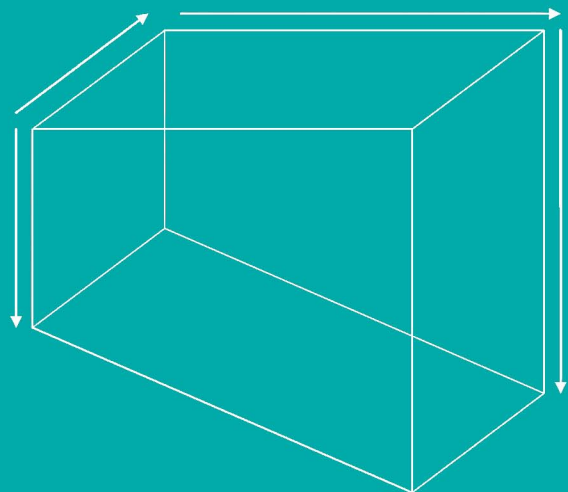
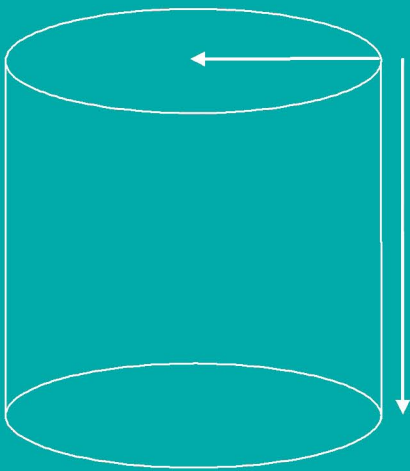


# EMQUAL

EMERGENCY MANAGEMENT  
QUALIFICATIONS

## Demonstrate Hydraulic Knowledge for Fire Fighting Support Resource



[www.emqual.org.nz](http://www.emqual.org.nz)



## Contents



Introduction .....	2
Learning hints .....	2
Surface area .....	3
Square metres.....	4
Rectangles .....	5
Circles.....	6
Triangles .....	7
Volume .....	9
Circular tanks (cylinders).....	11
Water sources with a sloping base .....	12
Flowing water sources .....	15
Other concepts .....	17
Converting.....	17
Decimals .....	18
Rounding .....	18
Estimating.....	19
Making use of it.....	19
Exercises .....	20
Answers .....	25



## Introduction

This guide supports unit standard 20385, *Demonstrate hydraulic knowledge for fire fighting*. It has been developed to help with the calculations needed for this unit.

It shows how to:

- **Calculate** surface area and volume
- **Estimate** the surface area and volume of a water source

### *Learning hints*

As a guide to using this resource, you'll notice that some of the words are in **bold**. These are the **subject words**, the ones you need to **understand** and remember for the purpose of this piece of learning.

Subject words include things like 'length' and 'volume'.





## Surface area

The paper you are holding has a surface that can be measured (it's 29.5 centimetres long and 21 centimetres high). This is called a **surface area**. You need to be able to calculate surface area before you can work out how big a body of water is.

You already work out surface area all the time, and unless you're doing a job that needs accuracy, you probably **estimate**.

### WORD CHECK

<b>Surface area</b>	How big the surface is.
<b>Estimate</b>	Knowing the approximate answer. Useful for testing the accuracy of your calculations.
<b>Calculating</b>	Using maths to get an exact answer.

Here are some questions that might sound familiar:

- How much paint will I need to cover the shed?
- How much pastry to cover a dish?
- How big a tarpaulin to cover the hole in my roof?

Surface area is usually measured in square centimetres ( $\text{cm}^2$ ), square metres ( $\text{m}^2$ ) or square kilometres ( $\text{km}^2$ ), depending on what you think is the best unit of measurement.

**Square centimetres ( $\text{cm}^2$ )** are best for measuring small surface areas, like the size of a picture you want to have framed.

**Square kilometres ( $\text{km}^2$ )** are best for measuring large surface areas, like the size of a National Park.

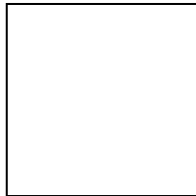
**Square metres ( $\text{m}^2$ )** are best for measuring the surface area of anything in between, such as a body of water. We will use square metres for our examples.



## Square metres

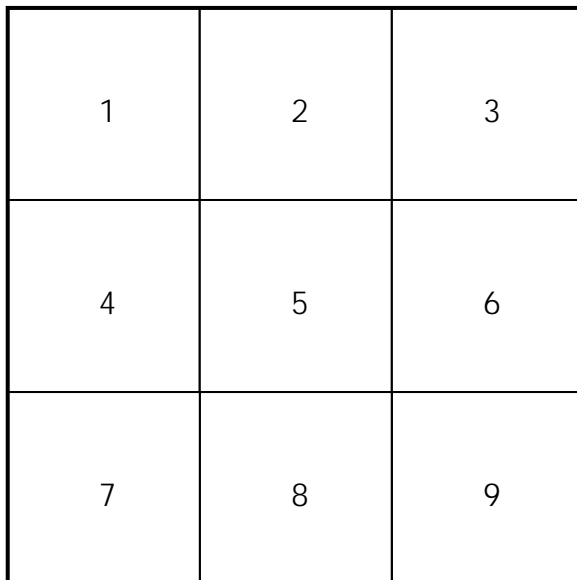
A square that is 1 metre long and 1 metre wide is **1 square metre (1m<sup>2</sup>)**.

1 metre



1 metre

When an object has a surface area of 9 square metres (9m<sup>2</sup>) it means that 9 of these squares will fit inside it.



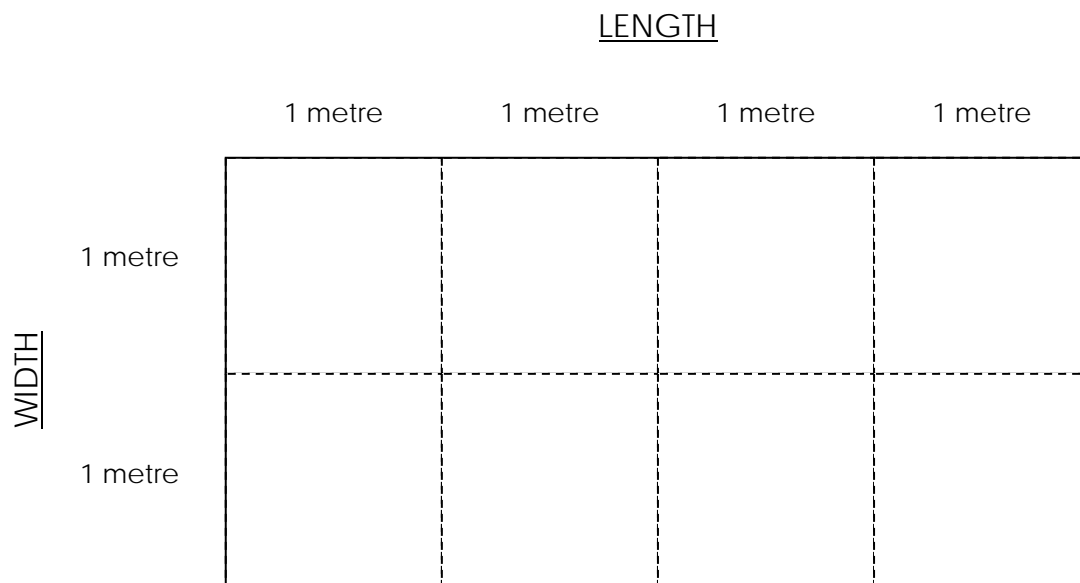
## Rectangles

Even though rectangles can be a range of sizes, there is a standard way of measuring their surface area.

The shape below is 4 metres long and 2 metres wide. One way to work out the surface area of this shape is by counting the number of square metres ( $m^2$ ) that fit inside it.

### WORD CHECK

<b>Length</b>	How long something is.
<b>Width</b>	How wide something is.



**This shape has 8 of these square metres ( $m^2$ ) inside it. So the surface area of the shape is 8 square metres ( $8m^2$ ).**

A quicker way to work out the surface area is by multiplying ( $\times$ ) the **length** and the **width** of the shape.

**It is 4 metres long and 2 metres wide.**

**By multiplying 4 and 2 together ( $4 \times 2$ ) we get 8.**

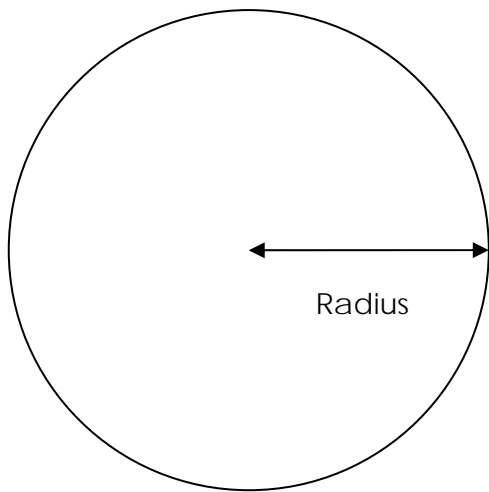
**The surface area of the shape is 8 square metres ( $8m^2$ ).**

When you work out the surface area of a rectangle-shaped body of water on the fire ground:

- **Measure the long side and the short side of the water source.**
- **Then, multiply these numbers together to get the surface area.**

## Circles

To calculate the area of a circle you first need to know the **radius** of the circle.



### WORD CHECK

**Radius** The distance from the middle to the edge of a circle.

You can also work out the radius by measuring the distance from one side of the circle to the other, and dividing ( $\div$ ) it by 2.

Once you know the **radius** of the circle:

- Multiply it by itself.  
For example, if the radius is 6 metres you would multiply 6 and 6 together  
(6 x 6).
- Then multiply your answer by **3.14**. This will give you the surface area of the circle in square metres.

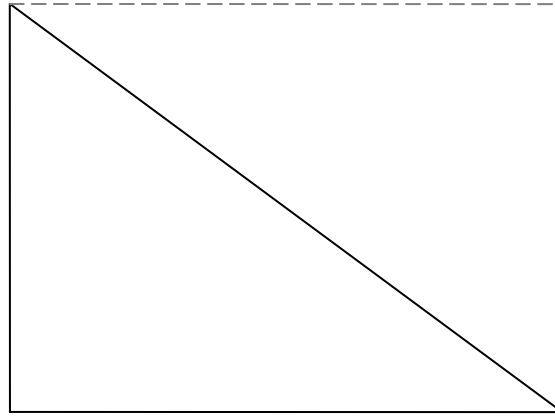
**3.14 is a standard figure used when calculating the surface area of a circle**

**TIP!** Once you have multiplied the radius of any circle by itself, you can **always** multiply the answer by **3.14** to get the surface area of a circle.



## Triangles

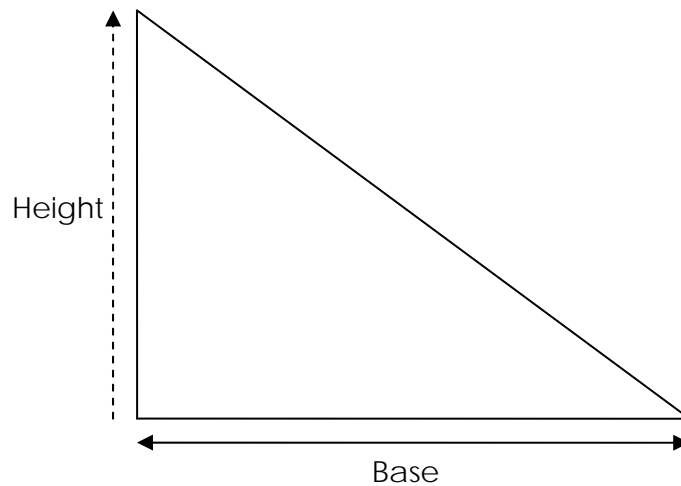
You can work out the surface area of a triangle in the same way you work out the surface area of a rectangle.



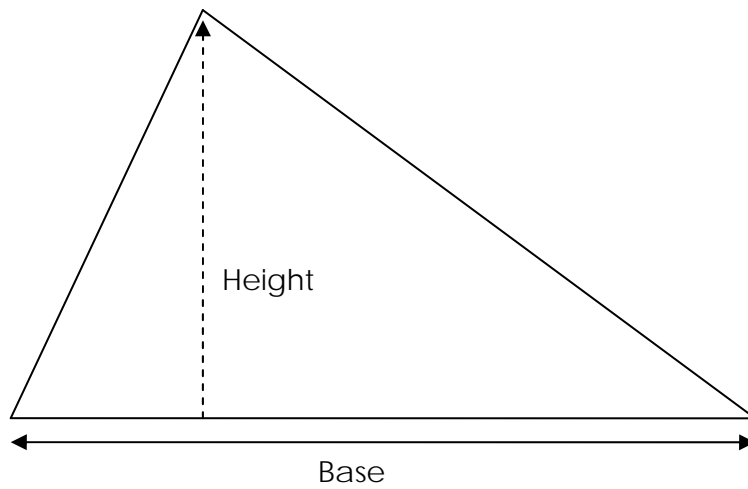
A triangle like the one above is half of a rectangle.

To work out its surface area:

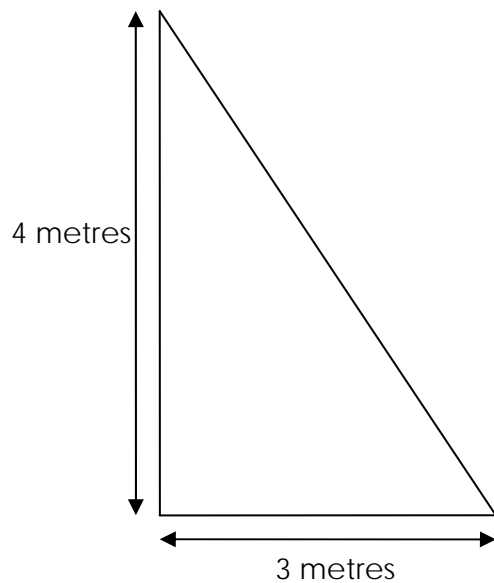
- Multiply its **base** by its **height** (as you would a rectangle)
- Then divide ( $\div$ ) the answer by 2.



There are other triangle shapes which can be calculated in the same way, like this one:



To work out the surface area of the triangle below multiply the **base** (3 metres) and **height** (4 metres) together.



Doing this gives us 12 square metres.

By dividing ( $\div$ ) this by 2 we get the surface area for the triangle ( $12 \div 2$ ), 6 square metres ( $6\text{m}^2$ ).





## Volume

On the fireground you may need to find a water source to help fight a fire. A surface area tells you how long and wide a water source is, but not how much water it holds. To know this we need to know the **volume** of the water source.

### WORD CHECK

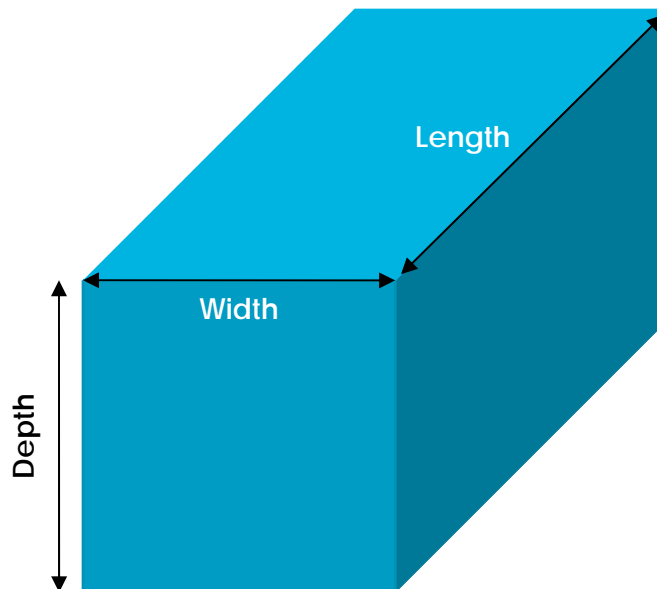
<b>Volume</b>	How much water is held within a shape
<b>Depth</b>	How deep the shape is.

Volume is usually measured in cubic centimetres ( $\text{cm}^3$ ), metres ( $\text{m}^3$ ) or kilometres ( $\text{km}^3$ ), depending on what you think is the best unit of measurement. You will use cubic metres on the fireground, so we will use cubic metres in our examples.

You might have already calculated the volume of something when:

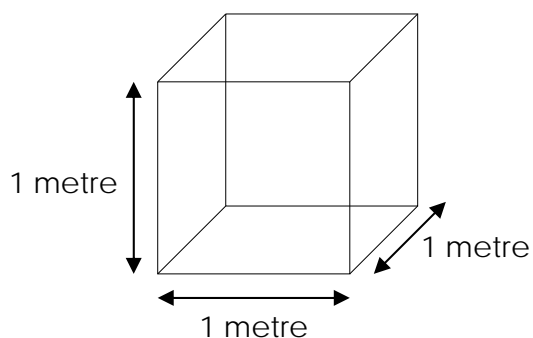
- Working out how many bales of insulation you will need for your ceiling.
- Figuring out how much concrete you need to make the footing for a house.
- Estimating how much wood can fit in a trailer.

Working out the volume of an object like a water source uses the calculation for surface area, multiplied by the depth.

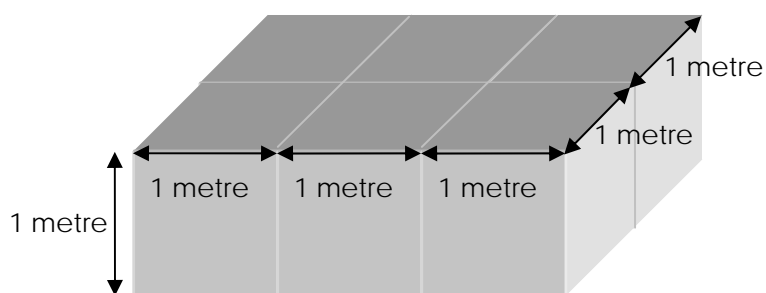


A cube that is 1 metre long, 1 metre wide, and 1 metre deep is **1 cubic metre (1m<sup>3</sup>)**.

Just as a cube is a 3 dimensional square, a rectangular tank is a 3 dimensional rectangle.



You can work out the volume of a rectangular tank by counting the number of cubes that fit into it:



The shape above fits 6 cubes, which are 1 cubic metre each. Its volume is 6 cubic metres (6m<sup>3</sup>).

**A better way to work out its volume is by multiplying (x) its length by its width, and then multiplying the answer by the depth.**

We can see that the shape above:

- is 3 metres wide.
- is 2 metres long.
- is 1 metre deep.

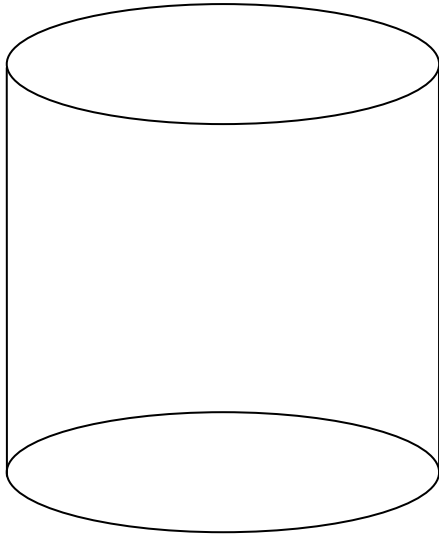
So to work out its volume we can multiply 3 x 2 x 1.

Its volume is 6 cubic metres (6m<sup>3</sup>).



## Circular tanks (cylinders)

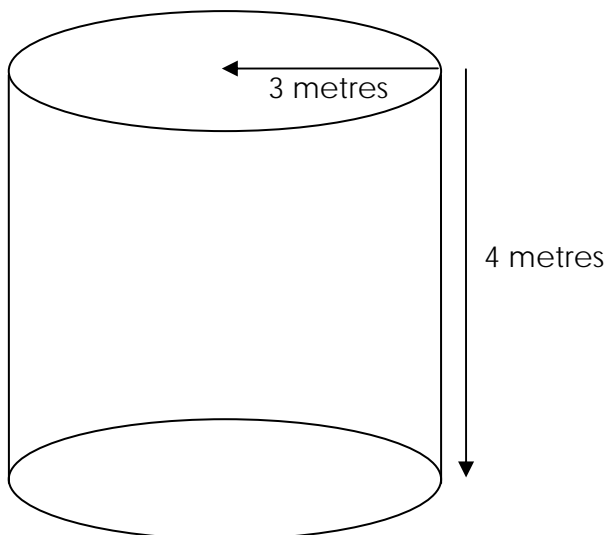
A cylinder is similar to a circle, but with depth.



To work out the volume of a circular tank you first need to know the surface area of the top of it.

You can use the same method you used earlier to work out the surface area for circles.

Once you have done this multiply your answer by the depth of the tank.



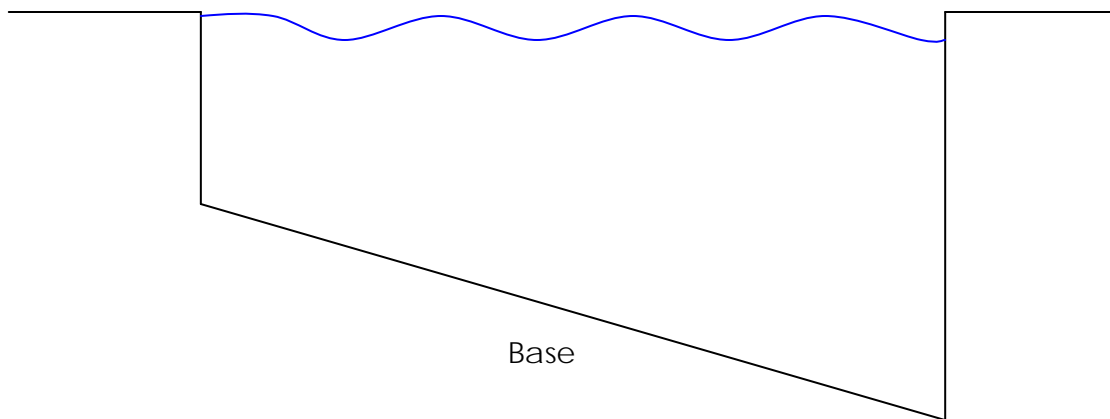
- The tank above has a radius of 3 metres.
- If we multiply 3 by itself we get 9.
- Multiplying this by 3.14 gives us 28.26. This means the top of the tank has a surface area of 28.26 m<sup>2</sup>.
- If we multiply this surface area by the depth of the tank (4 metres) we get 113.04.

The volume of this circular tank is a 113.04 cubic metres (113.04m<sup>3</sup>).

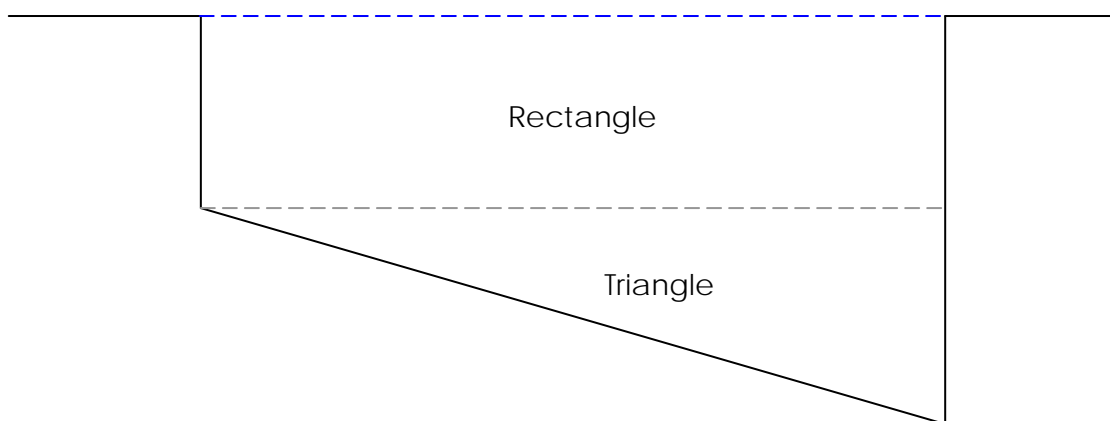


## Water sources with a sloping base

Sometimes you might come across a water source that is similar to a rectangular tank but has a sloping base, like the diagram below. A swimming pool is an example.

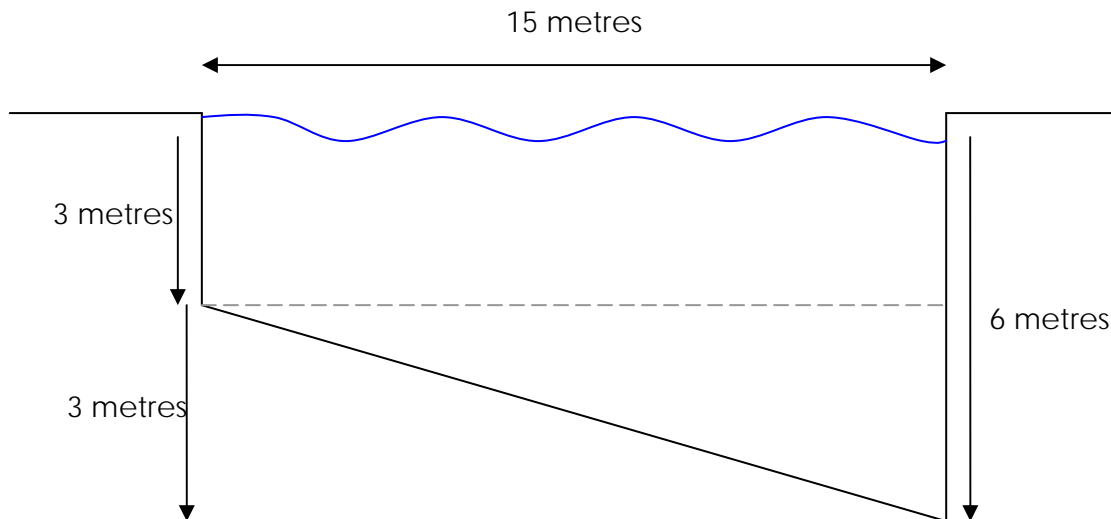


The best way to work out how much water this source holds is to break the shape into two.



This gives us a rectangle and a triangle. We can then work out the size of each of them separately, and add them together.





The **rectangle** in the diagram is 15 metres **wide** and 3 metres **deep**. Multiplying 15 by 3 ( $15 \times 3$ ) gives us an area of **45m<sup>2</sup>**.

The **triangle** in the diagram is 15 metres wide. To figure out the depth of the triangle:

- take the total depth of the water source (6 metres)
- and subtract (-) the depth of the **rectangle** (3 metres) from it

$6 - 3 = 3$ , the triangle is **3 metres deep**.

To work out the area of the triangle:

- 15 metres  $\times$  3 metres, gives an area of 45 metres
- **dividing by 2** is 22.5 square metres

Then **add (+) the area of the rectangle and triangle together to get the area of the whole shape:**

- 45 metres + 22.5 metres = 67.5 square metres.

The whole shape has an area of **67.5 square metres (67.5m<sup>2</sup>)**.

If we also measured the length of this water source, we could work out its **volume**. For example:

If it is 4 metres **long** then **multiply the area of the shape by 4**. This gives the volume in cubic metres (m<sup>3</sup>).

- $67.5 \times 4 = 270$

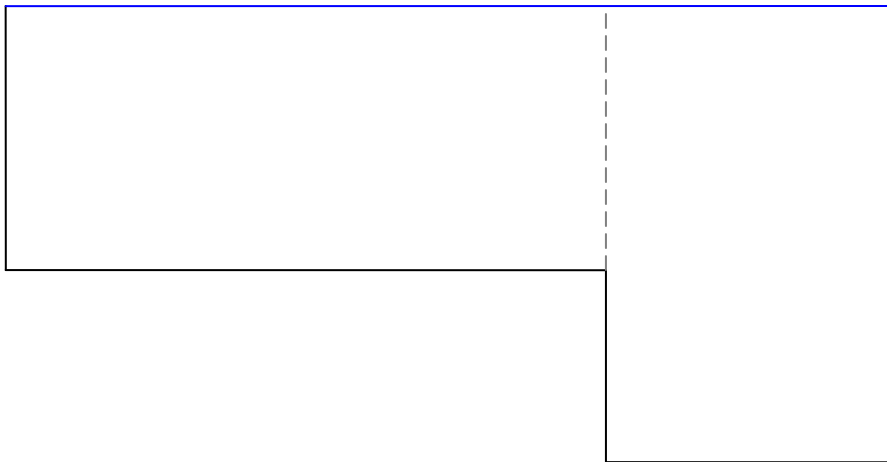
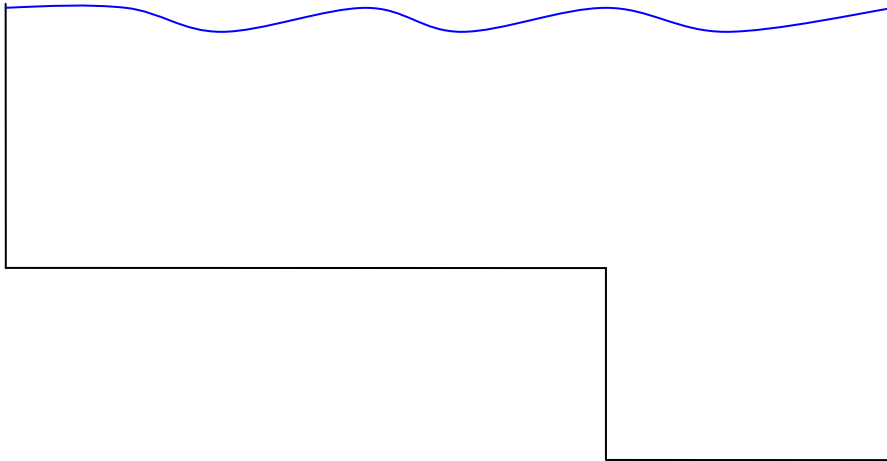
The volume is **270m<sup>3</sup>**.

You can use the same method to work out other unusual shapes.

Breaking unusual shapes into smaller shapes with a **surface area** or **volume** that you know how to work out.

Then add them together.

For example, the following water catchment area can be broken into two rectangles:



The surface area of the whole shape can be calculated:

- by working out the surface area for each of the rectangles
- then adding (+) these together



## Flowing water sources

Working out the volume of a moving water source, like a river, is very similar to a still or static body of water.

### WORD CHECK

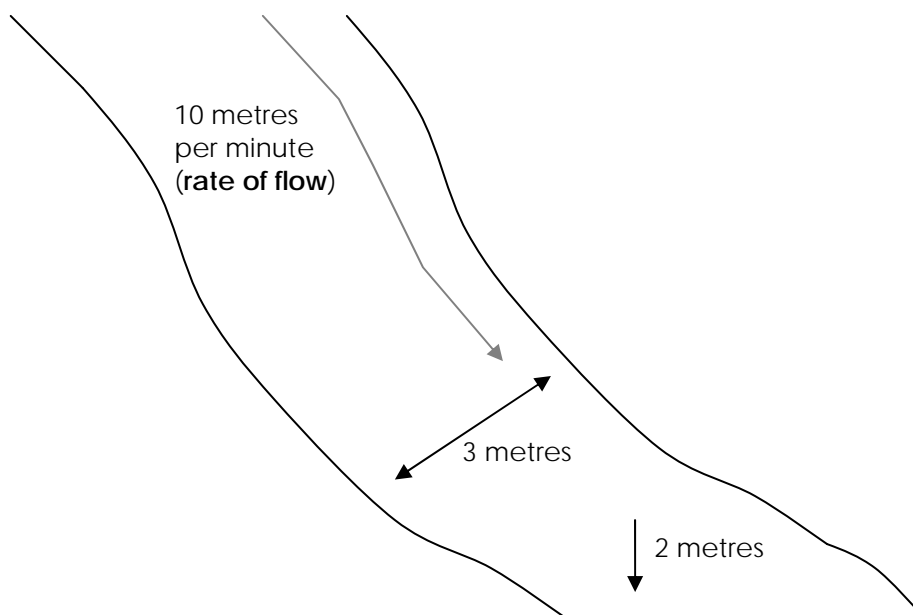
<b>Static</b>	Water that is not moving
<b>Rate of flow</b>	The speed the water is moving at

To calculate the volume of a moving water source you will need to know its **rate of flow**.

This is the amount of water that is moving through the source, and is usually measured in metres per minute.

By using the rate of flow of a water source you can work out the volume.

The river in the diagram below has a rate of flow of 10 metres per minute. This means that the water will move downstream by 10 metres every minute. The river has a width of 3 metres, and is 2 metres deep.



The volume of a moving water source is worked out in the same way as a shape. But instead of using its **length** use its **rate of flow**.

We can work out the volume of a moving water source by multiplying (x) the rate of flow by the width, and then multiplying the answer by the depth.

In our example the river is:

- moving at 10 metres per minute
- 3 metres wide
- 2 metres deep

**To work out its volume multiply 10 x 3 x 2.  
Its volume is 60 cubic metres (m<sup>3</sup>).**





## Other concepts



### Converting



**Just as one dollar is also 100 cents, 1 metre is also 100 centimetres.**

There is a relationship between millimetres (mm), centimetres (cm), metres (m) and kilometres (km) that is useful to know when measuring. You can convert between one measurement and the other by knowing about how they are related.

- 1 centimetre (1cm) is made up of 10 millimetres (10mm)
- 1 metre (1m) is made up of 100 centimetres (100cm)
- 1 kilometre (1km) is made up of 1000 metres (1000m)

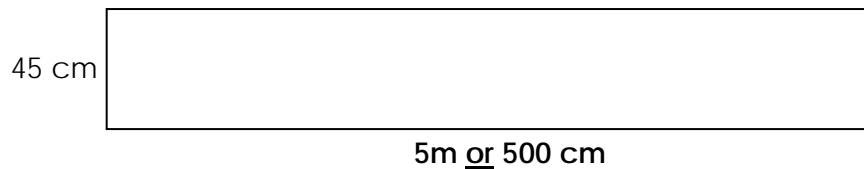
If you want to convert metres into centimetres, **multiply** (x) by 100.

If you want to convert centimetres into metres, **divide** (÷) by 100.

**A rectangle that is 5 metres (5m) long and a rectangle that is 500 centimetres (500cm) long are the same length.**

You can work this out by multiplying the number of metres by the number of centimetres that make up a metre.

$$5 \times 100 = 500$$



The surface area of the above rectangle is:

$$45 \times 500$$

$$= 22,500 \text{ cm}^2$$

or

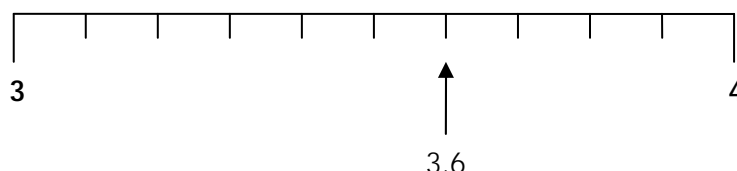
$$0.45 \times 5$$

$$= 2.25 \text{ m}^2$$



## Decimals

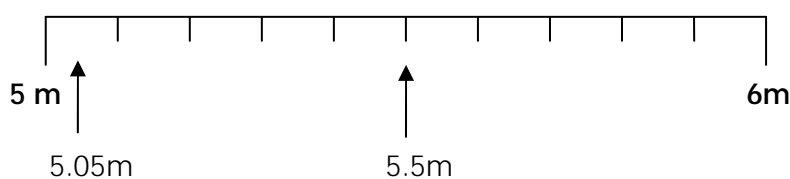
You will often find that a measurement has a decimal point (full stop) in it, like 3.6. This means that the number is more than 3 but less than 4. On a scale it looks like this:



If the scale was showing metres it would mean that the measurement is 3 metres and 60 centimetres (or 360 centimetres).

If the scale was showing kilometres it would mean that the measurement is 3 kilometres and 600 metres. Or 3600 metres. This is because a kilometre is made up of 1000 metres.

Just like \$5.50 is 45 cents more than \$5.05, 5 metres and 50 centimetres (or 5.5m) is 45 centimetres more than 5 metres and 5 centimetres (or 5.05 m).



**TIP!** Remember – when you are looking at numbers with decimal points, the numbers to the left of the decimal point (5.23444) is the most important. All the numbers to the right of the decimal point (5.2**3444**) are not only smaller, but become less and less important the further to the right they go.

## Rounding

Sometimes it's useful to 'round' a number up or down to make a whole number. It makes estimating easier. The general rule is that the partial number (the one to the right of the decimal point) gets rounded up or down to the nearest whole number (the one to the left of the decimal point). For example, 3.2 can be rounded to the nearest whole number, which is 3.

3.7 can be rounded up to its nearest whole number: 4.



## *Estimating*

When fire fighting, you may not have access to a body of water that is shaped like a rectangle, circle, or triangle. There may also be times when it is difficult to calculate a volume of water exactly. In fact, you may not even need to know the exact amount of water available at a source, but an approximate amount.

Instead of measuring the exact length of a water source you may be able to estimate its length or width by walking. If you know that each pace you take is approximately 1 metre, and a body of water is 20 paces long then it will be around 20 metres long.

When estimating remember you may not have an exact figure, and you will need to allow for this, especially when calculating the time a source of water may last.

## **Making use of it**

Every cubic metre (1m<sup>3</sup>) of volume holds 1000 litres of water.

If you estimate a water source to have a volume of 12m<sup>3</sup> then it will have approximately 12,000 litres of water.

A 113m<sup>3</sup> cylinder will be able to hold approximately 113,000 litres of water.

When you know how many litres of water are in a water source you can work out how long this water will last for fire fighting operations.

This can be done by dividing (÷) the number of litres in the water source by the discharge rate of the nozzle you are using.

There is a swimming pool that you know has 100,000 litres of water in it. The nozzle you will be using discharges 1,800 litres of water per minute.

Work out how long it will last by dividing (÷) the volume (100,000 litres) by the discharge rate (1,800 litres per minute).

- $100000 \div 1800 = 55.555555555$ .

**This means the water will last around 55 minutes before it runs out.**



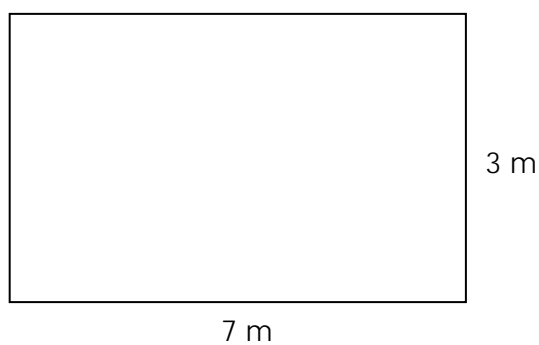
## Exercises

This resource provides exercises for each skill so you can be sure you've understood. To check your answers go to **page 25**.

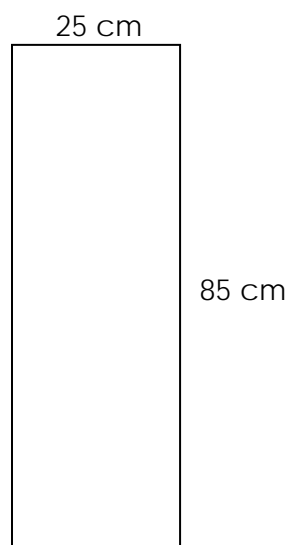
### 1. Calculating the surface area of rectangles.

What is the surface area of the below shapes:

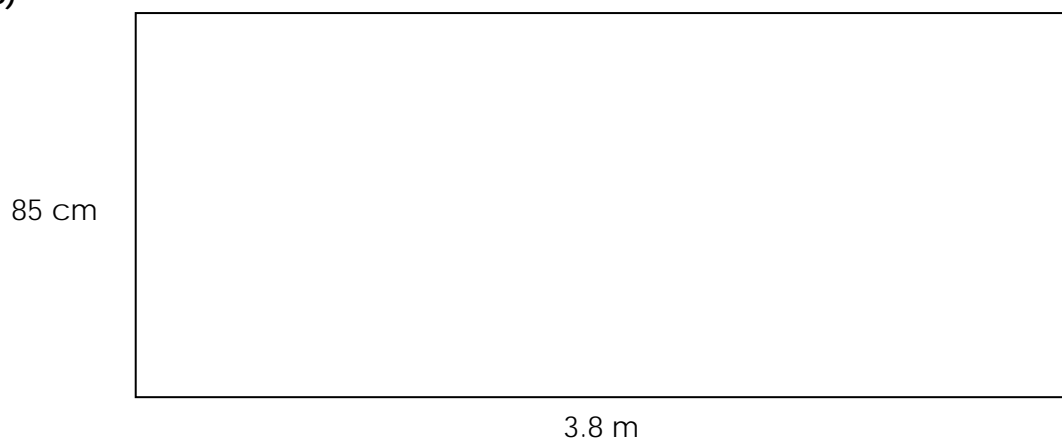
a)



b)



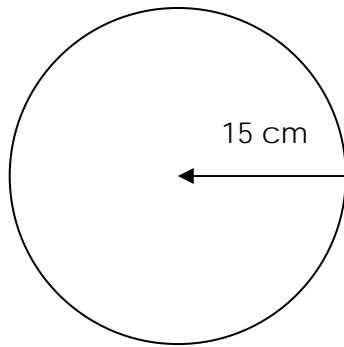
c)



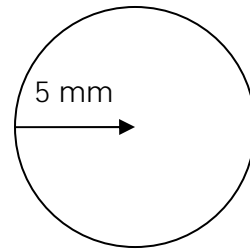
## 2. Calculating surface area of circles

What is the surface area of the below circles:

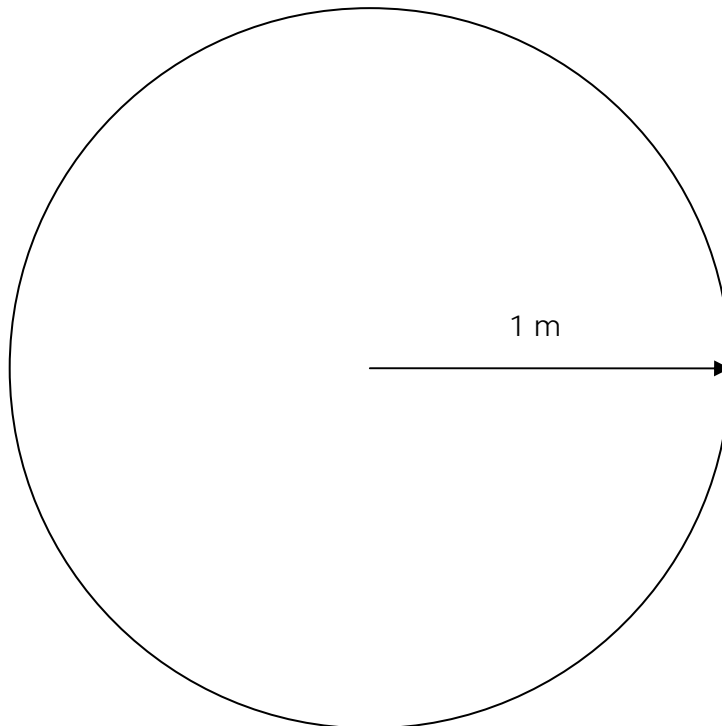
a)



b)

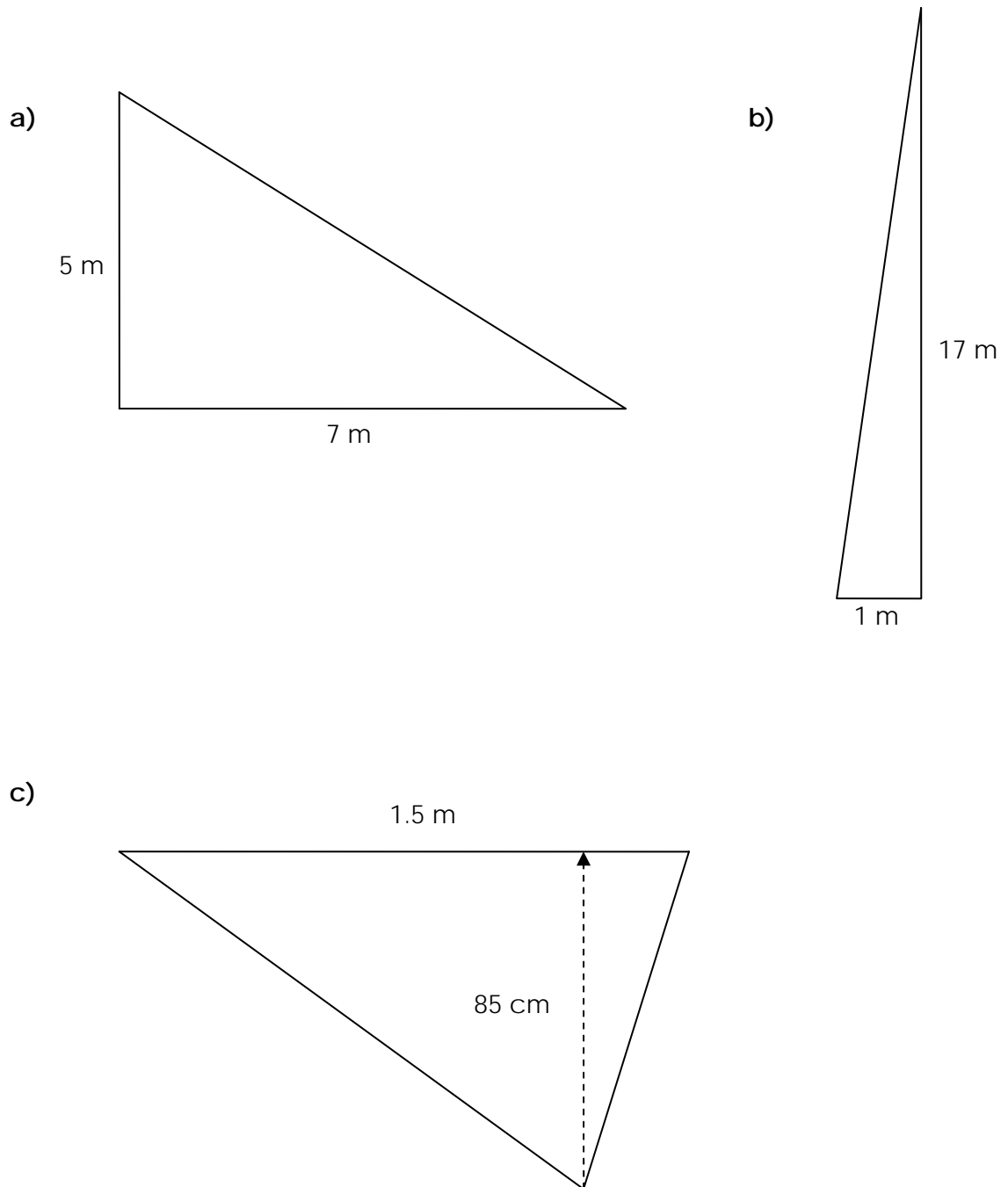


c)



### 3. Calculating the surface area of triangles.

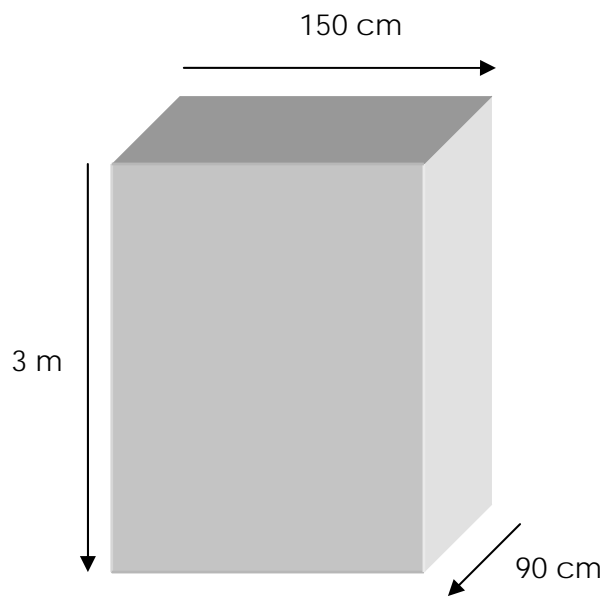
What is the surface area of the below triangles?



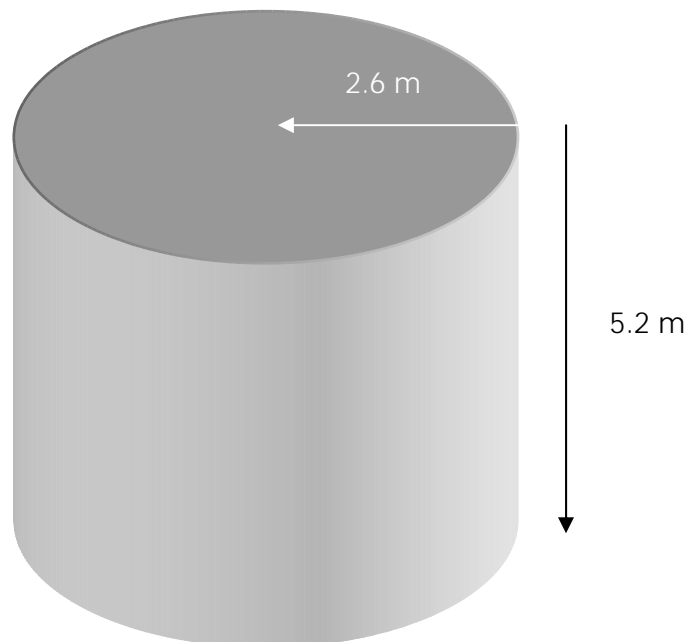
#### 4. Calculating volume

Calculate the volume of the following shapes:

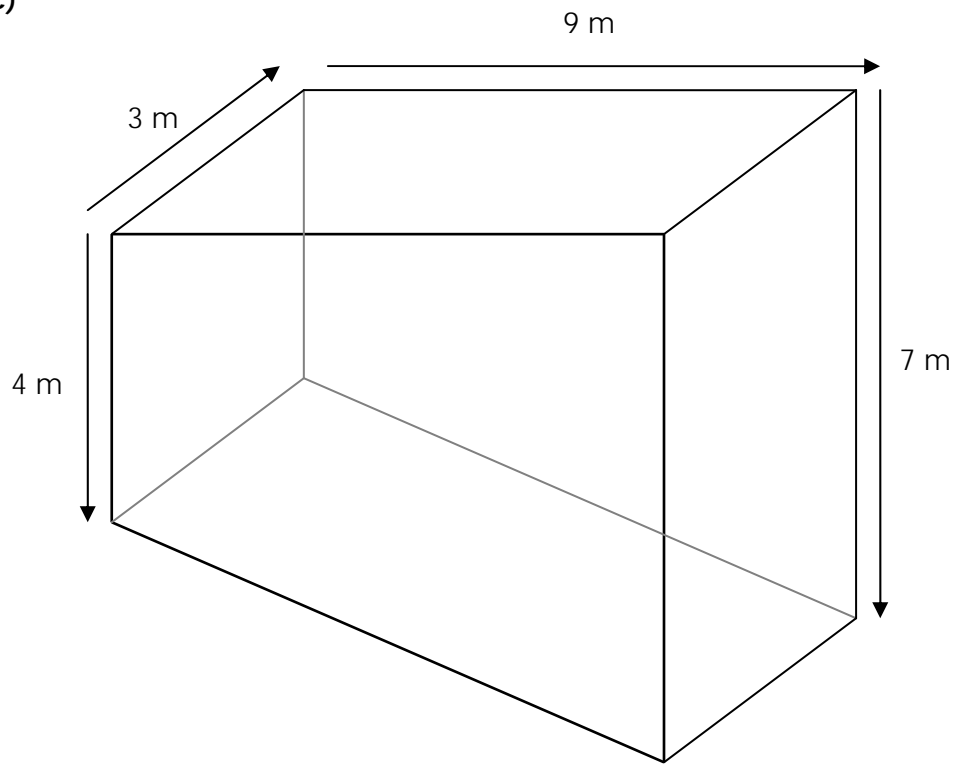
a)



b)

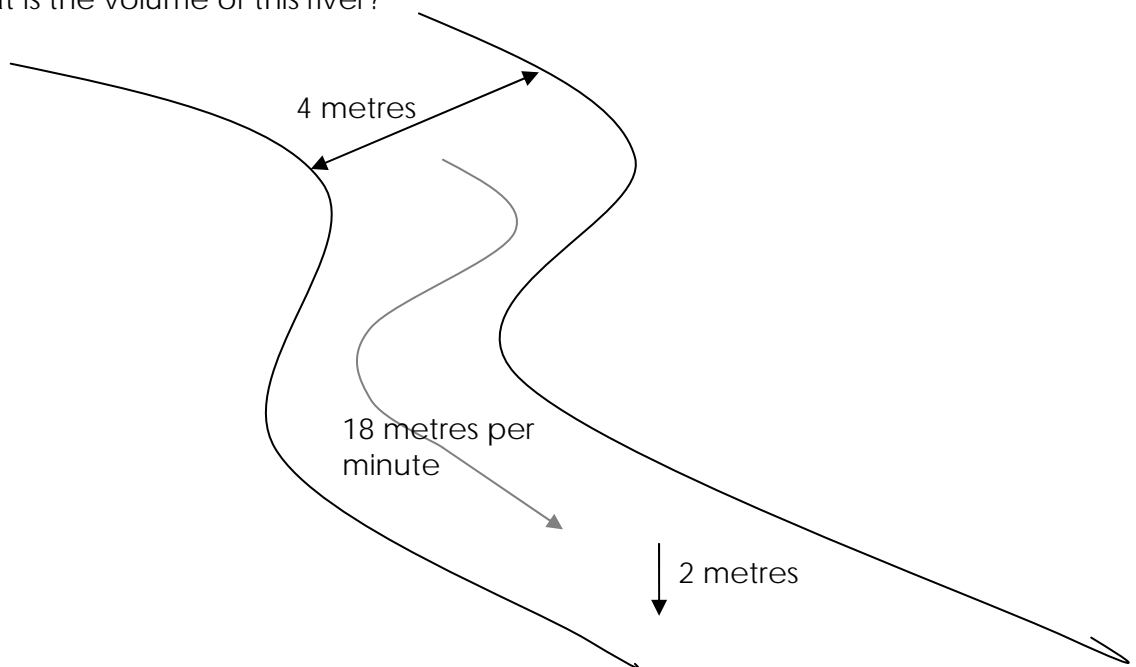


c)



### 5. Calculating rate of flow

What is the volume of this river?



## Answers

### 1. Rectangles

- a)  $7\text{m} \times 3\text{m} = 21\text{m}^2$
- b)  $25\text{cm} \times 85\text{cm} = 2125\text{cm}^2$
- c)  $0.85\text{m}^2 \times 3.8\text{m}^2 = 3.23\text{m}^2$

### 2. Circles

- a)  $15\text{cm} \times 15\text{cm} = 225\text{cm}^2$ ,  $225\text{cm}^2 \times 3.14 = 706.5\text{cm}^2$
- b)  $5\text{mm} \times 5\text{mm} = 25\text{mm}^2$ ,  $25\text{mm}^2 \times 3.14 = 78.5\text{cm}^2$
- c)  $1\text{m} \times 1\text{m} = 1\text{m}$ ,  $1\text{m} \times 3.14 = 3.14\text{m}^2$

### 3. Triangles

- a)  $5\text{m} \times 7\text{m} = 35\text{m}^2$ ,  $35\text{m}^2 \div 2 = 17.5\text{m}^2$
- b)  $17\text{m} \times 1\text{m} = 17\text{m}^2$ ,  $17\text{m}^2 \div 2 = 8.5\text{m}^2$
- c)  $0.85\text{m} \times 1.5\text{m} = 1.275\text{m}^2$ ,  $1.275\text{m}^2 \div 2 = 0.6375\text{m}^2$

### 4. Volumes

- a)  $3\text{m} \times 1.5\text{m} \times 0.9\text{m} = 4.05\text{m}^3$
- b) To work out the area of the circle:  $2.6\text{m} \times 2.6\text{m} = 6.76\text{m}^2$ ,  $6.76\text{m}^2 \times 3.14 = 21.2264\text{m}^2$ .

Then multiply by the height:  $21.2264\text{m}^2 \times 5.2\text{m} = 110.37728\text{m}^2$

- c) By breaking down the shape into a cuboid and a sloping base we get:

- A **rectangular tank** that is 9m long, 3m wide, and 4m deep.  $9 \times 3 \times 4 = 108\text{m}^3$
- A **sloping base** that is 9m long, 3m wide, and 3m deep (7m for the whole shape – 4m of this that we know is part of the cuboid).  $9 \times 3 \times 3 = 81\text{m}^3$ . Because this is a triangular shape we also need to divide this by two,  $81 \div 2 = 40.5\text{m}^3$

Adding these two shapes together we get:

$108 + 40.5 = 148.5\text{m}^3$ , so the whole shape has a volume of **148.5m<sup>3</sup>**

- 5.  $18 \times 4 \times 2 = 144\text{m}^3$

