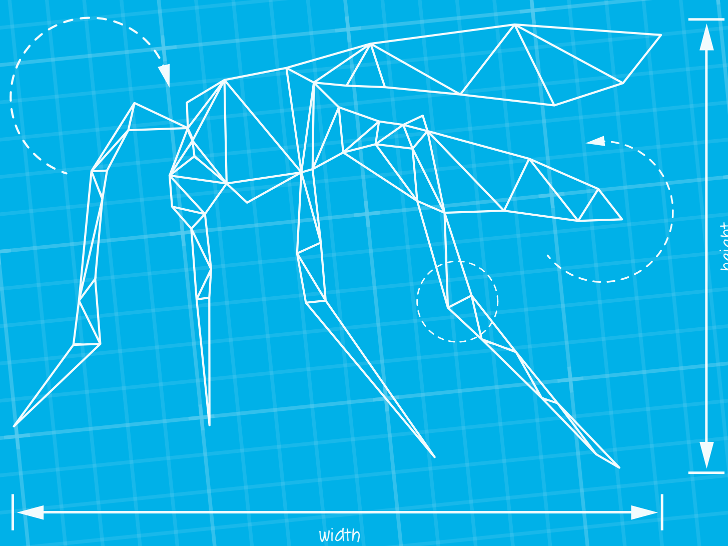
Royal Academy of Engineering

THIS IS ENGINEERING



DEPLOYABLE STRUCTURES

Mosquito nets

This resource aims to give students mathematics learning activities, set within the context of the prevention of malaria, which is a real and everyday problem for millions of people around the world.

INTRODUCTION

Malaria is a disease that is carried by mosquitos and affects millions of people around the world.

However, malaria can be prevented if people in areas affected by the disease used mosquito nets. The aim of this booklet is to use mathematics to investigate mosquito nets.

USEFUL WEB LINKS

Unicef

Fact sheet: malaria, a global crisis
www.unicef.org/media/media_20475.html

World Health Organisation

Information about malaria
www.who.int/malaria/en

PSHE Programme of Study

http://tinyurl.com/nd4hedw

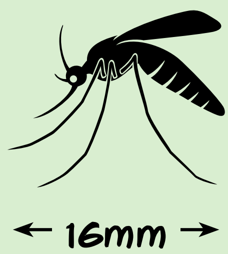
1. WHY ARE MOSQUITO NETS IMPORTANT?

The challenge

Use the information below to discuss the following questions with the people sitting near you.

1. How do you get malaria?
2. What can happen to you when you get malaria?
3. How do you think mosquito nets can help prevent malaria?
4. Why do you think some people don't use mosquito nets?
5. How might children and adults be encouraged to use mosquito nets?

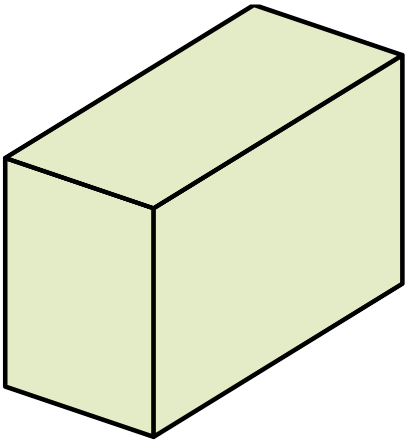
Malaria data and information cards

Malaria cases in 2010 200 million	Malaria deaths in 2010 655,000	Most deaths children < five years old	
Mosquitos infected with the malaria parasite are the cause of the disease in humans	Mosquitos usually bite between sunset and sunrise	When infected mosquitos bite they inject the malaria parasite into the blood	Malaria symptoms: fever headache chills vomiting
Quick treatment can cure malaria, but no vaccine exists	Bed nets can prevent mosquitos biting at night	Cost of single effective malaria treatment £1.50	Cost of a large bed net £5 lasts three years
In 2010 there was a 23% increase in bed net ownership in some countries, but only a 12% increase in their use	Cheap malaria treatments are beginning to stop working	Cheap malaria treatments cost pennies	Symptoms are difficult to recognise and can lead to death if not dealt with in 24 hours

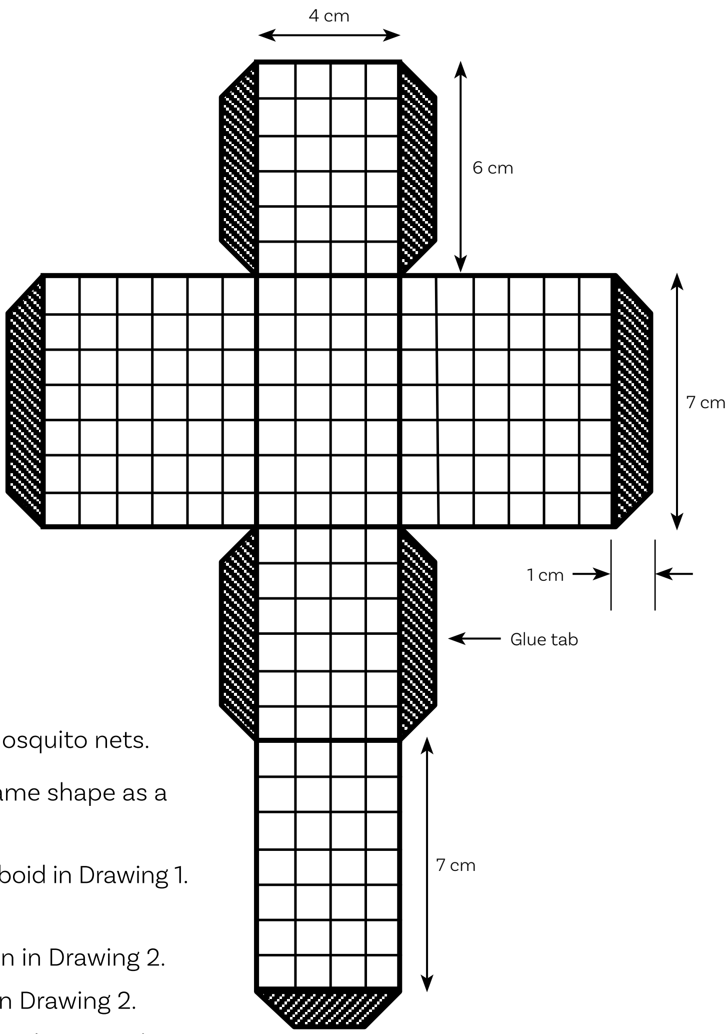
2. MAKING NETS (PART 1)

Photograph 1

Photograph 2



Drawing 1



Drawing 2
(not actual size)

The challenge

Photographs 1 and 2 show rectangular mosquito nets.

Drawing 1 shows a cuboid which is the same shape as a rectangular mosquito net.

Drawing 2 is the net for a model of the cuboid in Drawing 1. A full size version is on the next page.

1. Draw, cut, fold and glue the net shown in Drawing 2.
2. Calculate the area of the net shown in Drawing 2.
3. Calculate the volume of the cuboid you have made.

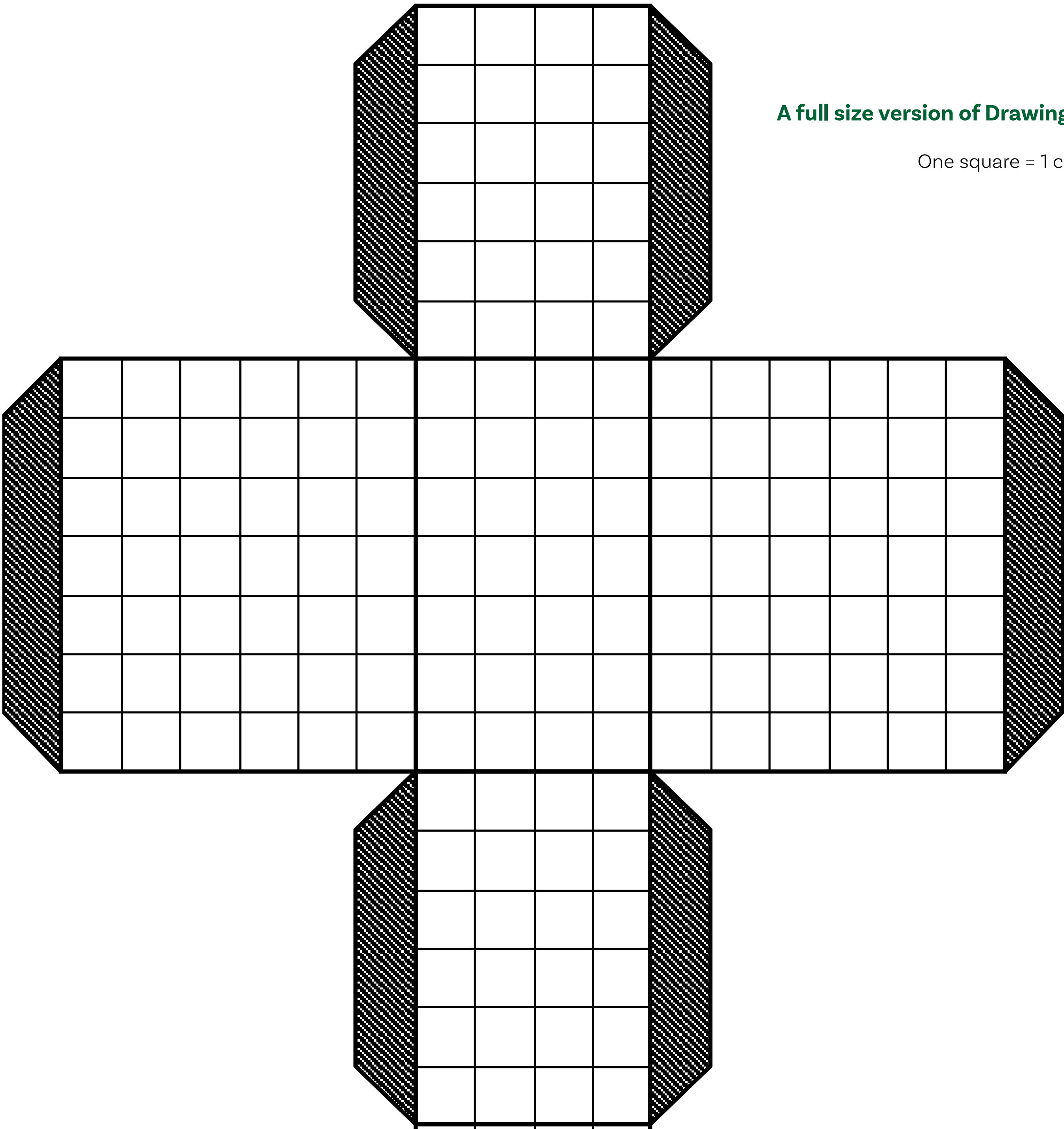
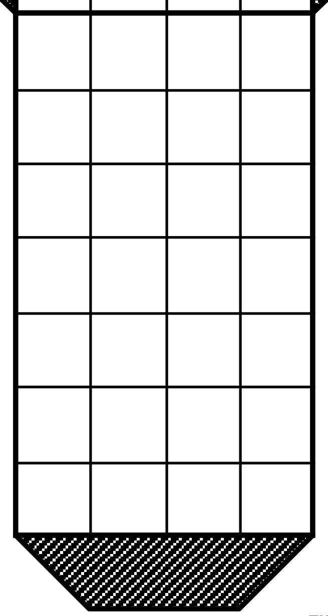
EQUIPMENT, MATERIALS AND TOOLS

You will need:

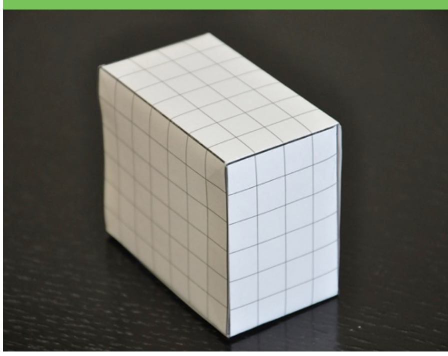
- A4 squared paper
- Pencil
- 30 cm ruler
- Scissors
- Glue stick
- Sticky tape

A full size version of Drawing 2

One square = 1 cm^2

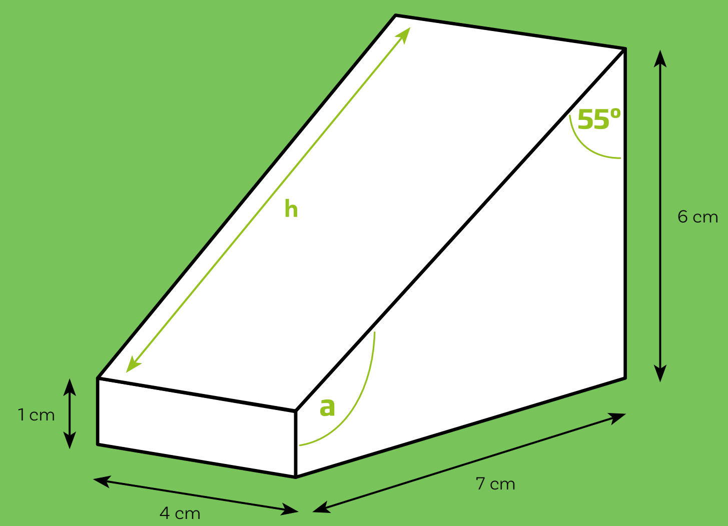
Photograph 3:
This is what the cuboid net looks like when it is cut out, folded and joined.



2. MAKING NETS (PART 2)

Lifemarque Limited

Photograph 4



Drawing 3

The challenge

Mosquito nets could cost less to make and buy if they used less material. Cheaper mosquito nets might mean that more people at risk from malaria could be provided with a net.

Smaller mosquito nets also take up less space when packed up and would be lighter. This means more nets could be transported and delivered at one time.

Photograph 4 shows a mosquito net design that uses less material than the rectangular net.

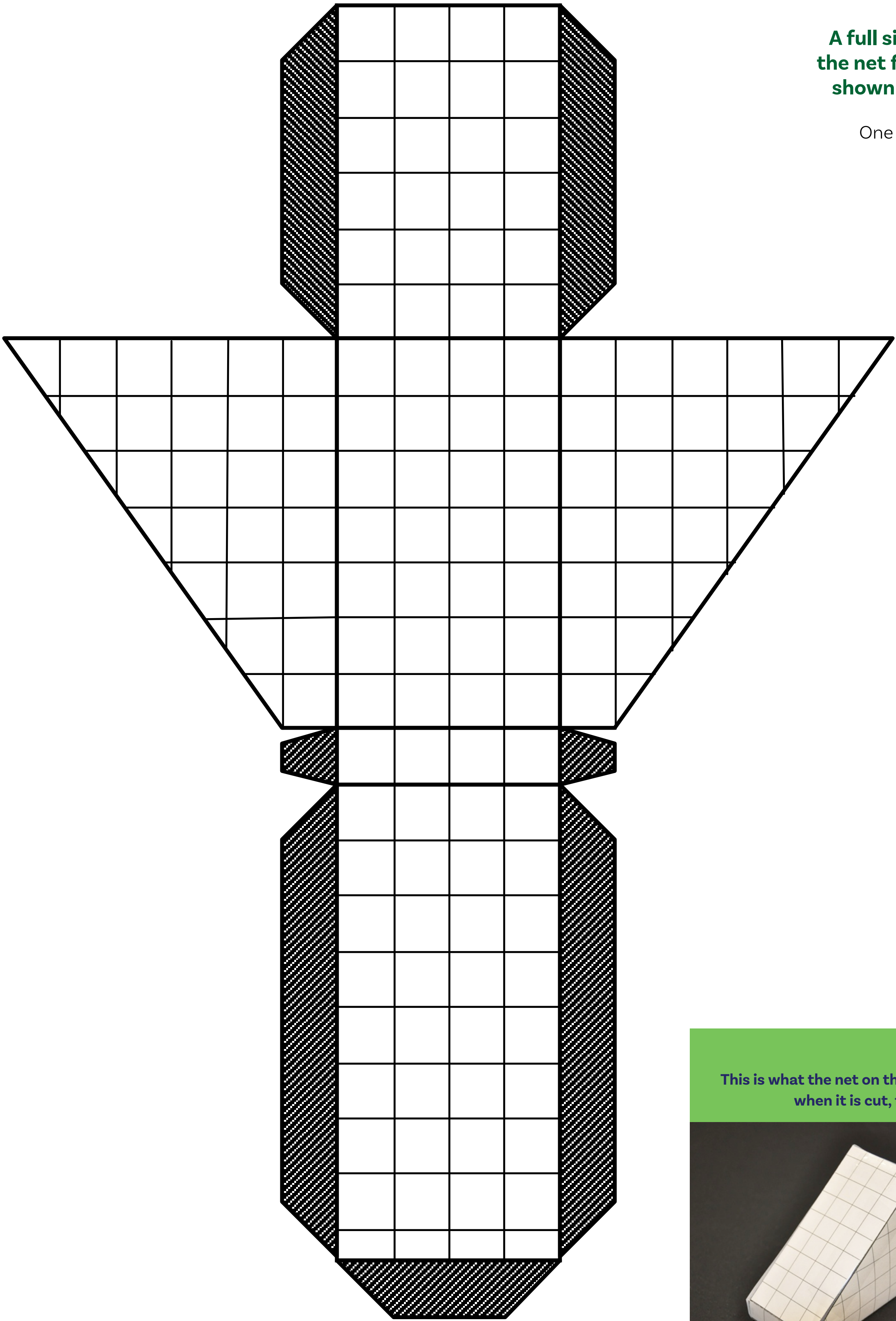
Drawing 3 is a three dimensional (3D) drawing of the mosquito net in Photograph 4.

1. Draw, cut, fold and glue the net shown in Drawing 4.
2. Calculate the surface area of the shape shown in Drawing 3 (include all six faces in your calculations).
3. Calculating angles in structures can be useful if further work needs to be done at a later time. Use your knowledge of angles (total angles in a quadrilateral) to calculate angle a.

EQUIPMENT, MATERIALS AND TOOLS

You will need:

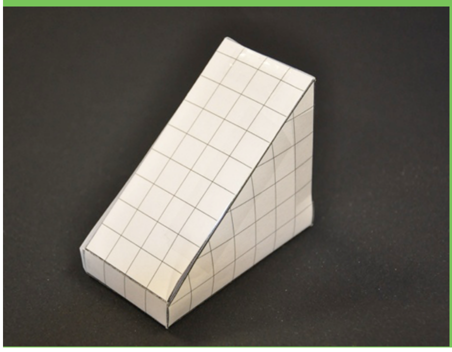
- A4 squared paper
- 30 cm ruler
- Pencil
- Scissors
- Glue stick
- Sticky tape
- Protractor



Drawing 4:
A full size version of the net for the shape shown in Drawing 3

One square = 1 cm^2

Photograph 5:
This is what the net on this page looks like when it is cut, folded and joined.



3. THE PROBLEM WITH MOSQUITO NETS (PART 1)

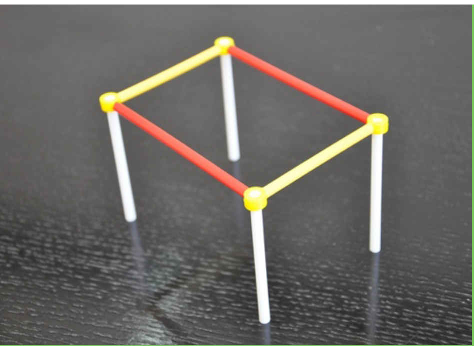
The problem

Not all of the mosquito nets supplied get used. One of the reasons for this is that some people find it difficult to hang them up above their beds.

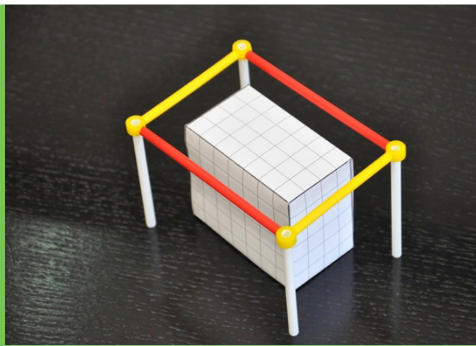
A possible solution

One way of making it easier for people to use mosquito nets would be to give them a frame that could be used to hold the net up.

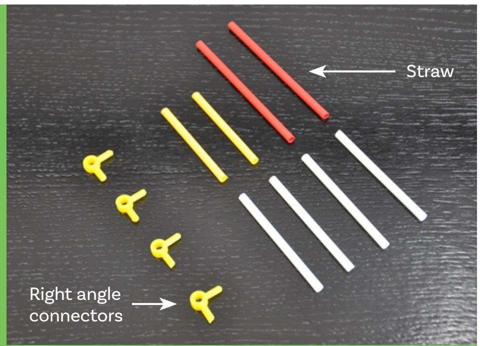
Photographs 6 and 7 show a model of a frame that could be used for tying up the four corners of a rectangular mosquito net.



Photograph 6



Photograph 7



Photograph 8

The challenge

1. Measure, mark and cut the plastic straws provided, so that you have:
   - Four 7 cm long straws
   - Two 9 cm long straws
   - Two 6 cm long straws
2. Join the straws using the right angle connectors.
3. Discuss how you could improve this mosquito net frame design. Use a sketch to illustrate your ideas. Or use the straws to make your ideas.

EQUIPMENT, MATERIALS AND TOOLS

You will need:

- Construct-o-straws or pipe cleaners
- 30 cm ruler
- Pencil
- Scissors

3. THE PROBLEM WITH MOSQUITO NETS (PART 2)

Even though they can help to save lives, not all of the mosquito nets supplied get used.

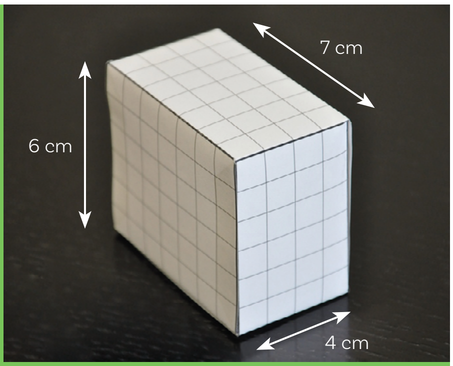
The challenge

1. Discuss the following four ideas for encouraging people to use mosquito nets.
2. Cut out the rectangles and circle below. Place the best idea (in your opinion) close to the centre of the circle below. Explain to those in your group why you think this is the best idea.
3. Now place the other rectangles down. Place the better ideas closer to the centre of the circle and your least favourite further away from the centre. Explain your choices to those in your group.

Reward	Education
Enterprise	Fear

Encouraging people to use mosquito nets

4. RATIO AND SCALE



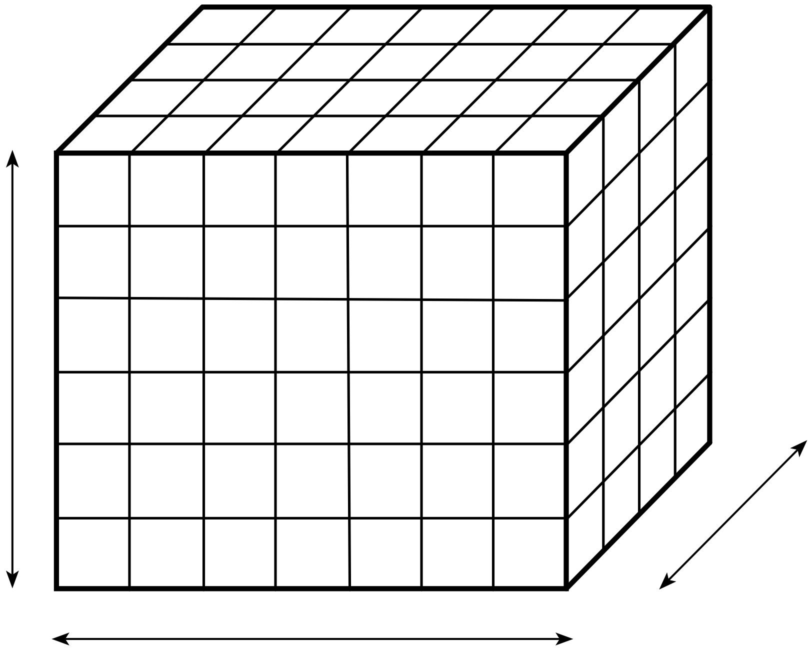
Photograph 9

The model you have made of the rectangular mosquito net is about 25 times smaller than real life rectangular mosquito nets. The **ratio** between the model and real life is 1:25.

If you multiply each of the measurements for the cuboid you have made by 25 you can find out how big a rectangular mosquito net is in real life.

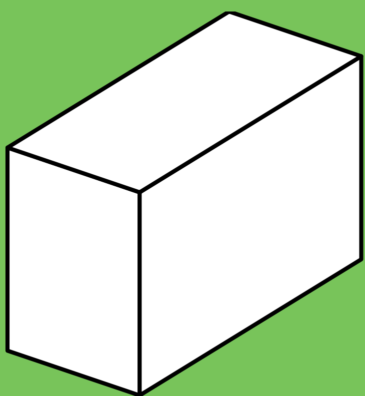
The challenge

1. Multiply the measurement of the cuboid model by 25 to find out the real life sizes of a rectangular mosquito net and label these on **Drawing 5**.
2. Convert your measurements into metres if you haven't already.



Drawing 5

Rectangular mosquito nets are made by joining rectangles of different sizes. Note that the mosquito net shown in Drawing 6 and Drawing 7 does not have a base.



Drawing 6

Drawing 7

3. Calculate the area of the rectangle of material that would be large enough to cut out all the parts needed to make a full size mosquito net. Give your answer in m^2.

4. The frame in **Photograph 10** is a 1:25 model, which means all of its parts are 25 times smaller than a full size frame.

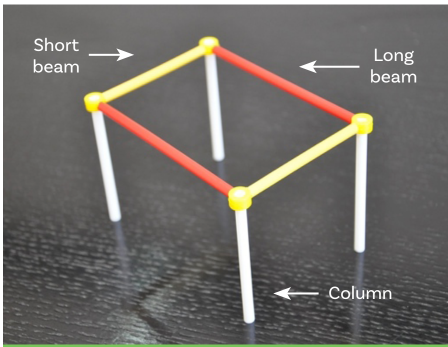
   Each of the model's four columns is 7 cm long.

   The two long beams are 9 cm long.

   The two short beams are 6 cm long.

   Complete the following table by calculating how long each of the frame's parts would be if they were 25 times larger.

Part name	Length (cm) at 1:25 scale	Full size length (cm)	Full size length (m)
Column	7 cm		
Long beam	9 cm		
Short beam	6 cm		
Combined length of 4 columns, 2 long beams and 2 short beams			



Photograph 10

5. **Photograph 11** (right) shows some strips of wood, which could be used to make a frame to hold up a mosquito net.

   If each of the strips of wood in the picture above were 2.4 m long, how many strips would you need to make four columns, two long beams and two short beams? Assume you cannot join pieces of wood together.

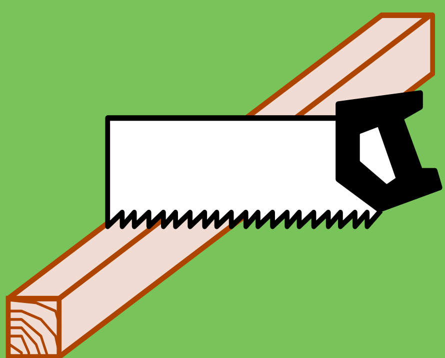
6. In order to make the wooden frame, each strip of wood would have to be cut to the correct length with a saw as in **Drawing 8**.

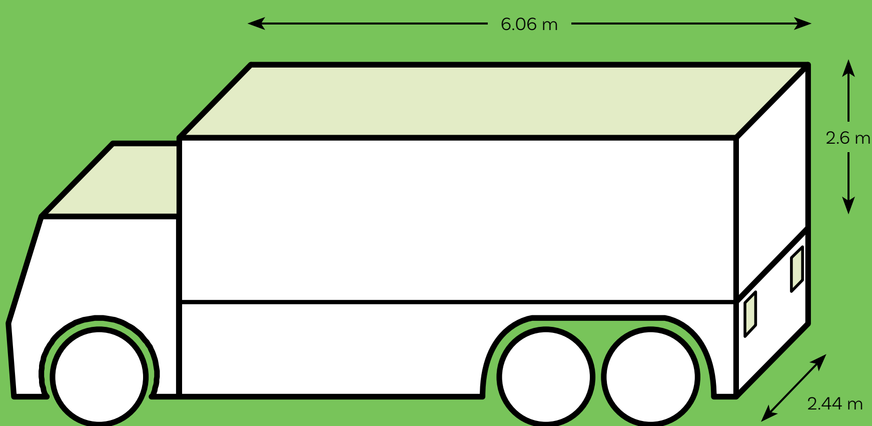
   How many metres of wood are left over after all the columns and beams have been cut?

7. The parts of the mosquito net frame fit into a box that measures 12 cm wide x 225 cm long and 12 cm high.

   Estimate how many of these boxes could fit into the lorry in **Drawing 9** below.

Photograph 11


Drawing 8



Drawing 9

DESIGN CHALLENGE

The challenge

Design a free-standing structure that could be used to support a mosquito net.

DESIGN SPECIFICATION

- It must be possible to take the structure apart.
- The structure must be made from a lightweight material.
- It must be possible to pack the structure into a volume that is 1.5 m long x 0.15 m wide and 0.10 m thick.
- The structure must be able to support a mosquito net that measures 1.8 m long x 1.3 m wide x 1.7 m high.

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1. Draw your design. Make sure your drawings show how your design fits together.
2. Label your design so that other people can see what it is made from.
3. Add real life sizes to your design drawings.
4. Use drawings and/or words to prove that it would be possible to pack the structure into a package that measures 1.5 m long x 0.15 m wide and 0.10 m thick.
5. Make a model of your design to help you communicate your ideas.

NOTES FOR TEACHERS – GUIDANCE

The context for this resource

The mathematics learning activities in this resource are set within the context of the prevention of malaria, which is a real, and everyday, problem for millions of people around the world. As a result, the first activity, *Why are mosquito nets important?* has been included to help students understand this context. However, it is not essential for students to have completed this activity before engaging with the mathematics in the other activities.

Working in groups

Students should be encouraged to complete all of these activities in groups.

Guidance for activity 1

1. Why are mosquito nets important?

This activity is an opportunity for students to develop an awareness of malaria by reviewing some key data and information about the disease.

In this activity students are asked to use the malaria data and information cards on page 2 to help them discuss the issues raised in questions 1 to 5.

Students could cut out the cards on page 2 and might use them as the basis for an activity where they present some of the data or information graphically, for example, using charts and graphs.

Guidance for activity 3

3. The problem with mosquito nets (part 2)

This is a discussion activity that could be used to enrich the STEM subjects as well as other areas of the school curriculum, such as PSHE and English. For example, PSHE requires students to develop an understanding of health and wellbeing and living in the wider world. And in English students need to be taught to "articulate and justify answers, arguments and opinions".

Getting started
A suitable starting point for this activity would be to have a discussion with the students about the different ways people might be encouraged to use mosquito nets. Brief descriptions of the forms of encouragement presented in the resource are given below.

Reward
People who use their mosquito nets might be a given a reward, such as a sum of money or a gift. The size of the reward might be greater for those people who don't delay in setting up mosquito nets for their family.

Education
Educating people about the effects of a disease and how to avoid catching it can help motivate people to take action.

Enterprise
Some people might not have the energy or skill to set up a mosquito net for their family. However, with a bit of encouragement, some people might see this as an opportunity to provide a mosquito net installation service and build a business around this.

Fear
Fear of the terrible effects of a disease might be used to scare people to take action to prevent harm to themselves and their children.

Developing the discussion
The next step for this activity might be to discuss the pros and cons of each form of encouragement. Students would then be in position to select their preferred form of encouragement and justify their choice. A discussion of the pros and cons might also help students to prioritise the different forms of encouragement.

NOTES FOR TEACHERS – ANSWERS

This section provides answers to the questions that require students to complete calculations.

2. Making nets (part 1)

2. The area of the net in Drawing 2 = 188 cm^2.

   If students have used paper with a 1 cm square they could check their answer by counting the number of squares covering the surface of their cuboid or net.

   The volume of the cuboid = 168 cm^3

2. Making nets (part 2)

2. The surface area of the shape in Drawing 3 = 139.4 cm^2

   This question could be approached using different strategies. For example:

   Strategy 1
   Students might calculate the surface area of the shape shown in Drawing 3 using measurements taken from the net they have drawn and cut out.

   Strategy 2
   Students that do not take measurements from the net they have drawn and cut out will need to know how to calculate the area of a right-angled triangle and how to use Pythagoras' theorem to calculate the length of h (see **Figure 1**).

3. Angle a = 125°

Drawing 3

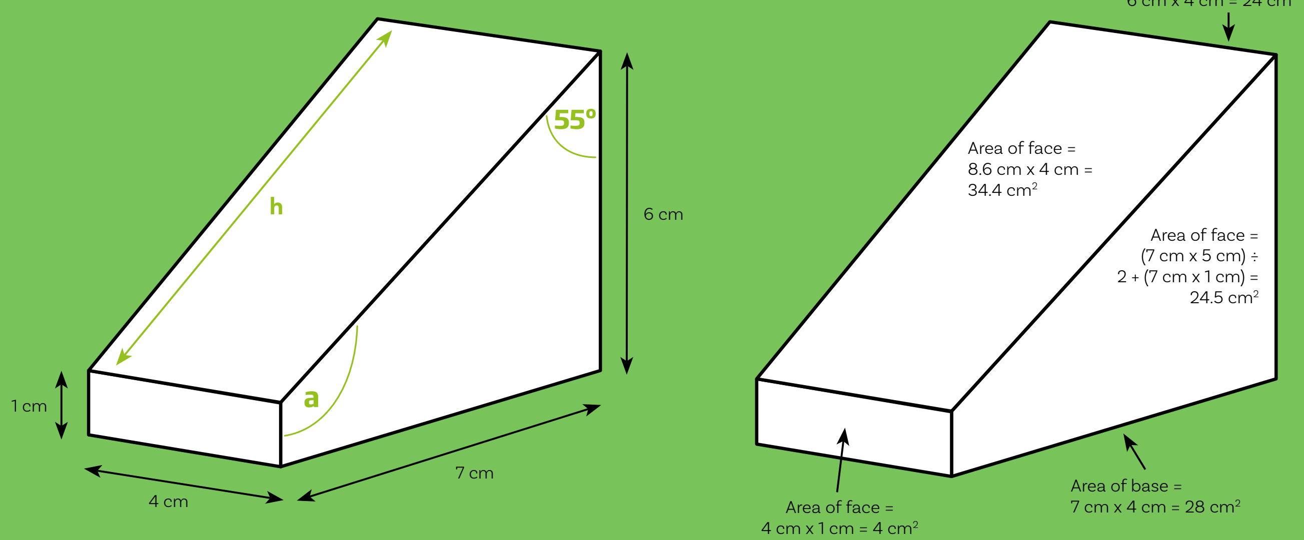


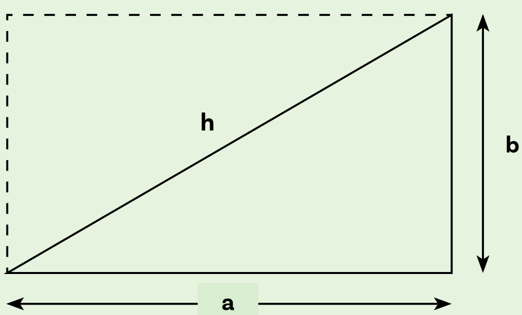
Figure 1

Area of a right-angled triangle

$$\text{Area} = \frac{(a \times b)}{2}$$

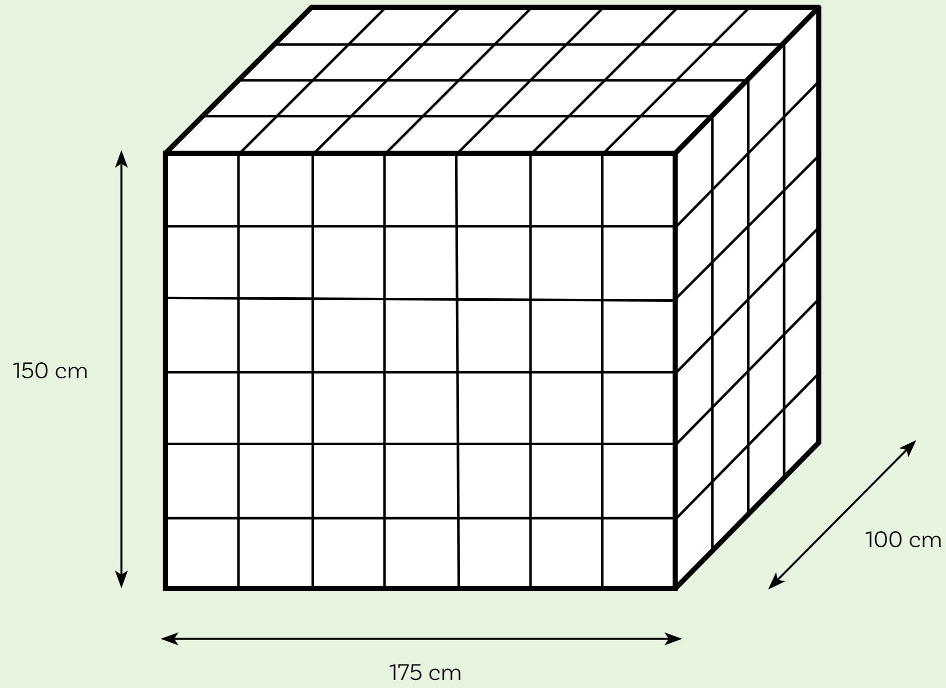
Pythagoras' theorem

$a^2 + b^2 = h^2$ h stands for hypotenuse



4. Ratio and scale

1.



3. The area of the rectangle required to cut out the parts needed to make a full size mosquito net =

   The area of the top of the net + area of the long sides + area of the short sides =

   (1.75 m x 1 m) + 2 x (1.75 m x 1.5 m) + 2 x (1.5 m x 1 m) =

   1.75 m^2 + 5.25 m^2 + 3 m^2 = 10 m^2

   This question could be used as a link to a discussion on area/volume scale factors.

4.

Part name	Length (cm) at 1:25 scale	Full size length (cm)	Full size length (m)
Column	7 cm	175 cm	1.75 m
Long beam	9 cm	225 cm	2.25 m
Short beam	6 cm	150 cm	1.5 m
Combined length of 4 columns (4 x 1.75 m), 2 long beams (2 x 2.25 m) and 2 short beams (2 x 1.5 m)		1450 cm	14.5 m

5. Eight strips of wood would be needed as multiple columns and/or beams cannot be cut from a 2.4 m length of wood.

6. 4.7 m of wood is left over once all the columns and beams have been cut.

   Example:

   Wood left over after cutting 4 columns = 2.4 m – 1.75 m x 4 = 0.65 m x 4 = 2.6 m

   Wood left over after cutting 2 long beams = 2.4 m – 2.25 m x 2 = 0.15 m x 2 = 0.3 m

Wood left over after cutting 2 short beams = 2.4 m – 1.5 m x 2 = 0.9 m x 2 = 1.8 m

Total = 2.6 m + 0.3 m + 1.8 m = 4.7 m

7. This question could be approached using different strategies. For example:

Strategy 1
Calculate the volume of one mosquito net frame box and the volume of the lorry's container. Then calculate how many times the volume of the box fits into the lorry's container volume.

Example:

Mosquito net box volume = 2.25 m x 0.12 m x 0.12 m = 0.03 m^3.

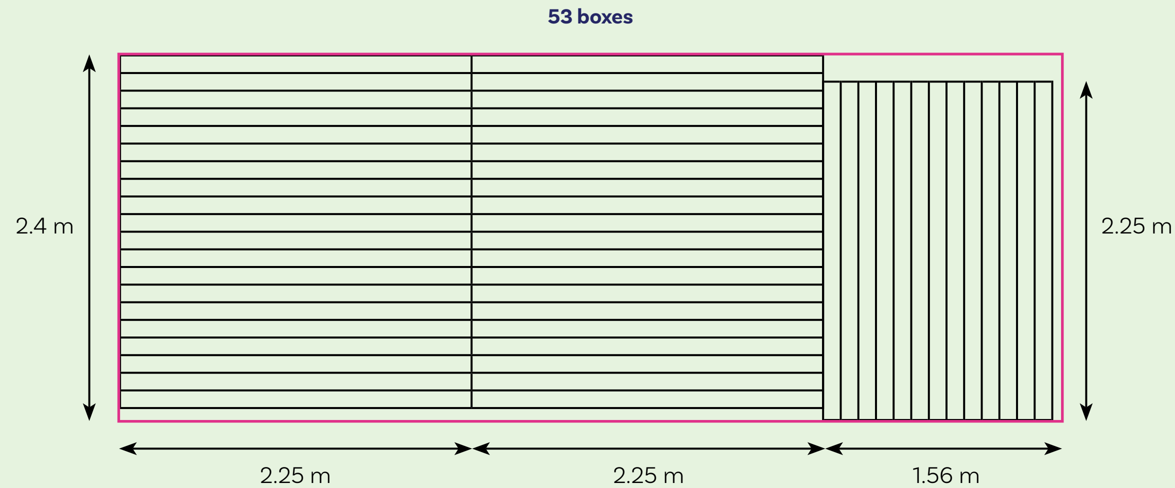
Lorry volume = 6.06 m x 2.44 m x 2.6 m = 38.44 m^3.

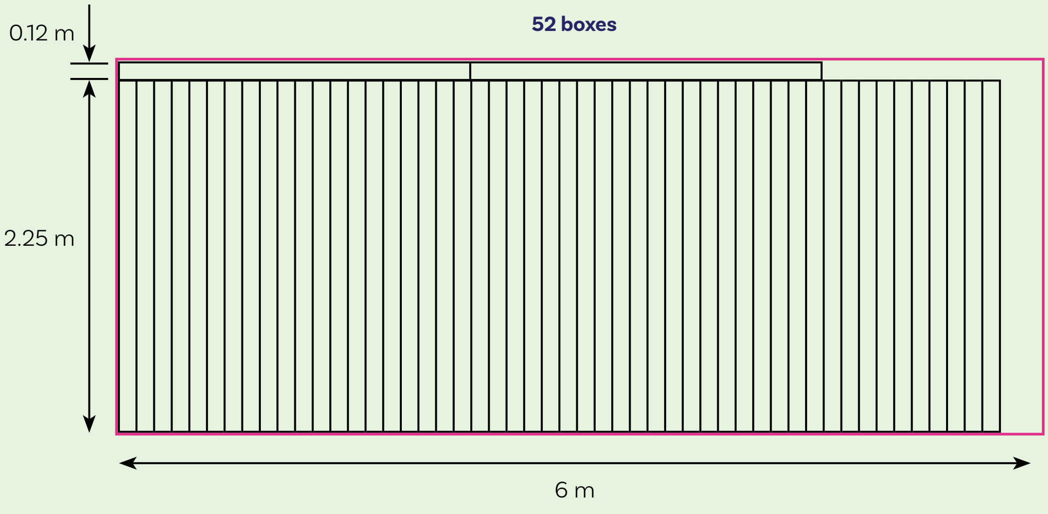
38.44 m^2 ÷ 0.03 m^2 = 1281.33 boxes.

The problem with this approach is that it wouldn't be possible to physically pack this number of boxes into the lorry's container because the dimensions of the boxes are fixed.

Strategy 2
Start by investigating how the maximum number of boxes might be arranged in a single layer on the floor of the lorry's container.

Examples:
Container dimensions 6.06 m long, 2.44 m wide and 2.6 m high





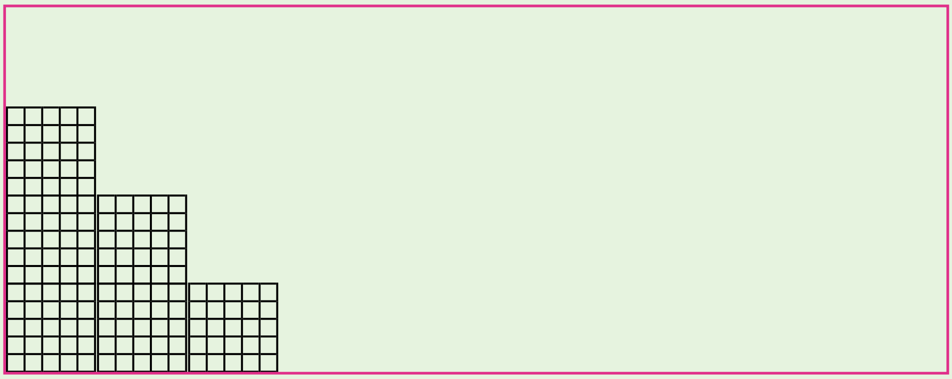
Then, calculate how many layers would fit into the lorry's container.
The container's height is 2.6 m and the height of one layer of boxes is 0.12 m.
So, the number of layers that can be packed into the container is:

2.6 m ÷ 0.12 m = 21.67.

Part boxes cannot be packed, so it would only be possible to pack 21 layers of 53 boxes.

53 x 21 = 1113

Strategy 3
An alternative strategy might be to pack the boxes on their ends.
For example:



Additional ideas to extend the task

There are lots of ways to link this task to other STEM subjects and even to subjects outside of STEM by looking at the moral/geographical/political aspects of fighting malaria.

Examples of possible links to STEM subjects include:

- Biology – spread of infection
- Design and technology – smart fabrics and the process of designing and building a frame
- Physics – airflow through nets
- Chemistry/Biology – use of pesticide treated malaria nets

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