



# DISASTER **RESPONSE**

How do engineers save lives in the aftermath of a natural disaster?

This resource aims to give students the opportunity to investigate the science, technology, engineering and mathematics (STEM) aspects of disaster response.

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(Note: Spreadsheet available to download from [www.raeng.org.uk/disaster-response](http://www.raeng.org.uk/disaster-response))

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## **Careers information sheet**

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## Disaster card sort

**HURRICANE**



**TORNADO**



**EARTHQUAKE**



**TSUNAMI**



**DROUGHT**



**WILDFIRE**



**FLOODING**



**VOLCANIC  
ERUPTION**



Speed comparison

**WALKING**



Speed comparison

**RUNNING**



Speed comparison

**ORDINARY CAR**



## Emergency shelter

**There are often several ways of solving a problem, and it is helpful to find a way of trying out different solutions to get the best one.**

Creating a scale plan of one family's area or one couple's area, then making several copies of that, allows you to try out different arrangements. The outline is a repeat unit or tile, and the tessellations you create by fitting tiles together are a way of exploring different solutions.

### TASK

**Use scale plans to develop and present your solution.**

1. Measure the floor area of the sports hall and choose a scale that will let you fit the sports hall floor plan on a sheet of A3 paper.
2. Draw the scale plan of the empty sports hall.
3. Measure or find out the size of the objects that will be in each family's floor space. For example:
  - An adult sleeping bag
  - A child's sleeping bag
  - A rucksack or case for personal belongings
  - Any other objects you think are important for the first night.
4. Create outline shapes on paper or card for each of these objects using the same scale as for the sports hall.

### NOTE

You could use squared paper for this, or you may prefer to create the outline shapes to the chosen size using drawing software, so that you can then copy and paste to produce as many outlines as you need before printing them out on paper.

5. Use these outlines to produce outline plans for the floor area needed by:
  - an individual
  - a couple
  - a family with 2 adults and 2 young children.
6. These outlines are your basic 'repeat units' or 'tiles': you will need to make several copies of them for your plan. Use them to estimate how many families, couples and individuals you could accommodate in the sports hall overnight.
7. Compare your group's plan with those produced by other groups.

### DISCUSSION

Which plan could fit in the most people?

Which plans do you think would work best? Why?



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## Scale plans: choosing the best scale and creating scale plans of the sports hall

### WHAT DOES THE SCALE MEAN?

Scale plans and scale diagrams represent real-life objects at a much smaller scale. For example, a 1:50 scale is often used for plans of the inside of buildings. On a 1:50 scale, every length on the plan is 1/50 of real life size, so a 1 cm line on the plan represents a 50 cm length in real life; a rectangular room 5 m wide (500 cm wide) would be represented by a rectangle 10 cm wide on the scale plan. On a 1:100 scale plan, every length is 1/100 of real life size.

#### Examples

Dimensions of real life object	Dimensions of representation on 1:10 plan (Real life dimension /10)	Dimensions of representation on 1:50 plan (Real life dimension /50)	Dimensions of representation on 1:100 plan (Real life dimension /100)
10 m (1,000 cm)	100 cm	20 cm	10 cm
5 m (500 cm)	50 cm	10 cm	5 cm
1 m (100 cm)	10 cm	2 cm	1 cm (10 mm)
50 cm	5 cm	1 cm	0.5 cm (5 mm)
10 cm	1 cm	0.2 cm (2 mm)	0.1 cm (1 mm)

### CHOOSING THE BEST SCALE TO USE

The best scale to use is the biggest that will fit the scale outline for the whole sports hall onto the paper, as long as the smallest objects you want to show individually will also be visible on the plan.

Paper size	Length (mm)	Width (mm)
A5	210	148
A4	297	210
A3	420	297
A2	594	420

**What size room would an A3 sheet represent if you used the whole sheet\*?**

<p><b>Using a 1:50 scale the room would be</b></p> <p>(50 x 420 mm) x (50 x 297 mm)</p> <p>= 21,000 mm x 14,850 mm</p> <p><b>= 21.00 m x 14.85 m.</b></p>	<p><b>Using a 1:10 scale the room would be</b></p> <p>(10 x 420 mm) x (10 x 297 mm)</p> <p>= 4,200 mm x 2,970 mm</p> <p><b>= 4.20 m x 2.97 m.</b></p>
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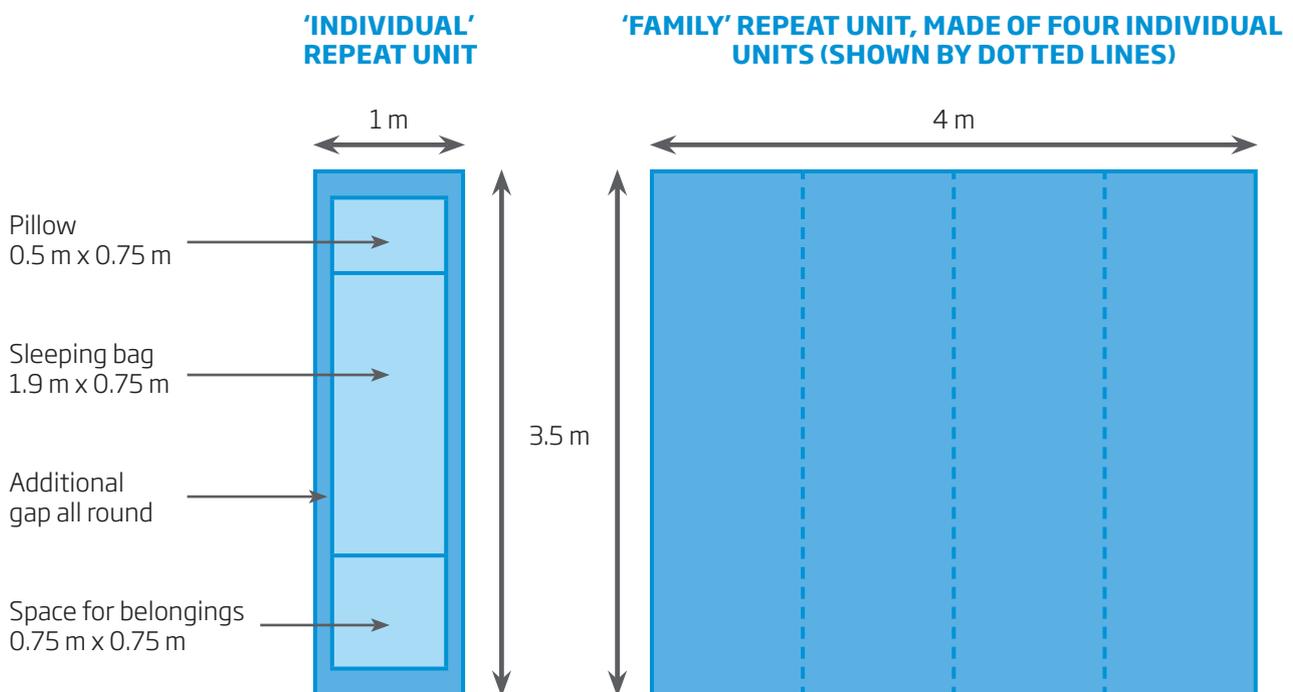
\*Remember that you will need to leave some room for a title and possibly a key, though.

## Tessellation: creating and using repeat units to solve a floor plan problem

It is easier to plan if you allow the same space for each family, couple, or individual, then use this as your repeat unit.

Once you've decided what the repeat unit is, you don't need to draw all the detail inside it. Just use the outline.

For example, you might decide that the 'individual' repeat unit and the 'family' repeat unit might look like this:



The diagrams are drawn to a 1:50 scale.

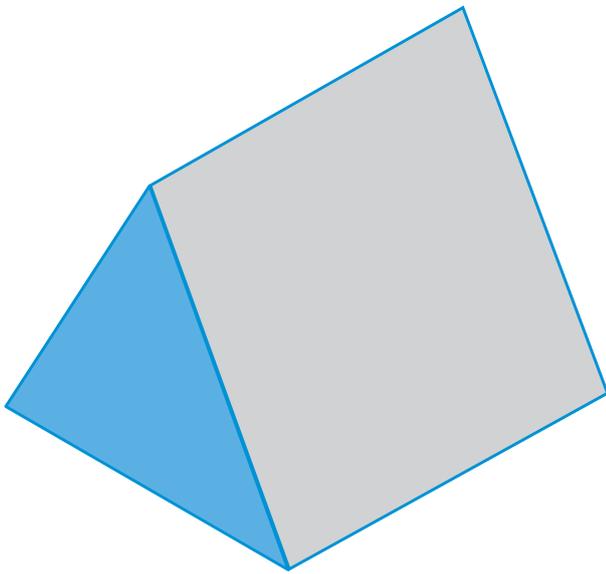


## Model shelters

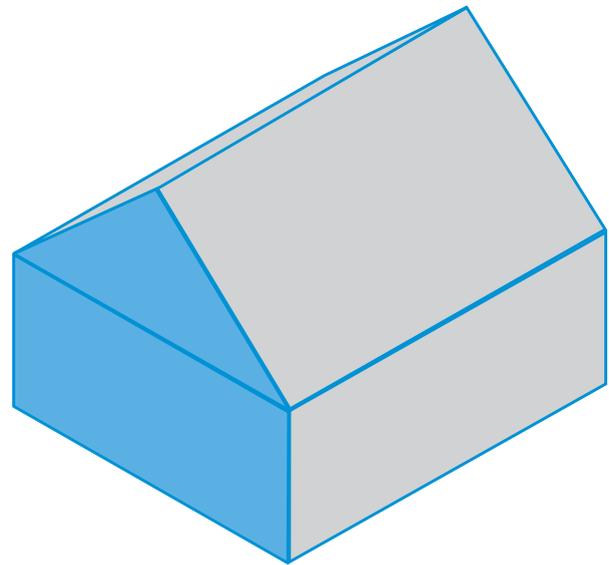
There are two basic shelter shapes, which could be made using flat sheets of stiff material or by covering a frame in fabric. They both have the same size of base, but have different cross sections and slightly different maximum heights.

The basic models are shown on the diagrams below.

'Triangle/prism' shelter



'Apex roof' shelter



## INSTRUCTIONS

**Basic shelter construction templates for rigid sheet construction.**

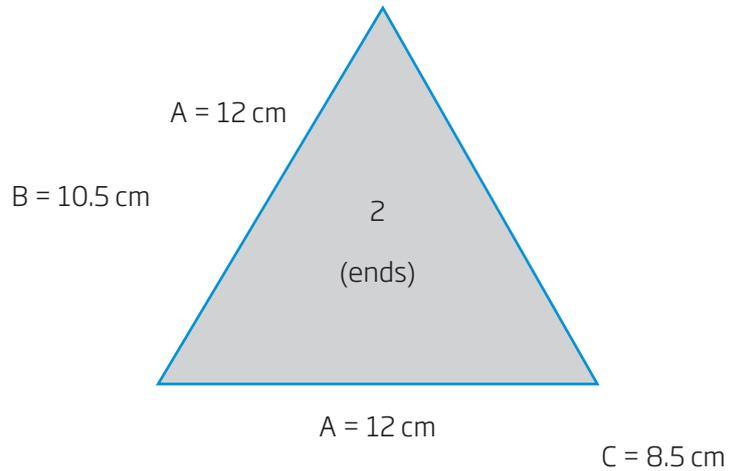
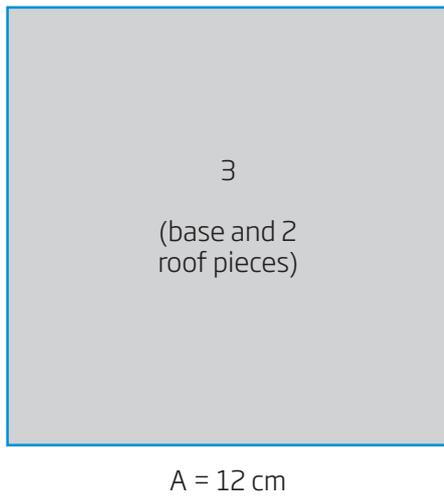
1. Mark out the correct number of each shape from the relevant template on paper.
2. Cut out all the paper shapes and assemble them on the sheet material to get the most economical arrangement before you start cutting the sheet material.
3. Check how you are going to test the models before you fix all the pieces in place.
4. Fix the pieces together using tape or joiners to produce the structures shown in the '3D' diagrams.

**Note:** All the models have the same size base (12 cm x 10.5 cm): the base is included as one of the template shapes shown below for each model. Dimensions are for cardboard/corriflute and are approximate, as thickness and fixing may affect the fit.

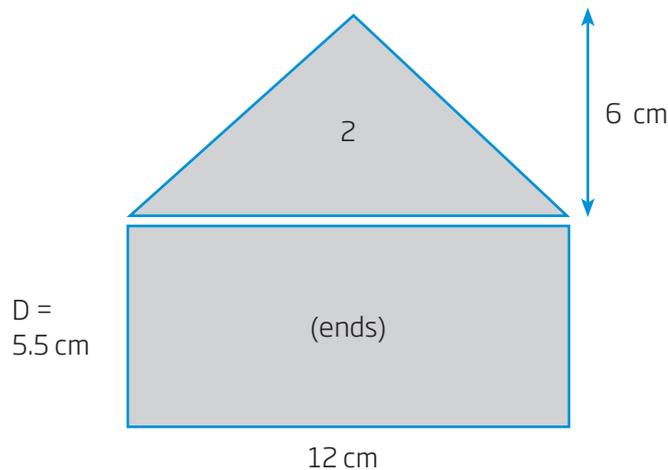
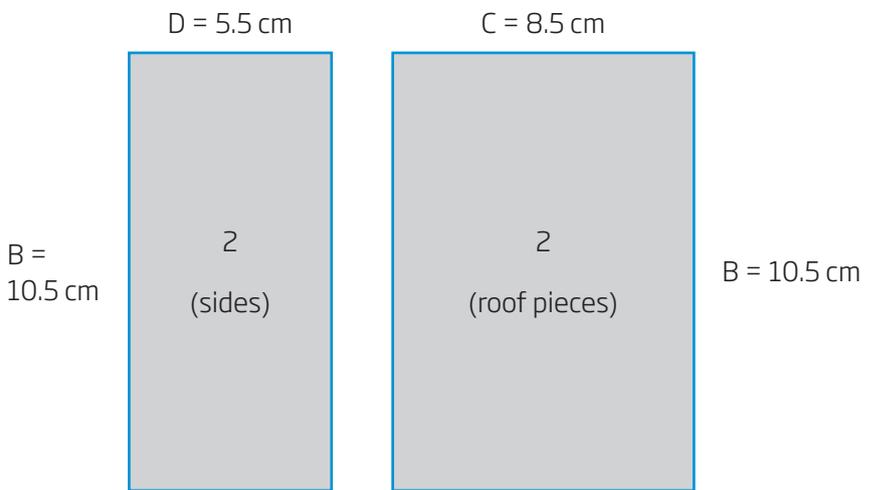
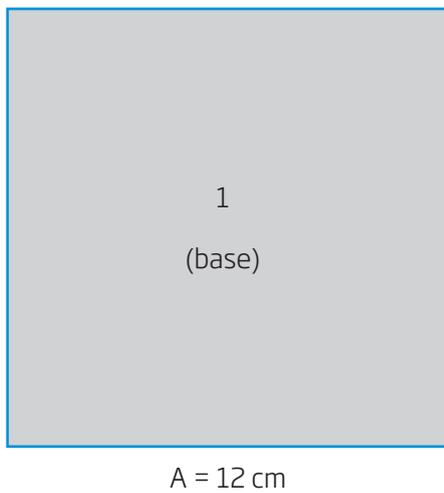


### BASIC SHELTER CONSTRUCTION TEMPLATES FOR RIGID SHEET CONSTRUCTION

'Triangle/prism': 2 shapes, 5 pieces



'Apex roof': 4 shapes, 7 pieces

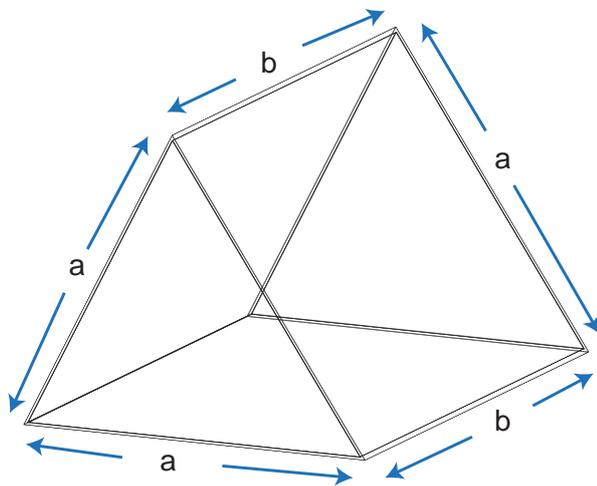


### FRAMEWORK AND FABRIC CONSTRUCTION:

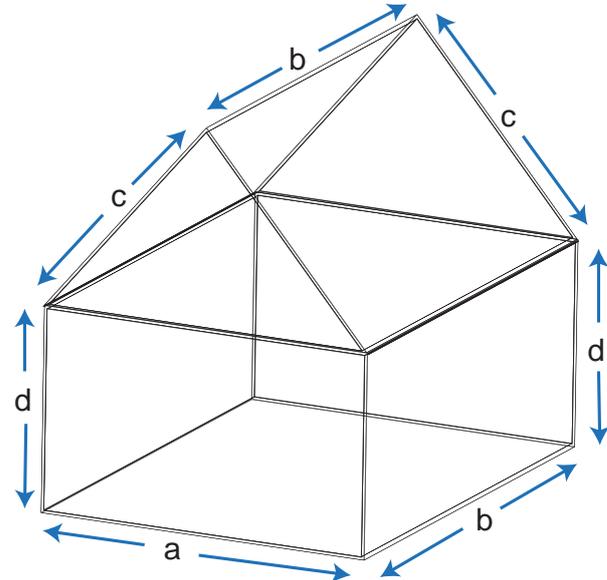
1. Create the frame shapes as shown in the 'wireframe' diagrams.
2. Use the rigid sheet templates to help you mark out fabric to cover the frames, but remember to allow an extra 0.5-1 cm all around overlap for fixing to the frame.
3. Check how you are going to test the models before you fix all the covering in place.
4. Attach your chosen material(s) to the frame by using clips, staples, tape or glue.

### BASIC 'WIREFRAME' DIAGRAMS FOR 'FRAME AND FABRIC' CONSTRUCTION

'Triangle/prism' shelter



'Apex roof' shelter



To construct a framework for each of the basic model shelters using 'constructostraws' and joiners you will need the following:

Component piece (letters refer to relative lengths shown on diagrams)	Basic model			
	'Triangle/ prism'	'Apex roof'		
<b>Straws</b>	a: 12 cm	6	4	
	b: 10.5 cm	3	5	
	c: 8.5 cm	-	4	
	d: 5.5 cm	-	4	
<b>Joiners</b>	8-arm star	✳	-	6
	6-arm star	✳	6	-
	4-arm (right angle cross) or	+	-	4
	2-arm (right angle)	L	-	4

## Facts and figures

*\*Based on information from the Sphere Project Handbook*

### WHAT SIZE OF TENT? HOW MANY TENTS?

**\*A minimum floor area of 3.5 m<sup>2</sup> per person of covered space.**

This figure is for people who will have to live in the shelters for weeks or months, so it allows more space than you would need just for sleeping in.

When you want to work out how many tents you can fit on the site, you will also need to allow for ropes to tension the tent and/or anchor it: these can add a metre or more on each side (so they can add 2 m to the length and the width).

### HOW MUCH WATER? HOW MANY WATER TAPS?

*\*Allow at least 15 litres per person per day of drinking quality water for drinking, cooking and personal hygiene.*

*\*Of this, allow 2.5 to 3 litres per person per day for drinking, or 5 litres per person for drinking and food preparation.*

*\*The distance to the nearest water tap for any household should be no more than 500 m.*

**Water tankers** bring in the largest amounts of water by road. They vary in capacity, but could typically be around 20,000 to 25,000 litres.

**Bowsers** are tanks that can be towed (by trucks) along roads. They have a smaller capacity – perhaps 2,000 litres.

Water tankers and bowsers are used for bringing water to a site rather than for storage. Where there is unlikely to be a piped water supply for more than a few days, there are likely to be large (static) storage tanks that water is transferred to from delivery tankers: there usually needs to be storage for at least one day's worth of water for everyone on the site.

The smallest '**Oxfam tank**' for water storage holds 11,000 litres of water (11 m<sup>3</sup>) and is nearly 3 m in diameter. The tanks are usually dug in so that the base is 30 cm or so below the surrounding ground level.

'**Bladder tanks**' and '**pillow tanks**' are also used for emergency water transport and storage. They are smaller than 'Oxfam tanks'.

### HOW MANY TOILETS?

*\*If several households are sharing a toilet, then there should be at least one toilet for every 20 people.*

*\*Shelters should be no further than 50 m from a toilet.*



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Oxfam GB



Bin im Garten / Wikipedia



## Estimating capacity

### 1. ESTIMATING THE AREA OF THE SITE

The scale on the site plan is \_\_\_\_\_ cm represents \_\_\_\_\_ m.

Length in cm of largest rectangle/triangle that fits the space is \_\_\_\_\_ cm, equivalent to \_\_\_\_\_ m in real life.

Width in cm of largest rectangle/triangle that fits the space is \_\_\_\_\_ cm, equivalent to \_\_\_\_\_ m in real life.

Area of largest rectangle/triangle that will fit on the space = \_\_\_\_\_ m<sup>2</sup>.

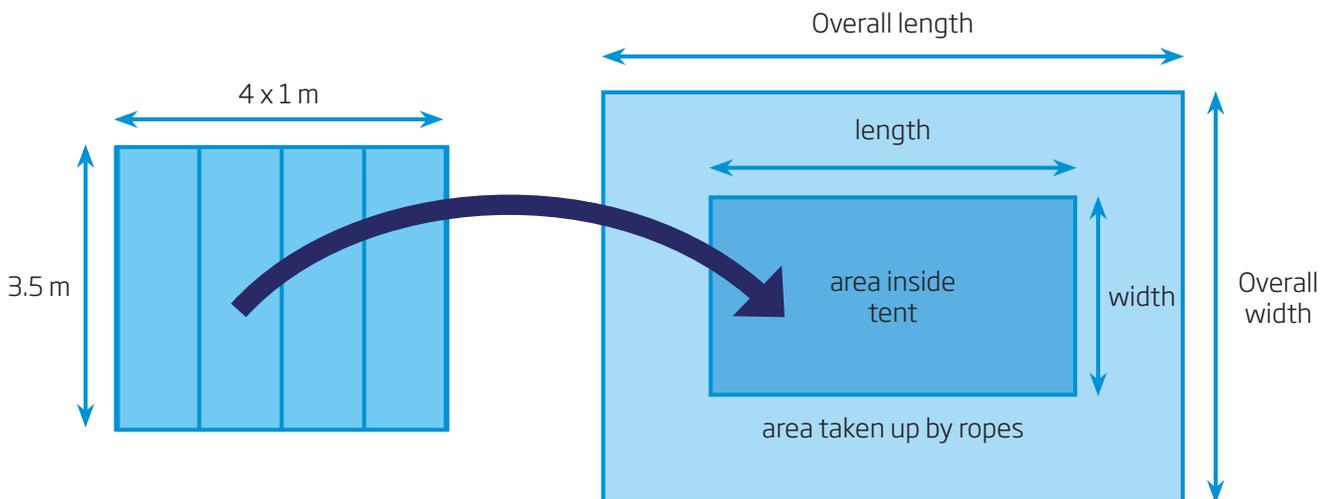
Other groups' estimates of the area:

Value we will use for the total area of the site = \_\_\_\_\_ m<sup>2</sup>.

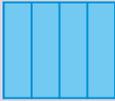
### 2. ESTIMATING THE MAXIMUM NUMBER OF TENTS AND NUMBER OF PEOPLE THAT WILL FIT ON THE SITE

Each person needs 3.5 m<sup>2</sup> of floor space. Allowance for ropes is 1m at each side and end.

eg for 4 people:





Number in tent	Diagram of floor area	Floor area of tent (m <sup>2</sup> )	Overall area of tent (m <sup>2</sup> )	Maximum number of tents	Maximum number of people
4		4 x 3.5 = _____	(4 + 2) x (3.5 + 2) = _____		
8					
12					
16					

### 3. ESTIMATING HOW MUCH WATER MIGHT BE NEEDED EACH DAY

Amount of water needed per day = amount per person x number of people  
= \_\_\_\_\_ x \_\_\_\_\_ litres = \_\_\_\_\_ litres.

For a bowser holding \_\_\_\_\_ litres and a water tanker holding \_\_\_\_\_ litres,

Total amount of water per day = \_\_\_\_\_ bowzers or \_\_\_\_\_ water tanker deliveries.

To store one day's worth of water would need \_\_\_\_\_ storage tanks (each tank holds 11,000 litres or 11 m<sup>3</sup>).

Area needed by storage tanks = \_\_\_\_\_ m<sup>2</sup>.

### 4. ESTIMATING HOW MANY TOILETS ARE NEEDED

Revised estimate of maximum number of people on the site : \_\_\_\_\_

Minimum number of toilets =  $\frac{\text{estimate of maximum number of people}}{\text{maximum number of people per toilet}}$

= \_\_\_\_\_ toilets

Estimated area of 1 toilet = \_\_\_\_\_ m<sup>2</sup>. Minimum area needed for toilets = \_\_\_\_\_ m<sup>2</sup>.

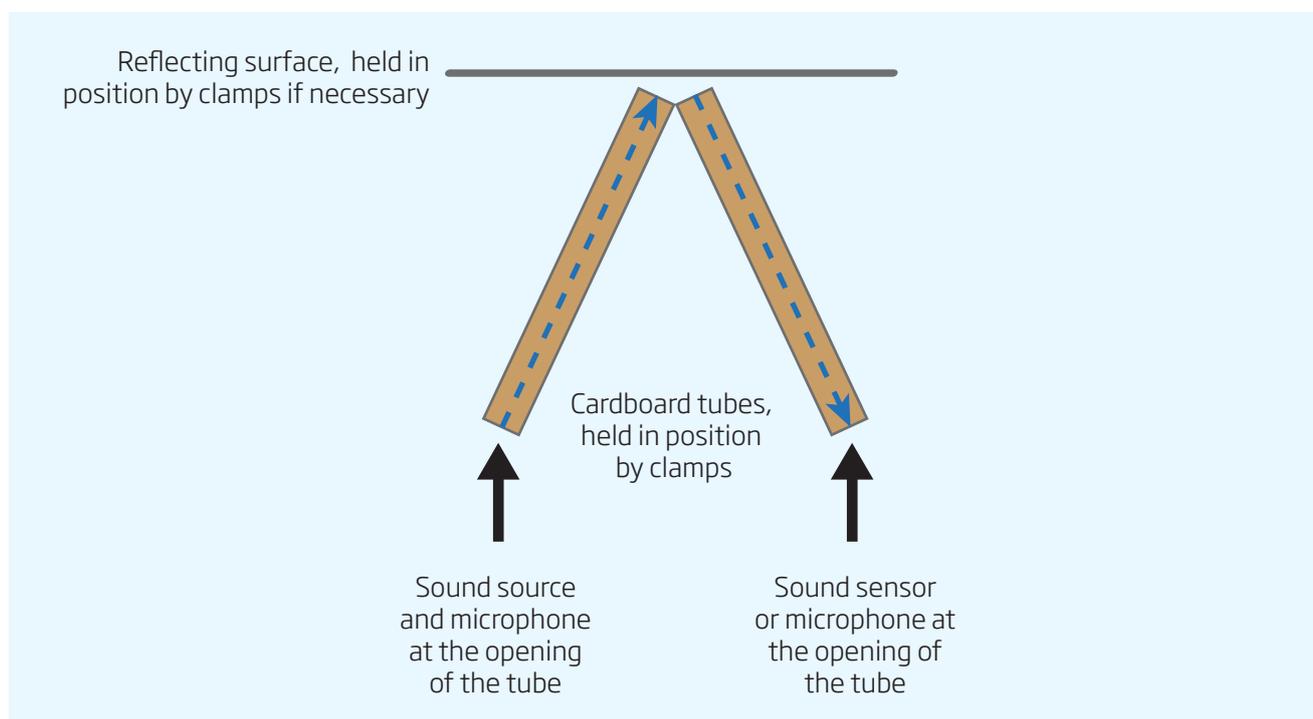
### 5. A FINAL ESTIMATE

Final estimate of maximum number of people the site can accommodate = \_\_\_\_\_

Total area per person = \_\_\_\_\_ m<sup>2</sup>.

## Sound test: comparing the intensity of reflected sounds

### Simplified plan view of testing arrangement

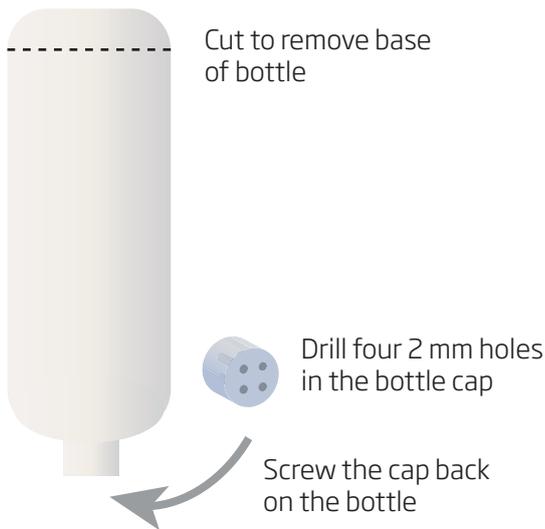


### Things to consider

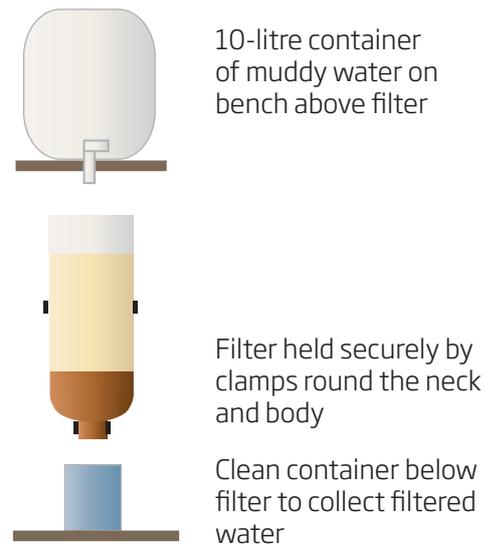
- You will need a consistent sound source. How will you check that it is consistent?
- To compare the intensity of reflected sounds you could use a sound sensor, a microphone connected to an oscilloscope, or a microphone connected to a computer running sound editing software. How will you compare the intensity of reflected sounds using your chosen arrangement?
- How will you try to ensure that your equipment is capturing the maximum amount of reflected sound for each reflecting surface that you test?

## Setting up the filters

### TURNING A BOTTLE INTO A FILTER



### SETTING UP EACH FILTER



### FOUR DIFFERENT FILTERS



## A biosand filter

The diagram below shows how a biosand filter is constructed and used:

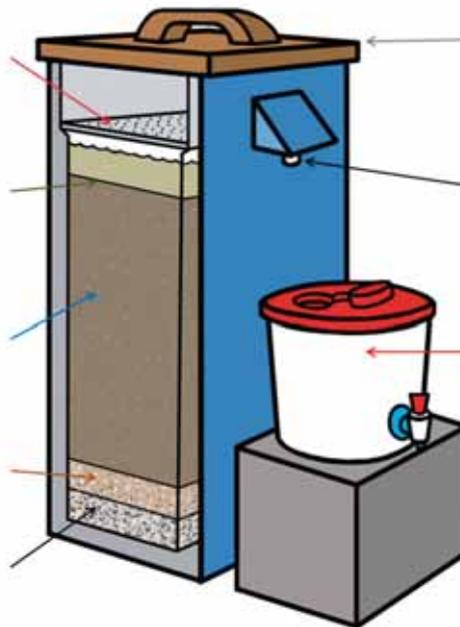
**Diffuser** - Protects the top of the sand and the biolayer from being damaged when water is poured into the filter

**Biolayer** - A community of micro-organisms that live in the top 1-2 cm of the sand. The micro-organisms eat some pathogens in the water, helping the filter treat the water better.

**Filtration sand** - Removes pathogens and suspended solids from the water. The filtration sand is specially selected and prepared to treat the water well.

**Separation gravel** - Supports the filtration sand and prevents it going into the drainage gravel and outlet tube.

**Drainage gravel** - Supports the separation gravel and prevents it going into the outlet tube.



**Lid** - A tightly fitting lid prevents contamination and pests in the filter.

**Outlet tube** - After the water flows down through the sand and gravel, it collects in the tube in the bottom of the filter. Gravity pushes the water up the tube, and it flows out the end of the tube on the outside of the filter.

**Safe water storage** - A water container with a lid and a tap protects the water from being contaminated again.



### The biosand filter in use

Diagram and photo courtesy of CAWST - The Centre for Affordable Water and Sanitation Technology ([www.cawst.org](http://www.cawst.org))



## Taps and waiting time

### Estimating one family's needs

1. The amount of water needed per person per day just for drinking and food preparation = \_\_\_\_\_ litres.  
The amount needed for drinking, cooking and personal hygiene is \_\_\_\_\_ litres.
2. The amount of water needed by a family of four = \_\_\_\_\_ litres.

### Estimating the number of supply points needed

3. Based on a guideline of 250 people per tap, a temporary camp of 2,500 people would need at least \_\_\_\_\_ taps.
4. At a supply rate of 7.5 litres per minute (L/min), if each person uses 7.5 litres per day then each tap would need to provide \_\_\_\_\_ litres and it would take a minimum of \_\_\_\_\_ minutes to provide this.
5. If each person uses 15 litres per day the total supply needed from each tap would be \_\_\_\_\_ litres and it would take a minimum of \_\_\_\_\_ minutes to provide this.

### Estimating the number of journeys per day to get water

6. If each household has a 20-litre storage container and a 10-litre carrying container, it will take \_\_\_\_\_ journeys to collect enough water for the family for 1 day just for drinking and food preparation.

### Estimating how much time is needed to fill a container

7. If the tap delivers water at a rate of 5 L/min, it will take \_\_\_\_\_ minutes to fill the container;
8. If the tap delivers water at a rate of 10 L/min, it will take \_\_\_\_\_ minutes to fill the container;
9. If the tap delivers water at a rate of  $n$  L/min, it will take \_\_\_\_\_ minutes to fill the container.

### Estimating the effect of a queue

10. At 5 L/min, if there are 5 people in the queue it will take \_\_\_\_\_ minutes for all of them to fill their container;
11. At 5 L/min, if there are 10 people in the queue it will take \_\_\_\_\_ minutes for all of them to fill their container;
12. At  $V$  L/min, if there are  $n$  people in the queue it will take \_\_\_\_\_ minutes for all of them to fill their container.

### Time spent getting water each day

13. If there are typically 10 people ahead of you in the queue when you join it, it will take \_\_\_\_\_ minutes to get to the tap each time you join the queue.
14. If you have to walk 200 m to the tap, walking there and back each time at a rate of \_\_\_\_\_ m/s will take \_\_\_\_\_ s, or approximately \_\_\_\_\_ minutes.
15. The amount of time spent in getting water for a family each day would be \_\_\_\_\_ minutes.

### Limiting the queueing time

16. If nobody should queue for more than 30 minutes, the maximum number of people ahead of them in the queue should be \_\_\_\_\_

## Facts and figures

### **WATER NEEDS**

Allow 2.5 to 3 litres per person per day for drinking, or 5 litres per day for drinking and food preparation, or 15 litres per person per day for drinking, cooking and personal hygiene

### **STORING AND CARRYING WATER**

#### **Allow**

1 x 10-20 litre water container per household for storage

1 x 10-20 litre water container per household for transportation

### **SUPPLY POINTS**

**Allow a maximum of 250 people per tap based on a flow of 7.5 litres/minute.**

Distance to nearest water tap for any household should be no more than 500 m.

Nobody should have to queue for more than 30 minutes at a tap.

*\*The figures above are approximate guidelines, based on information from the Sphere Project Handbook*



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## Prompt sheet

### IN YOUR PRESENTATION TRY TO ANSWER THE FOLLOWING QUESTIONS:

#### How do engineers help to provide appropriate shelter for survivors?

How do they make sure that there is shelter for everyone?

How do they make sure that people are safe where they are sheltered?

How do they make sure that people's needs for warmth, comfort and privacy are met?

#### How do engineers help to provide clean water for survivors?

How do they make sure the water is safe?

How do they make sure there is enough water for everybody?

How do they make sure that everyone can get the water they need every day?

**For each of these questions, try to identify the maths, science or technology knowledge that engineers use to help them find a solution.**

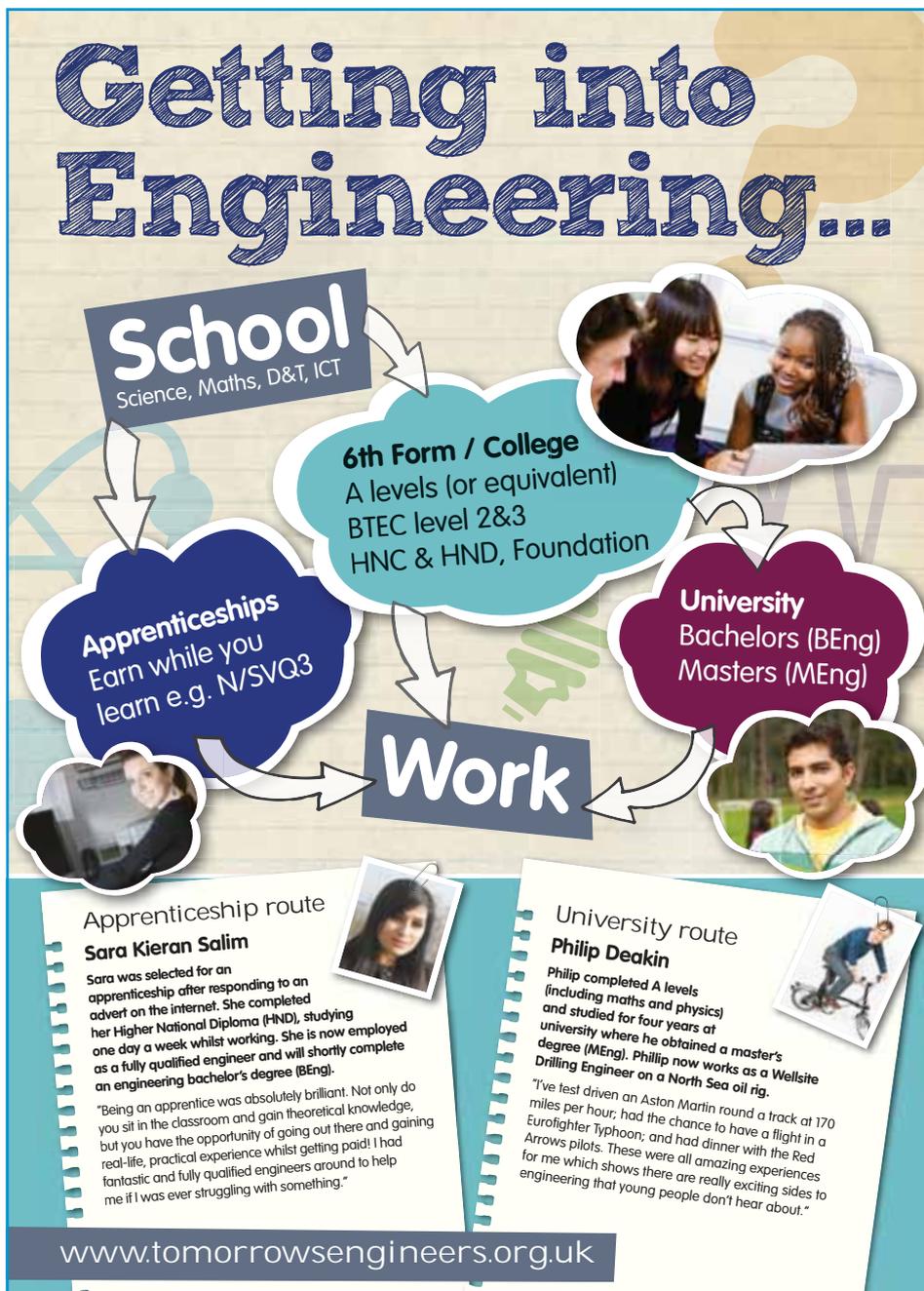


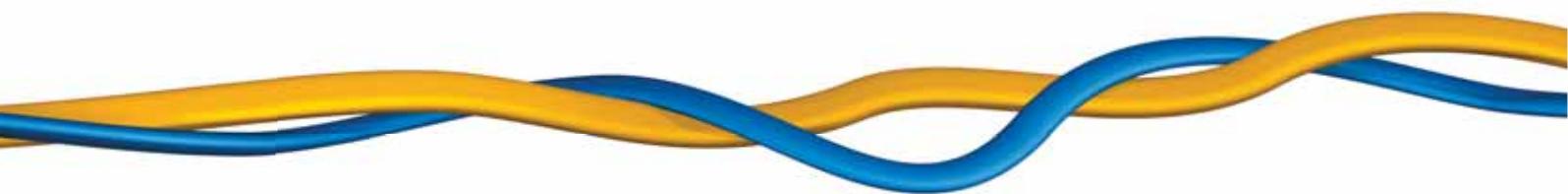
## Getting into Engineering

We work with our partners at Engineering UK and Tomorrow's Engineers to show young people the exciting careers available in engineering.

If you are interested in a career in engineering there is a helpful route map below.

You can find more information at [www.tomorrowsengineers.org.uk](http://www.tomorrowsengineers.org.uk)





As the UK's national academy for engineering, we bring together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering. We provide analysis and policy support to promote the UK's role as a great place from which to do business. We take a lead on engineering education and we invest in the UK's world class research base to underpin innovation. We work to improve public awareness and understanding of engineering. We are a national academy with a global outlook and use our international partnerships to ensure that the UK benefits from international networks, expertise and investment.

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