[illegible] 3 [illegible] 15 cm²

Area = 4 × 4 = 16

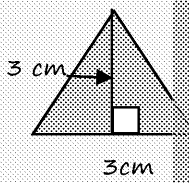
- **Area of a triangle** = $\frac{\text{base} \times \textbf{perpendicular}\text{ height}}{2}$

This is because any triangle is half a rectangle, like this:



Perpendicular
angles to the

WORKED EXAMPLES



Area = $\frac{[illegible]}{2}$ = $\frac{21}{2}$ = 10.5 cm²

Area = $\frac{3 \times 3}{2}$ = $\frac{9}{2}$ = 4.5

- **Area of a circle**

  You need to know the terms **radius** and **diameter**.

  If you are given the diameter of the circle, divide it by 2 to get the radius.

  There is only one formula for the area of a circle:

  $A = \pi r^2$, where **r** is the **radius** of the circle

  π (pi) is a **constant** which is used to find the area and circumference of circles. Its value is about 3.14.

  You can use the **π** button on your calculator, or else use 3.14.

WORKED EXAMPLE

Find the area of a circle with a diameter of 20 cm.

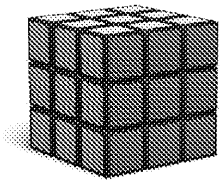
Solution

The diameter is 20 cm. Therefore, the radius is 10 cm.

Area = $\pi r^2 = \pi \times 10 \times 10 = 3.14 \times 10 \times 10 = \underline{314\ cm^2}$

__Volume__ is the amount of space taken up by a three-dimensional shape.

We measure volume in **cubic units: m^3, cm^3, mm^3, nm^3**, etc. For example, 6 m^3



It's about how many cubes would fit into the shape.

This cube is 3 centimetres long, 3 centimetres wide and 3

If you made it up out of 1 cm cubes, you would need thr

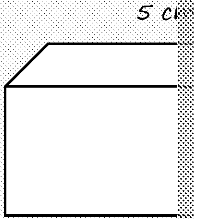
That's 3 × 3 × 3 = 3^3 = 27 centimetre cubes

The volume of this cube is **27 cubic centimetres** or **__27 cm__**

Calculating the volume of a **cube** or **cuboid**: – **Volume = length × width × heigh**

WORKED EXAMPLE

Calculate the volume of this cuboid:

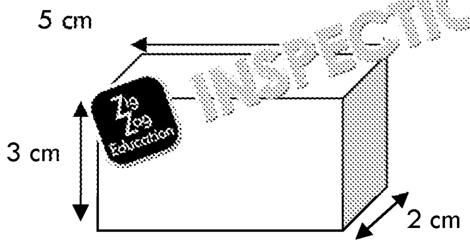


Solution

Volume = $3 \times 5 \times 2 = 30\ cm^3$

The **__surface area__** of a three-dimensional object is the area of the **outside** of the ob

To find the surface area of a cube or cuboid, find the area of each side, and the



Two sides are **3 cm × 5 cm = 1**

Two sides are **2 cm × 5 cm = 1**

Two sides are **2 cm × 3 cm = 6**

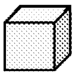
Surface area = (2 × 15) + (2 ×

= 30 + 20 + 12

★ ***The __surface-area-to-volume ratio__ of an object is the relationship between the siz amount it can hold inside it. It's written as __SA : V__.***

This ratio is very important in living organisms. For example, in plants, oxygen anc out through the surface of the leaves; the larger the surface-area-to-volume ratio,

Small objects have a greater SA : V ratio than bigger objects.

This is a 1 cm cube: 

It has six sides. Each side has an area of 1 × 1 = 1 cm^2

So, the total surface area = 6 × 1 = **6 cm^2**

The volume of the cube = 1 × 1 × 1 = **1 cm^3**

Therefore, **SA : V = 6 : 1**

If you put 27 of these cubes together like this:

It has six sides. Each side has an area of 3 × 3 = 9 cm^2

So, the total surface area = 6 × 9 = **54 cm^2**

The volume of the cube = 3 × 3 × 3 = **27 cm^3**

Therefore, **SA : V = 54 : 27 = 2 : 1**

Notice that you can cancel down the SA_:_V ratio so that you have n_:_1

Cancelling to **n : 1** in the ratio means that you can compare the SA_:_V ratios for d

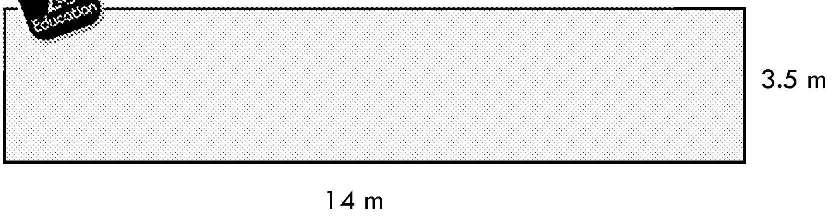
You are comparing how much surface area there is for one unit of volume.

You cancel down to n : 1 by dividing the surface area by the volume.

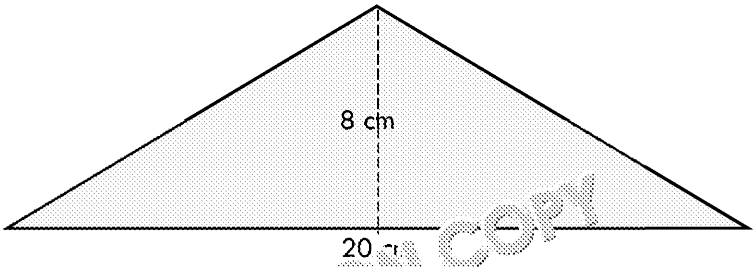
PRACTICE QUESTIONS

1. Calculate the area of these shapes. State the units in your answer.

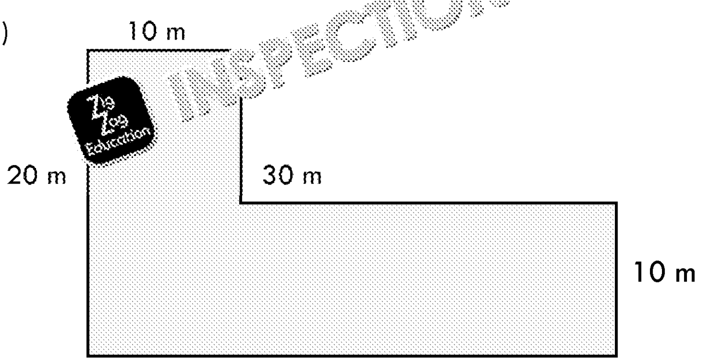
a)



b)



c)



2. Antibiotics are drugs that kill bacteria.

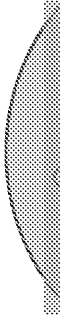
When bacteria are grown on dishes of nutrient jelly in the laboratory, they will reproduce and eventually cover the jelly completely.

To investigate the effect of an antibiotic on the growth of bacteria, a scientist soaked paper discs in different concentrations of the antibiotic.

They then placed the discs onto a culture of bacteria in a petri dish of nutrient jelly.

After incubating the dish for three days, the scientist measured the diameter of the clear areas around the paper discs, shown in the diagram. Clear areas show where no bacteria are growing.

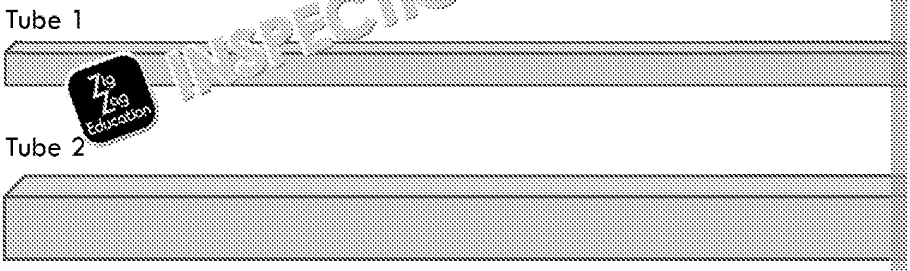
The scientist's results are shown in the table:



Concentration of antibiotic in arbitrary units	Diameter (mm)	Radius (mm
2	6	
4	12	
6	22	
8	34	

Calculate the radius and the clear areas to complete the table. Give your an to one decimal place.

3. Two tubes are in the shape of cuboids. They are both one metre long. (1 me



a) Calculate the volume, the surface area and the surface-area-to-volume answers in the table. Write the SA : V ratio in the form n : 1.

	Volume (cm³)	Surface area (cm
Tube 1		
Tube 2		

b) In humans, nutrients are absorbed into the bloodstream through the surfa Use your answers to part a) to explain why the small intestine is a long th

DIAGNOSTIC TES

1.2 ARITHMETIC AND NUMERICAL COMPUTATION

1. Write 0.85 as a fraction in its simplest terms.

....

2. Write ⅗ as a decimal number [illegible] percentage.

....

3. Write [illegible] 7[illegible] in standard form.

....

4. Write 5.08×10^6 as a decimal number.

....

5. There are 180 students in Year 11. 45 of them are taking GCSE Biology. Wha

....

6. To make up a solution for an experiment, a scientist mixed enzyme with wate
enzyme did she need to make 500 cm³ of solution?

....

7. Estimate the answer to $\frac{248 \times 5.99}{502}$ Give your answer as a single wh

....

....

DIAGNOSTIC TES

2.2 HANDLING DATA

1. Write 347 585 to two significant figures.

....

2. A student studied photosynthesis in pondweed. She put a piece of pondweec
counted the number of bubbles that the plant produced every minute for 10 r

30 [illegible] [illegible] 28 35 26 41 36

Calculate the mean number of bubbles per minute.

....

3. The first 24 clients to use a leisure centre one day were taking part in the foll

Swimming	Swimming	Badminton	Swimming	A
Aerobics	Aerobics	Weight training	Badminton	V
Swimming	Swimming	Aerobics	Weight training	A
Badminton	Badminton	Swimming	Aerobics	A

a) Design a frequency table for these data.

b) Display the data using a suitable chart.

4. 80 patients attend a diabetes clinic. The nurse wants to select 10 patients at
exercise questionnaire. Suggest a method she could use to choose the patient

....

....

5. a) A bag contains 12 red balls and [illegible] yellow balls. You pick a ball out
What is the probability that the ball will be yellow?

....

b) You replace that ball, mix them up and pick again. What is the probab

....

6. An elephant eats an average of 150 kg of vegetation per day. What is the
of food the elephant consumes in a year?

....

DIAGNOSTIC TEST

3.2 ALGEBRA

1. The formula for the speed of a moving object is

$$\text{speed} = \frac{\text{distance}}{\text{time}} \qquad s = \frac{d}{t}$$

a) Calculate the speed of an object that travels 72 kilometres in 4.5 hours.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

b) What would be the units of your answer to part a)?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

c) A different object travels at a speed of 52 mph (miles per hour). How lo
78 miles? Give the units of your answer.

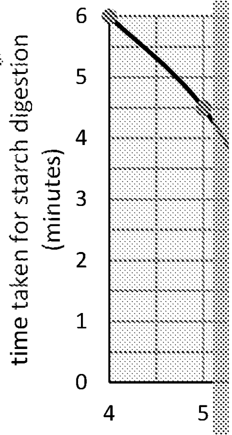
…………………………………………………………………………………………………

…………………………………………………………………………………………………

DIAGNOSTIC TES

4.2 GRAPHS

1. The pH of a solution measures how acidic or how alkaline it is. It affects how quickly digestive enzymes work to break down the nutrients in our food. The graph shows how long it takes an enzyme to digest 10 cm³ of starch solution at different pH values.



   a) Describe the effect on starch digestion of increasing the pH from 4 to 9.

   ....

   ....

   ....

   ....

   b) Estimate the time it would take to digest the starch at pH 7.5.

   ....

   ....

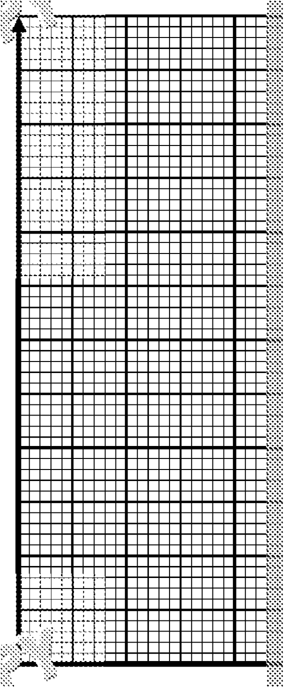
2. A plant weighs 100 g. It is placed outside in hot sunshine, and it loses mass at a steady rate of 6 g per hour.

   a) Plot a graph of the mass of the plant over a period of [illegible] hours. Label both axes of your graph.

   b) How much does the plant weigh after 4.5 hours?

   ....

   ....



DIAGNOSTIC TEST

5.2 GEOMETRY AND TRIGONOMETRY

1. Measure the angle shown in the diagram.

   ....

2. Calculate the area of the following shapes:

   a) Rectangle 20 m × 12 m

   ....

   ....

   b) Triangle base 8 cm, height 6 cm

   ....

   ....

   c) Circle with **diameter** 16 mm

   ....

   ....

3. This cuboid measures 5 cm × 5 cm × 8 cm.

   a) Calculate the volume of the cuboid. Give the units of your answer.

   ....

   ....

   b) Calculate the total surface area of the cuboid. Give the units of your an

   ....

   ....

SOLUTIONS TO QUES

DIAGNOSTIC TEST 1

1.1 Arithmetic and numerical computation

1. $^2/_5$
2. 0.625, 62.5 %
3. 1.5×10^4
4. 0.0035
5. 28 %
6. 3 : 1
7. 50 × 3 = 150 kg

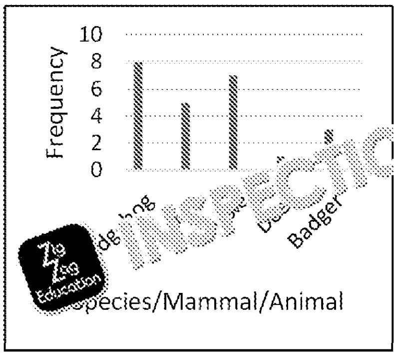
2.1 Handling data

1. 25 200
2. 25.77777 or 25.8
3. a)

Species/Mammal/Animal	Tally (optional)	Frequency
Hedgehog	~~IIII~~ III	8
Fox	~~IIII~~	5
Vole	~~IIII~~ II	7
Deer	I	1
Badger	III	3

Categories can be in any order

b)



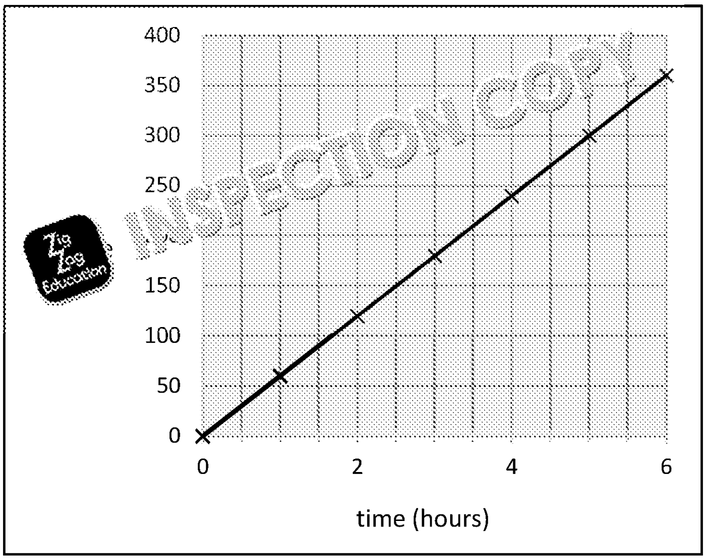
4. A valid method of achieving randomness; for example, giving each student a computer or a calculator to generate six random numbers between 1 and 1
5. a) ¼ or $^2/_8$
   b) ⅞
6. 150 × 200 = 30 000; that's 3×10^4 – the order of magnitude is 10^4

3.1 Algebra

1. a) 0.25
   b) g/cm^3, or grams per cubic centimetre
   c) 1.5 kg

4.1 Graphs

1. a) 75 million
   b) The population increased until day 4, and then stayed the same at 150
   c) 50 million per day
2. a)



   b) 150 kilometres

5.1 Geometry and trigonometry

1. Protractor
2. Degrees
3. a) 6 cm^2
   b) 20 cm^2
   c) $\pi \times 5^2 = 78.5$ or 78.5 cm^2
4. 24 cubic metres (m^3)
5. Surface area = 6 × (2 × 2) = 24 cm^2

PRACTICE QUESTIONS

Arithmetic and numerical computation

1. a)

Amount in words	Amount in figure
Thirteen thousand five hundred and six	13 506
Two thousand and sixty-four	2064
One million seven hundred and fifty thousand	1 750 000
Three thousand and seven	3007
Twenty-five thousand three hundred and sixty	25 360

   b) 2064, 3007, 13 506, 25 360, 1 750 000
2. 0.72, 0.702, 0.27, 0.207, 0.072, 0.027
3. a) 3×10^9
   b) 2.5×10^8
   c) 1.[illegible]^3
   d) 2 × [illegible]
4. a) A kilogram is 10^3 grams
   b) A millimetre is 10^{-3} metres
   c) A nanosecond is 10^{-9} seconds
   d) There are 10^6 µm in a metre

5. a) $3.6 \times 10^4 \times 10^6 = 3.6 \times 10^{10}$
   b) $8.7 \times 10^7 \div 10^2 = 8.7 \times 10^5$
6. Division time = 36 hours ÷ 1.5 hours = 24
   $2^{24} \rightarrow$ $\boxed{2\ x^n\ 24 =}$ 16 777 216
7. a) 4 : 1
   b) 10 : 1
   c) 20 : 1
   d) 9 : 2 = 4.5 : 1
8. 15
9. a) 240
   b) 250
10. a) $^6/$
    b) $^1/$
11. 75
12.

Fraction	Decimal	
$^1/_4$	0.25	
$^3/_8$	0.375	
$^2/_5$	0.4	
$^3/_{10}$	0.3	
$^8/_{10}$ or $^4/_5$	0.8	
$^4/_{100}$ or $^1/_{25}$	0.04	

13. 120 students + 14 teachers = 134
14. 15 ÷ 85 × 100 = 17.65 %
15. $\frac{30\ 000}{1926} \rightarrow \frac{1200}{201} = 15 - 10 = 9$ or $\frac{31\ 009}{2000} \rightarrow \frac{1000}{200} =$

Handling data

1. a) 5
   b) 0.
   c) 17. ÷ 100 × 2390 = 418.25 to 2 sf – that's 420 or 420.0
2. 13 + 6 + 12 + 7 + 6 + 4 + 8 = 56   56 ÷ 7 = 8
3. a)

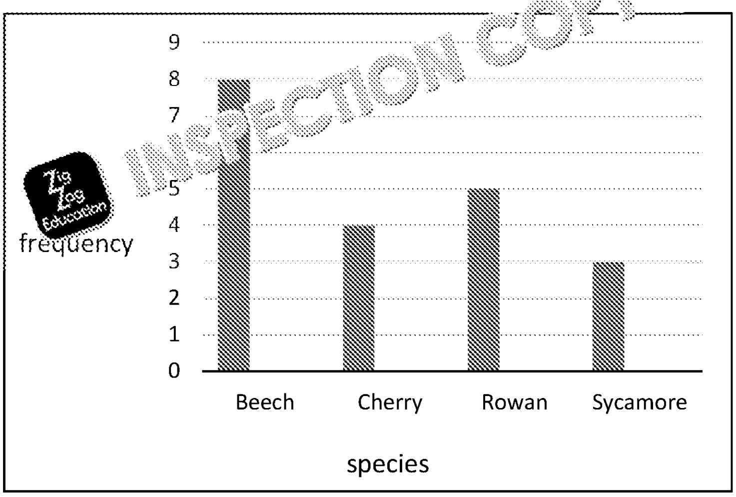
Mark	Frequency	
14	2	14 × 2 = 28
15	10	15 × 10 = 150
16	2	16 × 2 = 32
17	3	17 × 3 = 51
18	13	18 × 13 = 234

   Mean mark = 495 ÷ 30 = 16.5
   b) Everyone who got 14, 15 or 16 marks needs to [illegible] 2 + 10 + 2 = **14 s**

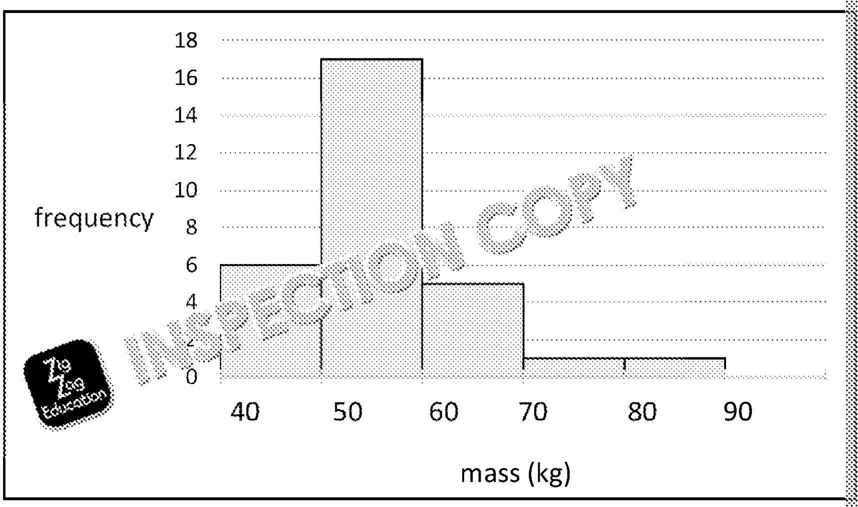
4. a)

Species	Frequency
Beech	8
Cherry	4
Rowan	5
Sycamore	3

b)



5. a)



b) $50 < x \leq 60$

6. a) ii. Use a grid with random numbers
   b) 4
   c) 8000 × 4 = 32 000

7. a) $^{1}/_{20}$, 0.05, 5 %
   b) $^{18}/_{20} = {}^{9}/_{10}$, 0.9, 90 %
   c) $^{11}/_{20}$, 0.55, 55 %

8. ⅔ × 3600 = 2400

9. 120 × 50 × 365 = 2 190 000 g
Divide by 1000 to get your answer in kilograms = 2190
To 1 sf that's 2000, or 2×10^3
Therefore, the order of magnitude is 10^3

Algebra

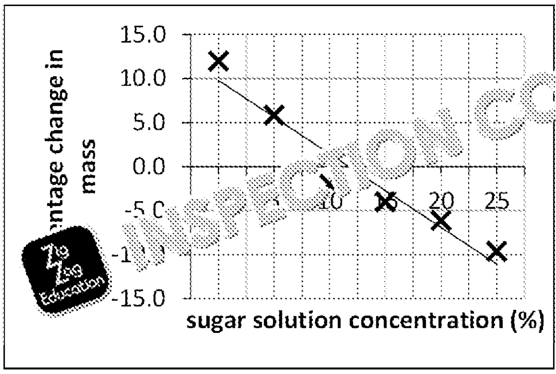
1. $100 = \frac{0.9}{t}$ → $t = \frac{0.9}{100}$ → t = 0.009 **seconds**
2. a) $A = \frac{I}{M} = \frac{29}{100} =$ 0.29 mm *or* 290 µm
   b) $M = \frac{I}{A} = \frac{48}{1.2} =$ 40×
   c) I = A × M = 0.6 × 15 000 = 7200 [illegible]
   7200 ÷ 1000 = 7.2 mm
3. Child dose = 1500 × [illegible] mg per day

Graphs

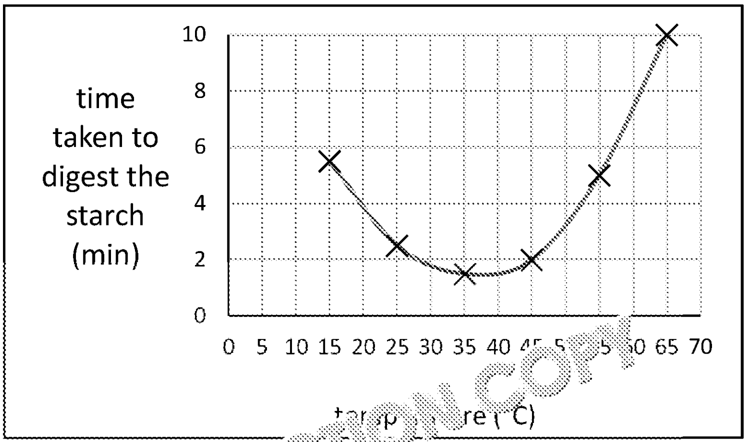
1. a)

Sugar solution concentration (%)	Percentage change i
0	+12.0
5	+5.9
10	-2.0
15	-4.0
20	-6.1
25	-9.6

b)



2. a)



★ T
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★ It
a

b) As the temper[illegible]ses the time needed for the starch to be dige
th[illegible]nc[illegible]gain. The starch is not digested at all at 65 °C.

3. a) 5 [illegible]s
   b) 10[illegible]pm
   c) 3 minutes
   d) During the five minutes of exercise, the man's heart rate increased fro
   108 bpm after four minutes. It stayed level for one minute, and then w
   decreased at a steady rate for three minutes, until it was back to 65 bp

4. a) blue
   b) 5 cm^3
   c) 20 – 5 = 15 cm^3
   d) Plant 1 (25 – 5) ÷ 8 hours = 2.5 cm^3 per hour (cm^3/h)
   Plant 2 (37 – 5) ÷ 8 hours = 4 cm^3 per hour (cm^3/h)

Geometry and trigonometry

1. a) 14 × 3.5 = 49 m^2
   b) $\frac{8 \times 20}{2}$ = 80 cm^2
   c) Divide the shape into two rectangles
   A [illegible] 20 = 200 m^2
   B → 10 × 30 = 300 m^2
   Total area = 200 + 300 = 500 m^2

2.

Concentration of antibiotic in arbitrary units	Diameter (mm)	Radius (mm) *Divide the diamete*
2	6	3
4	12	6
6	22	11
8	34	17

If you used 3.14 for π, then the clear areas for 4, 6 and 8 units of antibiotic ar
907.5 mm^2

3. a)

	Volume (cm^3)	Surface area (cm^2)
Tube 1	100 × 2.5 × 2.5 [illegible]	4 × (100 × 2.5) = 1000 2 × (2.5 × 2.5) = 12.5 1000 + 12.
Tube 2	[illegible] × [illegible] = 2500	4 × (100 × 5) = 2000 2 × (5 × 5) = 50 2000 + 50 = 205

   b) Tube 1 is thinner than Tube 2, and it has a much higher surface-area-to
   helps nutrients to be absorbed more rapidly/efficiently through the sur

DIAGNOSTIC TEST 2

1.2 Arithmetic and numerical computation

1. $^{17}/_{20}$
2. 0.6, 60 %
3. 2.75×10^{-4}
4. 5 080 000
5. 25 %
6. 25 cm^3
7. 250 × 6 ÷ 500 =

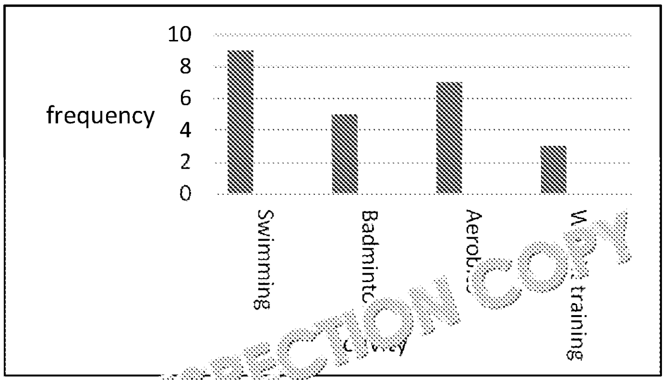
2.2 Handling data

1. 350 000
2. 32.3
3. a)

Activity	Frequency
Swimming	9
Badminton	5
Aerobics	7
Weight training	3

Categories can be in any order

b)



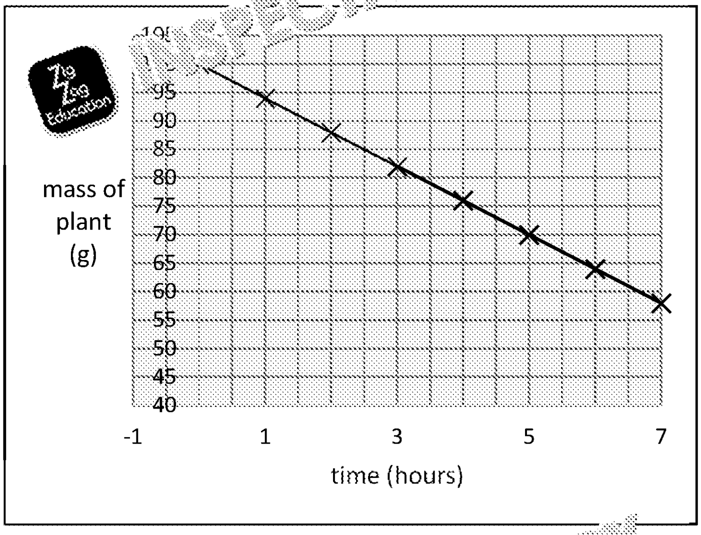
4. A valid [illegible] achieving randomness; for example, giving each patient a
compu[illegible] calculator to generate 10 random numbers between 1 and 8
5. a) $^{1}/_{5}$ or $^{3}/_{15}$
b) $^{1}/_{25}$ or $^{9}/_{225}$
6. 150 × 365 = 54 750; that's 5.475×10^4
The order of magnitude is 10^4

3.2 Algebra

1. a) 16
b) km/h, or kilometres per hour
c) 1.5 hours / 90 minutes / 1 hour 30 minutes

4.2 Graphs

1. a) The time it took to digest the starch decreased from 3 to 7, and then in
b) Answers between 2.2 and [illegible]
2. a)



b) 73 g

5.2 Geometry and trigonometry

1. 20° or in the range [illegible] to 21°
2. a) 2[illegible]
b) 24[illegible]
c) $\pi \times 8^2 = 200.96$ (if $\pi = 3.14$) or 201.06 mm^2
3. a) 200 cubic centimetres (cm^3)
b) Surface area = $2 \times (5 \times 5) + 4 \times (5 \times 8) = 50 + 160 = 210$ cm^2