# Maths skills – M0.3 Use ratios, fractions and percentages

### Tutorials

Learners may be tested on their ability to:

* Calculate percentage yields
* Calculate surface area to volume ratio
* Use scales for measuring
* Represent phenotypic ratios (monohybrid and dihybrid crosses)

### Percentage

‘Percentage' means 'out of 100'

*x* percent means *x* divided by 100.

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

So a percentage is a fraction of 100. For example, 30 percent as a fraction is 30 out of 100

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

Let’s look at how you convert 30/100 into a percentage. First you work out 30/100 as a decimal, which is 0.3, and then you multiply this by 100. Remember that percent means ‘out of 100’.

Let’s convert 30/110 into a percentage. Firstly work out 30/110 as a decimal – you might need a calculator to do this. And then multiply your answer by 100, which gives you 27 %. Working backwards, 27 % means 27 out of 100. And this is equivalent, or equal to, 30/110.

In biology you may be required to find a percentage of a quantity. For example in studying populations you might want to know the gender distribution in a population. To work out the percentage you need to divide the ‘part’ (the specific data you are looking at) by the ‘whole’ (the total number). To convert this into a percentage you multiply your answer by 100 %.

$$\frac{part}{whole}×100\%= \%$$

For example, in a population of 2200 rabbits there are 1000 males and 1200 females. You want to know the percentage that is female. Here 1200 is the ‘part’ and 2200 is the ‘whole’. So we divide 1200 by 2200, and multiply by 100 % to express the answer as a percentage. The answer is 54.5 %.

% female 🡪 $\frac{1200}{2200}×100 \%=54.5 \%$

Now we are going to look at percentage change

Percentage change is a useful calculation to compare values and determine how much a quantity has increased or decreased by.

In percentage change the ‘part’ is the increase and the ‘whole’ is the original quantity.

For example, you might subtract the initial mass from the final mass to find the increase. Then divide this by the initial mass. This is then multiplied by 100 to give the answer as a percentage. Doing it this way, you have to keep an eye on whether it is an increase or a decrease and make it clear in your answer.

For example, if the initial mass of some cellular tissue in an osmosis investigation is 5.6 g and after a day it is 4.7 g. You might want to find out the percentage change.

The percentage change is 4.7 – 5.6 divided by 5.6 and then multiplied by 100% which gives you a percentage change of -16 %. You could refer to this as a 16% decrease.

$$\frac{4.7- 5.6}{5.6}=-0.16$$

0.16 x 100 = - 16 % = 16 % decrease

Another way to calculate percentage change uses the idea of a multiplier.

Percentage change is calculated using this formula:

The original quantity times a multiplier equals the new quantity

The key point to remember is that a multiplier of 1 represents a change of 0 %, because if you substitute 1 for the multiplier in the equation, then the Original quantity equals the new quantity

The difference between the multiplier and 1, multiplied by 100 %, is the % change.

So a multiplier of 1.43 represents an increase of 43 % because 1.43 minus one, multiplied by 100 % equals 43 %, whilst a multiplier of 0.83 represents a decrease of 17 % because 1 minus 0.83 = 0.17, multiplied by 100 % equals 17 %.

Let’s return to the previous example where the initial mass of some cellular tissue in an osmosis investigation is 5.6 g and after a day it is 4.7 g

Then to work out the percentage change we have to work out the value of the multiplier:

The initial mass is 5.6 g, the final mass is 4.7 g.

Remember that the original quantity times the multiplier equals the new quantity.

Rearranging this equation to calculate the multiplier, gives you the new quantity divided by the original quantity, which is 4.7 divided by 5.6, which is 0.84.

Initial mass = 5.6 g, Final mass = 4.7 g

Original quantity x Multiplier = New Quantity

$$5.6×Multiplier=4.7$$

$$Multiplier=\frac{4.7}{5.6}=0.84$$

This represents a decrease of 1 - 0.84 which equals 0.16. To express this as a percentage you need to multiply by 100 % which gives you a 16 % decrease.

It doesn’t matter which method you use as long as you understand the principles behind the method you adopt.

### Percentage yield

The percentage yield is a way of looking at the limitations of a process.

You can work out mathematically what goes in and what comes out, but there are many steps in a biological process and the actual yield is rarely the same as the theoretical yield.

The percentage yield is a measure of the limitations of a biological or chemical process. You are essentially saying what percentage of the theoretical yield am I ending up with at the end of this process?

One area where percentage yield is relevant is in scientific experiments where yield can be limited by the amount of a reagent that is present. In these situations it is important to be able to work out how efficient a reaction is under certain conditions. This is where it helps to calculate a percentage yield.

For percentage yield calculations, the actual yield – the amount of product actually obtained in a chemical reaction – is divided by the theoretical yield – the amount of product that could possibly be produced according to the starting amount of the limiting reagent. To convert this into a percentage you then multiply by 100 %.

For example, imagine a scenario where you were producing insulin from genetically modified bacteria. You calculated that with everything you started with at the beginning you had a theoretical yield of 120 mg of insulin. However, when you carried out the procedure you only ended up with 90 mg – the actual yield.

The percentage yield is the actual yield, 90 mg, divided by the theoretical yield, 120 mg, multiplied by 100 %, which equals 75 %

In a big manufacturing process these calculations are very important as getting the highest possible percentage yield might be the difference between a process being financially viable or not.

### Ratio

A ratio is a relationship between two numbers and is used to compare values, with the quantities being in direct proportion.

When presenting the ratio of one quantity to another it is reported in the form *x* : 1,

x is found by dividing the first quantity by the second. So, expressing 40 to 5 as a ratio, 40 would be divided by 5. This would be expressed as a ratio of 8 to 1.

$x=\frac{40}{5}=8$ ratio = 8:1

Surface area to volume ratio is important in understanding processes such as gas exchange, heat loss and diffusion rates. Surface area to volume ratio is affected by size and shape. So keeping the volume of an object the same, but changing its shape, changes its surface area to volume ratio. Keeping the shape the same, such as a sphere, but changing the volume will also affect its surface area to volume ratio.

The surface area to volume ratio is calculated by dividing the surface area by the volume.

For example, a cube has sides of 1 cm. The total surface area is the sum of the areas of each side. A cube has 6 equal sides, each side of this cube has an area of 1 cm2. Therefore the surface area is 1 cm2, multiplied by 6. So the surface area of the cube is 6 cm2.

The volume of the cube is calculated by multiplying the length of each side:
1 cm x 1 cm x 1 cm = 1 cm3

The surface area to volume ratio is 6 divided by 1 which equals 6. Note that ratios have no units.

The ratio is 6:1 but in this scenario it is normally expressed as a single number

Ratios are commonly used in genetics to represent, for example, phenotypic ratios for monohybrid and dihybrid crosses.

For example, in a fruit fly genetics experiment the offspring were counted; 78 fruit fly offspring had red eyes and 20 had brown eyes

|  |  |
| --- | --- |
| **Phenotype** | **Number of offspring** |
| Red eyes | 78 |
| Brown eyes | 20 |

To calculate the ratio of red-eyed flies to brown-eyed flies 78 is divided by 20, which equals 3.9.

So the ratio of red to brown is 3.9:1

If we now look at the ratio of brown-eyed flies to red-eyed flies, we would divide 20 by 78 which equals 0.256. This can be rounded up to 0.3. So the ratio is 0.3:1

When more than two quantities are all being compared the order in which the ratio is given follows the order in which the different quantities are named and the last one will always be given as 1, with the other numbers all relative to that.

For example, imagine there were four options for eye colour in flies: red, purple, scarlet and white, and the numbers of offspring are 127, 50, 32 and 8 respectively. The respective ratios are all relative to the last number. Therefore you divide each by the last number, which here is 8.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Phenotype** | **Red eyes** | **Purple eyes** | **Scarlet eyes** | **White eyes** |
| **Number of offspring** | 127 | 50 | 32 | 8 |
| **Calculating the ratio of offspring** | $$\frac{127}{8}=15.9$$ | $$\frac{50}{8}=6.3$$ | $$\frac{32}{8}=4.0$$ | $$\frac{8}{8}=1$$ |

The ratios of red to purple to scarlet to white is therefore 15.9 : 6.3 : 4.0 : 1

Again remember that with ratios there are no units.

### Scales for measuring

NB: This topic is covered thoroughly in sections M0.1 and M1.8.

Units show what a quantity is measured in, and generally a measured quantity without units is meaningless.

Learners would be expected to be able to convert between different units, as detailed in section M0.1, with respect to the scale they are measuring in.

For example, bacteria would generally be measured in micrometres (µm), whereas an elephant would be measured in metres (m). As bacteria and elephants are nowhere near the same size, this example shows why understanding scales for measurements and the corresponding units are so important.

Being able to accurately label diagrams and pictures according to scale is essential, as detailed in section M1.8, and can be denoted by a sentence, ratio or scale bar.

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