Fractions, Decimals, Percentages

- These are really all variations of the same thing.
- We use a fraction, a decimal (below 1.0) or a percentage to describe a quantity as **part of a whole**.
- A percentage is a fraction of 100—this gives us an easy comparison.
- It is easy to convert a number between these three ideas.

For all of these, you will need to **divide one number by another**. The most common mistake is to use the wrong numbers. Try thinking it through in words before you reach for your calculator.

e.g. In a class of 25, 3 students forget their calculator. This is **3 out of 25** or **3/25**.

- To get a decimal, divide the number we're interested in (3) by the number of the whole we're comparing it to (25) to get **0.12**
- To convert a decimal to a percentage, just multiply by 100 to get **12%** - this is the number of students who would have forgotten their calculators if there had been 100 in the class.

Applications

- Efficiency = useful energy(J) / total energy(J)
- Sources of background nuclear radiation.
- Percentage yields in chemical and industrial processes.
- Proportions of isotopes or elements in a sample.
- Recommended Daily Amount (RDA) of vitamins and minerals in a diet.
- Population sizes and how common certain features are.

1 A tenth of all background radiation is cosmic rays. What percentage is this?

2 A biologist samples a group and finds that of the 40 observed, 5 had brown fur, 3 had grey stripes. How many of each would be seen in a population of 200?

3 A chemist calculates the maximum possible yield in an experiment is 400g of aspirin. 250g is actually made. What percentage is this?

4 The recommended amount of fat in a day for an adult is 80g. A man eats a packet of biscuits with 90% of this. How much more (in grams) can he have?

5 A hairdryer wastes 25% of the energy supplied to it. In 5 minutes it uses 600kJ. How much is wasted? How much is usefully transferred?

6 As a decimal, how many hours is 15 minutes?

7 What percentage of results on a fair die will be even (with a big sample)?

8 In a factory, 1 of the 200 toys made each day is tested. How many more would need to be checked so that the sample was 2%?

9 By mass, an alloy contains 60% tin. How much of the 500kg produced is tin?

10 A disease causes multi-coloured spots in 30% of those infected. 45 people in a town have these spots. How many have the disease?

Graphs and Charts

The whole point of a graph is to show a pattern in data. We usually need to choose between a **line graph** and a **bar chart** by looking at the independent variable.

Line graphs are used if what we change could have any value in between the ones we used. Bar charts are for when the independent variable is in types or categories.

1. Use a sharp pencil and ruler.
2. Draw the independent variable along the bottom (the x axis).
3. Draw the dependent variable up the side (the y axis).
4. Use a regular, sensible scale with equal intervals for each axis.
5. Label both axes with the **quantity** (variable name) and **unit**.
6. Plot points carefully with a small cross.
7. Ask yourself if the origin (0,0) should be a point.
8. For bar charts, draw **equal width** bars, usually with a gap between them. For a line graph, join the points with a **best fit line**, which could be **straight** (with a ruler) or a **curve** (freehand).

Applications

- How does height change from birth to 18?
- How does the speed of a moving object change over time?
- If the temperature of 100ml of water is changed what happens to the mass of salt we can dissolve in it?
- What is the frequency of different eye colours in a class, school or town?
- How does the voltage across a resistor affect the current passing through it?

1. For each of the examples above, sketch and label the axes. Add a prediction for what kind of shape you would expect.
2. Would you use a bar chart or a line graph for these independent variables?
   (a) time in seconds
   (b) colour of hair
   (c) different values of resistance in ohms
   (d) mass of magnesium in grams
3. Draw horizontal lines and then choose a good scale for each of these ranges:
   (a) temperature of water from 0 to 90 degrees Celsius
   (b) voltage across capacitor between –12 and 12 volts
   (c) mass of limestone from 0 to 50 grams
   (d) distance between lamp and pondweed, 0 to 30 centimetres
4. Draw and plot a graph of extension in centimetres (on the vertical axis) against force in newtons (on the horizontal.

Force (N)	0	1	2	3	4	5	6
Extension (cm)	0	0.8	1.6	2.3	3.3	4.0	4.8

Converting Units

We wouldn't use the same units to measure the width of a desk and the distance from Birmingham to London, even though they are both lengths. We choose a unit that is appropriate for whatever we are measuring. More detailed measurements or readings (smaller units or more decimal places) mean a better **resolution**.

There are 100 centimetres in a metre, so 1cm = 0.01m. If we divide measurements in centimetres by 100 we get a length in metres. To go from metres to cm, x 100. This method, using different factors, works for all conversions.

We use prefixes for fractions and multiples of standard units.

centi	1/100		
milli	1/1000	kilo	x1000
micro	1/1000 000	mega	x1000 000
nano	1/1000 000 000	giga	x1000 000 000

So to convert from **micro** to **standard** units, divide by 1000 000 (a million), because there are 1 million micrometres in a metre. The rules are simple:

From a small to a big unit, **divide**. From a big to a small unit, **multiply**.

Time is the odd one out. In science we normally use seconds. There are 60 seconds in a minute, 60 minutes in an hour, so 1 hour = 60 x 60 = 3600 seconds.

If you need to use hours, remember that fractions are not the same as minutes.

- 15 minutes is a quarter (0.25) of an hour, not 0.15 hours.
- 2 hours isn't the same as 20 or 200 minutes because they aren't decimal.

Applications
Being able to convert between units will be useful in all kinds of situations. It shouldn't take long before you have a 'feel' for what the solution will be, which makes checking your answers much easier. Industrial chemistry uses large masses and volumes, while atomic nuclei are measured using very small numbers.

1 15MW in watts
2 0.12 kJ in joules
3 25grams in kilograms
4 14mm in cm
5 14mm in metres
6 500ml in litres
7 6 minutes in seconds
8 6 seconds in minutes
9 1.4litres in millilitres (same as cm^3)
10 0.67kg in grams
11 2500W in kilowatts
12 700nm in metres
13 320000J in MJ
14 350micrometres in centimetres
15 3.2 tonnes in kg
16 963ms in seconds

Mean Averages

When we use averages in school science we are normally talking about the **mean**. This is used when we have more than one possible answer to a question, normally because we have **repeated** an experiment or a reading. It reduces the effect of random errors e.g. a fluctuating voltmeter.

An average is used to **represent a whole sample**. It tells us what usually or 'normally' happens. Often a range of values is actually 'normal', for example height or weight. The average gives us just one number to use or plot on a graph.

mean = total of all the values / number of values

A mean average will always be **within the range of values** for a result.
If you find it for heights in cm, you have calculated the **average length**, **also in cm**.
If one of the values is very different to the others and you think it may be an error (an **anomaly**) it may be best **not to use it** when you work out the mean.

e.g. A student measures the number of bubbles from pondweed in a minute, recording 23, 19 and 24 for their three readings.

mean = total of all the values / number of values
= (23+19+24) / 3
= 66 / 3
= 22 bubbles per minute

Applications

- Representing the results of a repeated experiment.
- Describing typical or 'expected' characteristics in a population.
- Getting one value to plot on a line graph or bar chart.

1 What is the mean of:
   (a) 17, 15, 16, 18 centimetres
   (b) 58, 60, 50, 54, 58 seconds
   (c) 26, 40, 30 degrees Celsius
   (d) 180, 165, 170, 165 grams
2 How can you tell that 48 seconds *cannot* be the answer to (b) above?
3 A chemical reaction is timed and results of 35, 40 , 38 and 220 seconds are recorded. What average do you get using all the data? Why is this not what you should do? What calculation should you do and what answer does it give?
4 Why do you need to do at least three repeats of an experiment before you make a judgement about anomalies?
5 Why would finding the average height of boys and girls in a class separately be better than working it out for the whole class?

Relationships and Equations

If one variable affects another (makes it bigger or smaller) then we can probably describe the relationship. "As time spent revising increases, exam marks increase."

We might plot a graph. In Maths, an upwards line is described as showing **positive correlation**. In science, we use the term **directly proportional** if doubling one variable means that the other doubles as well. These graphs will be a straight line through the origin (0,0). We may be able to use an equation to describe them.

An **equation** is not frightening, or shouldn't be. An equation or formula is just a method written down, a recipe for how you get an answer.

Just like with a recipe, you need to **start with the right ingredients** and **do the right things** with them, in the **right order**, to get what you were hoping for. There are several easy steps to help this happen and you should always **show your working**.

1 Write down the variables and values you know e.g. m=50g
2 Write down the equation (in words or letters) that you need to use.
3 Substitute in the values (some might need converting)
4 Use your calculator.
5 Add the unit.
6 Check that the answer makes sense.

Applications

- Describing a link between two or more variables.
- Defining a quantity e.g. voltage
- Working out a missing number if you know the others.

speed = distance/time	energy = power x time	stopping	=	thinking	+	braking
		distance		distance		distance

Choose the **correct equation** depending on the data given in each question.

1 A 100W bulb is on for 30 seconds
2 (a) A car travels 12m while the driver thinks and 24m while braking
 (b) The car travelled that distance in 3 seconds
3 A football moves 90m in 4 seconds
4 A 2kW hairdryer is on for 5 minutes
5 An athlete runs 10km in 45 minutes. Give your answer in:
 (a) m/s
 (b) km/h

Rearranging Equations

Sometimes an equation isn't in the right order—this means you need to rearrange it **before** you put in any numbers. For this to work you need to 'undo' any steps that stop the variable you need from being on its own. This may be described in Maths as 'putting an equation in terms of' or 'changing the subject of an equation'.

1 Work out which variable is your 'unknown'.
2 One step at a time, reverse the operations on that variable.
3 When you have finished, put your values into the rearranged equation.

e.g. You are given the equation speed=distance/time and told that an athlete travels at 8m/s for 15 seconds.

1 The unknown to work out must be the distance travelled.
2 To undo a 'divide by', multiply **both** sides by it.
  speed = distance/time
  speed x time = distance
3 distance = speed x time
  = 8m/s x 15s
  = 120m

Just remember, at each stage **do the same thing to both sides**.

Applications

- Using mathematical relationships.
- Making equations useful for a particular situation.
- Working out the cause from an effect instead of the other way around.

1 Rearrange these simple equations to give each possible version:
  (a) x = y + z
  (b) r = s x t
  (c) n = p/q
  (d) a = 2b
  (e) c = d/3
  (f) e = 2f/g
  (g) h = j/5k

2 These are a little harder:
  (a) $a = b^2$
  (b) $c = 6d^2$
  (c) $e = 1/4 \times f \times g^2$

3 Rearrange these science equations:
  (a) v = d/t
  (b) power = energy / time
  (c) W = mg
  (d) yield = made / predicted
  (e) V = IR
  (f) $KE = 1/2\ mv^2$

4 Rearrange the right equation from above then use to find the answer.
  (a) Find I 30Ω, 6V
  (b) Find t 20m/s, 100m
  (c) Find m 10m/s, 100J
  (d) Find E 60s, 10W