TECHNOLOGY

Grade 8

Book 1

CAPS

Learner Book

Developed and funded as an ongoing project by the Sasol Inzalo Foundation in partnership with the Ukuqonda Institute.

Published by The Ukuqonda Institute
9 Neale Street, Rietondale, 0084
Registered as a Title 21 company, registration number 2006/026363/08
Public Benefit Organisation, PBO Nr. 930035134
Website: http://www.ukuqonda.org.za

First published in 2013

ISBN: 978-1-920705-02-2

This book was developed with the participation of the Department of Basic Education of South Africa with funding from the Sasol Inzalo Foundation.

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Layout and typesetting: Lebone Publishing Services

Thanks for free sharing of ideas, and free access to photographs, to:
Cape Peninsula Fire Protection Association, National Sea Rescue Institute, Beate Hölscher (South African Environmental Observation Network), The Transitions Collective (www.ishackliving.co.za).

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Table of contents

Term 1

Term 2

TERM 1

Chapter 1
Roofs and pylons

In this chapter, you will learn more about **frame structures**.

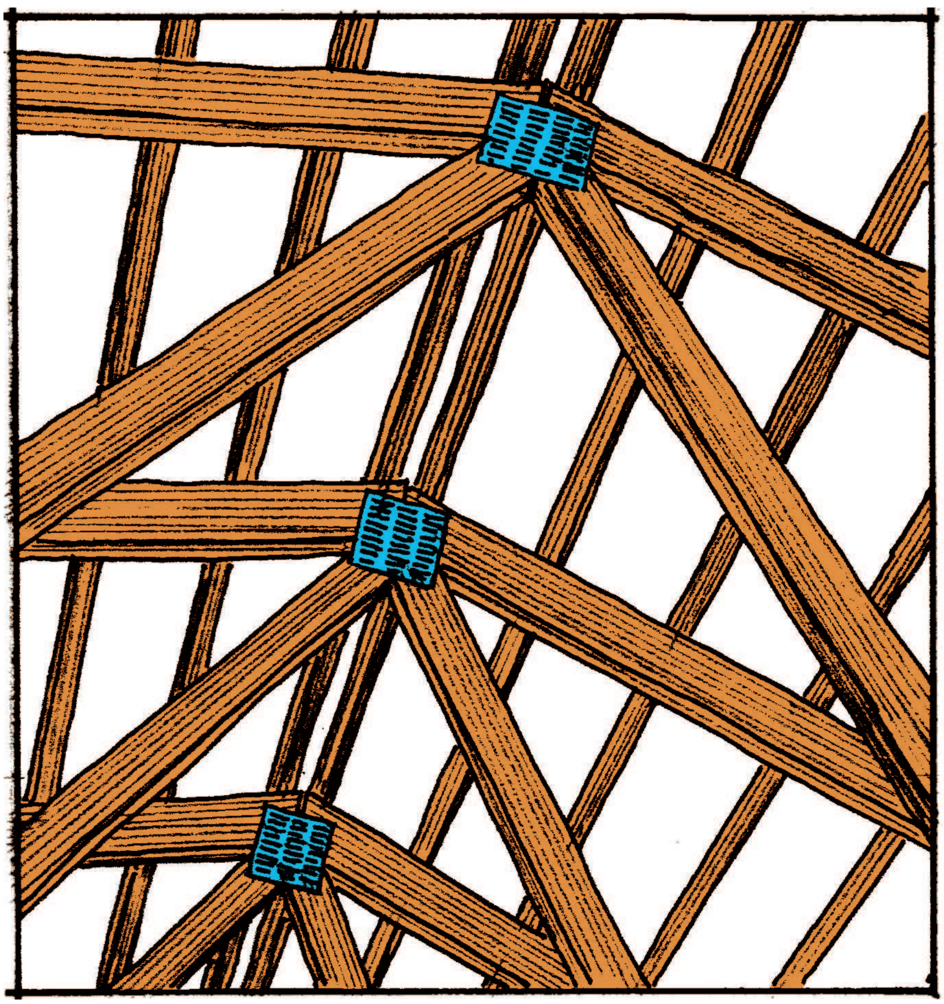


Figure 1: Internal view of a roof structure

Figure 2: Different types of electricity pylons

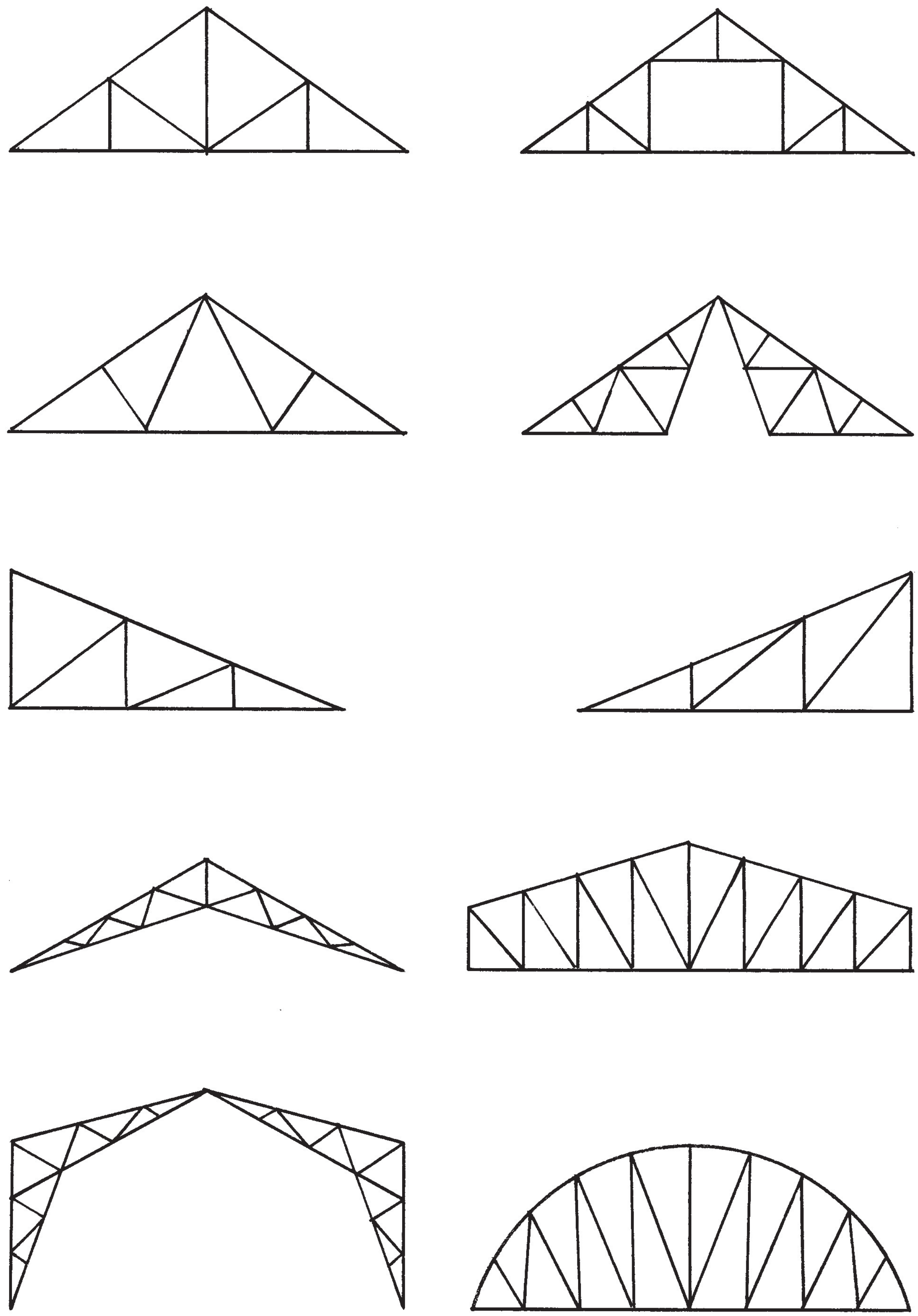


Figure 3: Different types of roof trusses

1.1 How can you make a roof withstand the forces acting on it?

People make and build many different kinds of things, such as houses, motor cars, roads and dams. We also make items like bottles, clothes, books and furniture. Some things, like forks and spoons and knives, are **solid objects** that consist of one part only. Other objects, like bottles, pots and water tanks, are hollow objects that can also be called **shells**. We also make objects that consist of different parts that are put together, like chairs, tables and bridges. These objects are called **frame structures** and it is important to try to make frame structures strong.

Learn about roofs

Fold a sheet of cardboard in the middle so that it looks like the roof of the house in Figure 4.

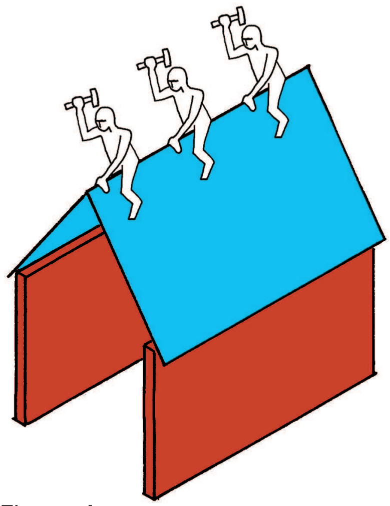


Figure 4

1. Use your hand to press down on the cardboard roof. What happens?

   ....

2. Your house's roof plates may be very strong and will not bend. But what will happen when a couple of big men sit on the roof to fasten the roof sheets?

   ....

   ....

One way to make a roof stronger is to use more and thicker materials. However, this is not always a good plan since it will cost a lot more money. It can also make the roof so heavy that the walls of the building are not strong enough to carry it.

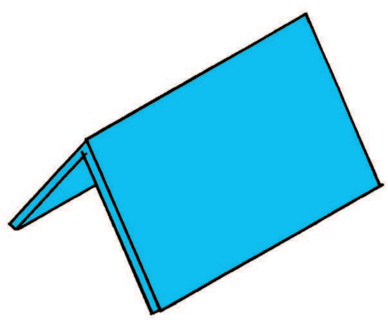


Figure 5

A few ways to strengthen a cardboard roof model are shown in the sketches below.

3. Look carefully at each of the sketches. Then write a sentence for each sketch to describe the method to strengthen the roof by **bracing** it.

The word "brace" comes from the French word "bras", which means "arm". When you brace a structure, you put in something like an extra arm to make it stronger.

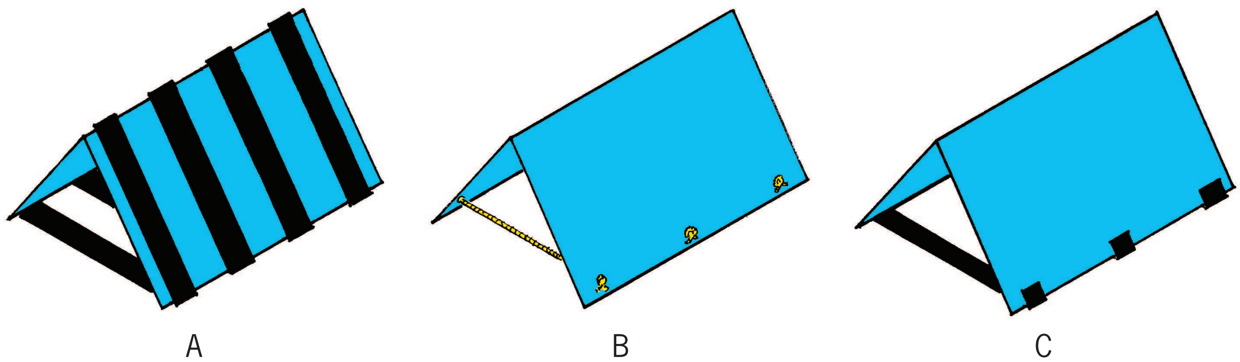


Figure 6

(a) Case A: ....

....

(b) Case B: ....

....

(c) Case C: ....

....

Many roofs are supported by frame structures called **trusses**. Trusses can be made of wood or steel. The different parts of a truss are called **members**. Each truss has a vertical member in the middle. This is called a **king post**.

In some truss designs, there are more vertical members. You can see more roof truss designs on the first pages of this chapter.

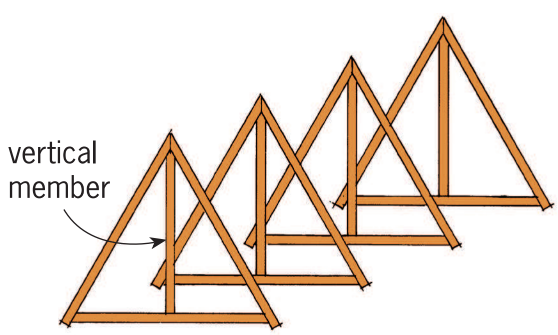


Figure 7: Incomplete roof trusses

Roof trusses have to support the weight of the roof materials, such as roof sheets.

4. What part of the roof trusses shown here will prevent them from tearing apart when the roof sheets are loaded onto them? Mark this part on one of the roof trusses on Figure 8.

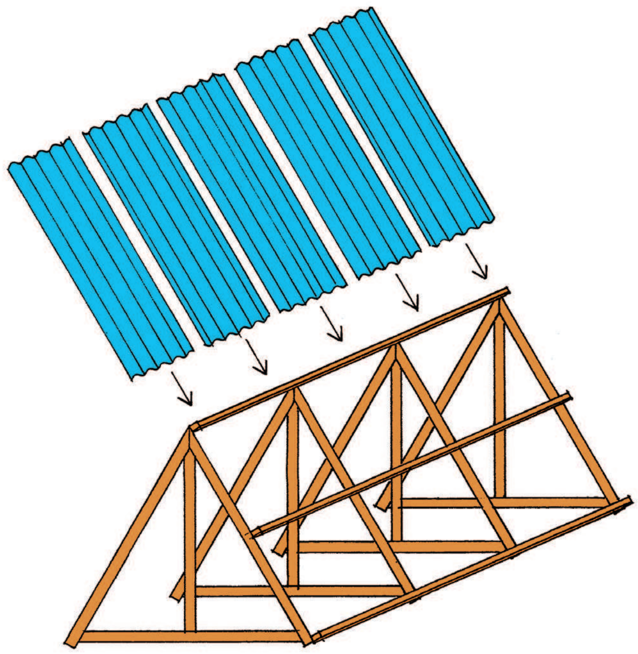


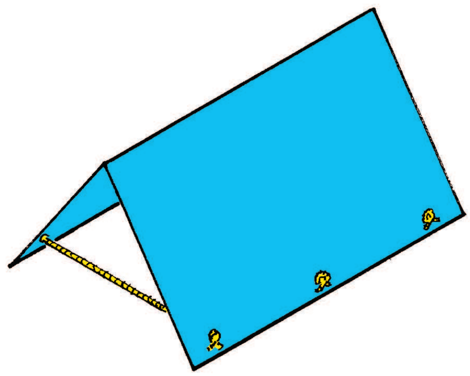
Figure 8

The horizontal member at the bottom of a truss prevents the two sides from ripping apart. Instead of a plank, a rope or a wire can be used to tie the bottom ends of the two sides together. When a plank or piece of steel is used for this purpose, it is called a **tie beam**.

A tie beam has to be strong enough so that it will not rip apart by the forces acting on it. The weight of the roof plates pressing down on the trusses can cause the ends of the trusses to pull apart.

You can say that there is **tension** in the tie beam, just like there is tension in a rope you pull.

Forces that cause tension are called **tensile forces**.



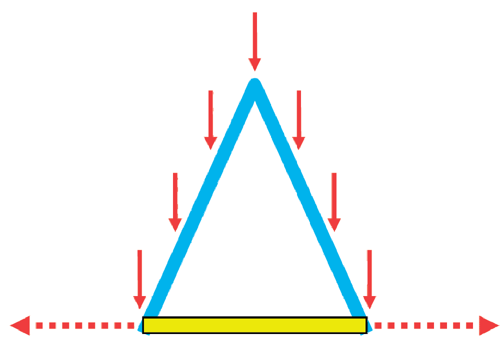


Figure 9: The yellow tie beam is under tension.

1.2 More types of forces

Making a roof even stronger

The two sloping members on the sides of horizontal beam in Figure 10 are called **rafters**.

1. Write the name of each of the four members next to the member on the diagram in Figure 10. This is called adding **labels** to the diagram.

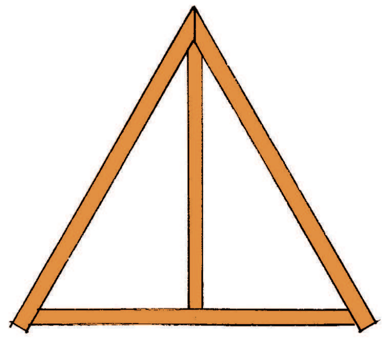


Figure 10

The rafters may bend when the wind blows against the roof, or when a heavy load is placed on the roof.

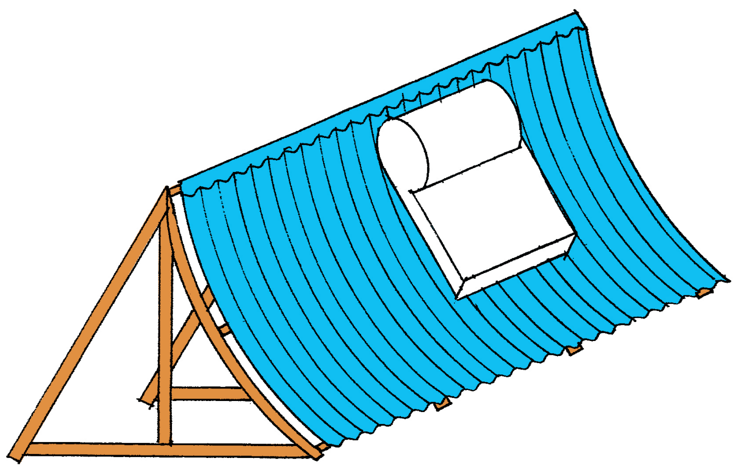


Figure 11

2. What can you do to strengthen the trusses so that the rafters will not bend when a heavy load is acting on them? Make a sketch here to show your plan.

The trusses on the right have **struts** to support the rafters.

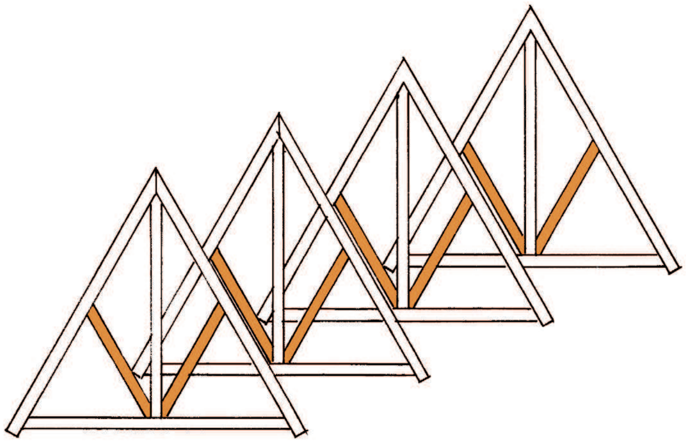


Figure 12

The two photographs below demonstrate the kind of force that acts on roof struts. When a force acts like this, it is called a **compressive force**.

Figure 13: Compressive forces acting on beams

A force that is able to stretch or pull something apart is called a **tensile force**.
A force that is able to compress or squash something is called a **compressive force**.

Torsion and shear force

1. Roll a sheet of paper into a tube and twist it like the person in the photograph is twisting the towel. By doing this you apply a **torsion** force on the paper tube.

Figure 14

2. Press your two hands together tightly as shown in this photograph. Then rub them against each other.

Figure 15

If you put a piece of clay between your hands while you do this, the shape of the clay will change. The force applied by your rubbing hands is called **shear force**.

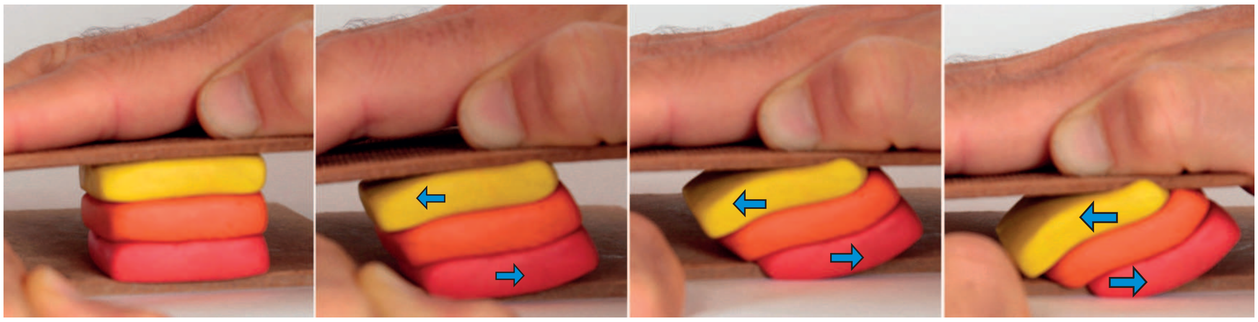


Figure 16

Figure 17 shows two pieces of wood joined with a bolt. If the two pieces of wood are pulled apart or pushed together, a shear force will act on the bolt. This can cause the bolt to bend or even to crack. A thicker bolt will resist a shear force better.

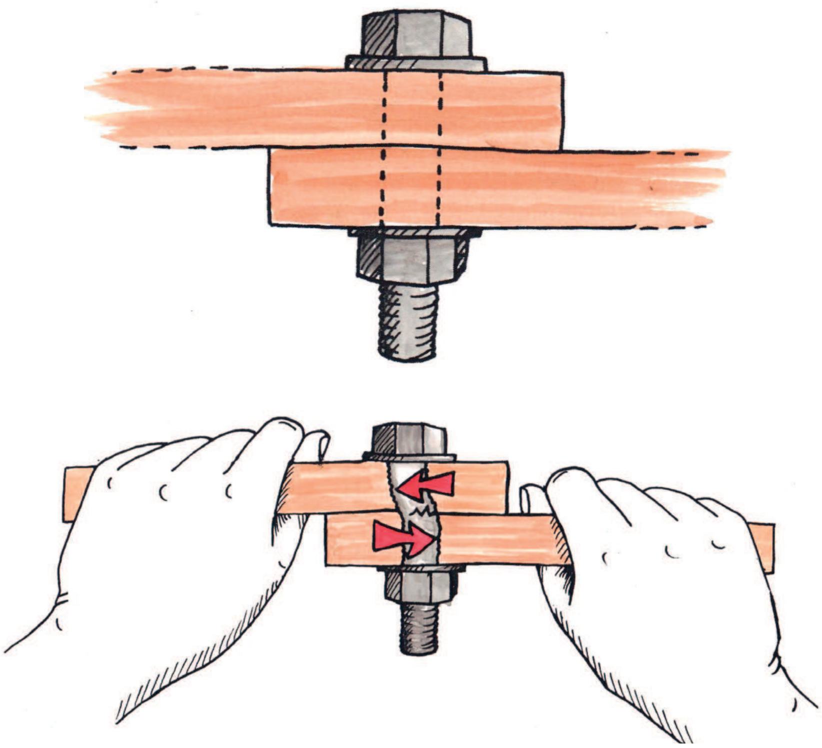
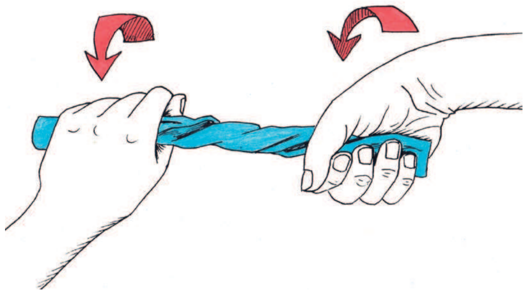
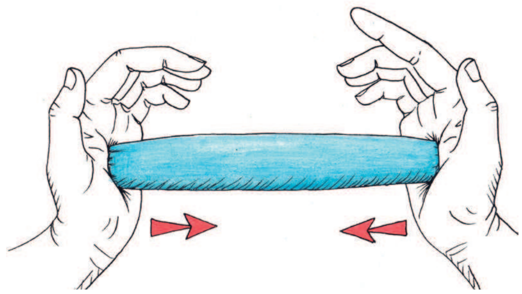


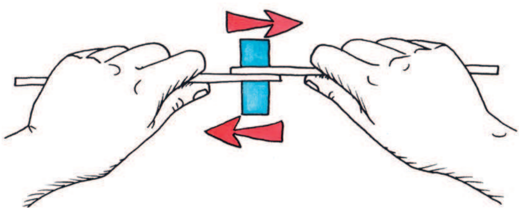
Figure 17

Revise what you have learnt in Grade 7

1. In each case, say which kind of force is demonstrated in the picture.







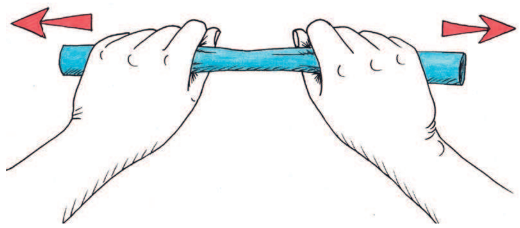


Figure 18: Different types of forces

2. Will this roof structure work well?

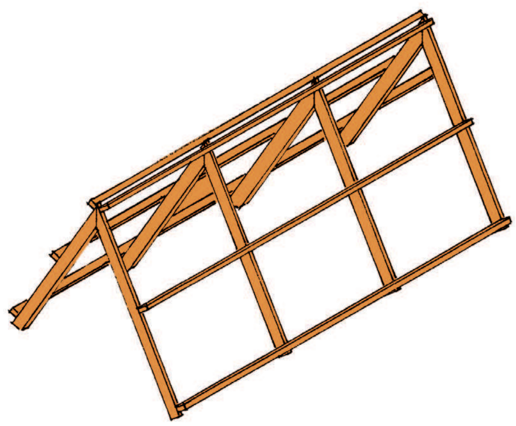


Figure 19

Describe what could go wrong when roof plates or tiles are put on this roof structure.

Trusses like the ones in the drawings below are called **queen-post** trusses. The two vertical members are called queen-posts. They are shaded in Figure 20.

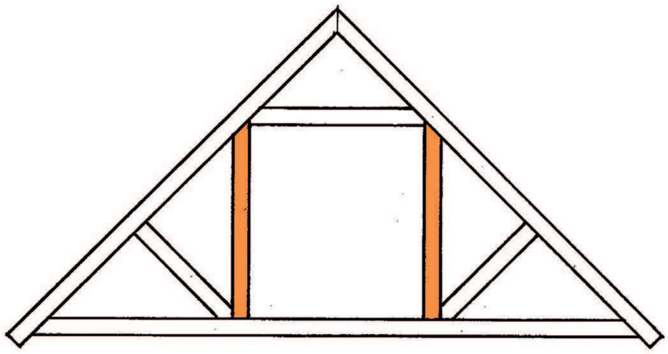


Figure 20

3. Figure 21 is a drawing of another type of queen-post truss. Shade the queen-posts on the drawing.

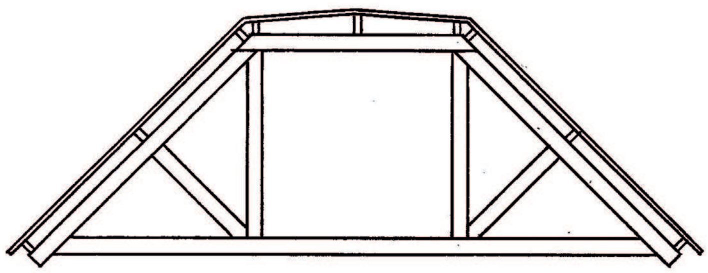


Figure 21

4. On Figure 22, label members under compression with a "C" and members under tension with a "T". Do this for all the members except for the rafters.

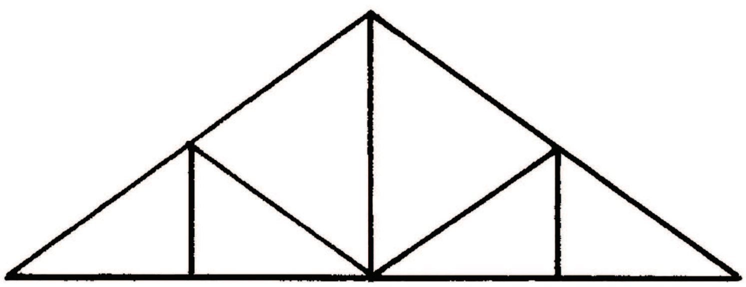


Figure 22

1.3 Electricity pylons

Different designs of electricity pylons

1. Look at the pictures below and on the next two pages. What purposes do these structures serve? Why do we built them?

....

....

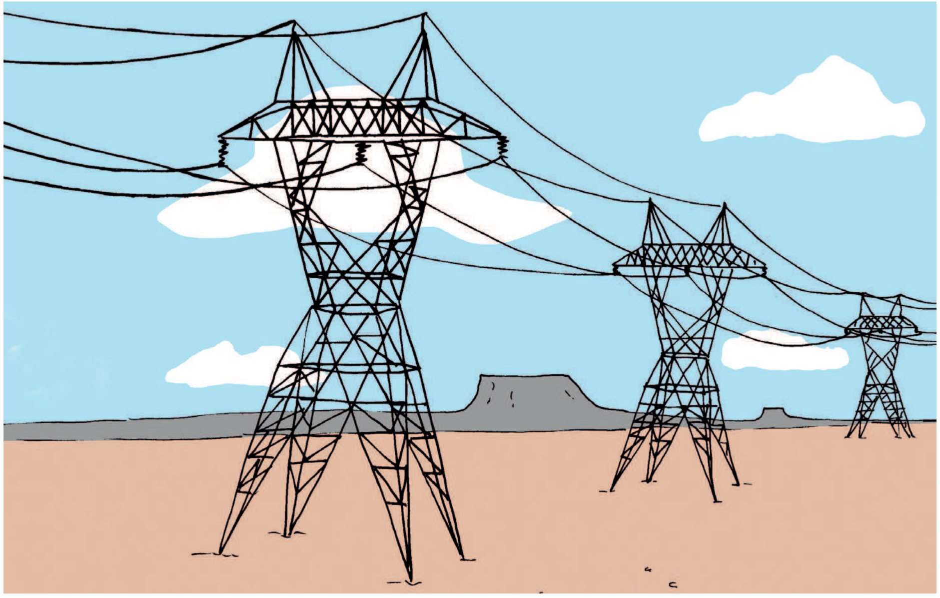


Figure 23

2. Why do you think the pylon in Figure 24 is designed the way it is, and not in the way shown in Figure 25?

....

....

....

....

....

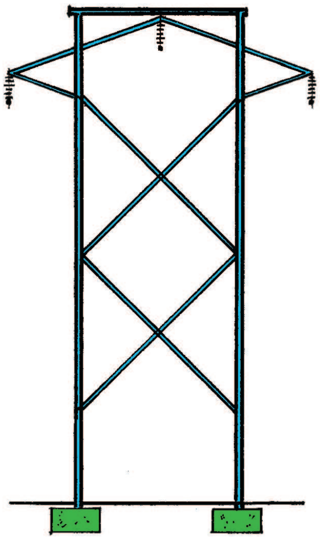


Figure 24

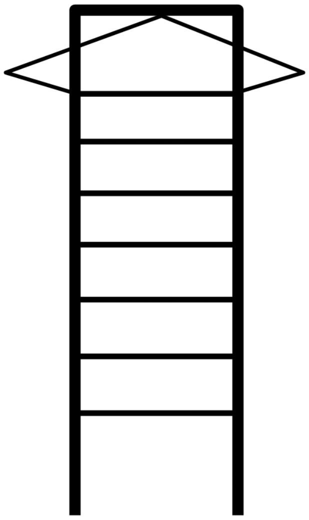


Figure 25

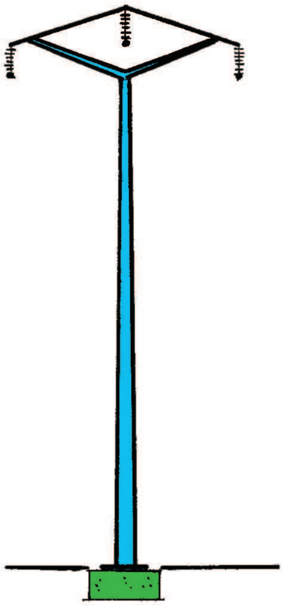


Figure 26

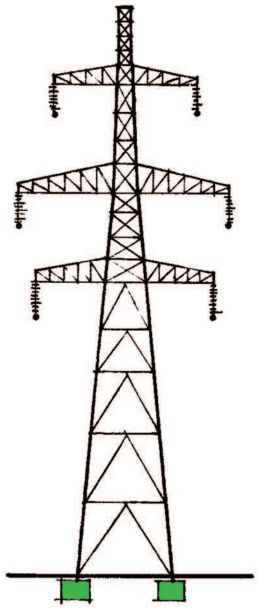


Figure 27

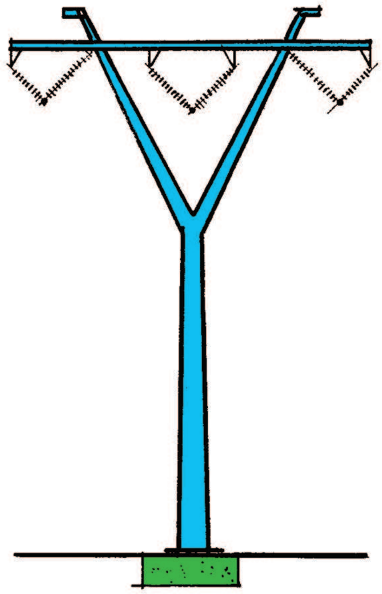


Figure 28

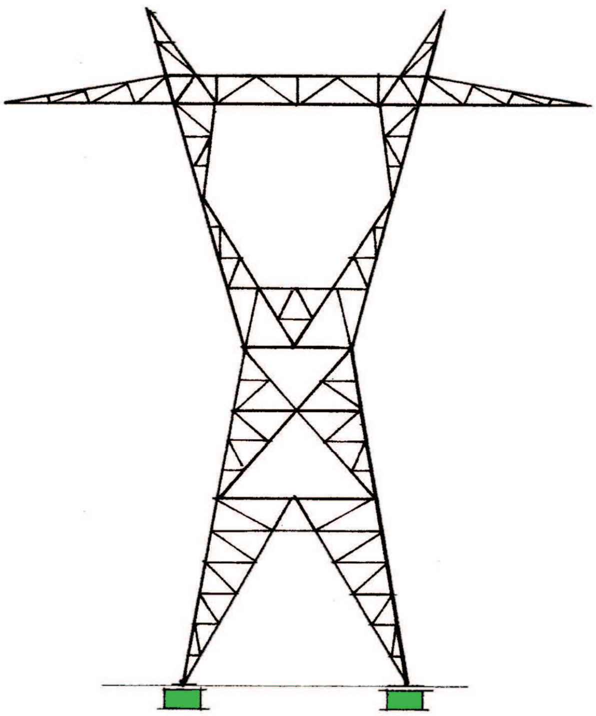


Figure 29

The pylons in Figures 26 and 28 are solid structures made from concrete. All the other pylons are steel frame structures.

3. What do you think is indicated by the green parts of these drawings?

....

....

Making a structure rigid using only a little material

Forces that act on a rectangular frame can make it skew:

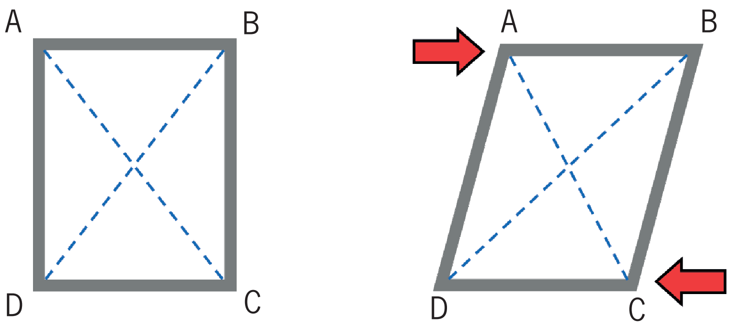


Figure 30: *Skewing of a rectangular frame*

> You can also use the word skew as a verb:
> You can say the "forces **skew** the frame".
> Or you can say that the "forces **are skewing** the frame".

1. What happens to the lengths of the lines AC and BD when the frame skews? Go measure it and find out!

To prevent a frame from skewing, a support can be inserted to **triangulate** it:

> A support inserted to triangulate a frame can also be called a **brace**.

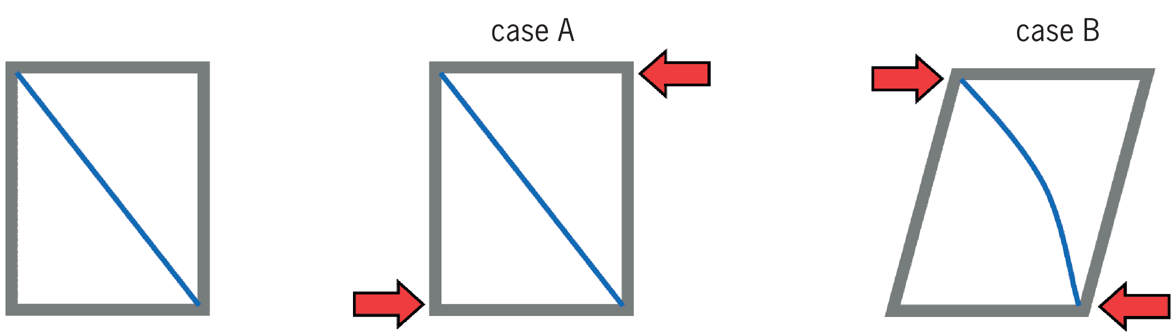


Figure 31: *Simple triangulation of a frame*

2. Compare what happens when you apply forces as in case A and case B.
   (a) Why does the frame keep its shape in case A but changes shape in case B? Hint: Think about the type of forces acting on the blue beam.

(b) How can you improve the design of the frame so that forces cannot make it skew?

....

....

Another way to prevent a frame from skewing is to triangulate it twice, to make a cross. One brace goes from the top left to the bottom right of the rectangle. The other brace goes from the top right to the bottom left of the rectangle.

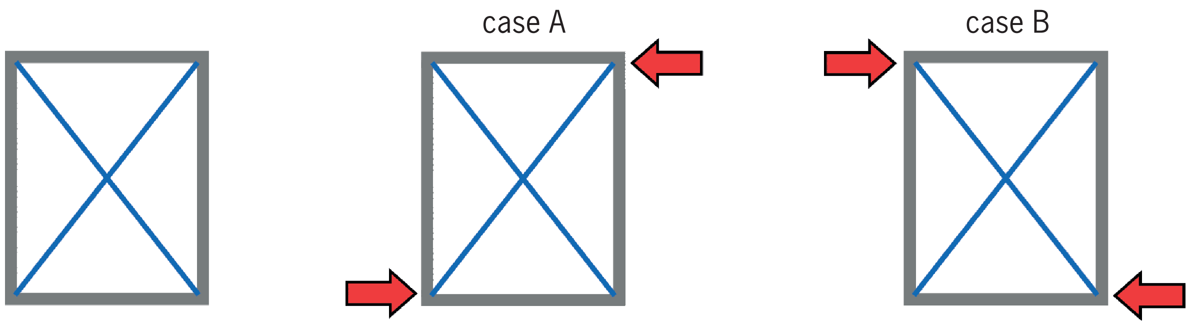


Figure 32: Cross-bracing a frame

This is called **cross-bracing**. It is a special kind of triangulation. With cross-bracing, the frame does not skew when forces are applied as in case A or case B.

3. Compare the frame design in Figure 31 with the one in Figure 32.
   (a) Can you use steel cables instead of beams for the braces in both of these frame designs? Explain your answer.

....

....

....

....

   (b) If you use steel beams as braces for both frame designs, do you have to use the same thickness beams in both designs? Or can you save material and use thinner braces in one of the designs?

....

....

....

....

How to make a tower resist twisting

The structure of a tower should resist changing shape. Two different ways of changing shape are shown below.

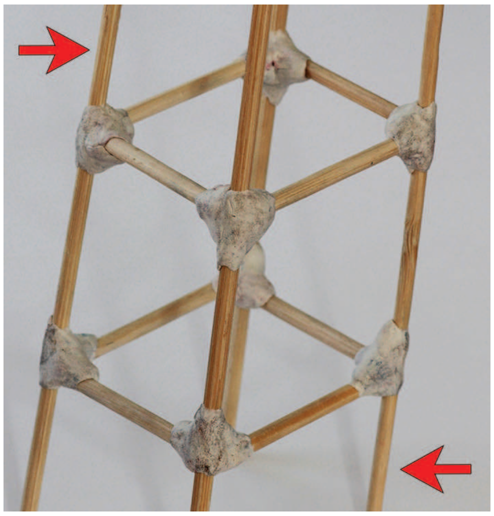


Figure 33: Skewing

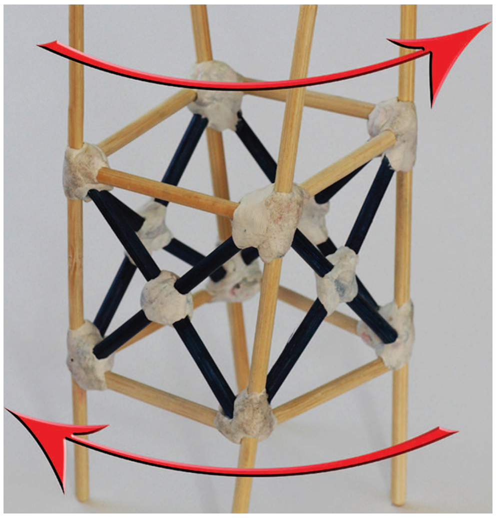


Figure 34: Twisting

Using triangulation or cross-bracing on the outside of a frame helps the frame to resist skewing. But it does not prevent it from twisting, as shown in Figure 34.

Twisting happens when torsion forces act on a structure, as shown by the red arrows in Figure 34. To prevent a tower structure from twisting, you can use cross-bracing *inside* the frame structure. The photos below show how a frame structure can be built with cross-bracing on the inside and on the outside. The cross-bracing on the inside is in red, and the cross-bracing on the outside is in dark blue.

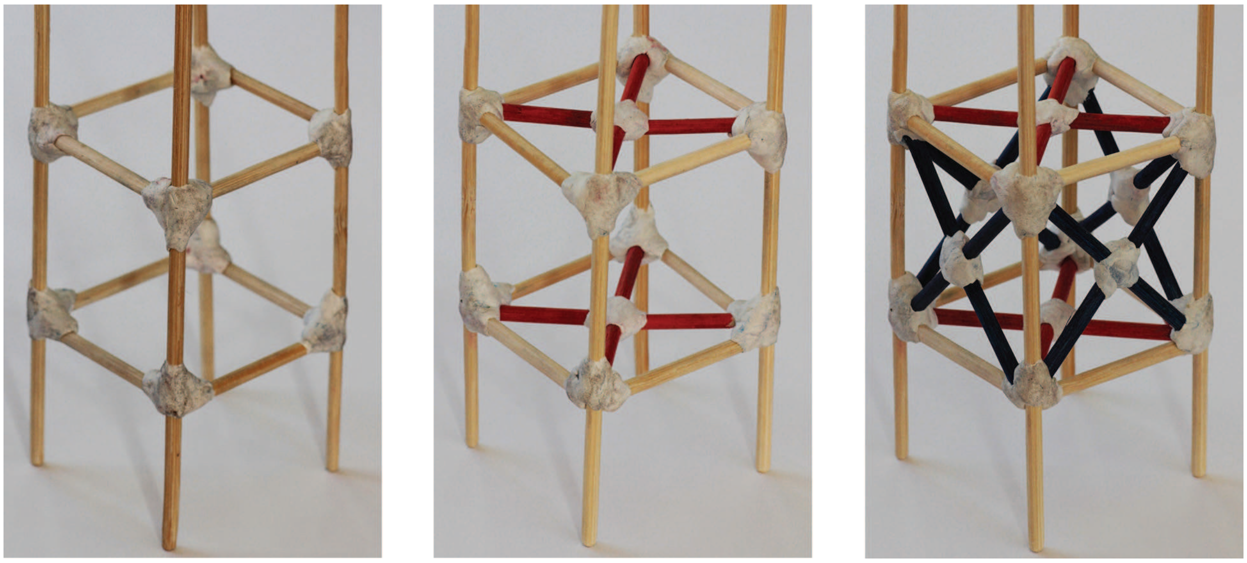


Figure 35: Internal cross-bracing

Chapter 2
Buildings and bridges

In this chapter, you will learn about bridges and other structures that span over spaces. You will learn about different types of bridges, and different ways of making bridges stable and strong.

You will need corrugated cardboard and a pair of scissors to do the work in this chapter. You will also need some sticky tape.

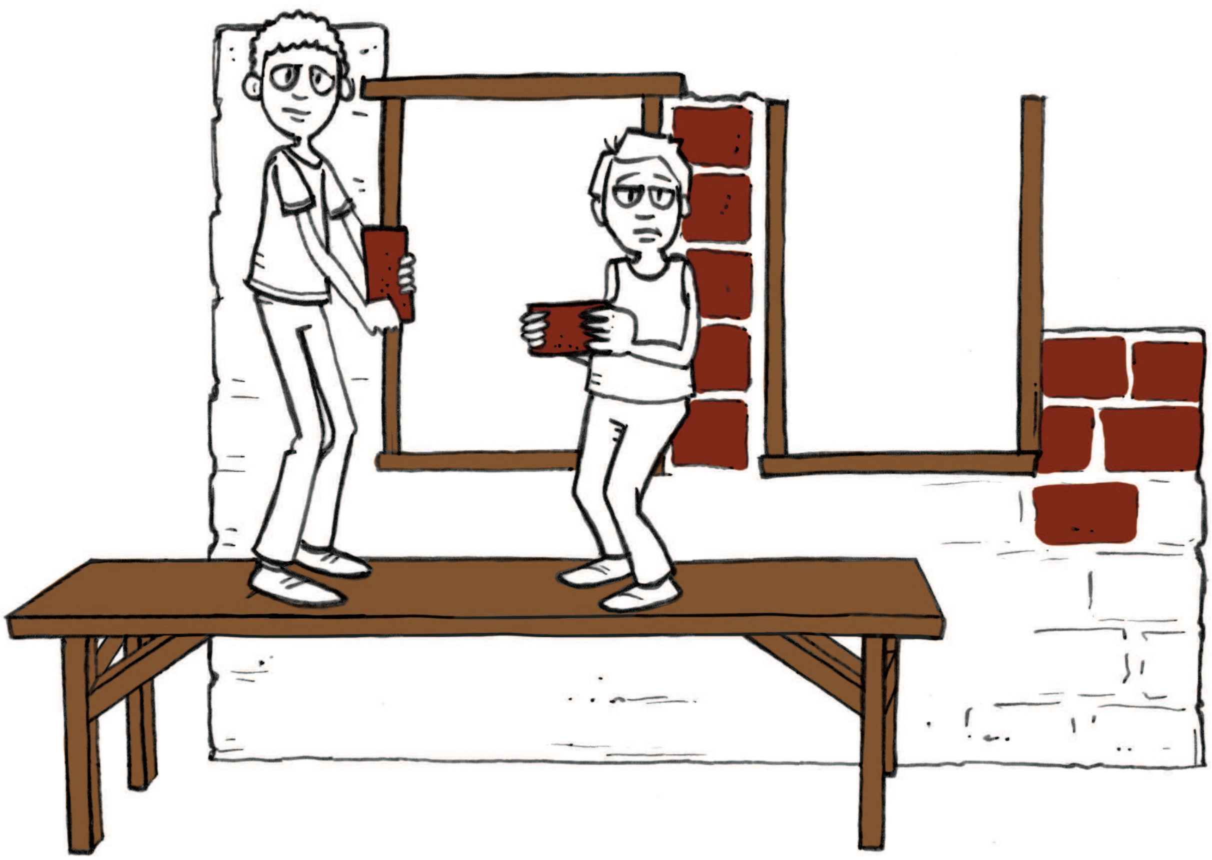


Figure 1: How can the builders lay bricks over the window?

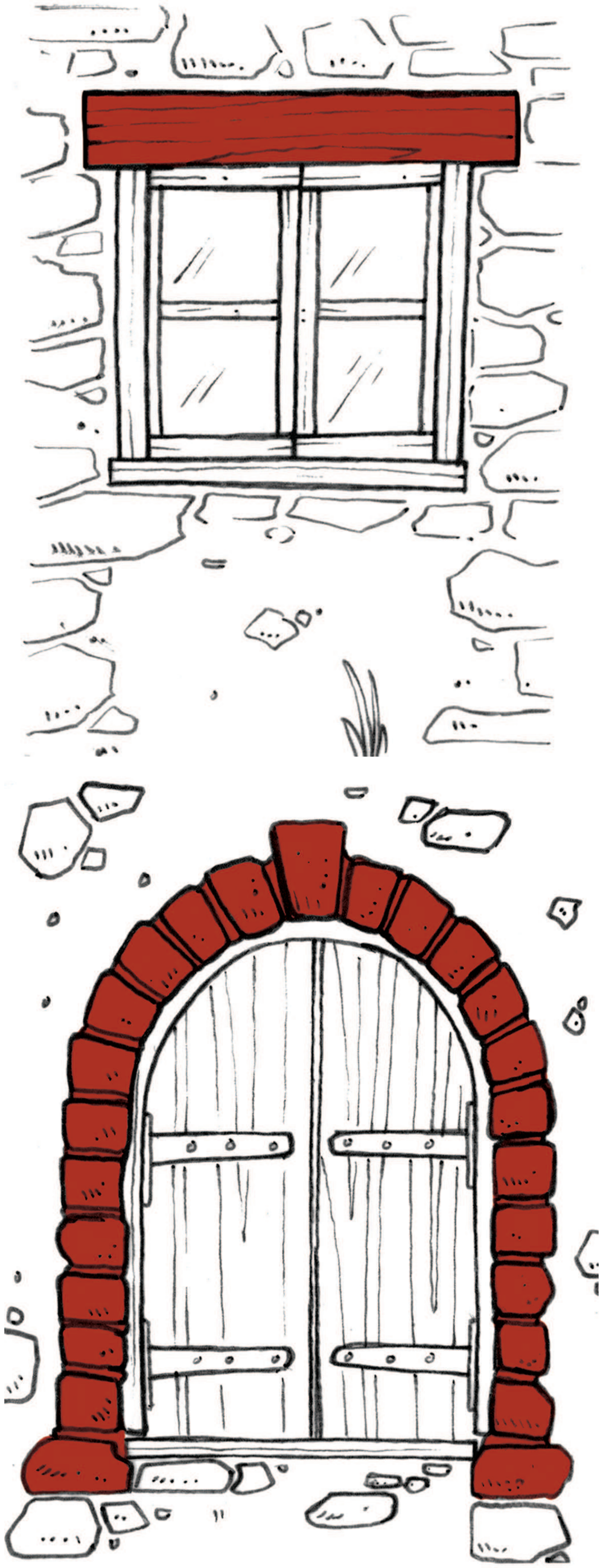


Figure 2: Different ways of supporting the wall above a window or a door.

Figure 3: What is this structure for? How is it supported?

2.1 Windows and tables

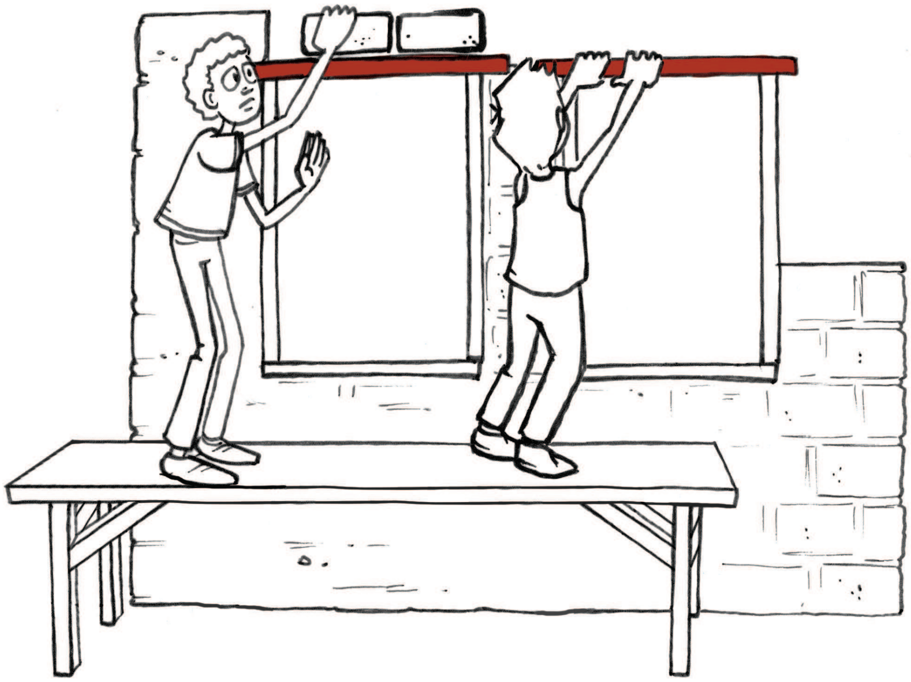


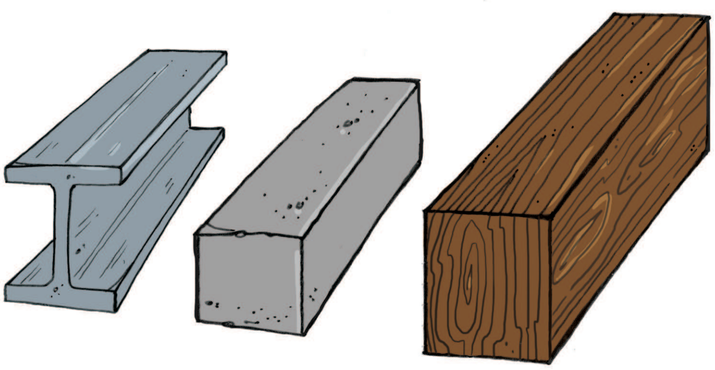
Figure 4

In the picture above one man is laying bricks above a window, but the window has not been built in yet. What keeps the bricks from falling down?

....

....

The other man is inserting a **lintel** across the window opening. A lintel is a piece of wood, steel or concrete that can support the wall above a window.



Lintels and objects like those in Figure 5 are called **beams**.

Figure 5

Build a model table

Valencia is in a hurry and needs a few extra tables for a wedding function at her house. She cannot afford to buy real tables, but she has many wide sheets of wood that can be used for tabletops.

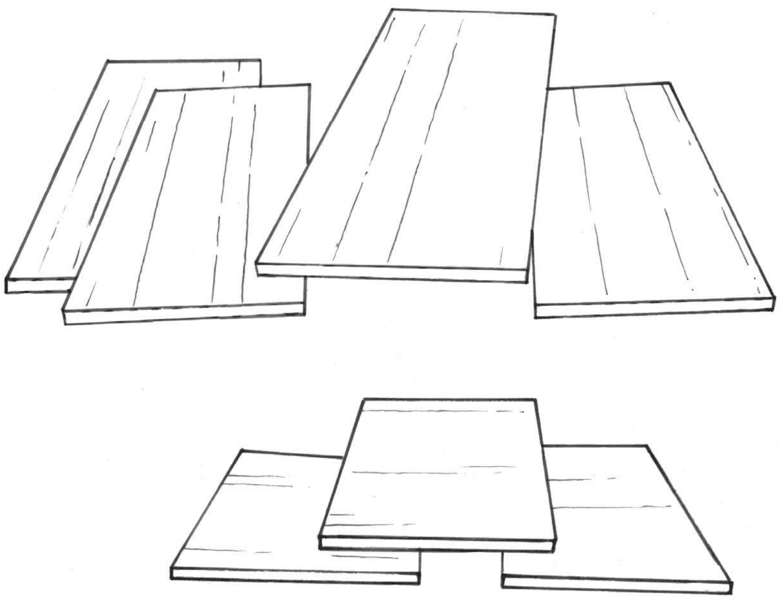


Figure 6

1. How can you use the sheet of wood to make tables, without having to cut the wood? Make a rough sketch of your plan below.

Jaamiah has a plan. She cannot describe the plan in detail, but she made this drawing to show how her plan will work.

Figure 7

2. Valencia does not really understand Jaamiah's drawing. Make a better drawing that will show more clearly what Jaamiah's tables will look like. You only need to make a quick freehand sketch to show what the table will look like.

To understand how Jaamiah's table will work and to test if it will work well, you can build a small model of the table. Use corrugated cardboard to do this.

You will need three pieces of corrugated cardboard, each about 20 cm long and 10 cm wide. Decide how you will cut the pieces for the tabletop and the two supports. You can cut them with the corrugations along the width, as shown in Figure 8, or with the corrugations along the length, as shown in Figure 9.

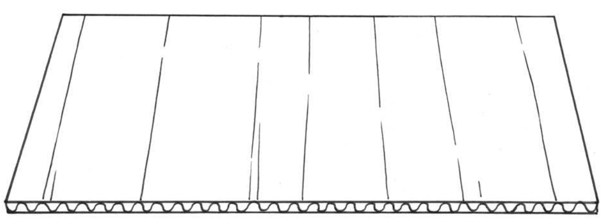


Figure 8: Corrugations along the width

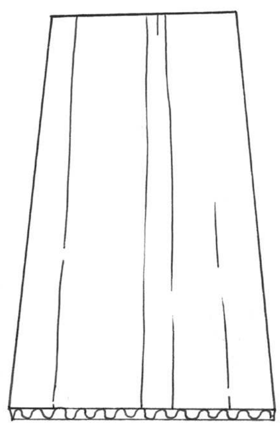


Figure 9: Corrugations along the length

Build your model table and test it to see if it will work well.

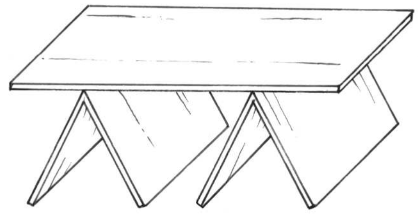


Figure 10

3. How should the corrugated cardboard be cut to make the strongest top for your table: with the corrugations along the width or along the length?

   ....

4. Show on the drawing in Figure 11 in which direction the corrugations should go to make the strongest supports for your table.

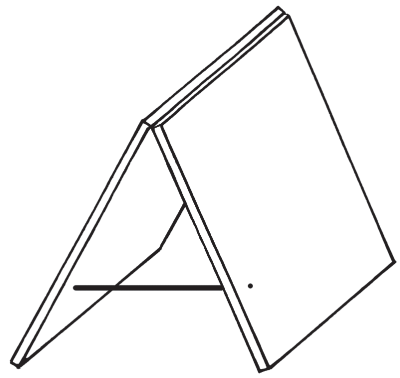


Figure 11

Now think of ways to make the table stronger so that it can support bigger loads. The table in Figure 12 is not strong enough to support its load without bending.

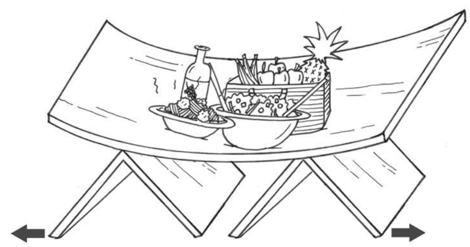


Figure 12

Suppose you have another sheet of corrugated cardboard with which you can make the table stronger. You can add the sheet as a second table top, as shown in Figure 13. Or you can cut the extra sheet in two pieces and make another A-frame support for the middle of the table, as shown in Figure 14.

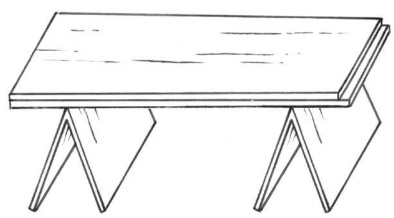


Figure 13

5. Which way of using the extra sheet will help the most to make the table stronger: the way shown in Figure 13, or the way shown in Figure 14?

   ....

   ....

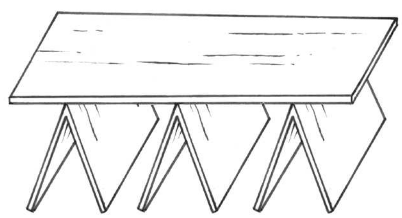


Figure 14

2.2 Different types of bridges

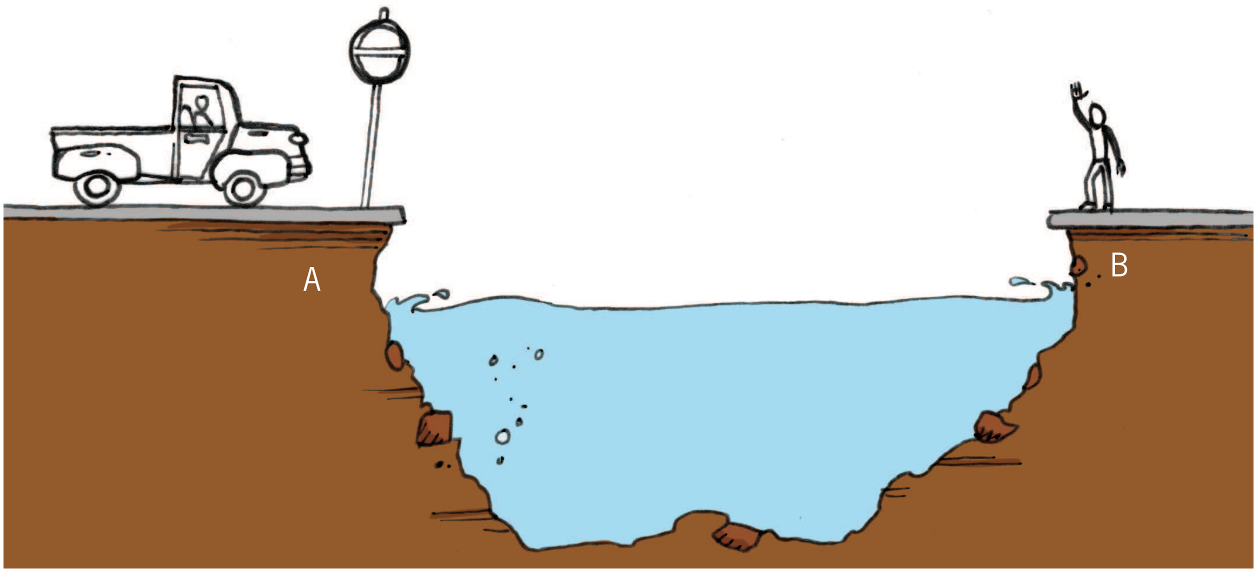


Figure 15

Investigate bridges

Look at Figure 15. A bridge needs to be built so that people can cross a river. The distance from point A to point B above is about 30 metres.

1. Make a drawing on Figure 15 to show what the bridge could look like.
2. Look at your drawing. In what way will the bridge be supported so that it will not bend when a heavy truck passes over it?

 ....

 ....

3. What materials do you think should be used to make the bridge?

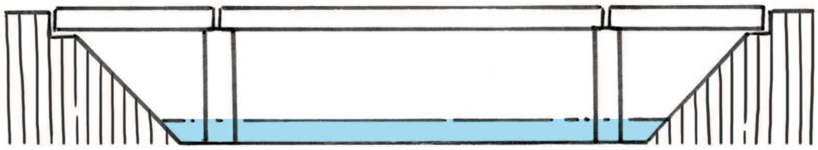
 ....

4. How wide should the bridge be?

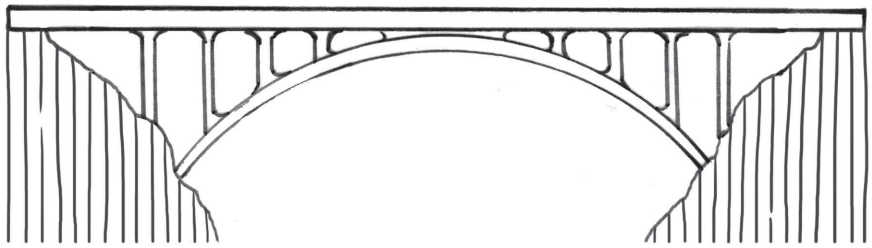
 ....

5. How many cars can be on the bridge at the same time?

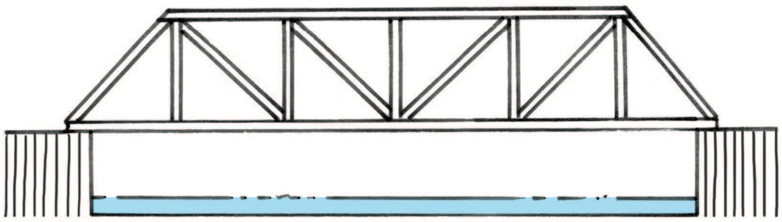
 ....



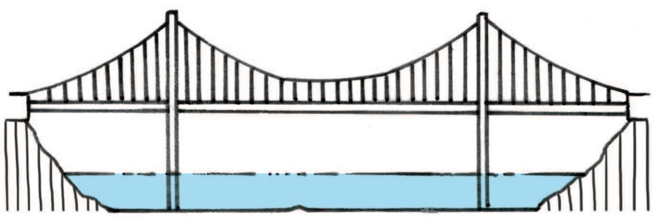
A beam-and-column bridge



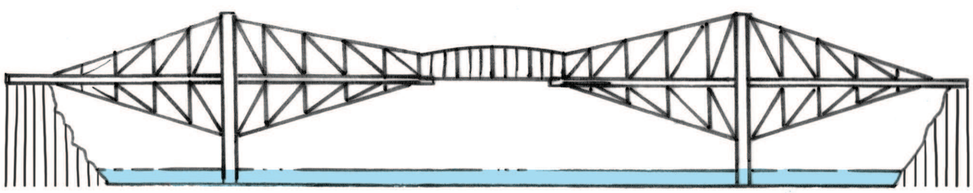
An arch bridge



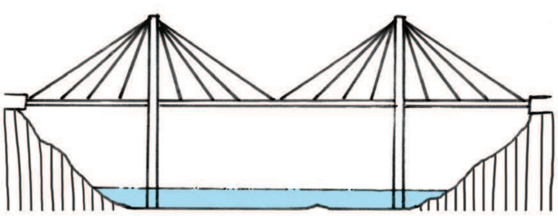
A truss bridge



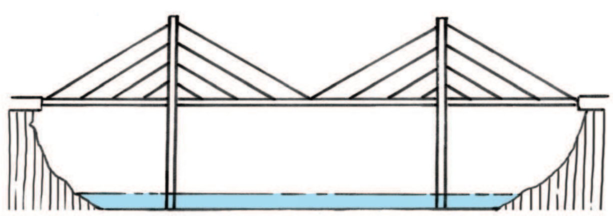
A suspension bridge



A cantilever bridge



A cable-stay bridge of the fan type



A cable-stay bridge of the harp type

Figure 16: Different types of bridges

You can easily make a small **suspension bridge** between two desks with sticky tape. When you do this, you use the tapes as **cables**.

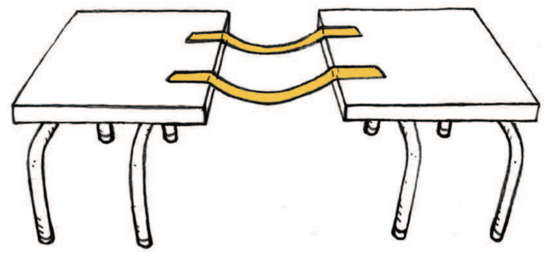


Figure 17

You can put strips of cardboard across the two cables to form a **deck** for the bridge.

6. Do you think this suspension bridge in Figure 17 will be strong enough to support a small bird walking on it?

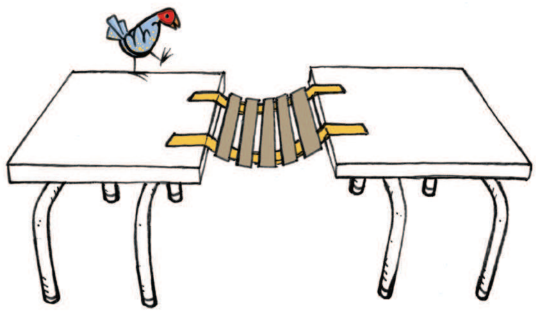


Figure 18

You can also easily build a small **cantilever bridge** between two desks. Put two pieces of corrugated cardboard on the desks, like the blue objects on the drawing below. Put an object like a book on one end of each cardboard sheet, so that they will not fall down.

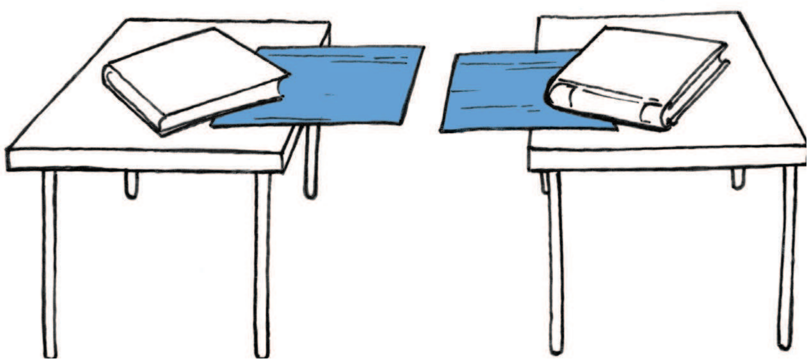


Figure 19

You now almost have a bridge, but there is still a gap.

7. How can you complete the cantilever bridge without moving the cardboard sheets or the desks closer together?

....

....

In a suspension bridge, the cables are **anchored** on the two sides, the same way you pasted your sticky tape strips on two desktops. In most suspension bridges, the deck hangs from the cables. We can also say the deck is *suspended from* the cables.

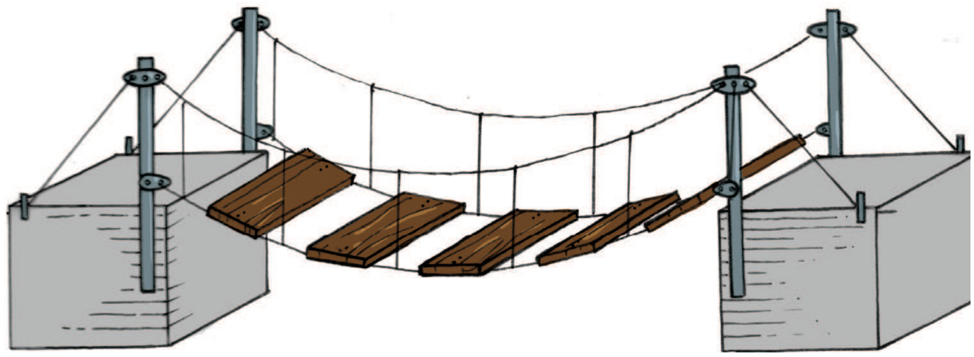


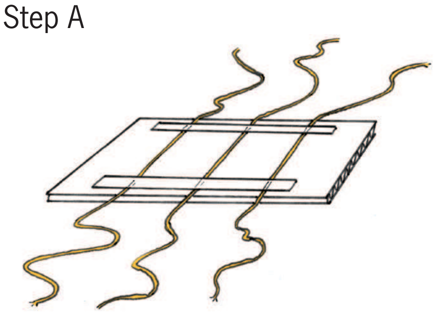
Figure 20

In a **cable-stayed bridge** the deck is also suspended from the cables, but the cables are anchored on support columns, not on the two sides of the bridge. To make a simple model of a cable-stay bridge, you can paste some pieces of string to a sheet of corrugated cardboard.

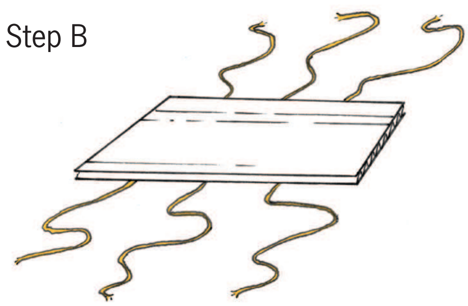
Turn the cardboard around so that the strings are at the bottom.

Pick up and hold all the string ends in one hand.

Step A



Step B



Step C

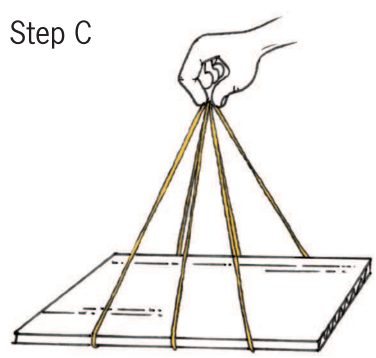


Figure 21

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2.3 Making structures strong enough

Investigate what could go wrong in structures

1. Do you think it will work well to use a sheet of window glass for a tabletop?

   ....

   ....

   ....

   ....

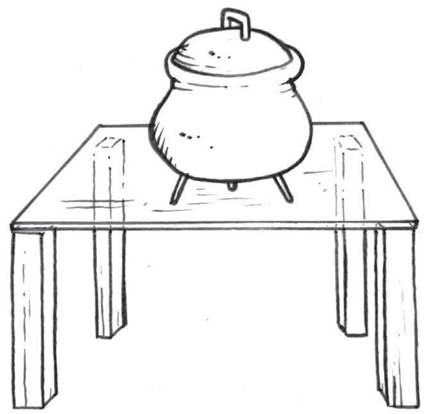

Figure 22: A table with a glass top

A glass top can easily crack or break, or fracture, when heavy objects are placed on it. There are also other things that could go wrong with structures.

2. What material was used to make the legs of the chair you are sitting on?

   ....

3. Why will it not work to use rubber pipes to make the legs of a chair?

   ....

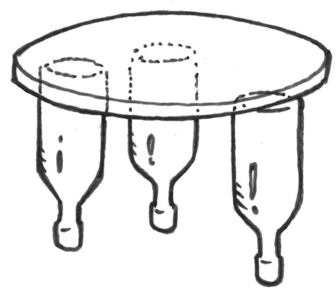

Figure 23: A table with a round top

Tom made this plan for a model table with a round top. His plan is to make three bottles stand on their small ends, with a round disk of cardboard on top of them.

4. Explain why this will not work well.

   ....

The following are examples of ways in which structures, like bridges or buildings, or parts of bridges or buildings, could fail to work.

> Some parts, or members, of the structure can **fracture**, or break apart.
> Some parts, or members, of the structure can **bend**.
> Structures or parts of structures can **topple over**.

5. The pictures below show different ways that bridges can fail. Describe what went wrong in each of the three cases, and how it could be prevented from happening again.

Figure 24

....

....

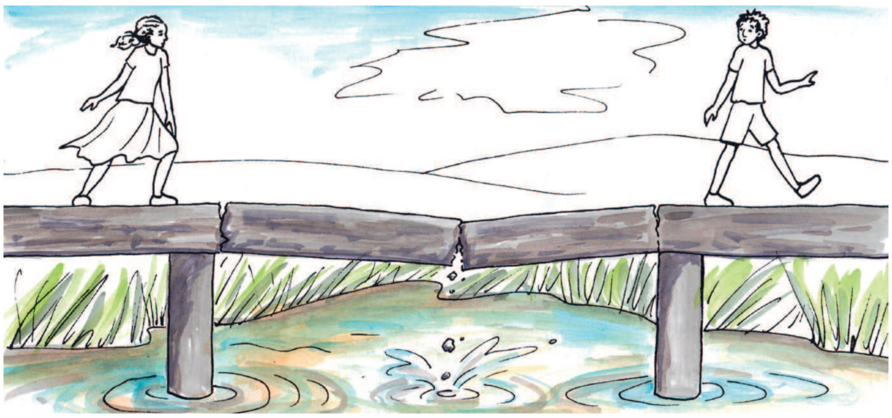

Figure 25

....

....

Figure 26

....

....

6. A design for a small table is shown here. In what ways could this table fail to work?

....

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....

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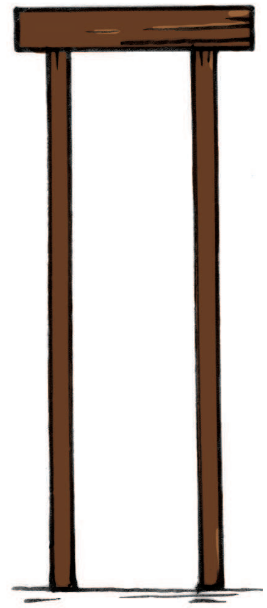

Figure 27

7. The pictures on the opposite page show a suspension bridge and an arch bridge.

   In a suspension bridge, the deck of the bridge hangs from the cables that carry the load. Explain in what way an arch bridge is different from a suspension bridge.

....

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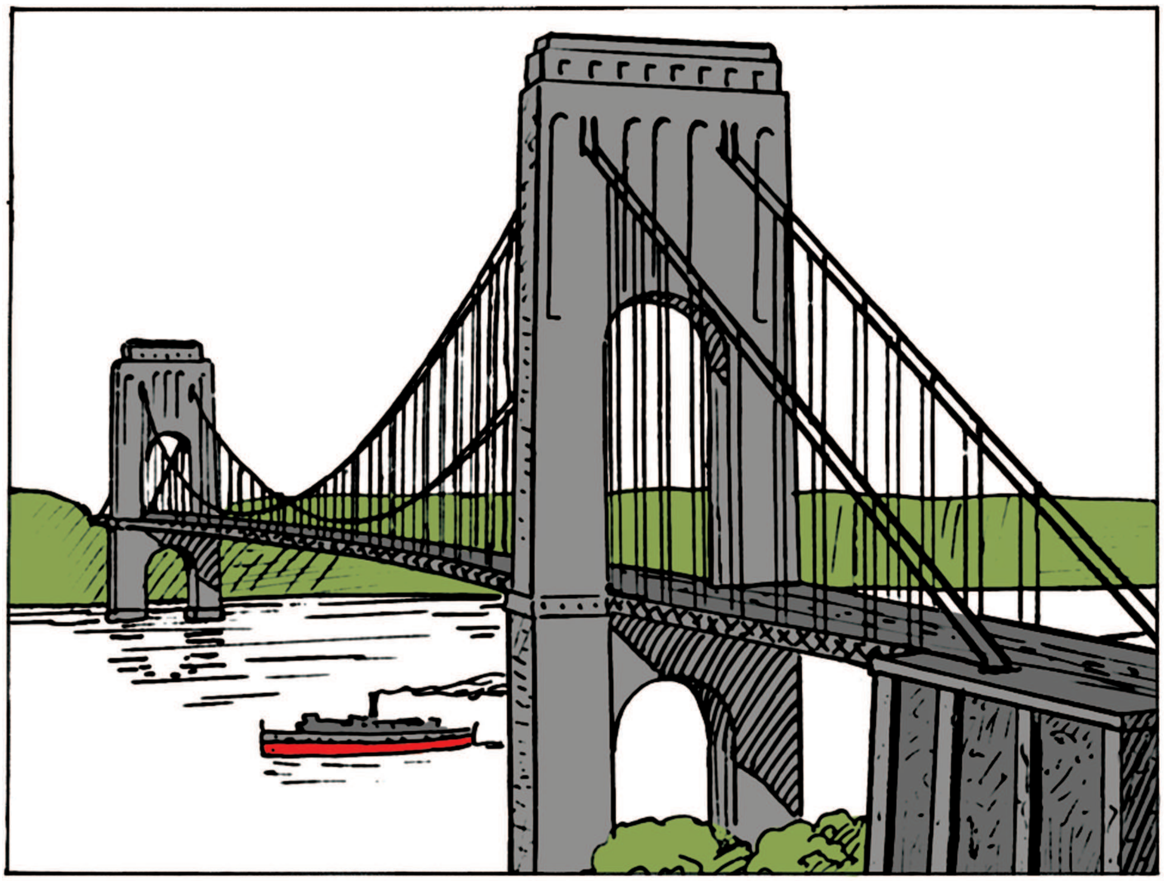


Figure 28

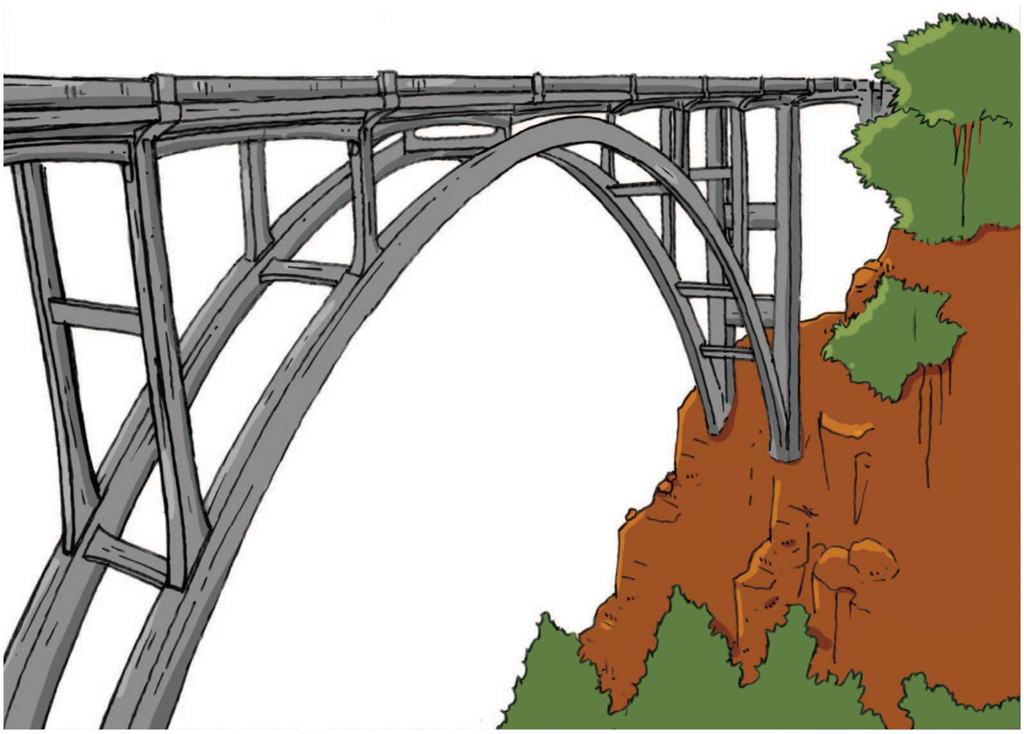


Figure 29

Homework: What have you learnt?

1. Where are lintels used in houses, and what are their purposes?

 ....

2. Can arches be used instead of lintels when houses are designed and built? Make a freehand sketch to illustrate your answer.

 ....

3. What is the difference between a beam-and-column bridge and an arch bridge?

 ....

 ....

4. When will you use an arch bridge instead of a beam-and-column bridge.

 ....

 ....

Next week

In the next two chapters, you will make more sketches and learn new drawing techniques.

Chapter 3
Flat and isometric working drawings

In this chapter you will learn about an important way to develop and communicate your ideas in Technology. You will start drawing freehand sketches. Then you will learn about drawing one face of an object in two dimensions. Finally, you will learn how to draw an object showing three dimensions.

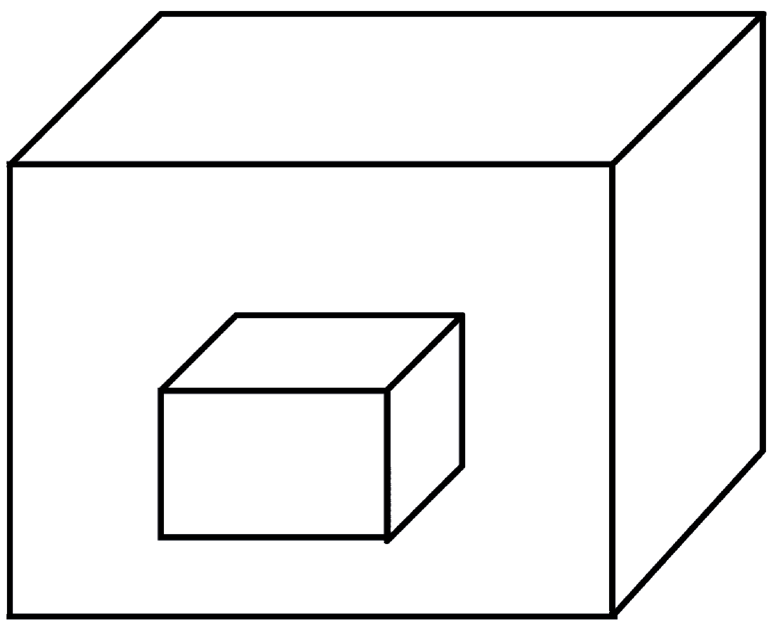
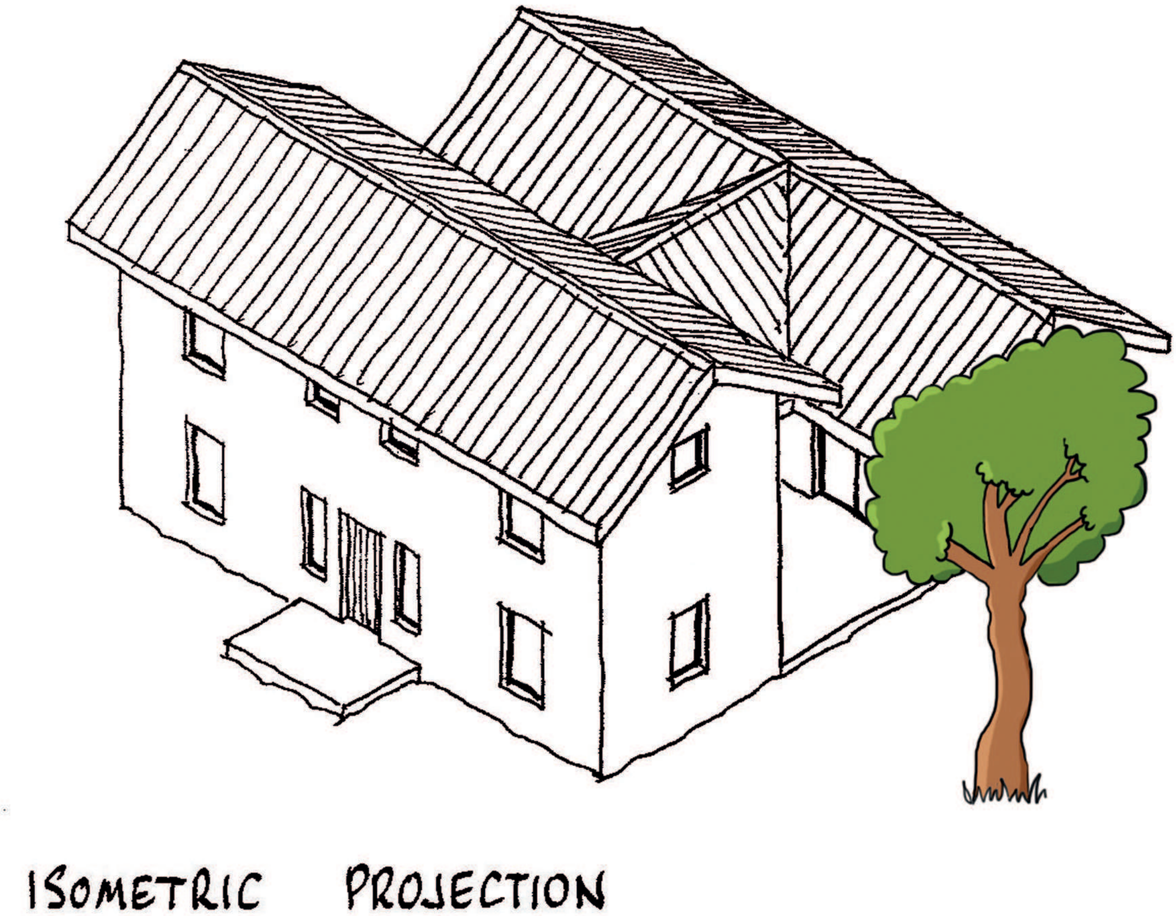


Figure 1



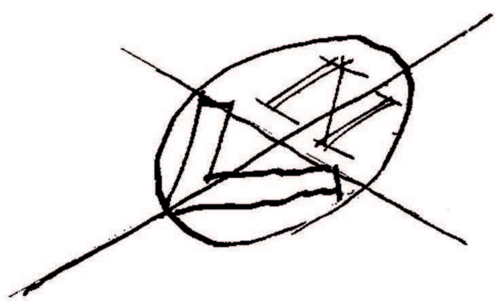


Figure 2

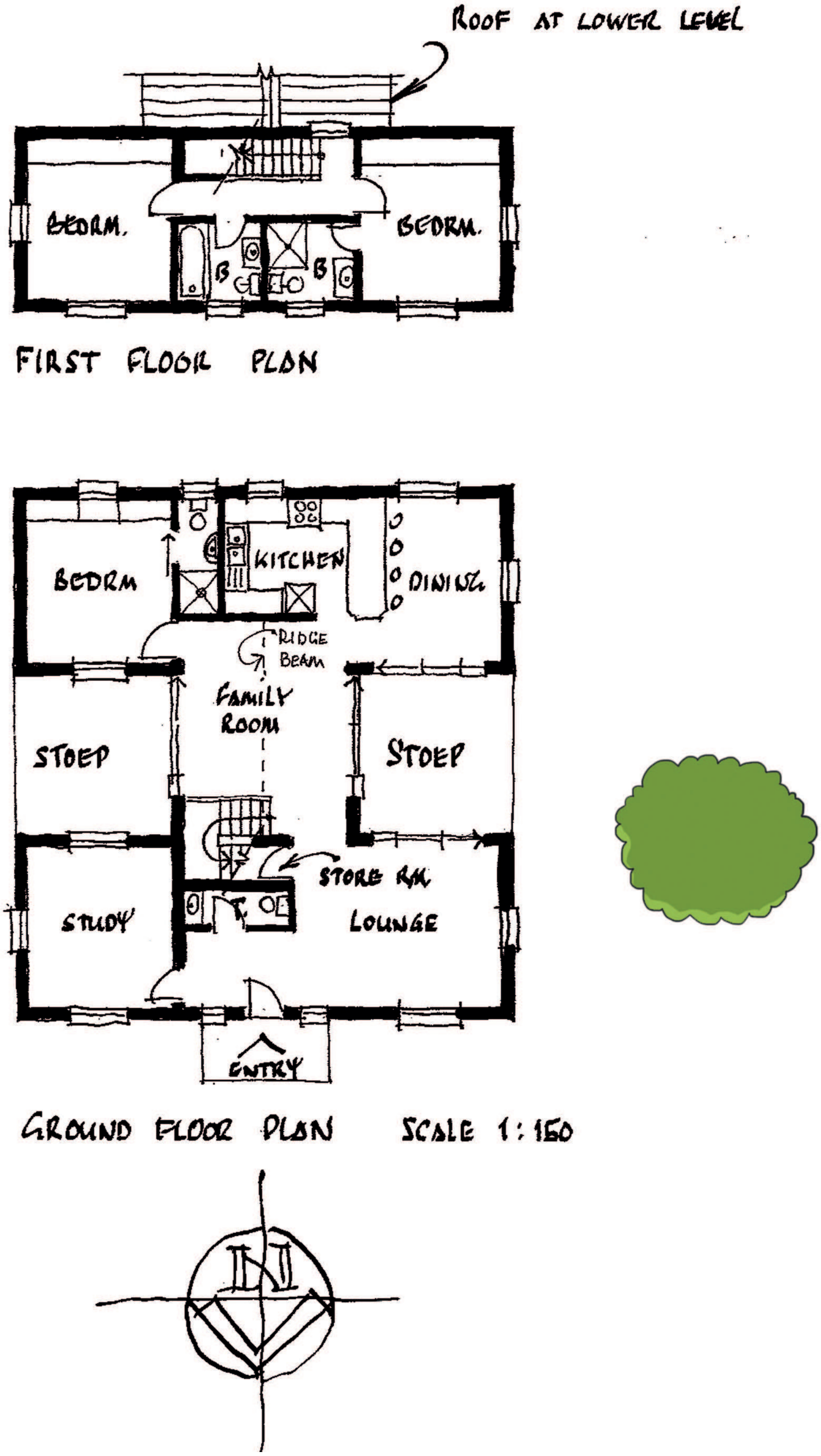

ROOF AT LOWER LEVEL
BEDRM.
BEDRM.
B
B
FIRST FLOOR PLAN
BEDRM
KITCHEN
DINING
RIDGE BEAM
FAMILY ROOM
STOEP
STOEP
STORE RM.
STUDY
LOUNGE
ENTRY
GROUND FLOOR PLAN
SCALE 1:150
N

Figure 3

3.1 Line types and scale drawing

Even the easiest of building projects needs to be designed first. To do this, someone has to be able to draw the structure that is planned. Very few people are able to make something without having drawn it first. So let us have a look at the basic principles of drawing.

Different lines for different purposes

Construction lines

Construction lines are normally drawn to begin to make a drawing. They are feint, thin lines that will later be replaced by the outlines.

Example:

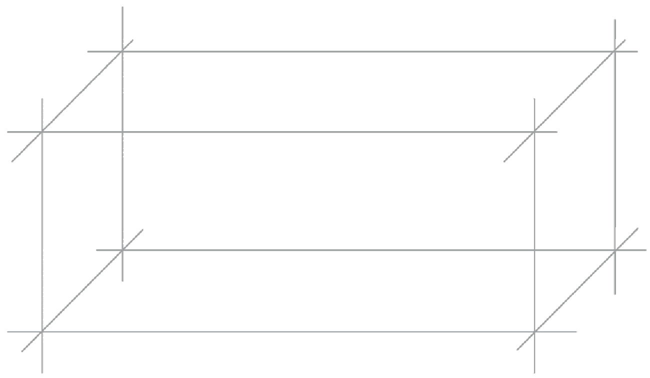


Figure 4

Outlines

1. These lines are also referred to as solid lines. They are slightly thicker and darker than construction lines.

Example:

Figure 5

Hidden detail

These lines are also known as hidden lines. These are lines you can't see when looking at the object. They are the same thickness as outlines but are broken.

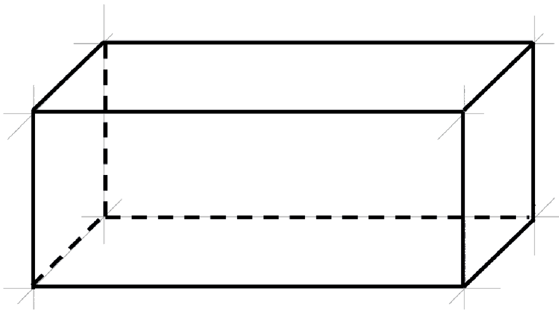


Figure 6

Centre lines

These lines show where the centre of a symmetrical object is, for example a circle. These lines are also called **chain dash-dot lines**.

When you need to drill a hole in an object, a centre line is useful because it shows you exactly where you should put the tip of the drill.

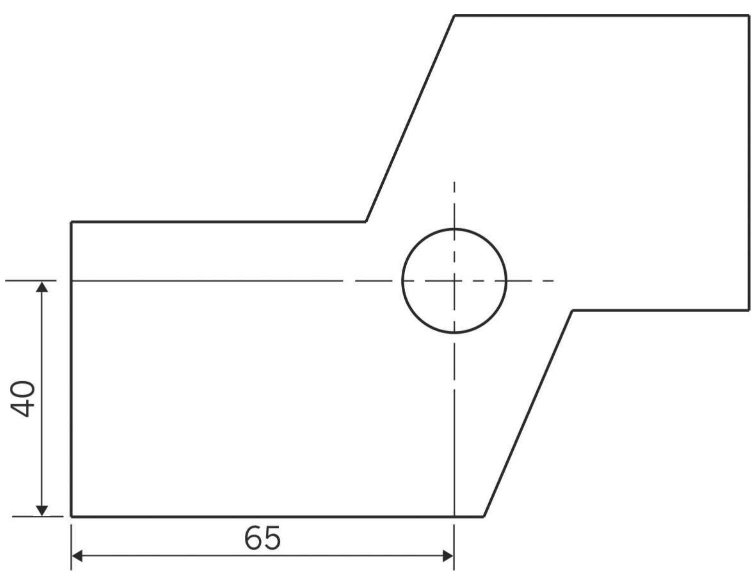


Figure 7

Figure 8

The symbol ø is used to indicate the diameter of a circle. The diameter is written at the end of an arrow that points to the centre of the circle.

Drawing to scale

It is not always possible to draw something according to its actual size in real life, because you might not be able to fit it onto the paper you use. So you need to be able draw something to a different **scale**. But how does this work?

- **Scale 1:1** This is full scale and means that a centimetre in your drawing shows a centimetre in real life.
- **Scale 1:2** This means that a centimetre in your drawing shows two centimetres in real life.

The drawing below shows the same object drawn to different scales. Measure the bottom line on the first and second drawings, to check that the second drawing is really to a scale 1:2.

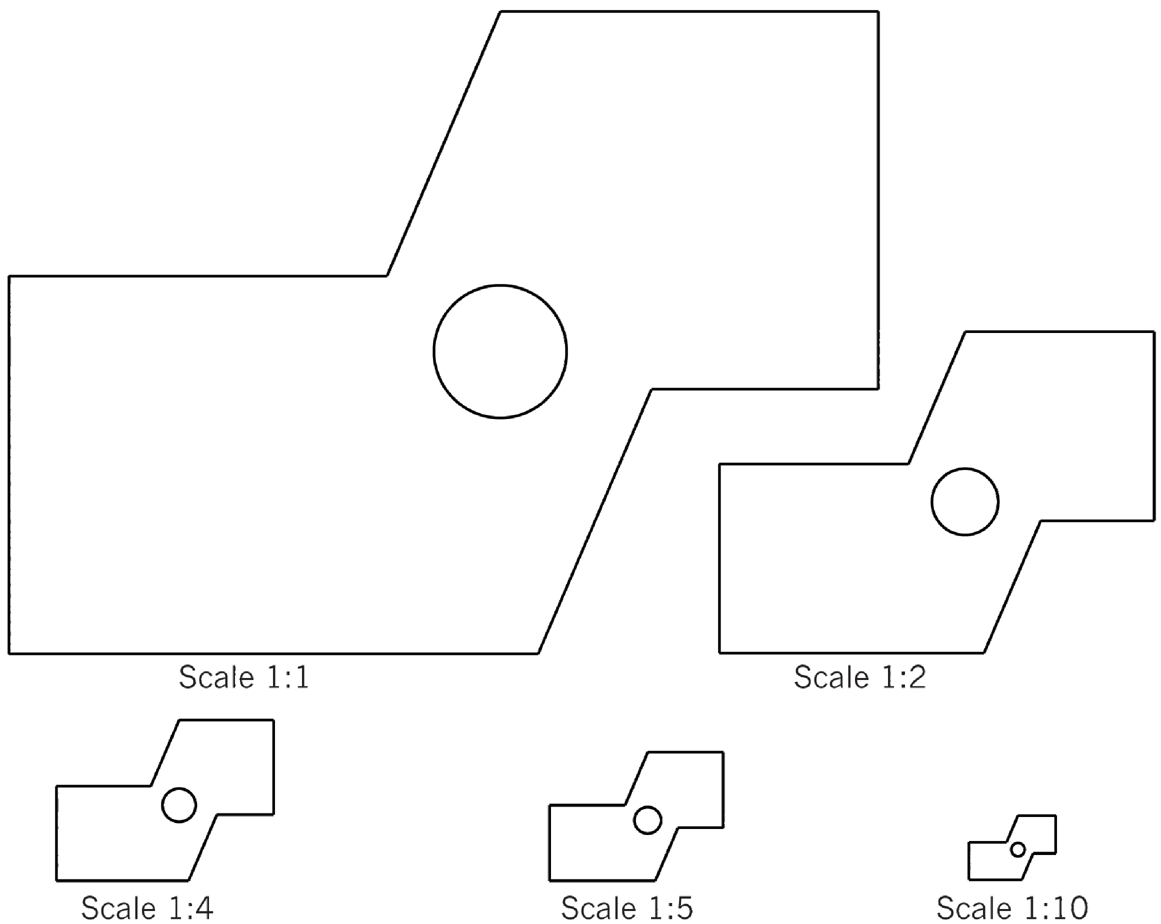


Figure 9

Look at the drawing of an object on the right.

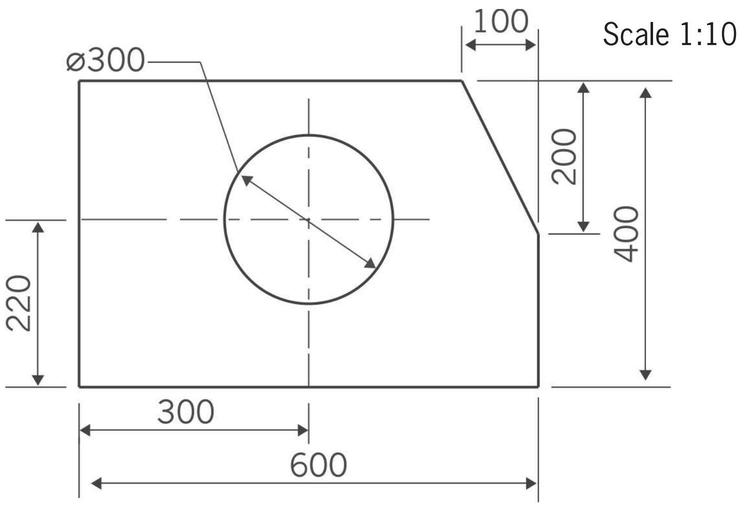


Figure 10

1. Redraw this object to a scale of 1:5. Use a ruler to make this drawing and all the other drawings in this chapter. Use a compass to draw the circle.
   - Show dimensions.
   - Show the centre lines of the circle.
   - Show the scale.

3.2 Single view flat 2D drawing

In the drawings that you made in the previous lesson, you showed the front, the side and the top of objects. Now you will make some drawings where you only show the front of an object. The front of the block in Figure 11 is red.

1. The lady only sees the red part of the block. Make a sketch of the red part on the grid below.

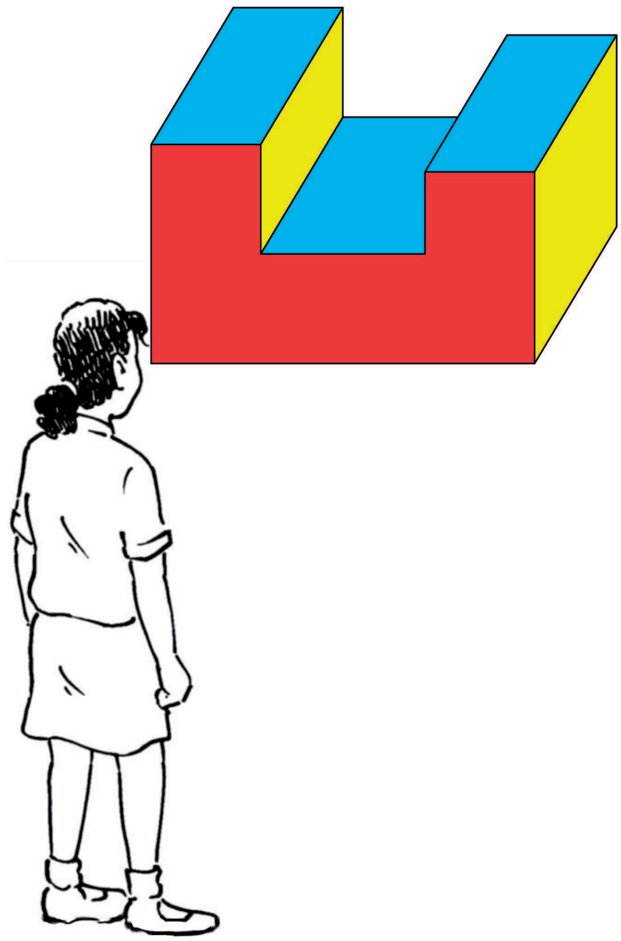


Figure 11

2. Make a 1:10 scale drawing of the front part of this object.
   - Show hidden lines.
   - Show dimensions.
   - Show the scale.

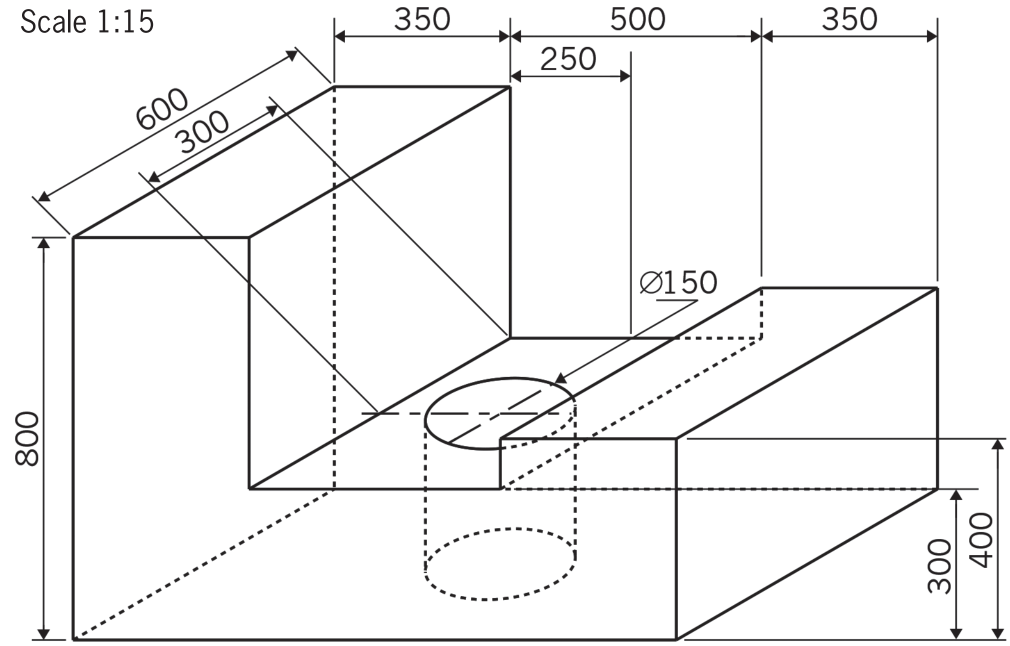


Figure 12

If you have time left at the end of this lesson, start reading about isometric drawing on the next page.

3.3 Isometric drawing

The differences between a 3D oblique drawing and an isometric drawing are demonstrated in the examples below. Both drawings are of the same object.

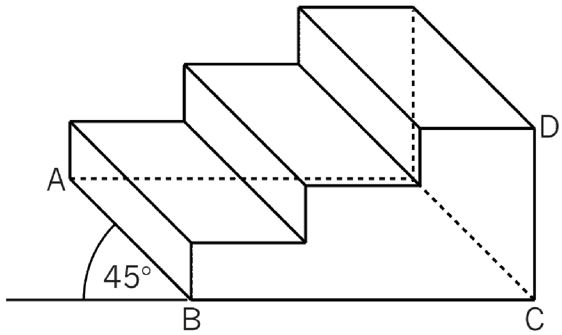


Figure 13: Oblique view

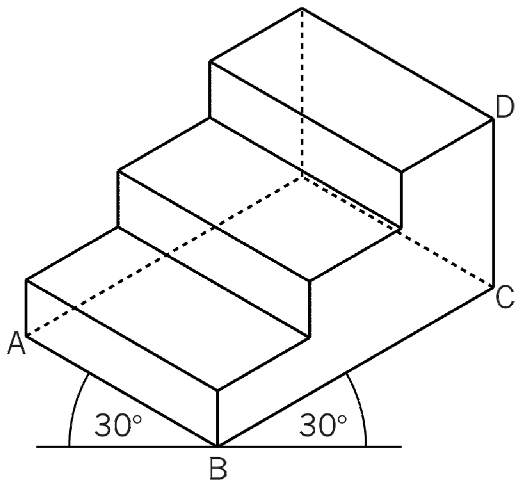


Figure 14: Isometric drawing

The oblique drawing shows the true lengths of lines BC and CD, but not the true length of AB.

The isometric drawing shows the true lengths of the lines AB, BC and CD.

The word "isometric" comes from the words "iso" and "metric".

"Iso" means "the same", and "metric" means "measurement".

1. Make an isometric drawing of the chalk box on the right on the isometric grid. Use a scale of 1:2.
   - Show hidden lines.
   - Show dimensions.
   - Show the scale.

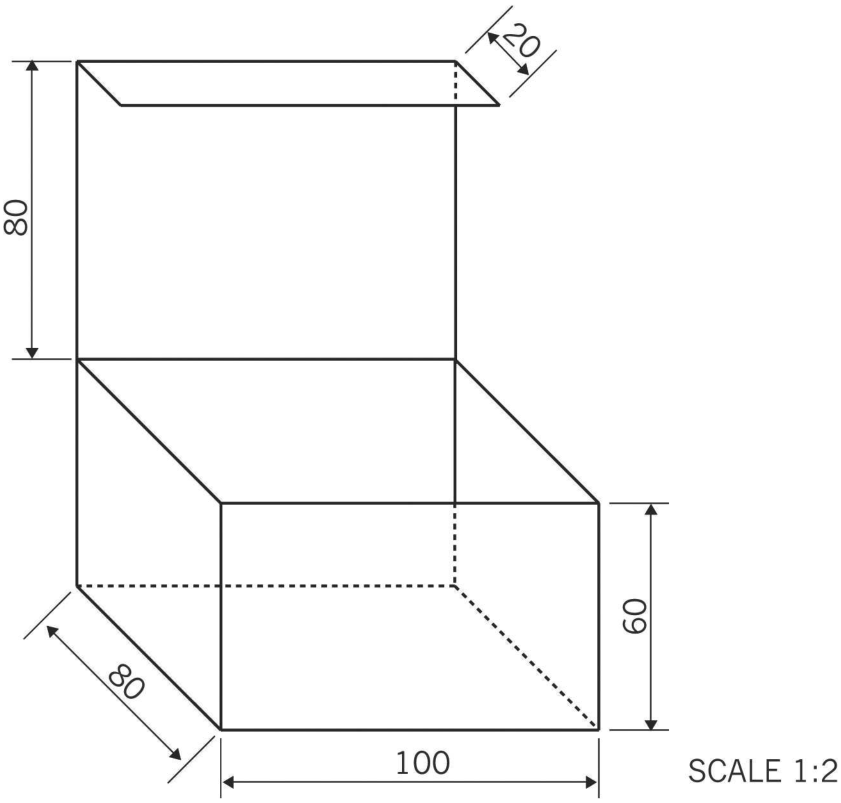
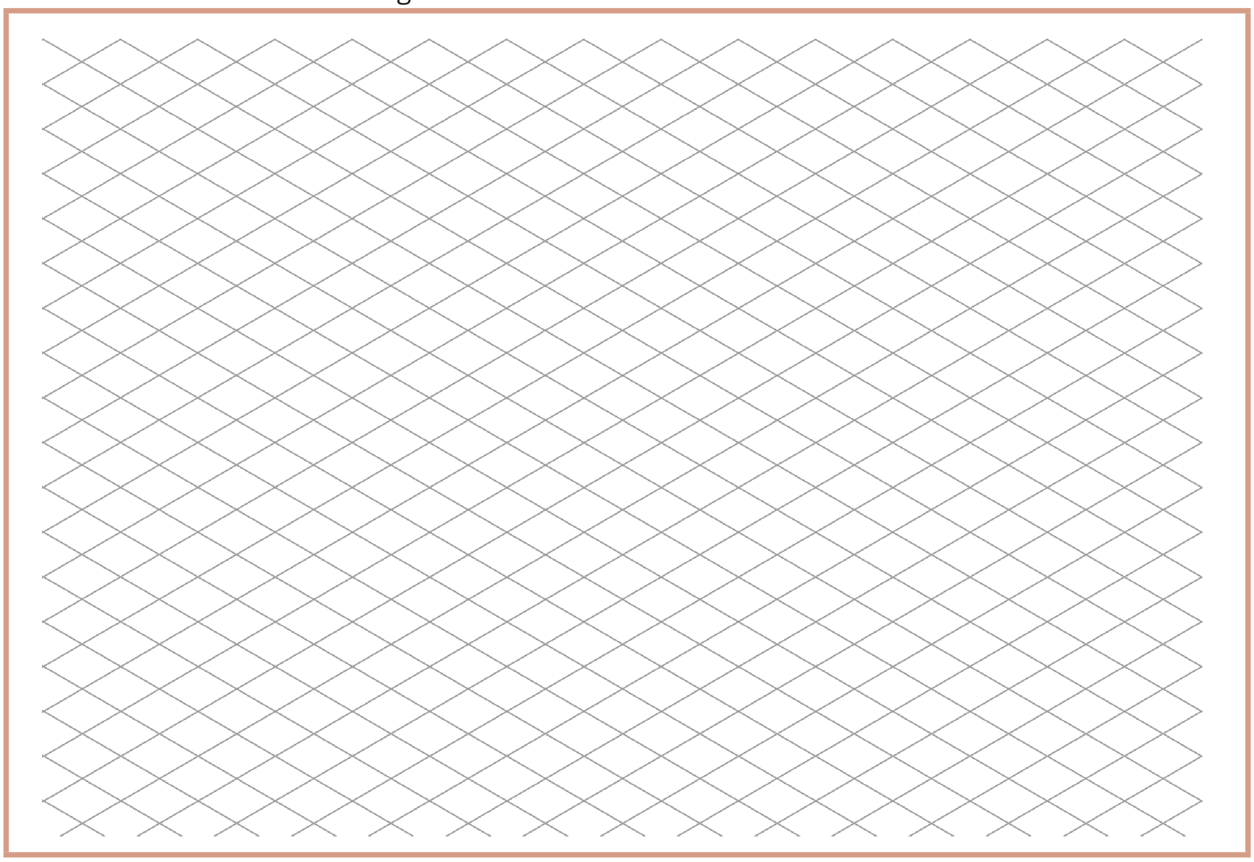


Figure 15



2. Make an isometric drawing of the piano on the right on the isometric grid. Use a scale of 1:25.
   - Show hidden lines.
   - Show dimensions.
   - Show the scale.

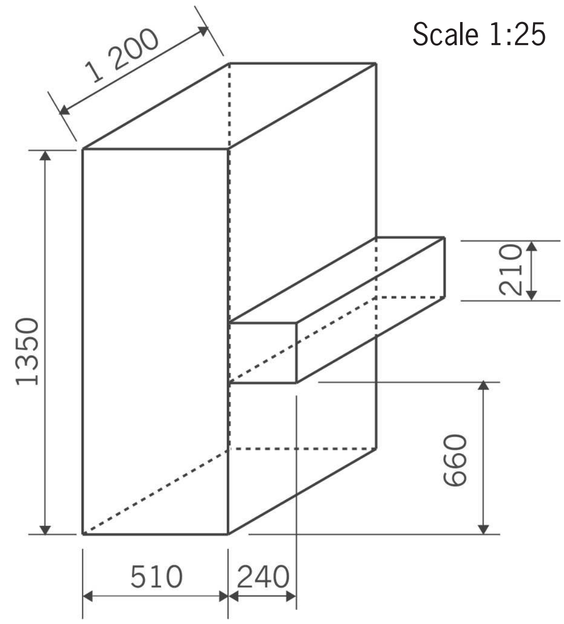
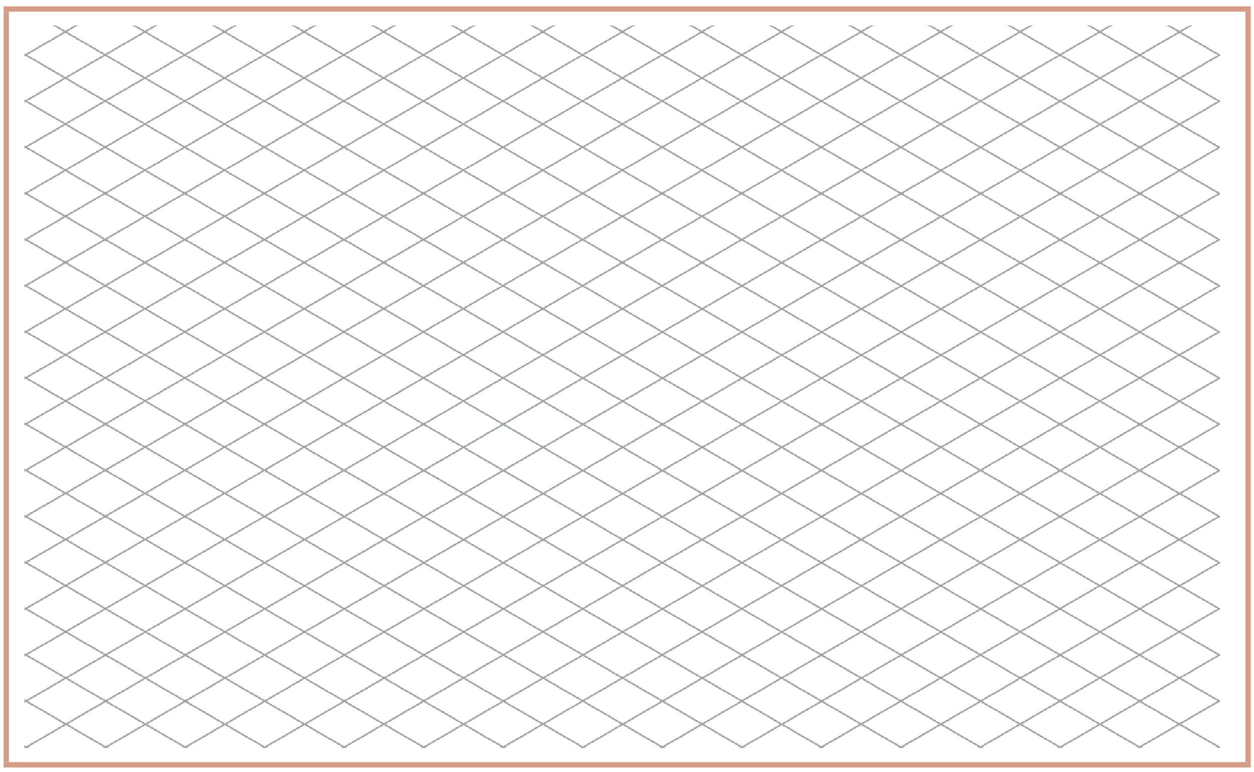


Figure 16



Next week

In the next chapter, you will learn to make drawings that show what you really see. Those drawings are artistic drawings, and they use some special techniques that you will learn.

Chapter 4
Perspective drawing

Figure 1: Everything we see around us is in perspective.

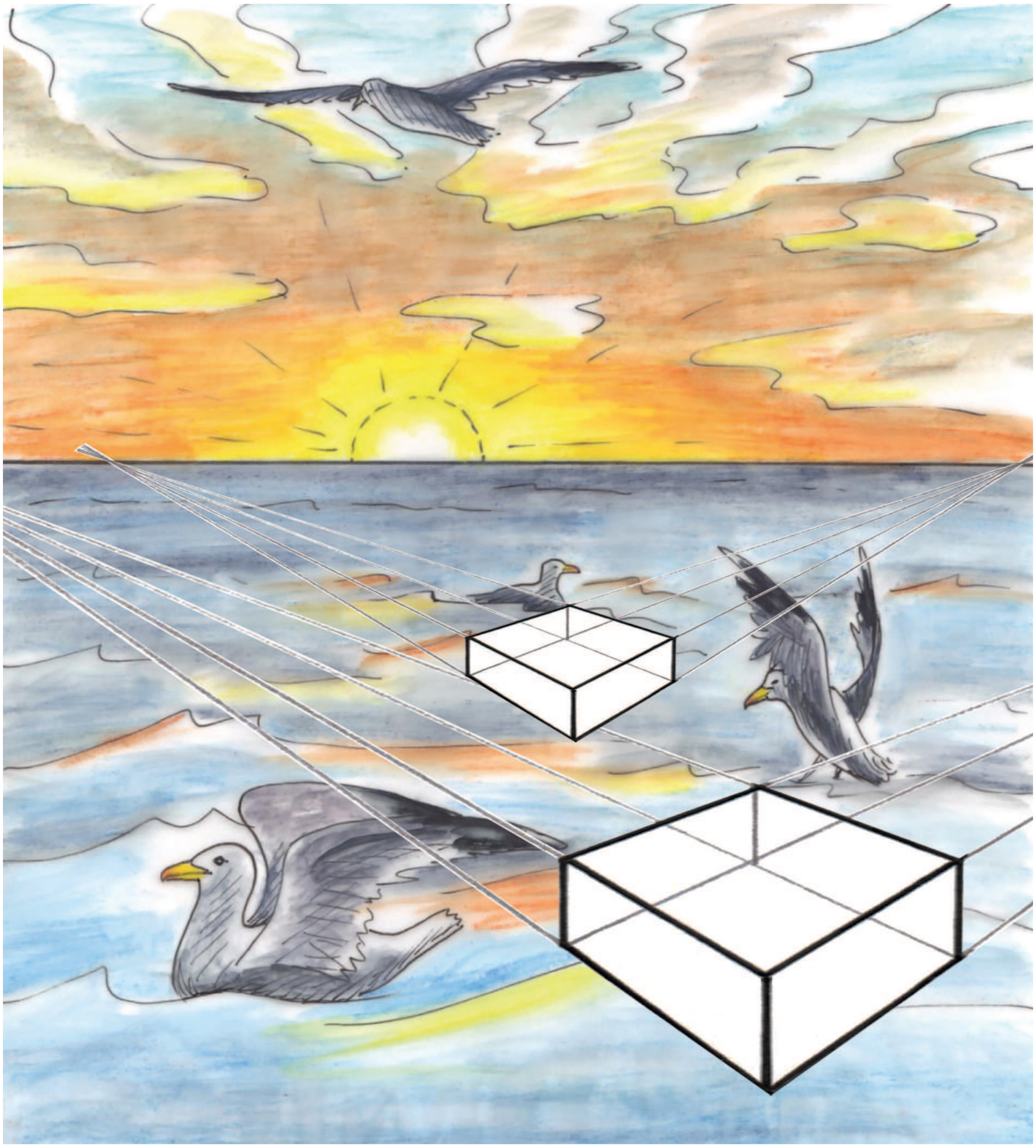


Figure 2: Where are the vanishing points for each box?

4.1 Double vanishing point perspective drawing

You were introduced to single vanishing point perspective in Grade 7. You will now go a bit further and look at double vanishing point perspective. Perspective views are often used by artists to sketch an object to try to represent what the human eye really sees.

If you stand looking out over the ocean, a big dam or a flat land area, you will see a horizontal line where the sky and water or land meet. This is known as the horizon.

To make a perspective drawing, you need to think of where the horizon line could be on your drawing.

In Grade 7 you learnt how to draw a box in single vanishing point perspective, as shown by the drawing below.

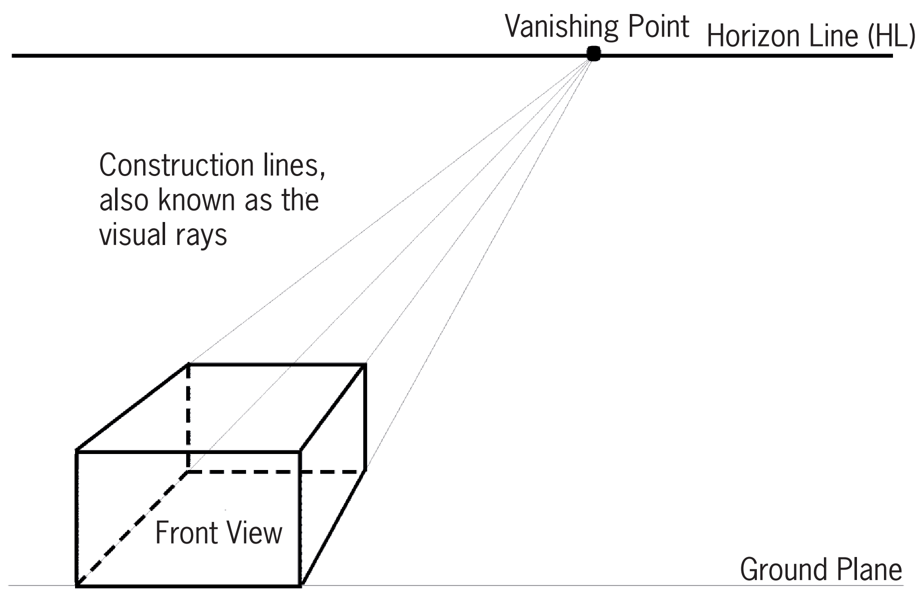


Figure 3

Two-point perspective

In a double vanishing point perspective drawing there are two vanishing points on the horizon line. On page 46 there is a double vanishing point perspective drawing of a box.

1. (a) To make a double vanishing point perspective drawing of a box, you can start by drawing a horizon line and one vertical edge of the box as shown below.
   (b) Then draw construction lines from the top and bottom of the vertical edge to two vanishing points on the horizon line.

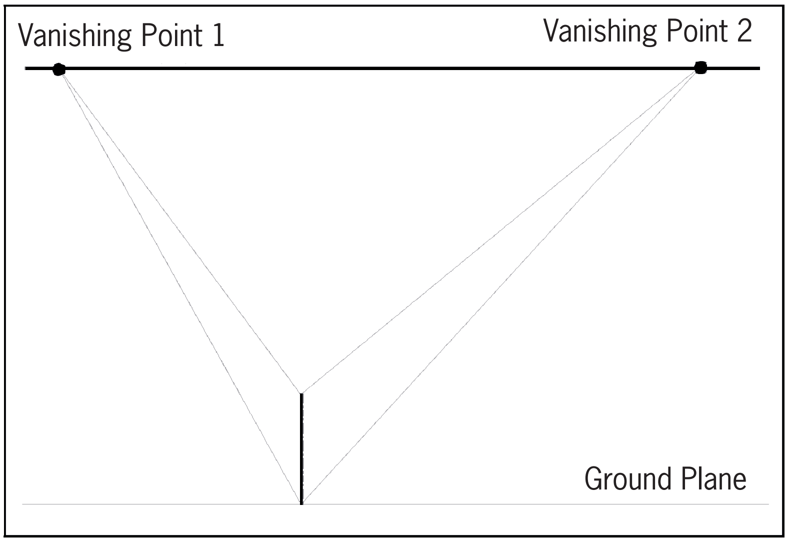


Figure 4

2. (a) Once you have done this, you have to mark off another edge of the block on the construction lines as indicated in Figure 5 at A and B.
   (b) From points A and B, draw construction lines to vanishing point 2.

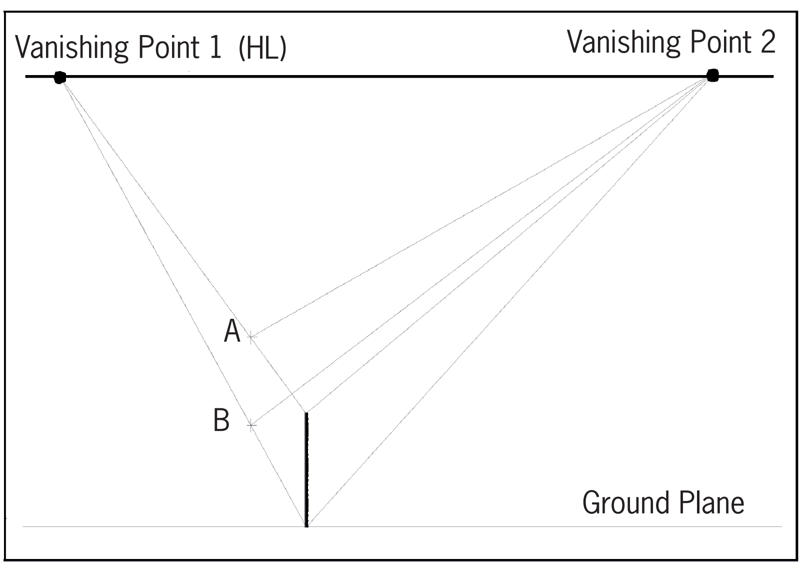


Figure 5

3. (a) Now mark off another edge of the block on the construction lines going to vanishing point 2 at C and D as in Figure 6.
   (b) Draw construction lines from points C and D to vanishing point 1.

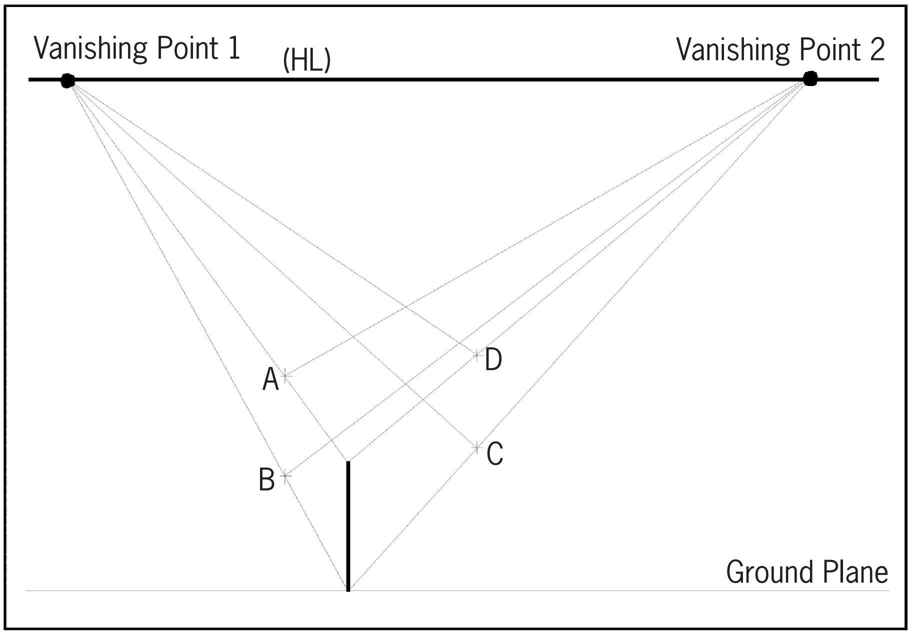


Figure 6

4. Make your own double vanishing point perspective drawing of a block below. Draw in your solid lines, as indicated on the block drawing on page 46.

4.2 A more difficult double vanishing point perspective drawing

You will now make a double vanishing point perspective drawing of a block with a piece that is cut out, as shown in Figure 7.

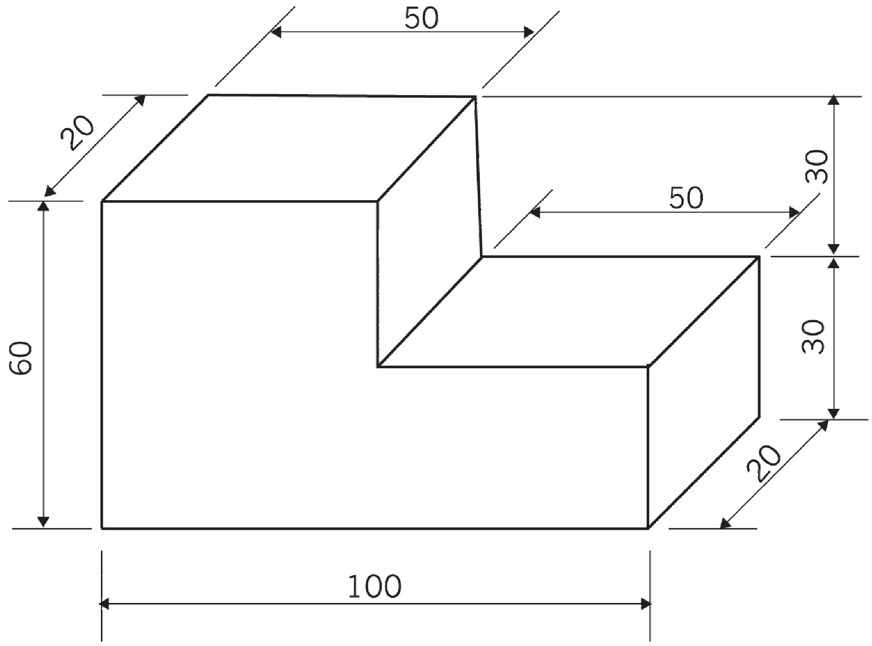


Figure 7

1. It is best to draw the block first, without the cut-out, as shown below.

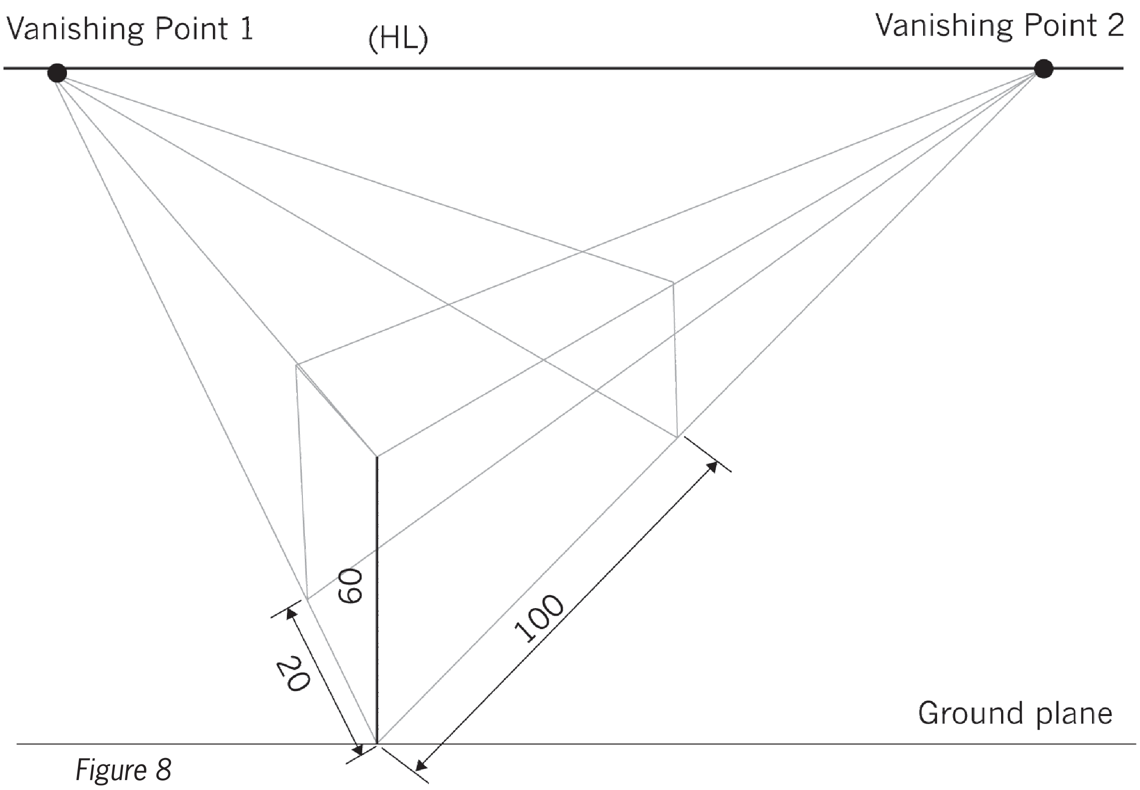


Figure 8

2. Then mark the cut-out, as shown below.

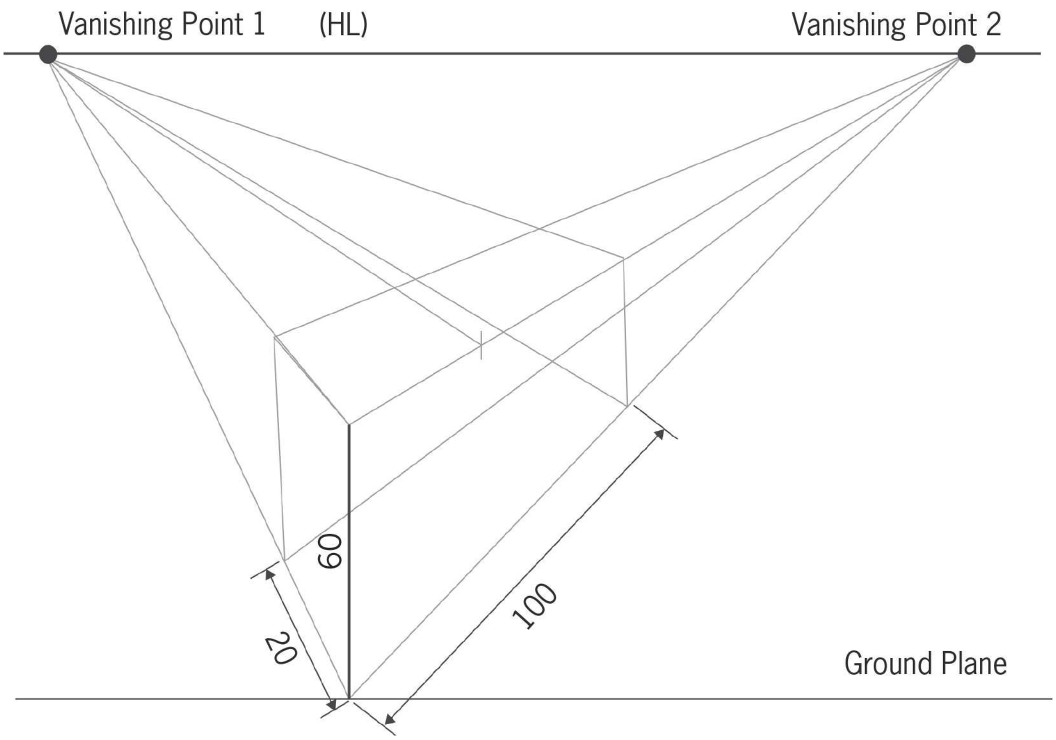


Figure 9

3. Make and complete your own double vanishing point perspective drawing of the object in Figure 7. Draw in solid lines where necessary.

4.3 Make drawings look more realistic using shading and texture

When you draw a picture of an object, you can use **perspective** to make the picture look more life-like or real.

When you've drawn your object in perspective, you can make it look even better by using **shading**. Shading is a way of showing that something is a **three-dimensional** shape, instead of a **two-dimensional** shape.

Compare Figures 10a and 10b, as an example.

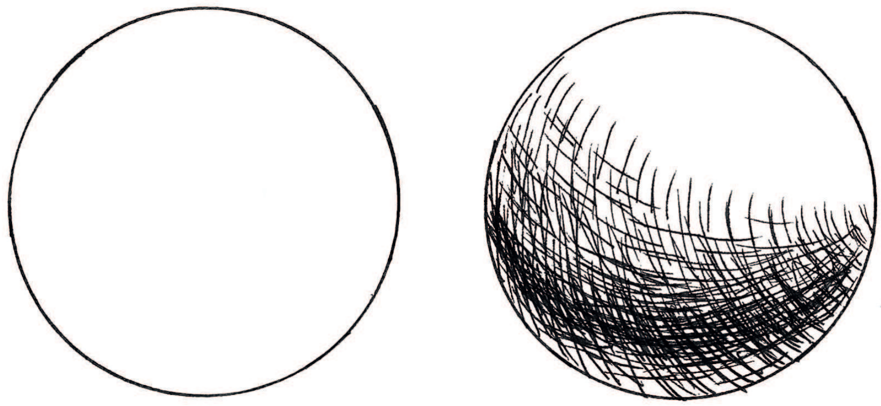


Figure 10a: a circle (two-dimensional) *Figure 10b: a sphere (three-dimensional)*

The basic principle of shading is light and shadow, as you can see in Figure 11. The position of a light source relative to an object determines which parts of an object are lighter and which parts darker.

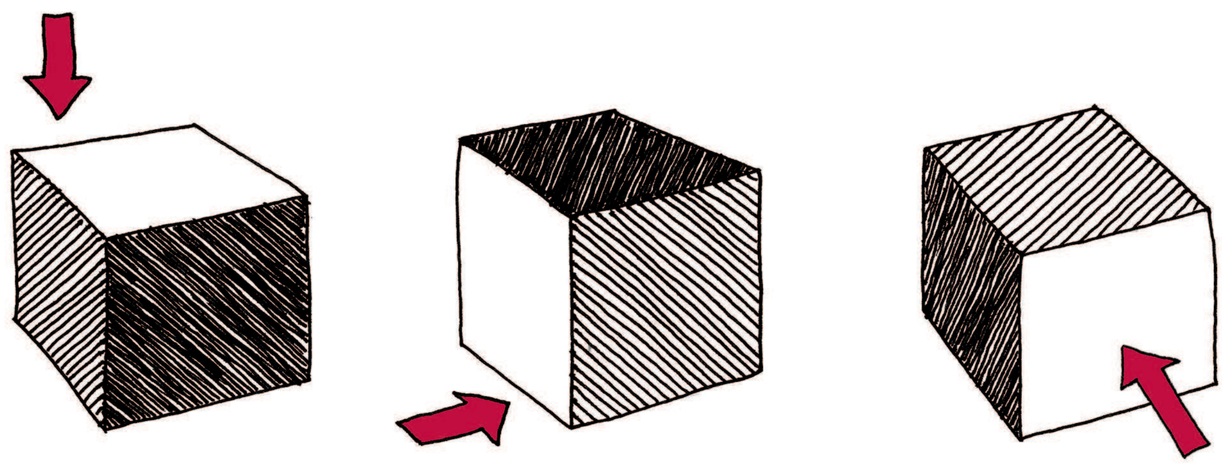


Figure 11: The position of light shining on the cube determines which parts will be darker or lighter. The position of the light on these cubes is shown by the red arrows.

There are a number of techniques that you can use to shade an object, regardless of the drawing tool you are using, such as a pen, pencil, coloured pencil, crayon, charcoal, brush or ink.

Hatching

Hatching means that you draw more-or-less parallel lines on the part of the object you want to be in shadow. The closer your lines are together, the darker you can make the shadow. Hatching works well with any drawing tool that can make lines.

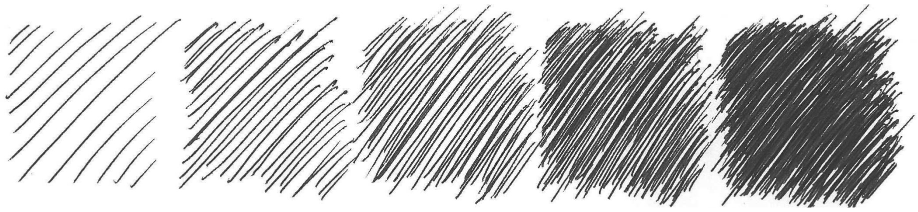


Figure 12: Different shades created by hatching

Cross-hatching

Cross-hatching is like hatching, except that you draw 2 sets of lines, crossing each other. Cross-hatching also works well with any drawing tool that can make lines.

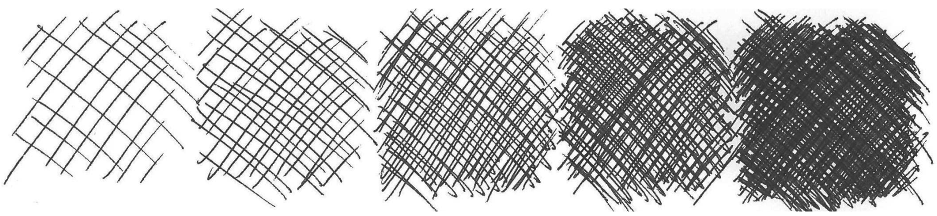


Figure 13: Different shades created by cross-hatching

Dots

Instead of drawing lines, you can use your pen, pencil or any other drawing tool to make dots for shading. The closer the dots are together, the darker the shade will be.

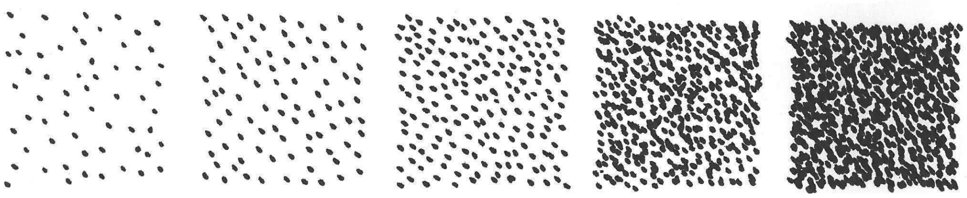


Figure 14: Different shades created by dots

Ink washes

You can dilute ink with water to create different shades. A lot of water and a bit of ink will make a lighter shade and a lot of ink with a bit of water will make a darker shade. Once you've mixed the ink and water, use a brush to apply the ink. If you don't have ink, you can use watercolour paint in the same way.

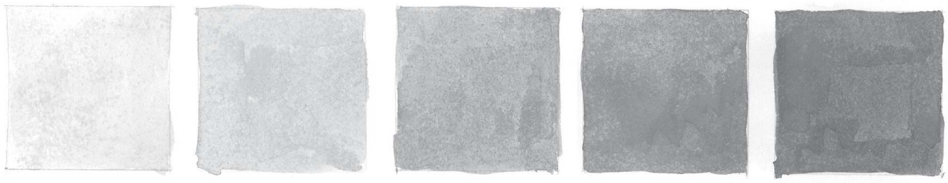


Figure 15: Different shades created by an ink wash and a brush

Here are examples of basic forms that have been shaded using these different techniques:

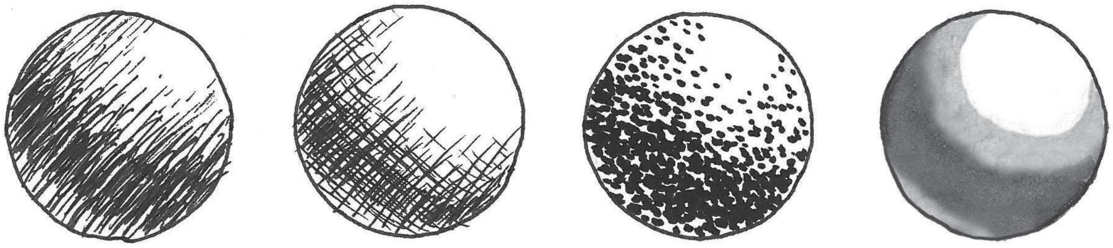


Figure 16: A sphere

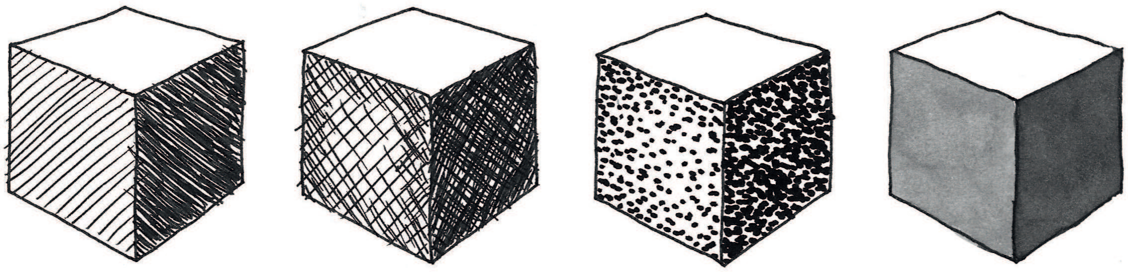


Figure 17: A cube

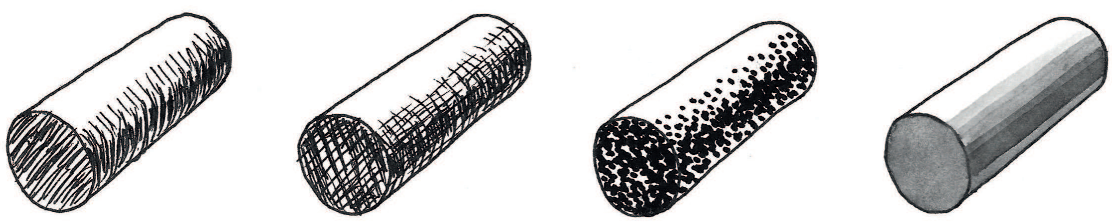


Figure 18: A cylinder

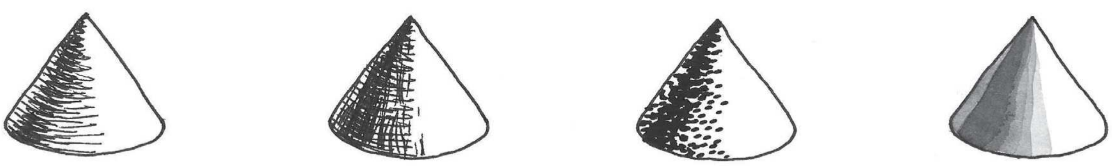


Figure 19: A cone

Below is a much more complex shape that has been drawn by an artist using a combination of shading techniques:

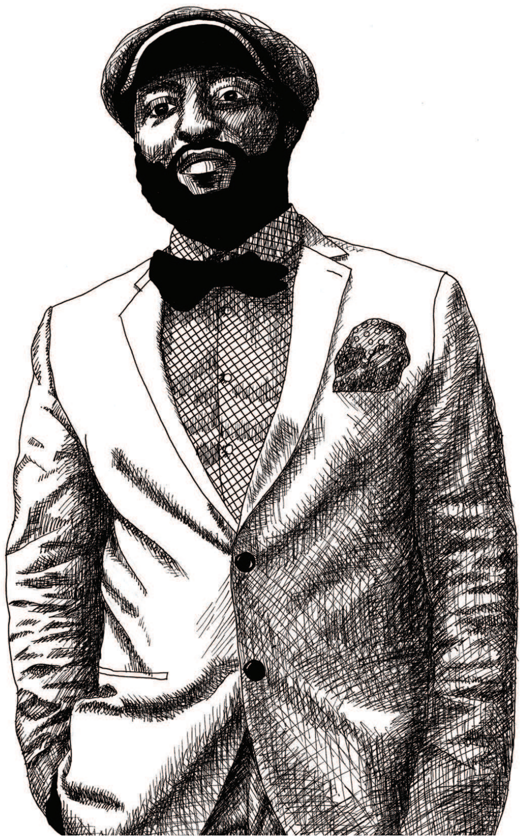


Figure 20: Portrait of a man in a suit

Drawing exercises

1. Create 5 different shades in the block below using one of the shading techniques you've learnt about.

2. Figure 21 is a drawing that consists of lines and shading. It shows a tree, a house and a car, drawn by combining different basic shapes

   Shade the copy of this drawing below. You can use any of the shading techniques you've learnt about in this chapter.

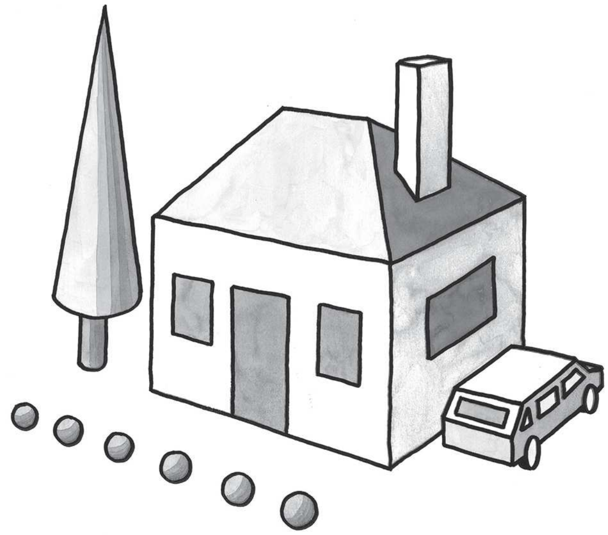
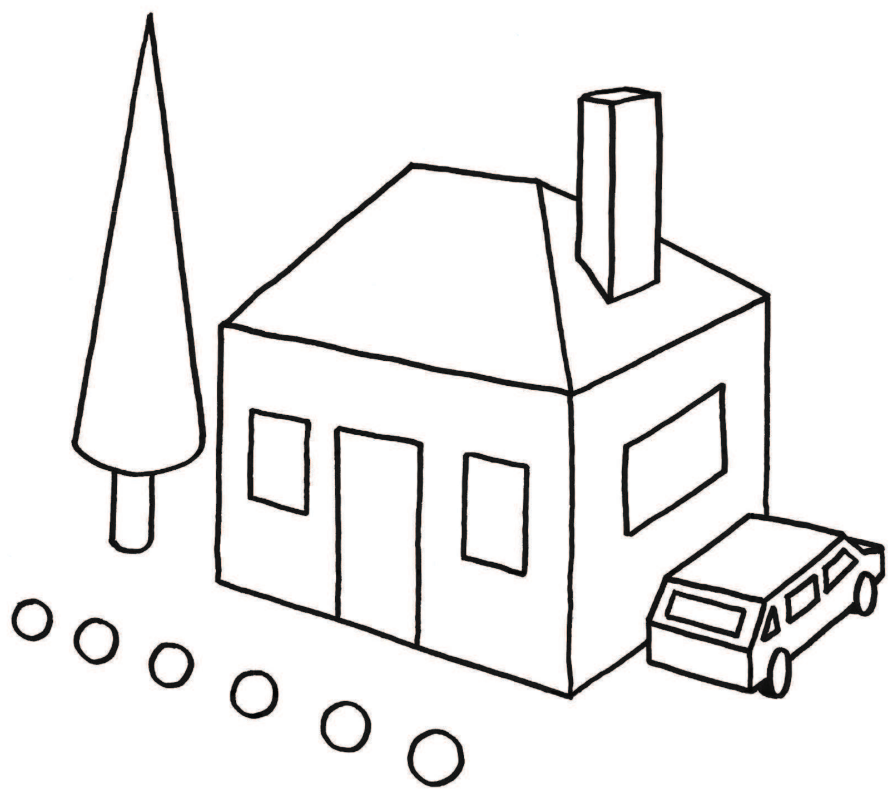


Figure 21



Next week

In the next three chapters, you will learn about different ways to change the way that things move, for example using gears and cranks.

Chapter 5
Wedges, wheels and gears

In this chapter you will learn how wedges, inclined planes, wheels and gears can change the direction and size of a force. These things are all called simple mechanisms. Different simple mechanisms can be used in combination with one another to create more complicated machines, like bicycles or cars.

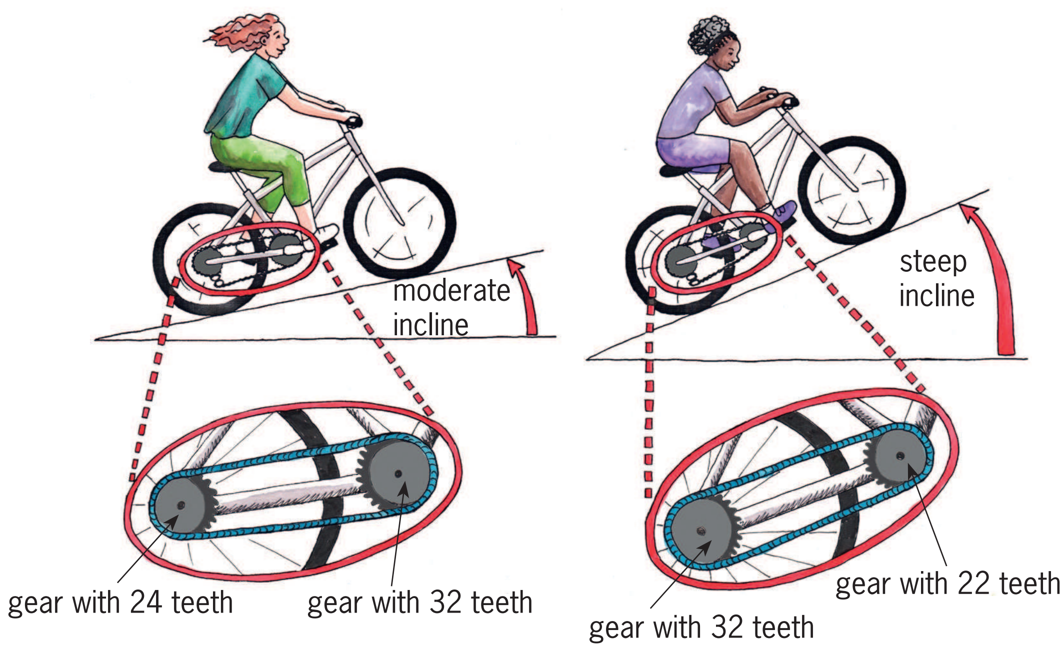


Figure 1: You use different combinations of gears on a bicycle when you cycle up a moderate slope or a steep slope. Why?

Words to talk about hills and roads going upwards

When a road is flat, you say that it is **level**.

When a road goes up or down, you say that it has a **slope**, a **gradient**, or an **incline**.

When a road goes slightly upwards, you say it has a **gentle** incline.

When a road rises more quickly, you say that it has a **moderate** incline.

When a road rises up sharply, you say that it has a **steep** incline.

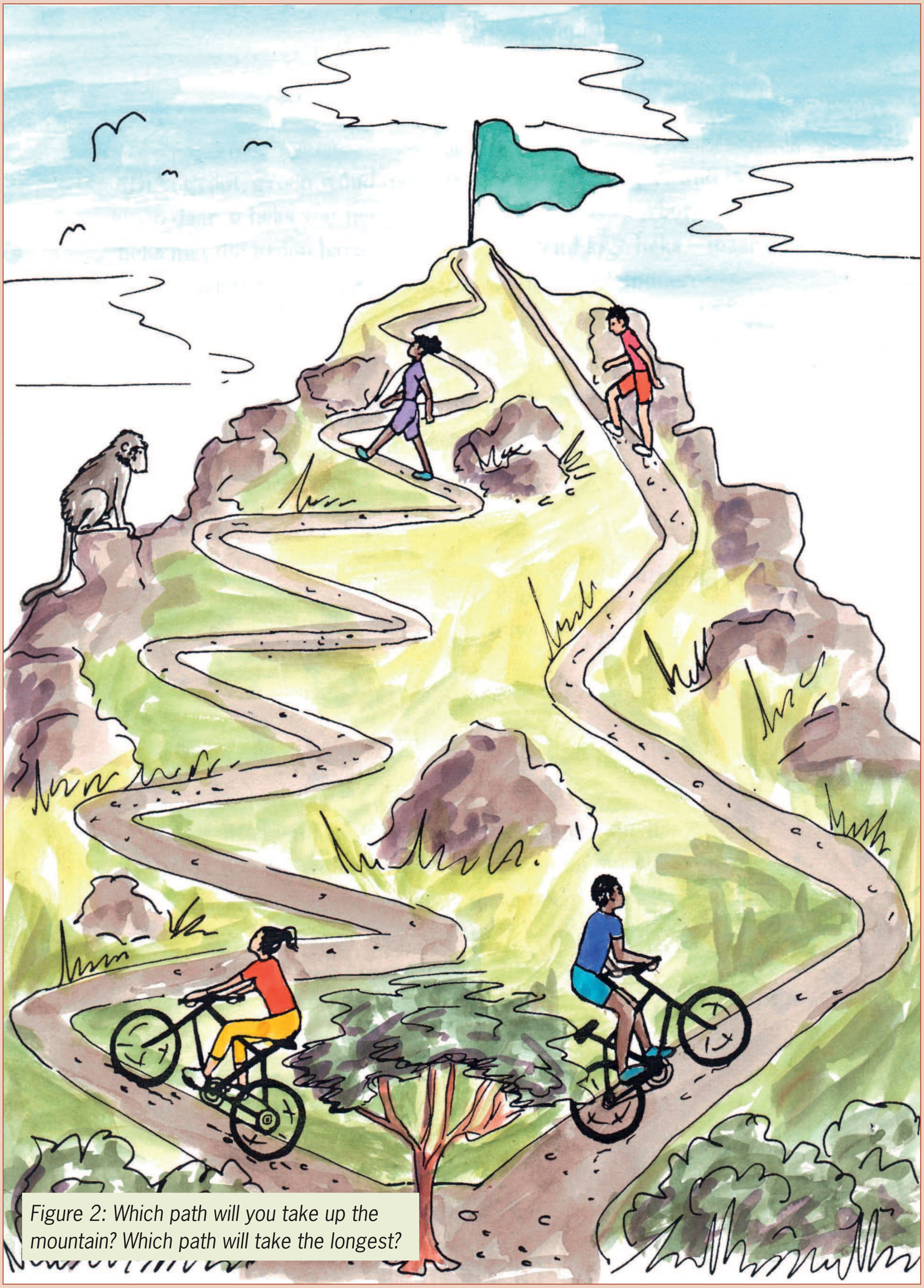


Figure 2: Which path will you take up the mountain? Which path will take the longest?

5.1 Inclined planes and wedges

Revision: Mechanical advantage

Levers, pulleys and cranks are different types of **mechanisms**. In this chapter, you will learn about more types of mechanisms.

In Grade 7 you learnt how levers, pulleys and cranks can help you to move things. To get an object to move, you need to push it or pull it. A push or pull is called a force. That force will make the object move over a distance. Force and distance are the two important things that are changed by a mechanism.

Some mechanisms change a small input force over a large distance into a large output force over a small distance. You can say that the mechanisms have a **mechanical advantage**, but a **distance disadvantage**. You get a mechanical advantage when a machine makes it easier to lift or move something.

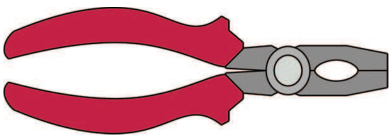


Figure 3: A pair of pliers that give a mechanical advantage.

Figure 4: A pair of kitchen tongs that give a distance advantage.

Other mechanisms change a large input force over a small distance, into a small output force over a large distance. You can say that the mechanisms have a **mechanical disadvantage**, but a **distance advantage**. You get a distance advantage when a machine makes something move further.

Whenever you look to see how a mechanism works, try to understand what is happening to the input force and the output force. Also try to understand what is happening to the input distance and the output distance. A distance advantage is often also a speed advantage, because if something moves further in the same time, it also moves faster.

Inclined planes

A road that goes up steeply can be called an **inclined plane**. The roof of a house that goes up at an angle is also an inclined plane.

Helping a boy in a wheelchair to get up a step

When people design buildings with steps, they also have to think about old people or people in wheelchairs. These people will struggle to get up steps, like the boy in the wheelchair in Figure 5.

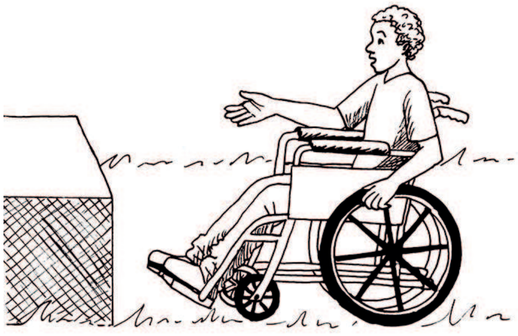


Figure 5

To help the boy, you can build a ramp to make a smooth path between the low place on the ground and the higher place. Two different designs of a ramp are shown below.

A ramp is also an **inclined plane**.

ramp A

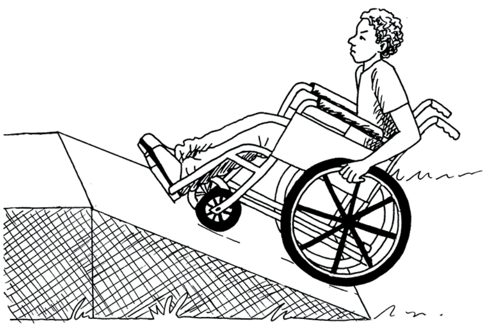


Figure 6

ramp B

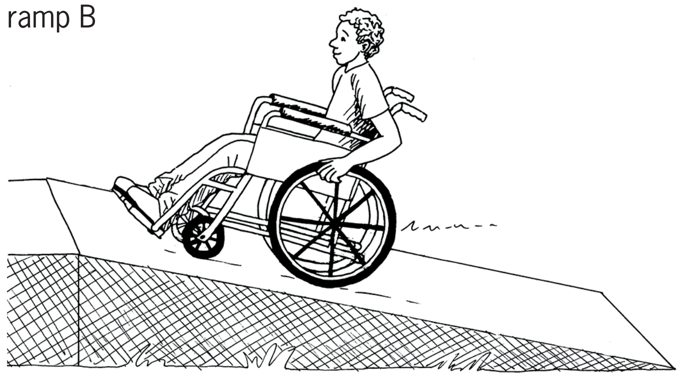


Figure 7

1. Which design will be the easiest for the boy to get from the ground to the higher place, and why? Hint: read the part on "Words to talk about hills and roads going upwards" at the bottom of page 57.

   ....

2. Will the boy travel the same distance up both ramps A and B, or will he travel a longer distance on one of the ramps? If yes, which one?

   ....

3. Will the force with which the boy has to turn the wheels be the same on both ramps, or will it be greater on one of the ramps? If yes, which one?

   ....

4. Use the following words to write a few sentences to explain why it is easier for the boy to go up the one ramp than the other:
   input force, output force, input distance, and output distance.

   ....

   ....

   ....

5. Which ramp gives the boy the greatest mechanical advantage?

   ....

Wedges

Axes and knives are wedges. Wedges change a small input force into a larger output force. They use a large input distance to give a small output distance.

Why does an axe make it easier to split wood?

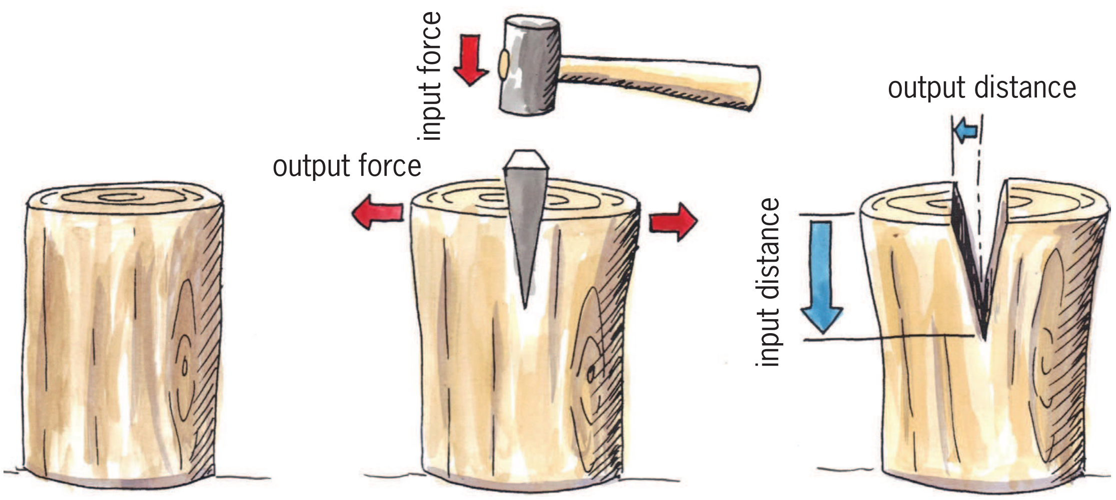


Figure 8: The wedge shape of the head of an axe makes it easier to cut wood.

When you cut wood with a wedge-shaped axe, a large input distance downwards causes a small output distance sideways.

1. Is the input force greater or smaller than the output force? Or are they the same?

   ....

2. Does an axe give a mechanical advantage or a distance advantage?

   ....

The drawing on the right shows how wedges can be used to make a house **level**. If a house is not level, and you put a ball on the floor, the ball will roll to the lowest side or corner of the house.

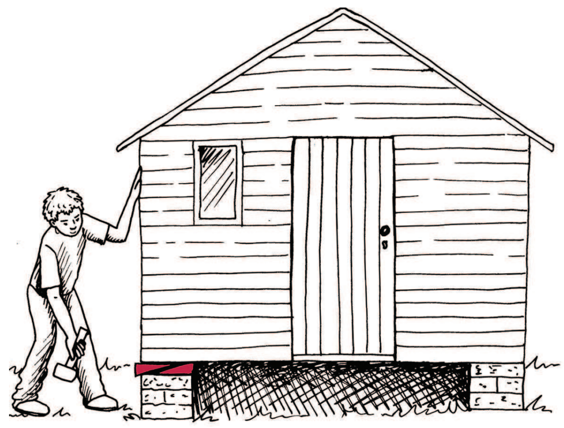


Figure 9: Wedges can be used to lift up very heavy objects, even houses!

5.2 Wheels

What is special about wheels? They can roll over a surface to cover a distance, just like a ball. When a wheel on the ground turns, it moves forward in a specific direction. So a wheel changes a turning or **rotational movement** into a straight or **linear movement**.

Without wheels, the only way to move objects over the ground or another surface would be to drag them across the surface. Perhaps you have moved a heavy cupboard or even a fridge or a stove over a floor. It is hard work! But if there were wheels underneath the heavy object, it would be much easier to move it, because the **friction** would be less.

The words "roll" and "rotate" both come from the same old Latin word "rota". "Rotational movement" means a rolling or circular movement.

The word "linear" comes from the word "line". "Linear movement" means movement in a straight line.

Friction is the resistance force that makes it hard to slide something along a surface.

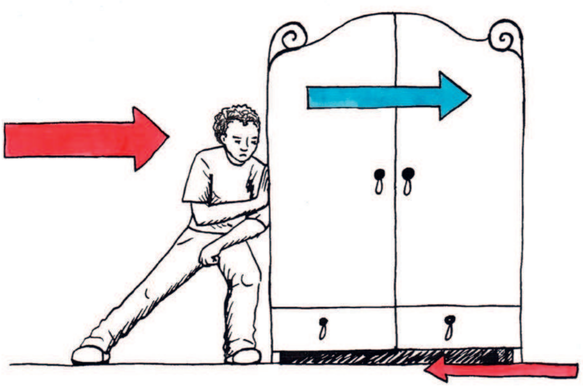


Figure 10

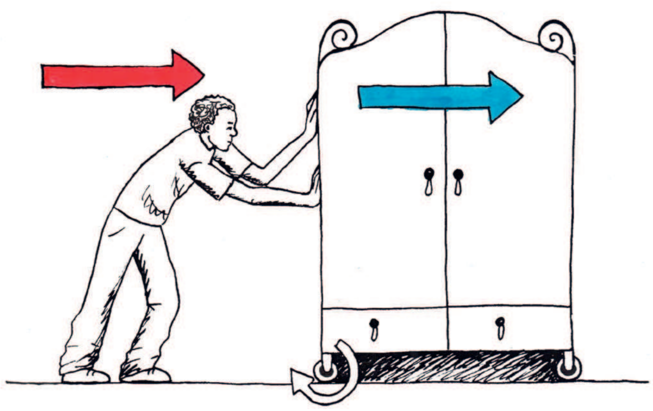


Figure 11

Imagine you are moving a heavy cupboard. Fortunately, the cupboard stands on wheels, like a shopping trolley. When you push the cupboard, the wheels turn and the cupboard moves forward. So your linear pushing movement is changed into the rotational movement of the wheels, which is changed into the linear movement of the cupboard. This is why you say that a wheel is a mechanism that changes the direction of movement. It changes the movement from linear movement, to rotational movement, and back into linear movement.

The wheels under the cupboard were freely turning, like the front wheel of a bicycle. You call that a **free-running wheel**.

The back wheel of a bicycle does not turn freely. It turns because the chain is pulling the gear on the back wheel to turn. You call that a **driven wheel**.

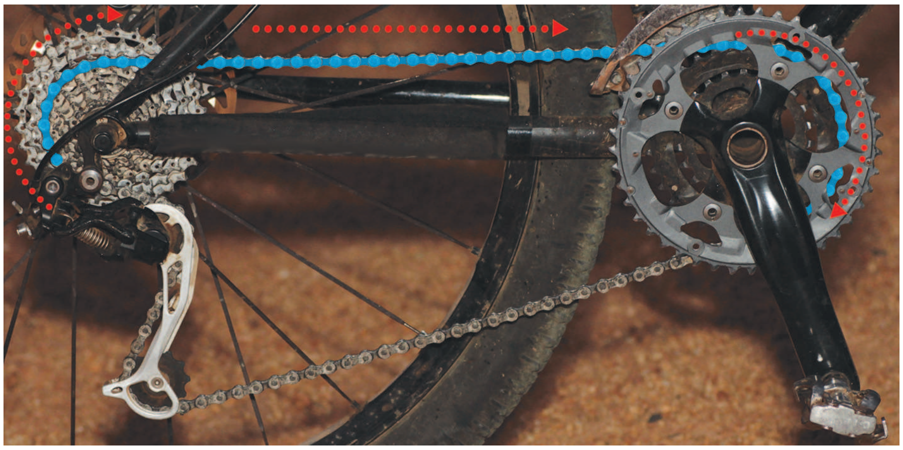


Figure 12: The back wheel of a bicycle is driven by the gear and chain mechanism

A wheel that is driven gives a distance advantage. The drawings on the right and below use a bicycle as an example to explain this.

The chain goes around a gear on the back wheel. That gear has a circumference of 30 cm. So if the chain pulls forward by 30 cm, then the gear will rotate once.

- When the gear rotates once, the wheel rotates once.
- The wheel has a circumference of 207 cm. If the wheel rotates once, the bicycles moves forward by 207 cm.
- Therefore, when you pull the chain forward by 30 cm, the bicycle moves forward by 207 cm. That is why a driven wheel gives a distance advantage.

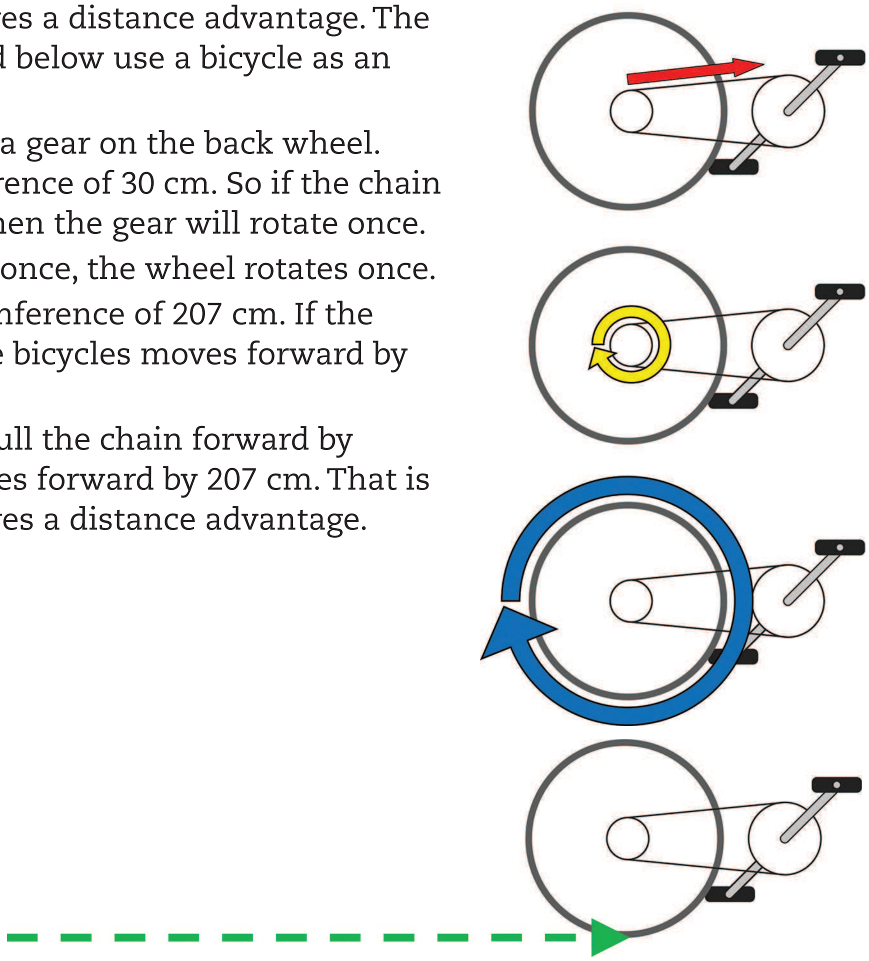


Figure 13: A wheel gives a distance advantage

For a wheel to turn, it has to turn around something that is at the centre of it. This is called the **axle**. An axle is for a wheel what a pivot or fulcrum is for a lever.

The inside of the wheel rubs on the axle, so there is some friction that tries to stop the wheel from turning. This friction is very small because:

- The distance moved at the outside of the wheel is greater than the distance moved at the axle. You can see this on Figure 14, where the distance moved at the outside of the wheel is shown in blue, and the distance moved at the axle is shown in red. For the same forwards movement, a bigger wheel will give a smaller movement at the axle. Therefore big wheels give less rubbing or friction at the axle.
- Most wheels have a very smooth oiled surface or bearings between the axle and the wheel, to reduce the friction even more.

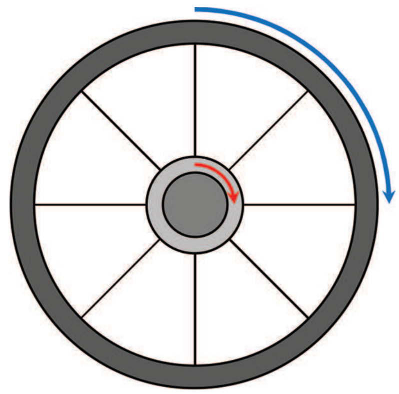


Figure 14

Group discussion

Work in groups of three or four. Write down your answers.

1. Why are some wheels small and others big?
   Hint: think of the advantages and disadvantages of small wheels and of big wheels. Also think of the weight and cost of the wheels.

   ....

   ....

   ....

   ....

2. A motor car, a 4 × 4 bakkie, a shopping trolley, and a skateboard each have four wheels. For each one of these examples, which wheels are driven and which are free-running?

   ....

   ....

   ....

Technology Gr 8 LG Book A.indb 64 1/6/2014 8:16:51 AM

5.3 Gears

Things can turn in two directions

The diagram below shows two levers that are mounted on vertical supports. The levers can turn around axles that are shown with round black dots.

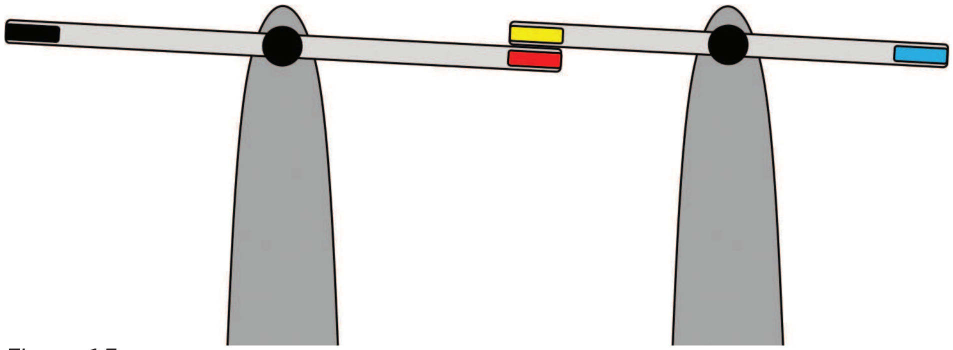


Figure 15

1. If you push the black end of the lever on the left down,
   (a) in what direction will the red end of the lever move, and

   ....

   (b) in what direction will the blue end of the lever on the right move?

   ....

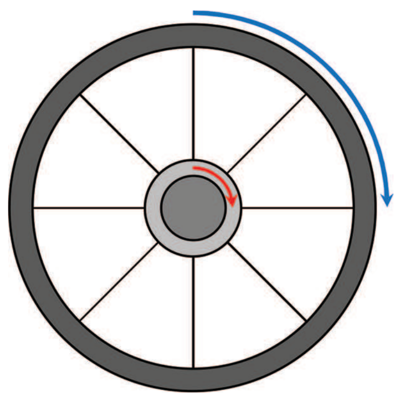


Figure 16: To talk about the direction that something moves over a distance, you use the words forwards, backwards, left, right, up and down. But what if something does not move to anywhere else, but turns while it stays in the same position? Then you talk about something turning like the hands or arrows of a clock.

2. If you push the black end of the lever on the left down, will the lever turn **clockwise** like this,

   or **anti-clockwise** like this?

   ....

3. If you turn the lever on the left anti-clockwise, in which direction will the lever on the right turn?

   ....

Technology Gr 8 LG Book A.indb 65 1/6/2014 8:16:51 AM

Gears are very similar to levers. Look at the drawings below.

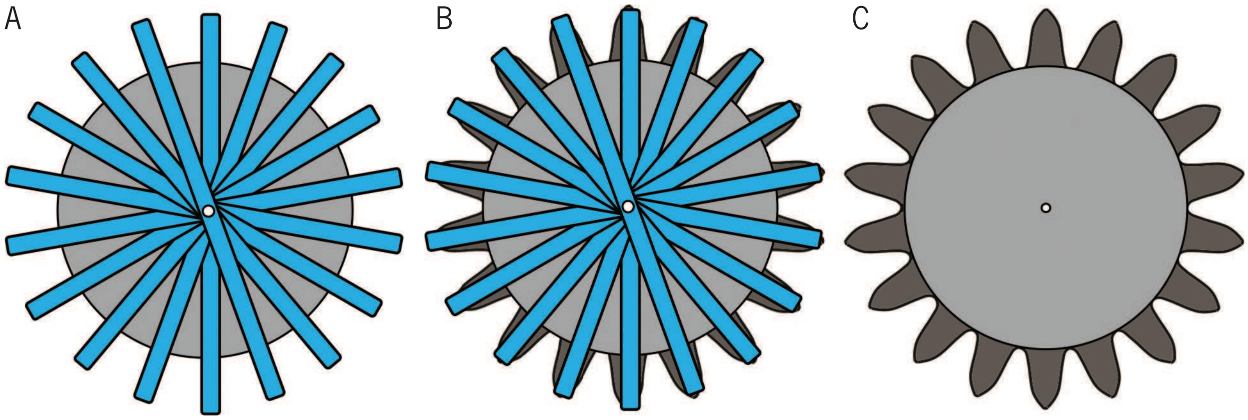


Figure 17: You can think of a gear as if it is made up of many levers.

Imagine you attach many levers to a round disc as in drawing A. If you then add material to make the ends of the levers into the shapes of gear teeth, you will have a gear, as shown by drawing B.

The type of gear shown in drawing C is called a **spur gear**. In Term 3 of this year and in Grade 9 you will learn about other types of gears.

4. The red gear below is turned anti-clockwise, until the tooth with the black dot reaches the arrow.
   (a) Draw another arrow to show where the tooth with the blue dot will be when the black dot reaches the arrow.
   (b) Draw a small cross to show where the red dot will be when the black dot reaches the arrow.

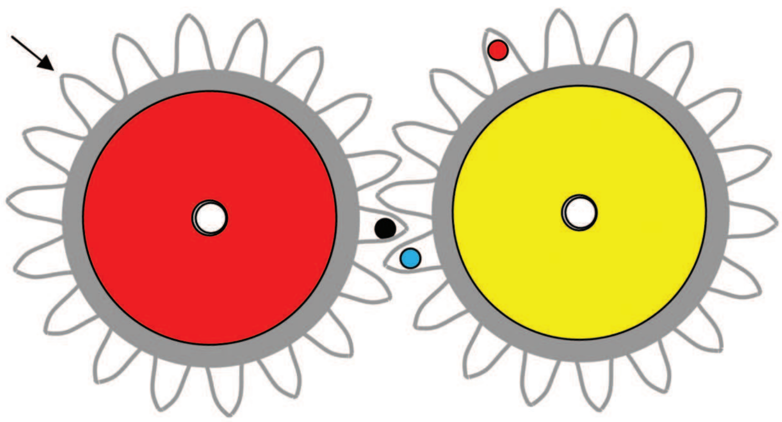


Figure 18

   (c) In what direction will the yellow gear turn, when the red gear is turned anti-clockwise?

....

5. (a) In what direction must the small gear on the right be turned so that the blue dot will move downwards when you start to turn?

   ....

   (b) If the small gear is turned clockwise until the red dot is back at the yellow arrow again, where will the blue dot on the big gear be? Make an arrow on the sketch to show where it will be.

   ....

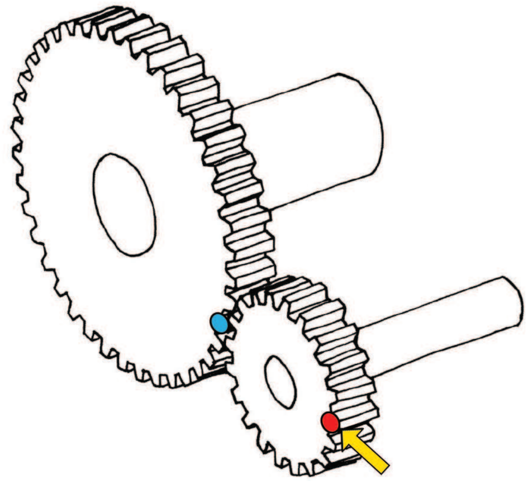


Figure 19

   (c) If you turn the small gear by hand, will the big gear turn faster or slower than the small gear? Explain your answer.

   ....

   ....

Spur gears work together in sets of two or more.
Any set of gears has an **input gear** and an **output gear**.
The input gear is also called the **driver gear**, and the output gear is called the **driven gear**.
If the small gear in Figure 19 is turned by hand then the small gear is the input gear.

When the teeth of two gears touch so that the gears turn together, you say that the two gears **mesh**.
Any two gears that mesh turn in opposite directions. This is called **counter-rotation**.

6. If you want the driver gear and the driven gear to turn in the same direction the two gears will not work. Can you make another plan?

   ....

Idler gears

The drawing below shows a set of three gears. The gear in the middle is called an **idler gear**. Its purpose is to make the driven gear turn in the same direction than the driver gear.

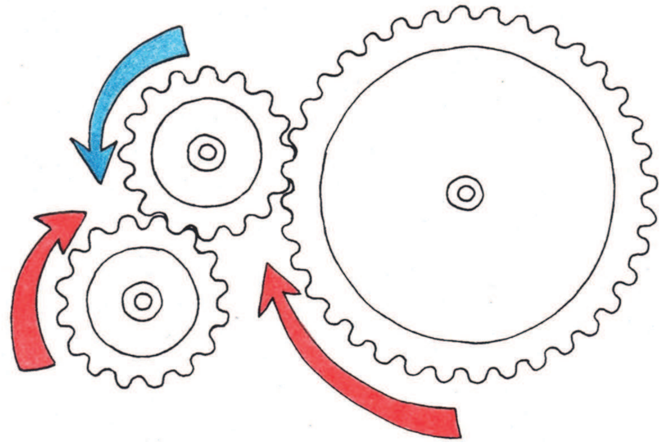


Figure 20: In a three gear set the input and output gears turn in the same direction.

1. Look at the system of gears in Figure 21. If the gear on the left is the driver gear, will the driven gear turn faster or slower than the driver, or will it turn at the same speed?

   ....

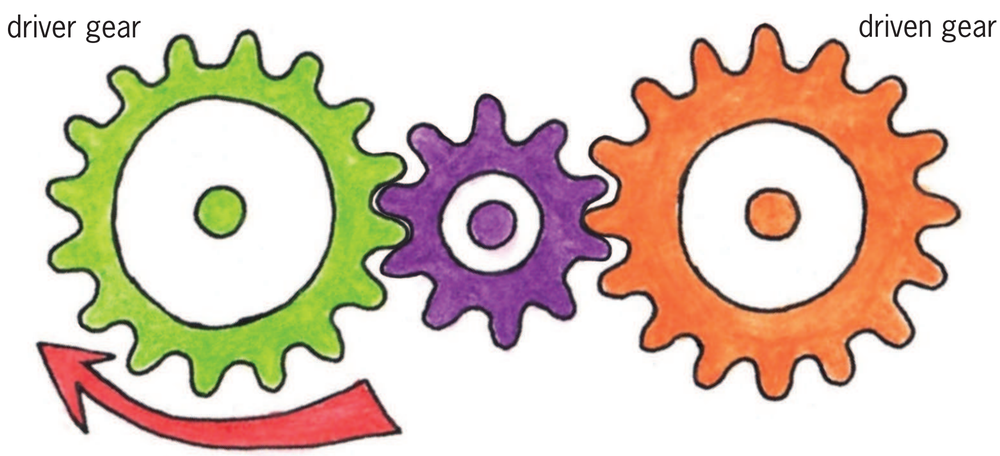


Figure 21

When an idler gear is smaller than the other gears, as for example in Figure 21, then it is made of harder material than the other gears. This is because the idler gear will rotate more times than the other gears. Every time a gear turns the metal rubs against the metal of the other gears, and a little bit of the metal rubs away. Have a look at the soles of your shoes. The same thing happens to them.

Gear ratios

1. Look at the gears on the right. The big gear is the input gear, and the small gear is the output gear.

   Each gear is fixed to an axle, and the axle drives a fan. The speed with which the fan turns is called the **rotational speed** of the axle.

   (a) Will the fan on the big gear rotate faster or slower than the fan on the small gear, or will it rotate equally fast?

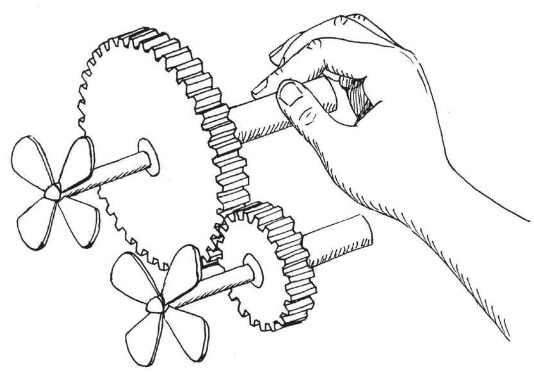


Figure 22

   ....

   (b) Will the force with which you turn the axle of the big input gear be smaller or bigger than the turning force on the axle of the small output gear?

   ....

A gear system can change a fast rotational speed into a slower one, or a slow rotational speed into a faster one. The gear ratio is equal to the speed of rotation of the input gear divided by the speed of rotation of the output gear.

Gear ratio and **speed ratio** is the same thing. It can also be called "velocity ratio".

The speed of rotation of each gear is "inversely proportional" to the number of teeth of the gear. Therefore the gear ratio can be calculated by dividing the number of teeth on the output gear by the number of teeth on the input gear.

In Figure 22 the big input gear has 40 teeth and the output gear has 20 teeth. So this gear system has a **gear ratio** of 20 ÷ 40 = ½. You can also write it as the ratio 1:2. It means that the input gear turns at half the speed of the output gear.

A gear system also changes the turning force on the input axle into a different turning force on the output axle. If the rotational speed of the output axle is faster, the turning force on the output axle will be smaller.

Turning force is also called **torque**.

For the gear system in Figure 22, the output axle exerts half the turning force of the input axle.

$$\text{gear ratio} = \frac{\text{rotational speed of input axle}}{\text{rotational speed of output axle}} = \frac{\text{turning force on output axle}}{\text{turning force on input axle}}$$

$$= \frac{\text{number of teeth on output gear}}{\text{number of teeth on input gear}}$$

Technology Gr 8 LG Book A.indb 69 1/6/2014 8:16:52 AM

Sometimes gears do not touch each other, but are rather connected by a chain, as on a bicycle. But the gear ratios still work in the same way.

On the left in Figure 23 are all the different gear choices at the front of a bicycle, between the pedals. On the right of Figure 23 are all the different gear choices at the back of this bicycle, on the back wheel. The number of teeth of each gear is written inside the gear.

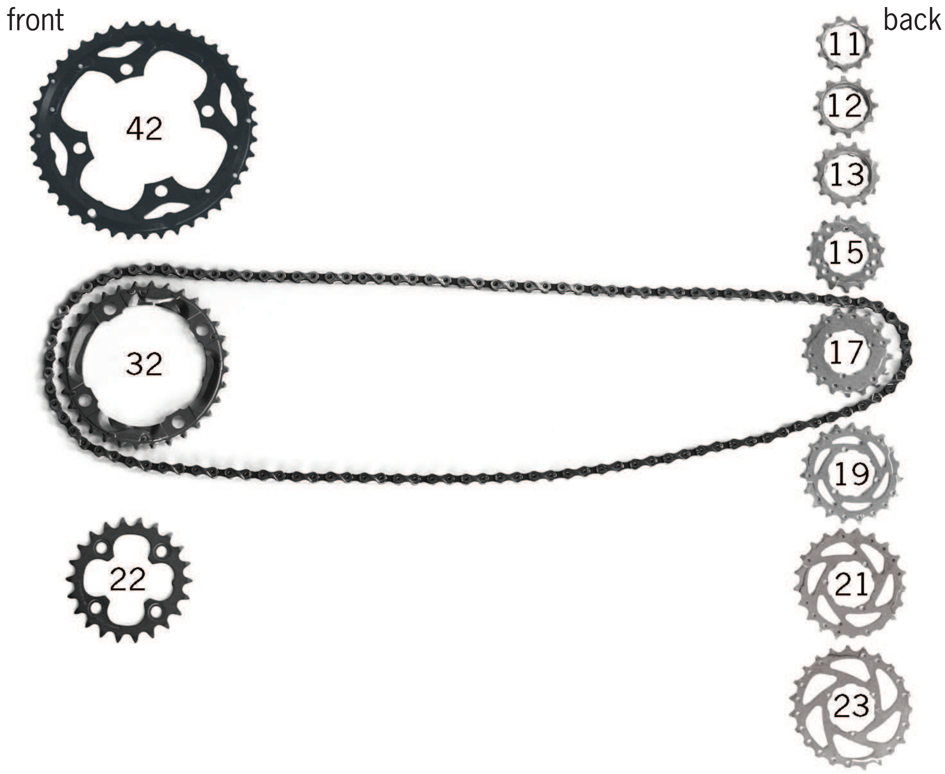


Figure 23: Gear choices on a bicycle

2. (a) What is the biggest gear ratio that you can choose on this bicycle? Choose the front and the back gears that you will use, and then calculate the gear ratio.

....

....

(b) What combination of the front gear and the back gear will you choose to a go up a very steep hill?

....

Chapter 6

Mechanisms that change the type of movement

In the previous chapter you learnt how mechanisms such as wedges, inclined planes, wheels and gears can change the direction, the distance and the force of a movement. For wedges and inclined plains, the movement was in straight lines. For wheels and gears, the movement was in circles, in other words, **rotational movement**.

In this chapter you will learn about another type of movement, that is in a straight line, but does not keep moving forward on that line. Instead, the movement is backwards and forwards or up and down along the line. When you cut bread with a knife, or you cut wood with a saw, you make such a movement. This type of movement is called **reciprocating movement.**

The word "reciprocate" comes from the old Latin words "re" and "pro". "Re" means back and "pro" means forward.

You will learn about mechanisms that change rotational movement into reciprocating movement, or reciprocating movement into rotational movement.

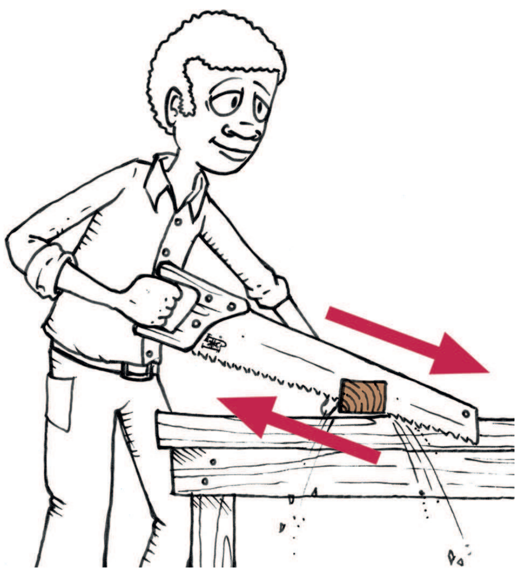


Figure 1: When you saw wood you make a reciprocating movement.

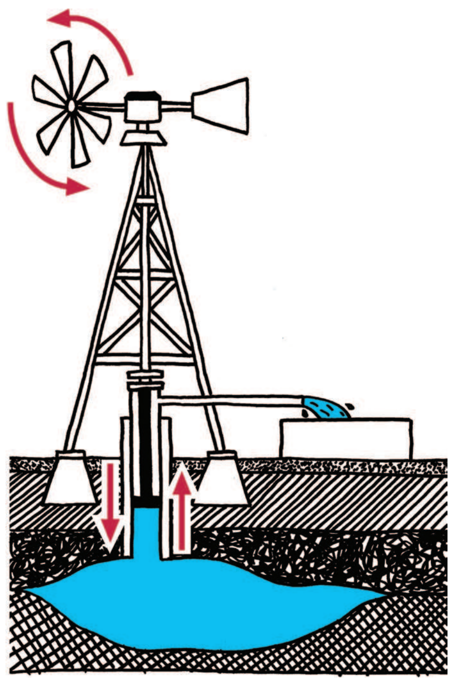


Figure 2: A wind pump converts a rotating movement into a reciprocating movement.

Figure 3: A steam driven locomotive uses a crank-and-slider mechanism to turn the wheels.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6.1 The crank-and-slider mechanism

Revision: A crank-and-spool mechanism

You learnt about cranks in Term 3 of Grade 7. There a crank was used to turn a wheel called a spool on which rope was rolled up. The crank was part of a bigger mechanism that is called a crank-and-spool mechanism or a winch. The crank can be turned one way to pull in the rope, and the other way to let it out.

> When a crank is part of a winch, it changes a big rotational movement with a small force into a small rotational movement with a big force. The longer the crank arm is, the more mechanical advantage it gives.

Some winches also use gears to give an even bigger mechanical advantage.

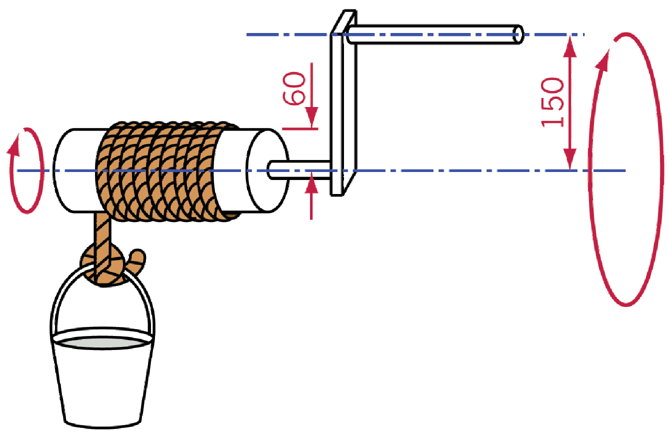


Figure 4: A simple hand-powered winch used to lift a bucket of water

Changing rotational movement into reciprocal movement

To change rotational movement into reciprocal movement, a crank is used in a different way, as shown by the pictures on the next page. A **slider** is attached to the crank by a **connecting rod**. The slider is normally round, and fits into a round hole. It can only move sideways, not up or down.

There is a **pivot** between the crank and the connecting rod, and another **pivot** between the connecting rod and the slider. Both pivots change position when the mechanism is working. The crank turns around an **axle**. The axle never changes position, it just turns.

The crank can be fixed to a **wheel**, to make the wheel turn with it. Or the crank can be part of the wheel.

> The way the crank works depends only on the distance between the centre of the axle and the centre of the pivot between the crank and the push rod. This distance is called the **crank throw**. This is shown on Figure 5.

The longer the crank throw is, the greater the mechanical advantage of the crank will be. The shape of the crank does not matter.

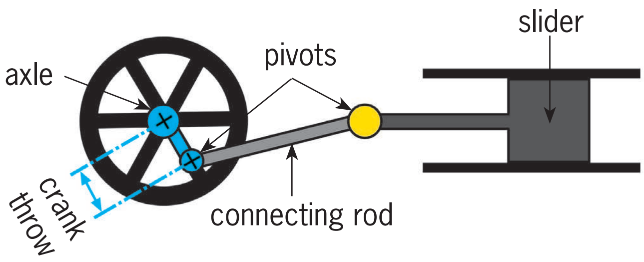


Figure 5: The different parts of a crank-and-slider mechanism

Thinking about the pictures

The different steps in the operation of a crank-and-slider mechanism are shown in the pictures on the right, in Figure 6.

1. How long is the crank throw in the mechanism in Figure 6?

   ....

2. How far is the movement of the slider from the furthest position on the left to the furthest position on the right? This can be called the "total sideways movement".

   ....

3. If the crank throw was twice as long, how long would the total sideways movement of the slider be?

   ....

4. Will the slider ever stand still while the crank is rotating?

   ....

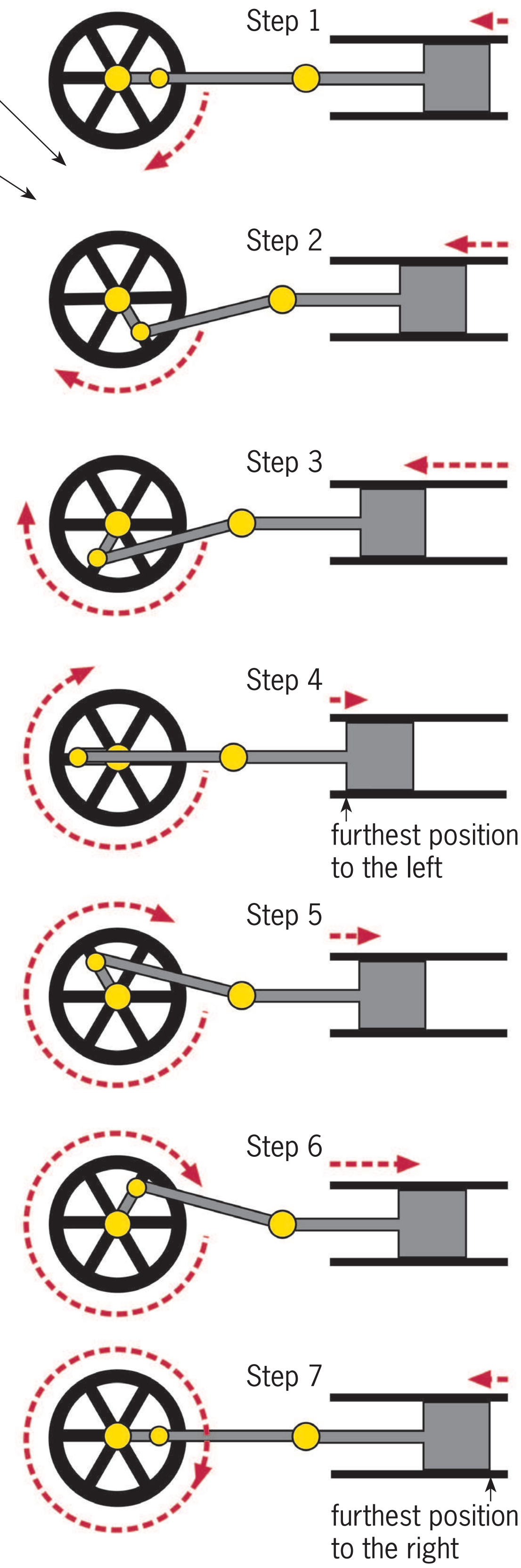


Figure 6: Different steps during the operation of a crank-and-slider mechanism

The crank-and-slider mechanism inside a steam engine

In a steam locomotive a coal fire is used to boil water. The water changes into very hot steam that has a **high pressure**. Imagine you are blowing up a balloon. You have to create a high pressure of air in your mouth to make the balloon bigger. The balloon becomes bigger because the high pressure air moves the sides of the balloon outwards. Steam at a high pressure can also move things.

Figure 7

The pictures on the right show how the movement created by high pressure steam is changed into the rotation of a wheel.

The hot high pressure steam is shown in red. When the steam expands, it also cools down. The cooler steam is shown in purple, and at the end it is shown in blue.

In an engine, the slider is called a **piston**, and the hole inside which the piston moves is called the **cylinder**.

A steam engine uses **valves** to let in the hot steam on the right or the left of the cylinder. The valves have to open and close at the right times. Is there some mechanism that can do this? This is what you will learn about in the next lesson.

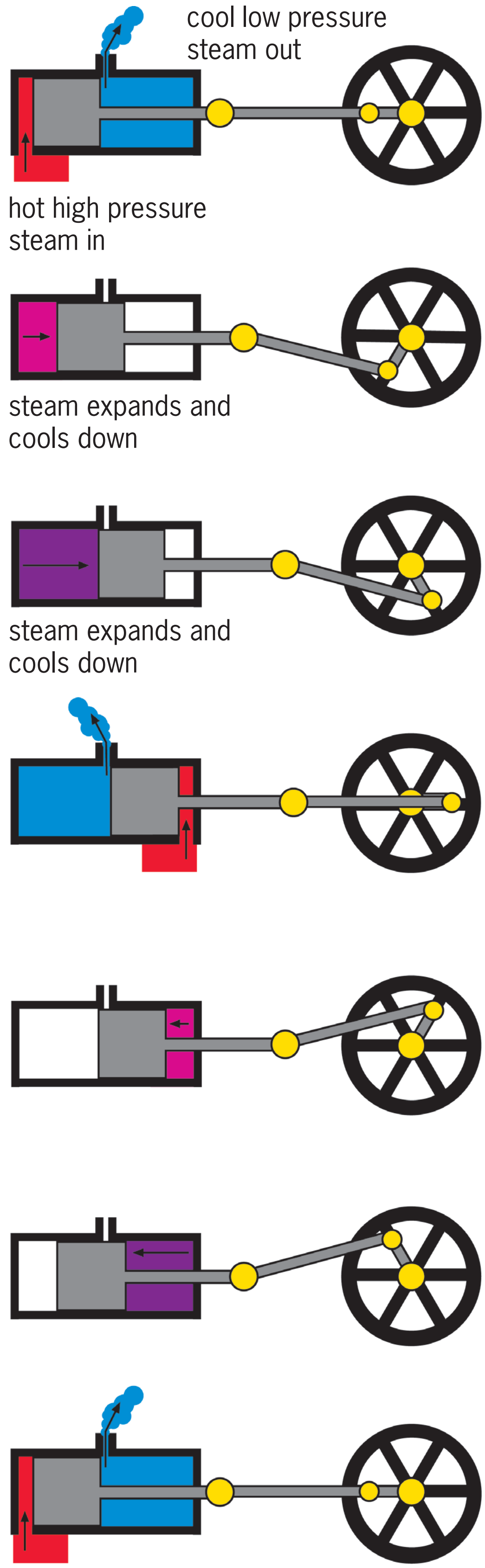


Figure 8: How a steam engine works

Look again at Figures 6 and 8.

A crank-and-slider mechanism can be used to change rotational movement into reciprocal movement, or it can be used to change reciprocal movement into rotational movement. In other words, if you move the crank, then the slider will also move. And if you move the slider, the crank will also move.

6.2 The cam-and-follower mechanism

A **cam** is a wheel that is not round, or it is a round wheel that turns around an axle that is not at the centre of the wheel.

A cam is used with a **follower**. The rotational movement of the cam is changed into the reciprocating movement of the follower. The follower is in a **sleeve**, so that it can move in one direction only.

A cam is **driven** by an **axle**, so that when the axle rotates, the cam rotates. When the cam rotates, the follower slides on the cam. The position of the follower depends on the angle at which the cam is rotated.

A cam and follower changes the rotating movement of the cam into the reciprocating movement of the follower.

Do you remember the difference between a driven wheel and a free-turning wheel about which you learnt in the previous chapter?

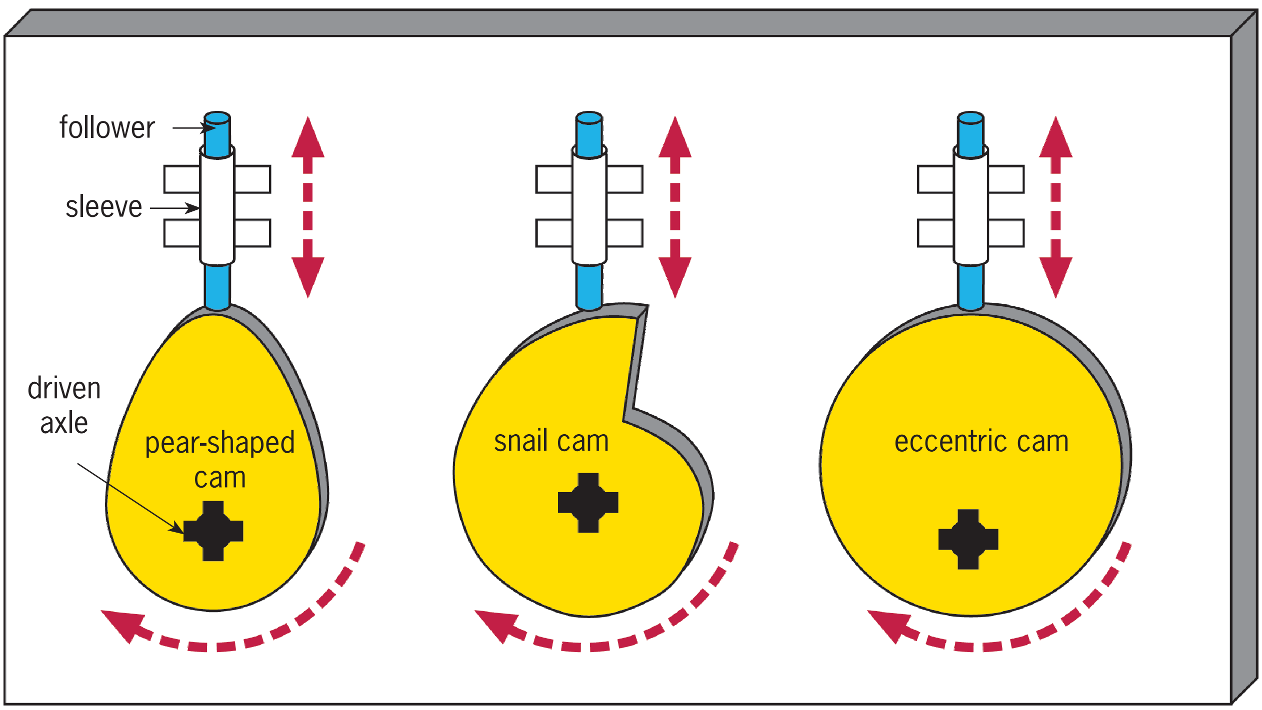


Figure 9: The different parts of a crank-and-slider mechanism, and different shapes of cams

Investigate how a cam can be used to open and close valves

Figure 10 shows how the rotation of a cam changes the position of a valve in an engine. The figure continues on the next page. Study this figure carefully before you answer the following questions.

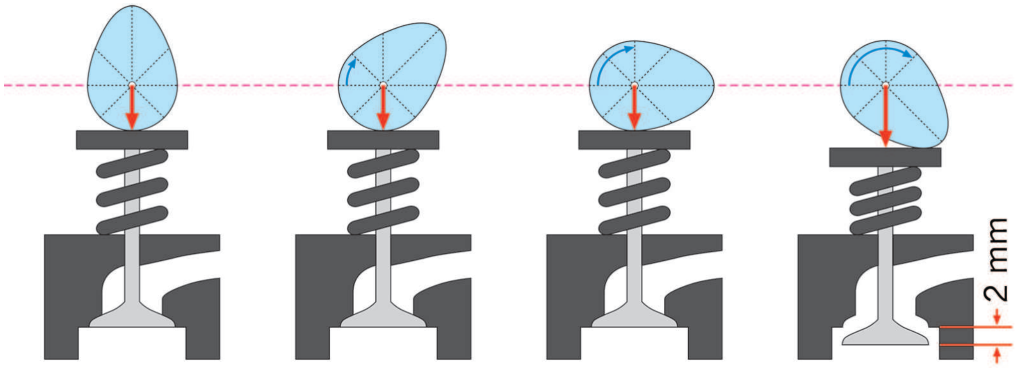


Figure 10: The movement of a valve as a cam rotates

rotation of cam	starting position	1 eight of a cam rotation	2 eights of a cam rotation	3 eights of a cam rotation
rotation of cam in degrees	0°	45°	90°	135°
distance that valve is open	0			2 mm

1. Complete the table above to show how far the valve is open at different positions of the cam in Figure 10. Measure the distance that the valve is open.

2. Which of the pictures above show the valve at its highest position?

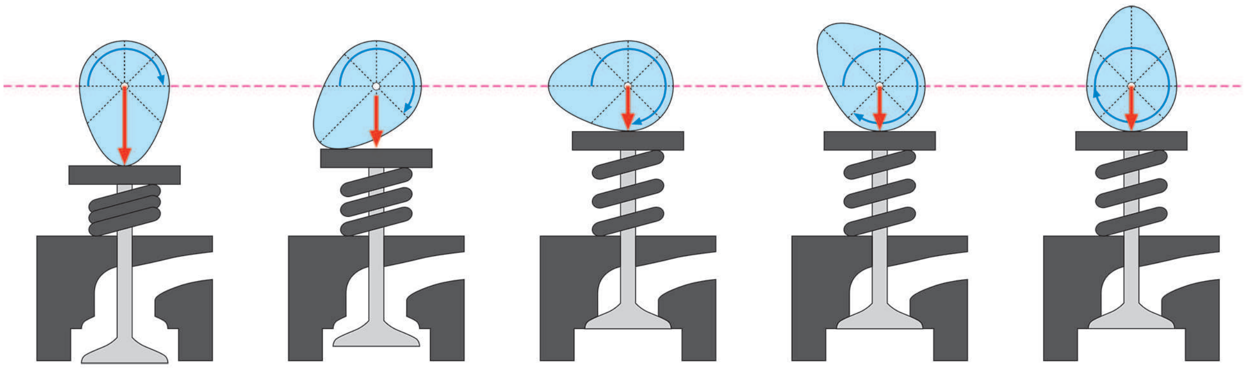
   ....

3. Which picture shows the valve at its lowest position?

   ....

Figure 10 above shows different positions of a cam and a valve as the cam is rotating. This is the way that the valves in most engines are opened and closed at the correct times.

A cam can convert rotational to reciprocal movement, but not the other way round



4 eights of a cam rotation	5 eights of a cam rotation	6 eights of a cam rotation	7 eights of a cam rotation	one full cam rotation
180°	225°	270°	315°	360°

The reciprocating movement created by a snail cam

1. The drawing on the right uses red arrows to show the distance between the centre and the edge of a snail cam at different angles of rotation. Each arrow is rotated with 45° clockwise from the previous arrow.
   Measure the different arrows, from the shortest to the longest and fill in your measurements in the table below.

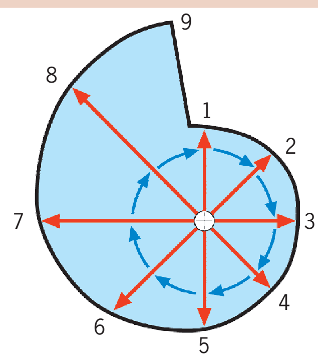


Figure 11: A snail cam

position	1	2	3	4	5	6	7	8	9
length									

2. Is there a pattern in the lengths of the arrows? How does the pattern work?

   ....

3. What happens between position 9 and position 1?

   ....

Something to read at home: another type of cam

Some cams are a round wheel, but they do not rotate around the centre of the wheel. These cams are called **eccentric cams**. They are used on many modern bicycles.

During a bicycle race, the cyclists sometimes get flat or punctured tyres. They then have to take the wheel off to remove the tyre before they can fix the tyre. This takes a lot of time, and they'll struggle to catch up with the other cyclists again.

Many years ago, engineers designed a mechanism with which you can quickly take a wheel off a bicycle, without using any tools. This is called a "quick release" mechanism.

Today, more expensive bicycles use quick release mechanisms on their wheels. They also use a quick release mechanism to make it quick and easy to change the height of the saddle. The photos below and on the right show how a quick release mechanism uses an eccentric cam to lock the saddle at the correct height.

Figure 12: A quick-release mechanism is used to clamp the seat post to the frame of this bicycle.

Figure 13: The sides of the quick release mechanism move or clamp closer together as the eccentric cam is turned by the handle.

Technology Gr 8 LG Book A.indb 80 1/6/2014 8:17:03 AM

6.3 A car engine: using a crankshaft and a camshaft

The different steps in the rotation of a four-stroke petrol engine

Figure 14 shows how a one-cylinder petrol engine works.

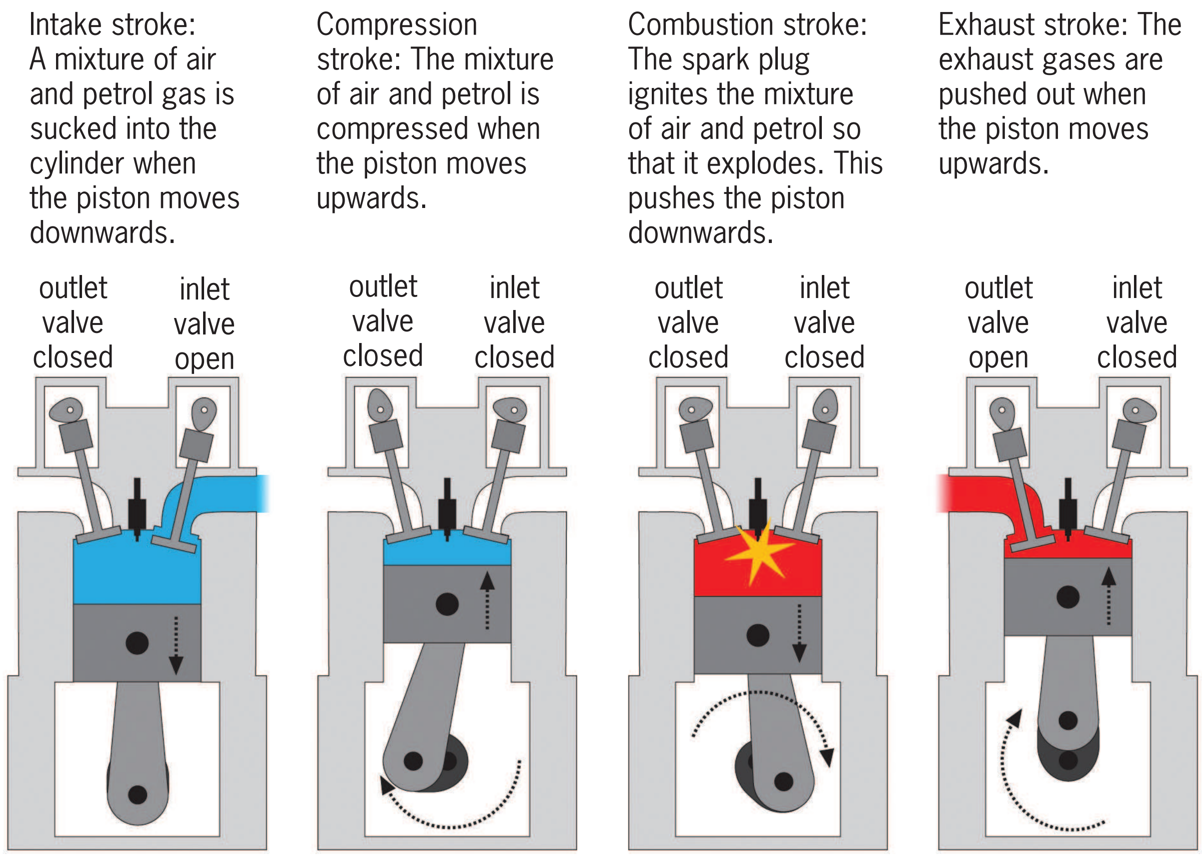


Figure 14

In a car engine, the cams are parts of camshafts that turn as the engine turns. You do not need to understand everything about the engine in Figure 14, as long as you can see that it is important that the inlet and outlet valves open and close at the correct times.

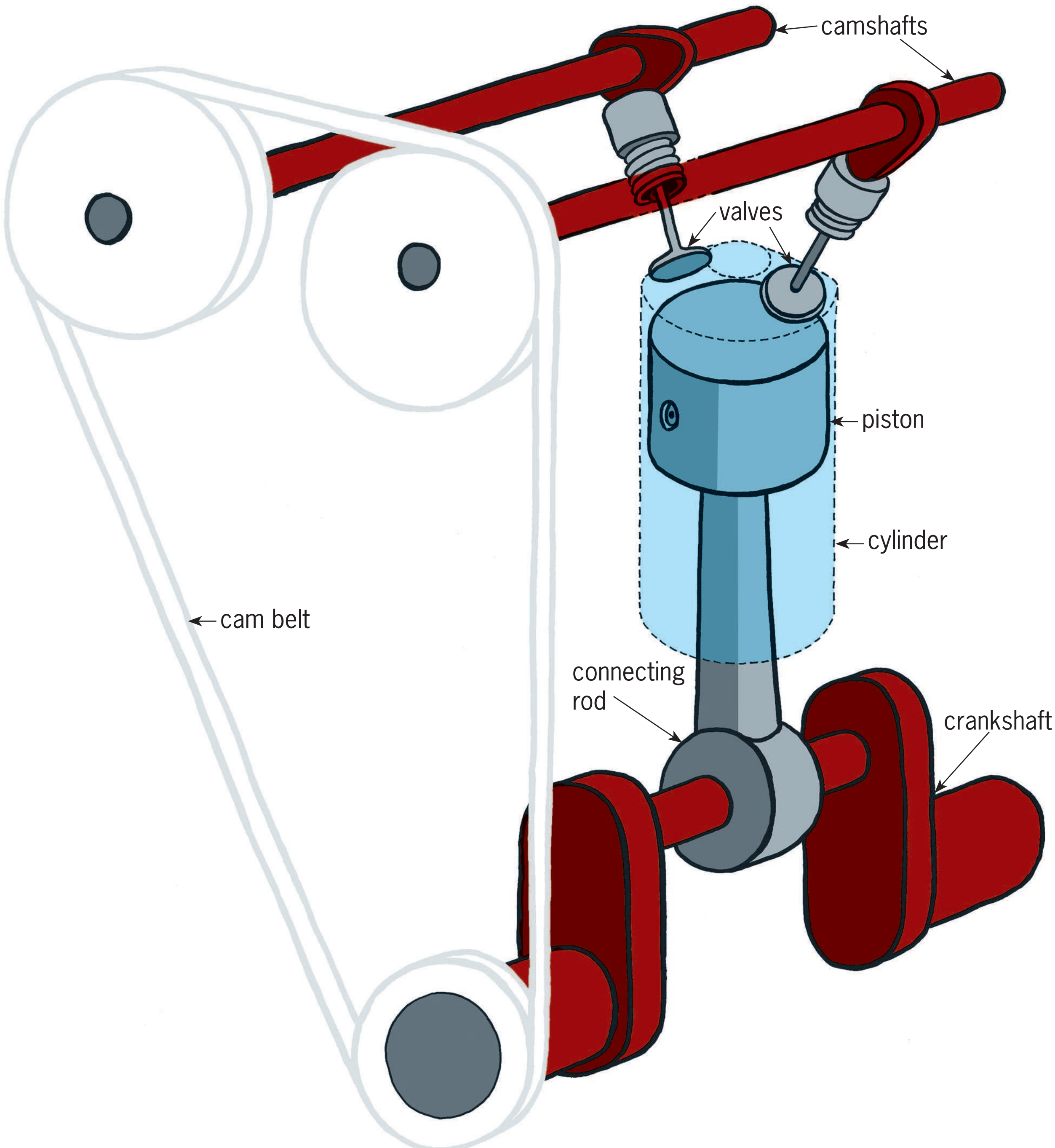


Figure 15: The moving parts inside one cylinder of an engine

Draw an engine crankshaft

1. Make a three-dimensional artistic drawing of the crankshaft of a one-cylinder engine. Use shading to make it more realistic. First make a rough drawing, before you make your final neat drawing.

   Hint: Look back at page 54 to see how you can use shading to make something look round.

Technology Gr 8 LG Book A.indb 83 1/6/2014 8:17:04 AM

Next week

Next week you will start with a practical project to design and make a model of a machine that can crush grain to make flour. This machine will change rotational movement into reciprocating movement.

Chapter 7 Mini-PAT
Design and make a model of a machine to crush grain

Over the next four weeks, you will design and make a model of a machine that can crush grains like mielies or wheat to make meal or flour.

Assessment

Investigate:

Evaluate different designs that other people made .... [6]

Design brief, specifications and constraints .... [6]

Design:

Design how to make the structure stronger .... [8]

Decide what type of mechanism you will use .... [4]

Make:

Build the basic structure and the mechanism in it .... [12]

Draw your design of parts to add to the model .... [12]

Make your improvement to the model .... [10]

Draw an artistic drawing in perspective of your model .... [12]

[Total marks: 70]

Figure 1: How do mielies become maize meal?

Figure 2: Before machines were invented to grind or crush the mielie seeds, it took a lot of hard work to make maize meal.

Week 1

Compare different designs and make your own design

Evaluate different designs that other people made (30 minutes)

This is **individual work**.

The drawings below show rough designs for grain crushers that other people made. These designs are not complete, and there could be problems with them. But there could be useful ideas that you may get from these designs.

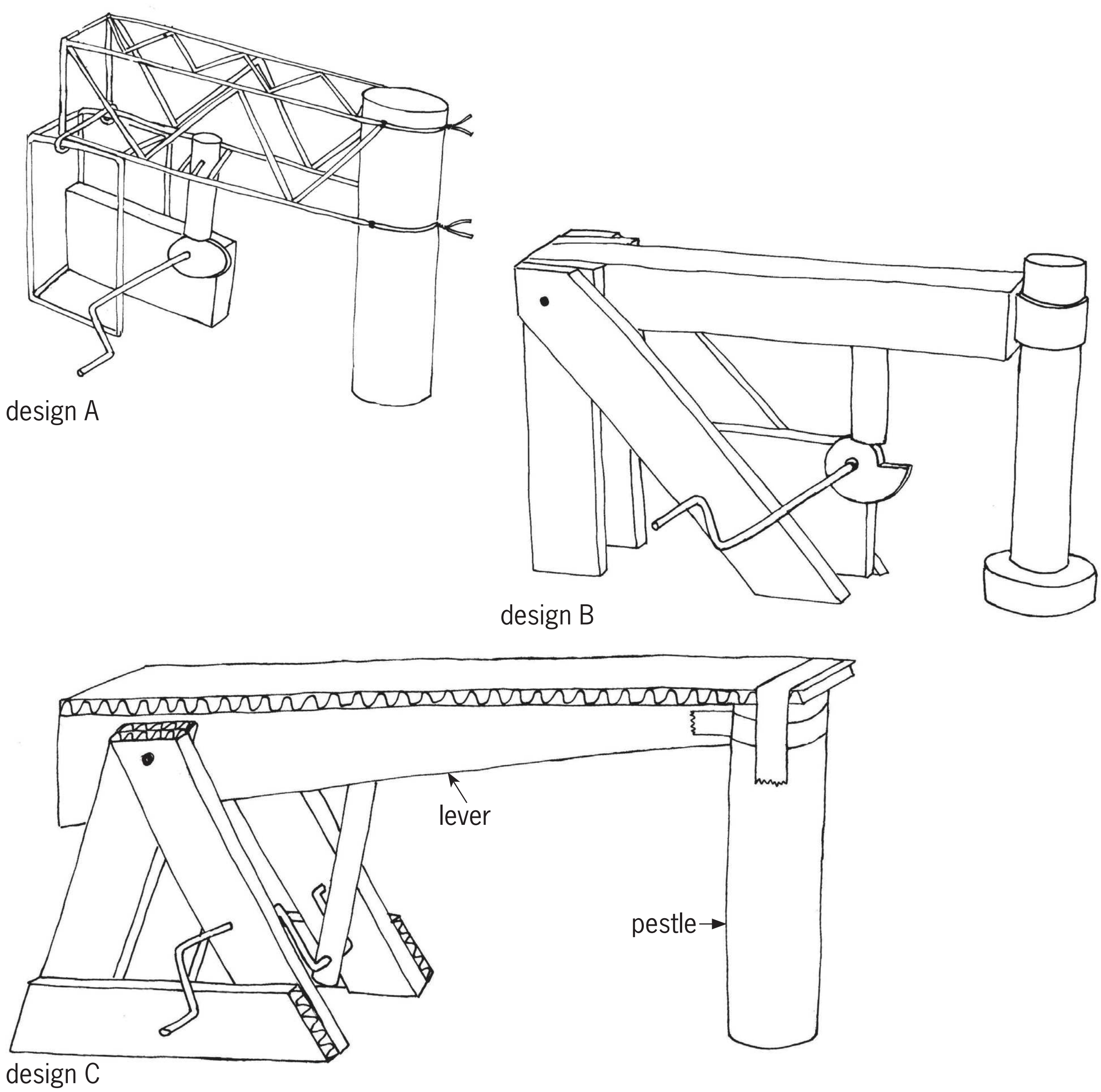


Figure 3: Rough designs made by other people

Make a list of the advantages and disadvantages of the different designs. Think about the following:

- How strong and stable is the structure?
- What materials and tools do you need to make the structure?
- How easy will it be to make the structure?
- How hard and fast will the pestle hit the floor?
- What is the mechanical advantage of the lever?

You will be accessed on the last two rows of the table, on advantages and disadvantages.

	Design A	**Design B**	**Design C**
Strength and stability of structure			
Materials and tools needed			
How easy to make?			
How hard and fast will the pestle hit the floor?			
Mechanical advantage of lever			
Advantages			
Disadvantages			

Total [6]

Design brief, specifications and constraints (30 minutes)

Discuss this in **teams of three or four**. There should be at least one boy and one girl in each group. Everyone has to write their own answers below.

1. Write the **design brief**. A design brief tells you what the problem is and who will benefit from or use the solution. (1)

   ....

   ....

   ....

   A machine to crush grain will usually be powered by an electrical motor that provides rotational movement. You will not use an electrical motor in your model, but will rather turn the handle of a crank by hand. This rotational movement should be changed into a reciprocating movement so that the grain will be crushed, like hitting it with a hammer.

   The mechanisms that your model uses should be housed inside a strong and stable structure.

2. Answer the following questions to identify the **specifications** for your design:

   (a) What different mechanisms could make the grain crusher work? (1)

   ....

   ....

   (b) What forces should the structure be able to withstand? (1)

   ....

   ....

3. Identify the **constraints**:

   (a) How much time do I have to design and make the model? (1)

   ....

   (b) What materials can I find easily to build the model? (1)

   ....

   (c) What tools do I already have with which I can make the model? (1)

   ....

[Total marks: 6]

Design to make the structure stronger (45 minutes)

Work in your teams again, but make your own sketches and give your own answers.

You will later be given instructions on how to build a structure such as the one below. But there are problems with this structure. It is not stable enough to withstand forces from the side. It can collapse or topple over.

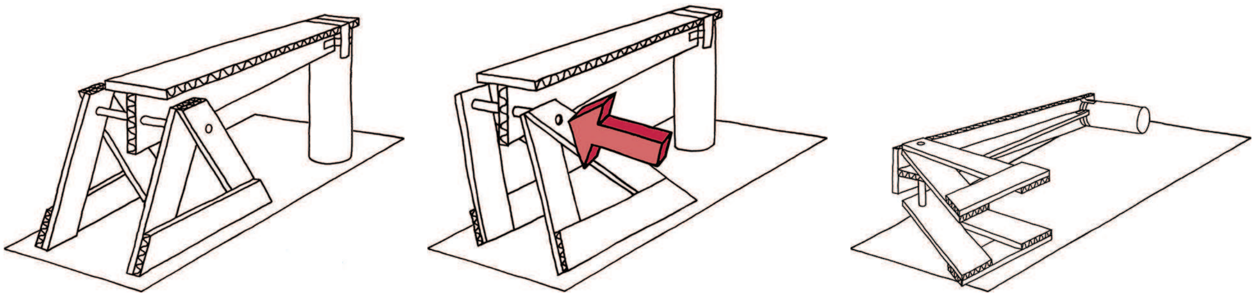


Figure 4: A structure for a grain crusher that is not strong or stable enough to withstand forces acting on its side.

Design something that you can add to the structure to prevent it from collapsing or toppling over sideways. Look at Chapter 1 to help you.

1. Make a rough sketch below of your plan to strengthen the structure. Each person in your team should make their own sketch of their own idea. Add notes and labels to the sketch to explain your design. (4)

2. Compare the rough designs of everyone in your team. Then decide together on what design you will use to strengthen the structure. Make a neat sketch of this design in the space below. Add notes and labels to the sketch to explain the design. (4)

[Total marks: 8]

Decide what type of mechanism you will use (15 minutes)

Look at the old method of crushing grain shown in the drawing on the right. The hollow vessel holds the grain seeds. The operator drops the heavy pole into the vessel with a strong and quick movement. This movement crushes the seeds into smaller pieces.

The mechanism that you choose should also give a strong and quick downwards movement of the pestle.

You can use a crank-and-slider mechanism or one of the shapes of cams below to change rotational movement into reciprocating movement. You learnt the names of these shapes of cams in Chapter 6.

You have to choose whether a crank-and-slider mechanism or a cam-and-follower mechanism will work best to crush the grain. If you choose a cam-and-follower mechanism, you also have to choose the shape of the cam.

Figure 5

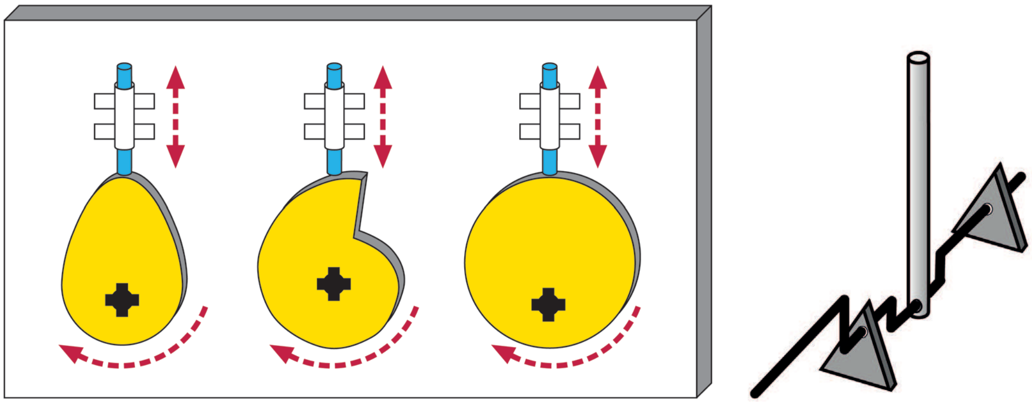


Figure 6: Different mechanisms that you can choose from to change rotational movement into reciprocating movement

1. What mechanism did you choose, and why?

....

....

....

....

[Total marks: 4]

Week 2

Draw your design and build the model

Build the basic structure and the mechanism in it (60 minutes)

First build the structure and mechanism according to the plans and instructions on the following pages. Add your own design for how to make the structure stronger later.

The photo below shows what the model will look like before you make your changes.

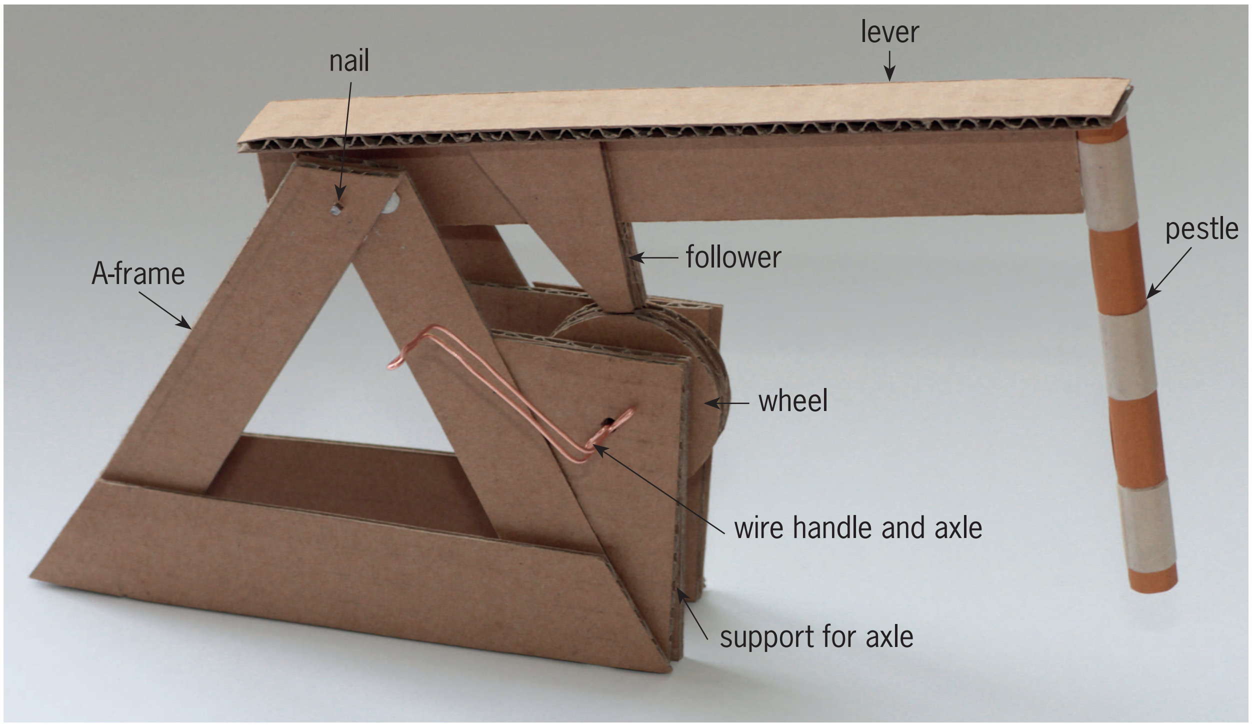


Figure 7

In the plans of the model, a wheel is used instead of a cam or a crank-and-slider mechanism. Therefore the model will not work. Use a cam or a crank-and-slider mechanism to make it work.

On the following pages there are drawings of the different parts that you have to cut out of corrugated cardboard. Trace the shapes onto cardboard before you cut them out. Make sure the **corrugations** are in the correct direction, as shown by the arrows on the drawings.

Corrugations are like tunnels between the two outer layers of the cardboard. Corrugated cardboard is stronger in the one direction than in the other.

You have to decide for yourself how many of each part you need to make. You also have to decide where you will use spacers, and how many to use.

Each member of the team should build their own model.

Cut out this page to trace the shapes of the parts onto corrugated cardboard. Put the page back into your book afterwards.

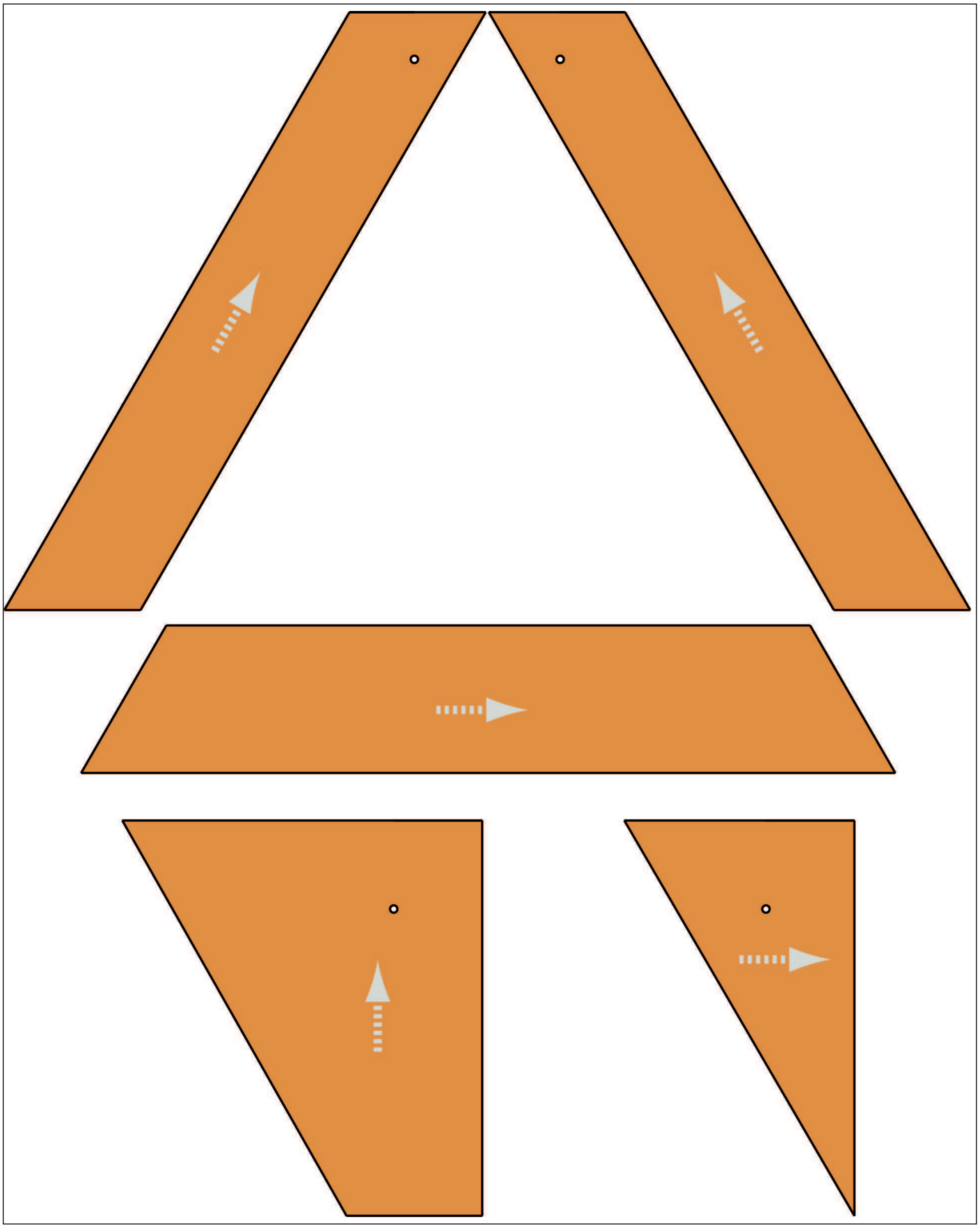


Figure 8: The parts of one of the two A-frames with its support for the axle.

Cut out this page to trace the shapes of the parts onto corrugated cardboard. Put the page back in your book when you're done.

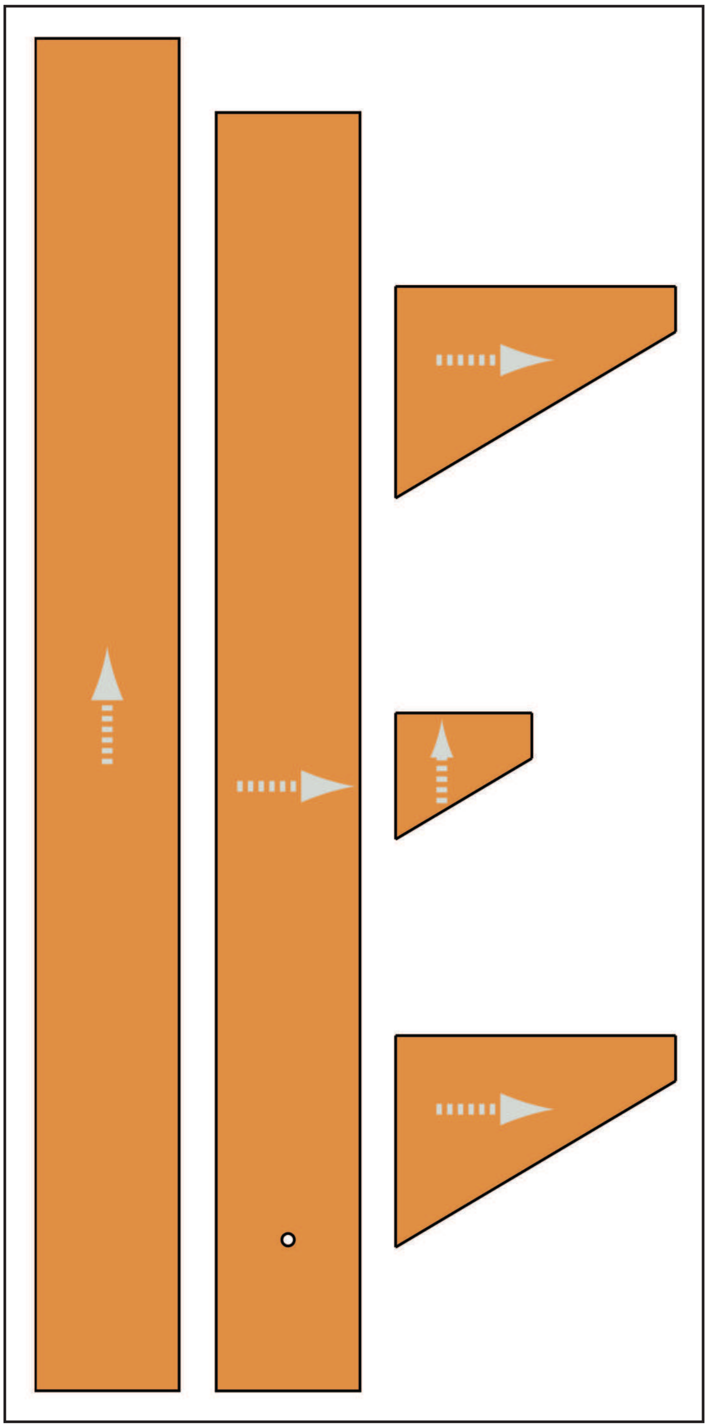


Figure 9: The parts of the lever, and the follower for the cam that will be attached to it

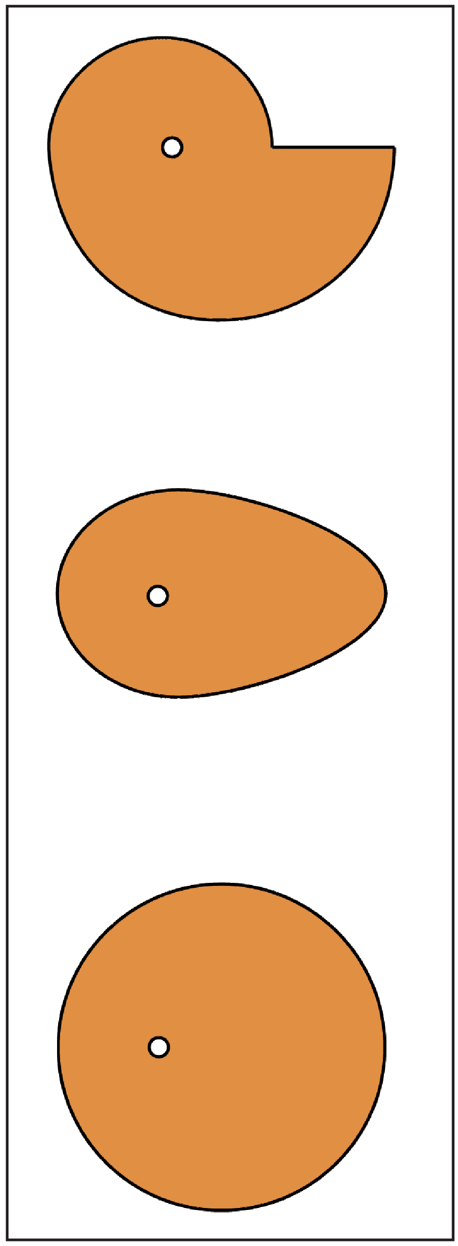


Figure 10: Three different shapes of cams to choose from

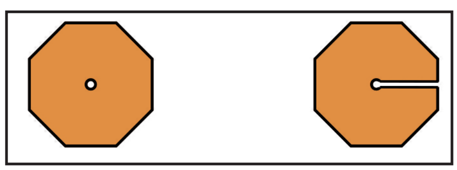


Figure 11: Spacers to use on axles

The steps for building the model are shown on the next two pages.

How to attach the parts of your model

Use Prestik to attach the pieces of cardboard, so that you can take them apart if you make a mistake or want to change something. After your project is completed you may use glue or tape to make the model stronger.

Other materials that you will need

For the axle of the cam or crank mechanism, use 1 mm thick copper wire. This is easy to bend and you can cut it with scissors. If you do not have copper wire, you can use thin steel wire. But you will need a pair of pliers to bend and cut that.

Use a nail or a piece of wire for the axle on which the lever swivels.

> **Safety warning**
>
> Do not remove any copper wire from electrical wiring. If you do this, you can be shocked to death, and other people won't be able to use electricity before the wires are fixed. You can also go to jail for stealing electrical wire.

Unwanted sideways movement on an axle

The model shown in the photos below does not work well because the lever can move sideways on its axle. If this happens the follower could fall off the cam.

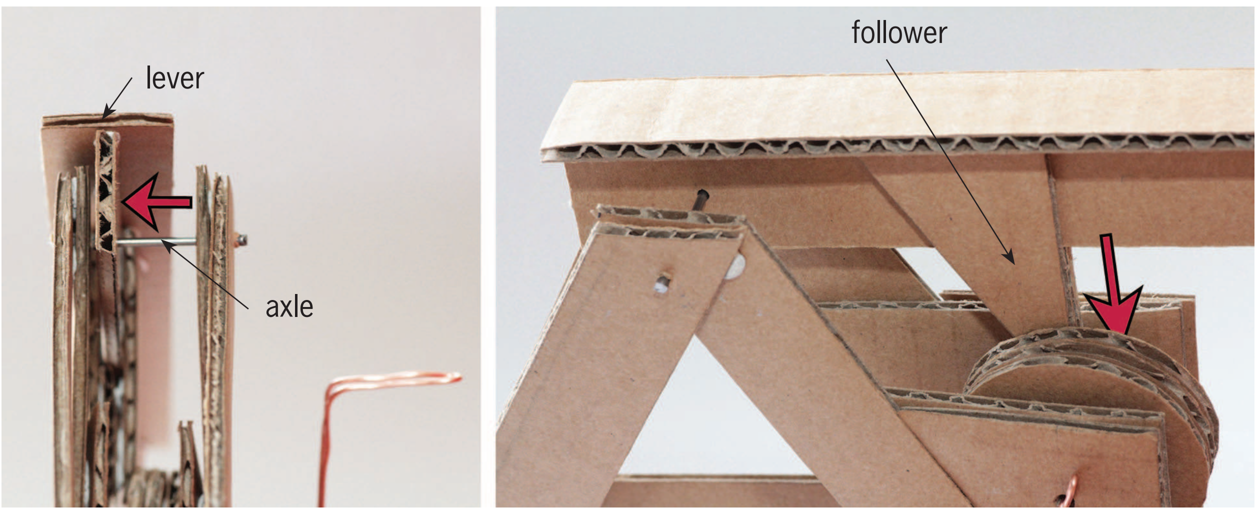


Figure 13

Mark allocation

Your teacher will look at the following to assess your model:

- You followed the plans and instructions successfully. (4)
- You made a mechanism to change the rotational movement of the handle into the reciprocating movement of the pestle. (3)
- The parts that turn on axles cannot move sideways. (2)
- Your model works well. (3)

[Total marks: 12]

Step 1

Step 2

Step 3

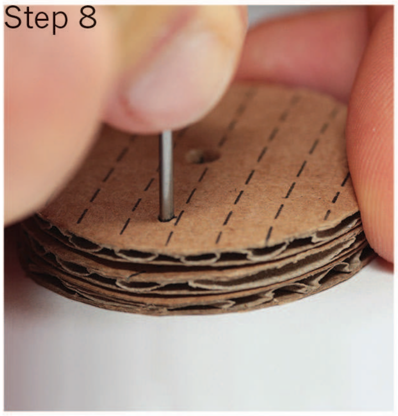
Step 4

Step 5

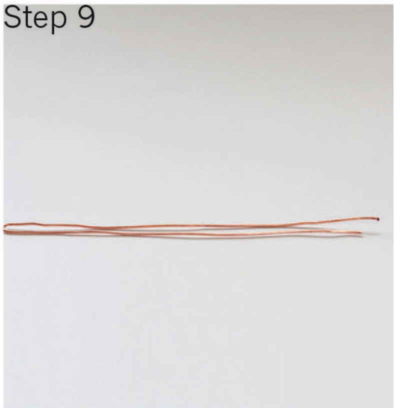
Step 6

Step 7

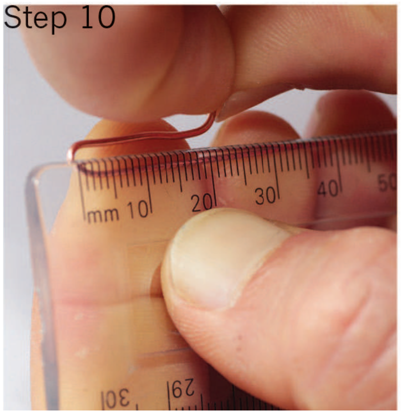
Step 8



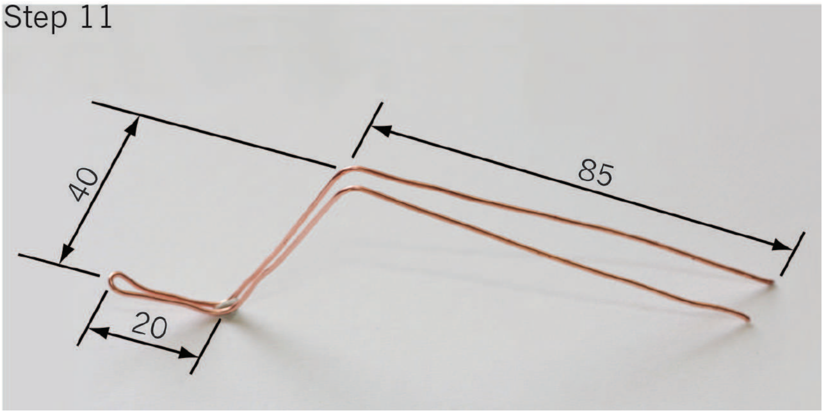
Step 9



Step 10



Step 11



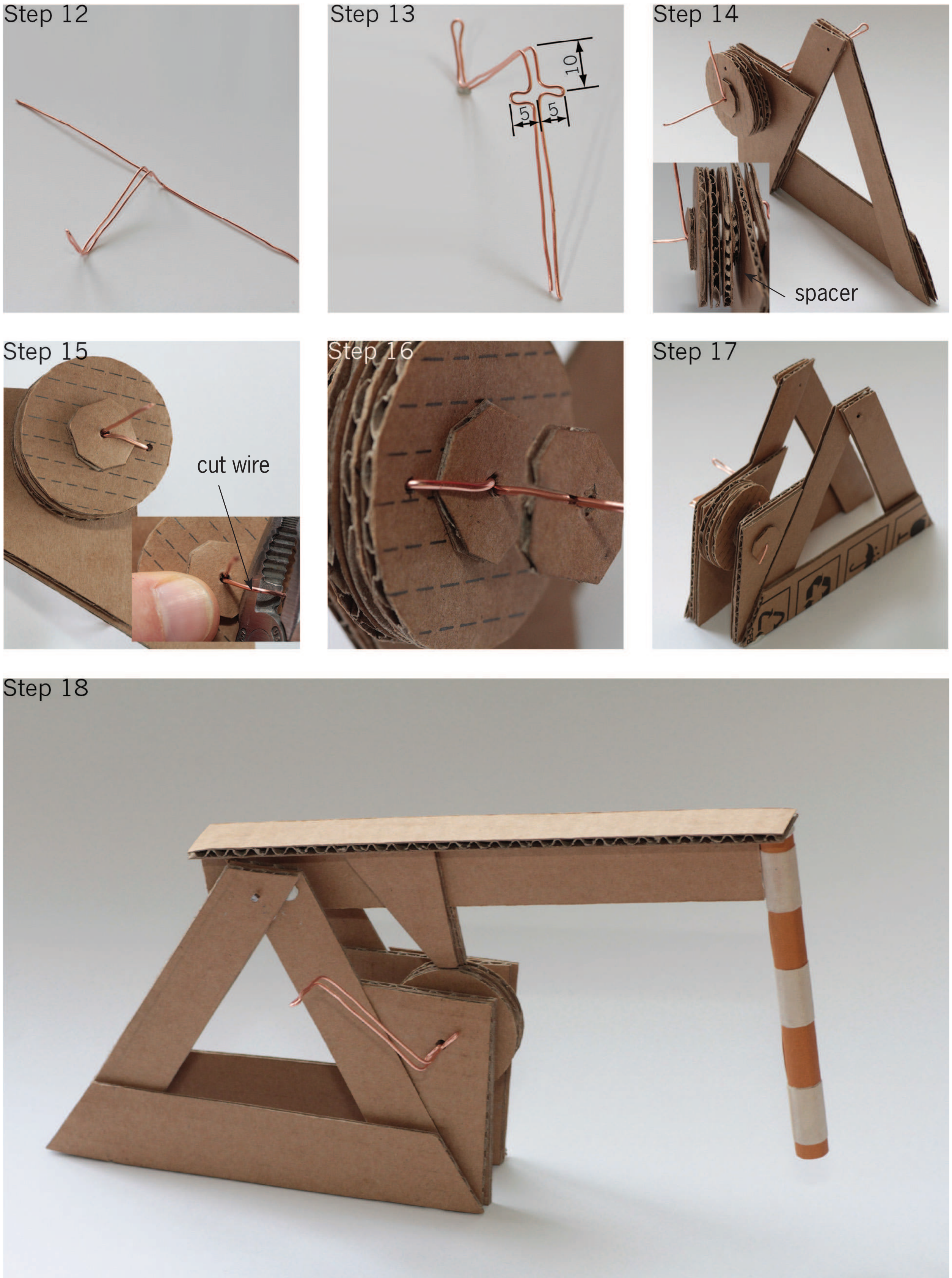


Figure 12: Different steps of building the model

Draw your design of parts to add to the model (60 minutes)

This is **individual work**.

Figure 4 on page 91 shows that the model you have made so far is not stable enough to withstand forces acting on its side. It can collapse or topple over. You want to design members to add to the structure so that this cannot happen.

Make: 2D working drawing

1. Make a working drawing in 2D of what you will add to the structure so that it cannot collapse or topple over.

   Decide for yourself what the scale should be so that the drawing will fit into the space below.

Your teacher will look at the following to assess your drawing:

- The drawing accurately shows the design you that sketched on page 92. (2)
- The drawing shows all important dimensions. (2)
- The drawing is to scale, and the scale is shown. (1)
- The drawing shows all hidden lines. (1)

Make: Isometric projection drawing

2. Make a 3D isometric drawing of what you will add to the structure Use a ruler. You have to decide on the scale yourself so that the drawing will fit onto the grid paper below.
   The drawing does not need to show hidden lines.

Your teacher will look at the following to assess your drawing:

- The drawing accurately shows the design you that sketched on page 92. (2)
- The drawing shows the dimensions in the correct way. (3)
- The drawing is to scale, and the scale is shown. (1)

[Total marks: 12]

Week 3

Make improvements to the model and draw an artistic perspective drawing of it

This is **individual** work, although team members may help one another by sharing ideas.

Make your improvement to the model (60 minutes)

Cut out the parts that you are going to add to the structure to strengthen it, and then attach them to the structure with Prestik.

Test your model to see if it is now stable enough to withstand forces acting on its sides. If it is not, you have to make some more changes. [Total marks: 10]

Draw an artistic drawing in perspective of your model (60 minutes)

Most double vanishing point perspective drawings have vanishing points that are so far away that you cannot draw them on the paper. If the vanishing points are close to the drawing of an object, it looks as if you are looking at the object from very close, like a fly would see the object. The drawing below is an example of this.

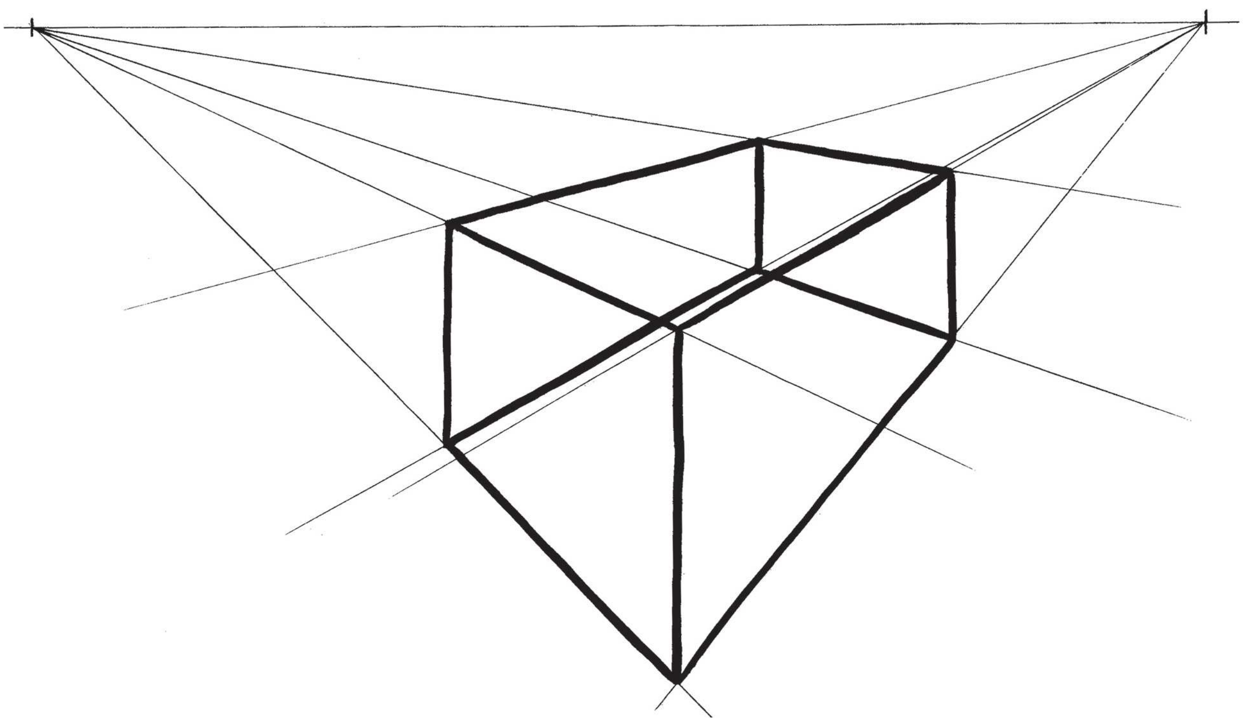


Figure 14: Looking at a rectangular frame from up close

This can look odd, and therefore artists mostly use vanishing points that are very far away and cannot fit on the paper.

Instructions for making the drawing

First draw a rectangular box into which the model will fit. Draw it in double vanishing point perspective. Use vanishing points that are far away and not on the paper. Draw feint lines for the visible as well as the hidden lines.

Then make a free-hand sketch of your model inside this box. Do not show hidden lines. After you have drawn all the outlines, use shading to make the sketch look more realistic. **Hint:** look back at what you learnt in Chapter 4 about shading.

> The following principle of perspective will help you to make the free-hand sketch:
>
> *Things look smaller the further away they are.*

The drawing below shows how someone else sketched a motor car in double vanishing point perspective, by first drawing a box into which the car will fit.

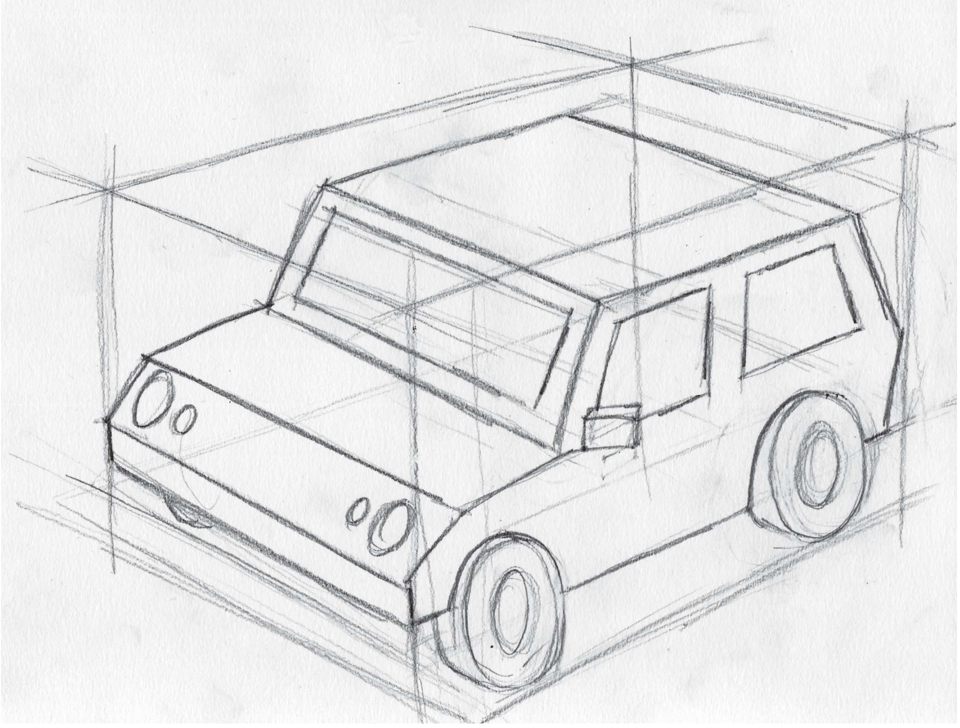


Figure 15: Making a double vanishing point perspective sketch of a complicated object

Something to do at home

Put this page on a large piece of newspaper. Make the lines of the rectangular frame longer to see where the vanishing points are.

First make a rough sketch on this page, before you make your final drawing with shading on the next page.

Mark allocation

Your teacher will look at the following to assess your model:

- It is easy to understand what the drawing shows. (3)
- You first made a rough sketch before you made your final drawing. (2)
- You drew a rectangular box in which your model will fit, using feint lines for visible and hidden lines. (1)
- You drew the box in double vanishing point perspective, using vanishing points that are far away and not on the paper. (2)
- You showed all your construction lines as feint lines. (1)
- You showed the outlines of your model as dark lines. (1)
- You used shading to make the sketch look realistic. (2)

[Total marks: 12]

Next week

Next week, you will hold an "Expo" of your projects. Each team will have a table where they show their models, their design drawings, and their final drawings. Each one of you will get the chance to walk between the tables of other teams to look at their projects, and to ask them questions. This way you will learn how other groups solved problems in a different way than your team did. This may give you ideas for things that you will design and build in future.

If any of your drawings are not completed yet, complete them over the weekend.

Leave your model with the Technology teacher over the weekend. Do not take it home.

Week 4

Present your model and drawings (60 minutes)

Each person in your team should be in charge of your team's table for 15 minutes. While you are in charge, you have to answer questions of the other learners who will come to look at your project.

When you are not in charge of your team's table, you should walk around to look at all the other teams' projects. Ask them questions about why they designed their models in the way they did.

Use the space below to write down and draw at least one new idea that you saw at another team's table. This should be an idea that you never thought about before your saw the other team's model.

....

....

....

Enjoy your Easter holiday! Next term you will learn about the impact of technology on society and the environment. You will learn how technology helps people, but that it often has a negative impact on the environment. Fortunately, there are clever ways of reducing the negative impact on the environment.

TERM 2

Chapter 8

The impact of Technology on society and the environment

In this chapter, you will learn how plastic waste damages the environment. Then you will learn how this negative impact can be reduced.

Figure 1: What is this swing made of?

Many years ago, people could only use the materials that they found in the **natural environment**. This means all of the natural things that are around us. It includes air, water, soil, plants and animals. Some examples of natural materials are wood, leather, clay and grass.

Today, people use many new materials that are not found in the natural environment. These materials are made in factories. They are often made from oil or coal that are found under ground. This includes materials like plastic, certain paints, and certain fabrics used to make clothes. You may have heard of “polyester clothes”, “PVA paint” and “neoprene rubber”. These are called **synthetic materials**.

Synthetic materials have many advantages. They are often more durable, lighter and cheaper than natural materials. Something is durable if it lasts for a long time.

But synthetic materials also have disadvantages. When they are thrown away, the waste lasts a long time. Therefore, it is better to use synthetic materials over and over again. This is called **reusing** materials.

Because synthetic materials are cheap, people can afford to buy more things that they want. One of the easiest ways to reduce the disadvantages of synthetic materials is to buy fewer things. This is called **reducing consumption**. Before you buy something new, ask yourself if you really need it.

There is another disadvantage to synthetic materials that most people do not see. Harmful waste is often formed at the factories where the synthetic materials are made. This waste can end up in the air, the water and the soil. Modern factories are designed better than older factories so that they release less harmful waste into the environment.

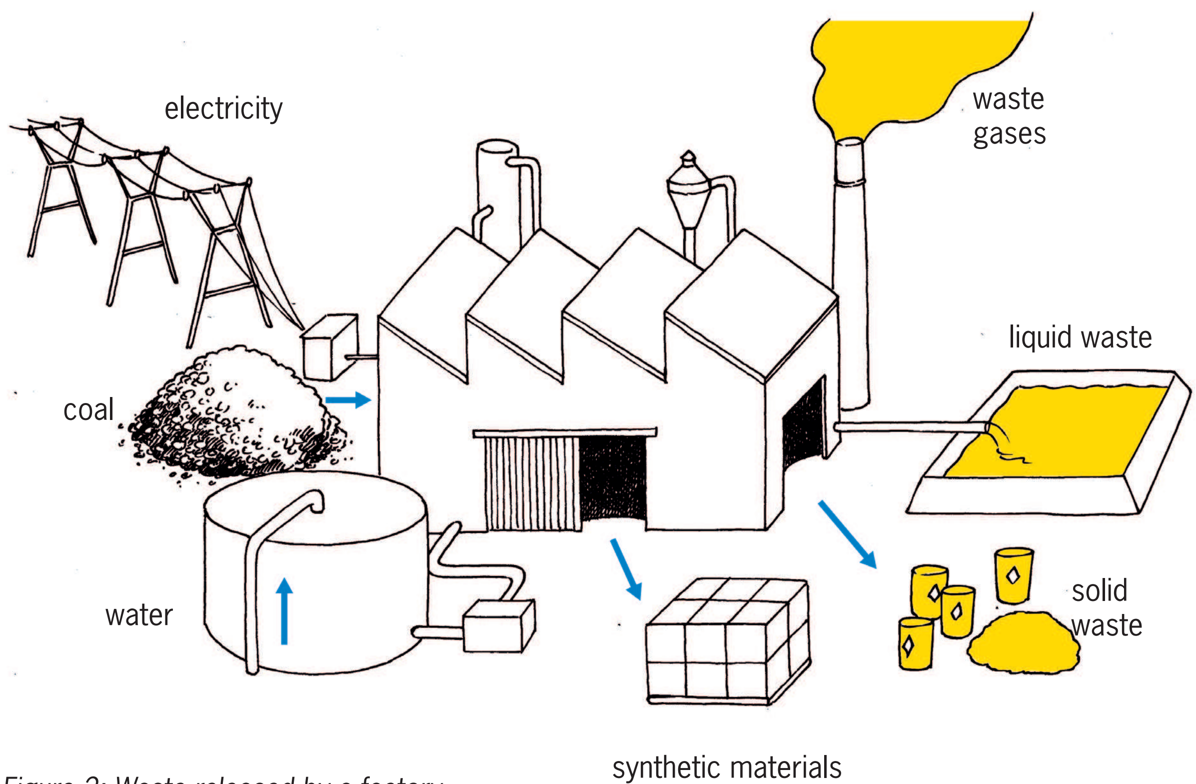


Figure 2: Waste released by a factory

One good idea is to keep waste of synthetic materials separate from waste of natural materials. This is called **waste separation**.

Waste of natural materials is broken down in the natural environment to form harmless substances like compost. Some natural materials break up into harmless substances simply when they lie in the sun or in water for some time.

A material is called **biodegradable** if natural processes can break the material into small harmless pieces.

Materials that cannot break down naturally into harmless substances are called **non-biodegradable** materials.

Many people throw all their fruit and vegetable peels on a compost heap. They also throw dead leaves, small tree branches and cut grass on it.

Over a few months, the waste on the compost heap changes into small dark pieces that feel like soft soil. This is called compost or humus. Compost is a valuable material, because plants grow better in soil that contains a lot of compost.

A compost heap should be kept wet, warm and filled with air. You can do this by covering the heap with a plastic sheet, and mixing the compost once a week.

Figure 3: A compost heap

8.1 What are things made of?

Look around you at the following objects in your classroom. For each object, do the following:

(a) Write down what you think this type of object was made of hundreds of years ago, before there were synthetic materials.

(b) Write down what this object is made of today.

Object	What was it made of hundreds of years ago?	What is it made of today?
Shirt		*Hint: Look at the label inside your school shirt.*
Jersey		*Hint: Look at the label inside your school jersey.*
Pen		
Something to write on	*Hint: What did the Egyptians write on? What did the Khoisan draw on?*	
Pencil case		
Paint		
Roof		
School bag		

After you have completed the table, discuss your answers with the learner sitting next to you.

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Homework for the next lesson

You need to do these exercises to be able to answer the questions in the next lesson.

1. Look at the contents of dustbins and garbage bags. Make a list of all the solid materials in the waste.

   ....

   ....

   ....

   ....

   ....

2. Stand in street near your home. Look around you, without walking to another position. Count how many plastic bags you can see. Go to a different street and do the same again. Then complete the table below.

	Number of plastic bags you can see
Street A	
Street B	

3. Look at plastic bags lying around outside that still look new.
   Also look at plastic bags lying around outside that look old.
   Why do some plastic bags look new and others old? What made the old ones look that way?

   ....

   ....

4. Look at new and old pieces of materials made from plants that are lying around, such as wood, cut grass, paper and cardboard. How do the newer pieces of this waste differ from those that have been lying around for a long time?

   ....

   ....

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How do you throw your waste away?

It is good for the environment if you put different kinds of waste in different garbage bags or boxes. This is called **waste separation**. For example, if you put all your glass waste into a box, then that glass can be taken by a waste collector to a factory that makes new glass bottles out of old glass. This is much better than if the old glass lies on a rubbish heap. We say that glass can be recycled. You will learn more about recycling next week.

Figure 4: The weekly waste from a household that separates waste

Figure 5: The weekly waste from a household that does not separate waste

8.2 What happens to things that are thrown away?

Discuss in groups of three or four

To answer these questions, think back to the homework exercises you did.

1. (a) What are the differences between waste materials that have been lying outside for a long time and those that have been there for a short time?

   (b) Which types of materials changed a lot with time? And which types of materials did not?

   (c) Do some materials change more with time than others?

2. (a) What do you think will happen to plastic bags that lie in the environment for more than 10 years, or 100 years, or 1 000 years?

   (b) Do the plastic bags that are thrown away as waste just get more and more? Or do they biodegrade? Or do they go somewhere else?

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Different properties of different materials

Siphosethu uses a **paper bag** to carry her shopping.
Brandon uses a **plastic bag**.
Thabang uses a **leather bag**.

They all reuse their bags, but all of their bags break after some time.

Answer the following questions for each type of bag on your own.

1. What will happen to the bag when it gets wet?

Paper bag	
Plastic bag	
Leather bag	

2. Do you need to care for the bag in some way so that it will last longer?

Paper bag	
Plastic bag	
Leather bag	

3. Can the bag be fixed when it breaks? If yes, then how?

Paper bag	
Plastic bag	
Leather bag	

4. What will happen to the bag if it is thrown away with other waste like rotting food? Where will the bag end up? What will happen to it there?

Paper bag	
Plastic bag	
Leather bag	

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Homework

Think about a place where garbage is burned. You may have seen places like this.

Figure 6: A burning garbage dump

1. What does the ground look like?

....

....

....

2. What does the air look like?

....

....

....

3. What does it smell like?

....

....

....

8.3 How can you stop people from throwing plastic bags away?

Case study: The negative impact of plastic shopping bags on people and the environment

During the past two weeks you have read and experienced a lot about the impact of plastic materials on people and the environment. Think back about this when you answer the following questions.

1. What can happen if an animal eats a plastic bag?

2. (a) What happens to people and animals who breathe in the smoke and gases that comes from burning plastic?

   (b) Where do the smoke and gases go after the fire has burnt?

   (c) What stays behind on the ground after the plastic was burnt?

3. What does it look like when there are lots of plastic bags lying around your house or school, or in the street, or in the veld?

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4. Look at the photo below:

Figure 7

What can happen when plastic bags end up in a river or stream?

....

....

....

5. What happens to plastic if it lies in water for a long time? Does it change?

....

....

....

....

Report: Reducing the negative impact of plastic bags

Until 2003, South African shops gave customers free plastic bags to carry their shopping. These bags were very thin, and broke easily. This meant that the bags were thrown away after they were used.

Our government wanted to reduce plastic waste. In 2003, it banned supermarkets from giving customers shopping bags for free, and banned the use of very thin plastic shopping bags. These bags are illegal.

Since then, supermarkets ask customers to pay for thicker, stronger shopping bags that can be used over and over again. The bags still look very thin, but they are less thin than the shopping bags used before 2003. Customers can choose not to buy new bags, and rather take old shopping bags with them to the shops.

The new, thicker plastic shopping bags are also easier to recycle by ***recycling*** *factories. But this only helps if people separate their waste so that the plastic bags can be sent to a recycling factory.*

Think back about what you saw when you were looking at the contents of dustbins and garbage bags, and at plastic bags lying around outside. Write a half-page report about this to answer these four questions:

1. Do you think that making people pay for thicker, reusable shopping bags helps to reduce the amount of plastic shopping bags that people throw away?
2. Are some shops still giving away thin plastic shopping bags for free?
3. What percentage of people do you think put their plastic waste separate, and not with their other waste?
4. Are there other things people can do so that less plastic bags are thrown away?

....

....

....

....

....

....

....

Figure 8: A wind turbine generates electricity by using the force of the blowing wind. The blades of the turbine are made of a synthetic material called "epoxy resin," that is combined with fibres. This makes the blades very strong, but at the same time very light. Also, it is possible to make this material into a special shape.

Next week

Next week you will be working with paper and cardboard in class. Instead of buying new paper and cardboard, you will reuse old paper and cardboard. Gather some paper and cardboard waste over the weekend, and bring it with you to school at the start of next week. Gather things like cardboard packaging for food.

Chapter 9
Making new things out of old things

In the following two weeks, you will learn how paper is recycled. You will also learn how to make new objects out of old pieces of cardboard. You will make your own packaging for a product.

Figure 1: Gathering paper and cardboard waste separate from other waste

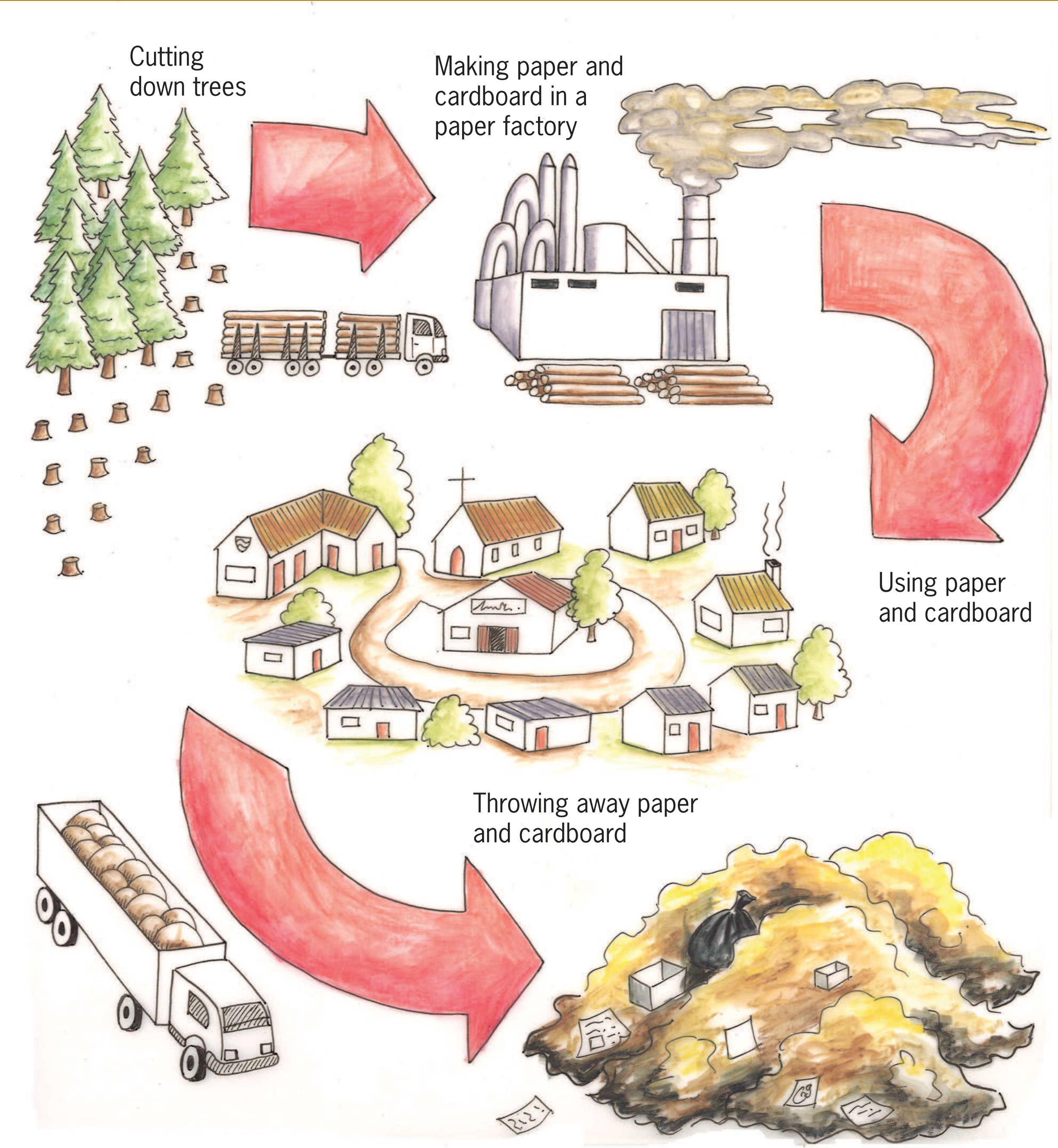


Figure 2: Using paper and cardboard without recycling it

Paper and cardboard are materials that are biodegradable. They do not damage the environment when they are thrown away. They can also be burnt in order to generate heat or electricity, and no poisonous gases will be given off. But to make paper and cardboard, trees have to be cut off. If paper and cardboard are recycled, fewer trees have to be cut down.

Did you know?

When 54 kg of newspaper is recycled, one less tree has to be cut down.

Almost 40% of municipal solid waste is paper and cardboard.

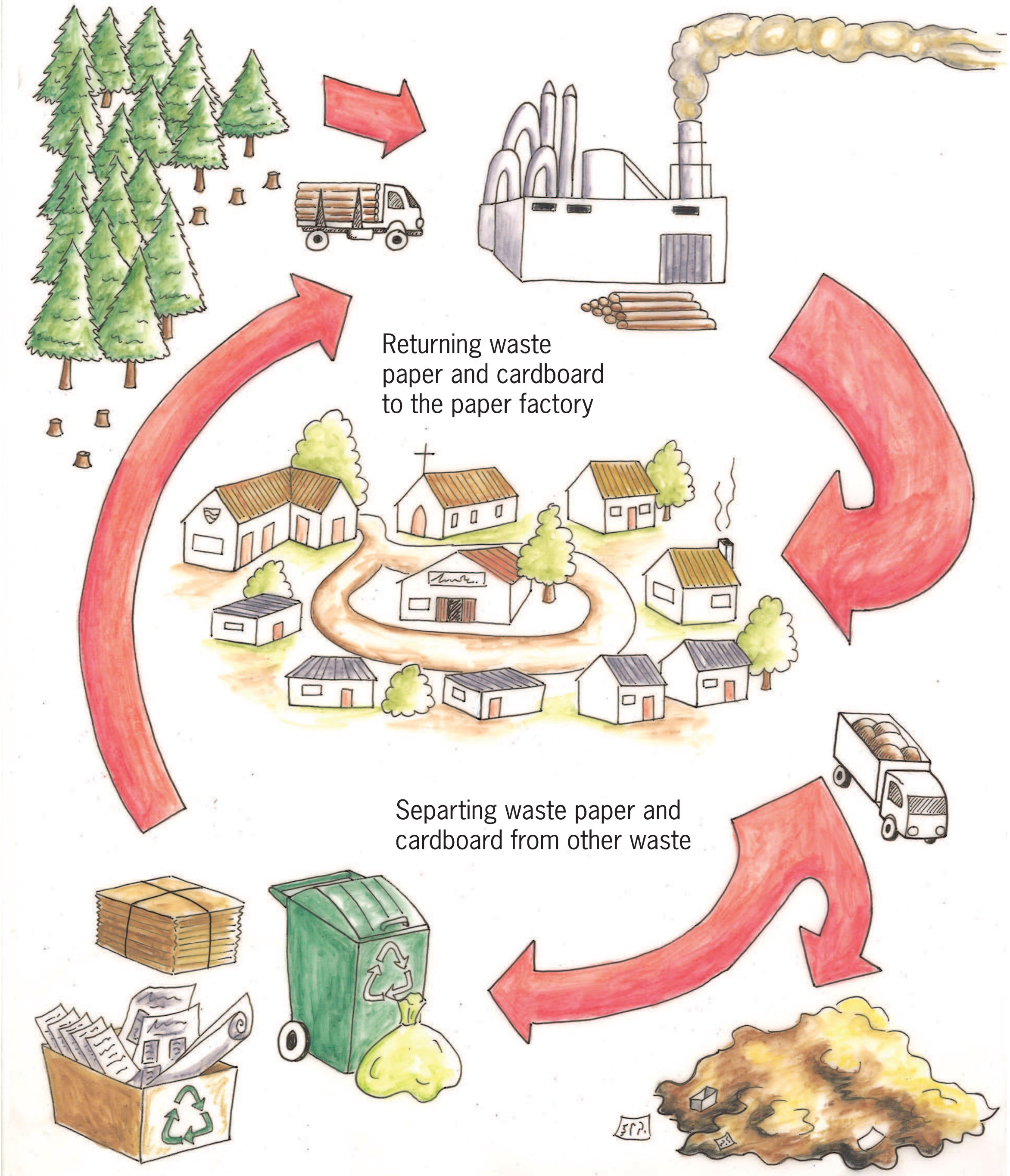


Figure: 3: Using paper and cardboard, and recycling it

Did you know?

The average person uses almost 50 kg of paper and cardboard per year.

Poisonous chlorine gas is used to **bleach** paper. To bleach means to make white. The chlorine can form poisonous gases called dioxins, which can be released into the atmosphere.

9.1 What are paper and cardboard made of?

A paper recycling factory makes new paper or cardboard out of waste paper. The way this is done is explained below. You can also make recycled paper at home.

1. Waste paper is mixed with warm water and chemicals. It is stirred and chopped up by a machine to separate the thin little fibres the paper is made of. The machine that stirs and chops up the mixture of paper and water, works like a food blender.

   The mixture of chopped-up paper and water is called paper **pulp**.

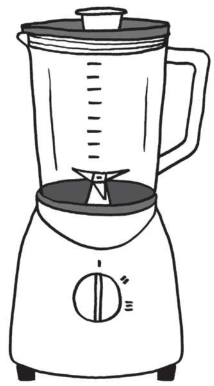


Figure 4

2. The pulp is poured through a **sieve**. Old glue and fibres that are very short pass through the sieve. Long, strong fibres remain on top. These fibres then go to a stirred tank where chemicals are added to remove ink from the pulp.
3. New glue is added to the pulp. Some clay is also added if the recycled paper will be used for writing or printing, because the clay gives the paper a smoother surface.

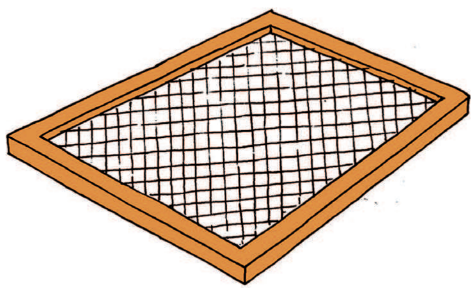


Figure 5: A sieve

4. The pulp goes to a paper-making machine, where it is pressed between two rollers to give it the required thickness, and to squeeze out water.

   Instead of waiting a long time for the paper to dry, it is dried more quickly by heating it and blowing hot air over it. Once the paper is dry, it is cut into the necessary size and packaged.

Paper fibres can be recycled as many as seven times. But each time it is recycled, the fibres get broken into shorter and shorter fibres. If it is recycled too many times, the fibres become too short and weak to use for making paper again.

Case study: Paper recycling

1. What is cardboard made of?

   ....

2. Why can paper not be recycled more than seven times?

   ....

3. What will happen when the holes of the sieve are too big?

....

4. What will happen when the holes of the sieve are too small?

....

Homework for the next lesson

Find some old empty pill boxes and bring them to school for the next lesson. If you cannot find a pill box, bring another **small box that can close after you opened it**. Try to find at least two such boxes. Some spices are packaged in boxes like these, as well as some light bulbs.

Safety warning

Do not remove pills from pill boxes. Pill boxes have labels that say what the pills are and how to use them. If those labels are lost, somebody may not know what medicine to take and how to take it.

Ask your parent or another adult for an empty pill box.

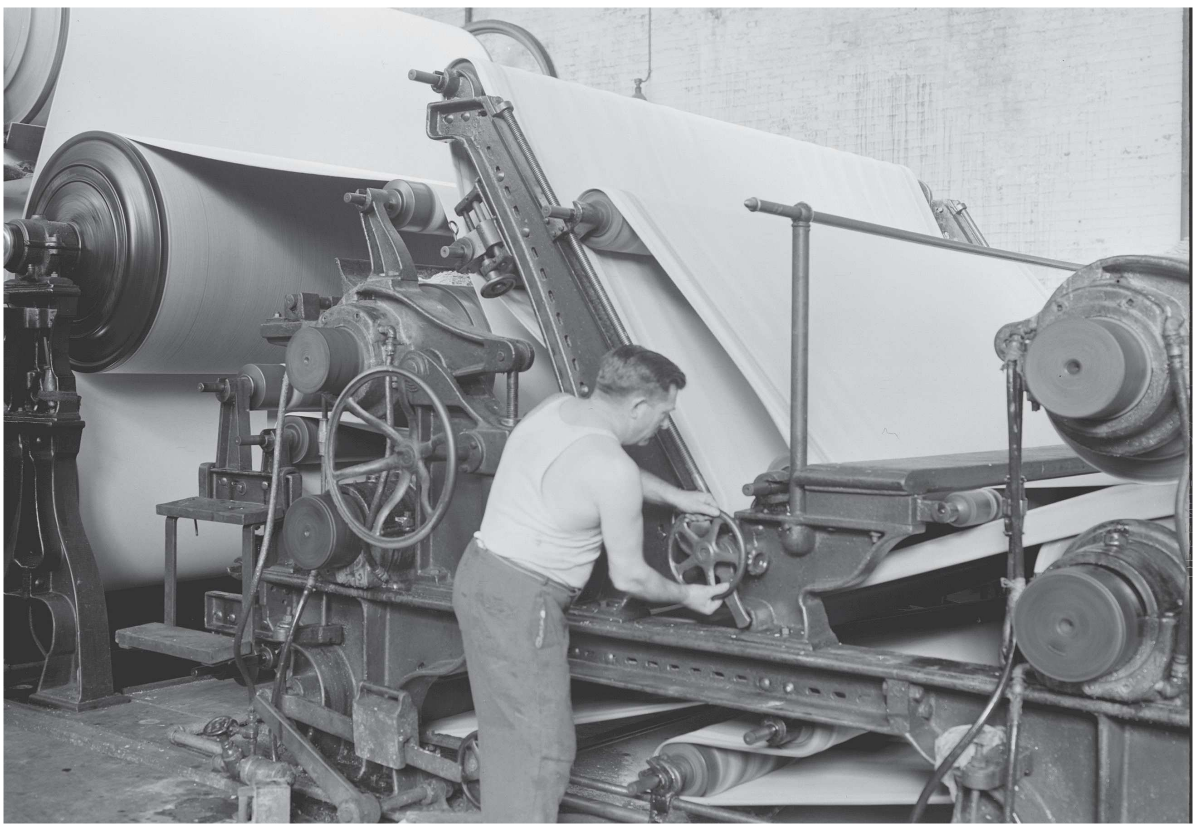


Figure 6: Part of an old paper-making machine

9.2 How are paper and cardboard recycled?

Take out one of the small boxes that you brought to school. Look carefully at all sides of the box. Then open the box so you can look inside it, but do not tear or cut the box to open it. While you are looking at the box, try to imagine how this box was made out of flat cardboard.

The following words describe different things about a box:

- A **face** is one of the flat surfaces of the box that can be seen from the outside.
- An **edge** is the line where two faces meet.
- A **corner** is where three faces meet at a single point. At this point, there are also three edges that are meeting.
- A **tab** is an extra flap attached to a face that helps to keep the box closed. It cannot be seen from the outside of a closed box.

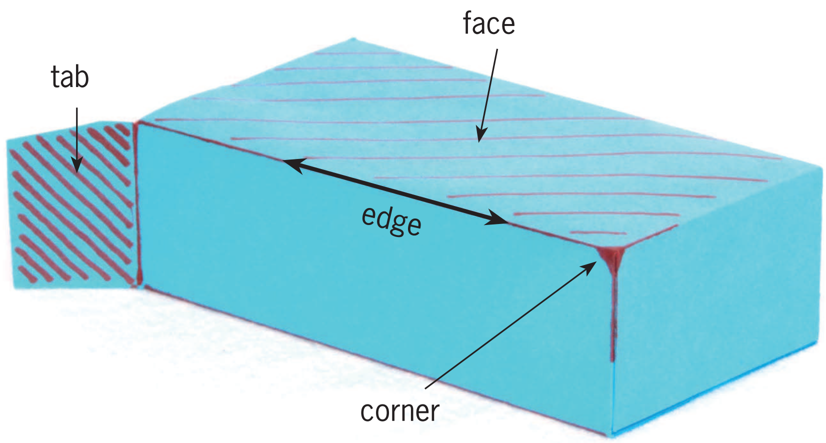


Figure 7: The different parts of a box

Think about the different parts of a box

1. How many faces does the box have?

....

2. How many edges does the box have?

....

3. How many corners does the box have?

....

4. Look at the two drawings of the box below. The drawings were made by looking at the box from different angles. A name is written on each face of this box. Write the same names on the different faces of your own box.

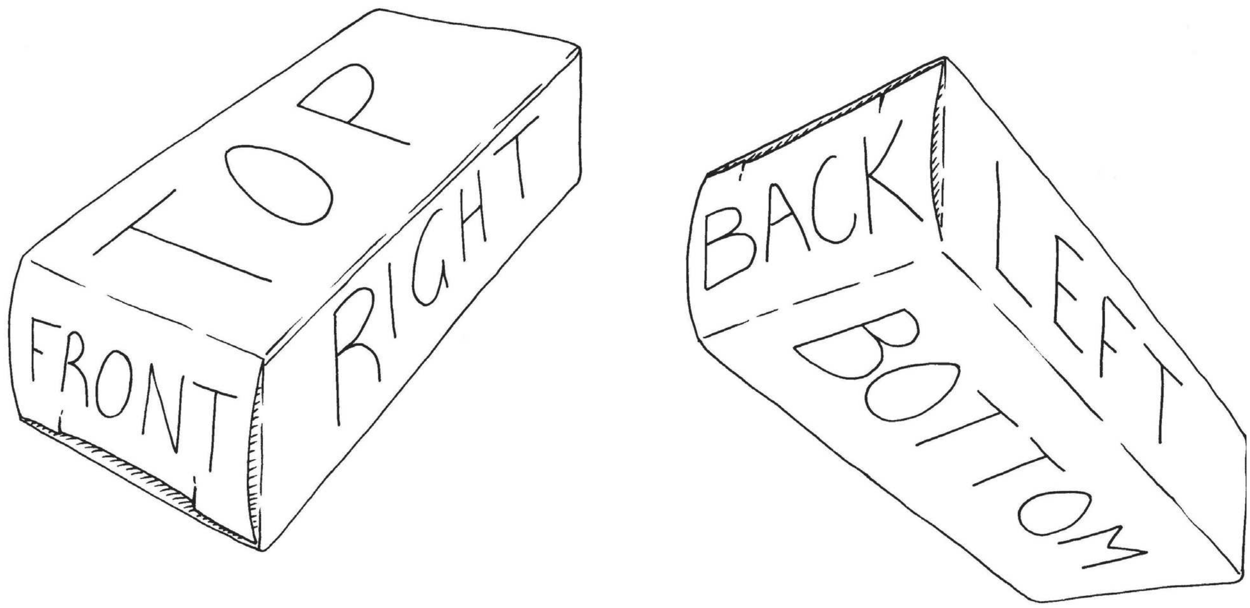


Figure 8: Giving names for the different faces of a box

5. Out of how many separate pieces of cardboard was the box made?

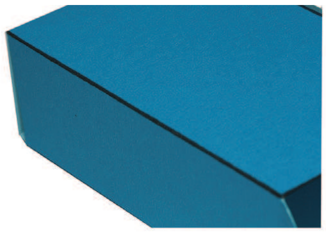
....

There are three different ways in which an edge can be made in a cardboard box.

- **Unbroken edge:** The cardboard is simply folded along a line.
- **Edge made using a tab**: One of the two faces that come together has a tab attached to it. This tab folds in underneath the other face to close the box.
- **Edge made with a tab glued to another face:** This is the same as an edge made with a tab, but this time the tab is permanently attached to the other face by glue.

The different types of edges of your box

1. The photos below show different edges of a box.
   Write what kind of edge is on each photo. Write the type below the photo.



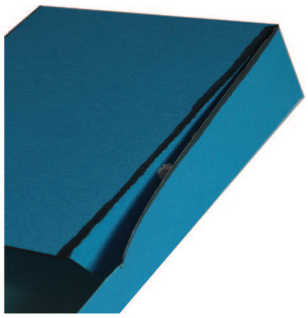


Figure 9

....

2. How many of the edges of your box are unbroken edges?

   ....

3. How many of the edges of your box are made using tabs that are not glued?

   ....

4. How many of the edges of your box are made using tabs that are glued?

   ....

5. How many tabs in total were used to make the box?

   ....

Homework

1. (a) Find an old cardboard box. It should be made of **thin, solid cardboard**. Cereal boxes and other boxes in which food are packaged are normally made from cardboard like this. The box must not be made of **corrugated cardboard**.
   (b) Cut the box and fold it flat. The flat sheet of cardboard in front of you should be at least as big as an A4 sheet of paper.
   (c) Do the same to make two more cardboard sheets.

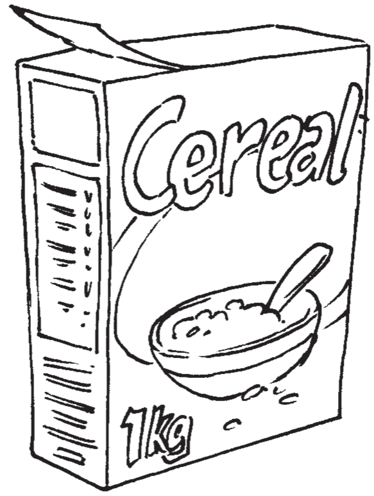


Figure 10: Boxes for packing food are made of thin, solid cardboard.

2. Find at least eight old A4 paper sheets. One side of each of these sheets should be clean, because you will draw on it.
3. Bring the paper and cardboard sheets to all your Technology lessons next week. You will reuse this old paper and cardboard to make paper and cardboard boxes.
4. Bring your pill boxes, or other small boxes, to your next lesson again.

Figure 11: Large boxes are made of corrugated cardboard.

9.3 Draw the development of a box

Cut the box open along the edge where it was glued together. Fold it flat. We call this the **flat plan** or **development** of the box.

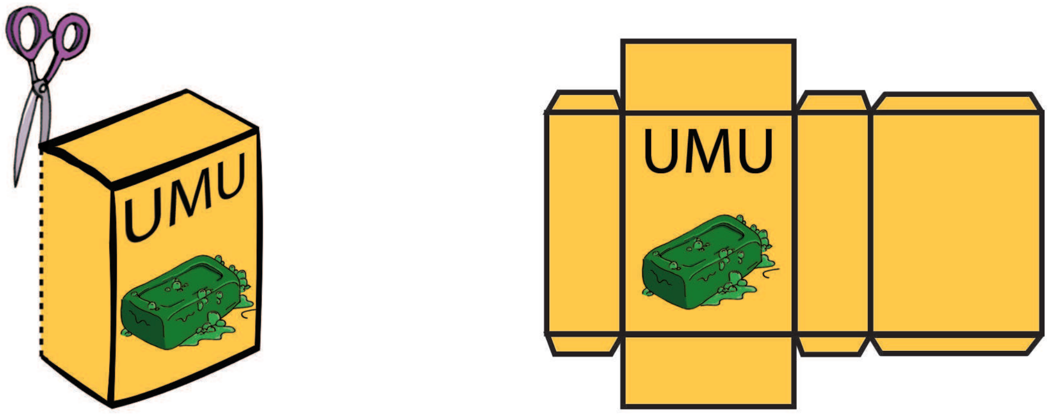


Figure 12: You can unfold a box to make one flat piece of cardboard. This is the development of a box.

Trace the development onto a piece a paper, using a **feint line**. Trace it in the middle of the blank piece of paper, so that there is space left around the traced development.You can use the development many times to trace, like the illustration below shows.

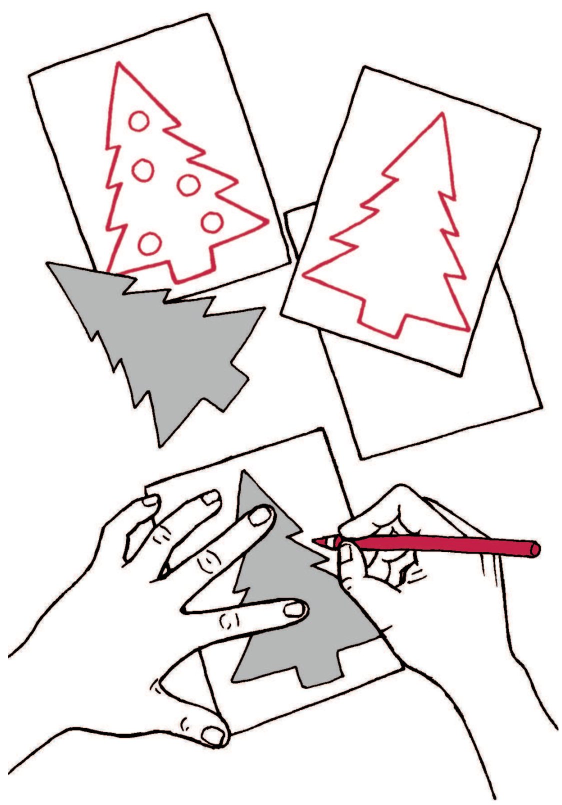


Figure 13: Tracing a shape to make many Christmas cards with the same picture.

When you traced the development of the box, your lines were not very neat and straight. That is why you made the lines feint. Now use a ruler to draw **straight dark lines** over the feint lines of your development. The dark lines has to show where the paper has to be cut. *Do not draw dark lines for any other reason, otherwise you may later cut off something that you don't want to cut off!*

Add **dashed lines** to show where the paper will be folded.

Now cut out your development. *Do not cut the dashed lines that are for the folds*. Fold the development to make it into a box.

If you accidentally cut off something that you should not have cut off, don't worry. Most people make mistakes when they try to design and make a box for the first time. But learn from your mistakes. Ask yourself what you should do next time to make the box right, or better.

Homework

1. (a) Make a new paper model of your box. This time make a neater one. Think carefully before you start cutting out your development, to make sure that you do not cut off something that should not be cut off.

   Remember that your paper model of the box should be made out of just one piece of paper.

   (b) Bring the cardboard box that you cut open and folded flat, as well as the paper model you made of this box, to the next lesson.
2. Remember to bring the paper and cardboard sheets that you gathered over the weekend to each lesson next week.

9.4 Make your own box

Learning the tricks

Now that you have successfully made a paper box, you will prepare for making a stronger box out of cardboard, using the same design.

Cardboard is more difficult to fold. And thick cardboard can crack when you fold it. You first need to learn a **trick** for folding cardboard. You also need to learn how to join two pieces of cardboard together with glue. You will have to do it in such a way that the glue will dry quickly, and the joint will be strong.

You will make a cardboard box this week, but you first have to learn a few **tricks**. People who do technological work call tricks like these **techniques**. It makes sense that the word technology is similar to the word technique!

How to glue cardboard

You will join two pieces of cardboard with white wood glue. But first do an experiment to find out whether it is better to use a lot of glue, or only a little bit of glue.

Join two small pieces of cardboard with a thick layer of glue between them. Press the pieces of cardboard together for two minutes, then let go. Has the glue dried? Try to gently pull the two pieces of cardboard apart. Is the joint strong?

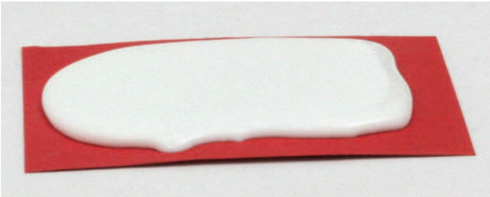


Figure 14: Using a lot of glue

Now try to join two other pieces of cardboard. This time use very little glue. Put only a drop of glue on the cardboard, and then spread it with your finger. Wood glue is not poisonous, and you can wash it off with water. The cardboard should look wet and shiny. It should not look white like the glue. Press the pieces of cardboard together for two minutes, then let go. Has the glue dried? Try to gently pull the two pieces of cardboard apart. Is the joint strong?

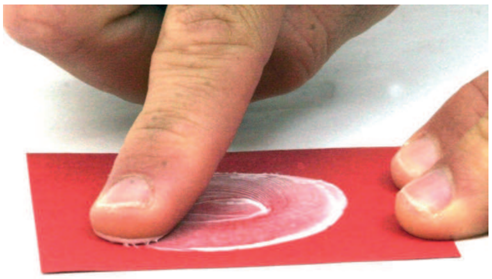


Figure 15: Using very little glue

How to fold cardboard

To fold cardboard to make a 90° bend, you first need to do the following experiment to find out what the best technique is.

Fold a rectangular piece of cardboard in half. Use a thick piece of cardboard, like the cardboard that a cereal box is made of. The length of the fold should be at least 10 cm. Cut three pieces of cardboard that you will fold in half in different ways.

With the first piece of cardboard, draw a pencil line on the inside and then fold along that line. Fold it all the way over, using the end of your pencil to make the fold sharp. Then bend it back so that it forms a 90° bend.

To fold the second piece of cardboard, first make a groove on the outside of the cardboard. Put your ruler where you want the fold to be, then draw a line with a ball point pen. Press hard with the pen, to make a groove in the cardboard. Grip the ruler tightly so that it does not move while you draw the line. Draw the same line two or three times, to make the groove deeper. Fold the cardboard along this groove. Fold it all the way over, using the end of your pencil to make the fold sharp. Then bend it back so that it forms a 90° bend.

To fold the third piece of cardboard, first make two grooves on the inside of the cardboard. Make a groove in the same way as before. The two grooves should be parallel, and 1 mm to 2 mm apart. Fold the cardboard along these grooves. Fold it all the way over, using the end of your pencil to make the fold sharp. Then bend it back so that it forms a 90° bend.

Now look closely at each of the three folds. Is it a neat fold? Are there any cracks on the outside of the fold? Was it easy or difficult to make the fold? Is the fold exactly where you wanted it to be?

Which way of folding do you think is the best?

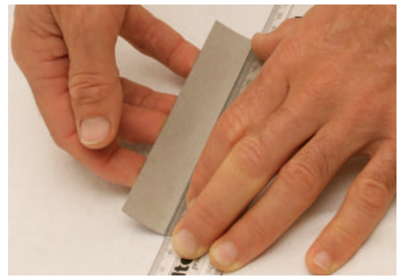


Figure 16: Make a fold without first making a groove.

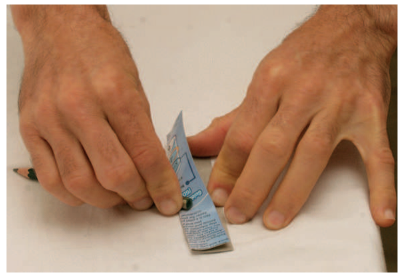


Figure 17: Use the end of your pencil to make the fold sharp.

Figure 18: Make a fold by first making a groove on the outside.

Figure 19: Make a fold by first making two grooves on the inside.

Technology Gr 8 LG Book A.indb 135 1/6/2014 8:17:41 AM

9.5 Your final box

Use the cardboard box that you folded flat to trace the same design onto a flat sheet of cardboard. (See Figure 12 on page 132.) Use feint lines. Once again draw the glued tab in the position where it was originally attached to the single piece of cardboard.

Do the same as you did to make your paper model of the box. But this time, use the best technique to make a fold in the cardboard.

When you have cut and folded the cardboard, first test whether it will make a box, and that all the tabs are there. If it is correct, then glue the one tab to the face to which it should be glued. Use the right amount of glue.

If you have time left in the lesson, also do the following activity.

Something extra you could do to make your box close better

Look closely at the tabs of a pill box. You will see small cuts in some of the tabs. What do you think is the purpose of those small cuts?

Make a new cardboard box, but this time also make those small cuts.

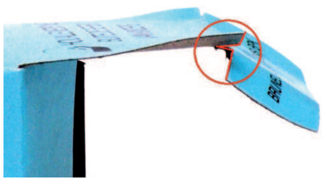


Figure 20: The small cuts in a tab that is used to open and close the box

9.6 Make a pencil case

Design a new box of a different size. The new box will be used as a pencil case. You should be able to fit two pencils, two pens, an eraser and a sharpener in it. You will design the pencil case by using the same ideas that you used to make your previous cardboard box.

First make a rough plan of how the development for the box will look. Do this on the next page. The rough plan should show all the **dimensions** of the development. Dimensions mean the same as measurements. To draw up the rough plan as quickly as possible, make the drawing by hand, without a ruler.

Then draw the plan accurately on a piece of cardboard, using your ruler to measure and draw straight lines. Remember to use dashed lines to show where the paper will be folded. Do not cut along the dashed lines.

Go on and make your own cardboard pencil case.

Make a rough sketch of a development for a pencil case:

Reduce, reuse, recycle

Last week you learnt that it damages the environment when more and more plastic is made and thrown away. You can reduce this negative impact on the environment in different ways. Firstly, you can buy less plastic things, which is called **reducing your consumption**. Secondly, you can use some things over and over, so that you don't have to buy new things. This is called reusing things.

This week you learnt about **recycling**. What if you have something, and that something gets broken or you don't need it anymore? Then you have to throw it away. Fortunately, there is a clever way of throwing things away, by **separating the different types of waste**. For example, if you and your family collect all your plastic waste separately, then someone can take that plastic to a recycling factory where new plastic is made from the old plastic.

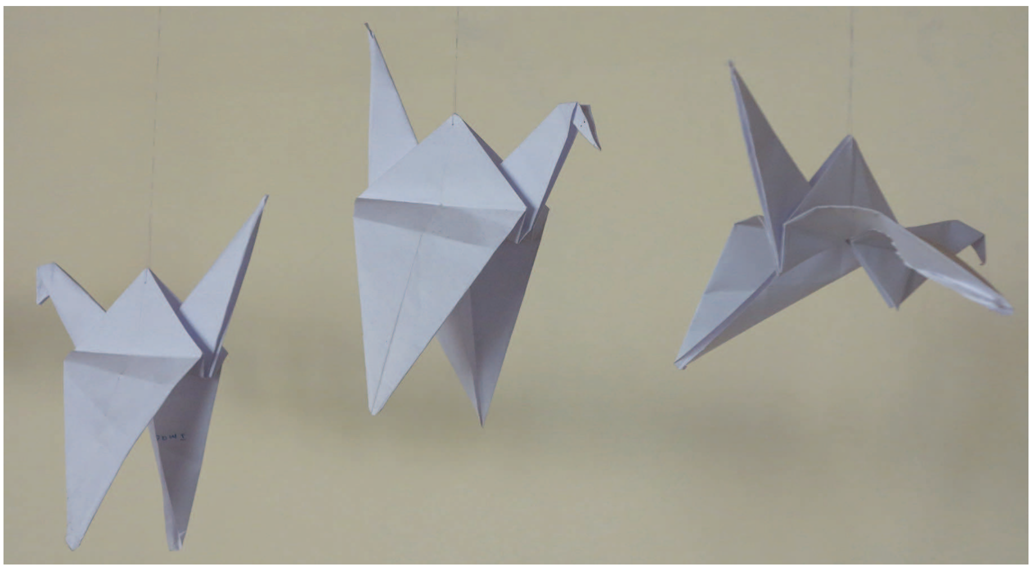


Figure 21

Next week

Next week, you will learn where electricity comes from. Generating electricity has a negative impact on the environment. Burning wood or gas or paraffin for heating or cooking, also has a negative impact. You will think of ways to reduce this negative impact, by designing a house in a clever way.

Chapter 10: Mini-PAT
Design a house to use less energy

When electricity is generated, it has a negative impact on the environment. To burn wood or gas or paraffin, also has a negative impact. During the next three weeks, you will think of ways to reduce this negative impact by designing a house in a clever way.

Assessment

Investigate:

The different parts of a power station .... [3½]

Carbon dioxide .... [4½]

What can you do to release less carbon dioxide? .... [6]

What forces act inside a beam that bends? .... [6]

Design:

How to improve a house to use less energy .... [10]

Make:

Build a model of a house .... [5]

Isometric projection drawing of your planned improvements .... [15]

Improve your model house .... [20]

[Total marks: 70]

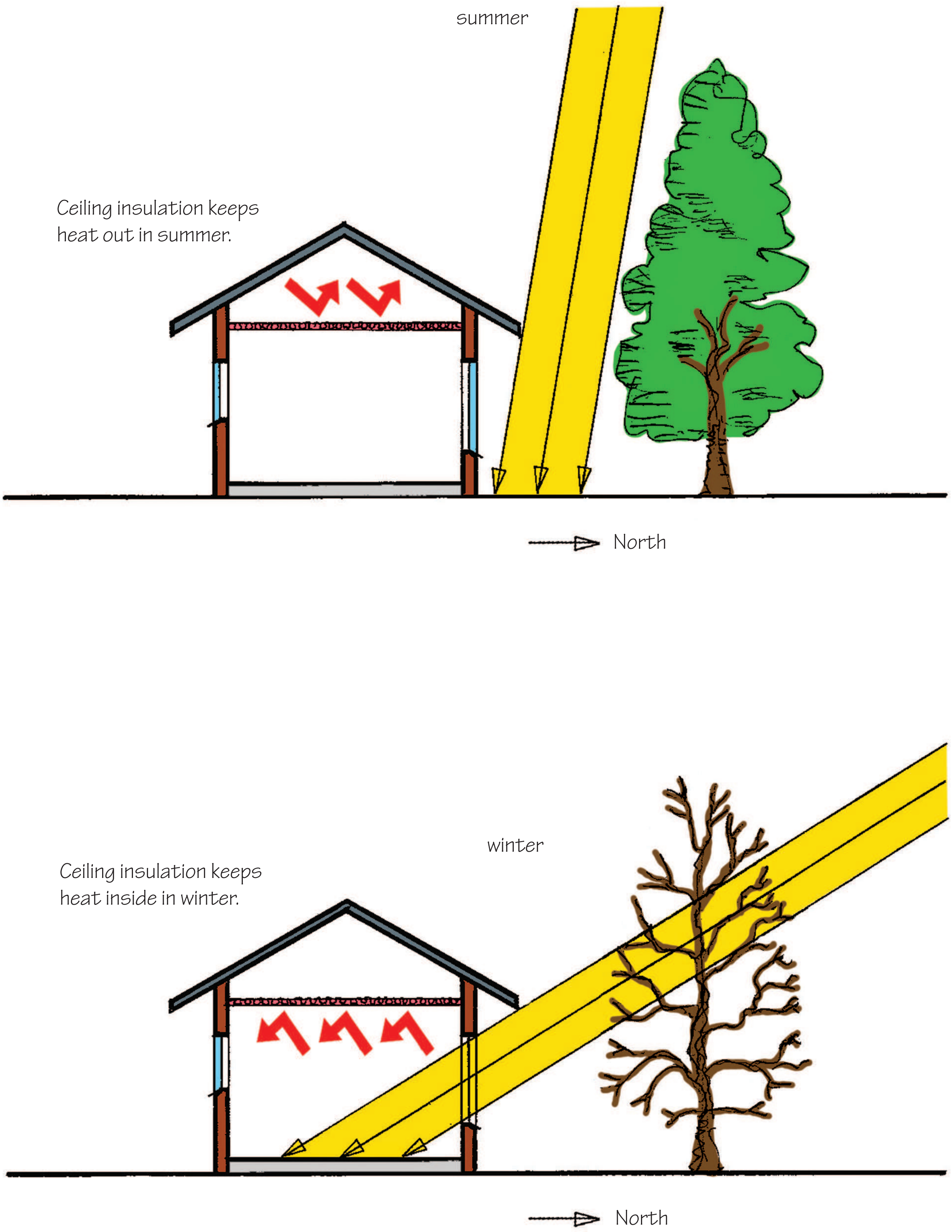


Figure 1: A cleverly designed house lets the sun's heat in on a winter's day, but keeps it out on a summer's day.

Week 1

The hidden cost of electricity

In the last few years, the cost of electricity has increased a lot. Some people are unhappy about this, because they don't have enough money to pay for electricity.

Electricity also has another cost that has nothing to do with money. This is the "cost" of electricity to the environment. Just like the amount of money that people have changes when they pay for electricity, so the environment changes when electricity is generated.

To make electricity is usually called to **generate** electricity.

This week, you will learn how the environment is changed by electricity generation. This change is often bad for the environment. You can say that electricity generation has a **negative impact** on the environment.

You will think about ways that this negative impact can be reduced.

Where does electricity come from? (30 minutes)

Figure 2

Technology Gr 8 LG Book A.indb 141 1/6/2014 8:17:45 AM

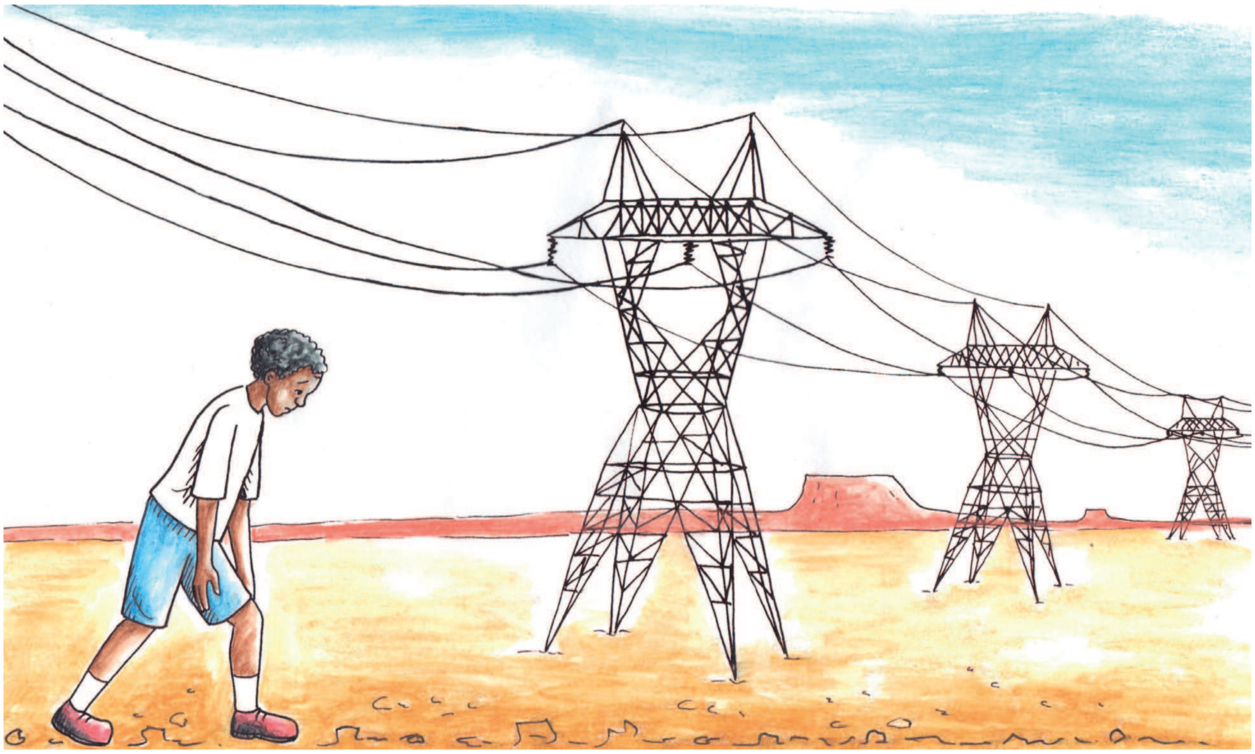


Figure 3

Figure 4

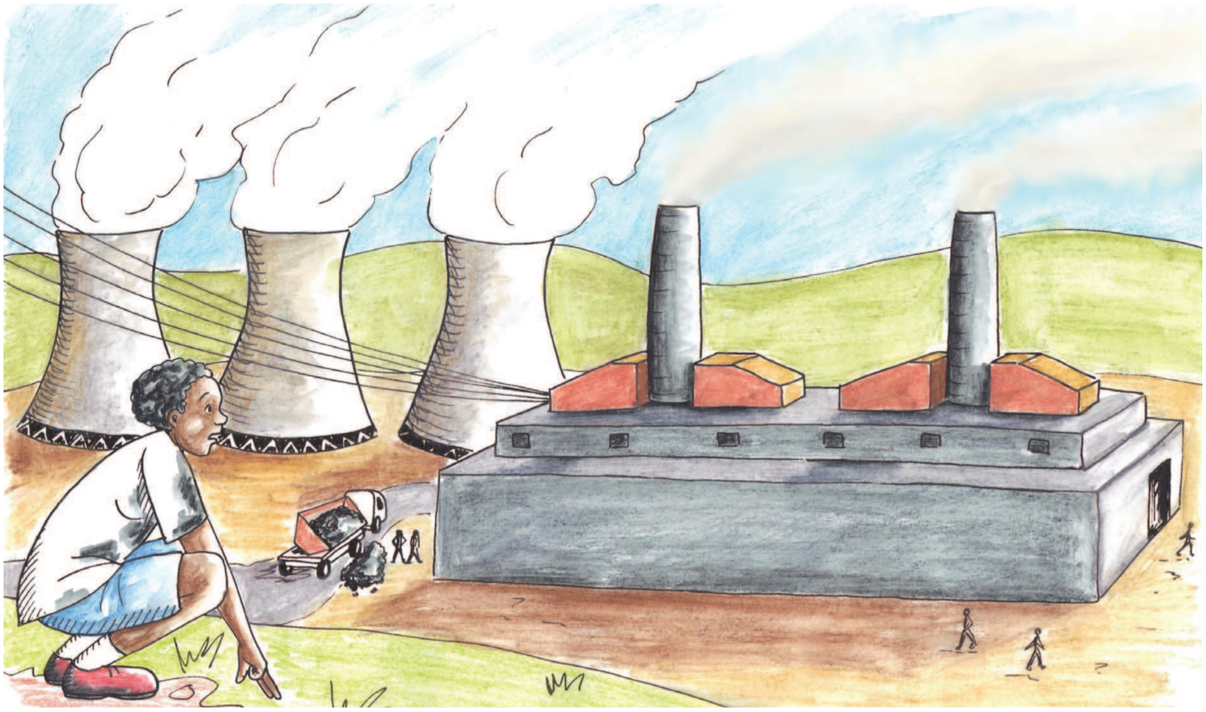


Figure 5

The boy followed the electricity lines to see where electricity comes from. When he went inside the power plant, a technician told him how a coal-fired power plant works. This is what she told him:

> *"In a power station, coal is burnt underneath a tank full of water that is called a boiler. The heat from the fire makes the water boil and evaporate to form steam with a high pressure. The high pressure steam blows through a turbine and makes it turn. This is very much like the wind making a wind pump turn. A device called a generator converts the rotational movement of the turbine into electricity.*
>
> *The gases and smoke from the fire passes through a filter before it goes through the chimney into the air. The filter removes most of the ash and soot particles, so that there is only a little bit of smoke that comes out the top of the chimney."*

When a balloon bursts, or when there is a puncture in a bicycle or a motorcar tyre, the air inside bursts out very quickly and strongly. This is because the air inside a balloon and a tyre is under high pressure.

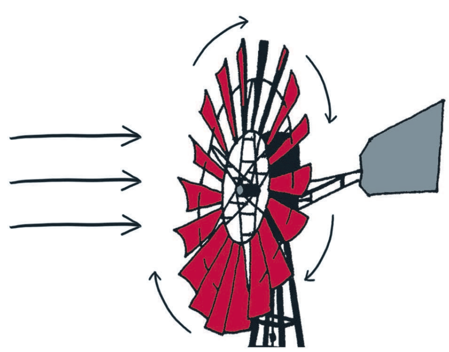


Figure 6

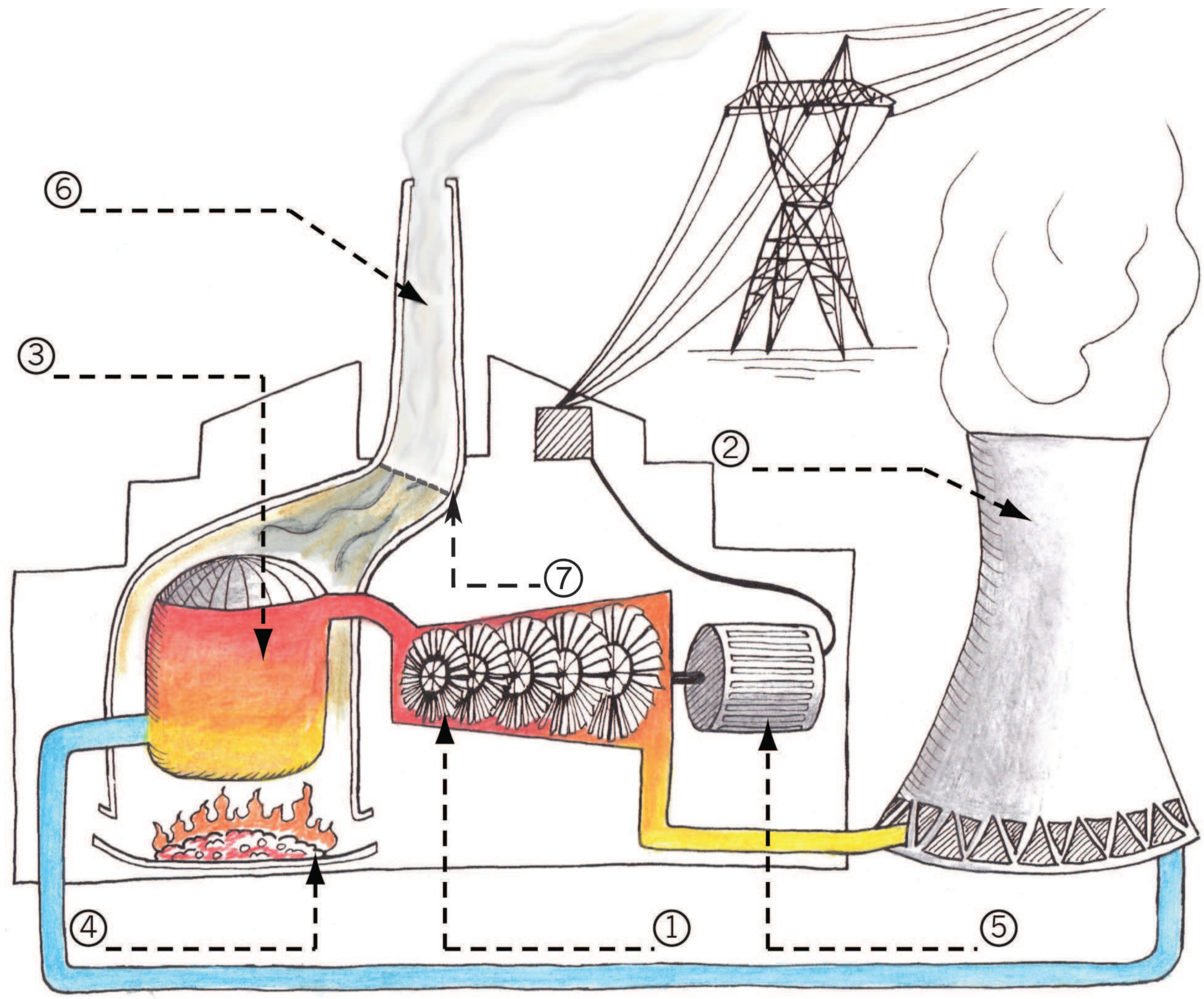


Figure 7

A coal-fired power plant has the following parts:

- A generator.
- A cooling tower. This tower uses air to cool the steam that comes out of the turbine. This makes the steam condense into water, which is then reused. Only a little bit of steam is released from the top of the tower.
- A furnace where the coal is burnt.
- A filter to remove ash and soot particles, so that they are not released into the air.
- A chimney releasing carbon dioxide into the atmosphere.
- A turbine.
- A boiler tank where water is changed into high-pressure steam.

Investigate: The different parts of a power station

Which part of a power station is shown by which number on the picture in Figure 7? Use your pencil to write the names of the parts on the dashed lines next to the numbers on the picture. [3½]

How does electricity generation impact on the environment? (30 minutes)

Look at the picture below.

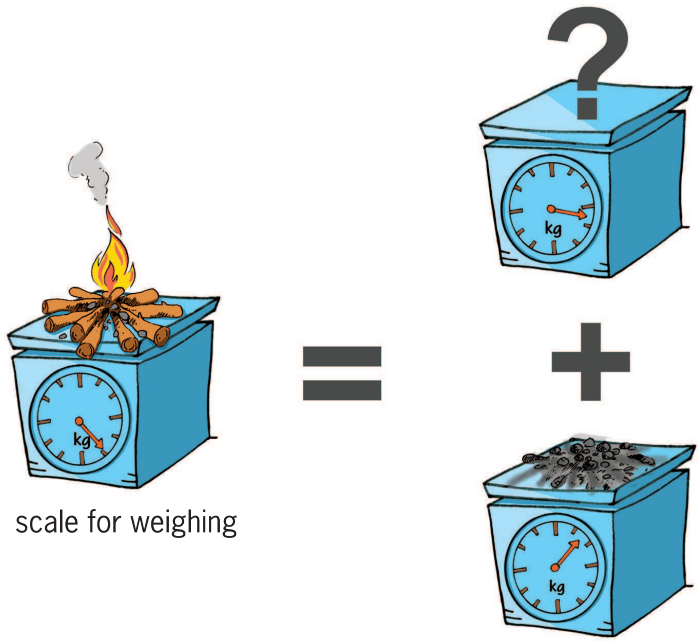


Figure 8: Can mass disappear into nowhere?

The ash left at the end weighs much less than the wood from which the fire was made at the start. What happened to the rest of the weight?

....

....

There are many different materials or substances that you can burn to create heat and light. Wood, coal, paraffin, gas and oil are some of the substances that you know about. They are called **fuels**. All of these fuels contain **carbon**.

Carbon is one of the main building blocks from which plants and animals are made. These building blocks are very small. It is impossible to see them. Carbon is a solid.

When two very small building blocks of a material are close together, they stick together, as if they were glued with very strong glue. This is called **chemical bonding**. You will learn more about this later when you do chemistry in natural science.

Carbon stores energy, like a battery. When carbon is on its own, you can say the battery is charged. When the carbon is **bonded** with another small building block called **oxygen**, then the battery is flat. Oxygen is a gas. When carbon is bonded to oxygen, they are together called **carbon dioxide**. Carbon dioxide is a gas.

Go outside on a very cold but sunny winter's day. Let the sunlight shine on your hand. Why does your hand start to feel warm, even though the air around it is very cold? It is because the sunlight is changed into heat, inside your skin. Light and heat are two different forms of energy. Movement and electricity are two other forms of energy.

When carbon bonds with oxygen, energy is released in the form of heat:

carbon + oxygen = carbon dioxide + energy.

This is what happens when an animal eats food that contains carbon and breathes air that contains oxygen. The carbon and oxygen combine inside the animal to give it energy and to make it grow. The same thing happens when plant material containing carbon burns in air.

To separate carbon and oxygen that is bonded, energy is needed. Plants separate carbon and oxygen by using the energy of sunlight:

carbon dioxide + light = carbon + oxygen.

Plants use the carbon to grow, because carbon is the main building block of plants. They release the oxygen back into the air.

The change of carbon into carbon dioxide and then back into carbon is called the **carbon cycle**. This is shown in the picture on the next page.

When you make a fire or burn gas or paraffin in your house, carbon dioxide is released into the air. When you use an electrical stove, no carbon dioxide is released from your house. But carbon dioxide is released from a power plant that makes the electricity you use.

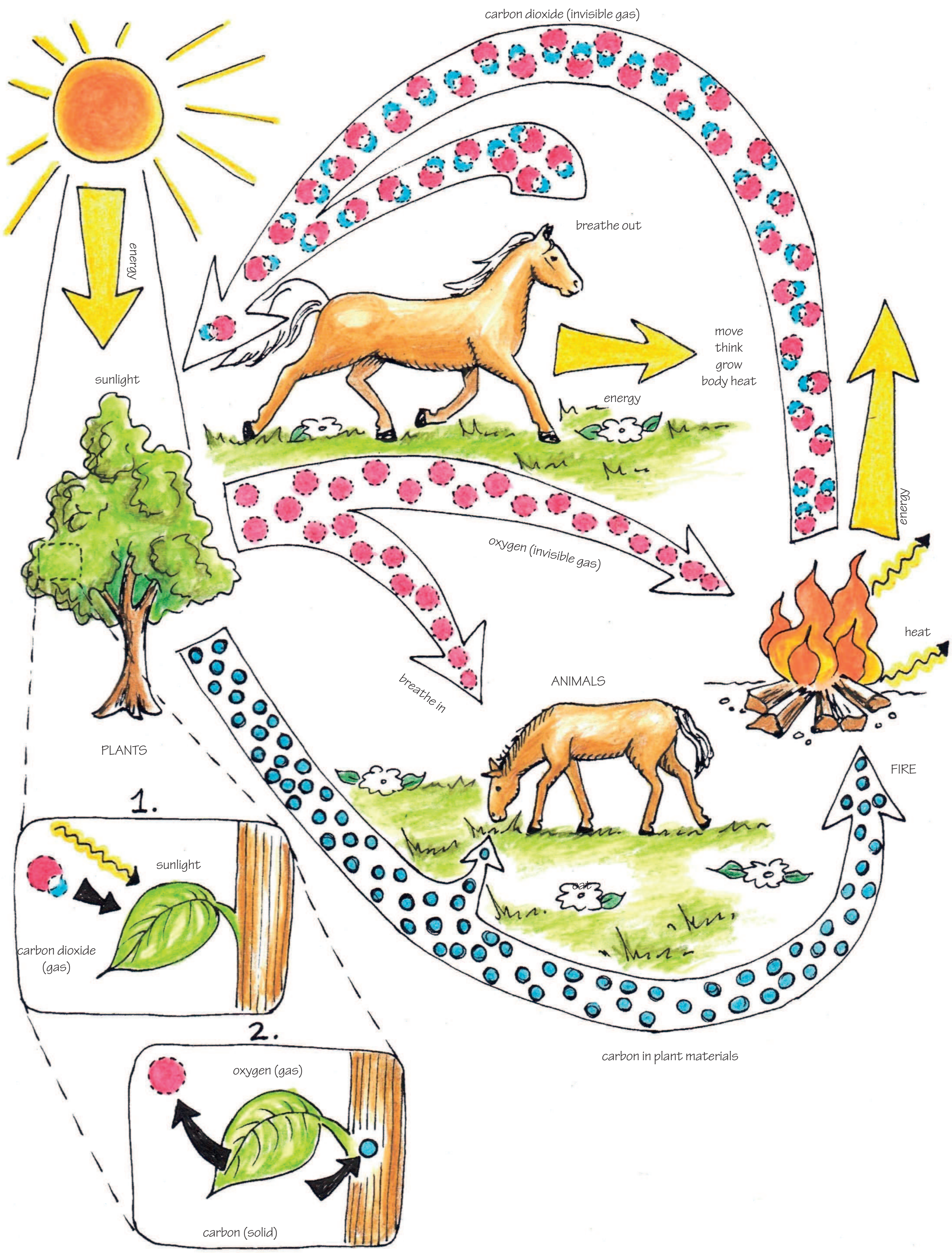


Figure 9: The carbon cycle

Investigate: Carbon dioxide

1. (a) What changes carbon dioxide gas back into carbon in a solid form? (1)

   ....

   (b) What does this solid carbon become part of? (1)

   ....

2. Can you see carbon dioxide rising from a fire? (½)

   ....

3. People use fuel for light and heat. What else do they use fuel for? (1)

   ....

On the right is a picture of a **greenhouse**. Greenhouses keep plants warm in winter, by using the energy of sunlight. It lets the energy of sunlight come inside, but does not let the same amount of energy go outside again. Therefore, it is warmer inside a greenhouse than outside. Greenhouses can be made from glass or plastic.

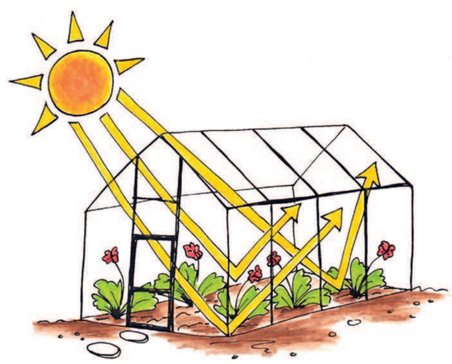


Figure 10

The layer of air around the earth is called the **atmosphere**. It is a little bit like the glass or plastic covering of a greenhouse. It lets the energy of sunlight in, but does not let the same amount of energy escape again. This is called the **greenhouse effect**. If this did not happen, it would be freezing cold every night!

When something is burnt, carbon dioxide is released into the air. Carbon dioxide is a gas that is very good at trapping the energy of sunlight. But only a small part of air is made of carbon dioxide. The more carbon dioxide is in the atmosphere, the more energy of sunlight is trapped, which means it will become warmer on earth. Many people are worried that the **climate is changing**, which can lead to droughts and storms.

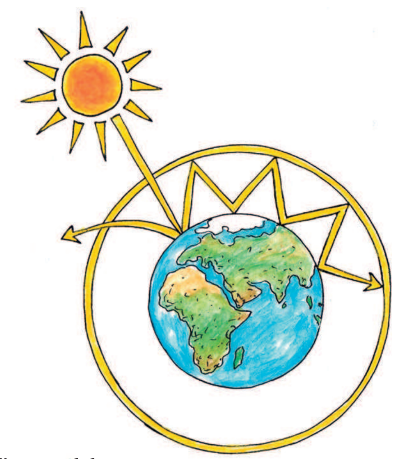


Figure 11

4. What would happen if the amount of carbon dioxide in the atmosphere increases? (1)

....

....

Total [4½]

How can the negative impact of electricity generation be reduced? (60 minutes)

Later this year, you will learn about different kinds of power stations. Some of them release less or no carbon dioxide into the atmosphere. There is hope that in future, less electricity will be generated by coal-fired power stations. But most electricity is still generated by coal-fired power stations, and this is not going to change soon.

You will now discuss what the *users* of electricity can do to reduce the amount of carbon dioxide released into the atmosphere. Every time you switch on a kettle or another electrical appliance, you use electricity. The more electricity people use, the more electricity the power stations have to generate.

There is also a *hidden way of using electricity*. Every time you buy something that was made in a factory, the factory used electricity to make the product. If people bought less of those products, then the factories would be smaller and use less electricity.

Investigate: What can you do to release less carbon dioxide?

In this lesson, your teacher will lead the whole class in a discussion about how ordinary people can use less electricity, or burn less wood, gas or paraffin. The following questions will give you some ideas for your discussion:

1. When you make tea or coffee, how much water do you put into the kettle to boil? Do you put in more water than you need? Does the amount of water that you boil have an effect on how much electricity you consume? (1)

....

....

....

2. When you leave a room, do you switch off the lights? Will that reduce the amount of electricity you use? (1)

....

....

3. Many houses have an electrical geyser to heat water. A geyser is a water tank that supplies hot water to taps. An electric element in a geyser heats the water, just like an electric element inside a kettle heats water.

   Sarah takes a warm shower for five minutes every day. Nyiko takes a warm shower for 20 minutes every day. Does the time you take to shower have an effect on how much electricity you use? (1)

....

....

4. Look at the following cut-away picture of a geyser. Can something be changed or added to a geyser so that it will use less electricity? (1)

....

....

....

....

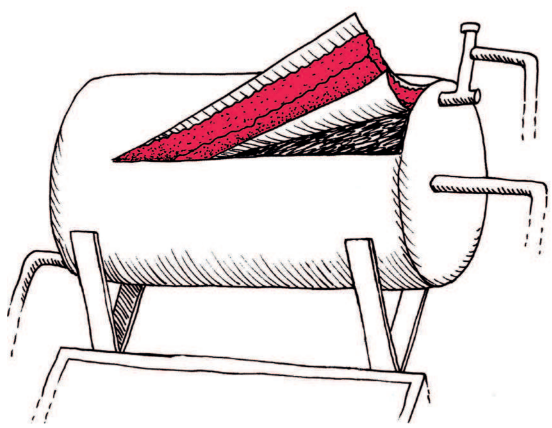


Figure 12

Figure 13: Some materials keep you warm. Why?

5. Thabo's family uses an electric heater to heat their house in winter. On the right is a photo of their roof from inside the house. Somebody told them that a lot of heat can escape through a roof. This means that a lot of the heat from the heater is wasted because it leaves through the roof. Can they change something to their house so that less heat will escape through the roof? (1)

Figure 14

....

....

....

....

....

....

....

....

....

6. Nabeelah's family live in a house without electricity. They use gas, candles and wood for heat and light. Katlego's family lives in a house with electricity. They only use electric lights and appliances. The two families are the same size. They both use about the same amount of light, hot water, and heat for cooking. Which family causes more carbon dioxide to be released into the atmosphere? (1)

....

....

....

....

Total [6]

Something you could do at home

Below is one idea for using less electricity or fuel when cooking:

Bring the food to boiling point in a pot on the stove. Then take the pot off the stove and wrap it in a thick jacket to keep it very hot. Leave it there for two to three hours. The idea is the same as a person dressing very warmly on a cold day. To wrap a jacket around a pot to keep it warm is called **insulating** the pot.

The photo below shows an insulated cooking box that was used to cook rice. This box was made from waste materials. Before the towel was wrapped around it, the box felt slightly warm after the pot was put into it. That meant that heat was escaping from the pot.

So an extra layer of insulation was added by wrapping a towel around the box. The towel was carefully wrapped around the box, so that it covered every part of the box. If some part of the box was not covered by the towel, heat could have escaped from that part of the box. It took two hours to cook the rice.

Safety warnings

Boiling hot water can burn you!

If the food in the box is warm but not hot, and it stays in the box for more than an hour, bacteria can grow. That can cause food poisoning. To prevent this, make sure that the box is well insulated, and do not leave food in the box for more than three hours.

Figure 15: Insulated cooking box made of waste materials

Week 2

Save energy by using less building materials

Factories use electricity or burn coal to make many building materials like cement and steel. You can say that there is an *energy cost* and a *carbon dioxide cost* to building materials.

How can the amount of carbon dioxide that is released into the atmosphere be reduced? One way is to design things cleverly so that less material is needed to build them. Then the factories will make less material. Another way is to cut down fewer trees, because trees help to reduce the amount of carbon dioxide in the air.

This week, you will learn about three materials made in special shapes, or combined in special ways, so that a small amount of material can make a strong object. You will learn about reinforced concrete, plywood, and steel I-beams. But first, you will do revision about the different types of forces that can act on materials.

Did you know?

About 9 kg of carbon dioxide is released into the air to manufacture 10 kg of cement or 10 kg of steel.

Forces acting on materials (30 minutes)

Revision questions

Look back on what you learnt in Chapter 1 to answer the following questions. If you find a question difficult, it can help you to first make a rough sketch of the situation. Your brain often works better if you can see the thing that you have to think about.

1. What forces can act on a tree trunk?

   ....

   ....

2. What type of force acts on a column or pillar under a bridge?

   ....

3. What type of force acts on the chain of a bicycle?

   ....

Technology Gr 8 LG Book A.indb 153 1/6/2014 8:17:59 AM

4. Take your workbook and bend it as in the photo below. Make sure that the left and right sides of the book stay at right angles to the front and back of the book.

Figure 16

(a) Why does the book make a "bubble" at the top when you bend it?

....

....

(b) What does it feel like at the bottom of the book? Are the bottom pages loose or tight?

....

5. Bolts and nuts are used to hold different pieces of material together, as shown in the picture on the right.
   What different types of forces can act on a bolt? Explain your answer or answers.

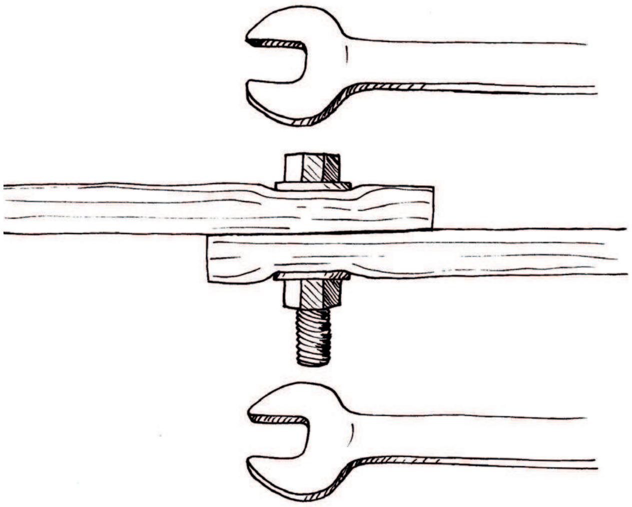


Figure 17

....

....

....

....

Reinforced concrete and plywood (30 minutes)

Reinforced concrete

Concrete is used in most modern structures and buildings. It can withstand very large compressive forces without breaking. But it cannot withstand large tensile forces. In most situations, concrete structural members like pillars and beams experience both compressive and tensile forces. To make concrete withstand large tensile forces too, steel rods or mesh is placed in the concrete when the wet concrete is poured into a shape or **mould**. Steel can withstand very large tensile forces. Concrete that has steel inside of it is called **reinforced concrete**.

Figure 18: Steel reinforcement is used to strengthen the concrete foundations of a new house.

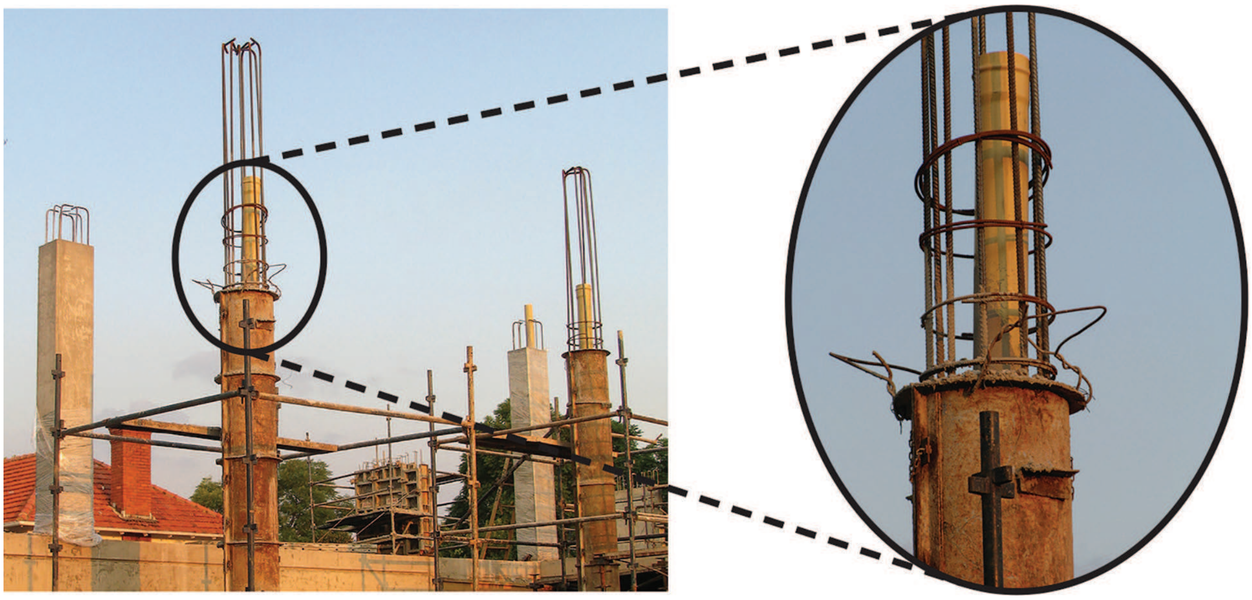


Figure 19: Steel reinforcement is put inside a concrete pillar of a big building.

Figure 20: Steel reinforcement is put inside a concrete wall of a big building.

Plywood

Wood is made of fibres that are arranged lengthwise in a tree trunk or branch. This arrangement is called the **grain** of the wood, and it can be seen as thin parallel lines.

Wood often cracks in the direction of its grain. This happens when a tensile force is applied *across* the direction of the grain.

Another way to say "across" the direction of the grain, is to say **at a right angle** with the direction of the grain.

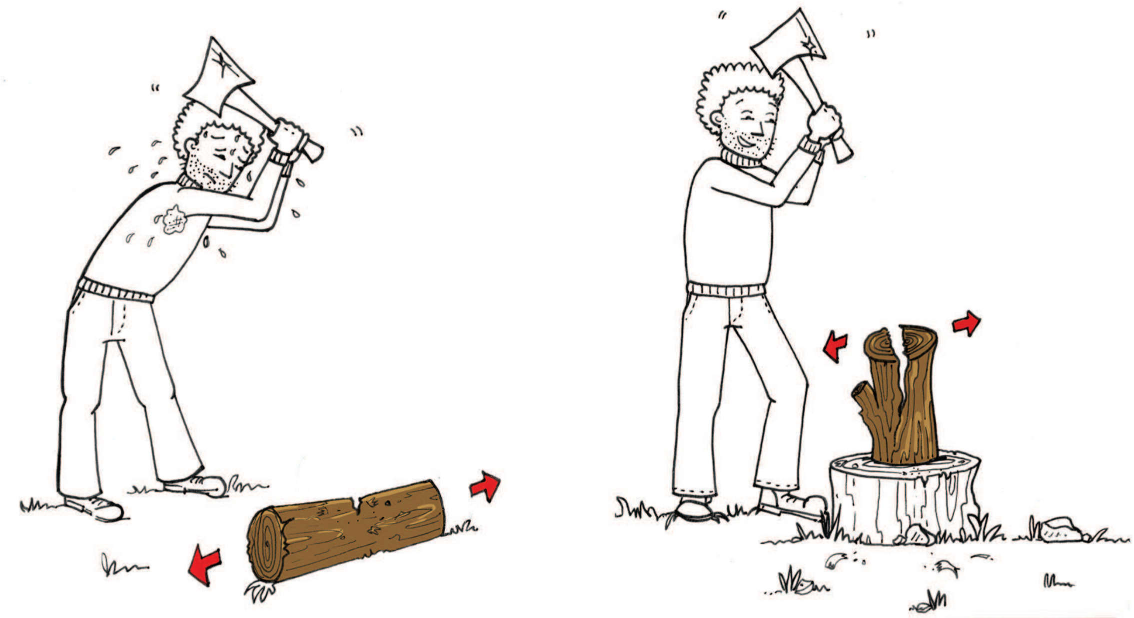


Figure 21: Splitting wood across the direction of the grain, or in the direction of the grain. Which is easiest?

Plywood is a made by glueing many thin layers of wood on top of one another. The grain in each layer is at a right angle to the grains in the layers above and below it. Plywood can therefore withstand large tensile forces in *both directions*.

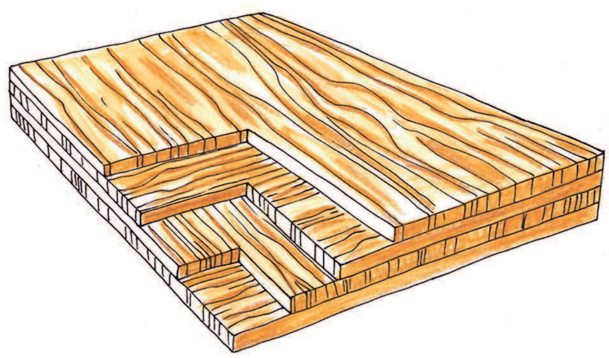


Figure 22: The different layers of plywood

Plywood is mostly used for shell structures that cover large surface areas, like floors. Other examples of the use of plywood are for seats and back rests of chairs, for table tops, and for skateboards.

A plywood shell structure is often supported by a frame structure underneath it.

Figure 23: A skateboard is made of plywood

Investigate: Properties of different materials

1. If a material is pulled in the directions of its length and its width using the same tensile force, will it stretch by the same amount in both directions?
   (a) The material of which a jersey is made:

   ....

   (b) The material of which a school shirt is made:

   ....

Look at the pictures below. A dry piece of wood cracks easily when you bend it, but the rubber sole of a shoe does not crack, even if you bend it a lot.

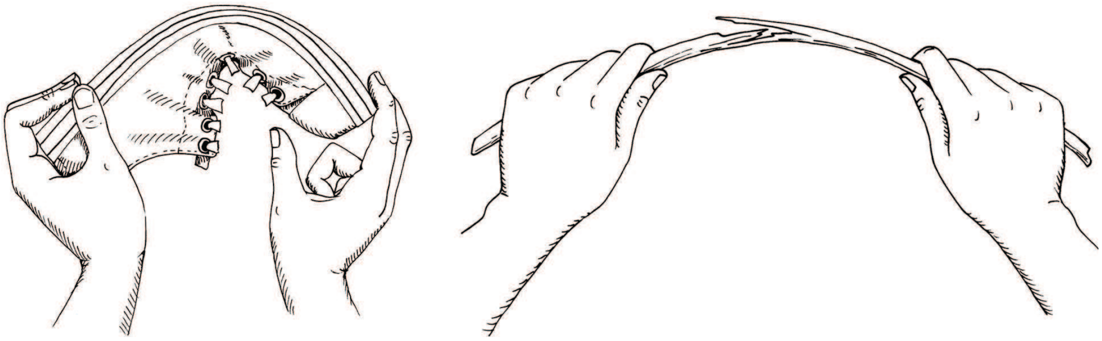


Figure 24

Rubber can change shape when it is pulled apart or pushed together. When you stop pushing or pulling it, it returns to its original shape. People say that rubber is an **elastic** material. Elastic bands are also made from rubber. When a tensile force is applied to an elastic rubber band, it gets longer. It also gets thinner.

Dry wood is only a little bit elastic, so it cannot get much longer when you apply a tensile force to it. Therefore, when the tensile force is too big, the wood will crack. You can also say the wood will **fracture**. Note that the wood cracks at the top or outside of the bend, and not on the inside.

Steel I-beams (60 minutes)

Metal beams can be shaped in special ways to make them resist bending. The shape called an I-beam is a shape that resists bending very well.

Figure 25: Steel I-beams are often used in buildings. Wood I-beams are often used during the construction of a building, but are removed once the building can support its own weight.

The pictures below compare the resistance to bending of an I-beam, to the resistance to bending of a rectangular-shaped beam. Both beams have the same length between the two supports. And the load is the same on both beams.

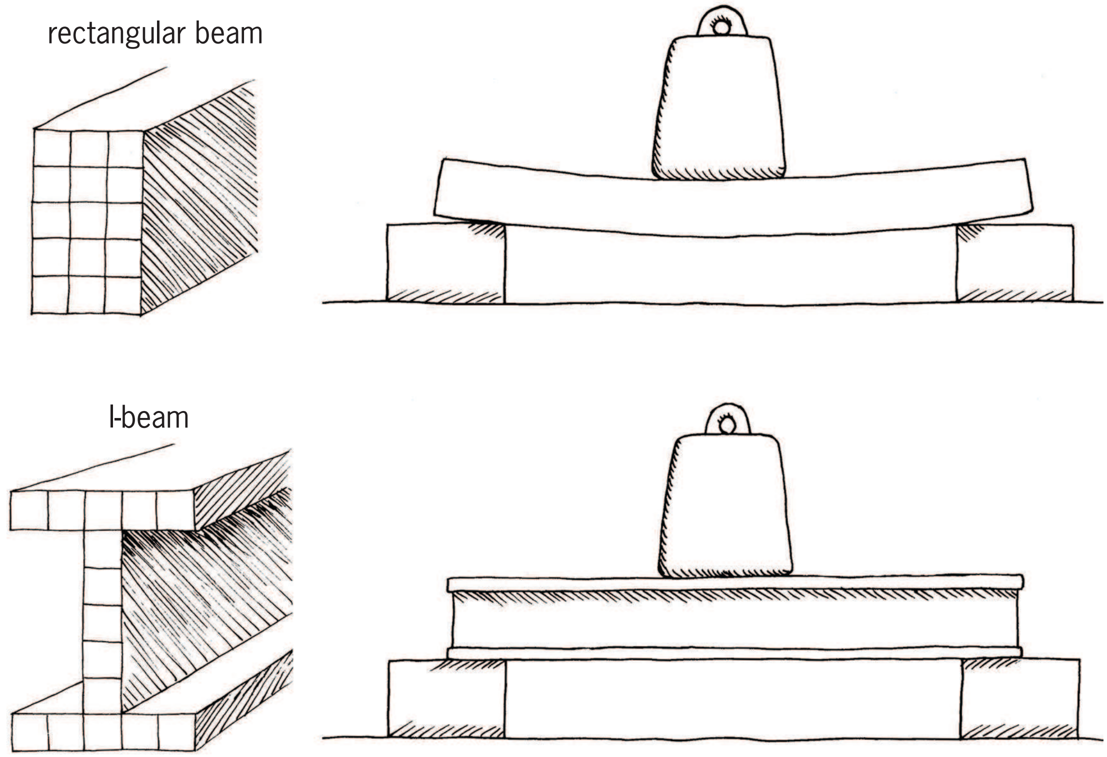


Figure 26

Count the blocks inside the pictures of the shapes of both beams. You will see that both beams are made from the same amount of material. That means that the weight of both beams are the same, and the cost of the material will be the same. Which beam bends the most under the weight of the load?

Because an I-beam resists bending better, a lighter and cheaper I-beam can be used to carry the same load as a rectangular beam. That also means that less steel will have to be made, so less energy will be used to make steel. In this way, clever design of material helps to reduce the negative impact of technology on the environment.

In the rest of the lesson, you will investigate *why* an I-beam resists bending better than a rectangular beam of the same weight. First, you have to understand what forces act at different places in a beam when it is bending.

Investigate: What forces act inside a beam that bends?

In the picture on the right, the dry piece of wood fractures at the top of the bend. That means there is a tensile force acting along the top of the wood. But the wood is only bent, so how can there be a tensile force acting on it?

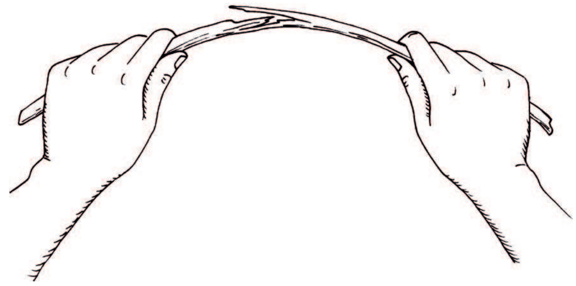


Figure 27

The pictures below will help you to understand what happens to a beam that bends. The pictures do not show what the material of which the beam is made of actually looks like. Instead, the pictures show an imagined idea that wood is made of a lot of little blocks that are connected by springs.

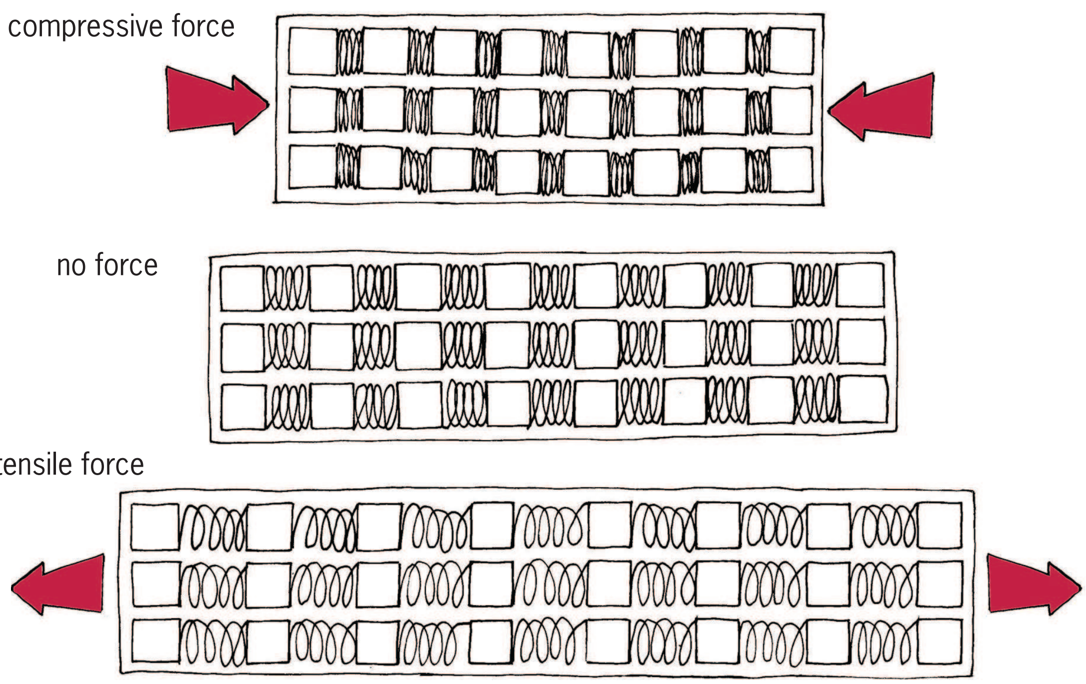


Figure 28: Pictures of a wooden beam as if it is made of small blocks connected by springs.

1. What happens to the imaginary springs when a tensile force acts along the length of the beam?

   ....

2. What happens to the imaginary springs when a compressive force acts along the length of the beam?

   ....

Below are pictures of a thin and a thick beam. Each beam bends when a load is applied in the middle of it. The pictures are drawn *as if* the beams are made up of many small blocks connected by springs.

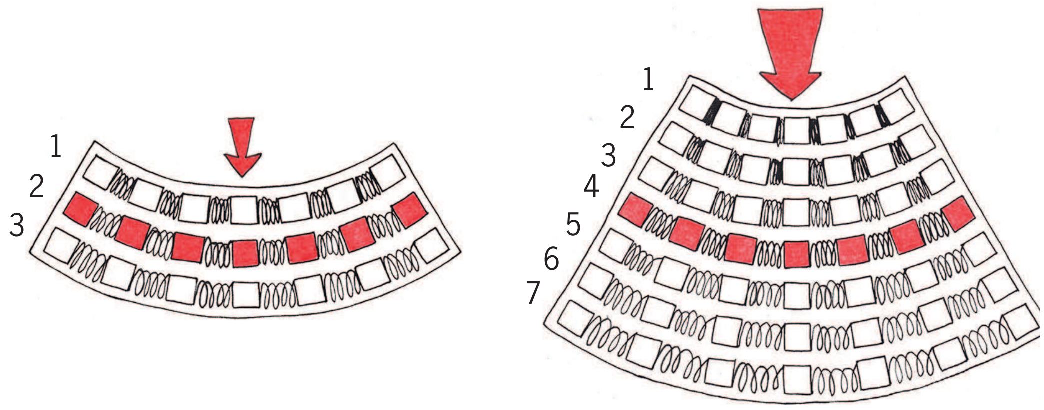


Figure 29

When a beam bends down, the following happens:

- The top gets shorter. It is compressed.
- The bottom gets longer. It is stretched.
- The middle stays the same length.

3. What type of force acts along the top of the beam when it bends down?

....

....

4. What type of force acts along the bottom of the beam when it bends down?

....

....

5. Is there a tensile or compressive force acting along the middle of the beam when it bends down? (1)

....

....

How does a spring work?

- The shorter you want to make a spring, the harder you have to press it.
- The longer you want to make a spring, the harder you have to pull it.

6. Look at the thick beam on Figure 29. There are seven rows or layers of blocks connected with springs. The layers are numbered.
   (a) Which two layers of the beam help it the most to resist bending? (1)

   ....

   (b) Does the middle layer of a beam help it to resist bending? (1)

   ....

7. Look at beam A and beam B below. They are both made of the same amount of material. You can count the blocks to check this.

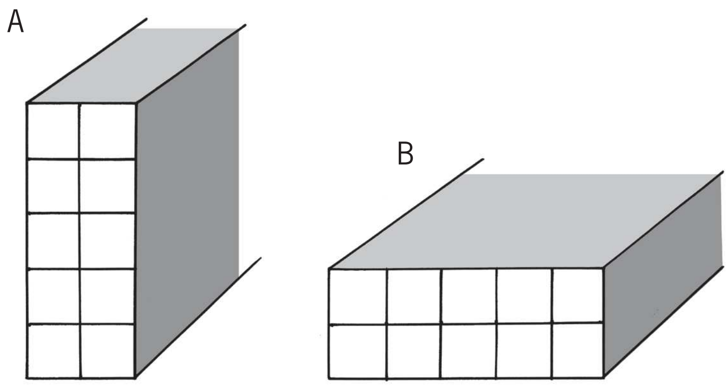


Figure 30

Which beam will bend the least if the same load is applied to both beams?

....

8. Compare beam C on the right to beams A and B. Will beam C resist bending better than beam B?

....

Beam C will resist bending the best when the force is acting *exactly* downwards. But if there is only a very small sideways force, beam C will **buckle** because it is so thin.

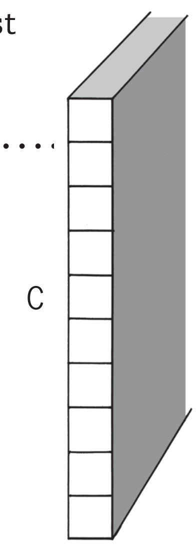


Figure 31

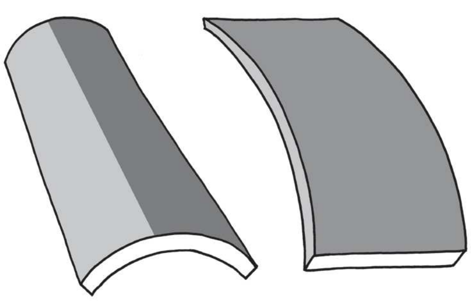


Figure 32

Technology Gr 8 LG Book A.indb 163 1/6/2014 8:18:07 AM

Engineers wanted to design a new shape for a beam that will resist bending more than beam B, but without buckling like beam C. They knew that the material in the middle of a beam does help a lot to resist bending, because it does not stretch or compress a lot in the middle of a beam when it bends. Figure 33 explains this.

So they took the design of beam B, and removed some material from the middle and rather added it to the top and bottom, where there will be more stretching and compression. In this way, they made the beam taller, but they also added short horizontal parts at the top and the bottom to prevent the beam from buckling sideways. This is shown in the pictures below.

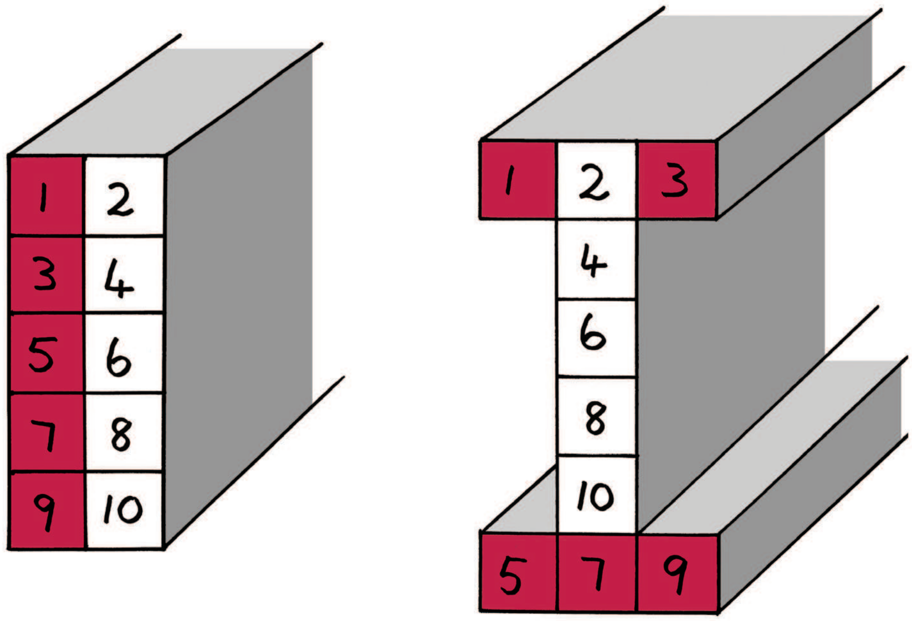


Figure 33

9. Why does an I-beam resist bending better than a rectangular beam made from the same amount of material?

   Your answers to the previous questions will help you.

....

....

....

Total [6]

Week 3

Build a model of a house

A lot of electricity or fuel is used to heat a building when it's cold, or to cool it when it's hot.

This week, you will build a cardboard model of a house from the plans you will be given. Then you will design and make changes to the house so that it will need less heating in summer, and less cooling in winter.

Some of the changes you will make will be *inside* the house, and others will be *outside*. You will build a model of only one half of a house, as if the house has been cut open along the length of the roof. This will make it easy to work inside the small cardboard house to make changes to it. It will also make it easy for other people to see the changes you have made.

Figure 34

Build a model of a house: Individual work (60 minutes)

The photo below shows the **developments** for different parts of the cardboard model that you will build. The walls and the floor are made out of one piece of cardboard. The roof and the inside wall of the house are made of two other pieces of cardboard. There are also thin strips of cardboard that will close the places where the windows are cut out and the door is cut open.

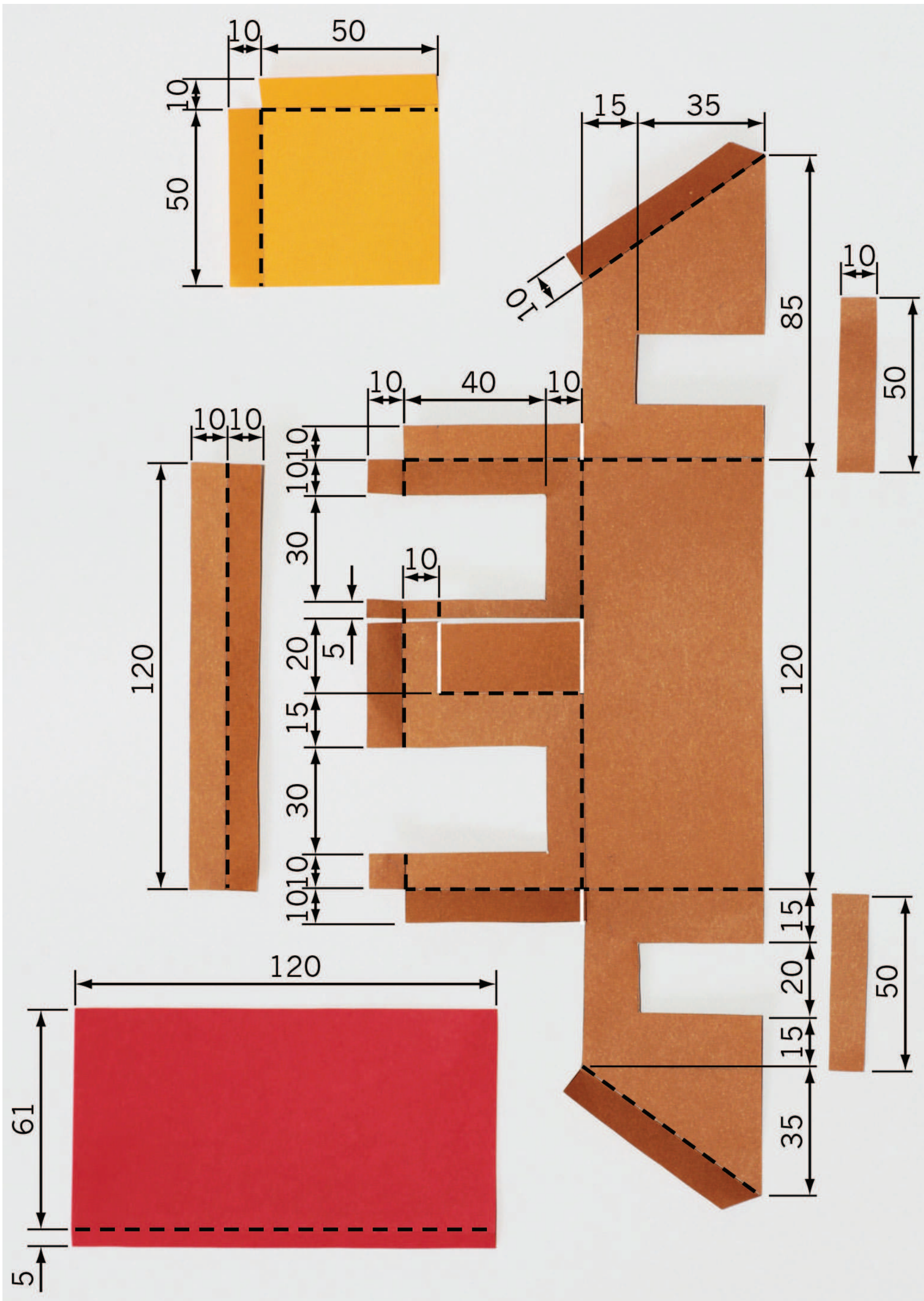


Figure 35: Dashed lines show where you should fold the cardboard.

You will make your model out of thin cardboard. To save time, do not make roof trusses for your model.

You could use some old cereal boxes for cardboard. You will later cut out, fold and glue together your model. But first do the following things:

1. Make accurate drawings of the developments of the different parts your model. Make these drawings on cardboard.
2. Cut out and fold the developments of the different parts of your model.
3. Glue the small strips of cardboard to the walls, to close the spaces where the windows were cut out and the door was cut open.

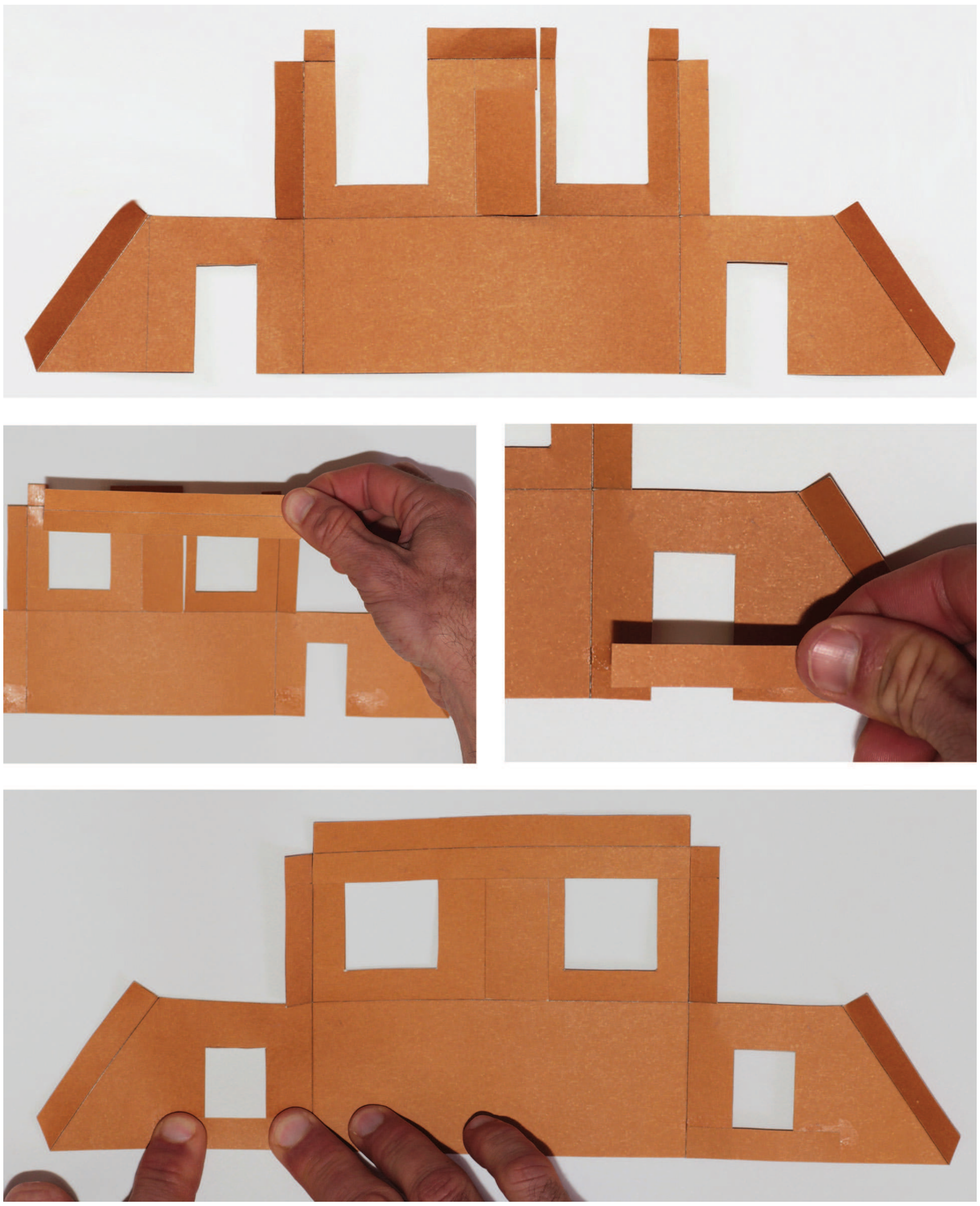


Figure 36

4. Fold the walls, and use Prestik to join them together. Then add the roof and the inside wall, also using Prestik. Have another look at Figure 36 if you are not sure how to do this.

   Do not use glue from now on. Rather use Prestik, because you might want to take out the inside wall, remove the roof, or fold the walls down later. After you have made the changes, you can put the walls and roof back with Prestik.

Total [5]

How do you know when heat is escaping?

Look at the pictures below. The same pot full of hot food is shown on the left and on the right. On the left, somebody tries to pick up the pot and burns his hands. On the right, somebody puts a bag filled with straw around the pot, and then picks up the pot without burning his hands. You can say the hot pot on the right is **insulated** by the straw bag.

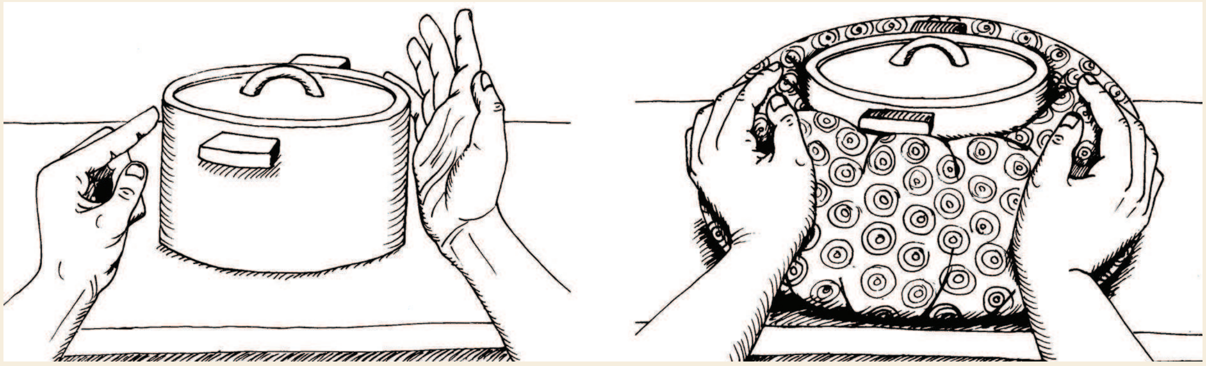


Figure 37: A hot pot with and without insulation

When you touch an object and feel that it is hot, it means that heat is escaping from the object. So the heat moves from the object to you. You are getting warmer and the object is getting cooler.

When you touch an object and it does *not* feel hot, it means that heat is not moving from the object to you.

You can feel the heat of the pot on the left, which means that heat is escaping from that pot. Therefore, the pot will cool down.

You cannot feel the heat of the pot on the right with the straw bag around it. That means heat is not escaping from that pot, or it is escaping very slowly. So the pot on the right will stay warmer for much longer than the pot on the left.

Technology Gr 8 LG Book A.indb 168 1/6/2014 8:18:12 AM

Team meeting on how to improve a house (30 minutes)

Design: How to improve a house to use less energy

Think of ideas to improve a house so that it will use less electricity and/or fuel. The questions below can help you. Working as a team will also help you, but you should still write down your own ideas. Your teacher will assess your ideas.

Try to think of changes to a house that will be cheap and easy to make. Maybe you can use recycled or natural materials, or even plants.

1. What can be changed about the roof design so that sunlight will not come through the windows in the middle of summer, but will come through the windows in winter? Make a rough sketch of your design. (2)

2. How can you prevent heat from escaping through the roof when it is cold outside? Make a rough sketch of your design. (2)

3. The owners of a house want to put in a small fireplace, like the one on the right, to heat the house in winter.
   (a) Where in the house should they put the fireplace and its chimney? Show the position of the fireplace on the **floor plan** below. A floor plan is what you see when the roof is off and you look at the house from the top.
   Hint: You want as much of the heat from the fireplace to stay inside the house. You do not want heat to escape to the outside. (1)

   Hint: Read the part in the coloured box on page 168 about the insulated pot.

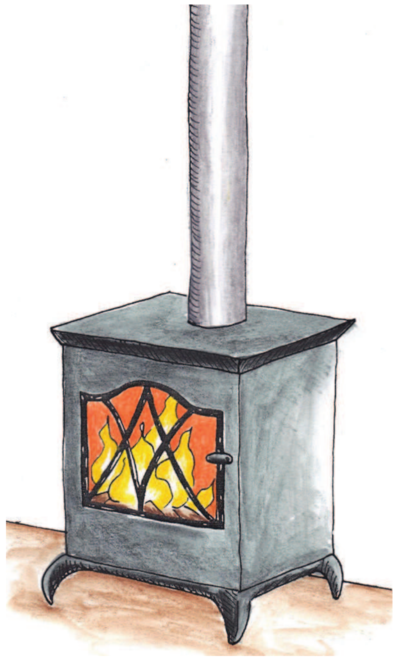


Figure 38

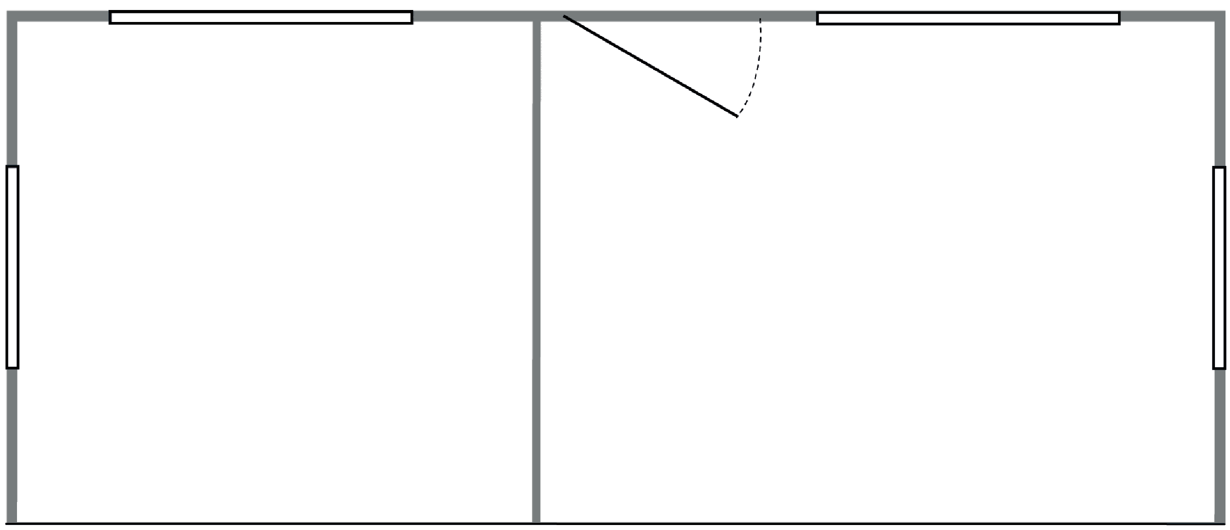


Figure 39: Floor plan of your model house

   (b) Why would you put the fireplace there? (1)

   ....

   ....

   ....

   ....

4. Three different people cook soup on a gas stove in different ways, as shown below.

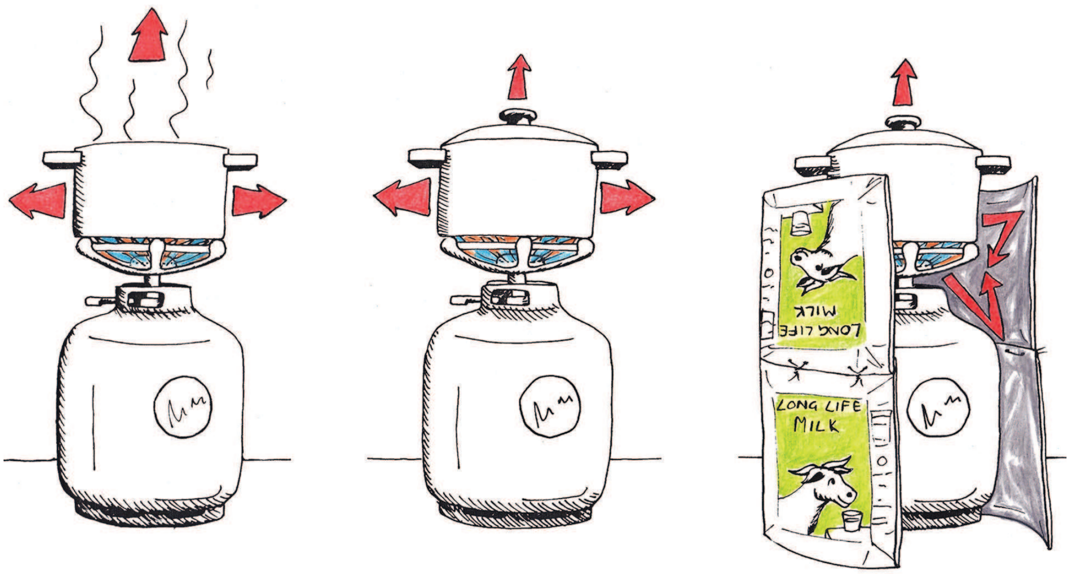


Figure 40

Who will use the least amount of gas to cook the soup?
Explain your answer. (2)

....

....

....

....

5. Have another look at the previous two chapters. Do any of the pictures give you other ideas on how to improve a house to save energy? (2)

....

....

....

....

....

....

Total [10]

Drawing your planned improvements to the house (30 minutes)

Make: Isometric projection drawing of your planned improvements

1. Make a freehand sketch in 3D to show what you plan to add or change to the **outside** of the house. Your sketch should show what you would see if you were sitting in a tree on the front, left side of the house. One of the photos in Figure 34 shows this view of the house.

   Add labels and notes to your sketch to explain the improvements.

Your teacher will look at the following to give you marks:

- You have shown at least one improvement on the outside of the house. (1)
- The improvements will really reduce how much energy the house will use, and it will be cheap and easy to make the improvements in real life. (2)
- It is easy for someone else to understand what you have sketched. (2)
- The labels and notes explain the improvements well. (2)

2. Make an isometric projection drawing to show your planned improvements to the **outside** of the house. Your drawing should again show what you would see if you were sitting in a tree on the front left side of the house.

    Do not show any hidden details.

Your teacher will look at the following aspects of the drawing to give you marks:

- It has an appropriate heading. (1)
- It is made from the correct viewing point. (2)
- It shows all the improvements shown in your sketch. (1)
- It shows all the visible lines of the house. (1)
- It shows all vertical lines as vertical and all horizontal lines at 30˚. (2)
- It is neat. (1)

Total marks [15]

Homework

1. Ask your grandparents or old people in your community for advice. Tell them:

   "I want to learn how to make changes to a house so that it will use less electricity or fuel for heating in winter, and less electricity for cooling in summer. Please tell me more about changes that are cheap and easy to make."

   Write down their advice below. You can also make sketches.

   ....

   ....

   ....

   ....

   ....

2. Gather materials that you can use to improve your model house, and bring it to school next week. Some waste materials will work well. You do not have to use the same materials on the model that you would use in real life. Also bring a piece of corrugated cardboard that is at least as big as an A4 sheet.

   If you do not bring these materials, you will not be able to show the improvements on your model house.

Week 4

Make improvements to your model house (60 minutes)

Make: Improve your model house

Individual work

You want to show other people the different improvements that can be made to the house, so that less energy will be needed to heat or cool the house. Some improvements may be on the outside of the house. Other improvements may be on the inside of the house. Some things may even be added on the ground around the house.

Stick your model of a house on a big flat piece of cardboard using Prestik. The flat piece of cardboard represents the ground around the house.

Now add or change things to the house so that it will use less energy. Use the materials you brought from home to make the changes.

For each thing that you add or change to the model, make a small paper sticker with a number on it, and stick it to the thing that you add or change. Write down the numbers of all the changes on a piece of paper. For each change, say what its purpose is and what it is made of. If you know the name of the thing, you can also write it down. For example:

1. What is it made of in real life?
   What is its purpose?
   What is its name?

This piece of paper is called a **legend**. It explains to people what the different things on your model are.

Total [20]

Evaluate your improvements to the house (60 minutes)

You will make an evaluation sheet to evaluate your own work, as well as the work of two other learners who are *not* on the same team as you.

Evaluate each model **objectively** and fairly. So you should pretend that you are evaluating the work of someone that you do not know. Do not give high marks to yourself or others if the improvements to the house are not good or not enough. Be prepared to explain why you gave a low, medium or high mark.

Evaluate: Make and use an evaluation sheet

1. Change each of the following **criteria** into a question. Then make a table with all the questions. You will give a mark next to each question, from one to three.
   - There should be at least two improvements on the inside of the house. The more improvements there are, the better. But ignore changes to the model house that will not reduce the amount of energy used.
   - There should be at least one improvement on the outside of the house. The more improvements there are, the better. Ignore changes that will not work.
   - The improvements should be as cheap as possible, and easy to make in real life. They should not require a lot of extra building to be done.
   - It will be good if some of the improvements are made with natural materials that can be found close by, or by re-using waste material.
   - The improvements on the model should be neat. It should be easy to understand what the improvements are just by looking at the model.
   - The legend should give a clear explanation of what the improvements are.

Evaluation sheet for your own model

Evaluation sheet for the model of ....

Evaluation sheet for the model of ....

Week 5

Present your model of a low-energy house

Your team will give a presentation of your improvements to a house later this week. The presentation should be between three and five minutes long. Each member of your team should do a part of the presentation. The other learners in the class can ask you questions after your presentation.

Prepare your presentation (30 minutes)

Team meeting

1. Decide which part of the presentation each one of you will do.
   - One of you should talk about the rough sketches, and the final isometric projection drawing you made.
   - One of you should show a model and explain all the changes inside and outside the model.
   - One of you should talk about the advice that old people gave you on how to improve a house to save energy. You should also talk about how natural materials can be used to improve a house.
   - If there is a fourth person in your group, he or she should talk about the first plans you made during your team meeting in week three, and how you improved or added to those plans later on.
2. Decide in what order you will give the different parts of the presentation. Who will talk first, and who will talk next?
   Write the parts of the presentation in the order that you will do them below, and show who will do which part.

Individual work

1. Plan your own part of the presentation.
   Use the space below to write notes about what you will do.
2. **Homework:** Practise your presentation.

Hints for presenting your work

- Stand up straight and look at the class when you speak.
- Do not write out everything that you will say. Rather make a list of the main things you will talk about. This should not be more than five things. Your list should not have full sentences, but only key words to remind you of what you want to talk about.
- What you are telling the class is very important, because it can help people save money and reduce the negative impact on the environment. Be proud of what you tell the class and speak loudly and clearly.
- Use your sketches, drawings and model to point to things while you are talking. This will help the class to understand what you are saying. Make sure they can see the sketches, drawings and model clearly.
- You can also bring pictures from magazines or newspapers, or examples of materials, and use that in your presentation.
- Know when it is your turn to speak.
- Keep to the time limit. It often helps to ask somebody else in the class to hold up cards saying how much time you have left.

Presentations of all the teams to the class (90 minutes)

Listen well to the presentations of the other teams. They may have interesting ideas that you did not think of. Write those ideas down below, to help you to remember them when you design or improve your own house one day.

Enjoy your winter holiday! After the holiday, you will make things that work with levers and gears.

Technology Gr 8 LG Book A.indb 180 1/6/2014 8:18:14 AM

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