# Maths skills – M2.3 Substitute numerical values into algebraic equations using appropriate units for physical quantities

# Maths skills – M2.4 Solve algebraic equations

## Tutorials

Learners may be tested on their ability to:

* Use a given equation e.g. Simpson’s index of diversity
* Solve equations in a biological context

e.g: cardiac output = stroke volume x heart rate

## Substituting numerical values into algebraic equations

Now that you understand how to rearrange formulae (M2.2 Change the subject of an equation) you need to be able to solve them. The first step of this process involves putting numerical values that are either given in the question or that you have already worked out into the equation. You then need to work out what the equation is now with the new numbers in it. For example, if you had the equation: and were told in the question that then the equation for would be

*y* = 2 multiplied by 4, plus 5.

Two times 4 is 8

giving . So y=13

There are a few rules that you need to remember. First is when you are substituting a negative number into . Brackets are essential for this sort of question. For example, substituting in gives us (-2)2. This means -2 times -2. Without the brackets you may mistake the question for 22 with a minus in front of the answer.

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Another important fact to remember is that when you multiply (or divide) two negative numbers, the answer is a positive number.

negative x negative = positive

Therefore, this means when you substitute in into to get -2 times -2, the answer is plus 4.

Remember, it is always true that two negative numbers multiplied or divided equal a positive:

−3 × −5 = +15

Whilst if only one of them is negative then the answer is negative:

-3 × 5 = −15

Addition and subtraction are different. Think of the number line for these calculations.

For example:

−3 + −5

Here you have minus three and then go a further minus five down the number line. If you take away -5 from -3 you are going the opposite direction, so you are adding 5 to minus three, which gives you plus 2.

−3 + −5

-3 – 5

-3 – 5 = -8

−3 − −5

-3 + 5

-3 + 5 = 2

An example of where understanding how to substitute numerical values into an equation is important in biology is when using Simpson’s index of diversity. This gives an index of diversity by taking into account the total number of organisms (N) and the number of each particular species (n).

Simpson’s Index of Diversity states:

N = Total number of organisms n = number of a particular species

For example, here we have the numbers of 3 different species of trees in two samples.

|  |  |
| --- | --- |
|  | **Number of individuals** |
| **Tree species** | **Sample 1** | **Sample 2** |
| Elm | 250 | 15 |
| Willow | 385 | 61 |
| Oak | 365 | 924 |
| Total | 1000 | 1000 |

For each species, we need to work out the number of that particular tree species (*n*) divided by the total number of trees (N), and square the answer. Then we need to add the answers for all of the tree species together. So, for this example we have 250 elm trees, 385 willow trees and 365 oak trees – these are all the *n* values. The total number of organisms is 1000 so each of these species numbers needs to be divided by 1000. We then square each term, using brackets to help separate them, and finally add them all together. This gives an answer of 0.34395.

We have worked out that = 0.32395. So . This gives an answer of 0.65605.

For sample 2 we can go through the same process. The index of diversity is 0.142278

Comparing the diversity values for samples 1 and 2 shows that sample 1 has a higher value for D and therefore a higher diversity according to the Simpson’s index of diversity.

Higher value for *D* = a higher diversity

## Solving algebraic equations

Solving an equation involves substituting values into a formula to calculate an unknown. This may involve rearranging the equation so that the unknown is on one side and the other values on the other side. Sections M2.2 and M2.3 explain how to rearrange equations and substitute in numerical values into a formula. You will then be able to solve your equation.

1. Rearrange the equation
2. Substitute values
3. Solve

For example, cardiac output is the volume of blood pumped by the left ventricle of the heart in one minute. This is calculated by multiplying the volume of blood pumped in one beat (stroke volume) by the number of beats in a minute (heart rate).

cardiac output = stroke volume x heart rate

By rearranging the equation and substituting in what we know, we can find the unknown.

Take this question: Heart rate during exercise is 185 bpm. The cardiac output is 10 dm3 min -1. What is the stroke volume?

heart rate = 185 bpm

cardiac output = 10 dm3 min -1

stroke volume = ?

First of all we need to rearrange the equation to make the stroke volume the subject of the equation. By looking at our original equation we can see that to make the stoke volume the subject of the equation we need to divide both sides by the heart rate. This gives is the equation: stroke volume = cardiac output/heart rate

cardiac output = stroke volume x heart rate

stroke volume = cardiac output/heart rate

Now we have our equation we need to substitute in the values we know. We know that the heart rate is 185 bpm and the cardiac output is 10 dm3 min -1. Therefore we now have the equation: stroke volume = 10/185

stroke volume = 10/185

By solving this equation we get a stroke volume of 0.054 dm3. This is better expressed as 54 cm3.

stroke volume = 0.054 dm3 = 54 cm3.

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