TECHNOLOGY

Grade 9

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CONTENTS

Structures

Types of Structures

Natural and Manmade structures

Structures are all around us, some are natural like eggshells, spider-webs, caves and trees and others are man-made like bridges, towers, houses, shopping bags and cups. Structures are further divided into three other groups namely frame, shell and mass structures:

Frame Structures

A frame structure is a structure made up of many rigid parts joined together to form a 'framework'. These different parts are called members.

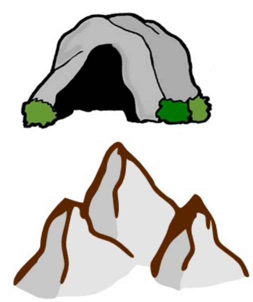
Shell Structures

A shell structure is more enclosing than a frame structure - it surrounds and encloses something.

Solid/mass Structures

Solid structures rely heavily on solid construction such as masonry to support loads and to transfer these loads safely to the ground. Advantages of solid structures are that they are held in place by their own weight, losing small parts often has little effect on the overall strength of the structure

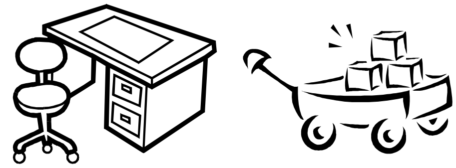
- Mountains, caves and coral reefs are natural mass structures
- Sand castles, dams and brick walls are manufactured mass structures



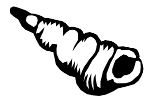
Functions of structures

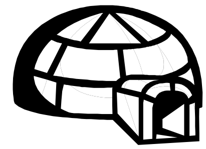
Supporting a load

A structure must be able to support its own weight and the load it has to carry. A load can be a person, an object or a force. A moving load is known as a dynamic load. A stationary load is known as a static load.

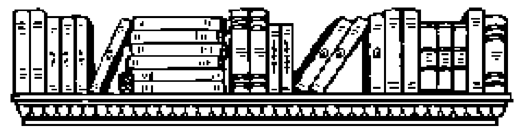


Enclosing people, animals or objects
All containers fulfill this function, as well as most buildings. Natural objects include shells, caves, hollow tree trunks etc.



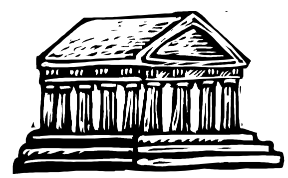


Spanning a gap
The most common structure fulfilling this function is a bridge. Bridges fulfills another function - supporting a load - they have to carry their own weight and the weight of whatever travels over them.

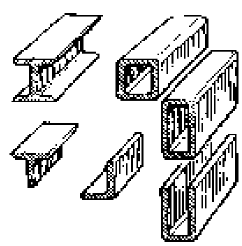
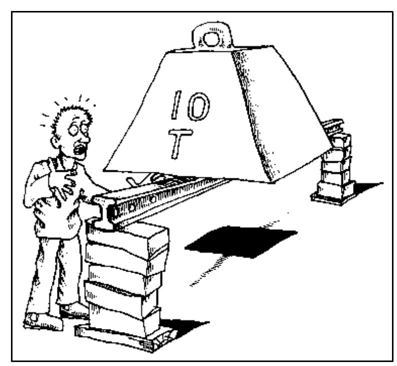



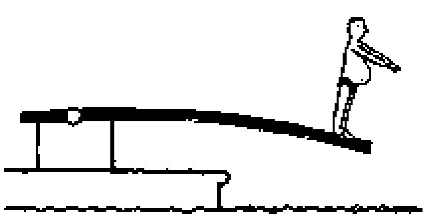
Structural members

Columns are vertical structural members.



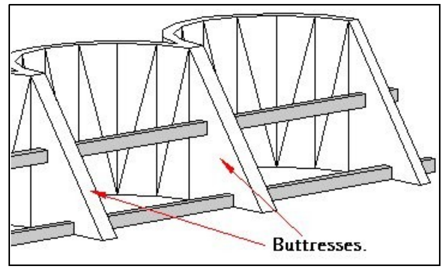
Beams are horizontal structural members. Beams often spread a load across two or more columns. How well the beam works depends the material it is made from and its shape. Beams used in larger structures take many different forms, some are simply solid, some are hollow, and others have special cross-sections to provide strength and rigidity.

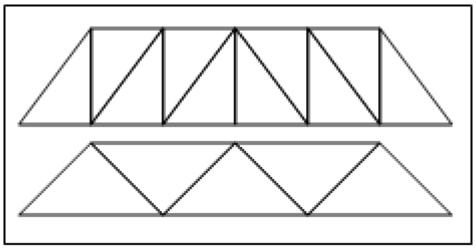





A **cantilever** is a structural member which sticks out like an arm form the main structure. A cantilever is a beam which is supported at one end only.

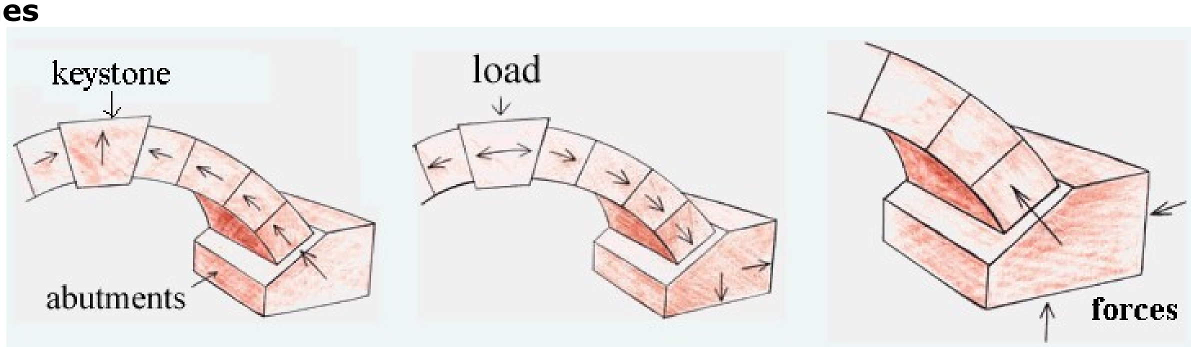
A **buttress** is a structure built against or projecting from a wall which serves to support or reinforce the wall.





A **truss** is a structure made up of triangles.

Arches



The load at the top of the key stone makes each stone on the arch of the bridge press on the one next to it. This happens until the push is applied to the end supports or *abutments,* which are enbedded in the ground.

The ground around the abutments is squeezed and pushes back on the abutments.

For every action there is an equal and opposite reaction. The ground which pushes back on the *abutments* creates a *resistance* which is passed from stone to stone, until it is eventually pushing on the key stone which is supporting the load.

Properties of Structures

Strength - the capacity to withstand forces that tend to break an object or change its shape; it is an object's ability to hold its shape without collapsing.
Rigidity - the ability not to buckle or distort.
Stability - the capacity of an object to maintain or return to its original position; the state of being balanced in a fixed position.
Why are some structures more stable than others?

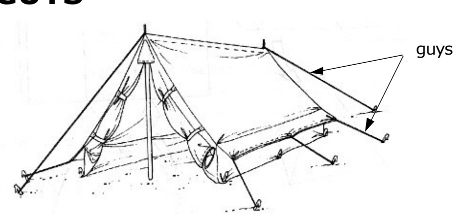
We say that a structure has high stability if, when it is loaded, it tends to return to, or remain in, the same position. The degree of stability depends on the relationship between the base, the height and the weight of the structure.
The weight of an object is due to the force of gravity pulling down vertically on the mass of the object. The invisible position of the mass through which the force of gravity pulls is called the centre of gravity. If the position of the centre of gravity is low and lies well inside a large base area, the object is said to be very stable. If the centre of gravity lies to one side of the base area, the object is much less stable. If the centre of gravity is outside the base area, the object is very unstable and may require further support. A tall object tends to be unstable because its centre of gravity is in a very high position. Because of this, it can be more easily moved outside the base area by the application of external loads. A structure is said to be stable when it will not topple over easily when acted upon by a force.

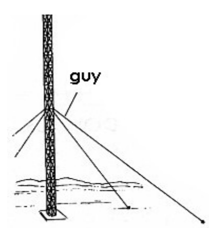
Some rules for stability:

- **A low centre of gravity.**
- A **wide base** is generally more stable than a structure with narrow base.
- More weight at the bottom.

It is not always possible to design structures that comply with these rules, and therefore sometimes special measures should be taken to make a structure stable. The tower crane is a long slender structure with a very thin base, and a very wide top. It has a large load to carry at the top at one end of the arm as indicated in the previous picture. A counter weight is placed on the opposite side of the crane arm to that of the. This system works by balancing the load with that of the counter weight.

GUYS

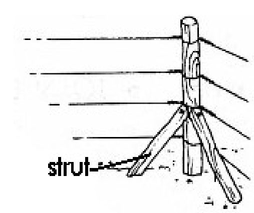


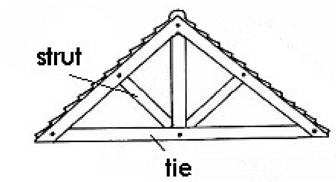


Structures like high towers and tents can also be made stable by anchoring it to the ground with guys. **Guys** are ropes, cables or chains (flexible members) that hold a structure firmly in place by pulling on it.

Struts and Ties

All structures have forces acting on them. Ties, guys and struts are structural members used to make structures stable. The part of the structure that has a tensile force acting on it is called a TIE and the part that has a compressive force acting on it is called a STRUT.



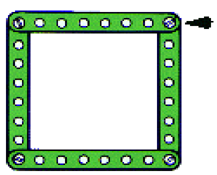


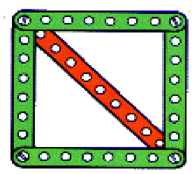
A tie (usually inflexible) holds other members in place by pulling on them. Many frame structures have members called struts (always inflexible). Struts hold members in position by pushing against them. Struts are made of materials like wood or steel which do not bend.

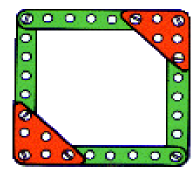
The design of structures

If you look at some pictures of familiar frame structures like cranes, electricity pylons or roof supports you may notice that triangulation is used to make them rigid.

Making Frame Structures Rigid





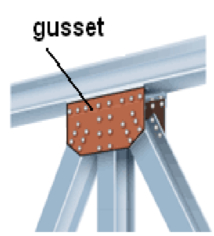


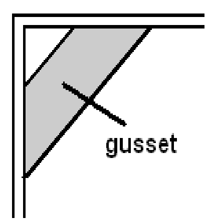
When forces are applied to a simple four-sided structure it can be forced out of shape quite easily. A structure which behaves in this way is said to be non-rigid.

By adding an extra bar or member (usually a strut) corners A and B are prevented from moving apart. The structure then cannot be be forced out of shape, and is said to be rigid. Notice that the additional member has formed two triangles in the structure.

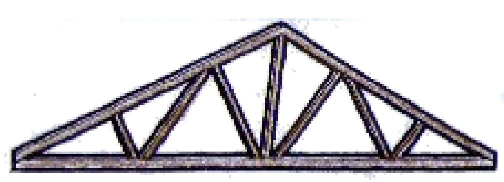
An alternative to triangulation is to use a gusset plate. A gusset is simply a piece of material used to brace and join the members in a structure. A triangular gusset plate has been used here but they can be made in a variety of shapes.

Gussets are made of rigid materials such as wood or metal and is used to brace or hold frame members together.

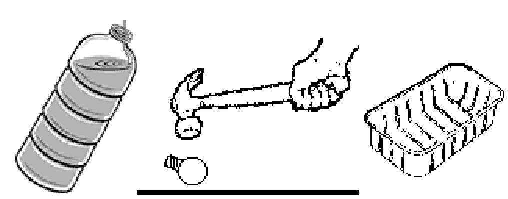




Framed structures achieve most of their strength and rigidity from the way they are assembled. Most frameworks are built using a combination of struts and ties to make triangles. Triangles make very strong and rigid structures. Using triangles in this way is called **triangulation**.

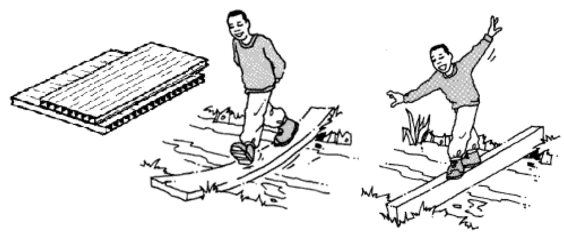


Most shell structures achieve their strength and rigidity from the way they are shaped. Shell structures very rarely have large flat surfaces they tend to be designed and made with ribs to



act as stiffeners. Egg and light bulbs containers are good examples. Both eggs and light bulbs can withstand considerable static forces if they are applied carefully. The same principle is used for corrugated iron.

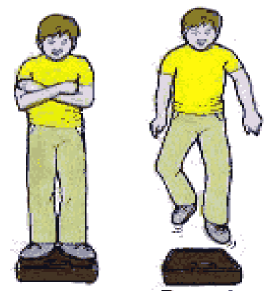
Materials which are used to make structures can be reinforced by using it in a different position. If two strips of are stuck to each other at a 90° angle, the cardboard will be stronger. The same happens to wood when it is laminated. The strips of wood are glued together at an angle of 90°. A beam is also stronger when it is used in an upright position rather than flat.



Forces

Forces can be either **static (stationary**) or **dynamic (moving**).

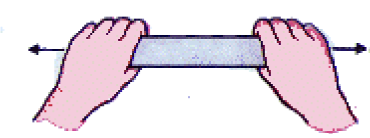
Static forces are usually forces caused by the weight of the structure and anything which is permanently attached to it.



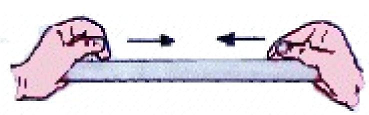
Dynamic forces are caused by things such as wind, waves, people, and vehicles. Dynamic forces are usually much greater than static forces and are very difficult to predict. These are the most common reason for structural failures.

An **external force** is a force placed on the structure from outside, by the wind perhaps or perhaps by someone sitting or standing on it.
Internal forces are the forces which the structure must provide within itself to resist the external forces placed upon it. If the external forces are greater than the internal forces, a structure will collapse.

Forces acting on and within Structures
External forces or loads cause internal stresses to be set up in a structure. Not all forces or loads act in the same way. Forces can bend, pull, press, or twist. Each of these types of force are given special names.



Tension : Is a force which tries to pull something apart. A structural member in tension is called a tie. A tie

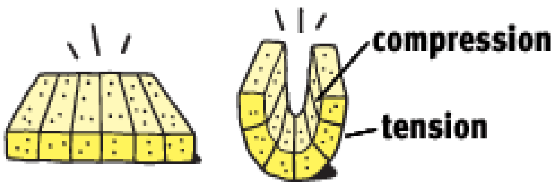


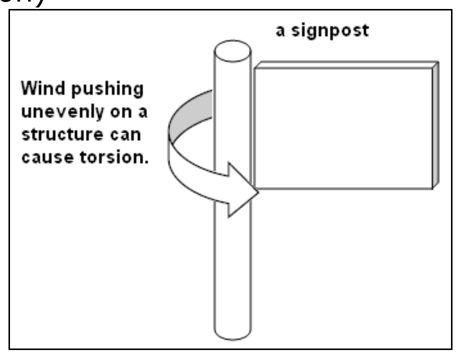
Compression : Is a force which tries to squash something together. A structural member in

Bending : Bending is a word you will have met before. A structure which is subjected to bending is being stretched

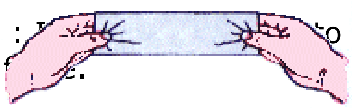
resists tensile stress.	compression is called a strut. A strut resists compressive stress.	and squashed at the same time.

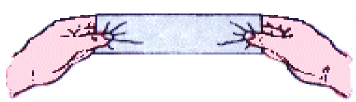
Bending: A combination of forces that causes one part of a material to be in compression and another part to be in tension. In this picture a sponge with lines drawn on it is bent. You can clearly see how the lines at the top are moved closer together (in compression) and the lines at the bottom is pulled apart (tension)

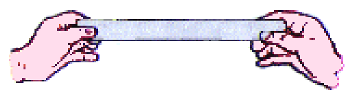




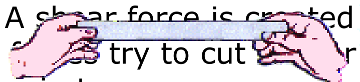
Torsion : T[illegible]o a turning or a twisting f[illegible]e.







Shear : A shear force is created where two opposite f[illegible]s try to cut [illegible]r rip something in two.



Materials used in structures

The properties of materials determine their function in structures

Tensile strength: ability of a material to withstand pulling or tension forces
Compressive strength: ability of materials to withstand pushing or compressive forces
Torsional strength: ability of material to withstand being twisted or placed under torsion
Stiffness: how little distortion or deflection occurs when a material is placed under pressure
Hardness: Ability to withstand being scratched cut or dented
Brittleness: When material fractures with little or no deformation
Toughness: Resistance to impact
Ductility: Allows a material to be elongated or stretched without breaking
Elasticity: When a material can be stretched out of shape, but it will go back to its old shape when you remove the force.
Flexibility: If a material bends easily and does not crack.
Plasticity: When a material changes shape when you press or squash it, it will not go back to its old shape when you remove the force.

Absorbent: Materials that suck up water easily.
Waterproof: Materials that seems to push water away, it just runs of the material
Corrosion resistant: rust of UV-rays of the sun
Heat resistant: will not burn or act as insulator against heat

Processing

What is processing?

Processing changes a raw material into a manufactured product.
A raw material is any material in its natural state. People process raw materials to change or improve their properties. For example, at a fish factory the fish is skinned, cleaned and frozen so that people can eat the fish long after it has been caught. Processing adapts raw materials to suit particular purposes. Materials can be galvanised, frozen, dried, painted, varnished or electroplated to improve their properties and to prolong their lifespan.
Processing is important for the following reasons:

- Processing improves the properties of the material
- Processing increases the value of the material
- Processing creates many job opportunities.

Raw materials and processed products

People make processed products from natural materials. For example, a concrete factory makes concrete from stones, sand, cement and water. The natural, unprocessed materials that are used in processing are called raw materials. People use technology to convert a natural material into a processed product which is more useful. Processing usually takes place in a factory. The manufacture of processed products often results in waste products, which can create many environmental challenges. During processing by-products are often formed.

Primary, secondary and tertiary activities

You have learnt that raw materials are usually processed in a factory. This gives rise to the industrial sector of our economy. The flow chart summarises the different types of economic activities:

Primary activities

Raw materials are taken from the environment but left unprocessed

Examples: Farming, fishing, forestry

Secondary activities

Raw materials are processed to improve their properties

Example: The process of milling maize to make mealiemeal is a secondary activity

Tertiary activities

Tertiary activities include the provision of services

Examples:
Transport and communication
Banking and financial services
Education and medical services

Materials

No substance, from metal to wood to food, will last forever. Many things can cuase substances to spoil, degrade or rot. People use their intelligence to find ways to prevent or slow down spoiling. Preserving is a response to the problem of spoiling. Many food preservation techniques were developed in the era before electricity and refrigeration, for example:

Biltong - salted and dried meat first used by the Voortrekkers
Bokkoms - salted and dried fish by the Cape Malay community
Mopane worms - sun-dried by the Venda people

We will deal with several methods of preservation in this module, for example: how can wood, metal and food be preserved.

Wood

There are two types of sawn wood.
The terms hardwood and softwood do not refer to the wood, but to the leaves of the trees: Softwoods come from trees with needle-like leaves; the most common types are pine, spruce and larch. Hardwoods come from broad-leaved trees such as mahogany and meranti. Not all hardwoods are hard - balsa is very soft.

Solid woods

Hardwoods
Balsa Ebony Mahogany Teak Eucalyptus
Softwoods
Cedar, Pine

Manufactured boards
Plywood, laminated wood, chipboard, block board, hardboard, fibre board, soft board

Preserving Wood

Wood is an excellent natural product, but it can easily be damaged if not properly cared for. Trees are vital components of the earth's ecosystem and are primarily responsible for converting carbon dioxide into oxygen during photosynthesis. When wood is burnt or allowed to rot, the process is reversed:

Carbon (from the wood) + oxygen (from the air) = CO_2

Burning a tree undoes the entire life's work of the treesin only a few hours. Whenever a tree is cut down. at least one indigenous tree should be planted as a replacement.

Some exotic (foreign) trees come from wetter climates than ours and are water-wasters. Exotic trees, like the Black Wattle, often invade river and stream banks, reducing the flow of water. They should be removed. The Australian Blue Gum trees tend to be much thirstier than our South African indigenous trees. Such trees should be replaced, especially in sensitive areas - like next to farmlands.
When trees are cut down, the wood should be utilised for furniture, school desks and roof trusses. Only smaller branches and bark should be used as firewood.

Deforestation

The forests of the Amazon River in South America and on the islands of Indonesia are being felled at a mind-boggling rate. The high-quality wood is exported to the richer nations of world, and local inhabitants reap very few benefits. These trees form the green lungs of our planet. Removing them is causing the quantity of carbon dioxide in the atmosphere to rise, and this is a major cause of global warming.

Remember that tropical forests take sixty years or more to mature. Temperate forests in cooler lands grow more slowly and take twice as long. Parts of Africa are also being looted for timber. The wood is exported outside our continent.

Trees are vital for the health of the planet and wood is a valuable commodity. Wood should be treated with respect and protected.

Although wood is classified as a renewable resource, trees grow too slowly. Careless or ignorant people are cutting trees down at a faster rate than they can be replaced. We must use our resources in a responsible, intelligent and sustainable way.

There are a number of important points to remember when protecting wood:

The protective material used . . .

- should be easily absorbed by the wood
- must poison organisms that attack the wood, but be safe for humans and animals.
- should be readily obtainable locally
- must be cost effective

The protective material used should not . . .

- reduce the strenth of the wood
- cause metals to corrode (rust) for example nails and screws
- change or affect the surface of the wood
- make the wood more flammable

Metals

All metals fall into two categories. They can either be pure metals or alloys. A pure metal consists of a single element, which means that it is a metal only having one type of atom in it. The most commonly used pure metals are aluminium, copper, iron, lead, zinc, tin, silver and gold.

An alloy is a mixture of two or more pure elements. Pure metals sometimes lack certain required properties. To create these properties a number of these pure metals are combined together.
Pure aluminium is rarely used because it is too soft. It is normally mixed with other metals, which produce aluminium alloys that are even stronger than mild steel, are resistant to corrosion but still retain the lightness of aluminium.

Ferrous metals

Ferrous metals are metals, which are mainly made of iron with small amounts of other metals or elements added in order to give the correct properties. Almost all ferrous metals are magnetic and can be picked up with a magnet. These metals rust or oxidise if not treated as they contain iron.
Type: Mild Steel, Cast Steel, Stainless steel, Cast Iron, Wrought iron

Non-Ferrous metals

Non-Ferrous metals are those metals, which do not contain iron. These metals are not magnetic and cannot be attracted by a magnet. Examples of these are aluminium, copper, lead, zinc and tin. These metals do not oxidise as they do not contain iron.
Types: Silver, aluminium, copper, zinc, lead, tin, brass, bronze, titanium, magnesium

Preserving metals

Iron is a metal that rusts easily by combining with oxygen in the air to form various iron oxides. Iron is the most widely used metal in industry, especially if it is alloyed to another metal to improve its strength or its resistance to corrosion. In 1889 the Eiffel Tower was built in Paris. This proved the abilities of iron in construction. It has become the most widely used material in high buildings.
Iron can be painted, chromed, tinned, galvanised with zinc or even rubbed with oil. It can be alloyed with chrome, vanadium, tungsten and titanium.

A metal is a substance that conducts electricity and heat well. All metals are shiny - you may have to clean off the oxide coating before you see the shine. They are malleable (can be pressed into shapes) and ductile (can be stretched to form wire). Most metals have high melting points (and even higher boiling points).

Copper is used for most electric wire because it is an excellent conductor, and it does not rust (corrode) easily. It is also used for household objects.

Gold and platinum are used in industry and jewellery because they do not rust at all. Platinum is used for jewellery and chemical catalysts. Gold is used for jewellery and very thin wires.

Other useful metals are aluminium (for cans, aeroplane bodies, cooking foil, pots), iron (for cans, construction, tools, cutlery, steel wire, steel springs, cars, ships, and so on.) and lead (for plumbing).

Some metals are alloyed (mixed) with the above-mentioned metals to improve their properties. For example:

- stainless steel is an alloy of chrome and iron
- tool steel is an alloy of vanadium and iron
- tungsten and iron gives a very hard steel for cutting tools and electric light bulb filaments
- brass is an alloy of copper and zinc (used for brass door handles, hinges)
- bronze is an alloy of tin and copper (used for bronze for statues, machines parts and bearings).

We saw earlier that iron rusts easily. Iron can be protected by coating it with paint, or with another metal that does not rust as easily: tin on iron (tin cans), zinc on iron (galvanised iron roofing sheets, fencing wire, pipes). The protection is very effective if undamaged. Once the metal coating has been damaged, the iron will begin to rust. The rate of the corrosion now will actually be faster than normal for uncoated iron.

Galvanised iron

The main method of protecting iron from rusting is to coat it with zinc. This is so common that corrugated galvanised iron roofing sheets are often called zinc roofing sheets - this is not accurate since the main metal is iron.

There are different methods of coating iron with zinc:

Galvanising can be done in several ways:

- Electroplating - using electric current to deposit zinc atom by atom.
- Hot dip coating - dipping iron into molten zinc.
- Sherardizing - covering the iron in zinc dust and baking it on in an oven.
- Spraying - applying molten zinc using a fine spray.

Zinc is easier and cheaper to apply than chrome, nickel or tin.

Electroplating

The piece of iron to be coated is placed in a bath containing a zinc salt solution - let us say zinc chloride. The iron is connected to the negative pole of the battery. Another piece of pure zinc is connected to the positive terminal of the battery and placed in the other end of the bath.

We need a steady direct current (d.c.) with a low voltage. You will not need more than 6 V to get satisfactory results. When the current flows through the solution, ions of zinc deposit out of the solution onto the iron at the `cathode' (the negative electrode).
Electrolytic plating can be done with several metals. The shiny chrome on a motorcycle is fixed to the underlying metal using electrolysis.

Before you can electroplate it, the object must be cleaned thoroughly. Wash the object thoroughly, using an old toothbrush if it has a rough surface. Dip it into an acid solution - vinegar will do if you leave it long enough. A smooth, polished object will give the best results.

Hot dip galvanising

This fast and effective method is widely used to galvanise iron on a large scale. The key to a good bond between the iron and the zinc is cleanliness. The process is as follows:

- Step 1: Degreasing - the iron is dipped into a hot caustic soda bath. This removes oil, organic materials and paint.
- Step 2: Pickling - the iron is immersed in acid to remove rust and dirt.
- Step 3: Rinsing - the iron is then washed to remove all traces of acid.
- Step 4: Heating - the iron is heated to a temperature of 455 °C to 460 °C.
- Step 5: Prefluxing - the hot iron is dipped into a solution of zinc ammonium chloride for final surface preparation.
- Step 6: Spelting - the hot iron is dipped into a bath of molten zinc.
- Step 7: Quenching - the hot coated iron is dipped into a zinc chromate solution to cool and to stabilise the surface to prevent early rusting.

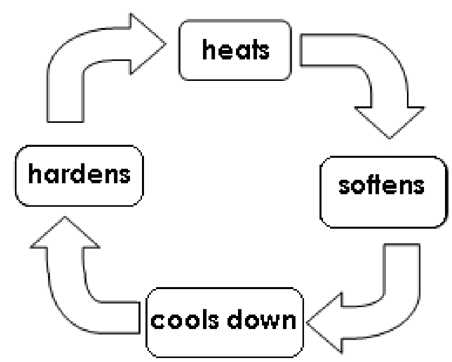
Composite materials:

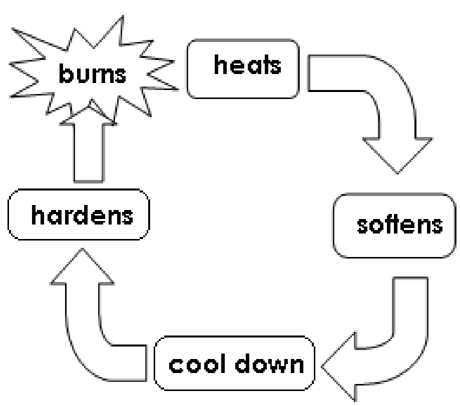
fibreglass, tyres, mud bricks, concrete

Plastics

There are two main types of plastics and these are named Thermoplastics and Thermosetting Plastics.

Thermosetting Plastics are made up of lines of molecules which are heavily cross linked. It creates a rigid molecular structure. They may be heated the first time and shaped but they become permanently stiff and solid. They cannot be reshaped again.





Thermoplastics are made up of lines of molecules with few cross linkages. This allows them to soften when heated and to be bent into a variety of shapes and forms. They become stiff and solid again when cold. This process can be repeated many times. Examples of Thermoplastics are: PET, PE-HD, PVC, PE-LD, PP, PS-HD. This type of plastic is usually used for packaging. The fact that it can be reheated and reshaped is ideal for packaging and recycling.

Have you ever wondered about those little numbers inside a triangle of arrows on the bottom of plastic containers? They tell you the kind of plastic is used to manufacture the soft drink bottles, laundry detergent packages, milk jugs, and other plastic bottles that you purchase. The numbers and letters are intended as resin identification codes to facilitate the recycling process. Plastic containers with the codes 1 and 2 are the easiest to recycle.

Plastic identification codes

Plastic Identification Code	Type of plastic polymer	Properties	Common Packaging Applications
01 PET	Polyethylene Terephthalate (PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars
02 PE-HD	High Density Polyethylene (HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas	Milk, juice and water bottles; trash and retail bags.
03 PVC	Polyvinyl Chloride (V)	Versatility, clarity, ease of blending, strength, toughness	Juice bottles; cling films; PVC piping
04 PE-LD	Low Density Polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids.
05 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups and plates.
06 PS	Polystyrene (PS)	Versatility, clarity, easily formed	Egg cartons; packing peanuts; "Styrofoam"; disposable cups, plates, trays and cutlery; disposable take-away containers;
07 O	Other (often polycarbonate or ABS)	Dependent on polymers or combination or polymers	Beverage bottles; baby milk bottles; electronic casing.

Preserving foods

From the moment a ripe fruit or vegetable is pickled, or an animal is slaughtered for the meat, the food begins to spoil. So we must either use foods that are as fresh as possible, or we msut use some form of food technology to keep it as fresh as we can, for as long as possible.

Why does food degrade?

Bacteria, yeasts, moulds and fungi are tiney living 'micro-organisms' that can spoil food very quickly. Chemical changes caused by enzymes (organic catalysts) soon affect the taste, texture and look of foods. Oxygen from the air may react with chemicals in the food leading to changes of colour, smell and flavour. Animals like insects and rodents cause huge losses in stored foods.

Food poisoning is most often caused by bacteria like salmonella, botulinum, and Staphylococcus. Food poisoning may occur from one hour or even up to three days after eating contaminated food. Symptoms include diarrhoea, nausea and vomiting, pains in the abdomen and fever.

The deterioration can be slowed if we create conditions that the causes of degradation do not like. Fungi and bacteria do like warm, moist conditions which make them grow. Heat also speeds up chemical processes. To fight them we just need to provide the cold and dry conditions that they do not like. In this way we are able to extend the shelf life of many foods.
If we cut off the oxygen supply by vacuum packaging or by storing in a sealed container we reduce the bad effects of oxidation. Using insect-proof containers stops the destruction of stored foods by animals.

Food processing

Many of the foods you eat have been processed before you buy and eat them. Food processing includes the treatment of food in a factory before it is sold. It also includes processes such as cooking, freezing or drying which may be performed at home. Some foods are more highly processed than others. Fast foods are usually highly processed. Highly processed foods are not always a healthy choice.

Food is processed in order to:

- make it safe to eat • improve the quality for eating
- make it easier to eat • make it easier to digest
- make it last longer or to preserve it • make it easier to transport
- provide it cheaper, especially if it is processed when it is in season.

Disadvantages of food processing are:

- the loss of some nutrients, especially water-soluble vitamins
- higher prices.

Methods of processing food include:

- drying

- using spices
- pasteurising
- cooking (including baking, boiling, frying, grilling, poaching, roasting, stewing, microwaving).
- freezing
- bottling or canning

Table showing nutritional changes that occur during processing:

Nutrient	Changes
Protein	Heating causes changes in the chemical structure of proteins. This does not usually affect nutritional value.
Carbohydrate	Cooked starch becomes more digestible when heated in water.
Fat	Changes occur when fat is used repeatedly, especially at high temperatures. This can make the fat dangerous to eat.
Vitamin A	Stable during mild heat treatment but destroyed at high temperatures.
Vitamin B group - thiamine - B6 foliate	All B group vitamins are heat sensitive. 50% of thiamine in rice can be lost in the cooking process. 50% of B6 foliate is lost in the canning process.
Vitamin C	Lost in cooking. Warm water, heat and exposure to air can destroy Vitamin C
Vitamin E	Slowly destroyed by heat during frying.
Minerals	Some dissolve in cooking water.

Food additives

In the past people preserved food by adding vinegar, sugar or salt. Today there are many other additives used to preserve food. Additives are also used to make food look and taste different. Additives are not foods on their own. Additives are substances that are added to food during processing to improve or preserve the food.

Manufacturers are allowed to add certain substances, natural or synthetic, to food for specific purposes:

- Additives are used to improve nutritional value. Nutrients, particularly those which may have been lost during processing, are added to improve nutritional value.
- Additives are used to improve the quality of food. Examples include colourants, preservatives, antioxidants, emulsifiers, stabilisers and anti-caking agents.

By law, manufacturers have to list additives on the food label. Additives are coded as follows:

- 100 - colourants
- 200-282 - preservatives and acids

- 300-341 - emulsifiers, stabilisers, thickeners and anti-caking agents.

Commonly used additives	Purpose
Colourant	To improve appearance
Flavouring	To add or increase taste
Preservatives	To make food last longer
Antioxidants	To prevent colour, taste and nutritional value spoiling
Emulsifiers and stabilisers	To prevent ingredients from separating
Anti-caking agents	To prevent ingredients from clumping together

Recycling

Let's look at the drive to become a recycling nation. A few years ago, South Africa's Minister of Environmental Affairs created laws to reduce the use of plastic bags. He did not outlaw them but wanted people to use them more responsible and to be aware of the negative impacts that waste has on the enviroment.

Recycling waste

The ability to recycle, reuse and re-manufacture shows our mettle as innovators - every one of us can be an innovator. An innovator finds exciting and creative ways to do existing jobs, using existing products and materials. Most products can be reused or recycled. And recycled materials can be re-manufactured.

The main rule with recycling and re-manufacture is BE CAREFUL of sharp edges, dirt and contaminants. Use latex gloves or cover your hands with a plastic bag when handling recyclable materials like organic materials. Treat any cuts or bruises immediately. Be very careful when working with rusted containers (use gloves when handling them.)

Paper and cardboard

Recycle

Paper and cardboard are made from wood fibres that have been soaked and formed into sheets. To recycle, re-soak paper and cardboard to make a pulp of the fibres, so that the material can be reformed to be used in sheet or any other form.
An easy way to do this is to break (tear) the material into sma pieces, soak it in water, and when it is all broken up, use the put again. Newspapers, old schoolbook pages, egg cartons, and so on are easiest to make into pulp.

Re-manufacturing

Pulp that is obtained from the recycling process is a material that can be used in a number of different ways.
For example, it could be formed into sheets to make organic-looking

paper that can be used for different applications such as notepads, greeting cards, lampshade coverings, etc.
The pulp can also be formed into 3D artefacts that are useful. You can cast it into thick stabs that can be used instead of wood. You can use it to make bricks and blocks. You can use it to make models, etc. When using it for 3D objects you may want to consider special glues and additives . depending on what properties and characteristics you are looking for. For example, if you add small chips of wood to the pulp, together with a little paraffin wax, you can make a block that will burn easily.

Reuse

- The top of milk cartons can be cut off and they can be used as containers for other liquids as well as for holding things.
- Egg cartons can be used to hold little trinkets like jewellery, fishing bits and pieces, needles, buttons, small change, etc.
- Newspaper can be cut into strips or small squares and laminated to form shapes. Newspapers can also be used as insulation in an emergency blanket as well as for wallpaper decorations, etc.

Plastic

Recyle

Plastic is a fairly durable material that has the wonderful property of being waterproof. Many plastic products are easy to reuse, and if you need to recyle plastic you need to break it down and then reconstitute it. To recycle plastic, all you need to do is cut or grind the plastic into a small pieces as possible they can then be re-melted or the bits can be bound together with a suitable glue like epoxy.

Re-manufacture and Reuse

Plastic bottles, especially those with handles, make useful carry containers. Cut away certain parts then you have a ready-made transporting container.
Cold drink bottles are useful for making artefacts like weather vanes and small terrariums, and the bottom can be cut off and used as a container for a range of things. A useful tip, especially if you want to cut into plastic bottle is to fill the bottle with sand first. The sand gives a firm grounding for the blade.

An empty cold drink bode an be used as a sprinkler in the garden: drill holes in the bottom and attach a garden hose to the top opening. Hang it from a pole or tree and watch the sprinkler water the garden.

You can make the sprinkier exciting by putting a few lightweight plastic charms in the bottle; watch how they move when the water is turned on.
You may have seen people getting caught in the rain without an umbrella or raincoat. Some people /use plastic bags to protect themselves. New or unused plastic bin bags can be into raincoats. Cut a hole for the head and arms. Use the pieces you have cut off to make a tie-around plastic belt and you have an emergency raincoat.

Milk is sometimes sold in plastic bags. People generally snip off one corner of the milk bag. You can use the empty bags to make enormous ice blocks. Fill the packet with water, seal the opening then put it in the freezer.

Metal

Recycle

When metal is recycled, it is crushed and then melted down. The molten metal is formed into sheet sections.

Re-manufacture

Metal can be re-manufactured like plastic, except it is much more difficult to cut. You could use a can opener or tin snips to cut it. Note that you will get sharp edges and these must be flattened and filed so that it is safe to handle. Another useful tip is to fold over the edge to make it safe.

Reuse

When reusing metal containers you need to be cautious of the sharp edges. Flatten the sharp and jagged edges using a hammer. If the container is too small for the hammer, use an extension piece. Once this is done you can use the container safety.

Wood

Recycle

Collect rough sawdust and woodchips, pack it tightly in a mold and bind with woodglue to make reconstituted board.

Reuse

Woodchips, which can be a by-product of cutting, planning, sawing, chiselling, etc. can be used in a garden or pot plant. Use wood chips as mulch to retain moisture in your garden soil. Thin pieces of wood (even broken dowel sticks) can be used to hold up flimsy plants such as creepers. Discarded bigger pieces can be used as potholders, spoon rack chopping boards, etc.

Re-manufacture

One easy way is to use leftover strips of veneer edging. Use wood glue and paste laminate strips on top of one another. You can use a former so that when the glue sets the finished product is in the form and shape that you intended. Much art deco furniture is made in and some bentwood furniture is actually laminated.

Organic material

Recycle

You can use the peels and waste from vegetable and fruit matter to

good compost for thee garden. One easy way is to put it into a container and mix some soil with it. Let it rest for a few weeks then use it in the garden when planting. You could also put it directly into the soil and mix it well.
A second useful tip is to use the skins of organic matter like onions, beetroot, and so on to make dyes. All you have to do is boil the skin and collect the coloured liquid to use as a dye. Experiment with the dyes as ink for drawing and writing.
Recycle old meat bones by removing all remaining meat and fat, thenn
wash them and leave in the sun to dry. Thereafter they can be crushed and used as bone meal, which is excellent organic food for plants. Reuse and re-manufacture milk that has gone bad. Soured milk can be used for baking. Be careful not to let it go rancid, as this is unhealthy to consume.

Water

Recycle and reuse

Recycling and reusing water sounds unhygienic but it can be done safely. Did you know that some of the water from taps is recycled? Find out about this
To recycle water, collect water from the bath and shower and use it to water your plants. Calculate how much water you will be saving by measuring the amount of water you collect this way. Find out how much water costs, then work out how much money is saved. You will be surprised!

Packaging

What is packaging and why do we need it? When you buy food, it
is often packaged in some sort of container. This package can be as simple as a sheet of newspaper wrapped around a fresh green mealie. Packaging can also consist of several layers of cardboard, paper, moulded polystyrene and plastic.

Reasons for packaging food are:

- to protect the food, particularly during transport
- to make food easier to handle during transport
- to make food easier to store
- to prolong the lifespan of food
- to maintain the quality of food.

Although manufacturers are using less and less packaging per pack, the amount of packaging found in landfill sites is increasing. This is because processed foods have more packaging than unprocessed foods and are becoming increasingly popular. The increased use of food packaging has many negative effects on the environment:

- increases the amount of raw materials used in manufacturing
- fills up landfill sites
- litters the environment
- uses water and energy, which are both scarce resources.

Environmental packaging

Packaging causes many problems in the environment. For this reason, environmental packaging is recommended. Environmental packaging includes the following ideas:

- Reduce the amount of packaging wherever possible. Food is often over-packaged. This is bad for the environment as it increases the amount of raw materials used. It also increases the volume of packaging in landfill sites or littering the environment. Water and energy are valuable, scarce resources, which are used during the process of making packaging.
- Use recyclable packaging. Recycling creates job opportunities, reduces litter and reduces the amount of material in landfill sites. In some cases, though, recycling uses more resources than can be reclaimed. Use recycled packaging wherever possible.
- Use a deposit system. An extra amount is sometimes charged for a food container. This is called a deposit. If you return the container so that it can be reused, then the deposit is refunded. Milk and cold drinks are sometimes sold in bottles which carry a deposit. Research has shown that a deposit system has had little effect on litter reduction in Britain. People have suggested that a deposit system could have a greater impact in developing countries such as South Africa.
- Use biodegradable packaging. In many cases the process of biodegrading is too long and too unpredictable to make a difference to the urban environment.
- Use paper rather than plastic. Paper is biodegradable, while many plastics are not. Generally paper bags are not reused. Wood is the raw material used to make paper and deforestation is a problem in many countries. If you do use plastic bags, then reuse or recycle them.
- In 2003, legislation was passed in South Africa making it compulsory for shopkeepers to charge customers for plastic bags. This was an attempt to reduce litter. Many people called the plastic bag the national flower as it was so common in the landscape. There was some resistance to this legislation from plastic bag manufacturers who were concerned about job losses. Environmentalists agree that this legislation has reduced the amount of litter caused by plastic bags.

The six R's for a healthier environment

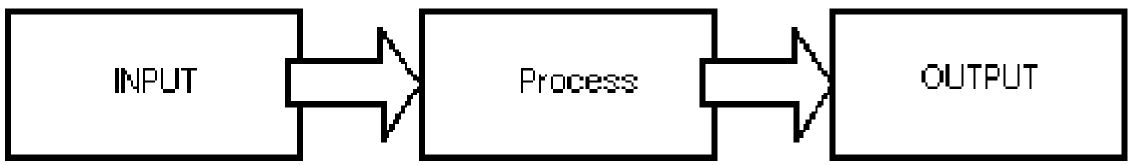
- Reuse
- Repair
- Recycle
- Re-manufacture
- Renew
- Reduce

MECHANISMS

Most manufactured products can be thought of as ***systems***.

*A system is a group of **components** connected so that they work together to perform a task.*

The component parts may be ordered steps in a procedure or organizational structure but we need only concern ourselves with physical components each of which has its own contribution to make to the overall operation of a system.
All systems consist of at least three clearly identifiable sections. The ***input*** stage is where energy or information is fed into the system. The ***process*** stage is where energy or information is processed or converted. The ***output*** stage causes something to happen.

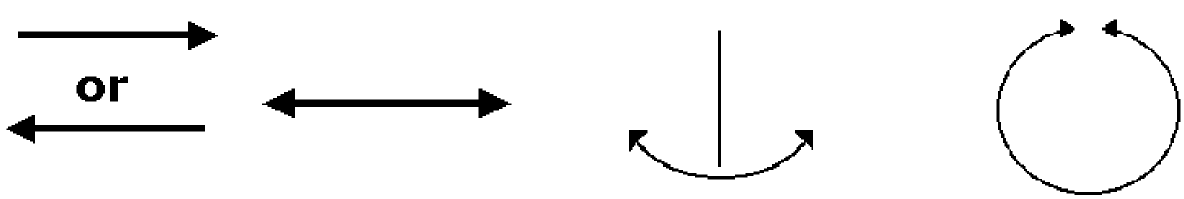


The ***energy source*** of the system will determine which type of component is required at each stage. If the energy source is compressed air the components will need to be pneumatic components and these will combine to produce a pneumatic system. If the energy source is electricity the components will need to be electrical or electronic and these will combine to produce an electronic or electrical system. The energy input into a system can be:

Movement - *(mechanical systems),*
Oil/water under pressure - *(hydraulic systems),*
Air under pressure - *(pneumatic systems),*
Electricity - *(electrical or electronic systems).*

Mechanical Systems

Movements



Linear motion movement in a straight line and in one direction

Reciprocating motion movement backwards and forwards in a straight line

Oscillating motion a swinging back and forth

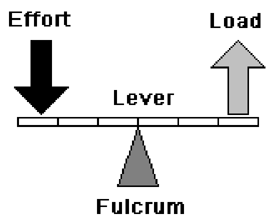
Rotary motion a circular motion.

Levers

A lever helps you do more work with the strength you already have.

A lever is a simple machine. All tools are combinations of the simple machines. Simple machines are things like: a wheel, a screw, an incline, a pulley or a lever. All levers have 3 parts, or 3 things we can find on them. The fulcrum, the load, the effort and of course the lever, itself.

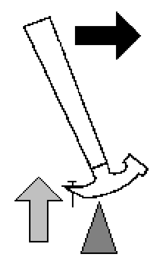
Here's the key to these different kinds of levers:

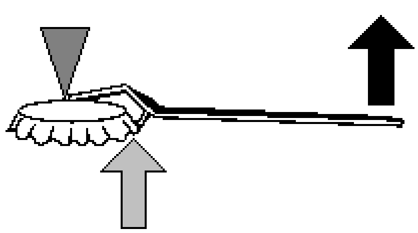


The fulcrum (FULL-krum) is the place a lever rocks back and forth. You could call it a pivot. When it's right in the middle of the lever, the amount of effort you push down equals exactly the amount of load you can lift with the other end.

First Class Lever L △ E

Pound a nail almost all the way into some wood. Use your fingers to pull it out. Now try pulling it out with the hammer. It's a lot easier. The claw on a hammer is a lever. We call this kind of lever a first-class lever. It does not mean it's a better lever - just that it's the first kind of lever.



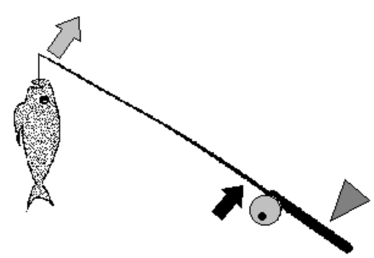


△ L E **Second Class Lever**

Use your first finger and thumb to pop off a metal cap from a soda bottle. Don't twist it off, pry it off. Now try a bottle opener. Much easier, right? A bottle opener is a
second-class lever, which means the fulcrum is at the end of the lever and the load is in the middle.

L E △ **Third Class Lever**

A third-class lever has its fulcrum at one end and the load at the other end, with the work you do in the middle. It's how a fishing pole works. You lift just a short distance at the handle, but the end of the pole pops up several feet - hopefully with dinner on the line.



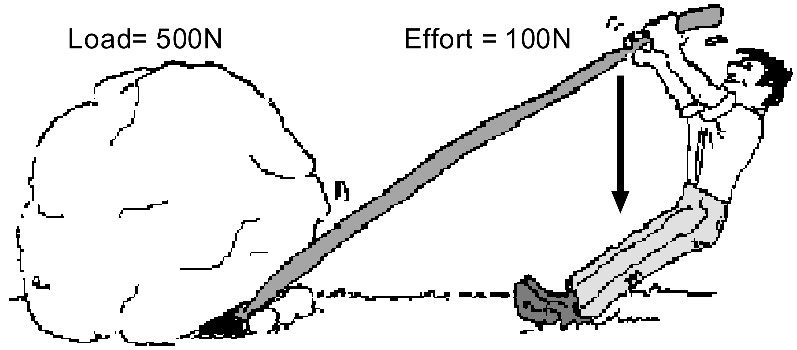
Mechanical Advantage (MA)

The unit in which force is measured is Newton (N). A force of 10 N is necessary to lift a mass of 1 kg. (100 g = 1 Newton)

$$MA = \frac{Load}{Effort}$$

$$MA = \frac{500\ N}{100\ N}$$

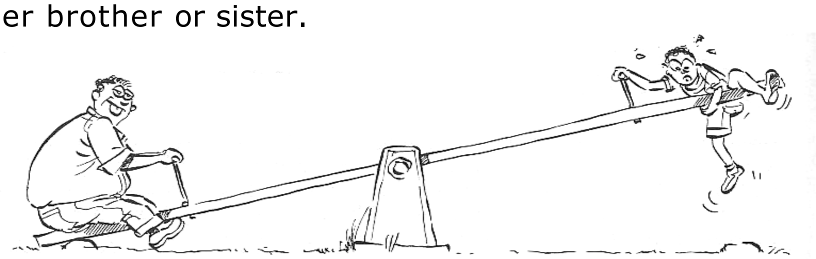
$$= 5$$



The greater the mechanical advantage, the more help the lever gives you.

Moments

To understand moments think about kids playing on a see-saw. It is no fun playing on a see-saw with a yourger brother or sister.



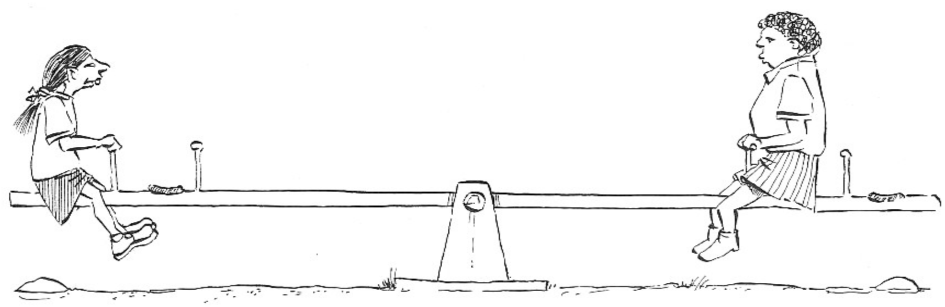
To use a see-saw correctly the heavier person should sit closer to the fulcrum. We can determine exactly where each child should sit by using the priciple of moments.

The **turning effect** which each child has on the see-saw is called the moment and depends on 2 factors:
1. The **force** which is determined by the child's weight, and
2. The length of the beam (the distance from the fulcrum to each of the children).

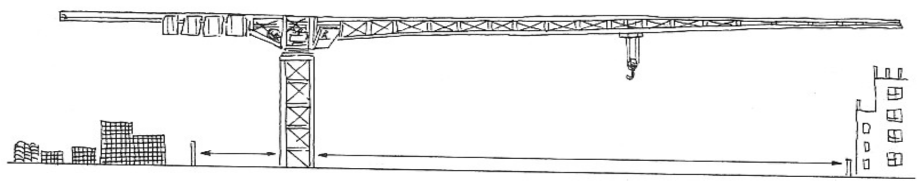
The force multplied by the distance is the **moment** of the force.
Moment = force x distance

In the drawing below, the 600N force is trying to turn the beam clockwise.
The moment around the fulcrum is:
600 N x 1 m = 600 Nm (clockwise moment)
The 300 N force also tries to turn the beam anti-clockwise.

The moment around the fulcurm is:
300 N x 2 m - 600 Nm (anti-clockwise moments)
It is only when the clockwise moment is equal to the anti-clockwise moment that the beam will be in balance.



Calculate moments

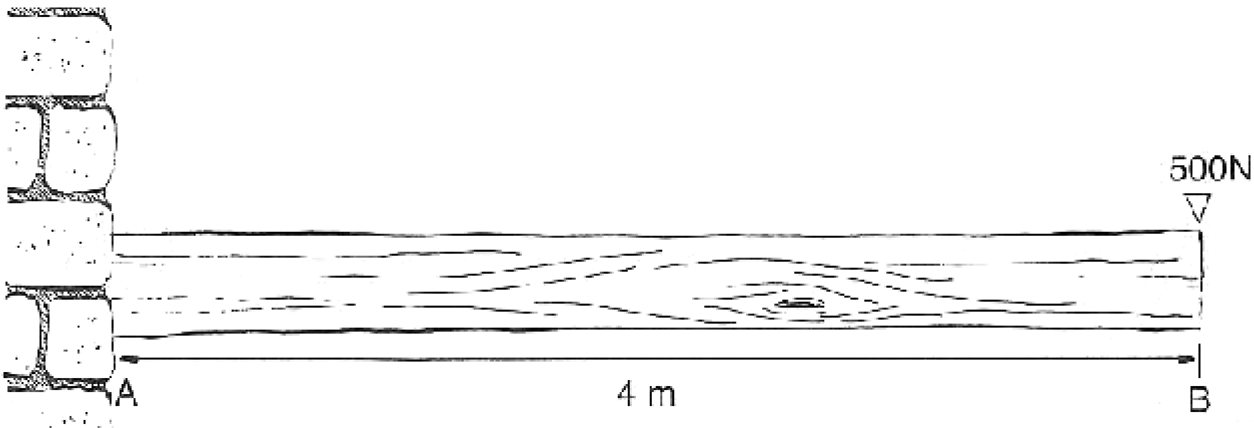


In this activity you have to design a crane which will transport building materials. The maximum load of the crane may not exceed 5000 N. You will have to determine the weight of the counterweight if the crane is used to lift the maximum weight.

If the load is moved along the crane beam the crane will become unstable and fall over. Why will this happen?
Design your crane to also be stable under these circumstances.

Cantilevers
A beam that is only supported on one side is called a cantilever.

When a force is excerted on a cantilever there will be tension between **A** and **B**
The end closest to where the beam is attached (A), will probably be where the beam will break. Therefore we could say that the largest bending moment will be at A.
Bending moment is the product of the force multiplied by the distance between the force and the place of bending.

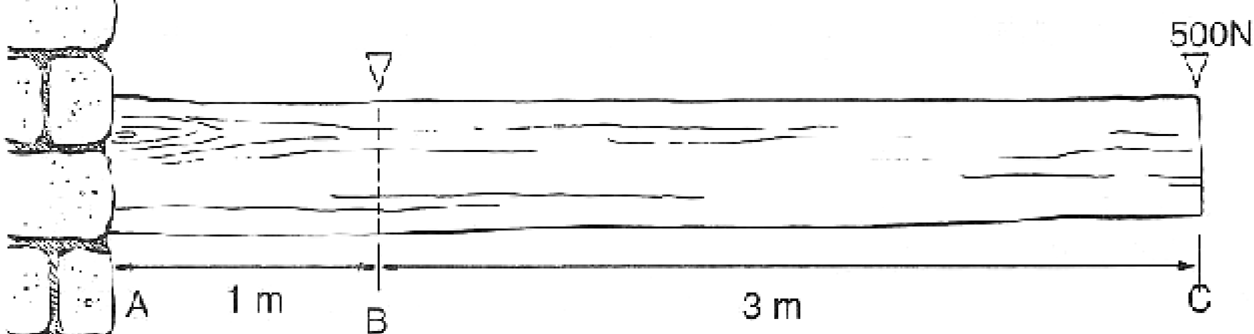


Bending moment = force x distance

$$= 500 \times 4$$

$$= 2000 \text{ NM}$$

Calculate the bending moments for A and B in the next diagram.



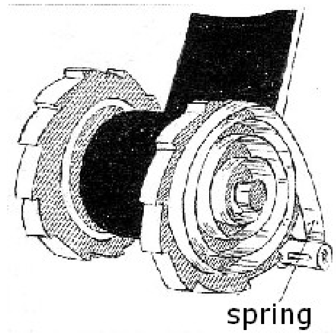
The place where the bending moment is the largest is where most support is necessary to avoid the breaking of the beam.

Control mechanisms

Ratchet and pawl

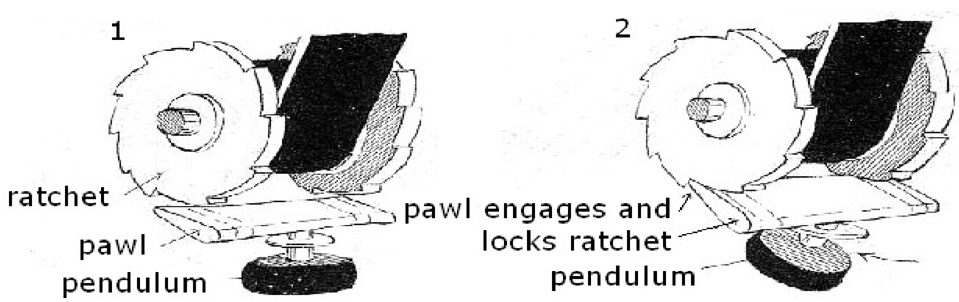
Like the cleat, the ratchet and pawl mechanism is an important control device and adds additional safety to lifting systems. It allows movement in one direction only, as it locks one mechanism from going in the other direction.

Seatbelt safety



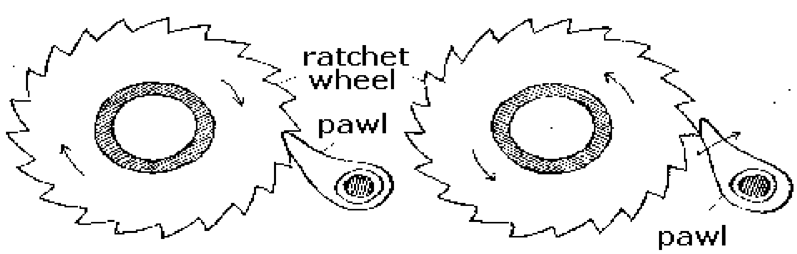
Many deaths or serious injuries in car accidents could be *belts. A basic function of a seatbelt is that it prevents you* hitting the dashboard if the car is in an accident. How is it possible for a piece of material to be a lifesaver.

Let's examine the mechanisms in seatbelts more closely. A simple seatbelt mechanism consists of a very strong belt connected to a retractor mechanism on a spool. The function of the retractor mechanism is to pull in the belt if you release it from your body. The most important safety aspect of the seatbelt is its locking mechanism called a ratchet and pawl. An important part in the seatbelt mechanism is a **weighted pendulum.** When the driver of the car applies brakes suddenly, *the pendulum swings forward. (See illustration 2)* It forces a **pawl** on the end of the pendulum to catch hold of a toothed **ratchet gear** attached to the spool. With the pawl gripping one of its teeth, the gear can't rotate anti-clockwise. It is this action that causes the belt to jerk and prevents your body from being thrown through the windscreen.



Have you ever thought that a simple typed comma could play a safety role in a machine? The design of the ratchet wheel is very important. It has specially shaped teeth which look like a comma. These teeth allow the pawl to grip (or bite) into the wheel. The pawl is a lever pivoted above the ratchet wheel. As the wheel turns, the pawl follows and slides over the teeth. It catches the teeth if the wheel turns in the opposite direction. This stops the wheel from rotating in a different direction.

This mechanism is useful where a type of winch or wind-up mechanism is needed, such as in mechanical clocks. In the drawing below left, it acts as a winch to lift up a heavy object. If the ratchet is turned, the rope will be wound onto the cylinder. The pawl prevents it from unwinding.



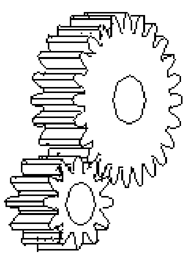
Gears

Gears are wheels with teeth. Gears can be used to slow things down or speed things up, change direction and/or control several things at once. Gears are wheels whose perimeter is made up of evenly sized and spaced teeth. The teeth of one gear mesh with those of an adjoining one and transmit rotary motion between the two gears. The driven gear always rotates in an opposite direction to the driving gear. If both gears have the same number of teeth, they will rotate at the same speed, however if they have different numbers of teeth then the gear with fewer teeth will rotate more quickly. A gear system is a combination of two or more gears working together. Two gears connected together turn in opposite directions; the gear upon which the effort force is being applied is the DRIVER gear and the other gear is the FOLLOWER (driven gear). By placing a gear (IDLER) between the driver and the follower gear, you can make the driver and follower gear turn in the same direction. The smaller driver gear connected to a larger follower gear, results in slower speed, but greater force in the follower gear (gearing down). A larger driver gear, connected to a smaller follower gear results in faster speed, but less force in the follower gear (gearing up).

There are different types of gears: spur gear, bevel gear, worm gear, rack and pinion.

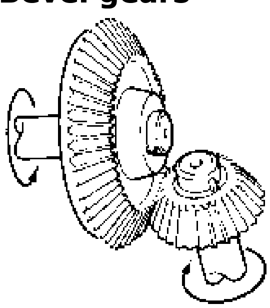
Types of gears

Spur gears

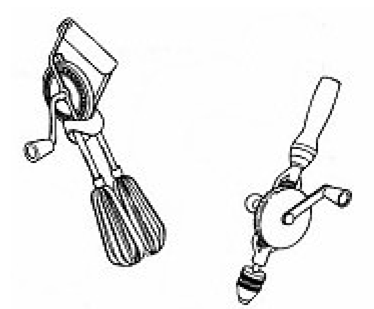


Multiple gears can be connected together to form a gear train. If there are an odd number of gears, the output rotation will be the same direction as the input. If there are an even number, the output will rotate in the opposite direction to the input. Note that for the simple type of gear train shown, the number of teeth on the intermediate gears does not affect the overall velocity ratio which is governed purely by the number of teeth on the first and last cog.

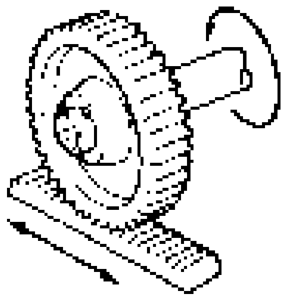
Bevel gears



Bevel gears are used to change rotational movement through an angle of 90°. Bevel gears will provide some mechanical advantage or increase in velocity ratio.

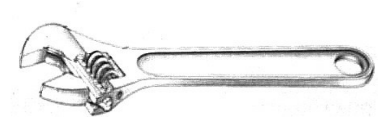


Rack-and-spur gears



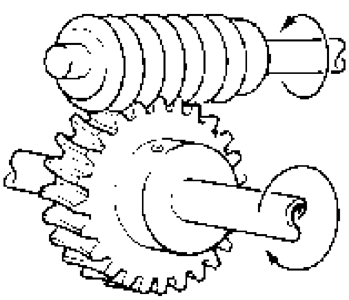
The rack-and-spur gear is used to convert between rotary and linear motion. Often the spur rotates in a fixed position and the rack is free to move - this arrangement is used in the steering mechanism of most cars. Alternatively, the rack may be fixed and the spur rotates moving up and down the rack. This latter arrangement on two-handled cork-pullers.

Rack-and-worm gears

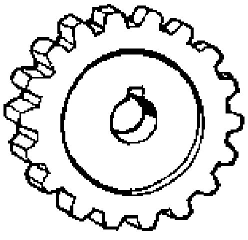


The rack-and-worm gear changes rotational movement into linear movement. In a shifting spanner, the rack-and-worm system is used to adjust the position of the jaw of the spanner—to make the gap wider or narrower. The worm is turned to adjust the position of the spanner. So for each revolution of the worm, the rack advances the distance between two consecutive teeth on the rack.

Worm-and-spur gears

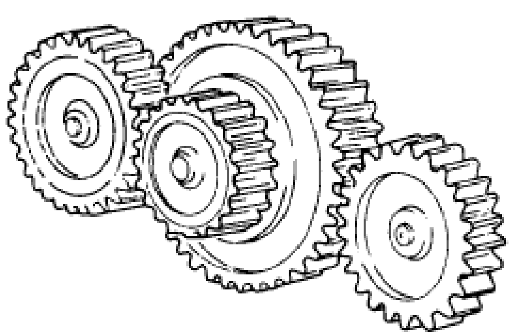


A worm-and-spur gear is often used when a large speed reduction is required and not much power is needed. Unlike ordinary gears, the motion is not reversible, a worm can drive a gear to reduce speed but a gear cannot drive a worm to increase it. The velocity ratio of two adjacent cogs can be calculated by dividing the number of teeth on the driven gear by the number of teeth on the driving gear. The velocity ratio of a worm-and-spur gears is easily calculated because the worm has only one tooth. The worm gear is always the drive gear. For example, if the wheel gear has 60 teeth and the worm gear has 1 tooth, then the velocity ratio is 1/60 = 1:60



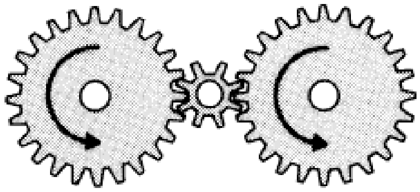
The **spur gear** is the simplest kind of gear. It is a wheel with teeth around its circumference.

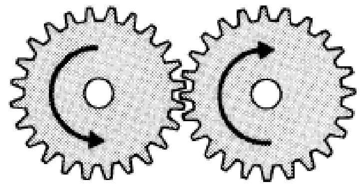
Multiple gears can be connected together to form a gear train.



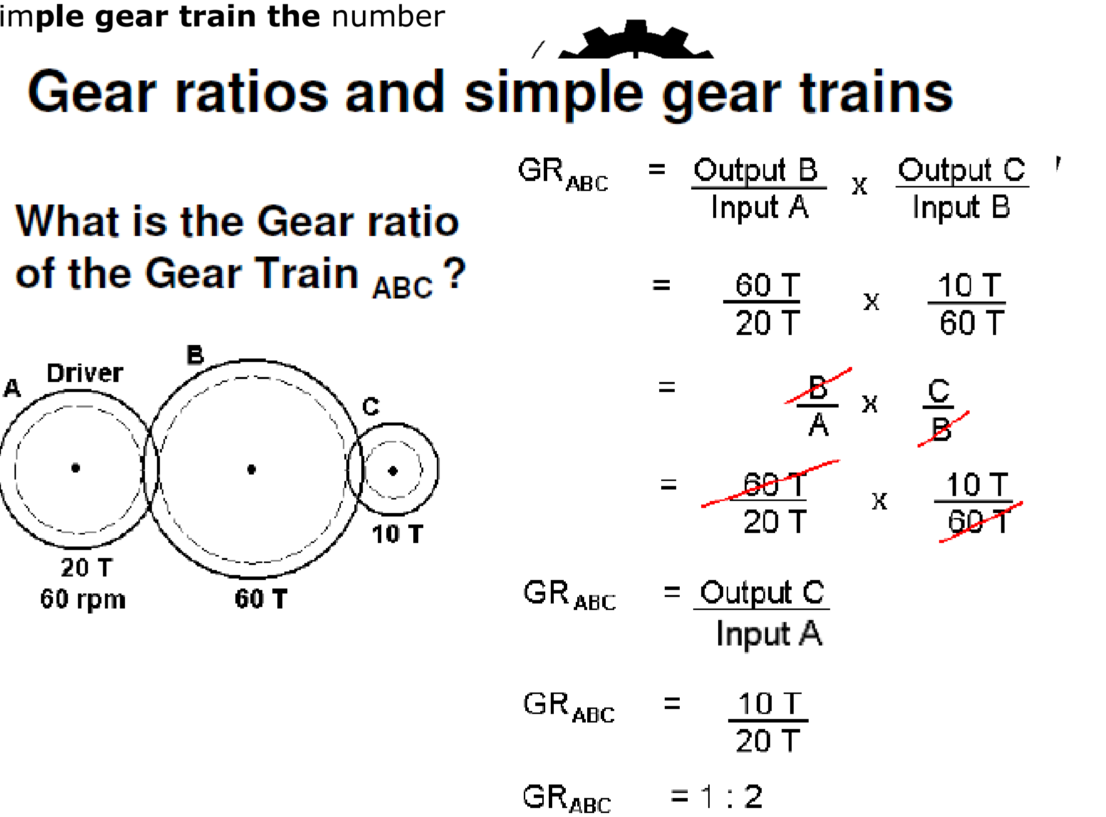
If there are an odd number of gears, the output rotation will be the same direction as the input.

If there is an even number, the output will rotate in the opposite direction to the input.



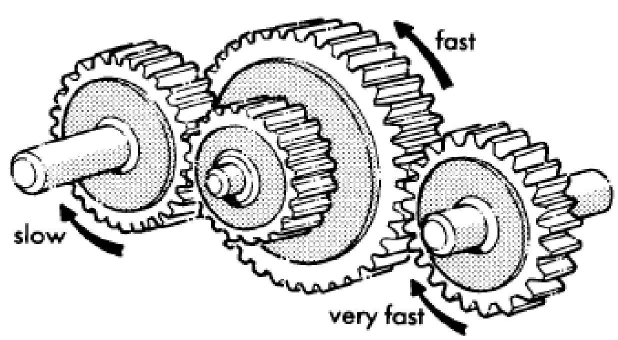


In a simple gear train the number



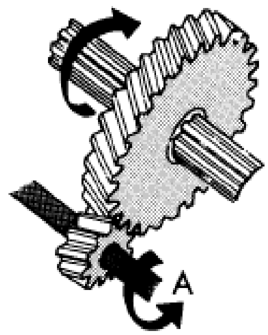
of teeth on the idler gears will have no effect on the overall gear ratio or velocity ratio. It is only determined by the teeth on the first and last gear.

In compound gear trains (when there are more than one gear on an axle) the gear ratio and velocity ratio can be affected by die idler gears.



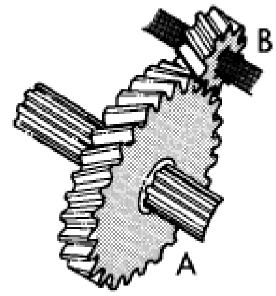
Gearing down

Small driver (A) Large follower (B)
Result: decrease in speed or gearing down.
Gear B turns more slowly than gear A and has greater torque (pulling ability).



Gearing up

Large driver (A) Small follower (B)
Result: increase in speed or gearing up.
Gear B turns much faster than gear A but has less torque (pulling ability).



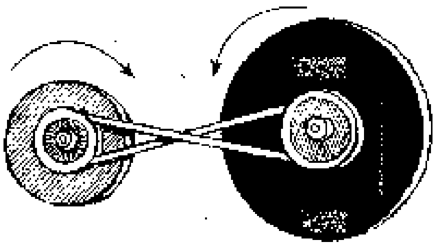
Formula:

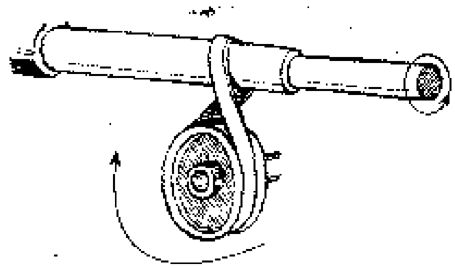
$$\text{Mechanical Advantage} = \frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}} \quad \textbf{OR} \quad \frac{\text{diameter of driven gear}}{\text{diameter of driver gear}}$$

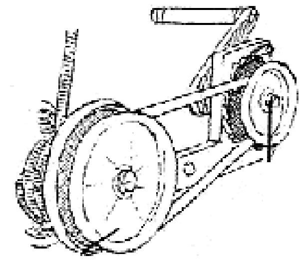
Belt drives

Pulley systems that are joined together by means of belts are known as belt drives. Many machines use belt drives, for example sewing machines and motor vehicles. As the driver pulley rotates, the belt moves causing the driven pulley to rotate. Belt drives are an example of how pulleys transfer rotary motion. The diagram shows how a belt drive can be used in a winch.

Using belt drives to change direction of rotation
Pulley systems can also change the direction of rotation of motion. You can change the direction of rotation by twisting the rope or belt.
Pulleys and gears perform similar functions. A manufacturer will choose either a pulley system or a gear system for a machine depending on the purpose of the machine. Pulley systems are quieter and simpler to manufacture, but do not handle well when a large torque is needed. Pulleys can also work over a larger distance whereas gears need to be close to one another. Gears can handle large torque loads but are more complicated to manufacture.

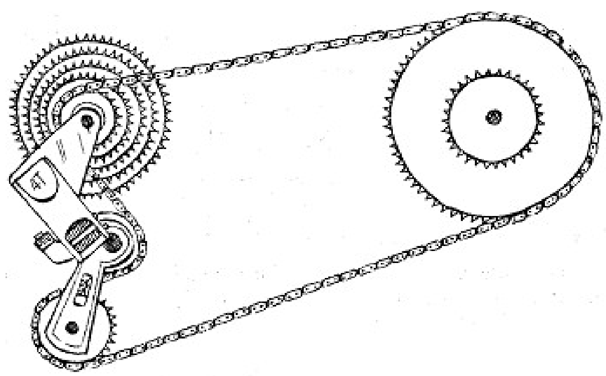


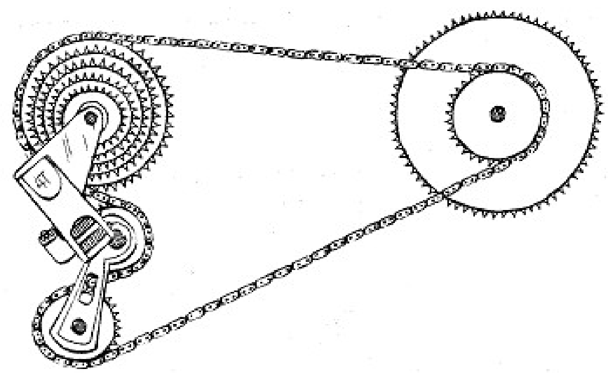




Chain-and-sprocket pulley system

One of the problems with belt drives is that when the load increases too much, the belt begins to slip. One way of overcoming this problem is to use a chain-and-sprocket pulley system. In a chain-and-sprocket pulley system, the driver pulley and driven pulley are toothed wheels, like gears. A chain then fits into these teeth on the pulleys. When the driver pulley rotates, the chain moves and causes the driven pulley to rotate. A chainand-sprocket pulley system ensures that the belt does not slip.

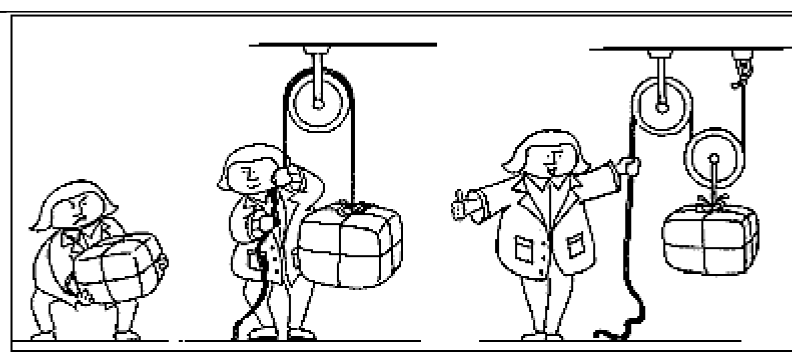




A chain-and-sprocket pulley system is used in bicycles. Cyclists need to be able to transfer the rotation of the pedals into high torque rotation in the bicycle wheel. As the cyclist pedals the smaller driver pulley rotates. The wheel is then attached to a larger driven pulley. Because the driven pulley is larger than the driver pulley, the driven pulley has more torque or turning strength. This ensures that the cyclist can pedal up hills more easily.

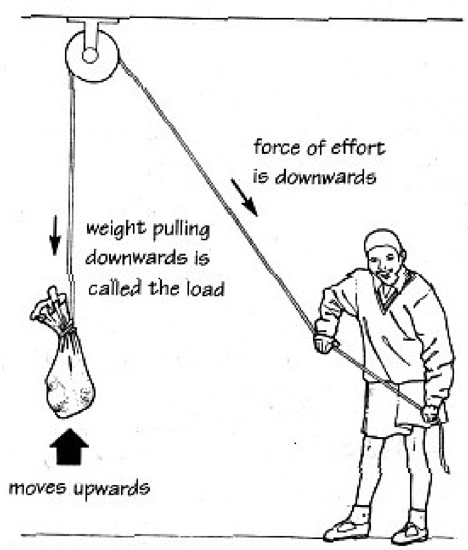
The Pulley

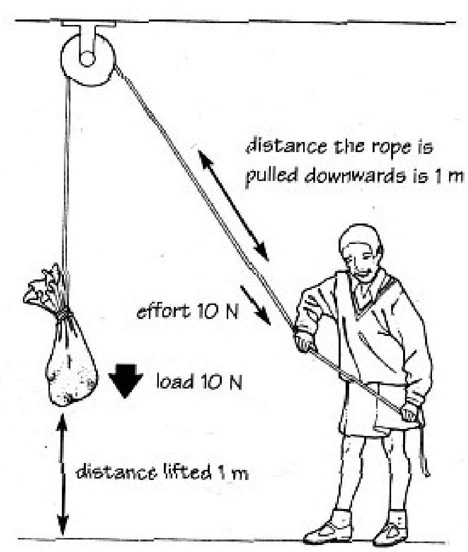
The pulley is a simple machine that consists of a grooved wheel and a rope. Like a lever, it provides a mechanical advantage in lifting a heavy load. There is a direct relationship between the number of ropes that form the pulley and its resulting advantage.



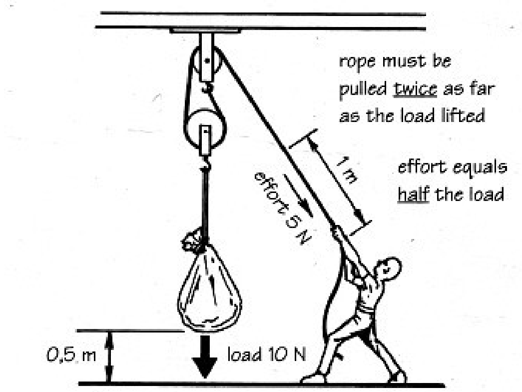
There are two basic types of pulleys. When the grooved wheel is attached to a surface it forms a **fixed pulley**. The main benefit of a fixed pulley is that it changes the direction of the required force. For example, to lift an object from the ground, the effort would be applied downward instead of pulling up on the object. However, a fixed pulley provides no concrete mechanical advantage. The same amount of force is still required, but just may be applied in another direction.	
	Another type of pulley, called a **movable pulley**, consists of a rope attached to some surface. The wheel directly supports the load, and the effort comes from the same direction as the rope attachment. A movable pulley reduces the effort required to lift a load. Moveable pulleys do provide a mechanical advantage. The effort needed to raise a load is reduced according to the number of ropes supporting the load.

Using a simple pulley, the effort needed to lift an object is about the same as the weight of the object. If the pulley rotated freely with no friction, then the effort would be equal to the load lifted. The object moves the same distance as the rope moves down. A simple pulley changes the direction of a force. The object is lifted up as the girl pulls the rope down.





These two types of pulleys can be combined to form double pulleys, which have at least two wheels. There are various combinations which can result in a double pulley, some of which will be explored in the student experiment. As the pulley becomes more complex, the total lifting effort decreases.
For example, a system consisting of a fixed pulley and a movable pulley would reduce the workload by a factor of two, because the two pulleys combine to lift the load. A **compound pulley** or **block and tackle** is a system of ropes and pulleys used for lifting heavy loads.



When you use a compound pulley, the effort needed to lift the load is the weight of the object divided by the number of falls. The rope has to be pulled the distance which the object is lifted multiplied by the number of falls.

One Newton (N) is the force exerted by gravity on a mass of 0,1 kg

100 g = 1 Newton

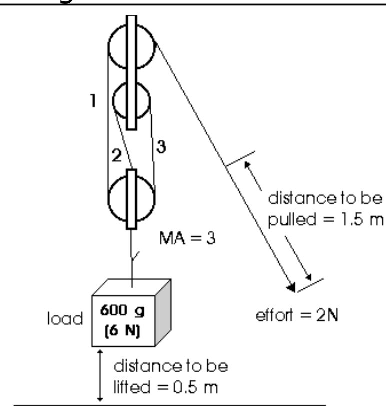
Mechanical advantage

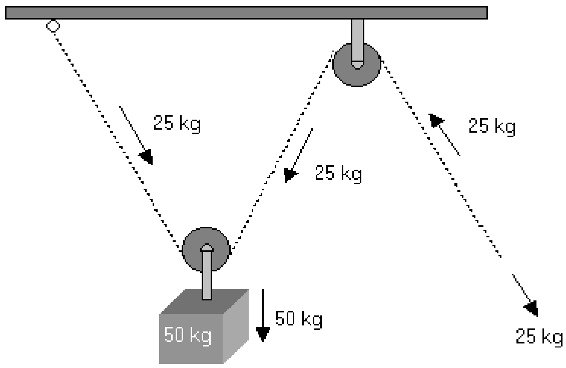
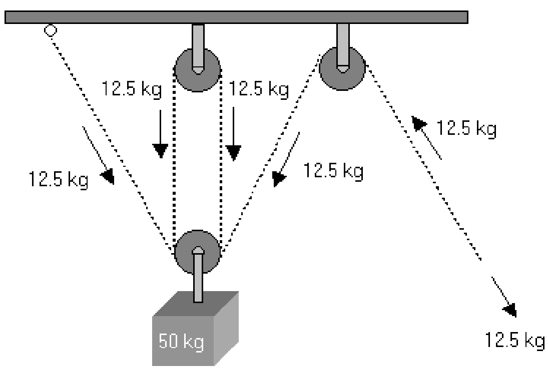
The following are formulas you may need when working with mechanical advantage:

MA = Number of falls supporting the load

$$\textbf{Effort} = \frac{\text{Load}}{\text{Number of falls (MA)}}$$

Load = Effort x Number of Falls (MA)



<table>
<tr>
<td>The following figure shows the arrangement after adding a second pulley:

</td>
<td>This arrangement actually does change things in an important way. You can see that the weight is now suspended by two ropes rather than one. That means the weight is split equally between the two ropes, so each one holds only half the weight, or 25 kg. That means that if you want to hold the weight suspended in the air, you only have to apply 25 kg of force (the ceiling exerts the other 25 kg of force on the other end of the rope). If you want to lift the weight 40 m higher, then you have to reel in twice as much rope - 80 m of rope must be pulled in. This demonstrates a force-distance tradeoff. The force has been cut in half but the distance the rope must be pulled has doubled.</td>
</tr>
<tr>
<td>The following diagram adds a third and fourth pulley to the arrangement:

</td>
<td>In this diagram, the pulley attached to the weight actually consists of two separate pulleys on the same shaft, as shown on the right. This arrangement cuts the force in half and doubles the distance again. To hold the weight in the air you must apply only 12.5 kg of force, but to lift the weight 40 m higher in the air you must now reel in 160 m of rope. A block and tackle can contain as many pulleys as you like, although at some point the amount of friction in the pulley shafts begins to become a significant source of resistance.</td>
</tr>
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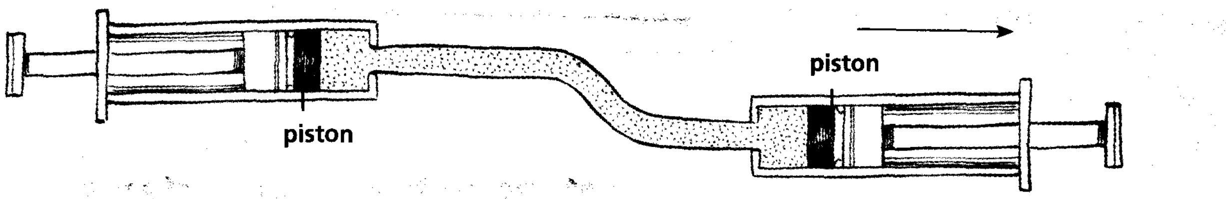
Hydraulic systems

Machines are often required to produce powerful forces to do jobs such as lifting cars, digging big holes and compressing large objects. The machines that can do these jobs rarely use gears, pulleys or levers. These machines use hydraulics to do the work. Hydraulic machines use oil or water in strong cylinders to create powerful forces. The use of hydraulic machines is an efficient way of gaining mechanical advantage.

First rule of hydraulics
The first diagram shows a hydraulic system consisting of a closed container filled with a hydraulic fluid such as oil. On each side of the closed container is a piston. When you exert a downwards force on the piston on one side of the container, the force pushes the fluid along the container causing the second piston to move upwards. The piston that is pushed down is called the input piston. The piston that moves up is called the output piston. All hydraulic systems work on this principle. This **is** called the first rule of hydraulics.

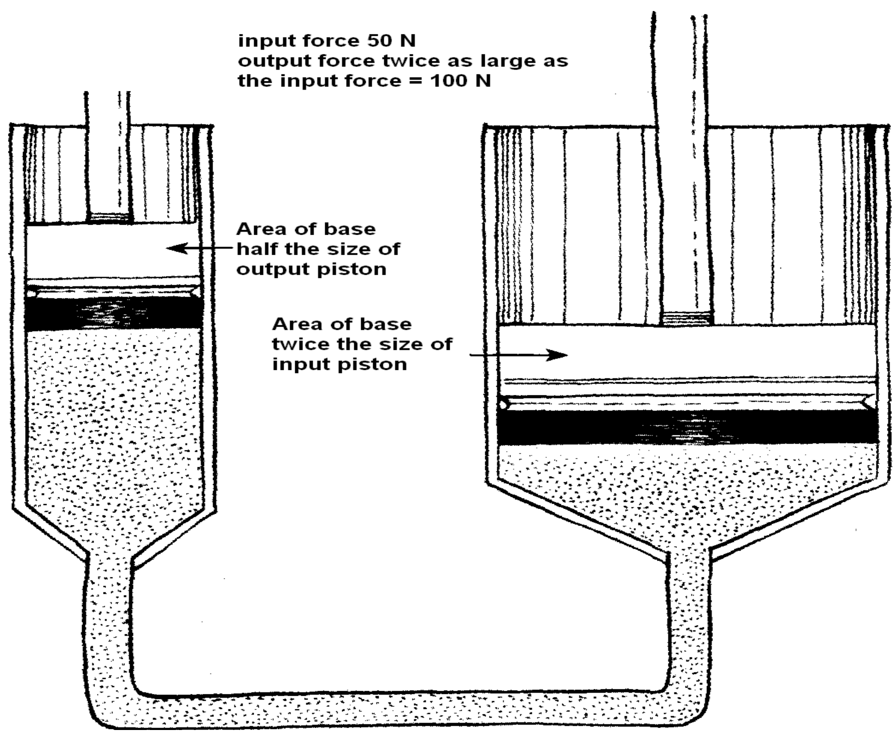
The second diagram illustrates a simple hydraulic system that you can build yourself. You need two syringes, rubber tubing and water. Set up the apparatus as shown in the diagram. As you push the piston of the one syringe down, the piston of the second syringe will move out.



A simple hydraulic system

Second rule of hydraulics

In the diagrams on page 137 the area of the bases of the pistons is the same. If you push on the input piston with a force of 50 N, then the output piston moves up with a force of 50 N.
If you change the area of the bases of the pistons, you can create a mechanical advantage. This is the second rule of hydraulics. If the area of the base of the output piston is twice as large as the area of the base of the input piston, then the output force will be twice as large as the input force. In other words, if the input force is 50 N, then the output force will be 100 N. Note that when the area of the base of the output piston is larger, the size of the cylinder that holds this piston must also be larger.

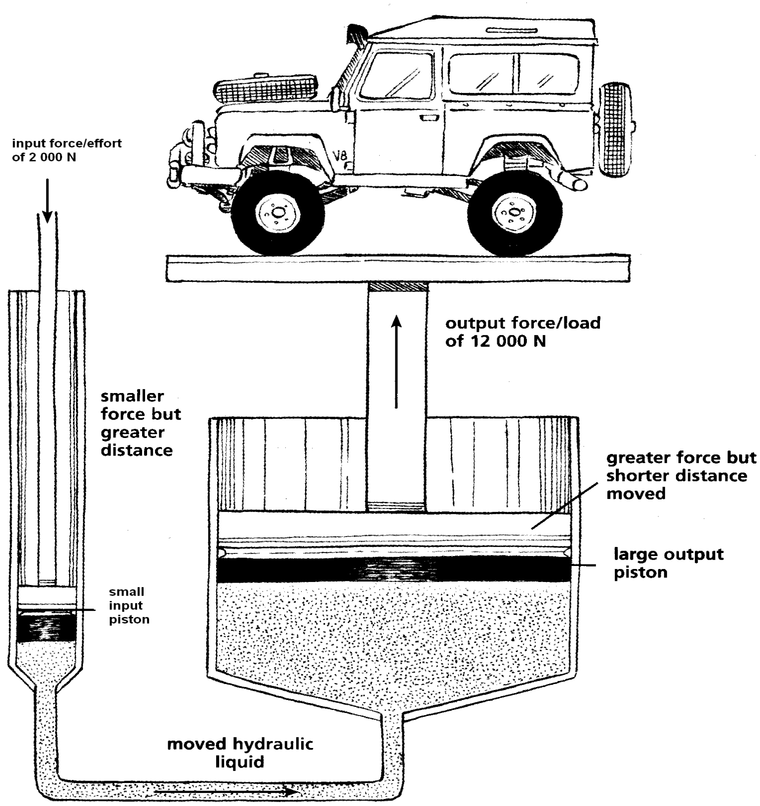


Mechanical advantage in hydraulic systems

Remember that mechanical advantage tells us how much easier the system is making the work. The greater the number is above one, the greater the mechanical advantage. You can work out the mechanical advantage in a hydraulic system using the following formula:

Mechanical advantage = Load ÷ Effort

The diagram shows a hydraulic system in a car lift. The force applied to the input piston is 2 000 N. The output piston lifts the car with a force of 12 000 N.



Calculating mechanic advantage

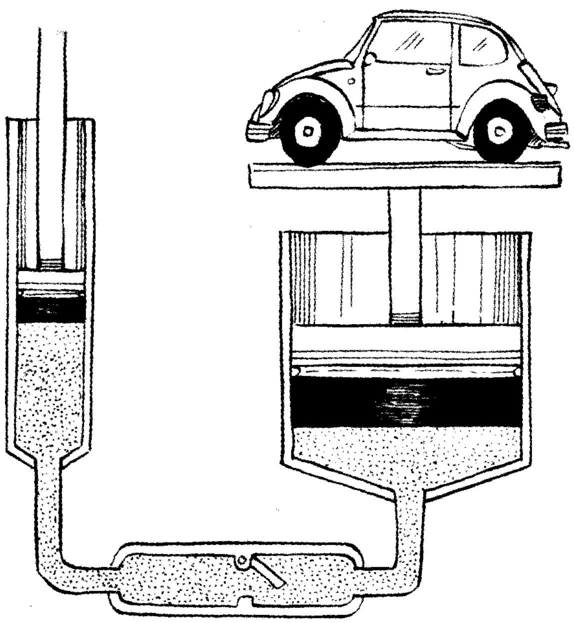
You can work out the mechanical advantage:
Mechanical advantage = Load _ Effort
Mechanical advantage = 12 000 N = 2 000 N
Mechanical advantage = 6

This means that the hydraulic system is making the work six times easier but the distance the input piston must move is six times further than the output piston.

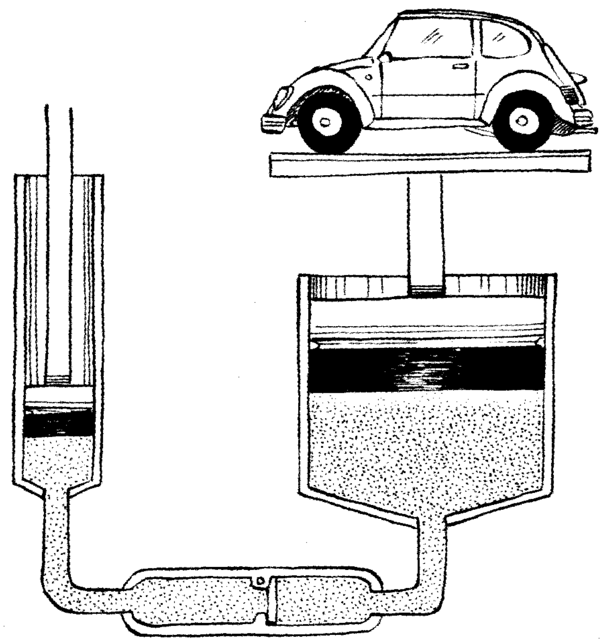
Control mechanisms in hydraulic systems

Control mechanisms in hydraulic systems allow you to direct the flow of fluid to your advantage. The car lift in Unit 13 would not work properly unless it had certain control mechanisms. When the car has been fully raised, what prevents the output piston from dropping and returning to its original position? You can use a one-way valve to prevent the output piston from dropping back to its original position. The valve stops the hydraulic fluid flowing back by closing the passage in the cylinder.

Input piston pushes fluid causing output piston to rise and lift the car The valve prevents the fluid flowing back so that the car stays raised



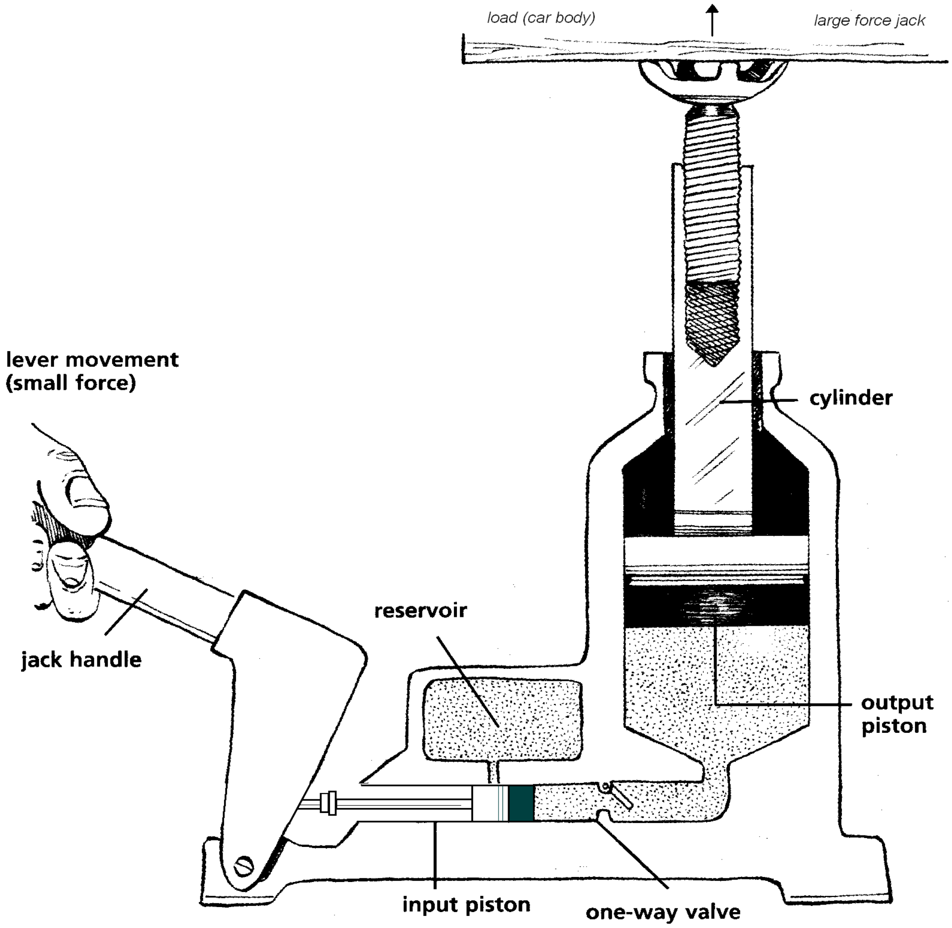
Input piston pushes fluid causing output piston to rise and lift the car.



The valve prevents the fluid flowing back so that the car stays raised.

The amount of movement a hydraulic system generates depends on the amount of fluid inside the cylinders. Some hydraulic systems have reservoirs that add more hydraulic fluid to the system when needed. A reservoir is used in a jack. A jack is a device used to lift heavy objects. For example, you use a jack to lift the side of a car when you have to change the tyre. Pumping the handle of the jack causes hydraulic fluid to move into the output piston to lift the car. A valve prevents the output piston from falling back.

As you pump the jack's handle, fluid is forced into the output piston chamber forcing the output piston to rise. When you release the pump, a valve closes preventing fluid from flowing out of the output piston chamber. At the same time, a valve from the reservoir opens allowing fluid from the reservoir into the input piston chamber. When you pump the handle, the reservoir valve closes and the output piston valve opens. The fluid is forced into the output chamber causing the output piston to rise. The whole process is repeated until the desired height is achieved.



The use of a reservoir in a hydraulic jack

Advantages and disadvantages of hydraulic systems

The biggest advantage of hydraulic systems is that you can create very large output forces. You can also make hydraulic cylinders in any shape.
This allows you to reach difficult places, for example around corners.

The disadvantage of hydraulic systems is that they are expensive to build. The parts of a hydraulic systme are expensive and have to be extremely strong to withstand the high forces generated by the system. You must also keep hydraulic fluid clean so that it does not clog up the system.

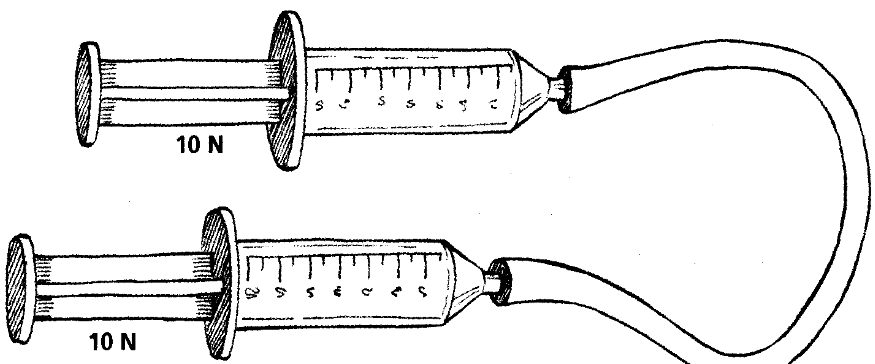
Pneumatic systems

Pneumatic systems are found in machines and tools that use compressed air. Compressed air is air that has been forced into a small space. Compressed air is an efficient way of using energy. When air has been compressed, it has potential energy to expand again. Pneumatic systems use the potential energy of compressed air to make machines and tools work.

There are always at least four parts to a pneumatic system:

- A compressor compresses the air going to the receiving cylinder.
- Air lines or pipes transfer the compressed air to the receiving cylinder.
- A receiving cylinder uses the compressed air.
- Valves control the flow of compressed air.
-

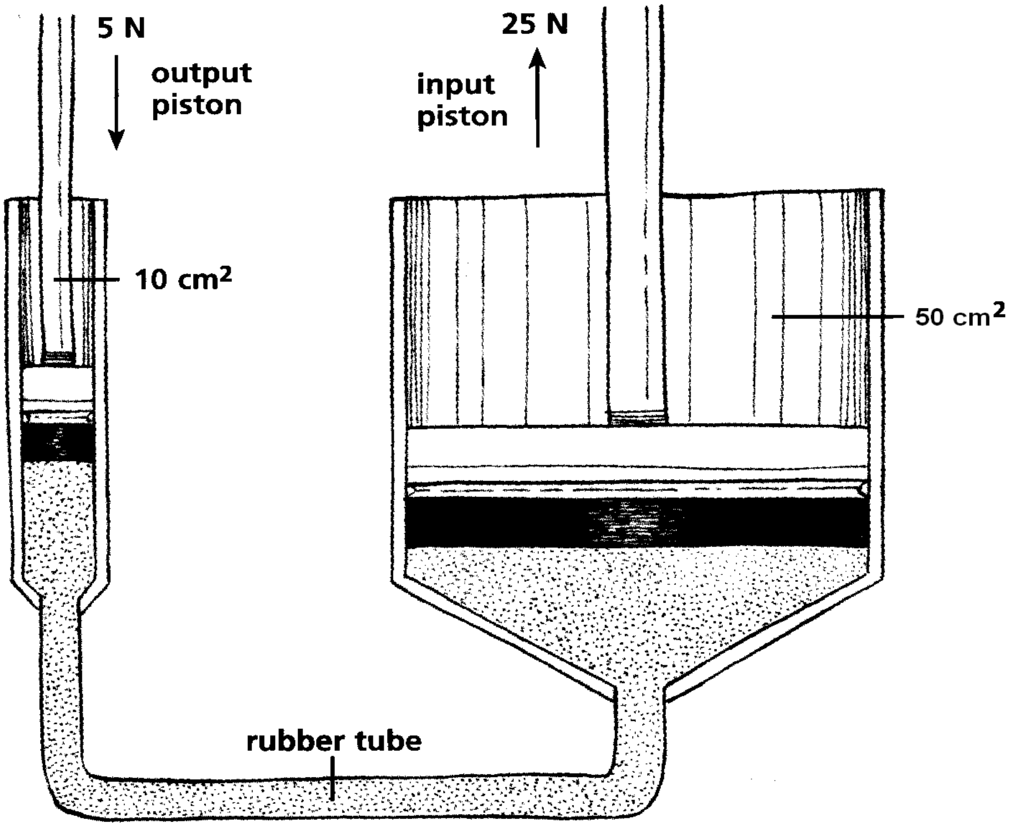
A jackhammer is a good example of a device that uses a pneumatic system. The receiving cylinder of the jackhammer uses compressed air to force a piston downwards. A drill bit is attached to this piston. The drill bit digs into the ground or breaks up rocks.
A compressor near the jackhammer compresses air. The compressed air flows along an inlet air line to the receiving chamber of the jackhammer and forces the piston down. As the piston moves down, a valve closes over the inlet air line. When the piston has moved down far enough, the compressed air rushes out of an outlet pipe. A strong spring at the base of the piston forces the piston up again. The valve over the inlet air line opens. Compressed air rushes into the receiving chamber and forces the piston down again.
You can set up your own simple pneumatic system using two syringes and a rubber tube. Set up the apparatus as shown in the diagram. As you push down on the piston of the syringe on one side, the piston of the other syringe rises. Assume that the syringes are the same size. When you push down with a force of 10 N on the one syringe, the other syringe will rise with a force of 10 N.



Making you own simple pneumatic system

Mechanical advantage in pneumatic systems

You can gain a mechanical advantage by using pneumatic systems. If you increase the area of the base of the output piston, then the force at which the piston rises will also increase. For example, in the diagram the area of the base of the input piston is 10 cm^2. The area of the base of the output piston is 50 cm^2. If you push down on the first syringe with a force of 5 N, then the second syringe will rise with a force of 25 N. The force is five times stronger. The distance travelled by the output piston will be a fifth of the distance travelled by the input piston.



Gaining mechanical advantage in pneumatic systems

You can also work out the pressure that has been exerted on the base of the output piston. You know that the second syringe rises with a force of 25 N. You also know that the area of the base of the output piston is 50 cm^2. Use the following formula to work out pressure:

Pressure = Force ÷ Area
Pressure = 25 N ÷ 50 cm^2
Convert to SI units: Pressure = 25 N _ 0,5 m^2
Pressure = 50 N/m^2

This means that the pressure exerted on the base of the output piston of the second syringe is 50 newtons per square metre.

Electricity

Electricity vs Electronics

As you look around your school and home, you will be aware of devices that use electricity. If you were to turn off the electricity in a house, very few of these devices would work. All these devices use electrical energy. We get electrical energy from verious places such as:

- ESKOM
- Batteries
- Solar panels

The devices that use electrical energy, are referred to as an electrical system. An electrical system converts this electrical energy into any other type of energy, like heat, light, sound and movement.

Many of these systems make use of sensors such as heat sensors, light sensors, motion sensors, etc. to control them. These sensors make sure that the electrical systems work correctly according to their purpose. These sensors are small components in an electrical system. Due to their size, they use less energy (less voltage and less current) than the electrical system itself. Because they are so small we refer to them as electronic components. But these sensors cannot control an electrical system on their own. They form part of another system that we call an electronic system. An electronic system differs from electrical systems in these ways:

- It senses information from the environment
- It processes the information
- It responds to the information in a suitable way.

Many of the devices that we use every day, have an electronic system inside them, or, is an electronic system on its own.

In this module, you are going to learn about the basic components of an electronic system and how they work. At the end you will have the knowledge to build your own electronic system.

Electrical: has to do with the general concept of electricity; the **flow of electricity** as it relates to a specific event and is more concerned with high voltage electrical parts like motors, generators and transformers.

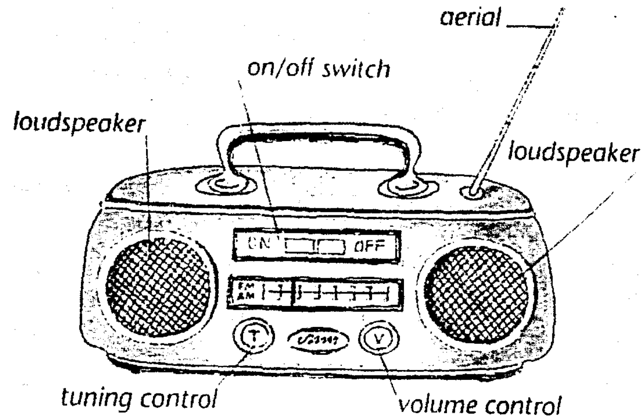
Electronics: relates more to the complex functions performed **within a given device** and is more concerned with low voltage components like diodes, transistors, resistors and their design.

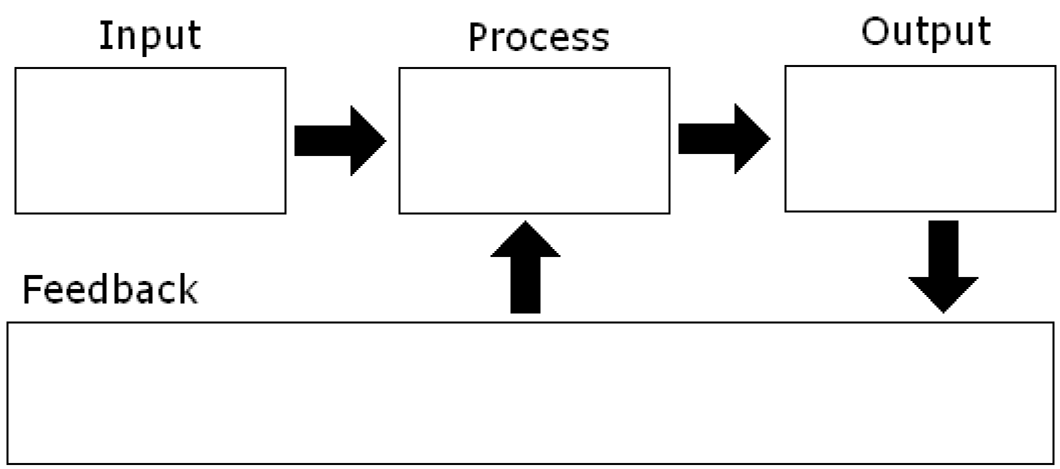
Electronic systems

Any electronic system can be divided into 4 main sections. These sections are:

- Input
- Process
- Output
- Feedback

Why is it important to know this?
These sections describe a basic electronic system and every electronic system can be subdivided into these basic blocks. These sections can be put together as seen in the diagram below.





Input:
The input is the section that controls the system and supplies it with information. The volume knob on your radio controls the volume of the radio. The antenna of your radio supplies your radio with signals. The battery of you radio supplies your radio with electricity.

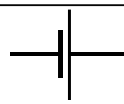
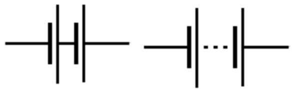
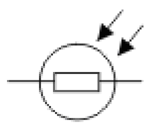
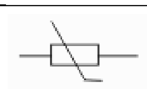
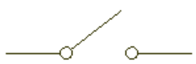
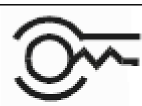
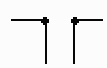
Process:
The process is the section where information, which is received from the input, is changed so that it is ready and correct for the output of the system. The process is responsible to make sure that everything is working correctly and that all commands are executed correctly.
Let us think about your radio. You want the sound to be louder. So you turn the volume knob a bit. The process is responsible for making sure that the sound becomes louder. We can basically say that the rest of the things in your radio are part of the process section.

Output:
The output is the section that produces the information and makes it possible for you to hear or see this information. The speaker on your radio produces the sound of the song

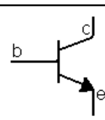
that you listen to. The display screen of your radio tells you to which radio station you are listening.

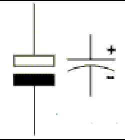
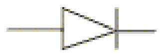
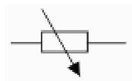
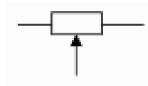
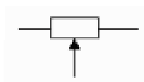
Feedback:
The feedback is the section that makes sure that the process is doing what it is supposed to do and is in working order.

The INPUT is what makes the circuit turn on or off.

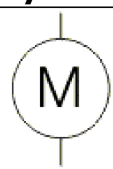
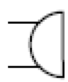
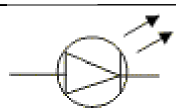
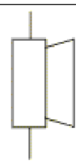
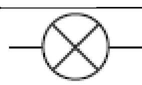
Input Device	**Symbol**	**Used for**
Cell		Provides energy to circuit
Batteries		Provides energy to circuit
Light Dependent Resistor (LDR)		Detects changes in light intensity and changes its resistance accordingly.
Thermistor		Detects changes in temperature and changes its resistance accordingly
switch		Opens or closes a circuit.
Push switch		Closes a circuit while it is held down.
Magnetic / reed switch		Closes a circuit if you place a magnet next to it.
Vibration switch		Detects changes in movement
Moisture sensor		When it detects moisture, the circuit is completed

The PROCESSOR operates the device – the "brains of the operation".

Processor	**Symbol**	**Used for**
Transistor		Can be used as an automatic switch or to amplify electric current or voltage.
Resistor		Limits the amount of current flowing through the circuit.

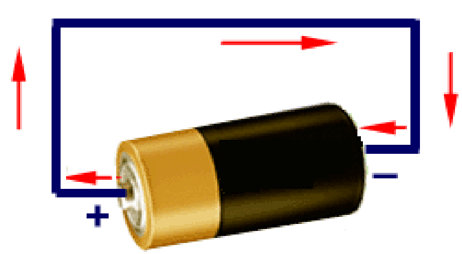
Capacitor		Capacitors are components that are used to store an electrical charge and are used in timer circuits.
Diode		A diode allows electricity to flow in one direction only and blocks the flow in the opposite direction. They are usually used as a form of protection.
Variable resistor (potentiometer)	 	Can be used to manually increase or decrease the resistance in a circuit.
Pre-set potentiometer		Used to pre-set the resistance (by and electrician, since it is inside the electrical device)

The OUTPUT is what we see, hear or feel when the circuit turns on.

Output Device	Symbol	Used for
Motor		Rotates and can be used to power a fan, wheels, gears or pulleys
Buzzer		Warnings, alarms
LED		Indicator
Loudspeaker		Broadcasts music and speech and other sounds
Light bulb		To illuminate

What is electricity?

Electricity is the flow of charge around a circuit carrying energy from the battery (or power supply) to components such as lamps and motors. Electricity can flow only if there is a complete circuit from the battery through wires to components and back to the battery again.



Conventional current

Which Direction does Electricity Flow?
We say that electricity flows from the positive (+) terminal of a battery to the (-) terminal of the battery. This flow of electric charge is called **conventional current**.

Electron Flow
When electricity was discovered scientists tried many experiments to find out which way the electricity was flowing around circuits, but in those early days they found it was impossible to find the direction of flow.
They knew there were two types of electric charge, positive (+) and negative (-), and they decided to say that electricity was a flow of positive charge from + to -. They knew this was a guess, but a decision had to be made! Everything known at that time could also be explained if electricity was negative charge flowing the other way, from - to +.
The electron was discovered in 1897 and it was found to have a negative charge. The guess made in the early days of electricity was wrong! Electricity in almost all conductors is really the flow of electrons (negative charge) from - to +.
By the time the electron was discovered the idea of electricity flowing from + to - (conventional current) was firmly established. Luckily it is not a problem to think of electricity in this way because positive charge flowing forwards is equivalent to negative charge flowing backwards. To prevent confusion you should always use conventional current when trying to understand how circuits work, imagine positively charged particles flowing from + to -.

Voltage and current

The flow of charge, or amount of electrons flowing through the wire, is called the **current** and it is the rate at which electric charges pass though a conductor and it is measured in **Amperes** or **Amps**.
The charged particle can be either positive or negative. In order for a charge to flow, it needs a push (a force) and it is supplied by **voltage**, also called **potential difference** and is measured in **Volts**. A potential or pressure builds up at one end of the wire, due to an excess of negatively charged electrons. The charge flows from high potential energy to low potential energy.

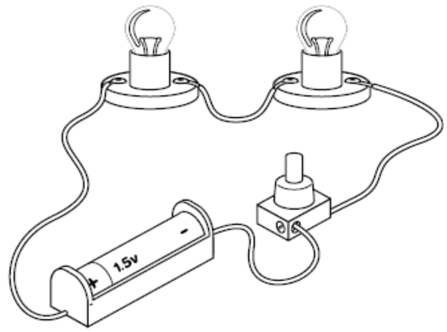
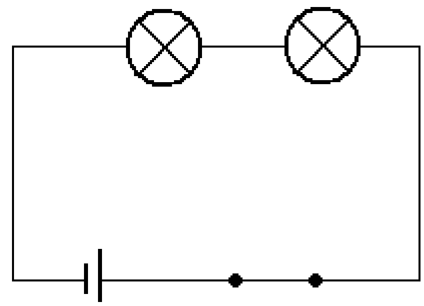
Types of current

Alternating current (AC) is electrical current which the direction of the flow of electrons switches back and forth at regular intervals or cycles. Current flowing in power lines and normal household electricity that comes from a wall outlet is alternating current.

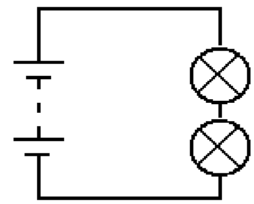
Direct current (DC) is electrical current which flows consistently in one direction. The current that flows in a flashlight or another appliance running on batteries is direct current.

Circuits

Circuit diagrams
Circuit diagrams are a pictorial way of showing circuits. Electricians and engineers draw circuit diagrams to help them design the actual circuits. On the right is a circuit diagram of the circuit on the left.

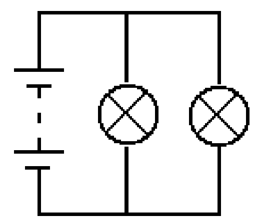
	
Circuit	**Circuit diagram**

The important thing to note on this diagram is what everything stands for. The straight lines that connect each of the symbols together represent a wire. The symbols represent electronic components.



Series circuit

In series circuits, each component in the circuit has the same current. The voltage of the battery is divided between the two lamps and each will have half of the battery's voltage.



Parallel circuit

In parallel circuits, each component has the same voltage. Both components have the full voltage of the battery accross them and both the lamps have the full battery voltage across them.

Conductors and Insulators

Electric current only flows through a closed circuit. Some materials let electricity through, these materials are called **conductors**. Materials that do not let electricity through are called **insulators**. Insulators can also protect you from being shocked by electricity. Most metals are conductors and most non-metals are insulators.

Resistance

A conductor like a piece of metal has its atoms so arranged that electrons can readily pass around the atoms with little friction or resistance. For example, gold, silver, and copper have low resistance, which means that current can flow easily through these materials. In a nonconductor or poor conductor, the atoms are so arranged as to greatly resist or impede the travel of the electrons. Glass, plastics, and wood have very high resistance, which means that current can not pass through these materials easily. This resistance is similar to the friction of the hose against the water moving through it. **Resistors** allow electrons to flow, but provide some resistance. The resistance or electrical friction is measured in **Ohms**.

Electronic Components

Every electronic system consists of electronic components. Components are basically bits and pieces where each bit or piece has a basic function that it needs to perform in the bigger system. There are millions of electronic components in the world we live in - each with its own function.

We are going to study 6 of them:

Resistors
A resistor is a component that controls the electric current that passes through a circuit. It is therefore useful for limiting the amount of current passing through a component. Resistance is measured in ohms. The symbol for ohm is Ω .

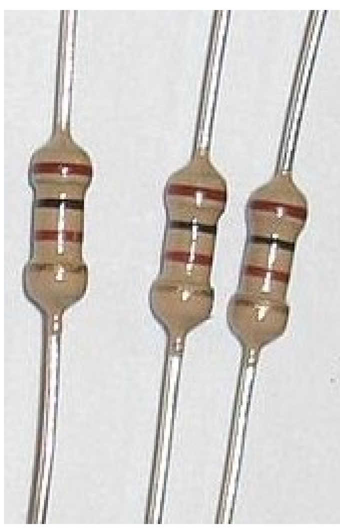
Resistor values are normally shown using coloured bands. Each colour represents a number as shown in the table.
Most resistors have 4 bands:

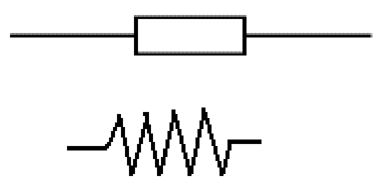
- The **first band** gives the **first digit**.
- The **second band** gives the **second digit**.
- The **third band** indicates the **number of zeros**.

The fourth band is used to shows the tolerance (precision) of the resistor, The tolerance of a resistor is shown by the fourth band of the colour code. Tolerance is the precision of the resistor and it is given as a percentage. silver = 10%, gold = 5%,

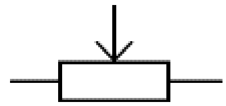
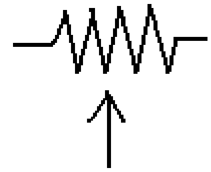
The Resistor Colour Code

Colour	**Number**
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Purple	7
Grey	8
White	9

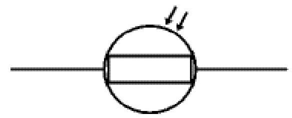
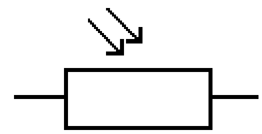




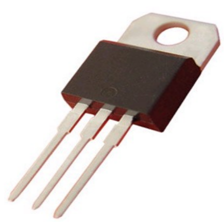
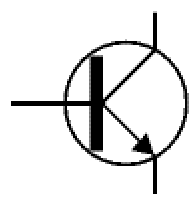
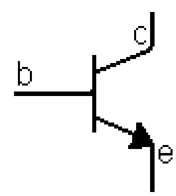
Variable Resistors
Also called potentiometers, can vary the resistance in a circuit. This means the resistance can be increased or decreased. Light-dimmers in light switches in homes, make the litght dimmer or brighter.

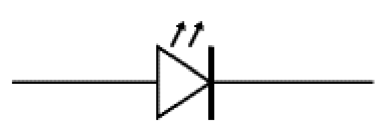
The Light Dependent Resistor (LDR)
The resistance of a light dependent resistor decreases as the illumination on it increases. It can therefore convert changes in light intensity into changes in electric current. The resistance of the LDR is high in a dark place (low light level) and low in a light place (high light level)

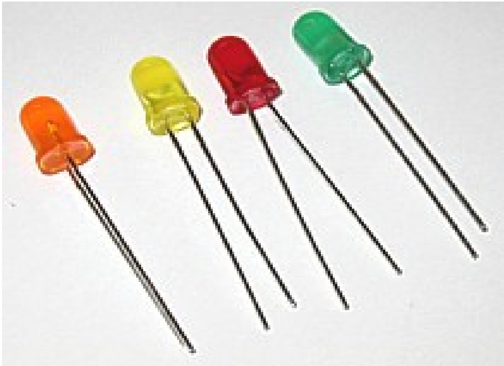




Transistors
A transistor is a three terminal semiconductor device that is able to provide current amplification. A transistor may be used as a switch or as an amplifier. For example they can be used to amplify the small current from an LDR so that it can operate a streetlamp. It consists of three legs namely the collector (c), base (b) and emitter (e). what ever goeis in at the base is multiplied by a known factor, and gets emitted at the emitter.

Light-emitting diode (LED)
LEDs are used as indicator lamps. The more current that flows through the LED, the brighter it will shine. They have the advantages of small size, long life, a small operating current and high operating speed. LEDs must be connected the correct way round, The negative side is the short leg and the body of the LED is flat on that side. Never connect an LED directly to a battery with a high voltage, it will burn out. Always connect an LED in series with a resistor. LEDs are available in red, orange, amber, yellow, green, blue and white. Blue and white LEDs are much more expensive than the other colours. The colour of an LED is determined by the semiconductor material, not by the colouring of the plastic body.



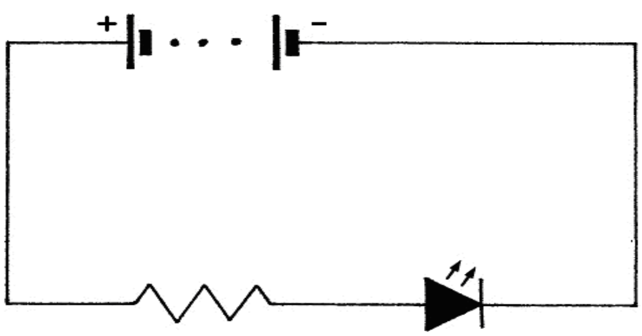


How to connect an LED in a circuit
Take care

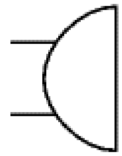
An LED will blow if the electric current that flows through it is too large. It can be used with a 1.5V battery, but if you use it with a 9V battery you have to use a 1KΩ resistor to protect it. The resistor will limit the current passing through the LED.

The electric current can pass through an LED from one direction only. The arrow in the circuit diagram symbol shows the direction in which the electric current will pass through the LED. An electric current coming from the positive terminal of the battery will pass through the LED from left to right, leaving through the flat side of the LED.

1. An LED has a flat side to indicate which way round it should be connected. The flat side must be facing the negative terminal of the battery.
2. The circuit diagram below shows how to connect an LED in a circuit.



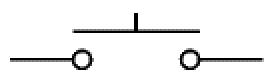
Buzzer
These devices also convert electrical energy to sound. Buzzers have a voltage rating but it is only approximate, for example 6V and 12V buzzers can be used with a 9V supply. The more voltage you supply, the harder it buzz. Buzzers must be connected the right way round, their red lead is positive (+).



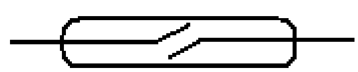
Types of switches

Simple switch (Single Pole, Single Throw = SPST)
a simple on / off switch

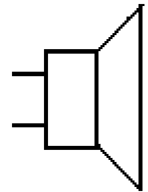
Push-to-make
A push-to-make switch returns to its normally open (off) position when you release the button, this is shown by the brackets around ON. This is the standard doorbell switch.



Reed switch
The contacts of a reed switch are closed by bringing a small magnet near the switch.



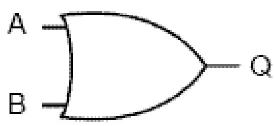
Loudspeaker
Speakers convert an electrical signal to sound



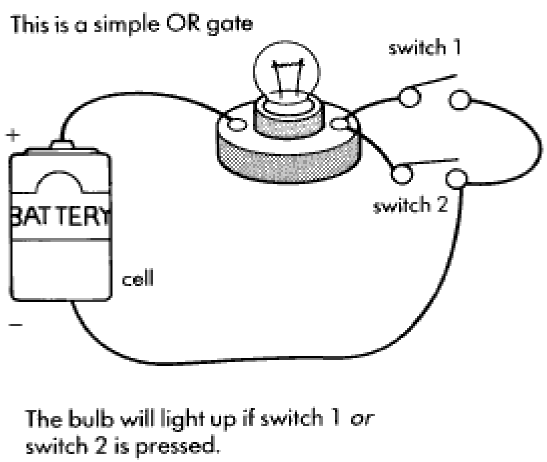
Logic Functions

Logic gates are components used to make decisions in circuits. The inputs can be connected to various sensors, and circuits can be designed to operate when certain conditions are met. When using logic, we refer to **ON** as a '1' and **OFF** as a '0'. Each gate has its own rule it follows to produce an output.

OR gate

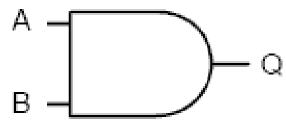


A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

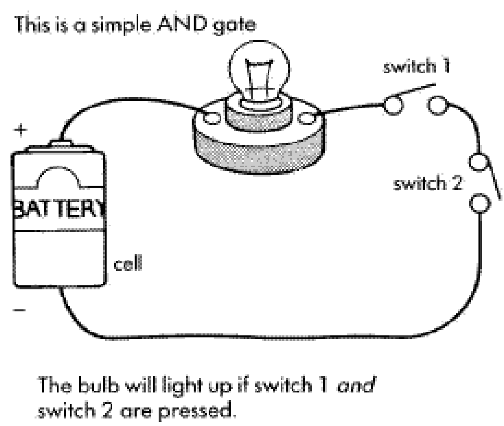


Rule:
Output is **on** if A **AND** B are on

AND gate



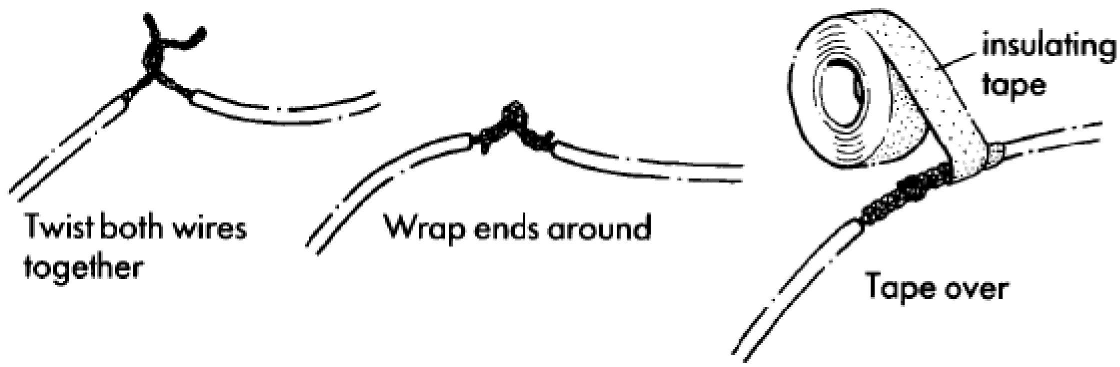
A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

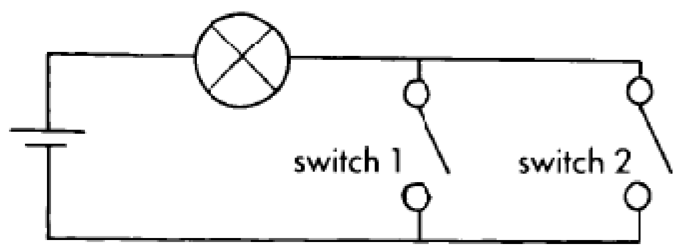


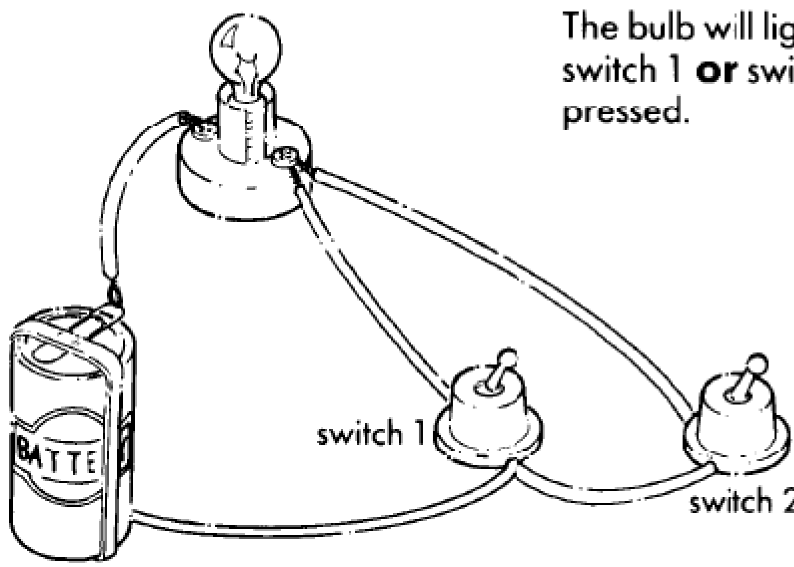
Rule:
Output is **on** if A **OR** B are on

Some tips to help with your project:

Joining two wires together

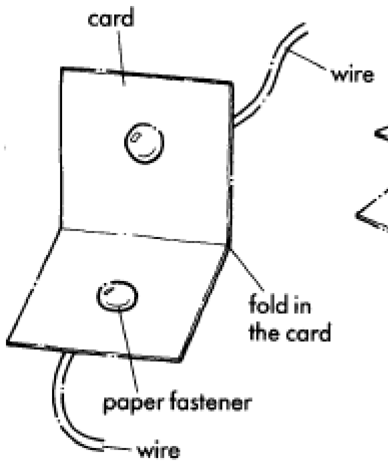


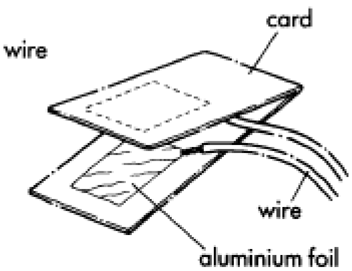


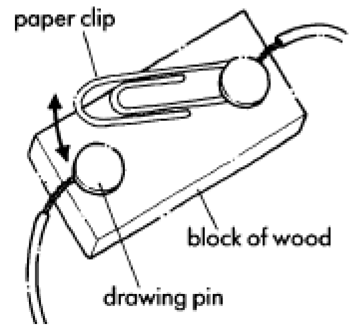


The bulb will light up if switch 1 **or** switch 2 is pressed.

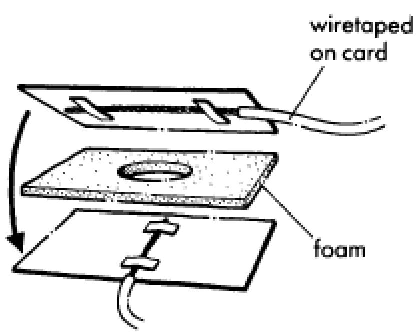
Home-made switches



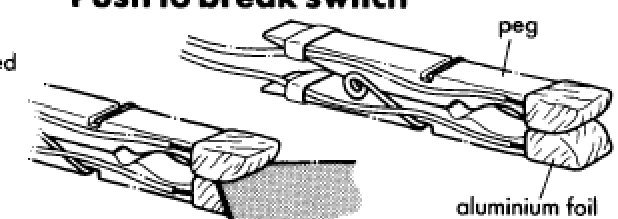




Push to make switch

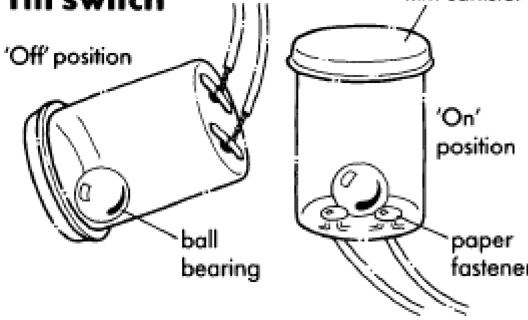


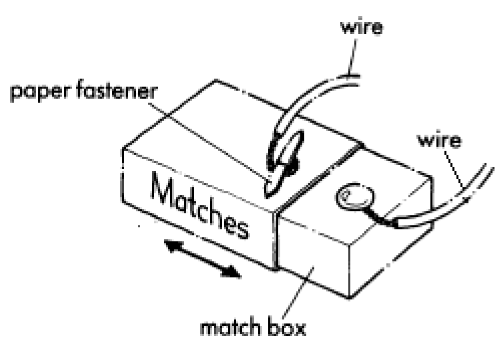
Push to break switch



Card can be used to keep the electrical contacts apart. Salt crystals could be used as a moisture sensor as they will conduct electricity when wet.

Tilt switch





Technical Drawing

There are various ways of representing objects in drawings and knowledge of these different methods is valuable in order to intelligently read or produce a drawing or plan.

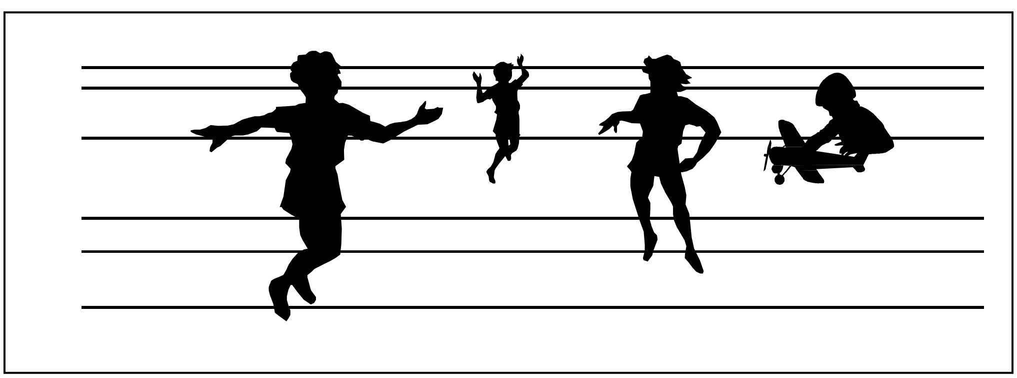
Perspective

These views look more natural and are useful in drawing artistic representations of an object. While a perspective drawing shows an object as it appears to the eye—with more distant objects drawn smaller—it is less useful for drawing plans since the measurements of the object cannot easily be taken off the drawing. Lines drawn from points on the object to the eye converge and intersect at the point of sight. Very far from the eye the distance between these lines becomes virtually zero and they seem to meet at a single point, which is called the vanishing point. For large objects such as buildings or rooms, perspective projection provides a more realistic image of an object because it takes account of foreshortening (the effect that makes objects appear smaller as they get further away).

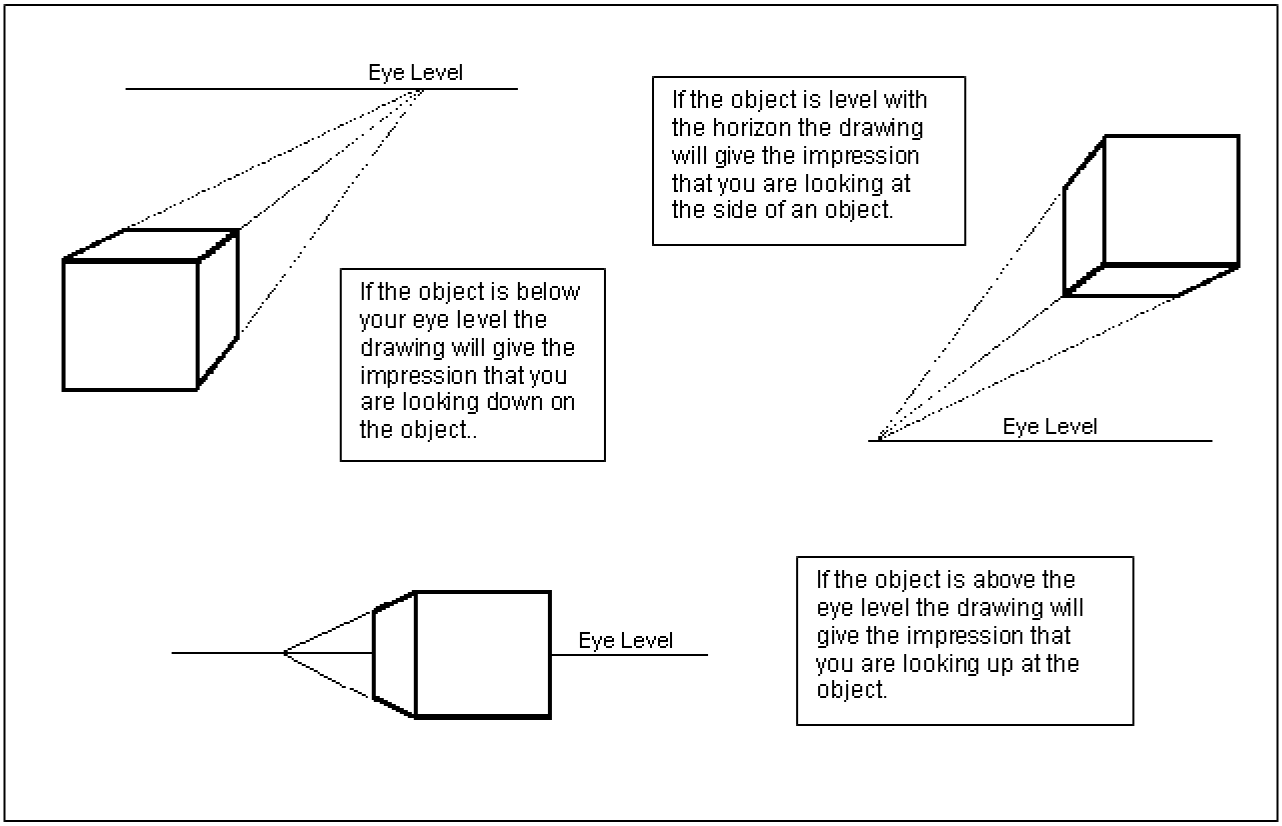
Some points to keep in mind:

- The limit of vision is a horizontal line called the horizon, situated at the height of the eye.
- Objects of equal size appear smaller with increasing distance.
- Parallel lines converge into one point, called a vanishing point—for horizontal lines this point is situated at the height of the eye, I.e. it lies on the horizon.
- Vertical lines are drawn vertical.
- The location of the observer's eye is called the point of sight and is located on the horizon.

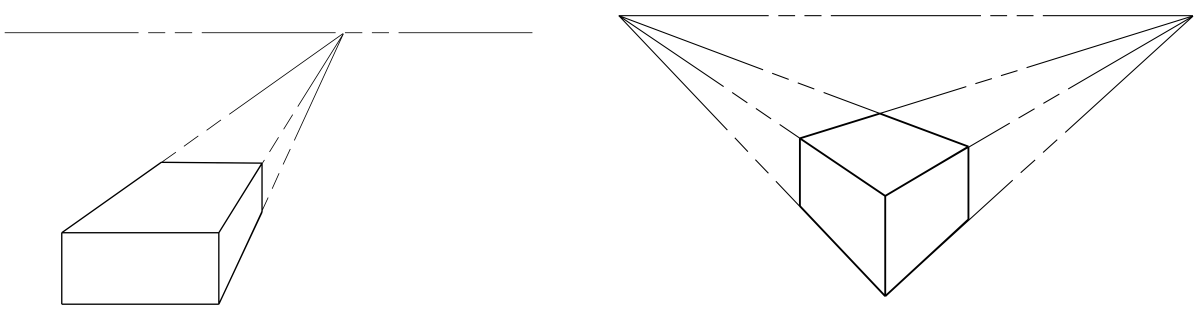
To show depth, all the eyes are on the horizon line and figures decrease in size in relation to the distance from the observer. Sitting figures are placed slightly lower than the horizon line.



Single point perspective



Two point perspective



Single point

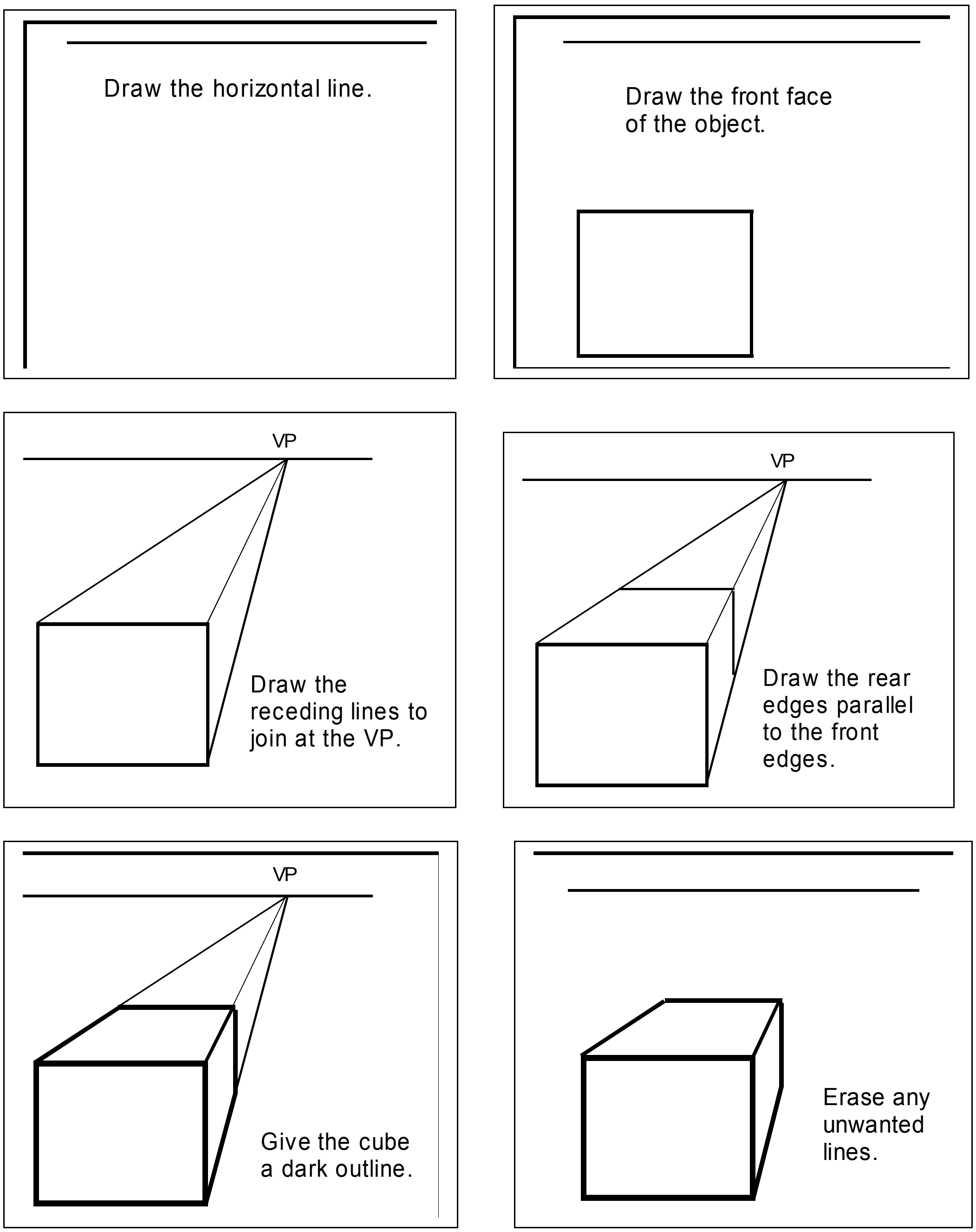
Single point perspective is similar to oblique projection in that one side of a object is parallel to the picture plane. The front face of the object being drawn is drawn true shape and size and the receding edges are drawn back to a single vanishing point on the horizon or eye level line.

Two point

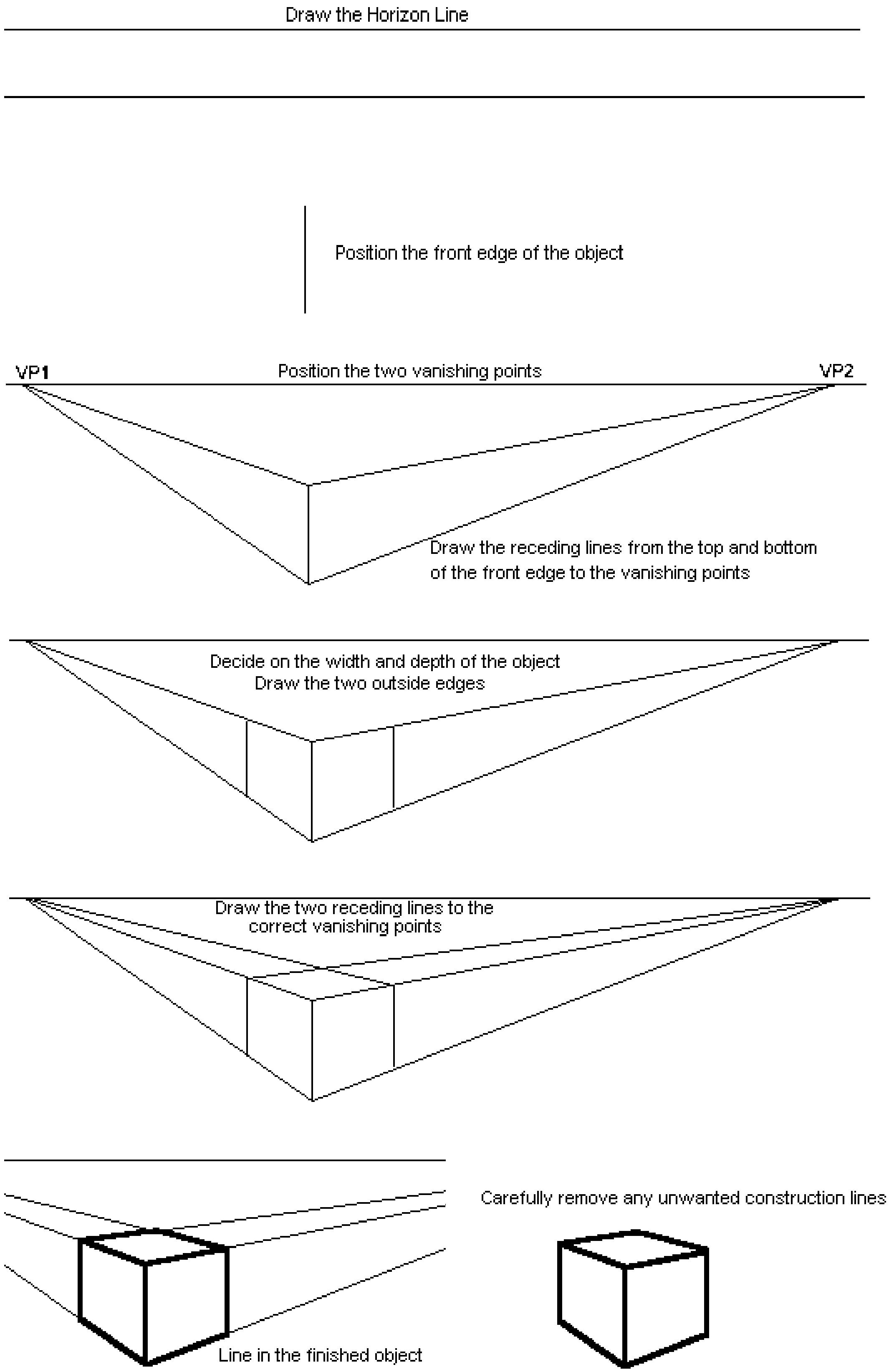
Two point perspective is similar to Isometric projection in that the front edge of an object is parallel to the picture plane. The front edge of the object being drawn is drawn true size and the receding edges are drawn back to the corresponding vanishing points on the horizon or eye level line.

HOW TO:

Single point perspective drawings:



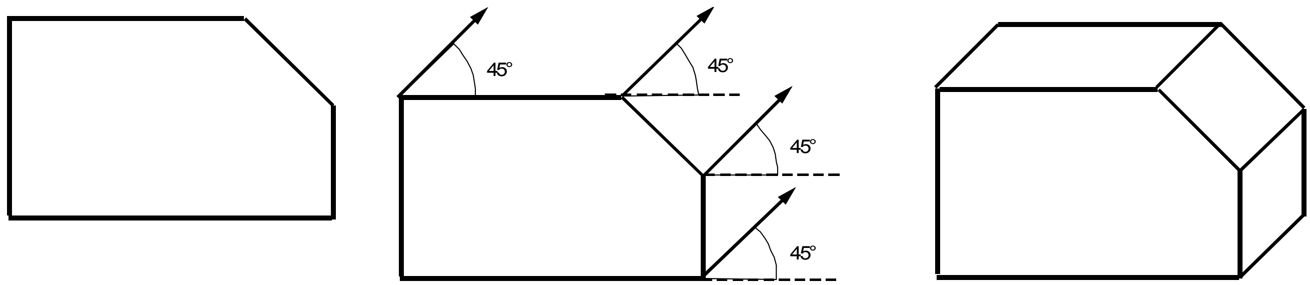
HOW TO: Double-point perspective drawings:



Drawing in 3-d

All objects have three dimensions: length, width and height. When you draw an object and three sides are visible you are drawing in 3-D.

Freehand 3-D drawings

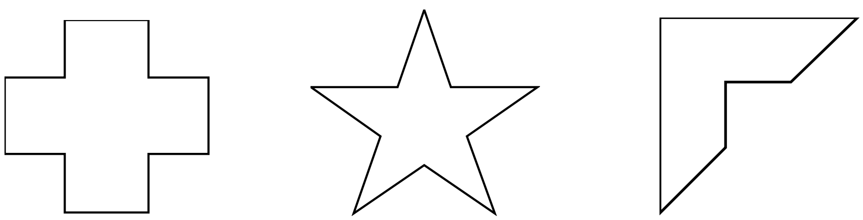


Step1 - Draw the flat front view of the object.

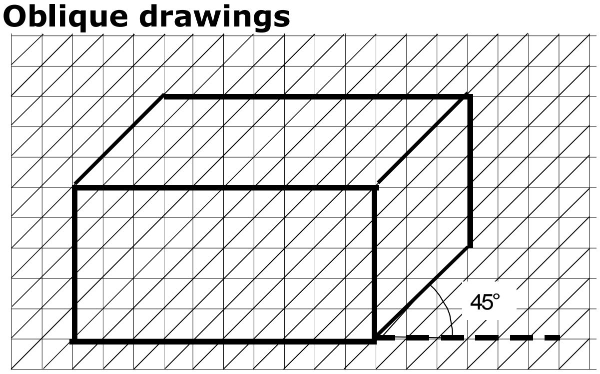
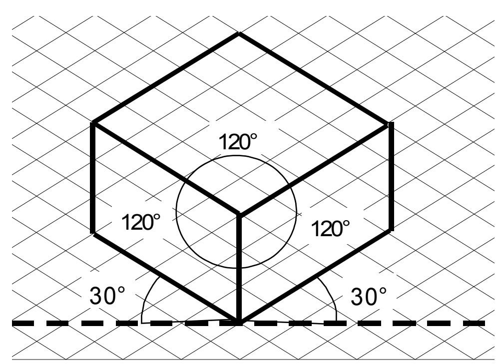
Step 2 - Draw parallel lines from the orners of the object at a 45° angle to the horizontal.

Step 3 - Join up the lines you have just drawn. You now have a 3-D object!

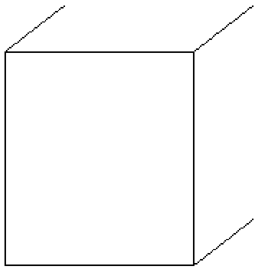
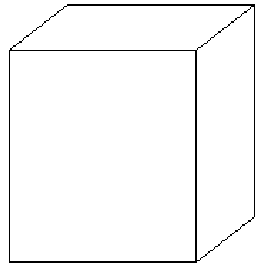
Try drawing these shapes as 3-D objects. Follow the guidelines given above.



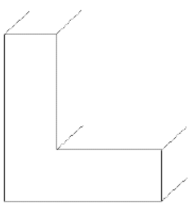
Oblique and Isometric Drawings

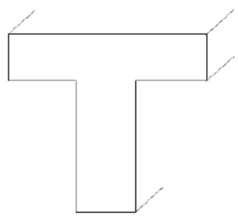
Oblique drawings  	**Isometric drawings** 
Oblique projection is created by drawing one side of the object facing the observer. This side is always drawn as a true shape. The receding lines are usually drawn at 45° .	An isometric projection is constructed from 3 axes created by dividing a circle into 3 equal angles of 120°. The receding lines are usually drawn at 30°.

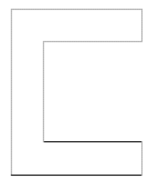
Oblique projection

	Step 1: Draw the front view and project 45 degrees lines from each corner		Step 2: Draw the back two lines of the cube in position.

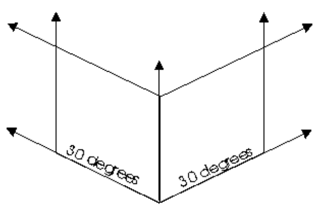
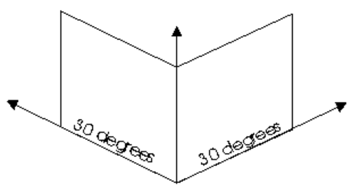
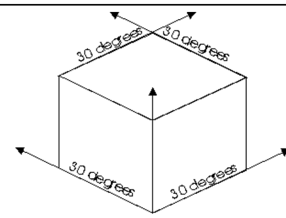
Complete the three shapes shown below - in oblique projection.



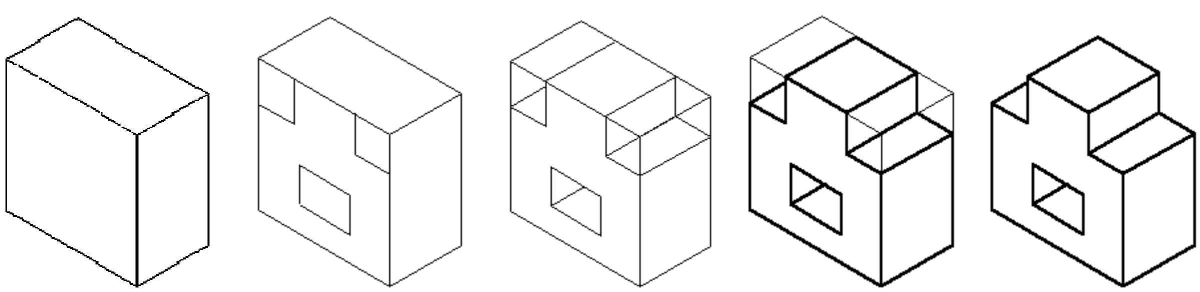




Isometric projection

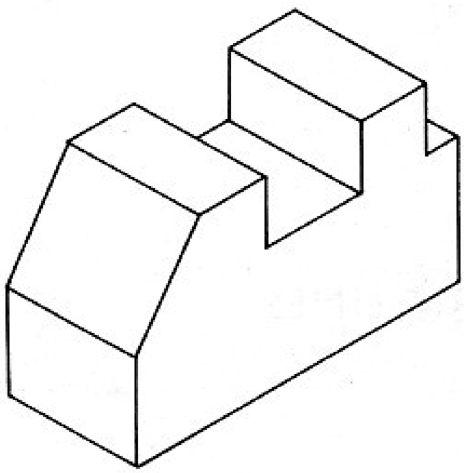
		
Step 1: Use the guidelines to draw the left and right sides of the cube.	**Step 2:** Draw the two sides parallel to the center guideline	Step 3: Complete the top of the cube by projecting 30° lines as shown above.

Difficult shapes can be drawn by starting with the box or crate that the finished object will fit into and then adding or removing the bits that are not required.

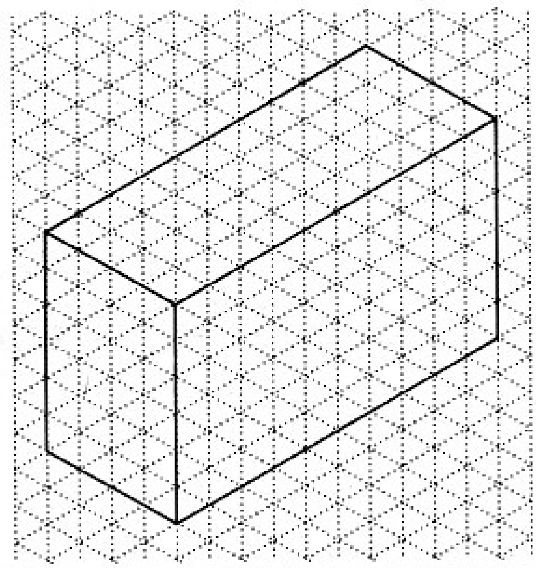


HOW TO DRAW BY TAKING AWAY

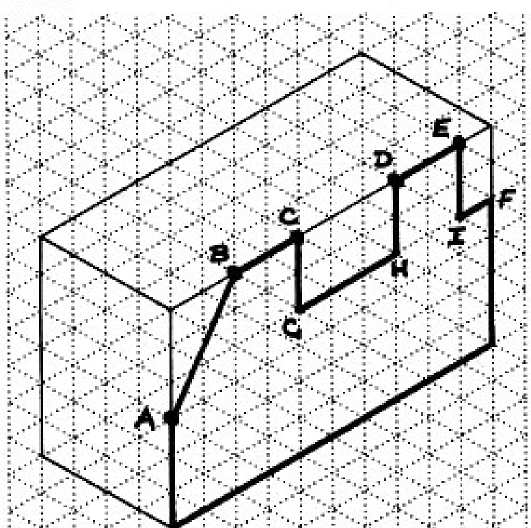
1. An isometric drawing of a shaped block.



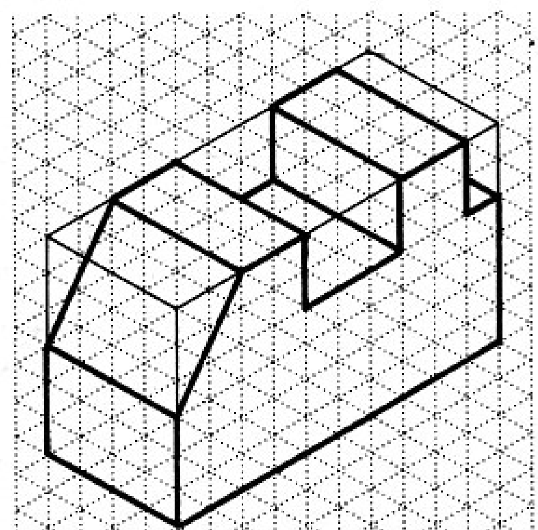
2. Draw the box (the crate) into which the object will fit.



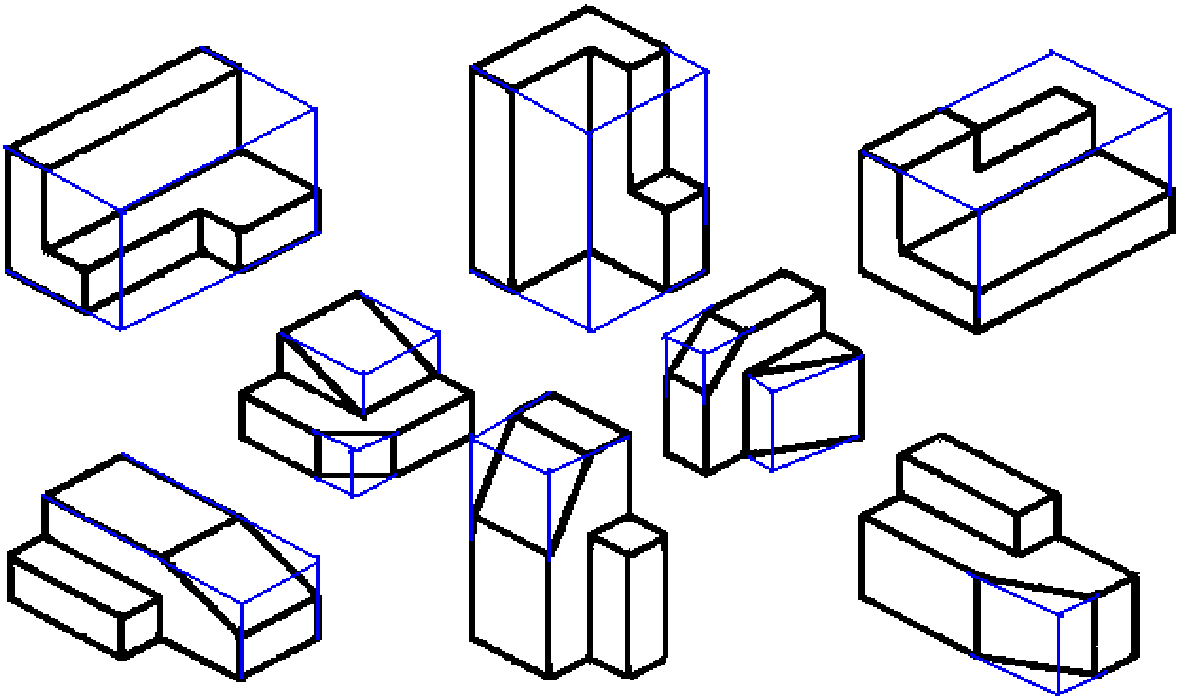
3. Mark points A, B, C, D, E and F by measuring the distance from the corner on the isometric line. (By drawing the crate you have all the isometric lines you need.)



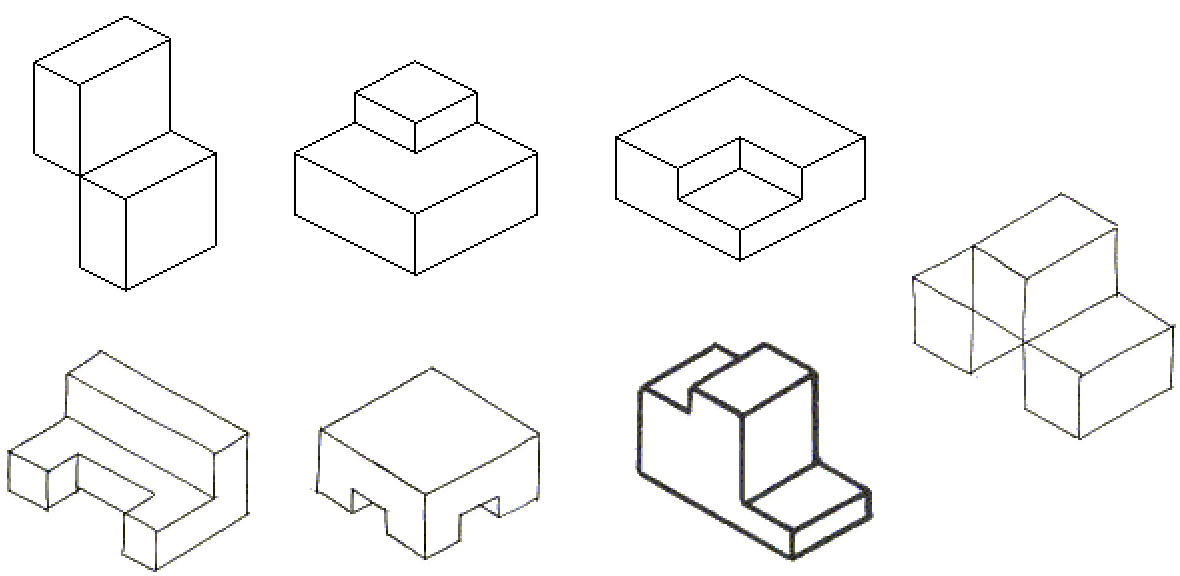
4. Complete the 30° lines to finish the drawing.



Draw these shapes using the crating method.

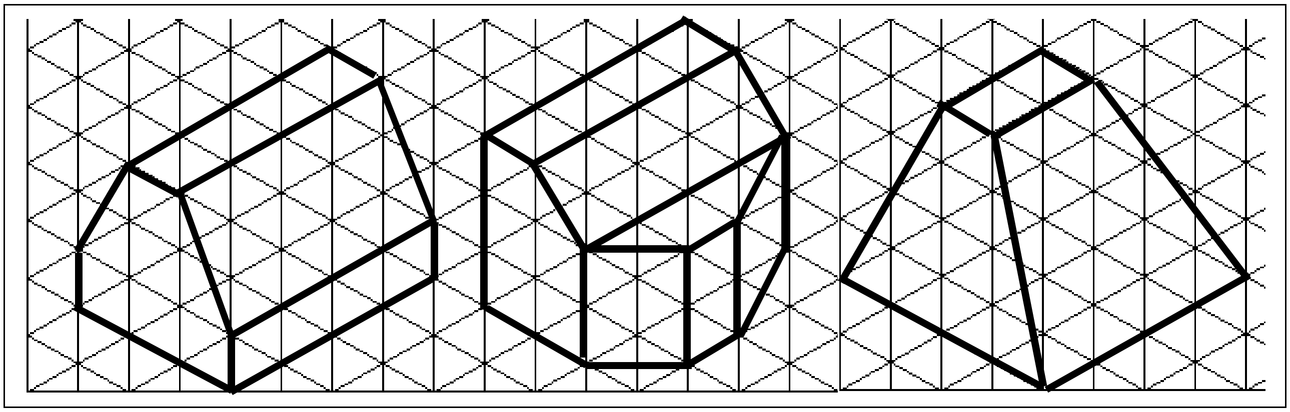


Draw these shapes on oblique and isometric grids.

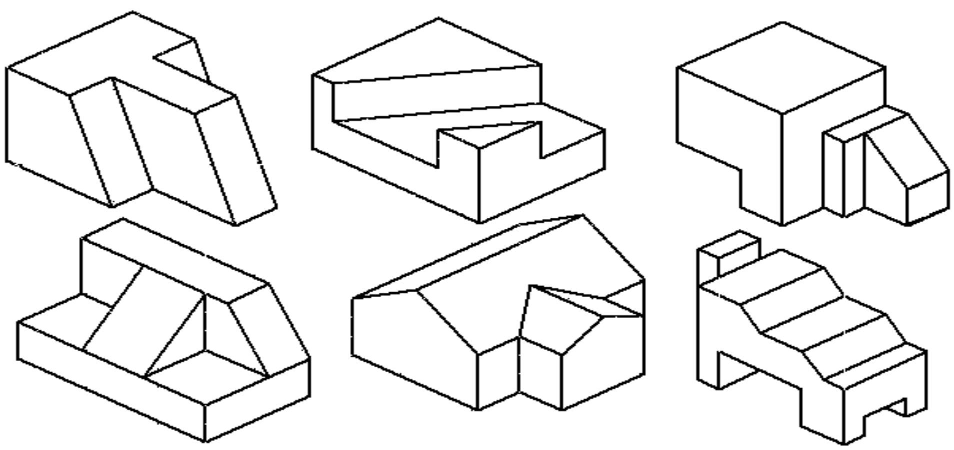


Slanted lines

Not all forms that we draw have isometric lines only.

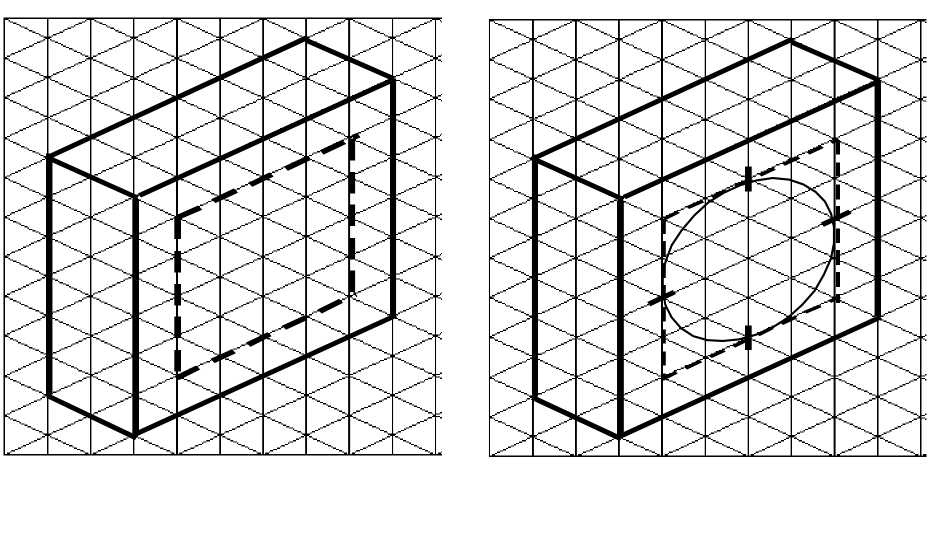


Draw these shapes on oblique and isometric grids.



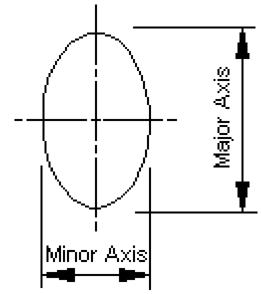
Drawing circles in isometric

First draw a square, mark the centre of each side of the square, connect the marks and there you go!

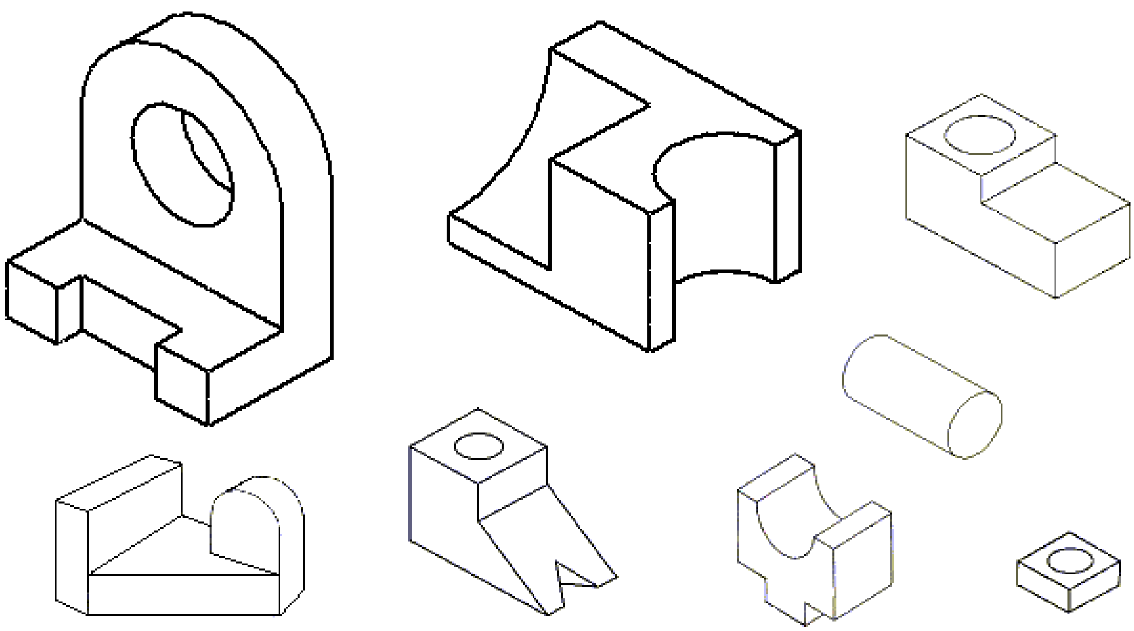


Circles drawn in oblique or isometric views

A circle drawn on a sloping surface in oblique or isometric projection will be drawn as an ellipse.
An ellipse is a circle turned through an angle. In order to draw curved surfaces we need to know how to draw ellipses. An ellipse has a major axis and a minor axis. The major axis is the axis about which the ellipse is being turned. The minor axis becomes smaller as the angle through which the ellipse is turned approaches 90^0.

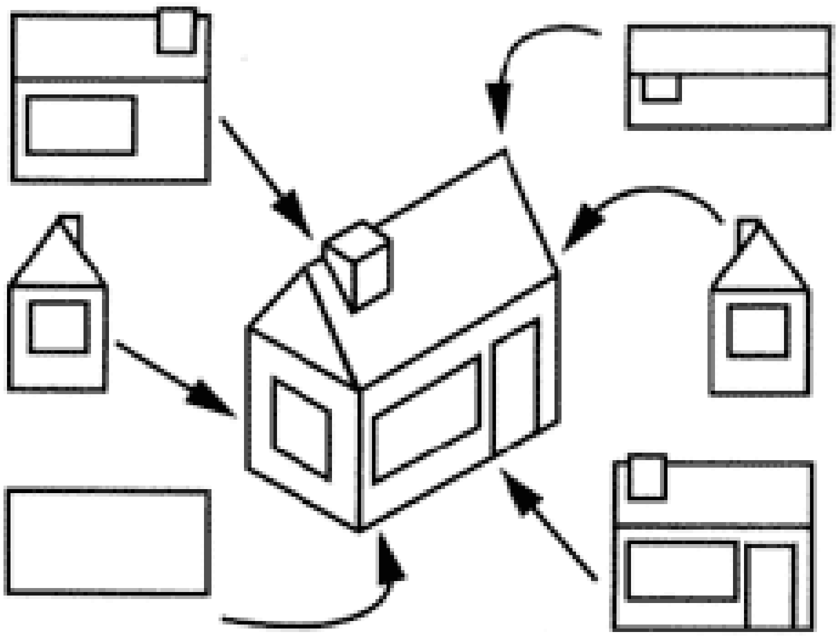


Draw these shapes on the grid using isometric projection.

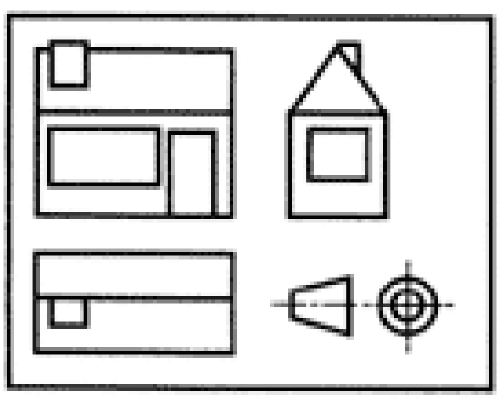


Orthographic

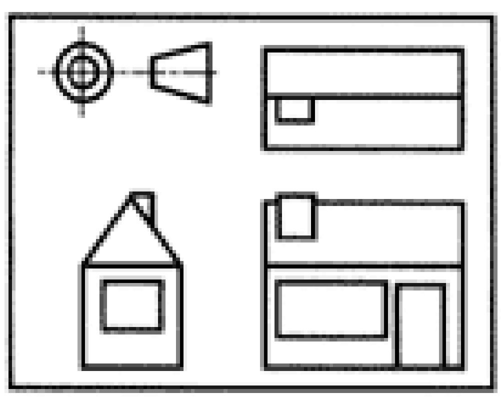
Orthographic Projection is used for accurate scale drawings of your design. You can see from the house design below that we can obtain six flat views of the object. These can be arranged on the paper as **working drawings.**



Usually you only need to draw three views of your design to give enough detail about scale and dimensions. These are laid out in two different ways, **first angle projection** and **third angle projection**.
The Orthographic projections below of the house use the standard symbol to show whether it is first or third angle.



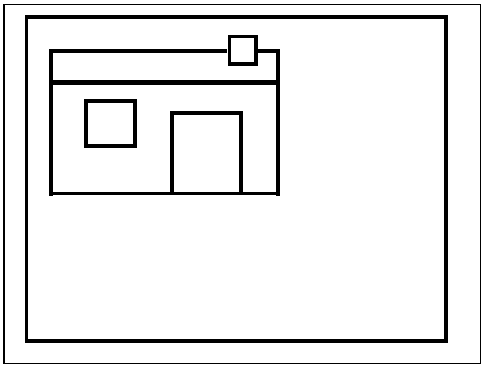
First Angle Projection



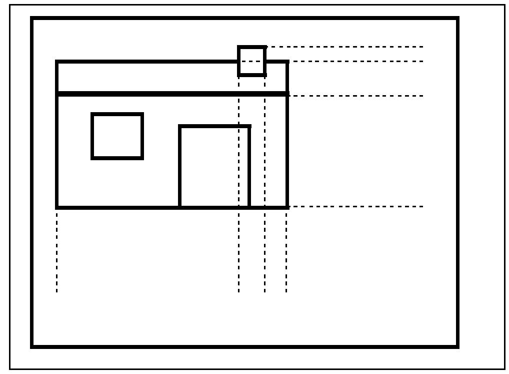
Third Angle Projection

Orthographic drawings

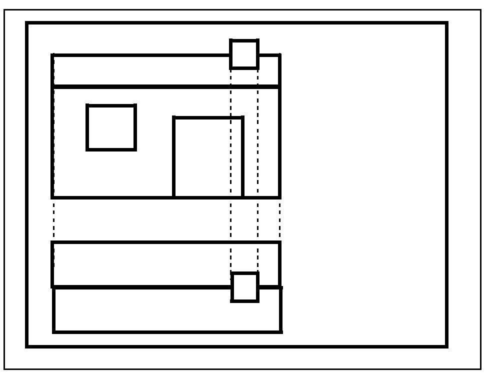
Step 1:
Draw the front view towards the top left of your sheet op paper.



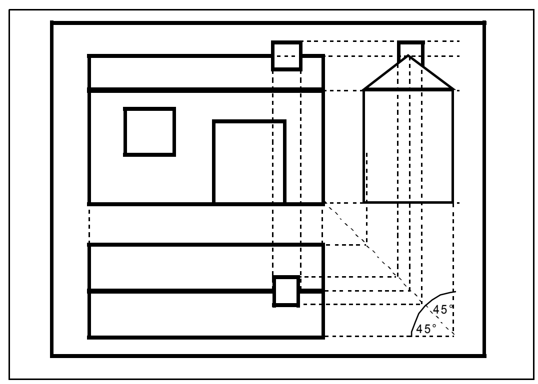
Step 2:
Project faint lines vertically and horizontally from the front view as shown.

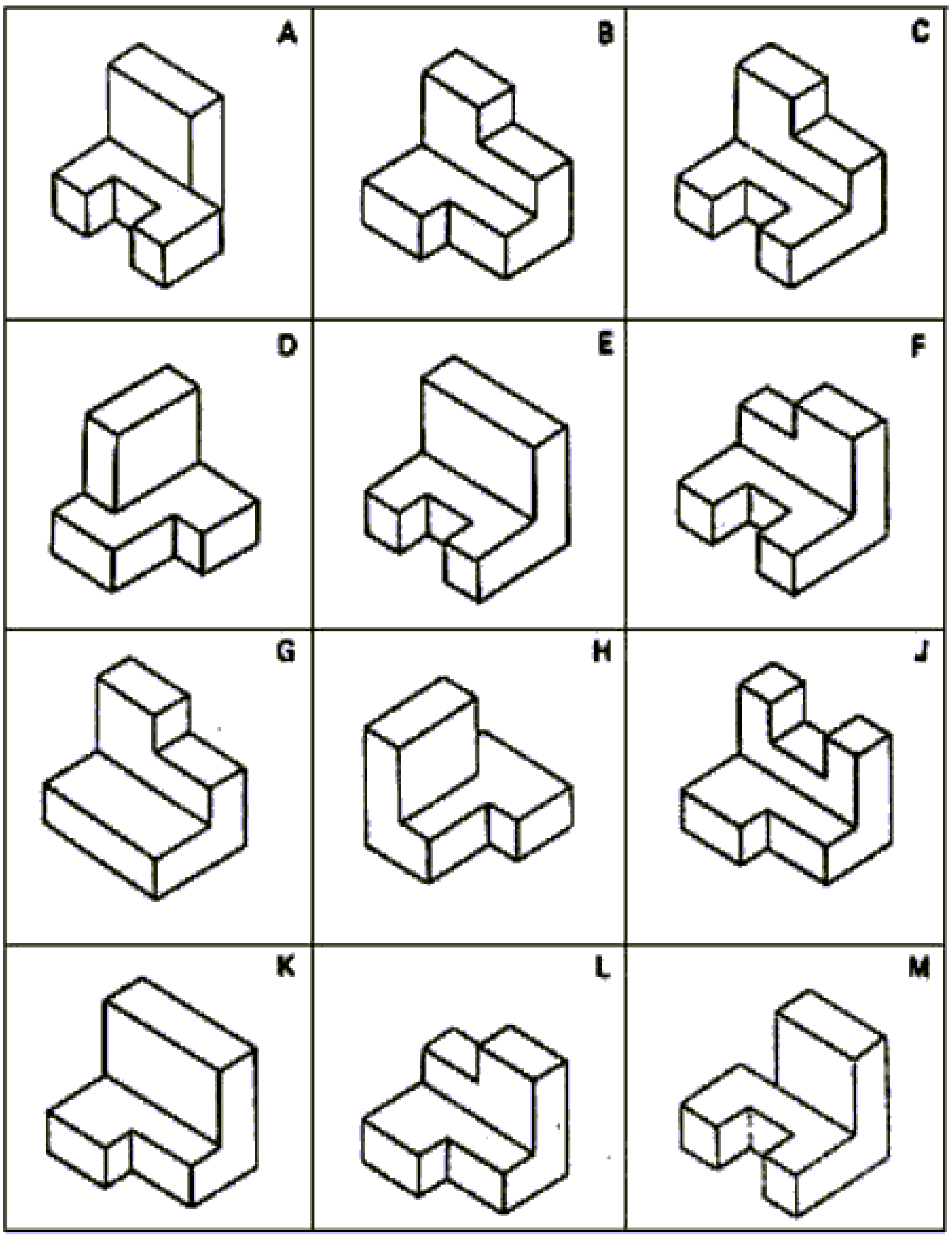


Step 3:
Draw the top view using the faint lines to help you, as shown.



Step 4:
Draw a diagonal line at 45° from the corner as shown. This is used to transfer sizes from the top view to the side view. You then complete the left view using information provided by the other two views.




A
B
C
D
E
F
G
H
J
K
L
M

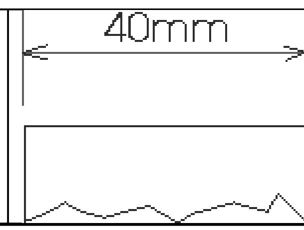
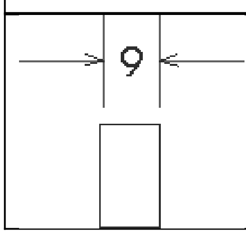
Dimensioning

Working drawings are either full size or scaled if they are too big to fit on a page. All measurements are placed on the drawing to enable it to be made on the factory floor. When we add measurements, we call it dimensioning.

Rules for dimensioning:

- Don't let measurements clutter the drawing.
- All vertical measurements should be read from the right i.e. turn the drawing 90° (clockwise) to read them.
- Do not repeat dimensions if you already have them or they can be worked out from others you have on the drawing.
- Avoid putting dimensions inside a drawing or between the different views.
- Use arrowheads showing exactly where you are measuring from and to.
- Measurements should be in mm.

It is very important to add dimensions (measurements) when drawing accurate orthographic or working drawings. An orthographic drawing is usually the last drawing before manufacture and so dimensions must be clearly presented and understood. Dimensions can also be applied to simple sketches and designs as they help anyone looking at these to understand the overall size or scale. However, dimensions are usually drawn in a particular way and some examples are shown below.
Normally at least six dimensions are placed on a working drawing. They are drawn quite faintly except for the arrow heads and the numbering which are darker. The arrow head must be sharp but above all the dimensions must be accurate.

Example of a standard dimension. The dimension is drawn quite faint with the exception of the number and arrow heads.	
	If a measurement is 9mm or smaller the dimension is drawn in a slightly different way. The arrows point inwards, towards the number.

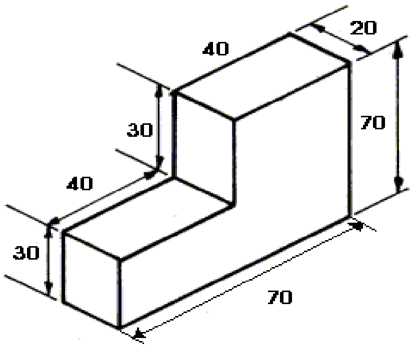
Scale

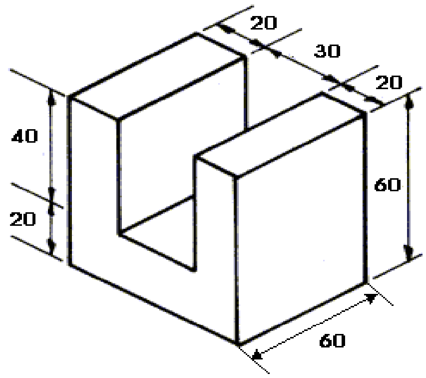
When doing drawings where size and measurements are important, you need to show whether you are drawing the object as its actual size or how many times larger or smaller than this size. This ration between a picture representation and the real size of an object is called the scale of the drawing. A scale of 1 to 100 means that one unit of the drawing represents 100 units of the dimension of a shape or object; for example 1 cm represents 1 m. When drawing on scale, angles and **proportions** never change. Scale is written 1:100 where the first number is the measurement on the drawing and the second the actual size.

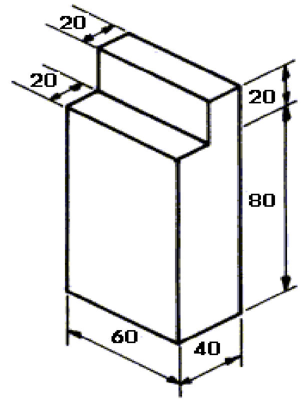
Scaling up and scaling down

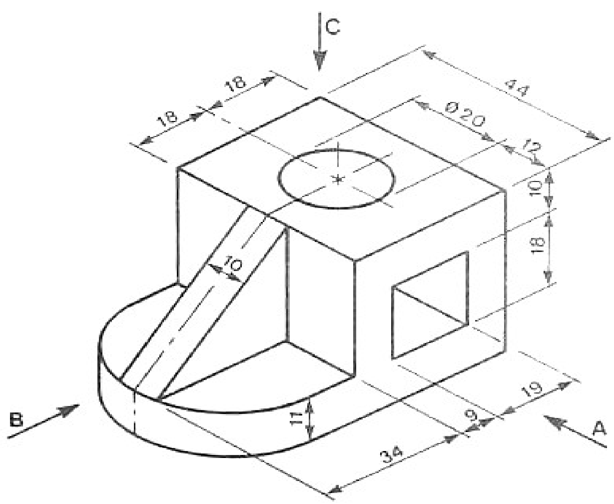
Some objects need to be drawn smaller in order to fit on a page. This is called *scaling down*. An example of this would be drawing a map or house plan. If you wanted to show detail on a very small object, you would have to draw it larger than it's actual size, this is called *scaling up.* Detail on jewellery or coins could be drawn by scaling up. In this case the scale would be written 5:1 where 5 mm on the drawing would represent 1 mm in reality.

Proportion means keeping the same ratio between length, width and height on your drawing.









Draw in 1st **angle orthographic** projection the front, left and top view of the bridge. The front view is indicated by arrow A. You may use the grid provided on page 7 of the Answer Booklet.

The bridge:

- spans a distance of 20m;
- is 4m wide;
- is 8m high above the deck;
- is 4m below the deck.

You must:

- use a sharp pencil and ruler;
- include all necessary dimensions;
- the drawing must be neat and tidy;
- use the scale of 1:200.