Building and Construction

Carry out measurements and calculations

Learner Guide

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Calculations in Building and Construction [1]

Most jobs in building and construction involve measuring and calculating. This resource will show you how to measure and calculate in a number of different building situations.

Calculations are used in the building industry to work out the size and quantity of materials and to cost jobs.

To be able to do these calculations you need to be able to:

- add
- subtract
- multiply
- divide.

You need to be able to do these calculations with **whole numbers** and **decimals numbers**.

You should also be able to work with **fractions** and **percentages**.

Whole numbers

Doing calculations

Do you know how to do these types of calculations with whole numbers:

- adding
- subtracting
- multiplying
- dividing?

Look at the following examples of using these calculations.

Adding

An example:

Three different trucks have delivered roof tiles to a building site. To check that all the tiles have been delivered you can **add** the quantity delivered by each truck.

[1] Source: Flexible Learning Toolbox, as at https://nationalvetcontent.edu.au/alfresco/d/d/workspace/SpacesStore/5d45b757-16eb-4f2c-b81e-f4c8230d8a3e/index.htm?guest=true, as on 9th June, 2014; National VET Content, as at https://nationalvetcontent.edu.au/share/page/search?t=Carry%20out%20measurements%20and%20calculations&a=true&r=false, as on 9th June, 2014.

Subtracting

An example:

To work out how much timber has been used from a stack, count the remaining timber and **subtract** that amount from the amount delivered.

Multiplying

An example:

The total cost of insulating a house can be calculated by **multiplying** the cost of one bag of insulation by the number of bags needed for the job.

Dividing

An example:

The number of studs needed for a wall can be calculated by **dividing** the length of the wall by the standard space between each stud.

How to add

Adding is putting two or more numbers together and finding the **total**.

Often you will need to add up a list of numbers, so the numbers are set out one above the other.

Fractions

What are fractions?

A fraction is a part of a whole thing. In the building industry fractions are often used to refer to parts of things.

Look at the following examples of fractions.

Half ½

When a new fence is built between two properties the cost of the fence is split equally between the two property owners. They each pay **half** the cost.

Example:
Total cost of fence $2000
Property owner one pays $1000
Property owner two pays $1000

Thirds ⅓

Developers of a building estate specify that a **third** of the front of a house must be of a different material than the rest of the front.

Example:
In this photo you can see that the lower part of the front of the house looks different to the upper parts. The lower part is one third, the upper parts are two thirds.

Quarters ¼

If you want to cut one length of timber into four equal lengths, each piece would be a quarter of the original piece.

Example:
A one metre length of timber is cut into four equal parts. Each of the four would be 250 mm long and therefore each be a **quarter** of the original length.

Writing fractions

Fractions are usually written $\frac{2}{3}$ or sometimes like this ⅔.

The bottom number is the total number of parts that make up the whole.

The top number is the number of parts.

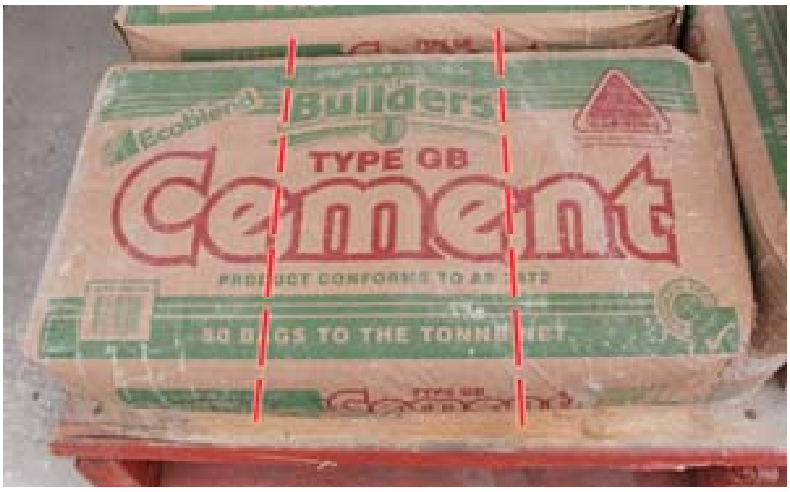
The fraction above is two thirds and this diagram shows a rectangle with two thirds shaded.

Estimating fractions

There are times when you will be required to estimate parts of things. For example:

- "Move half of this stack of timber."
- "Use a third of a bag of cement."

In cases like this it may not be necessary to count or measure exact amounts. Instead you can judge how much by looking and comparing.

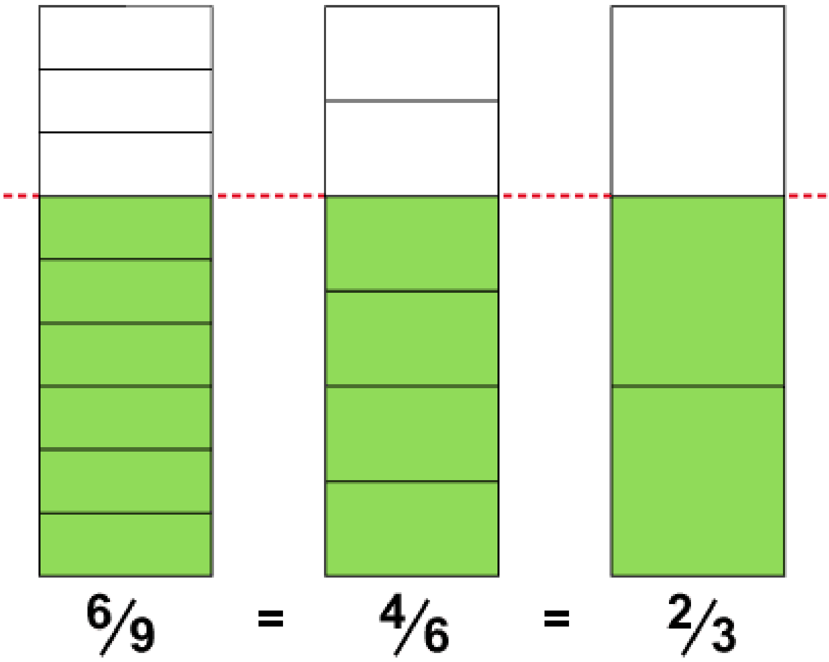


Equivalent fractions

Equivalent fractions have the same value but use different numbers to express that value. Some examples are shown below:

6/12 = 5/10 = 4/8 = 2/4 = 1/2
6/18 = 5/15 = 4/12 = 3/9 = 2/6 = 1/3

The diagram shows that the fractions 6/9, 4/6 and 2/3 all have the same value. They are equivalent fractions.



Simplifying fractions

Simplifying a fraction means changing a fraction to its simplest equivalent fraction. For example:

5/10 in simple form is 1/2
2/8 in simple form is 1/4
6/18 in simple form is 1/3

To simplify a fraction, divide the top and bottom by the highest number that can divide exactly into both numbers.

An example of simplifying the fraction 15/25 is shown in the image below. Five is the highest number that will divide into 15 and 25. 3/5 is the simplest equivalent of 15/25.

$$\begin{array}{c} 15 \div 5 = 3 \\ \hline 25 \div 5 = 5 \end{array}$$

Decimal numbers

Decimal calculations

Decimal numbers relate to the numbering system we use — counting by tens. But they also refer to any number that includes a decimal point (a decimal fraction).

Decimals are a common way to express fractions in the building industry.

Look at the following information about decimal calculations.

Decimal fractions

For fractions often, instead of writing one number above another, a decimal point is used. For example:

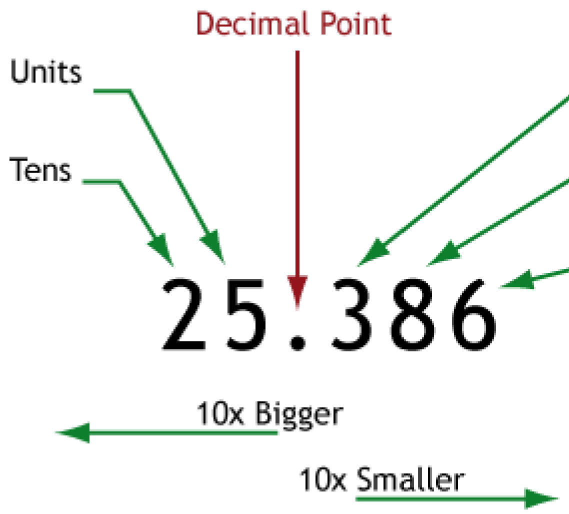
3/10 (three tenths) written as a decimal is **0.3** (zero point three).

9/10 (nine tenths) written as a decimal is **0.9** (zero point nine).

Most of the fractions that you deal with will be decimal fractions. The metric system uses decimals.

Decimal numbers

Decimal fractions relate to tenths, hundredths, thousandths, etc. The image below shows the makeup of a decimal number.



The number shown to the left of the decimal point (25) is a whole number (two tens and five units).

The number to the right of the decimal point (386) is a decimal fraction (three tenths, eight hundredths and six thousandths).

Fractions as decimals

Fractions can be shown as a decimal fraction. Examples:

1/2 is the same as 5/10 as a decimal fraction is **0.5**

1/4 is the same as 25/100 as a decimal fraction is **0.25**

3/4 is the same as 75/100 as a decimal fraction is **0.75**

1/3 is almost the same as 33/100 as a decimal fraction is **0.33**

Working with decimals

When doing calculations with decimals, for example adding, list the numbers with the decimal points aligned. An example is shown below:

1,075.000
248.320
5,789.654
456.100

56.990
Total 7,626.064

Notice extra zeros are added to give each number tenths, hundredths and thousandths.

Process Example - Setting up to concrete a slab

Before you begin
There is a large amount of preparation needed before you are ready to pour a concrete slab. A lot of measuring and calculating needs to be done.

Check your company's standard policies and procedures for the level of accuracy required in your measurements and calculations. These may be listed as tolerances in a Quality Manual.

Skills you need:

Using scale

Scale is used to show objects bigger or smaller than they really are.

Example

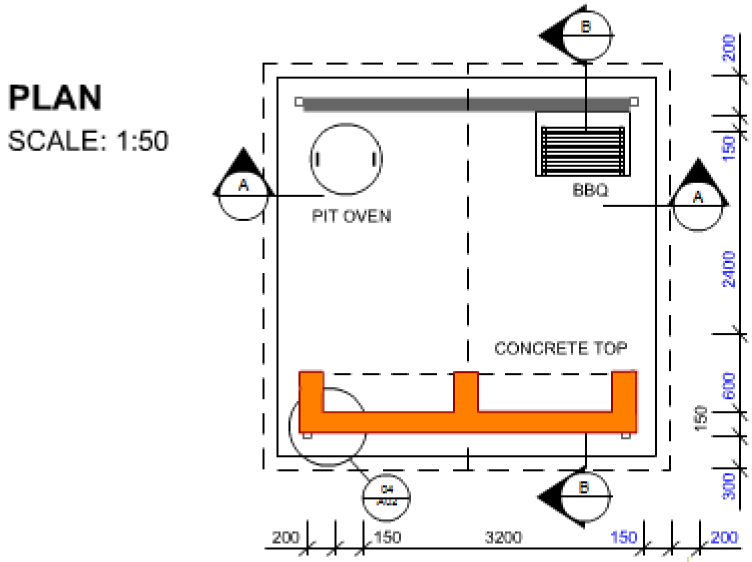
It would be difficult to draw buildings full size. To show the plan of a building on a sheet of paper, it must be scaled down in size. It might be drawn on a scale of 1:10 (one to ten).

This means that everything on the plan is ten times smaller than its actual size in real life.

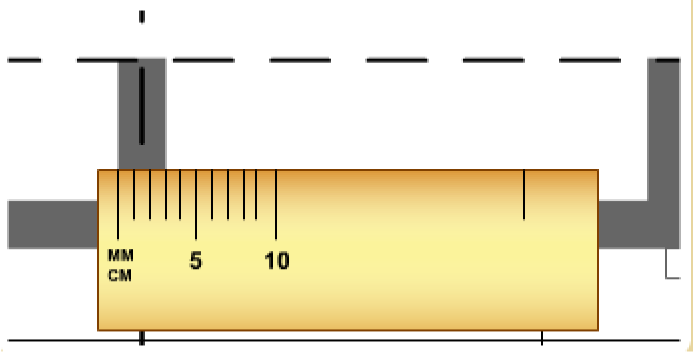
A wall shown as 20 mm thick on the plan is actually 20 x 10 = 200 mm wide.

Using scale to work out a length

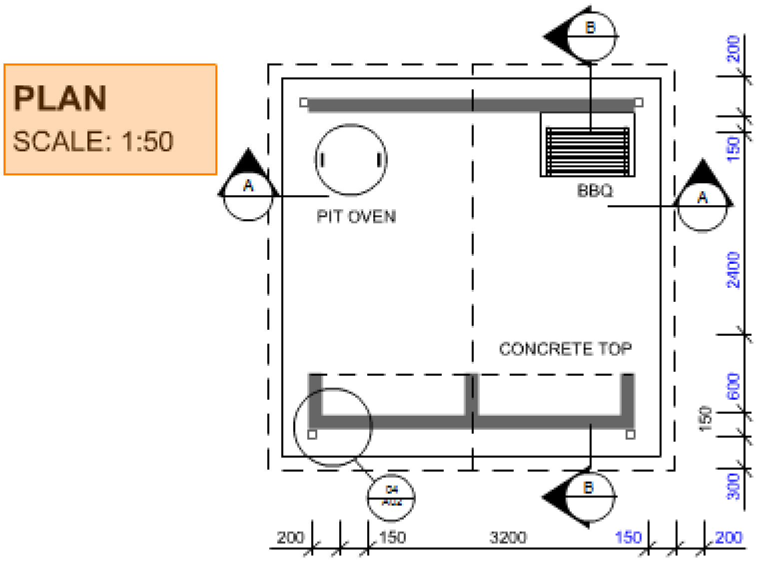
How thick is the wall (highlighted in orange on the plan?)



Use a ruler to measure the thickness in millimetres. The wall is 3 mm thick on the plan.



The scale is 1:50, so 3 mm on the plan means 3 x 50. This would give a true width of 150 mm.



Reading scale

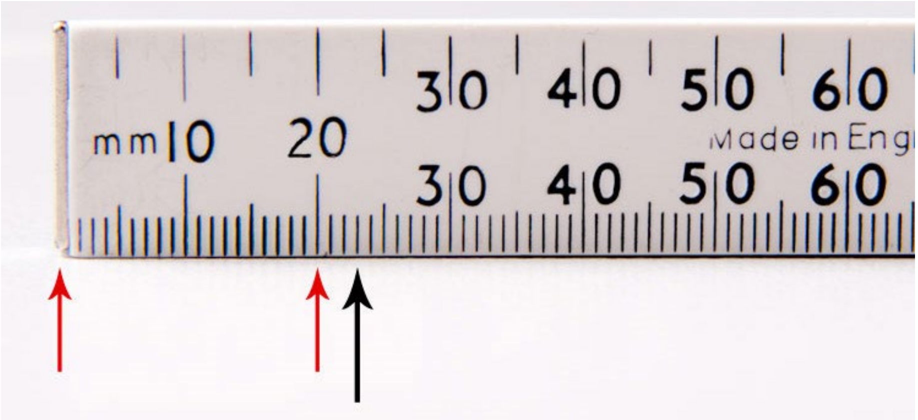
Rulers and tape measures use the same metric scale.
The smallest markings or divisions on the scale are 1 mm apart.
Numbers are only written every 10 and 100 millimetres.

The following examples show how to read a metric scale on a ruler or tape measure.

Example 1
To work out the measurement at the black arrow:

- start from 0, the left hand end of the ruler (first red arrow)
- from zero look across and read the last number before the black arrow – this number is 20 (second red arrow)
- count the number of divisions between 20 and the black arrow – there are 3
- add the two numbers together
- 20 + 3 = 23 mm.

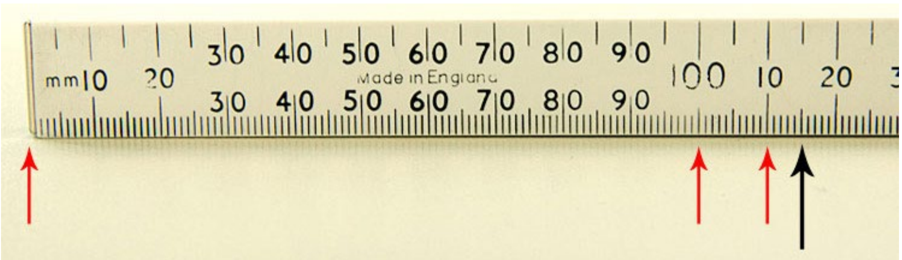
The distance from the left hand end of the ruler to the black arrow is 23 mm.



Example 2
To work out the measurement at the black arrow:

- start from 0, the left hand end of the ruler (first red arrow)
- between the left end of the ruler and the black arrow there is one 100 mark – 1 x 100 = 100 mm
- read the last number between the 100 mark and the black arrow – this equals 10 mm
- count the divisions from 10 to the black arrow – this is 5 mm
- add the three numbers together
- 100 + 10 + 5 = 115 mm.

The distance from the left hand end of the ruler to the black arrow is 115 mm.



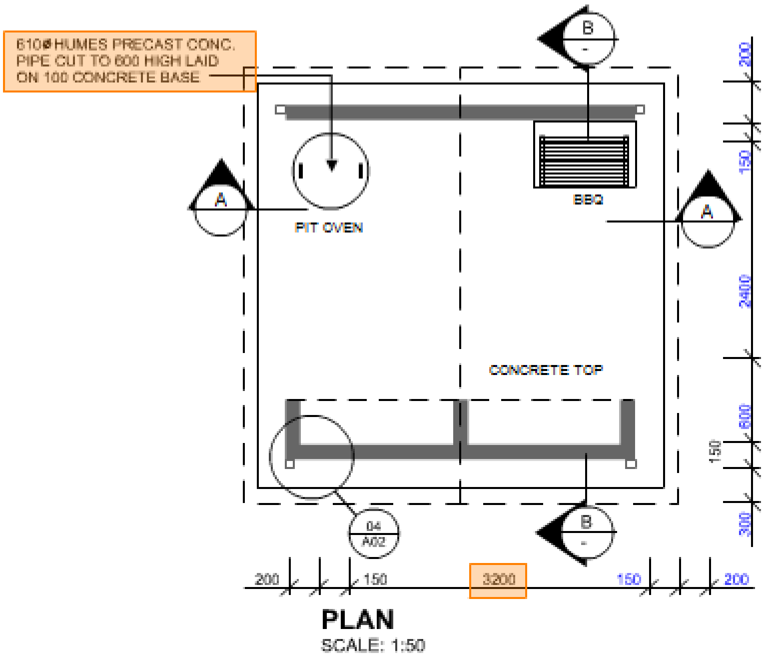
Calculating length

There is an old saying in the trades: 'Measure twice and cut once.'
It's important to get measurements right. Measuring accurately will:

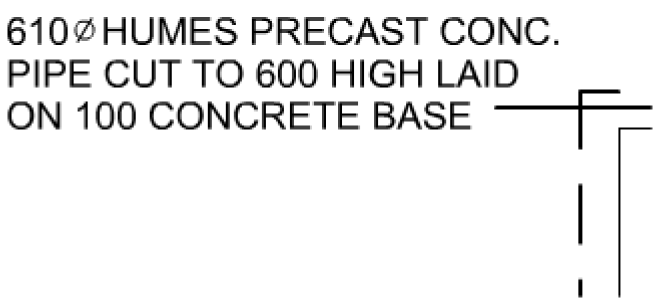
- reduce waste
- save time
- save money.

Units of length

There are two kinds of lengths used in building - metres (m) and millimetres (mm).

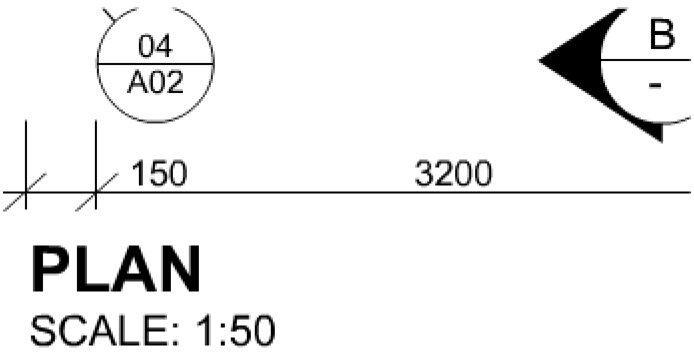


In building and construction, measurements are understood to be in millimetres if the units are not specified. 600 and 100 on this plan mean 600 mm (millimetres) or 100 mm.



Don't use spaces if there are 4 digits or less.

However, if there are 5 digits (eg 13 000), leave a space before the last three digits to make it easier to read.



Unit relationship

1 kilometre = 1000 metres
1 metre = 100 centimetres or 1000 millimetres
1 centimetre = 10 millimetres

To convert metres into millimetres, multiply the metres by 1000.

Example
1.4 metres equals how many millimetres?
1.4 x 1000 = 1400 millimetres.

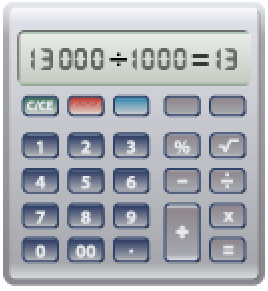
To convert millimetres into metres, divide the millimetres by 1000.

Example
800 millimetres equals how many metres?
800 ÷ 1000 = 0.8 metres.

Changing millimetres to metres

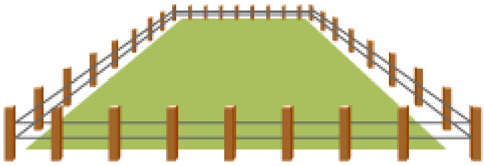
To change millimetres into metres, divide by 1000.

Example
13 000 mm ÷ 1000 = 13 m



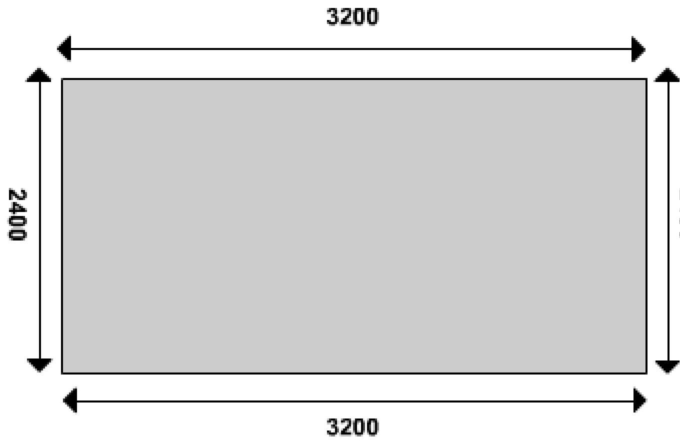
Perimeter - the distance around a shape
Perimeter is the distance around the outside boundary. It is the total length of all the sides.

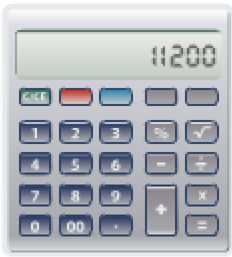
The perimeter of a paddock will tell you the length of fencing you need to go around it.



To find the perimeter of anything which has straight sides, add up the lengths of the sides.

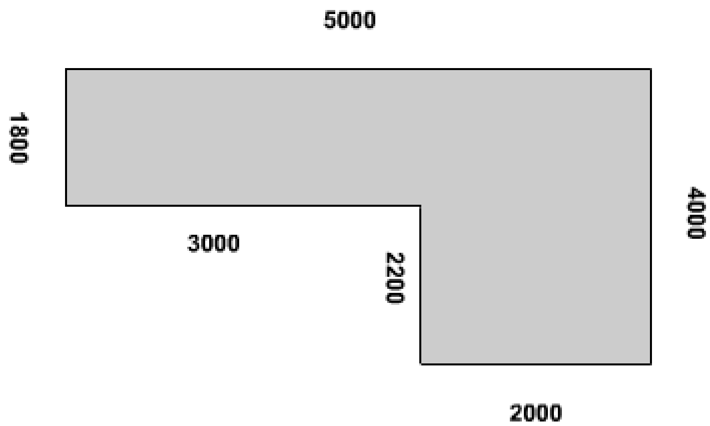
Example 1

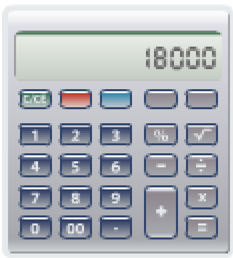




Perimeter = 2400 + 3200 + 2400 + 3200 = 11200

Example 2



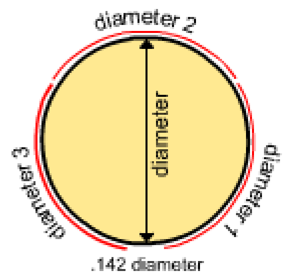


Perimeter = 5000 + 4000 + 2000 + 2200 + 3000 + 1800 = 18 000 mm

Perimeter of a circle

The perimeter of a circle is also called the **circumference**. The **diameter** of a circle is a straight line passing from one side of the circle to the other, through the centre.

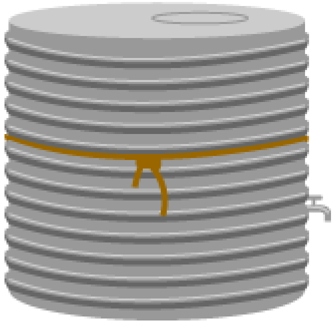
The perimeter of the circle is just over three times the diameter.



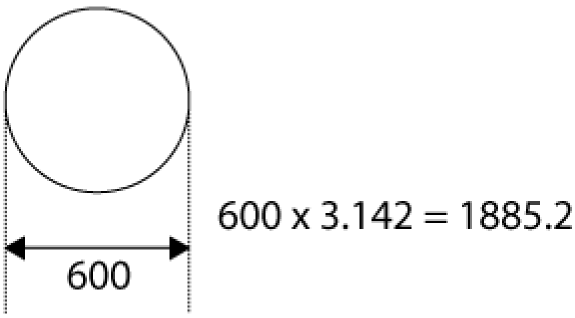
The perimeter of a circle is worked out by multiplying the diameter by 3.142.It actually fits about 3.142 times. This number is given the name 'pi' (3.142).

Example

How long would a piece of rope need to be to fit around the outside of a water tank?



The distance around the outside of water tank is calculated by multiplying the diameter of the tank by 'pi' (3.142).



Measuring right angles

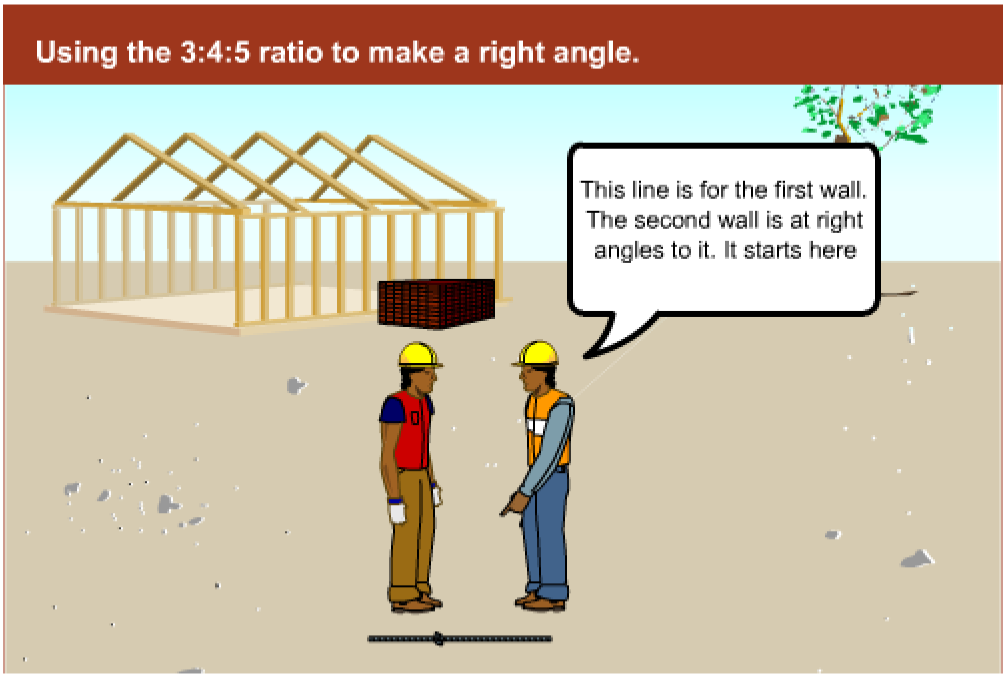
Square method
A quick way to check whether an angle is a right angle is to place a square around or inside the angle.
3:4:5 method
Another way is to use the 3:4:5 method. To work out whether an angle is a right angle, measure along one side to 300 mm, measure along the other side to 400 mm and check the diagonal between the two points to make sure it is 500 mm. If it is, then the angle will be a right angle.

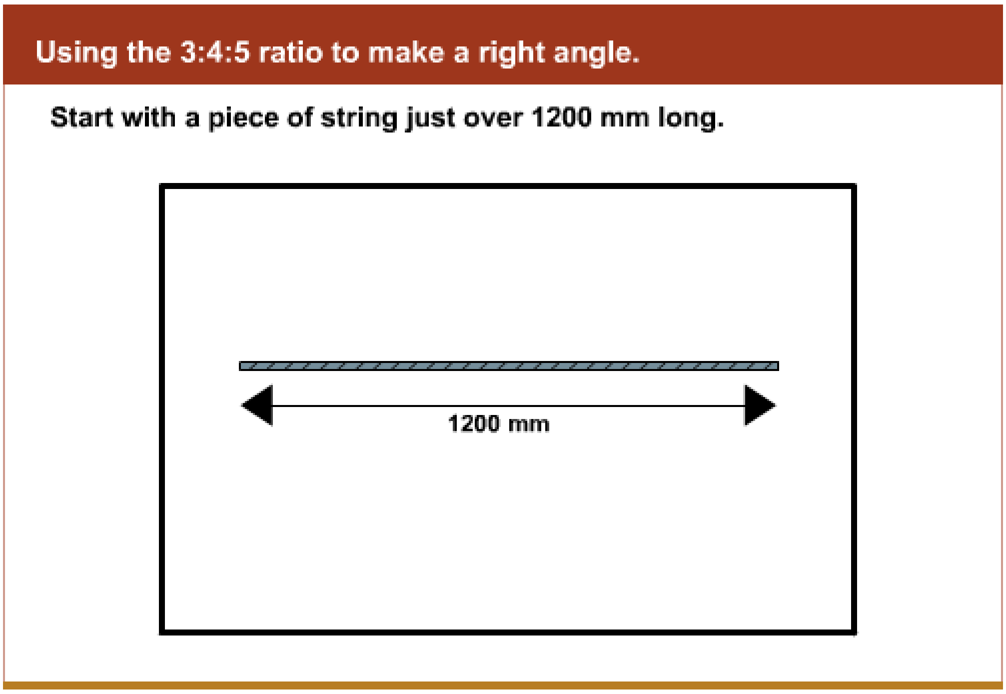
Fractions or multiples of 3:4:5 method

If your shape is smaller, use fractions of 3, 4 and 5 such as half of each measurement, (150 mm: 200 mm: 250 mm). This should work as long as you use the same fraction for all three measurements (eg divide them all by 2 to find half, or divide them all by 3 to find a third).

String method

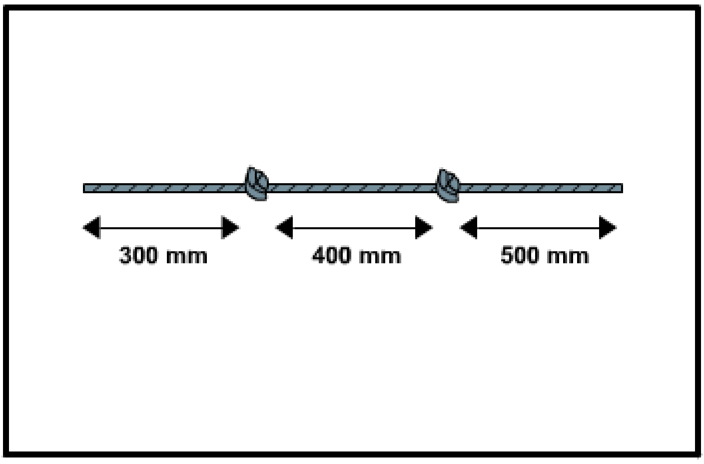
Another way is to use a piece of string marked at 300, 400 and 500 (or at 1.5 m, 2 m and 2.5 m if that is more useful for your job) and lay this along the sides of your angle.





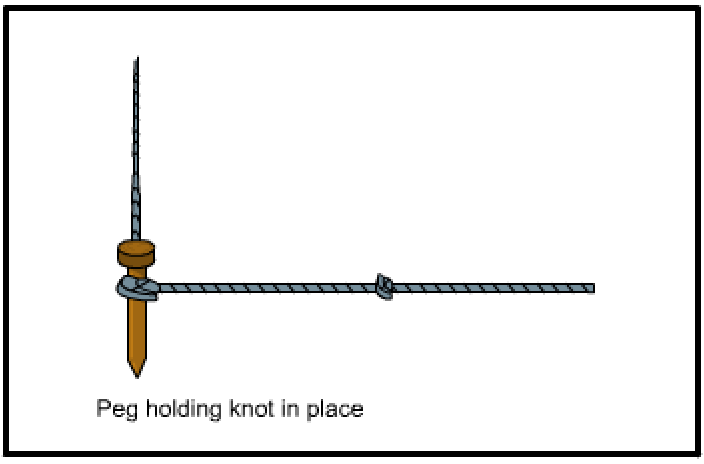
Using the 3:4:5 ratio to make a right angle.

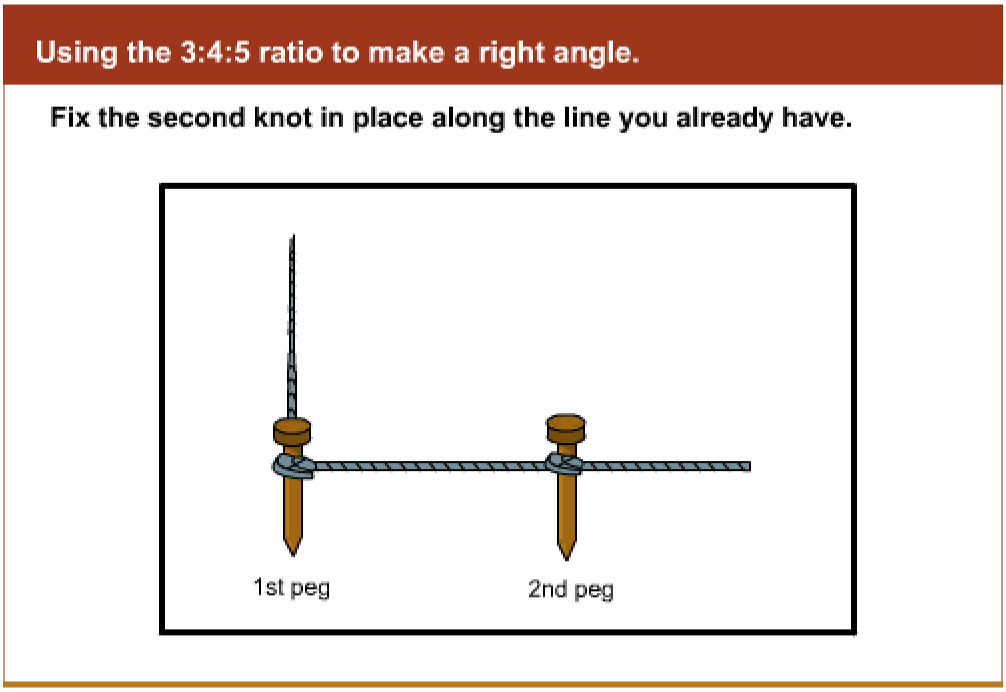
Tie knots at the distances shown.

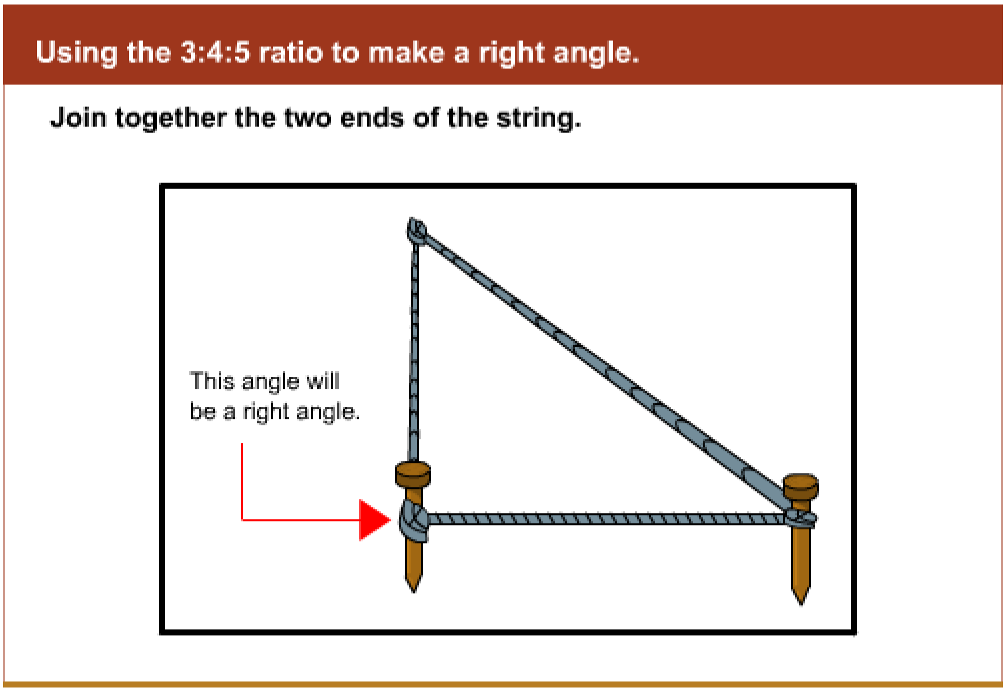


Using the 3:4:5 ratio to make a right angle.

Fix the first knot at the point on our line where you want the right angle.



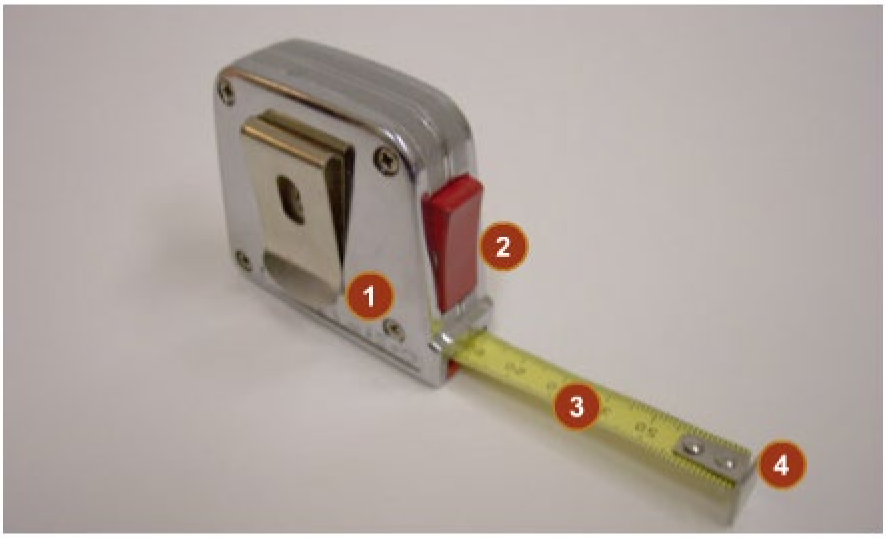




Using a tape measure

The standard tape measure with a retractable steel tape is a useful tool for builders.

Parts of a tape measure
Knowing the parts of a tape measure can help you to take accurate measurements.



1. Casing

Look carefully at the outside casing of the tape measure. You should see that the width of the casing box is marked there. The tape measure shown is marked as '83 mm'.

You should add the width of the casing when taking 'internal measurements', where the tape measure is placed inside the distance you are measuring.

2. Lock

Retractable tape measures are spring-loaded. You use the lock to stop the tape from retracting in the middle of a measurement.

3. Tape

Tapes of 2 - 8 m are commonly used by builders. Longer tapes of 20 - 30 m are used when measuring building sites.

Most tape measures are marked in millimetres. Some may show the main values in centimetres. Readings in centimetres need to be multiplied by 10 to convert the measurements to millimetres.

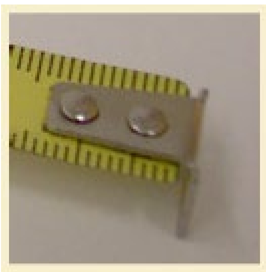
The tape in this picture is marked in millimetres, but only every 10 mm are numbered. Each small line marks 1 mm so these have to be added to your measurement.

Longer tapes of 20 - 30 m are used when measuring building sites.

Most tape measures are marked in millimetres. Some may show the main values in centimetres. Readings in centimetres need to be multiplied by 10 to convert the measurements to millimetres.

The tape in this picture is marked in millimetres, but only every 10 mm are numbered. Each small line marks 1 mm so these have to be added to your measurement.

4. Tab



The steel tab on the end of a tape measure can be hooked over the edge of a frame or object. This allows you to pull the tape along the length you are measuring.

The tab is usually joined to the tape by two or three rivets that allow it to slide back and forth a short distance. This means that you can take highly accurate internal and external measurements without the width of the tab itself giving you an incorrect reading.

With internal measurements, the width of the tab is included when the tab is butted up to one end of the object you are measuring.

With external measurements, the tab sits over the edge of the object you are measuring and is not included.

Taking measurements
These tips will help you to take different sorts of measurements with a tape measure.

Internal measurements

When taking internal measurements, you must add the width of the tape box to the measurement. This will be marked on the casing.

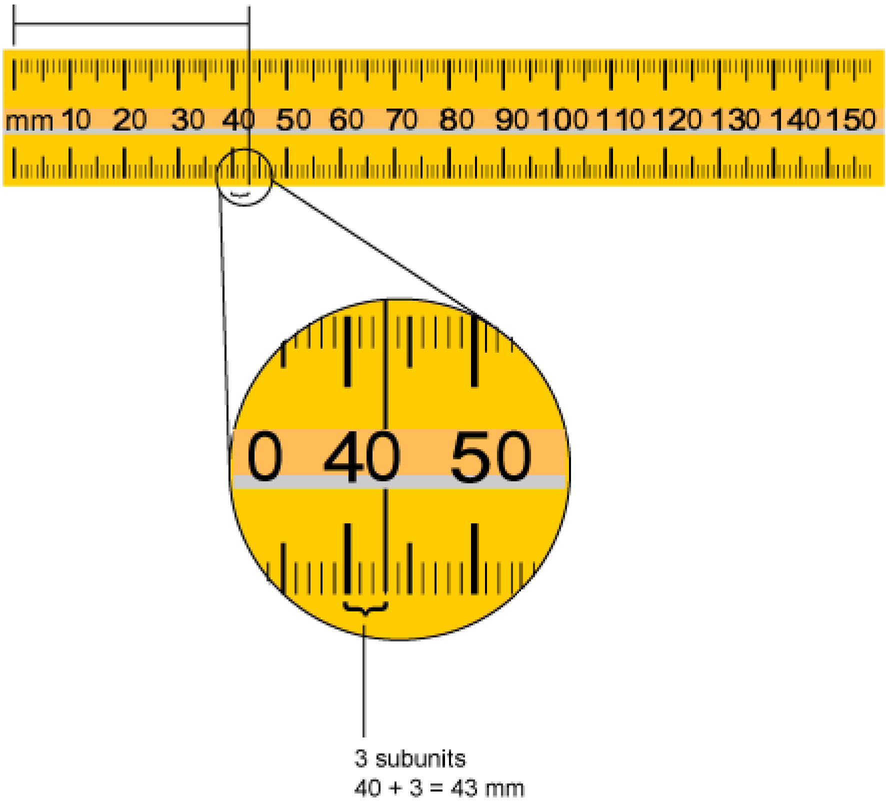
External measurements

Anchor the tab at one end. Make sure the tape is kept flat and straight. Run it along the length of the object being measured. Read the value of the tape measure at the edge of the casing.

Long measurements

When measuring long distances, anchor the tape securely. Otherwise it might retract. You may need to get a workmate to help you.

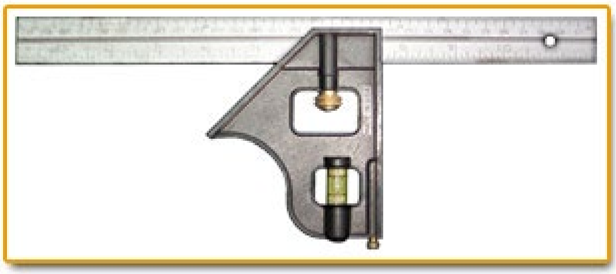
Reading a measurement
Read the number of units on the largest mark to the left of the point you are measuring, then add on any sub-units.



Using squares

There are several types of squaring tools available and each has a specific use. Your trainer may be able to show you the most common types.

Types of squares



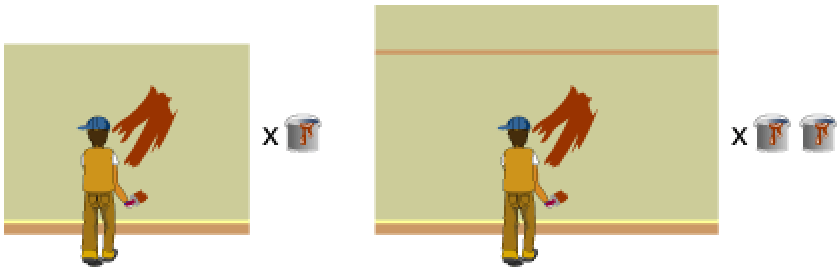
A combination square has a sliding blade that can be locked into any position. It also has a bubble in it which can be used as a rough guide for checking level.

A roofing square is an L-shaped solid piece of metal with markings on it similar to a ruler.

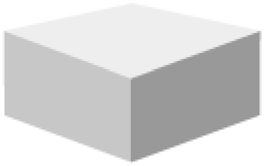
Calculating area

Area is a measure of the amount of space covered on a flat surface.

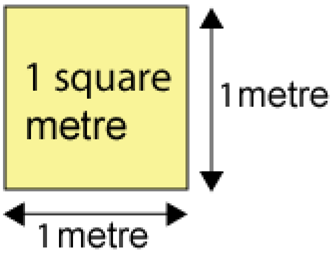
When you are painting, the amount of paint you need depends on the area of the surface to be painted.



To work out the amount of concrete you need for a job, you first need to work out the area to be covered. This will then be multiplied by the depth of the concrete to work out the volume of concrete needed.



Units of area
Area in building jobs is measured in square metres (m2).



The total area of a building may be 53 square metres.

Larger areas are measured in hectares (ha) and square kilometres (km^2).

1 hectare (1 ha) = 10 000 m^2 (about the size of two soccer fields).

Area is the amount of space on the surface of a shape.

Area is measured in units called metres squared (m^2).

This photo shows what one square metre looks like. The chipboard sheet measures **one metre** by **one metre** so it is 1 m^2.

Rectangle

To work out how many square metres of concrete you need for this concrete slab, you need to calculate the area of the rectangle.

Circle

To work out how many bricks you need to pave this area, you need to calculate the area of a circle.

Triangle

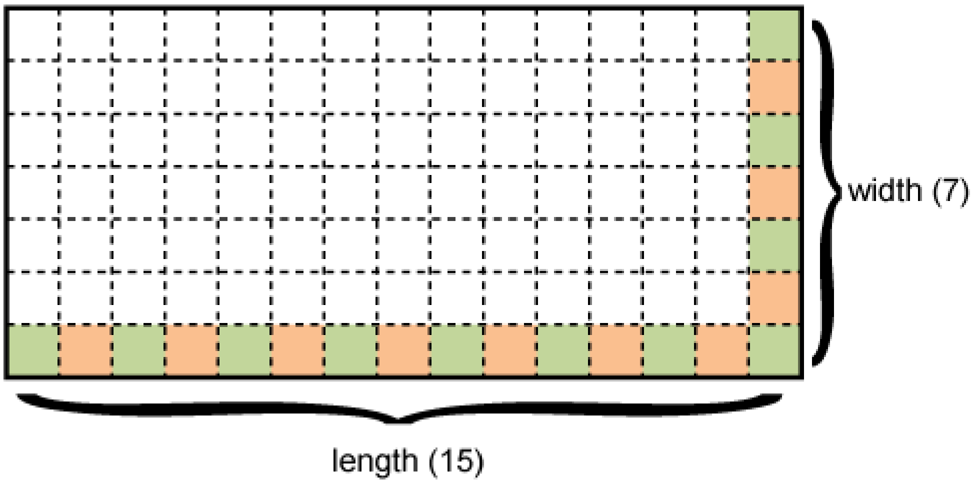
To work out how much material you need for this roof pitch, you need to calculate the area of a triangle.

Combined shape

To work out how many square metres of floor space this new building has, you need to calculate the area of a few shapes and add them together.

Calculating the area of a rectangle

Trying to count the number of squares in this rectangle is difficult. It is much easier to use a **formula** to calculate the area.



The formula is:
Area = **l**ength times **w**idth
A = **l** X **w**

So for this example:
A = 15 X 7
A = 105 squares

There are 105 squares. But how big is each square? If the measurements of length and width were in metres then the area would be 105 square metres (**105 m²**).

Units for area

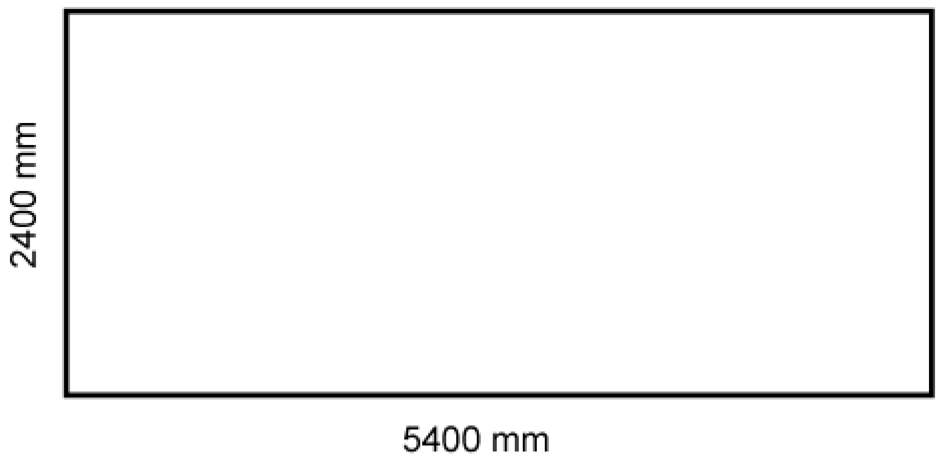
Area can be measured in any of the following units.

Metric units for area.		
Unit	**Symbol**	**Equivalent**
square millimetre	mm^2	0.001 m^2
square centimetre	cm^2	0.01 m^2
square metre	m^2	1 m^2 (= 10,000 cm^2 = 1,000,000 mm^2)
hectare	ha	1 ha (= 10,000 m$^{2)}$
square kilometre	km^2	1 km^2 (= 100 ha = 1,000,000 m^2)

The most common unit of measurement in the building trade is metres squared (m^2). If measurements are in millimetres, they need to be converted to metres before calculating area.

Converting millimetres to metres

If you need to know the area of the rectangle below:



first convert millimetres to metres

length **5400 mm** = **5.4 m**.

width **2400 mm** = **2.4 m**.

then apply the formula to calulate area, A = l X w

A = 5.4 X 2.4

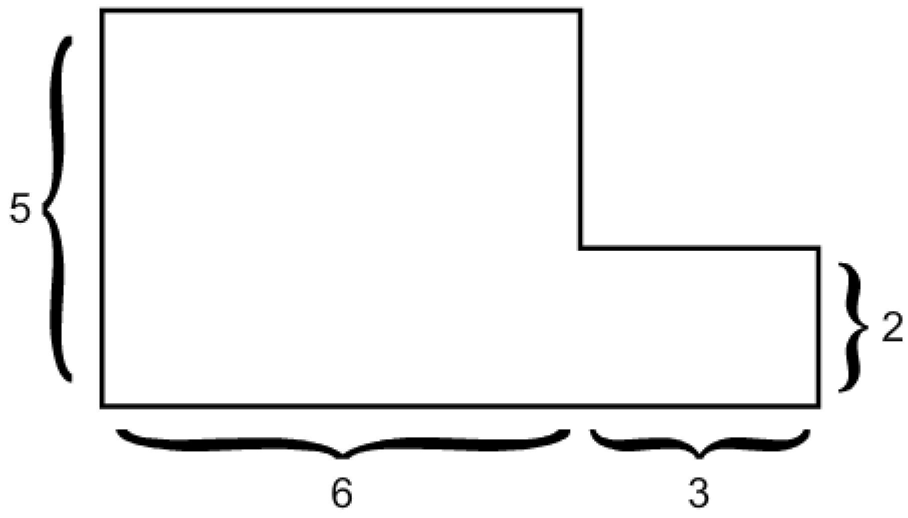
A = 12.96 m^2

In square millimetres this is: **12,960,000 mm^2**

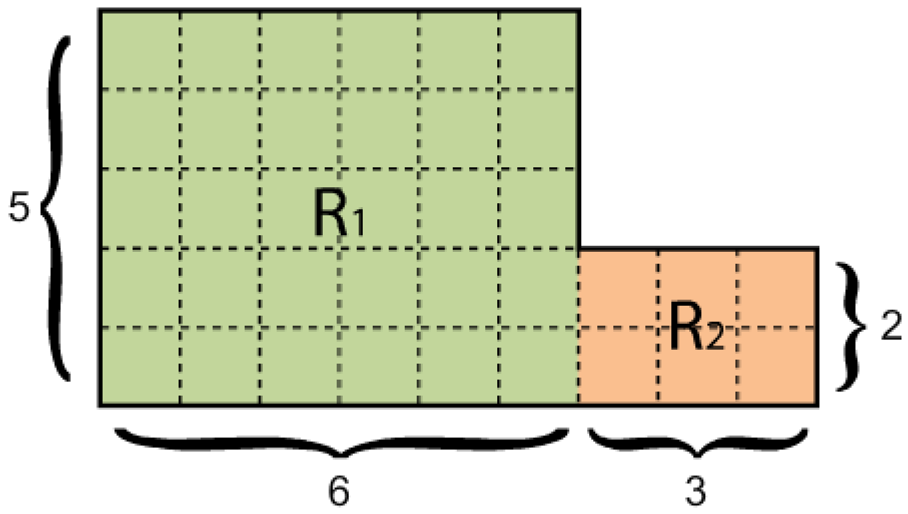
You can see, it's much easier to work in metres!

Shapes made of combined rectangles/squares

To calculate the area of this shape you can break it into two rectangles as shown in the next image.



This image shows the shape broken into two rectangles, $\mathbf{R_1}$ and $\mathbf{R_2}$. Calculate the area for each then add them together to get the total area.



Steps required to find the total area:

Three steps required to calculate area.

Step 1	Step 2	Step 3

Area of $\mathbf{R_1}$
A = l X w
A = 6 X 5
A = 30 units

Area of $\mathbf{R_2}$
A = l X w
A = 3 X 2
A = 6 units

Total area ($\mathbf{A_t}$)
A_t = A $\mathbf{R_1}$+ A $\mathbf{R_2}$
A_t = 30 + 6
A_t = 36 units

How this area is calculated:

Area **t**otal = Area of $\mathbf{R_1}$ plus Area of $\mathbf{R_2}$
A_t = A $\mathbf{R_1}$ + A $\mathbf{R_2}$
A_t = (**l** X **w**) + (**l** X **w**)
A_t = (6 X 5) + (3 X 2)
A_t = 30 + 6
A_t = 36 units

Triangles

To find out how many weatherboards are needed to cover the gable end in this photo you need to know how to calculate the area of triangles.

This section provides information and activities on calculating the area of triangles.

Area of a triangle

The area of a triangle is **half** the area of a rectangle that the triangle fits into, as shown in this diagram.

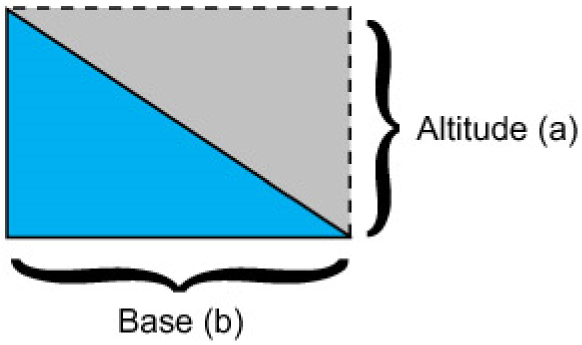
The **base** can be any one of the three sides. The **altitude** is the distance (at 90°) from the base to the top point of the triangle.

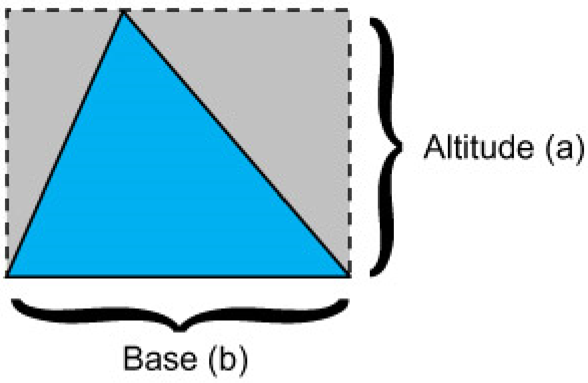
The formula is:

Area = half of **a**ltitude times **b**ase
A = 0.5 X **a** X **b**

base times **a**ltitude finds the area of a square that the triangle would fit into. It's the same as **l**ength times **w**idth for a rectangle.

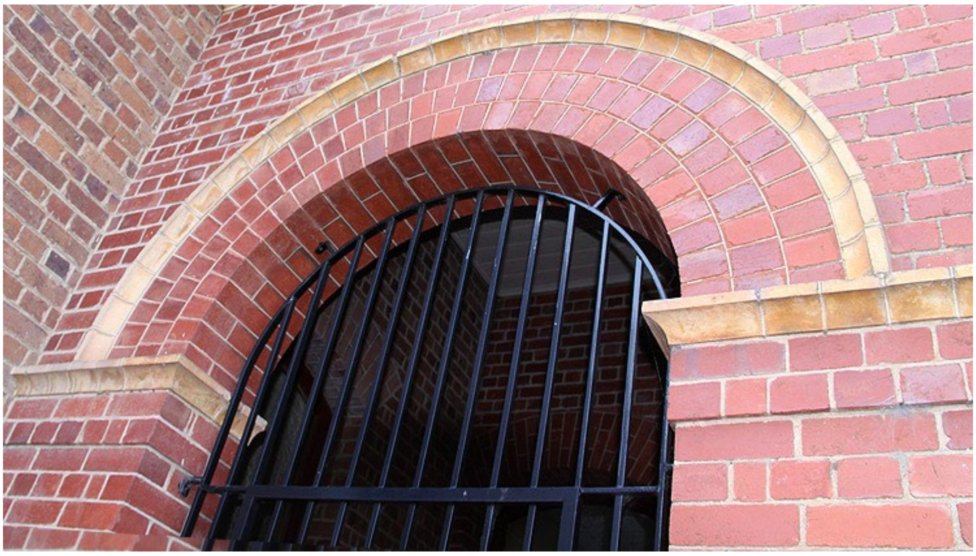
Multiplying the answer by 0.5 calculates half that area.



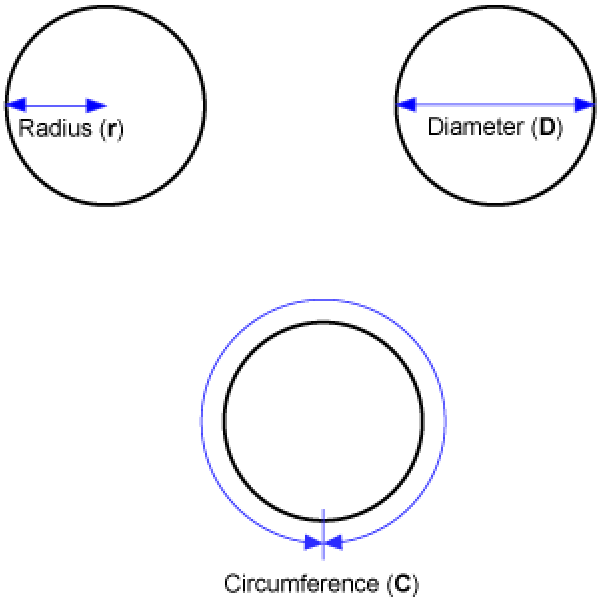


Circles

Sometimes in the building trade you may need to calculate the area of a circle or part of a circle. For example you might have to calculate the number of tiles to go onto the floor of a circular room or the amount of material to go above a doorway with an arch at the top.



Before you can do calculations with a circle you need to know the correct terms for the parts of a circle.



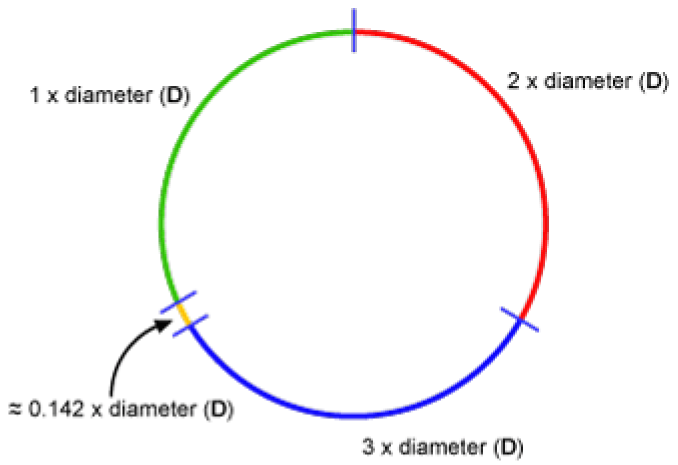
Parts of a circle

The following names are used when measuring circles.

The **radius** (r) is the distance from the centre to the edge.

The **diameter** (D) is the distance from one edge of the circle, through the centre, to the other side.

The **circumference** (C) is the distance around the circle.



Relationship of parts of a circle

The **radius** is half of the diameter (r = D ÷ 2).

The **diameter** is two times the radius (D = r X 2).

The **circumference** is approximately 3.142 times the diameter (C = 3.142 X D).

Pi (π)

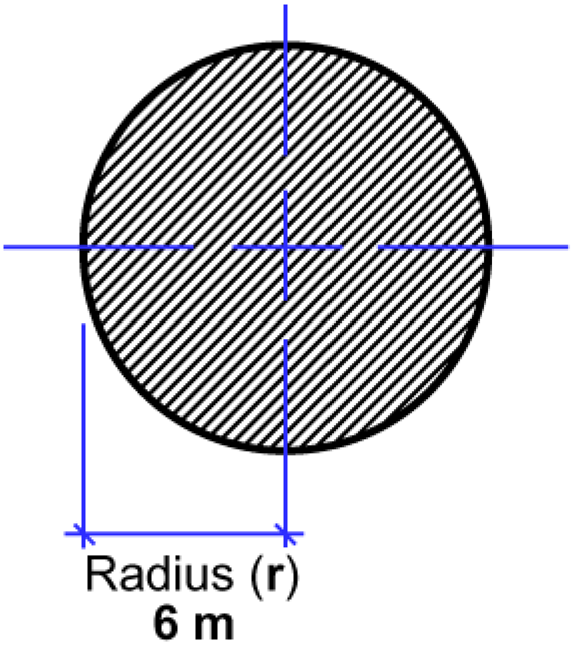
Pi (the symbol is the Greek letter **π**) is the ratio of the circumference divided by the diameter which is approximately **3.142**.

So **pi** (**π**) is **approximately** equal to **3.142**

Pi is **not exactly** 3.142, it is a number with decimal places that keep on going. Below pi is shown to 31 decimal places.

3.14159265358979323846264338327950….

For most calculations three decimal places is accurate enough. Rounded to three decimal places pi is 3.142.



Area of a circle

The formula to calculate the area of a circle is:

Area = pi times radius squared
A = **π** X **r²**
A = **π** X **r** X **r**
A = **3.142** X **6** X **6**
A = **113.112 m2**

Note: Calculations done with pi will often return very long decimal numbers; the answer would usually be rounded to one, two or three decimal places.

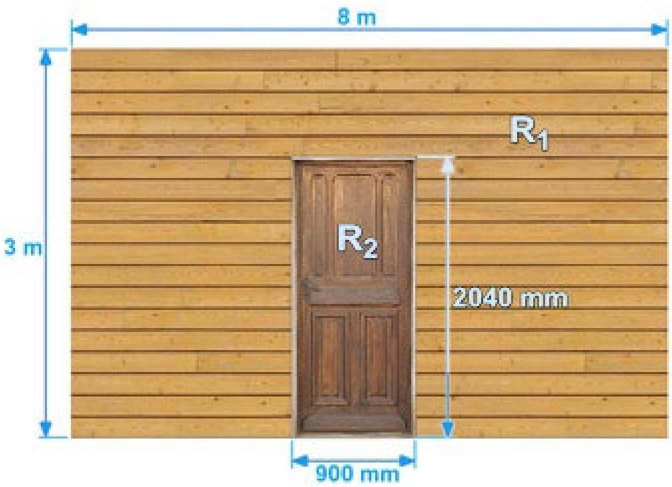
Combined shapes

A lot of the shapes that you work with in building are a combination of shapes – not just one triangle or rectangle or circle etc. Houses could have triangular and/or circular sections, as well as rectangular sections, like doors and walls.

How much paint would you need to paint a house? You don't need to paint the windows or other openings so you need to calculate the area of the openings and subtract that from the total area of the walls.

This section shows how to work out areas for walls that have openings and odd shapes.

Area of a wall with a door



Method to use:

- Convert all measurements to metres.
- Find the area of the two rectangles, $\mathbf{R_1}$ (the wall) and $\mathbf{R_2}$ (the door).
- **Subtract** the area of the door from the area of the wall.

Example:

Area **T**o be painted= Area of $\mathbf{R_1}$minus Area of $\mathbf{R_2}$

$A_t = A\,\mathbf{R_1} - A\,\mathbf{R_2}$

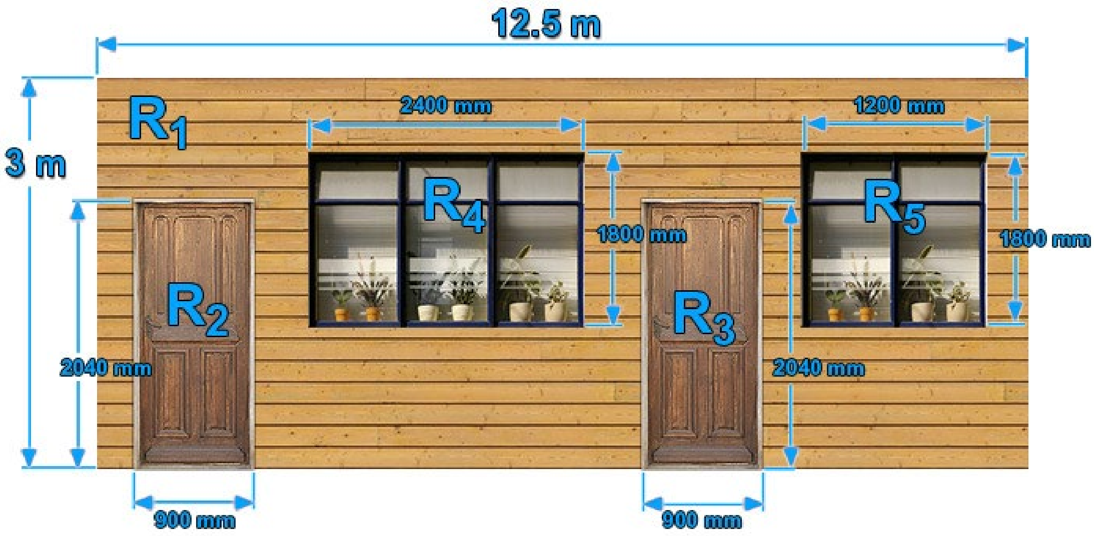
$A_t = (\mathbf{l} \times \mathbf{w}) - (\mathbf{l} \times \mathbf{w})$

$A_t = (8 \times 3) - (0.9 \times 2.04)$

$A_t = 24 - 1.836$

$A_t = 22.164\ m^2$

Area of a wall with doors and windows



Method to use:

- Convert all measurements to metres.
- Break the area into a number of rectangles (wall, doors and windows).
- Find the area of each, $\mathbf{R_1}$(the wall), $\mathbf{R_2}$ and $\mathbf{R_3}$ (the doors), and $\mathbf{R_4}$ and $\mathbf{R_5}$ (the windows).
- **Subtract** the area of the doors and windows from the area of the wall.

Example:

Area **T**o be painted = Area of wall ($\mathbf{R_1}$) minus area of all windows and doors ($\mathbf{R_2} + \mathbf{R_3} + \mathbf{R_4} + \mathbf{R_5}$)

$A_t = A\,\mathbf{R_1} - (A\,\mathbf{R_2} + \mathbf{R_3} + \mathbf{R_4} + \mathbf{R_5})$

$A_t = (\mathbf{l} \times \mathbf{w}) - ((\mathbf{l} \times \mathbf{w}) + (\mathbf{l} \times \mathbf{w}) + (\mathbf{l} \times \mathbf{w}) + (\mathbf{l} \times \mathbf{w}))$

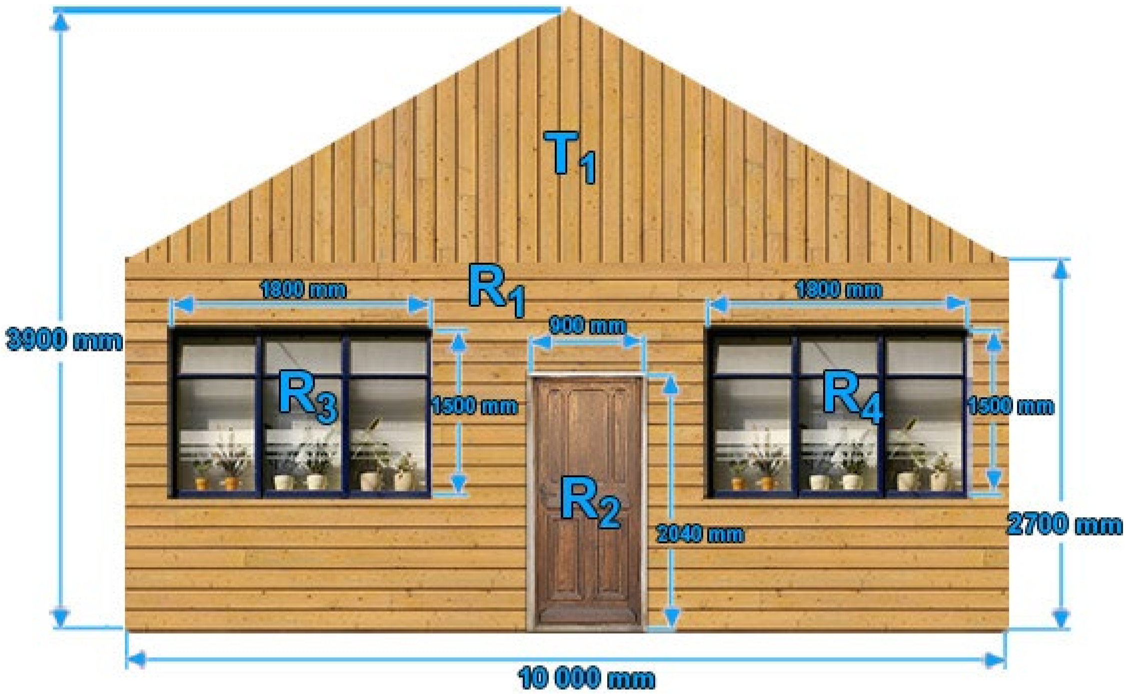
A_t = (12.5 X 3) – ((0.9 X 2.04) + (0.9 X 2.04) + (2.4 X 1.8) + (1.2 X 1.8))

A_t = 37.5 – (1.836 + 4.32 + 1.836 +2.16)

A_t = 37.5 – 10.152

A_t = 27.348 m^2

Area of a wall with door, windows and gable.



Method to use:

- Convert all measurements to metres.
- Break it into a number of shapes (triangle and rectangles).
- Find the area of each, $\mathbf{T_1}$ (the gable), $\mathbf{R_1}$ (the wall), $\mathbf{R_2}$ (the door) and $\mathbf{R_3}$ and $\mathbf{R_4}$ (the windows).
- Add the area of $\mathbf{R_1}$ the wall and $\mathbf{T_1}$ the triangle for the overall wall area.
- **Subtract** the area of the doors and windows from the area of the wall to get the total area.

Example:

Area **T**otal = Area of wall ($\mathbf{T_1}$ + $\mathbf{R_1}$) minus area of all windows and doors ($\mathbf{R_2}$ + $\mathbf{R_3}$ + $\mathbf{R_4}$)

A_t = A ($\mathbf{T_1}$ + $\mathbf{R_1}$) – (A $\mathbf{R_2}$ + $\mathbf{R_3}$ + $\mathbf{R_4}$)

A_t = ((**l** X **w**) + (0.5 X **a** X **b**) – ((**l** X **w**) + (**l** X **w**) + (**l** X **w**))

(The altitude (**a**) for the triangle is 3.9 minus 2.7 = 1.2.)

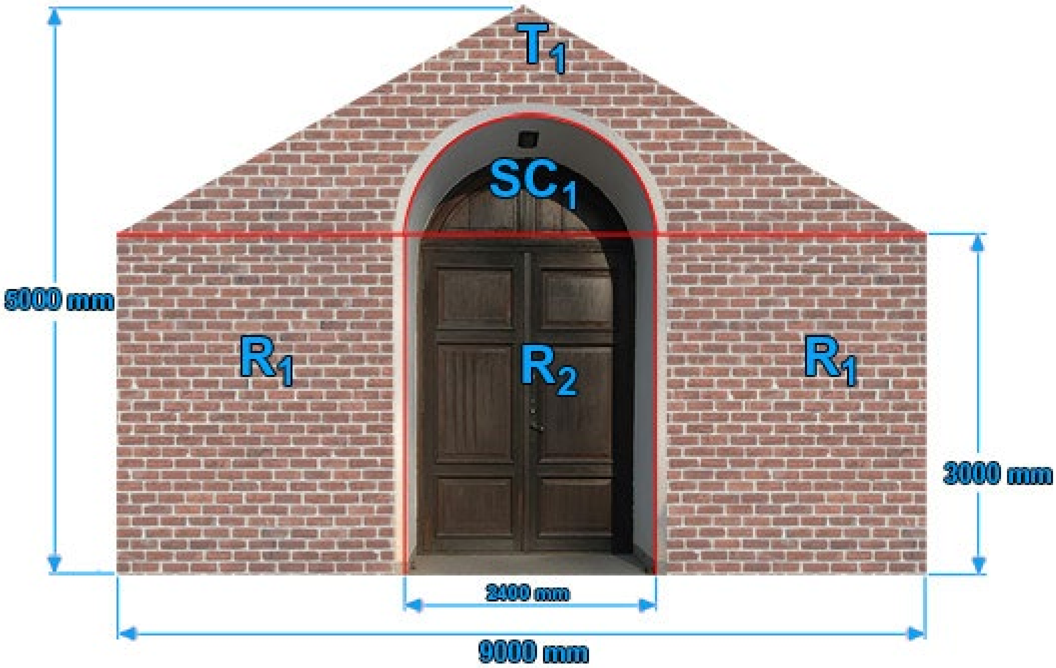
A_t = ((10 X 2.7) + (0.5 X 1.2 X 10)) – ((0.9 X 2.04) + (1.5 X 1.8) + (1.5 X 1.8))

A_t = (27 + 6) – (1.836 + 2.7 + 2.7)

A_t = 33 – 7.236

A_t = 25.764 m^2

Area of wall with opening including an arch (semi-circle).



Method to use:

- Convert all measurements to metres.
- Break it into a number of shapes (triangle, rectangles and semi-circle).
- Find the area of each, $\mathbf{T_1}$ (the gable), $\mathbf{R_1}$ (the wall), $\mathbf{R_2}$ (the door) and $\mathbf{SC_1}$ (the arch).
- Add the area of $\mathbf{R_1}$ the wall and $\mathbf{T_1}$ the triangle for the overall wall area.
- **Subtract** the area of the door and arch from the area of the wall to get the total area.

Example:

Area **T**otal = Area of wall ($\mathbf{T_1}$ + $\mathbf{R_1}$) minus area of door and arch ($\mathbf{R_2}$ + $\mathbf{SC_1}$)

A_t = **(**A (**$\mathbf{T_1}$** + **$\mathbf{R_1}$**)**)** – **(**A (**$\mathbf{R_2}$** + **$\mathbf{SC_1}$**)**)**

A_t = **((l** X **w**) + (0.5 X **a** X **b**)**)** – **((l** X **w**) + ((**π** X **$\mathbf{r^2}$**) ÷ 2)**)**

(The altitude (**a**) for the triangle is 5 minus 3 = 2.)
(The diameter for the circle is 2.4, the same as the width of the door opening. The radius is half of the diameter.)

$r = D \times 0.5$

$r = 1.2$

$A_t = \mathbf{(}(9 \times 3) + (0.5 \times 2 \times 9)\mathbf{)} - \mathbf{(}(2.5 \times 3) + ((3.142 \times 1.2 \times 1.2) \div 2)\mathbf{)}$

$A_t = \mathbf{(}27 + 9\mathbf{)} - \mathbf{(}7.5 + 2.26224\mathbf{)}$

$A_t = 36 - 9.76224$

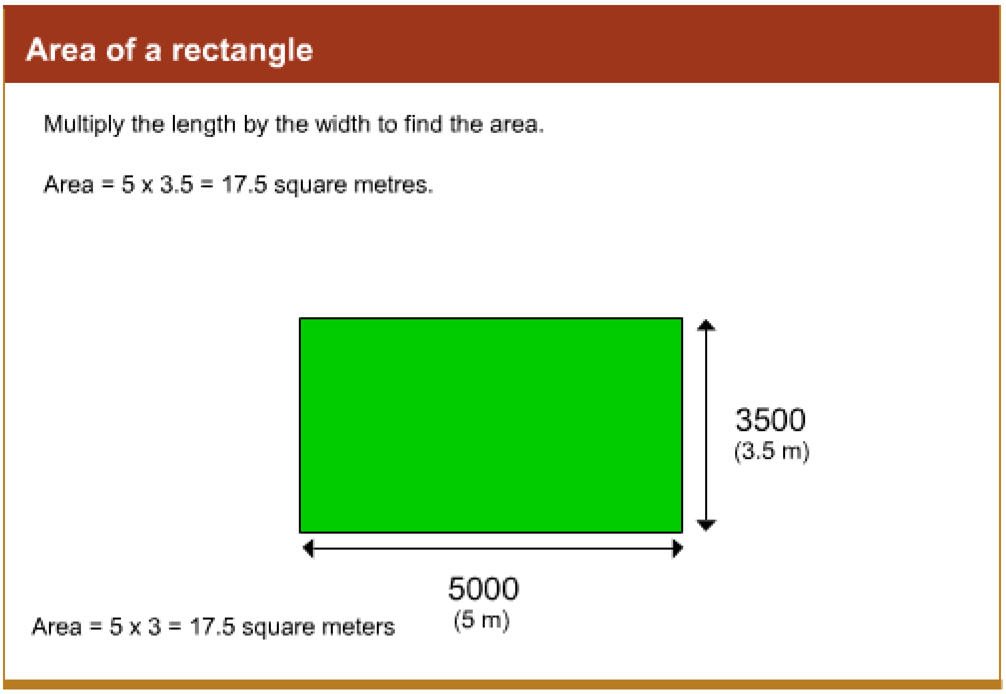
$A_t = 26.23776 \text{ m}^2$

Rounded to three decimal places:

$\mathbf{A_t = 26.238 \text{ m}^2}$

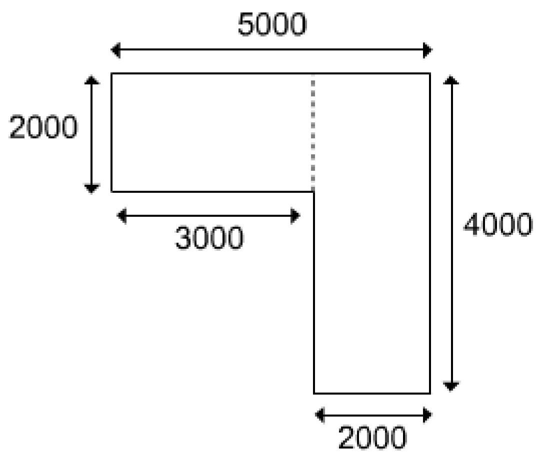
Other Examples
A property may be 90 ha.

Finding areas of shapes



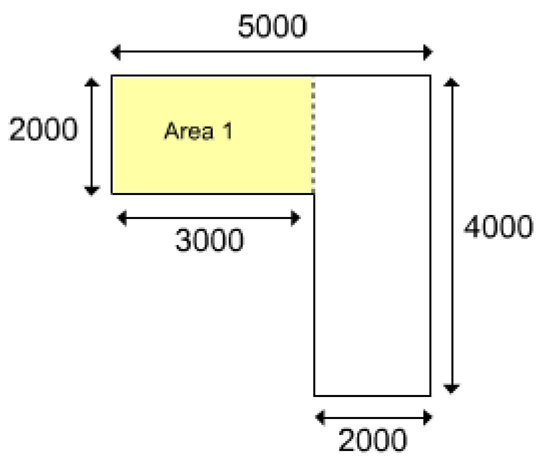
Area of a rectangle

When you have a more complex shape like the one below, you can break it up into two (or more) rectangles.



Area of a rectangle

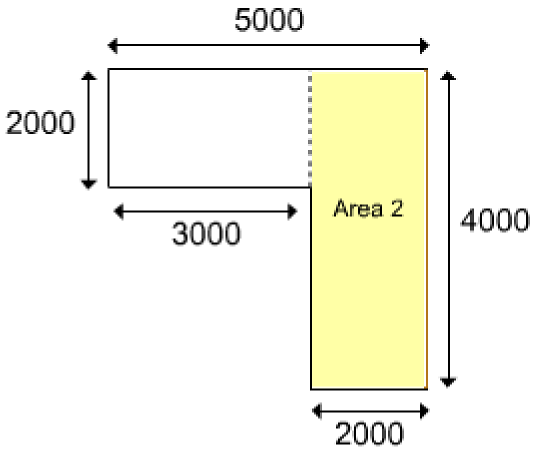
Calculate the area of each rectangle separately.



Area 1 = 2 x 3
= 6 m²

Area of a rectangle

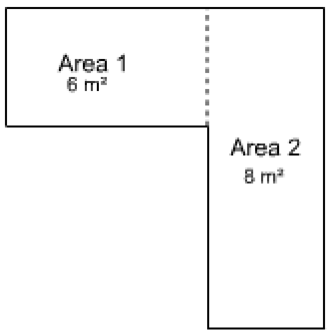
Calculate the area of each rectangle separately.



Area 2 = 2 x 4
= 8 m²

Area of a rectangle

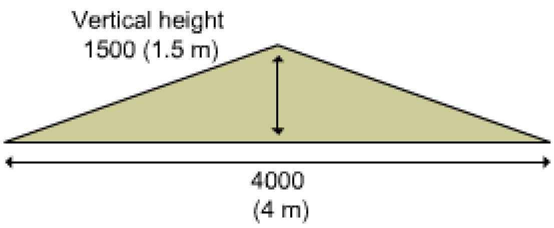
To find the total area, add the two results together.



Total area = 6 m² + 8 m²
= 14 m²

Area of a triangle

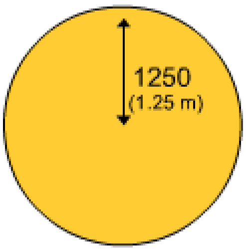
The area of a triangle like this gable end is calculated by multiplying the vertical height by the base and dividing the result by 2.



Area = 1.5 x 4 ÷ 2 = 3 square meters.

Area of a circle

The area of a circle like the base of this water tank is worked out by multiplying pi (3.142) by the radius squared.



The radius is the distance from the centre of the circle to any point on the circumference.
The diameter is a straight line passing from one side of the circle to the other, through the centre.

Area = 3.142 x 1.25 x 1.25 = 4.9 square metres (rounded off to one decimal place).

Calculating volume

Volume is the amount of space taken up by a three-dimensional shape, such as a cube or a cylinder.

Volume is the amount of space an object occupies. A way to visualise volume is to think about how much water would fit inside the object.

Volume is used in the building trade for ordering or specifying things like:

- liquids such as paint or adhesives
- skips for waste removal
- amounts of concrete
- amounts of gravel or sand
- how much soil needs to be excavated from a site.

A tube of construction adhesive.

A rubbish skip.

A pile of brick clay.

A concrete truck.

A concrete slab being laid.

An excavator on a construction site.

Measuring volume

Units for measuring volume

In the building industry volume is measured using:

- cubic metres for solid objects
- litres for liquids.

Cubic metres

The **length**, **width** and **height** of the box shown in the photo are each one metre. The volume of the box is **one cubic metre**.

The volume of solid objects is measured in **cubic metres** (**m**^{3}). The **3** in the symbol indicates three dimensions of **length**, **width** and **height**. In the building trade most volumes are related to solid objects.

Litres

The litre (L) is the unit of measure for volume of liquids.

The following five pictures show different sized containers for liquids as follows:

375 millilitre can of soft drink

2 litre bottle of milk

4 litre can of paint

20 litre jerry can

9,000 litre water tank.

Cubic metre and litre

It would take 1,000 litres of milk to fill one cubic metre:
1,000 L = 1 m³.

One litre is one thousandth of one cubic metre:
1 L = 0.001 m³.

Examples

To work out the amount of concrete you need for a concrete slab, work out the volume of the slab.

To work out the amount of water that a tank can hold, work out the volume of the tank.

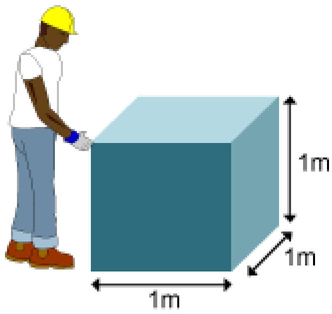
Units of volume

Volume is measured in **cubic** units – cubic millimetres (mm^3), cubic centimetres (cm^3) and cubic metres (m^3).

Volume is related to **capacity**, which is the amount of liquid that a container can hold. Capacity is measured in **litres** (L).

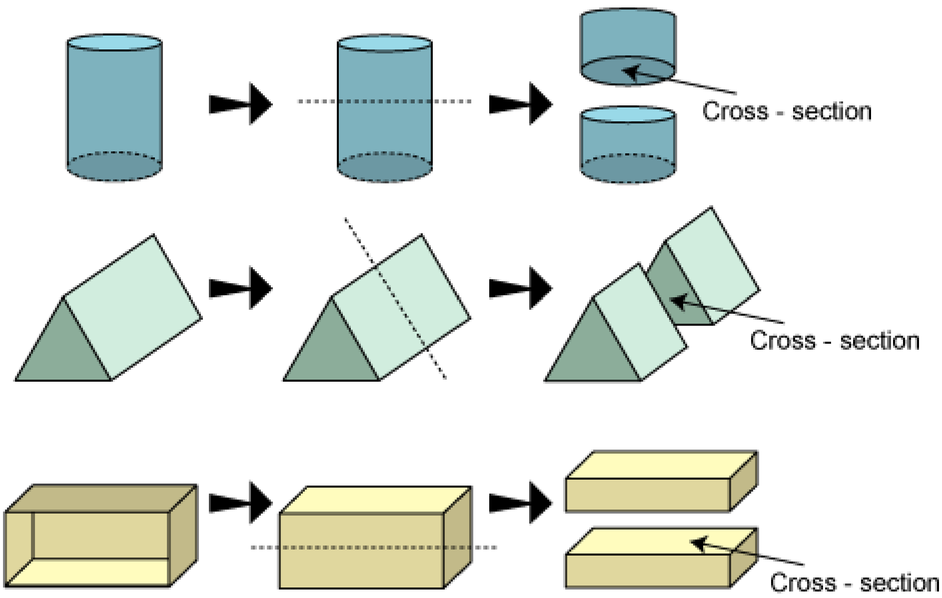
1 m^3 holds 1000 L.

1 cm^3 holds 1 mL.

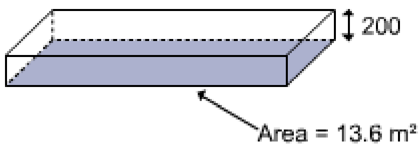


What is a cross-section?

Each of the shapes below has a uniform cross-section. This means that you would get the same shape wherever you cut them.



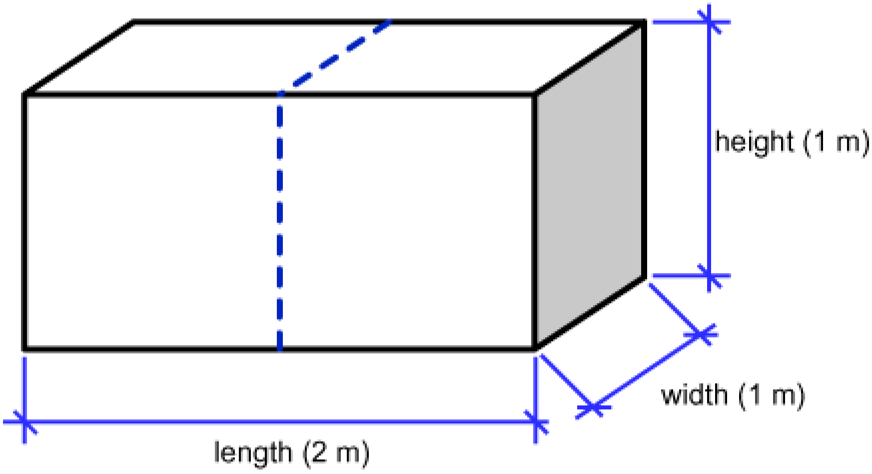
Volume of a rectangular box shape



To find the volume, multiply the area by the depth of the object (200 mm or 0.2 m).
Volume = 13.6 x 0.2 = 2.72 cubic metres.
Pre-mixed concrete is purchased in cubic metres in quantities of 0.2 m^3 . This means you could order 2 m^3, 2.2 m^3, 2.4 m^3, 2.6 m^3, 2.8 m^3, etc. Always round off concrete calculations to the **next** 0.2 m^3 - in this case, 2.8 m^3.

To find out how much concrete is needed to pour the footpath in this photo you need to know how to calculate the volume of a rectangular prism.

Do you know how to calculate the volume of rectangular prisms?



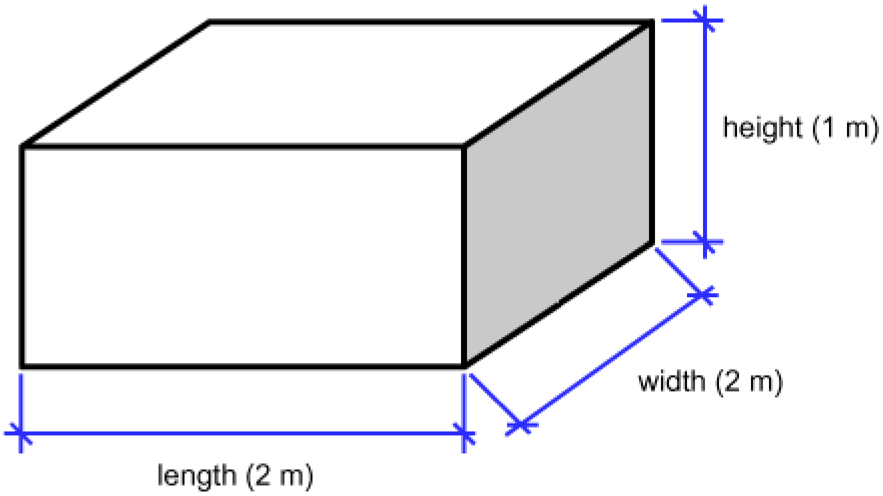
Calculating volume

The formula for calculating **volume** is:
Volume = **A**rea by **h**eight
V = **A** X **h**

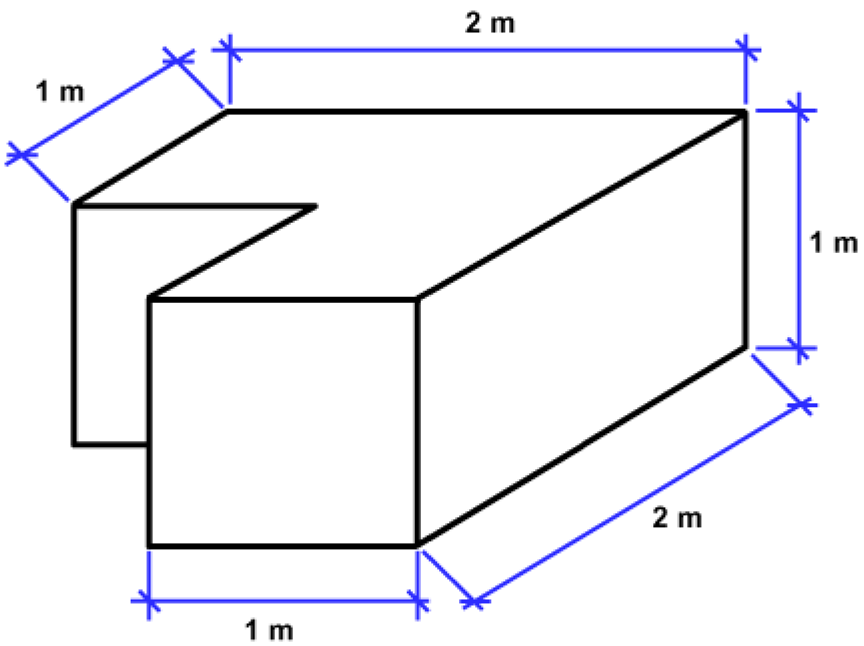
The formula for calculating **area of a rectangle** is:
Area = **l**ength by **w**idth
A = **l** X **w**

So the **volume** of a **rectangular prism** can be calculated using the formula:
Volume = **l**ength by **w**idth by **h**eight
V = **l** X **w** X **h**

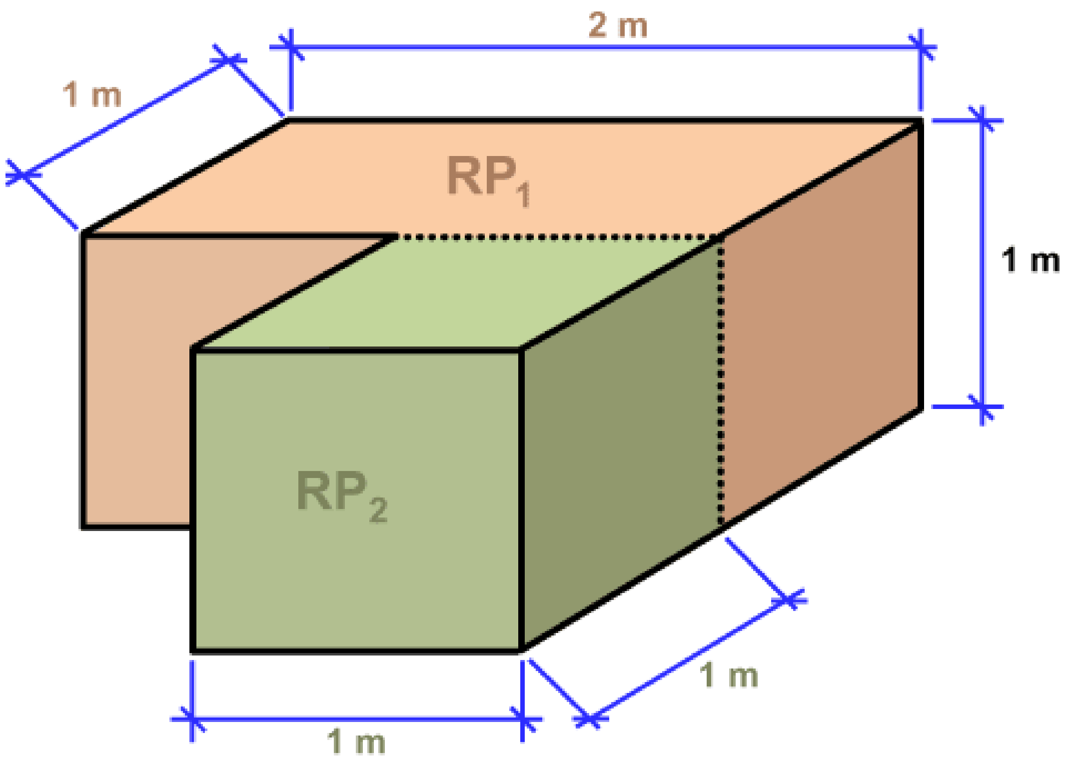
For the rectangular prism in the diagram:
V = 2 m X 1 m X 1 m
V = **2 m^3** (cubic metres)



Shapes made of combined rectangular/square prisms



To calculate the volume of this shape you can break it into two rectangular prisms (**RP_1** and **RP_2**).



Method to use:

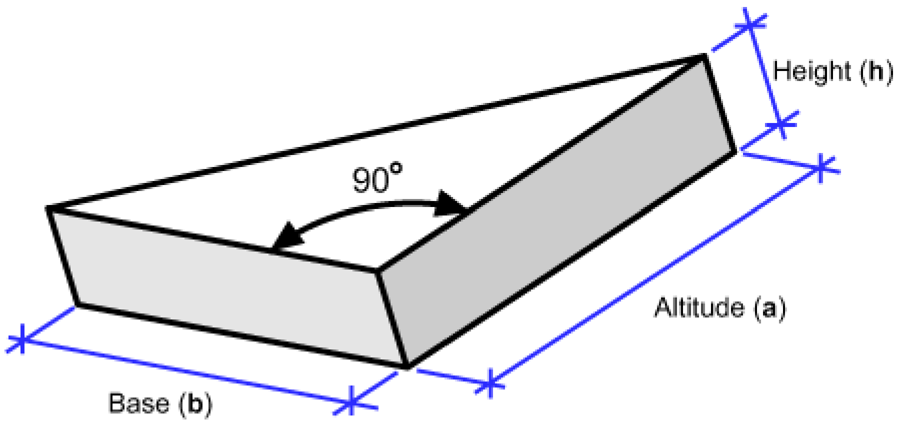
Volume **t**otal = Volume **RP$_1$** plus Volume **RP$_2$**
Vt = V **RP$_1$** + V **RP$_2$**
Vt = (l X w X h) + (l X w X h)
Vt = (2 X 1 X 1) + (1 X 1 X 1)
Vt = 3 + 1
Vt = 3 m^3.

Triangular prisms

There are situations where you will need to calculate the volume of a **triangular prism**. This could include a triangular section on a concrete slab or the excavation of soil from a sloping block.

Do you know how to calculate the volume of triangular prisms?

Calculating volume



Remember the formula for calculating volume is:
Volume = **A**rea by **h**eight
V = **A** X **h**.

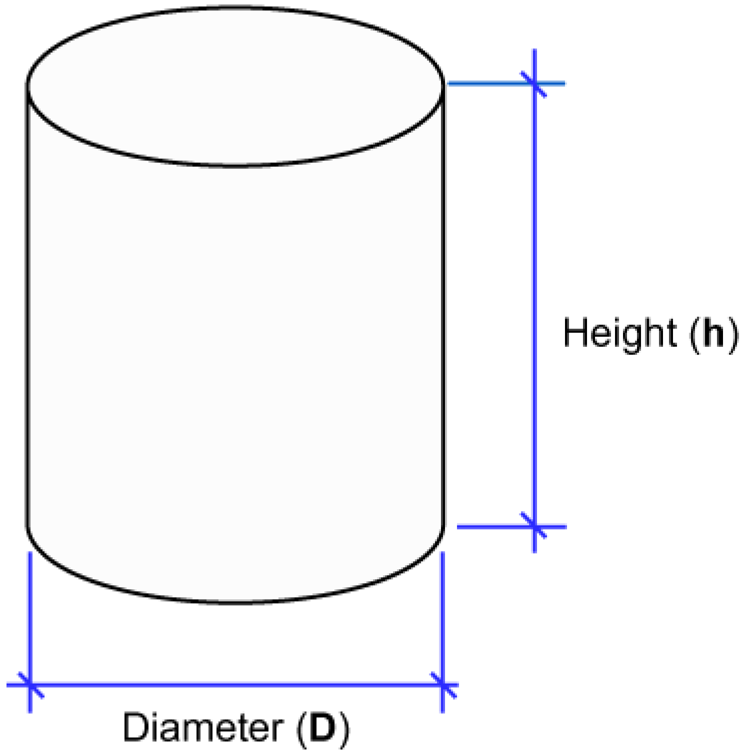
For a triangle the area is calculated using the formula:
Area = half of **b**ase by **a**ltitude
A = **0.5** X **b** X **a**.

So to calculate the **volume** of a **triangular prism,** the formula is:
V = **0.5** X **b** X **a** X **h**.

Cylinders

Sometimes you may need to calculate the volume of a **cylinder**. This could be for circular concrete footings or it could be for the volume of water that will be in a tank.

Do you know how to calculate the volume of cylinder?

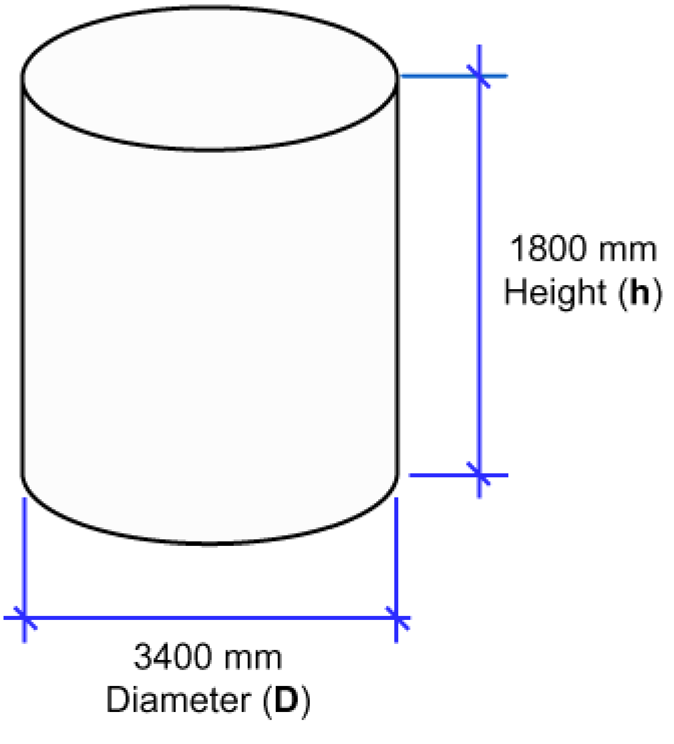


Volume of a cylinder

Remember the formula for calculating volume is:
Volume = **A**rea by **h**eight
V = **A** X **h**.

The area of a circle is calculated using:
Area = **pi** times **r**adius squared
*(The following diagram shows the diameter; halve it to calculate radius: Diameter/2 = **r**adius.)*
A = **π** X **r²**
A = **π** X **r** X **r**.

So to calculate the **volume** of a **cylinder,** the formula is:
V = **π** X **r** X **r** X **h**.



Example cylinder volume calculation

Step 1 – Convert all measurements to metres.
height (**h**) = 1.8 m
diameter (**D**) = 3.3 m.

Step 2 – Calculate the radius.
radius = diameter/2
r = 3.4 / 2
r = **1.7**

Step 3 – Calculate the volume.
V = **π** X **r** X **r** X **h**
V = **3.142** X **1.7** X **1.7** X **1.8**
V = **16.344684 m³**
Answer rounded to thee decimal places:
V = 16.345 m³.

Rounding off

Your calculator will often give you answers to more decimal places than you need. Round off answers to the level of accuracy that you can measure.

- Round off lengths to the nearest mm.

  Example

  Write 1931.33 mm as 1931 mm.

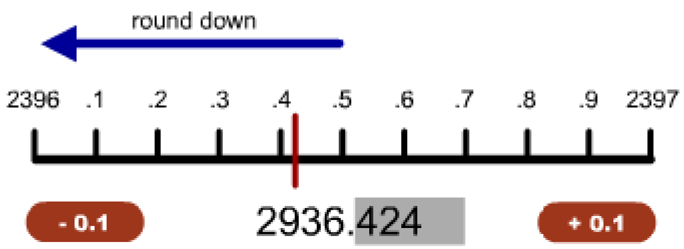
- Round off area to the nearest square metre or to one decimal place.

  Example

  Write 17.427 m^2 as 17 m^2 or 17.4 m^2.

How to round off
When rounding off:

- if the extra digits being dropped start with 0, 1, 2, 3 or 4, just remove them
- if the extra digits being dropped start with 5, 6, 7, 8 or 9, remove them and increase the last digit in the number by 1.



Decimal calculations often have answers with a lot of decimal places, like these:

7196.807556
3.14159265358979323846264338327 95
14.87999

Rounding is reducing the number of digits. In most cases one, two or three decimal place is accurate enough.

How to round

- Decide which is the last digit to keep (how many decimal places).
- Don't change the last digit if the next digit is less than five.
- Increase the last digit by one if the next digit is five or more.

Example 1

4528.85499 rounded to 2 decimal places is **4528.85**

Example 2

103.807556 rounded to 3 decimal places is **103.808**

Rounding examples

The table below shows three numbers rounded.

7196.807556
3.14159265358979323846264338327 95
14.87999

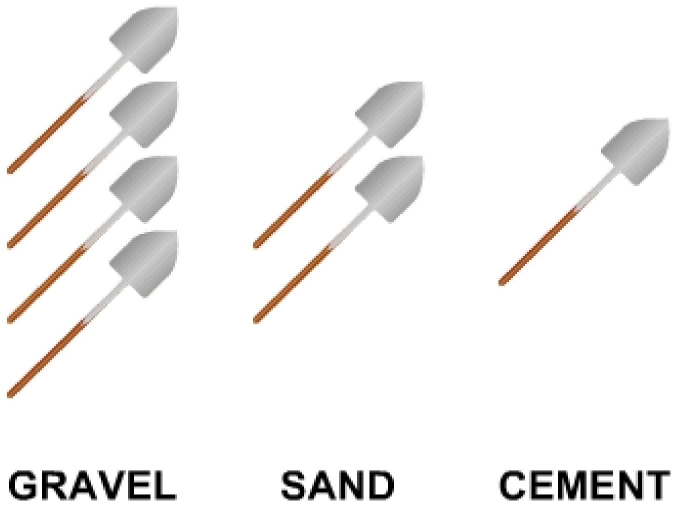
Rounding examples			
three decimal places	**two decimal places**	**one decimal place**	**no decimal places**
7196.808	7196.81	7196.8	7197
3.142	3.14	3.1	3
14.880	14.88	14.9	15

Using ratios

Ratios tell you how much of each ingredient to put into a mixture to make any quantity.

Example

Mix 4 parts gravel, 2 parts sand and 1 part cement to make concrete.



If you use twice as much gravel, use twice as much sand and cement as well.

Quality assurance

The company you work for will have standards for the levels of accuracy required when measurements are made. You will need to find out the company's quality assurance requirements for construction operations so that you can apply them when taking measurements.

Quality assurance requirements in the area of door installation, for instance, might be as follows.

A properly hung door will have 3 mm of clearance between the sides of the door and the doorframe, and 2 mm clearance at the top of the door. If the door is to be fitted with a draught excluder or weather strip at the bottom of the door, you also need to make clearances according to the manufacturer’s instructions.

Before you hang a door, make sure you sand down any sharp edges (called 'arris') left after using saws to resize the door.

Percentages

What are percentages?

Percentages are another way of referring to parts of things. So a percentage is a fraction.

A percentage is written as a number followed by the percentage sign "%", for example 10%.

Percentages are commonly used to indicate part of total amounts of money for things like:

- increases
- discounts

- taxes
- profit/loss.

Percentages are also used to specify parts of areas and quantities, for example:

- 30% of the floor area
- 10% of materials.

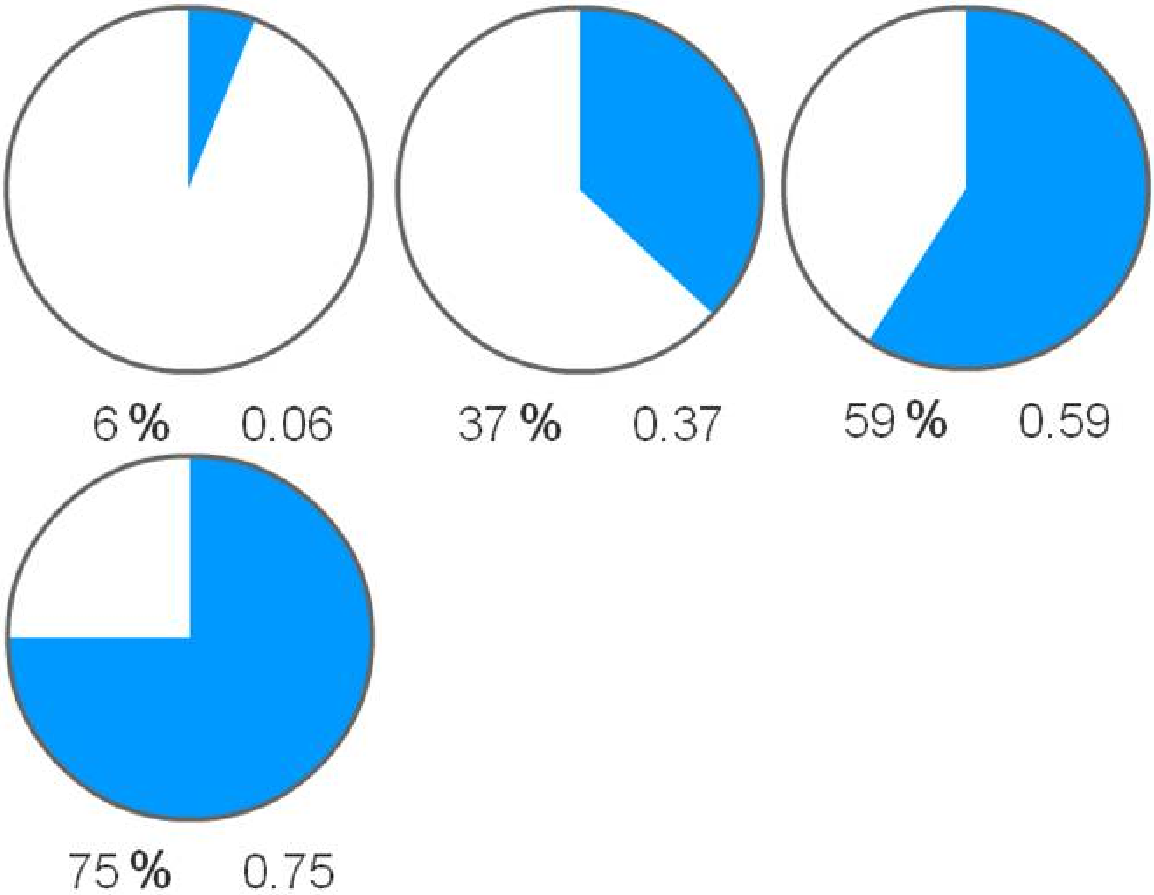
Percentages are fractions

Percent (%) means **per 100**.

So **50%** is the fraction **50/100** (50 parts of 100) or (as a decimal fraction) **0.5**.

100% refers to the whole object.

The following diagrams show different percentages of blue shading on a circle. The percentage and the equivalent decimal fractions are shown.



Percentages, decimals and fractions

A specific value can be represented as a percentage, decimal or fraction. These are different ways of showing the same value. The following table shows some examples.

Fraction, decimal and percent values.		
Fraction	**Decimal**	**Percent**
1/100	0.01	1%
1/20	0.05	5%
1/10	0.1	10%
1/5	0.2	20%
1/4	0.25	25%
1/3	0.3333...	33.33...%
1/2	0.5	50%
3/4	0.75	75%
4/5	0.8	80%
9/10	0.9	90%
	1	100%

Conversion

To convert a percentage to a decimal:

- remove the "%" sign
- move the decimal point **2 places to the left**.

Example: The percentage **25%** as a decimal is **0.25**.

To convert a decimal to a percentage:

- move the decimal point **2 places to the right**
- add the "%" sign.

Example: The number **0.475** as a percentage is **47.5%**.

Percentage calculations

"How much is **15%** of **$145**?"

To calculate a percentage of a number, convert the percentage to a decimal and then multiply the number by the decimal.

15% is equal to **0.15** so to calculate 15% of $145 use this method:

0.15 x 145 = 21.75

So **15%** of **$145** is equal to **$21.75**.

Percentages increase

How to calculate the value of a **percentage increase**.

"If the cost of four litres of paint is $56 and the price increases by 5%, what will be the new price?"

Because 5% is equal to 0.05 you can use this method:

0.05 x 56 = 2.8 (5% of 56)
5% of **$56 = $2.80** price increase.

Add the increase to the old price
$56 + $2.80 = $58.80 new price.

Percentages decrease

How to calculate the value of a **percentage decrease**.

A bulk order of timber attracts a discount of 12%. If the starting price of an order is $2500 what will be the value of the discount and the price after discount?

Because **12%** is equal to **0.12** you can use this method:

discount = **0.12 x 2500 = 300**

new price = starting price − discount
new price = $2500 − $300
new price = **$2200**

Costing

Cost per Single item

Cost per single item is the simplest method of costing materials

All that is required is to multiply the cost of one item by the number of items required.

Cost of 1 item x number of items

E.g. Cost of 35 bags of cement when 1 bag costs $10.50

Cost = unit cost x number

= $10.50 x 35

= $367.50

Cost per Linear Metre

This can be calculated by finding out how many pieces of materials are required, and then multiply by the length and this will give the linear (running) measurement.

E.g. calculate the cost of tem 1.5m length of 90 x 35 pine when one metre costs $3.50

Cost = Number x Length x Cost per unit

= 10 x 1.5 x $3.50

= $52.50

Cost per Square Metre

A formula can be developed to work out m^2 costs.

Cost of $1m^2$ x number of m^2

E.g. calculate the cost of $100m^2$ of asphalt at $4.55 per m^2

Cost = number x unit cost

= 100 x $4.55

= $455.00

Cost per Cubic Metre

The volume must first be calculated by multiplying width x height x length of the materials then multiplying by the dollar value per m^3.

E.g. Calculate the cost of concrete in a strip footing 300mm x 600mm x 20m long when a cubic metre of concrete costs $130.

Volume	=	.3 x .6 x 20
	=	$3.6m^3$ x \$130
	=	\$468.00