TECHNOLOGY

Grade 8

Hoërskool Gerrit Maritz

CONTENTS

Structures

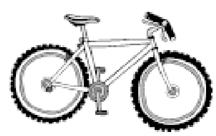
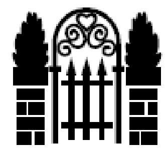
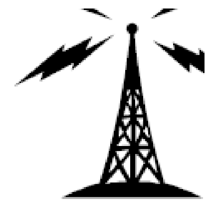
Types of Structures

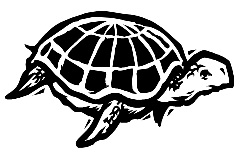
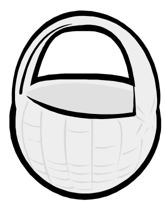
Natural and Manmade structures

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.

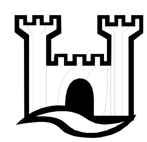
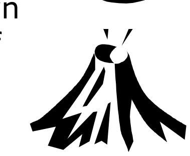

Shell Structures

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

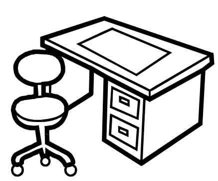
- Mountains, caves and coral reefs are natural mass structures
- Sand castles, dams and brick walls are manufactured mass structures

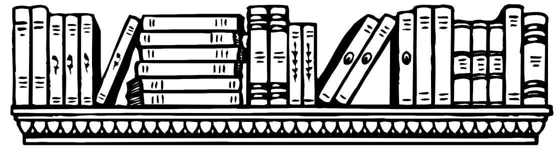
Functions of structures

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.

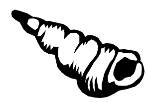


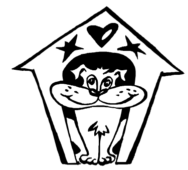

Spanning a gap

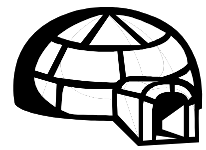


The most common structure fulfilling this function is a bridge. Bridges fulfills another function - supporting a load - they have to carry their own weight and the weight of whatever travels over them.

Enclosing people, animals or objects

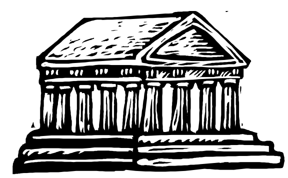






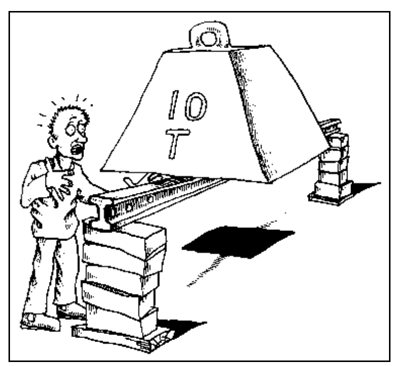
All containers fulfill this function, as well as most buildings. Natural objects include shells, caves, hollow tree trunks etc.

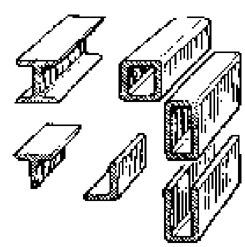
Structural members



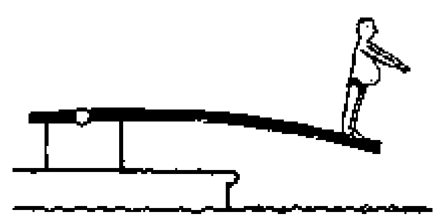
Columns are vertical structural members.

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.

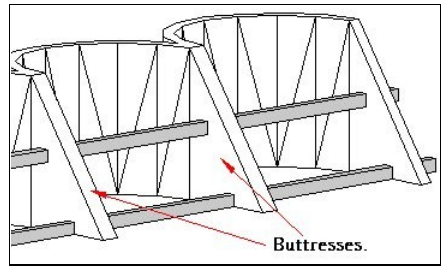




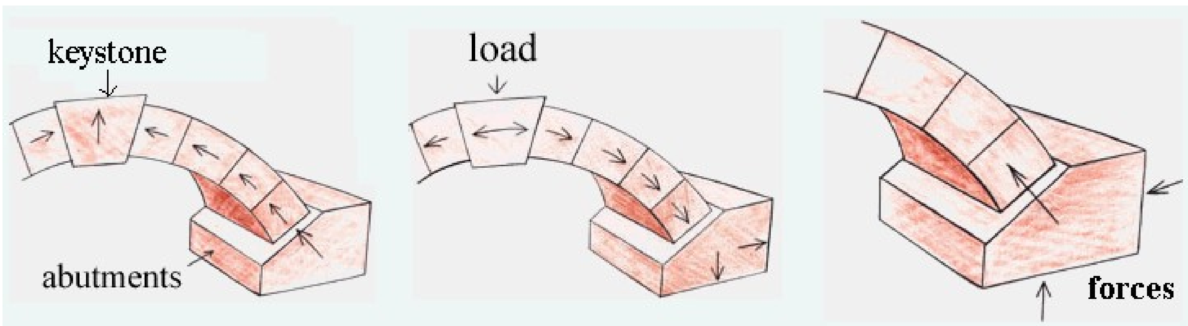
A **cantilever** is a structural member which sticks out like an arm form the main structure. A cantilever is a beam which is supported at one end only.



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



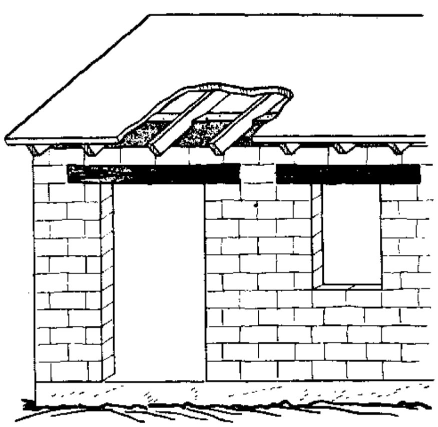
Arches



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.

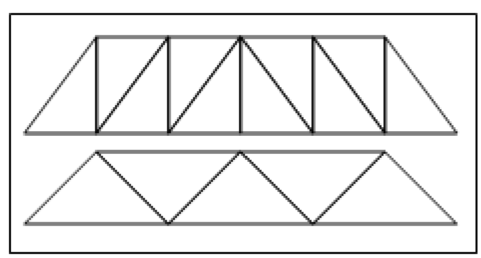
The load at the top of the key stone makes each stone on the arch of the bridge press on the one next to it. This happens until the push is applied to the end supports or *abutments,* which are enbedded in the ground.

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



Lintels are beams made of concrete and reinforced with steel bars. They spread the weight of the structure above the opening of doors and windows to the structure beside them.

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



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:

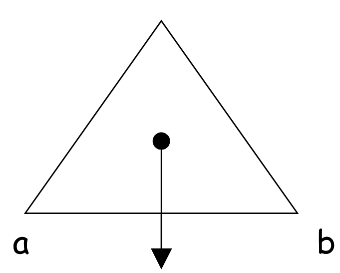
the capacity of an object to maintain or return to its original position; the state of being balanced in a fixed position.

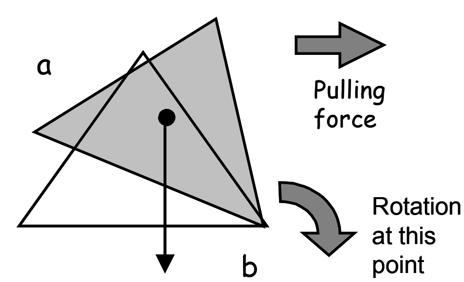
Why are some structures more stable than others?

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.

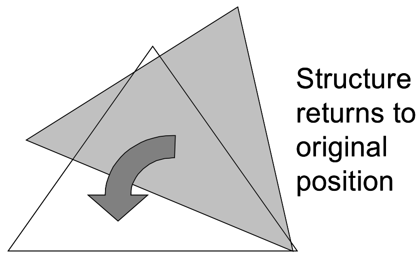
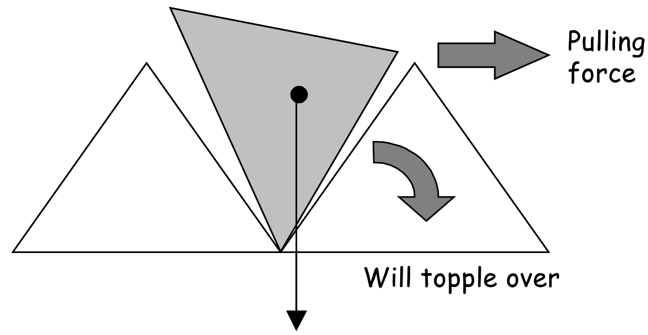
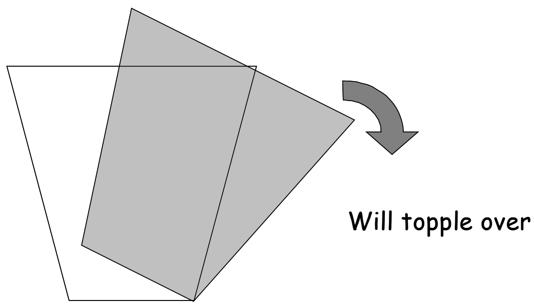
The relation between stability and centre of gravity

The stability of a structure is related to the position of the centre of gravity for that structure. As indicated in the diagram below, as the structure is tilted, its centre of gravity rises. It is rotated about point b, caused by the pulling force.





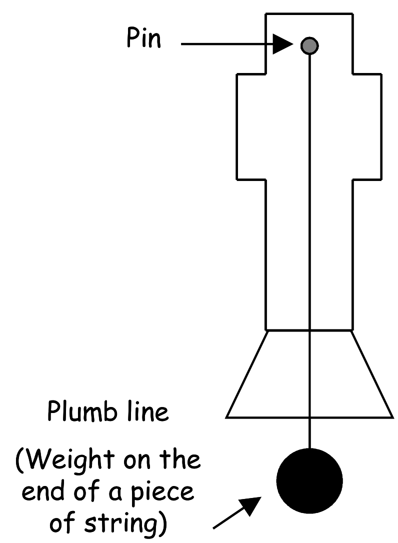
If the structure is stable, on release of the pulling force the structure will return to its original position.

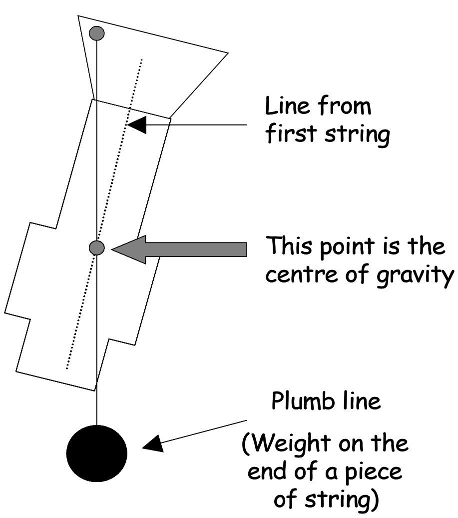
<table>
<tr>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>
</td>
<td>However, it must be noted that this will only be the case if the centre of gravity <u>remains inside the base of the structure</u>. When the structure is tilted to such a degree that its centre of gravity is outside its base, then the structure will become unstable as gravity acts on it and causes it to topple over.
If an unstable object is rotated as shown, when the pulling force is removed the structure will continue to rotate and will eventually topple over.</td>
</tr>
</table>

LET'S TRY IT !

Accurately determining the centre of gravity.

Use a piece of thick card and cut out an irregular shape as shown opposite. Hang a plumb line from a pin as shown. Hold onto the pin and mark the position of the plumb line with a pencil.



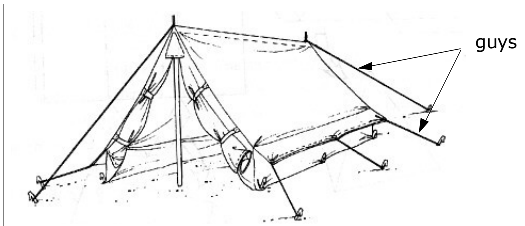


Repeat the process again twice, but each time place the pin at a different location, and mark the position of the plumb line string. Where the three pencil lines cross is the centre of gravity of the shape.

Some rules for stability:

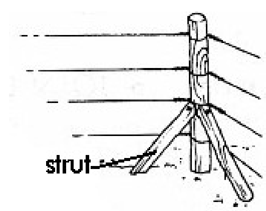
- **A low centre of gravity.**
- A **wide base** is generally more stable than a structure with narrow base.
- The **weight at the top** of the structure should by less that the weight at the bottom.
- using **struts**, **guys** and **stays** to hold it
- using a **foundation**

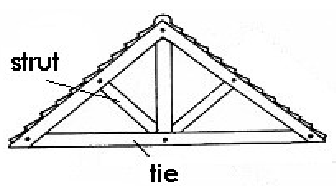
It is not always possible to design structures that comply with these rules, and therefore sometimes special measures should be taken to make a structure stable. The tower crane is a long slender structure with a very thin base, and a very wide top. It has a large load to carry at the top at one end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



GUYS
Structures like 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.

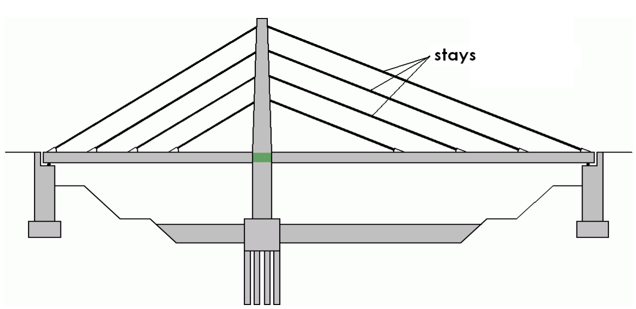
STRUTS and TIES
All structures have forces acting on them. Ties, guys and struts are structural members used to make structures stable. The part of the structure that has a tensile force acting on it is called a TIE and the part that has a compressive force acting on it is called a STRUT.

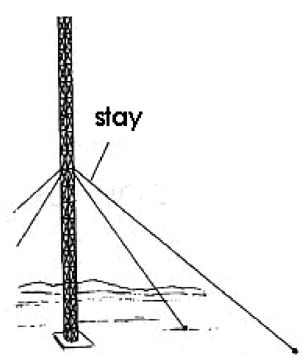




A **tie** (usually inflexible) holds other members in place by pulling on them. Many frame structures have members called struts (always inflexible). Struts hold members in position by pushing against them. Struts are made of materials like wood or steel which do not bend.

STAYS are cables used to secure a mast (to keep a mast in place). Cable stayed bridges make use of stays as well as some pylons or high towers.

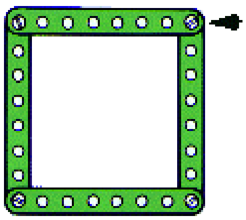


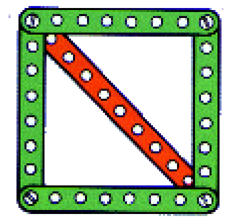


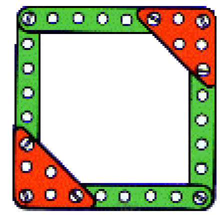
The design of structures

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 Structures Rigid



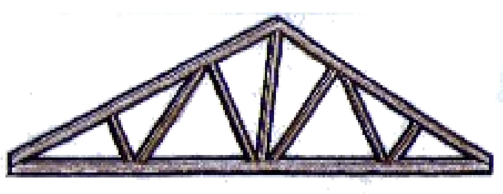




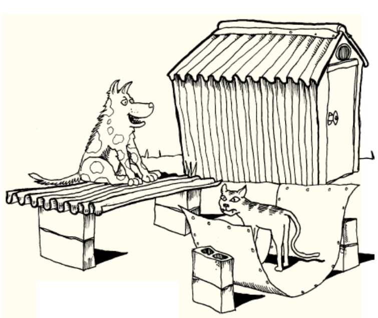
When forces are applied to a simple four-sided structure it can be forced out of shape quite easily. A structure which behaves in this way is said to be non-rigid.

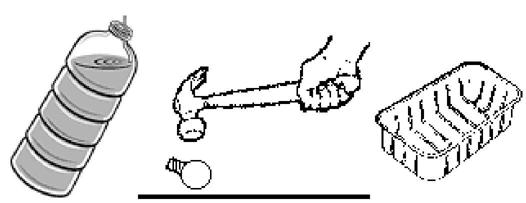
By adding an extra bar or member (usually a strut) corners A and B are prevented from moving apart. The structure then cannot be be forced out of shape, and is said to be rigid. Notice that the additional member has formed two triangles in the structure.

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.



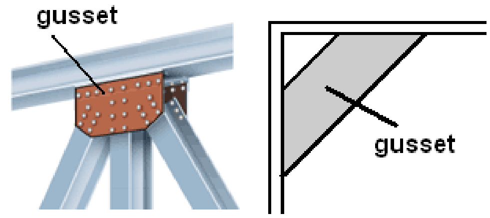
Framed structures achieve most of their strength and rigidity from the way they are assembled. Most frameworks are built using a combination of struts and ties to make triangles. Triangles make very strong and rigid structures. Using triangles in this way is called **triangulation**.

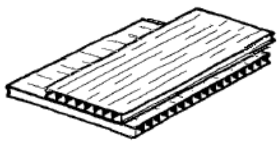




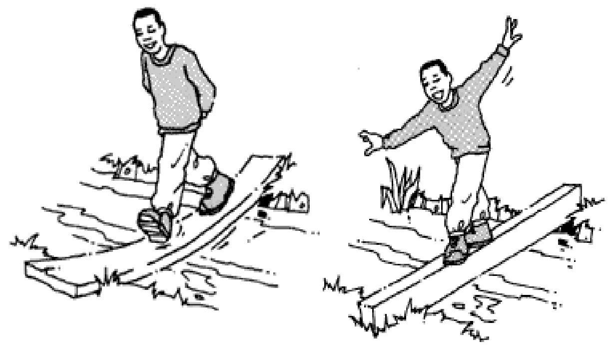
Most shell structures achieve their strength and rigidity from the way they are shaped. Shell structures very rarely have large flat surfaces they tend to be designed and made with ribs to act as stiffeners. Egg and light bulbs containers are good examples. Both eggs and light bulbs can withstand considerable static forces if they are applied carefully. The same principle is used for corrugated iron.

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





Materials which are used to make structures, can be reinforced by using it in a different position. If two stripsof 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 the wood is glued together at an angle of 90°. A beam is also stronger when it is used in an upright position rather than flat.

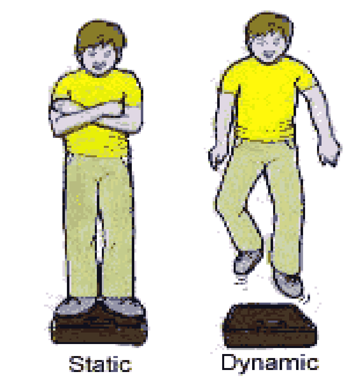


Forces

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.

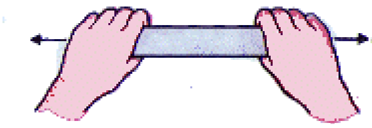


An **external force** is a force placed on the structure from outside, by the wind perhaps or perhaps by someone sitting or standing on it.

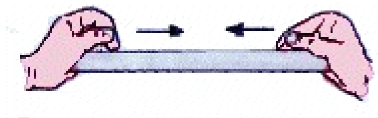
Internal forces are the forces which the structure must provide within itself to resist the external forces placed upon it. If the external forces are greater than the internal forces, a structure will collapse.

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.



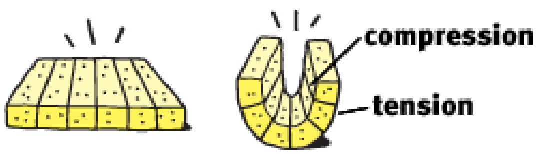
Tension : Is a force which tries to pull something apart. A structural member in tension is called a tie. A tie resists tensile stress.

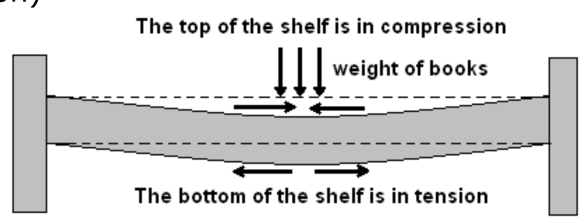


Compression : Is a force which tries to squash something together. A structural member in compression is called a strut. A strut resists compressive stress.

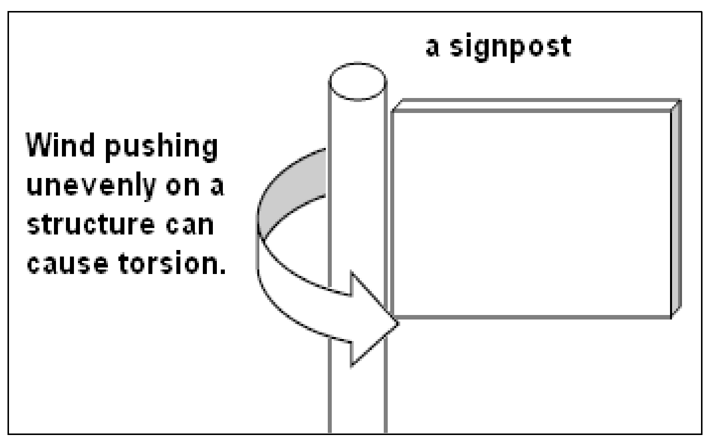
Bending : Bending is a word you will have met before. A structure which is subjected to bending is being stretched and squashed at the same time.

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)

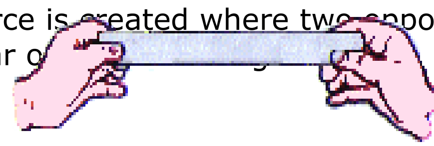




Torsion : Is the name given to a turning or a twisting force.

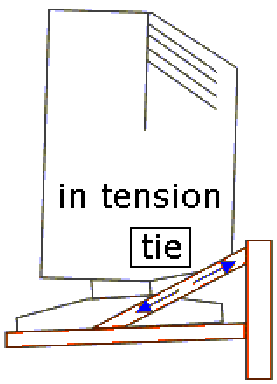


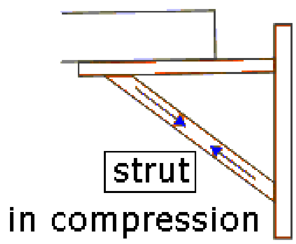
Shear : A shear force is created where two opposite forces try to cut tear o

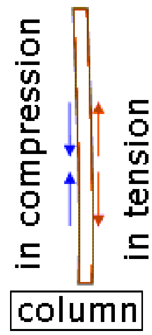


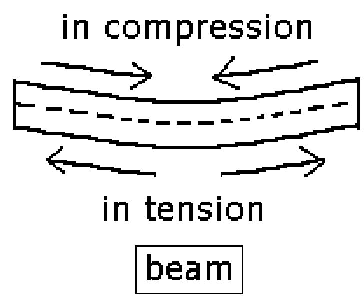
Identifying structural members

Under load, a **beam's** top surface is pushed down or **compressed** while the bottom edge is stretched or placed under **tension**, the same happens to a **column** - one side will be in **tension** and the other side in **compression**. **Struts** are always in **compression** and **ties** are always in **tension**.

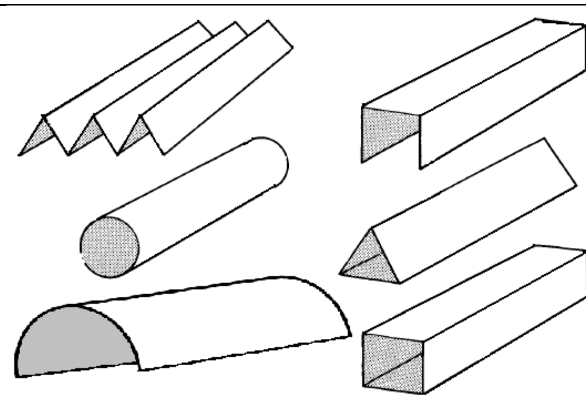






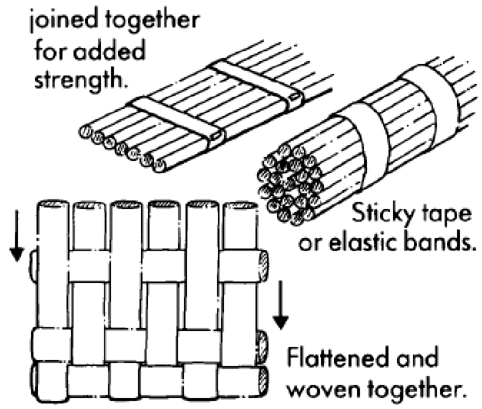


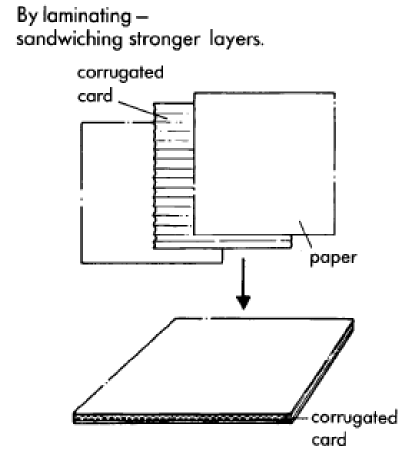
Paper Structures

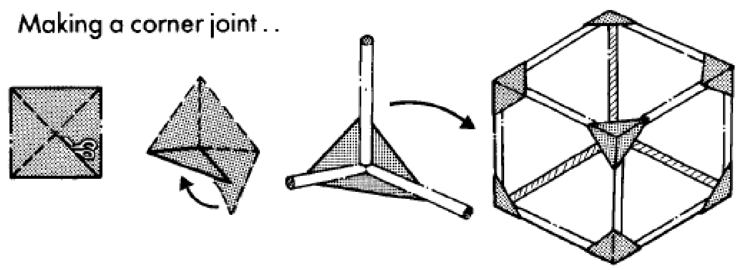
What shapes are the strongest? Use paper and fold 3-D shapes as shown to the right. Determine which shapes will be the strongest. Use the shapes as beams and columns and see which can hold the biggest load. Try to make these shapes stronger, by reinforcing the paper and / or the structure.	

Help with structure building

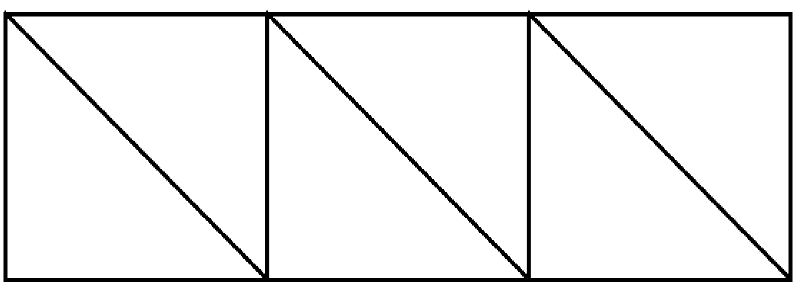
Strengthening

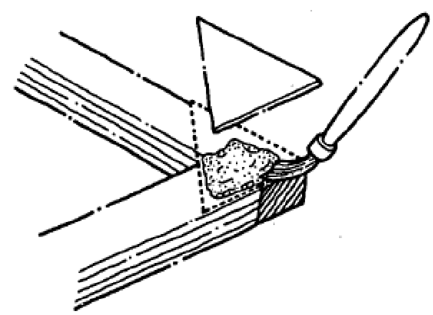




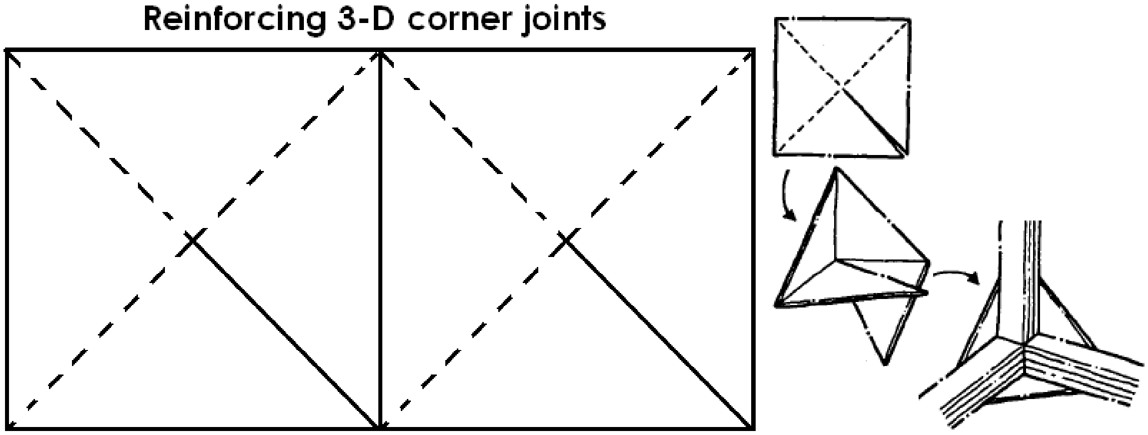


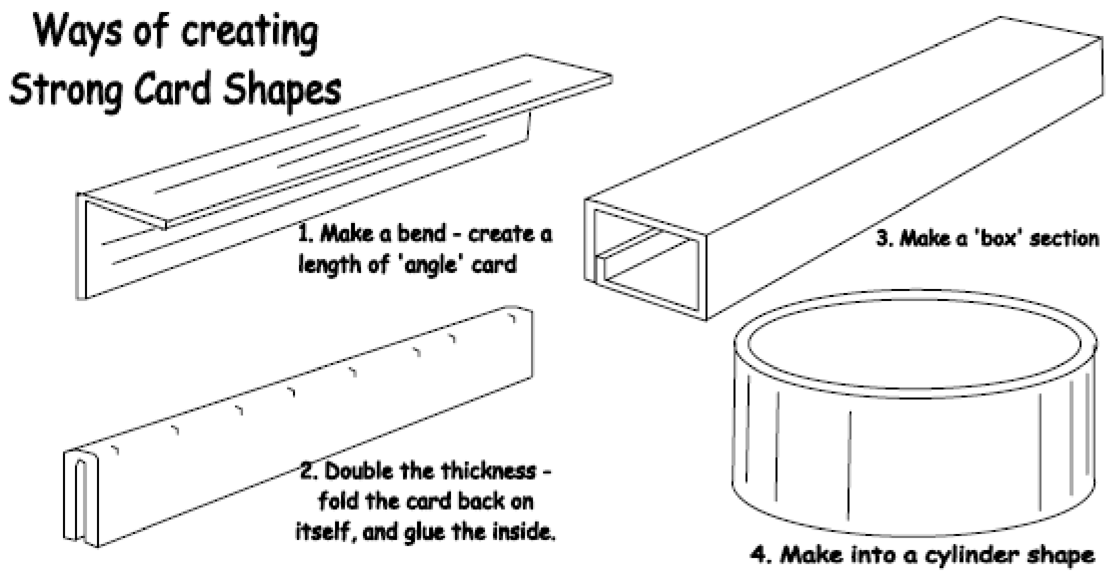
Reinforcing 2-D corner joints

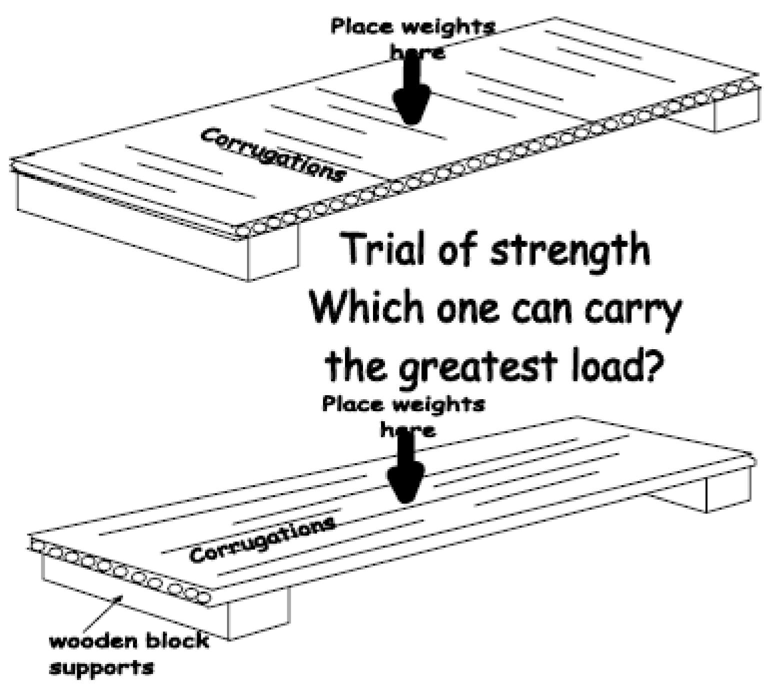




Reinforcing 3-D corner joints




Ways of creating
Strong Card Shapes
1. Make a bend - create a length of 'angle' card
2. Double the thickness - fold the card back on itself, and glue the inside.
3. Make a 'box' section
4. Make into a cylinder shape


Place weights here
Corrugations
Trial of strength
Which one can carry the greatest load?
Place weights here
Corrugations
wooden block supports

Processing

Since the earliest times people used different materials to make articles. Cothes were made of animal skins, hammers were made of sticks and stones. Over the ages people learnt how to process materials to fulfill certain needs. Bones and stones were sharpened against rough surfaces to make knives and needles. Textiles were woven from wool. The development of technology created thousands of processing possibilities. Nylon is one of the first sinthetic textiles which today has countless uses.

We are going to investigate different materials and how it can be processed to enhance its properties or to adapt it for specific uses.

Materials

Materials can be natural or manmade. Natural materials come from plants, animals or minerals.

Properties of materials

One of the most important questions that should be asked, before a product can be made, is what material will be used. Materials are chosen based on their properties and the purpose for which the product will be used. You would, for example not use paper to make an umbrella, since an umbrella must be water resistant..

- **Stiffness**: how little distortion or deflection occurs when 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**: can be stretched out of shape, but will return to original shape.
- **Flexibility**: If a material bends easily and does not crack.
- **Plasticity**: After pressing or squashing a material the shape changes permanently.
- **Absorbent**: Materials that suck up water easily.
- **Waterproof**: Materials that seems to push water away, it just runs of the material
- **Corrosion resistant**: resists corrosion (rust) or UV-rays of the sun
- **Heat resistan:** will not burn or acts an insulator against heat
- **Conducts electricity**: lets electricity pass through it
- **Magnetic**: is attracted by a magnet
- **Transparant:** can see through it

Types of materials

Metals

Ferrous metals contain iron which rust and is magnetic. Examples: steel, iron

Non ferrous metals contain no iron, do not rust and is not magnetic. Examples: zinc, copper, silver

When two or more metals are mixed it is called an alloy. Metals are alloyed to obtain properties which are absent from pure metals. Examples of alloys are; brass, a mixture of zinc and copper, stainless steel is a composition of carbon, chrome, nickel and magnesium. Bronze consists of copper and tin.

Wood

Timberwood is very expensive and since it is a natural resource we should not abuse it. There are plantations which are grown with the purpose of supplying wood for wood products and paper. At these plantations fast growing trees are planted.

> 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; they include oak, ash and beech from the temperate zones, and a wide variety of tropical hardwoods such as mahogany, meranti and jelutong. Not all hardwoods are hard - balsa is very soft.

Manufactured board

Manufactured board is made by glueing together layers of woodfibres of veneers. It is usually made with leftover wood and has mainly been developed for industrial use, since it is possible to make many similar sheets of baord.
This type of wood is much cheaper than real wood, but because the appearance is not as attractive as the real thing, a veneer is often glued as a top layer.
Types of manufactured board are: plywood, laminated board, chip board, softboard, fibre board and softboard.

Composite materials

When two or more materials with different properties are combined, they form a composite material. The different materials work together to create a new material, which has the propeties of both. The two materials can clearly be distinguished in the new composite material.

Examples:

<u>Mud and straw bricks</u>
Humans have been using composite materials for a long time in order to build our dwellings. Some of the earliest forms of building were built of mud bricks. Mud bricks work well when they are being compressed (compression forces) but a cake of mud is easily broken if it is bent (bending forces). This is because the act of bending places a tension force on one edge.
At the same time as the mud block buildings were being built other people were making straw dwellings. Straw has a great deal of tensile strength (resistance to pulling forces) but it is very weak when crumpled. These early builders realised was that if straw, which has a good tensile strength was embedded in a block of mud, which has good compressive strength and left to dry the resulting brick would resist both tearing and squeezing. These composite bricks made excellent building materials.

Car tyres
Modern tyres are constructed of layers, which may include rayon cloth, steel bands and nylon belts all set in a matrix (binder) of rubber.

Concrete
Concrete is made from small stones and gravel called aggregate, sharp sand and cement. The small stone and gravel (aggregate) is the reinforcement and the cement is the matrix that binds it together. Concrete has good strength under compression but it is weak in tension. It can be made stronger under tension by adding metal rods, wires, mesh or cables to the composite. The concrete is cast around the rods. This is called reinforced concrete.

Fibreglass
Consists of two distinct materials, a fibres of glass (ceramic), which is the reinforcement and a polymer resin called polyester, which serves as the matrix. The polyester resin polymer alone is brittle and has a low strength but when fibres of glass are embedded in the polymer it becomes strong, tough, resilient and flexible. It becomes an ideal material to make boat hulls, swimming pool linings, car bodies, roofing and furniture.

Textiles

Textiles have been used for clothes and shelters for hundreds of years. Much earlier animal skins and natural textiles like wool, cotton and silk were used. The development of technology has provided a great variety of manmade textiles for the modern day technologist. Examples are nylon, polyester, and acrylics.

Textiles are made by weaving or knitting fibres together, sometimes it is only squashed together and is kept together by the friction between the fibres. Some fabrics consist of layers which are bonded together and covered with plastic layer to make it water resistant. Strength of fabrics depends on the weaving methods and the type of fibre used.
Other properties which are of importance are flexibility, water resistance, ventilation, isolation against heat and cold, wind resistance, shrinking and stain resistance. The properties of fabrics especially the strength, stiffness and tear resistance depends on the direction in which the force is applied.

Packaging:

Thanks to modern technology and the discovery and development of different types of materials, packaging has improved vastly over the years, especially as far as food and perishable products are concerned, it is now much more convenient and safe.

Purpose of packaging:

- protects products against dust, moisture and bacteria
- Keeps the contents together for better transport and handling
- Gives information about the product, instructions, ingredients and sell by dates.
- Acts as advertisement to attract attention of possible customers.

Designing packaging for fruit juice containers:

Specifications for packaging:

- must keep light and oxygen out
- must provide resistance against transport and storing damage
- may not burst open or damage if it falls
- must pour easily
- may not be to expensive
- must be visible and attractive
- must preserve the product

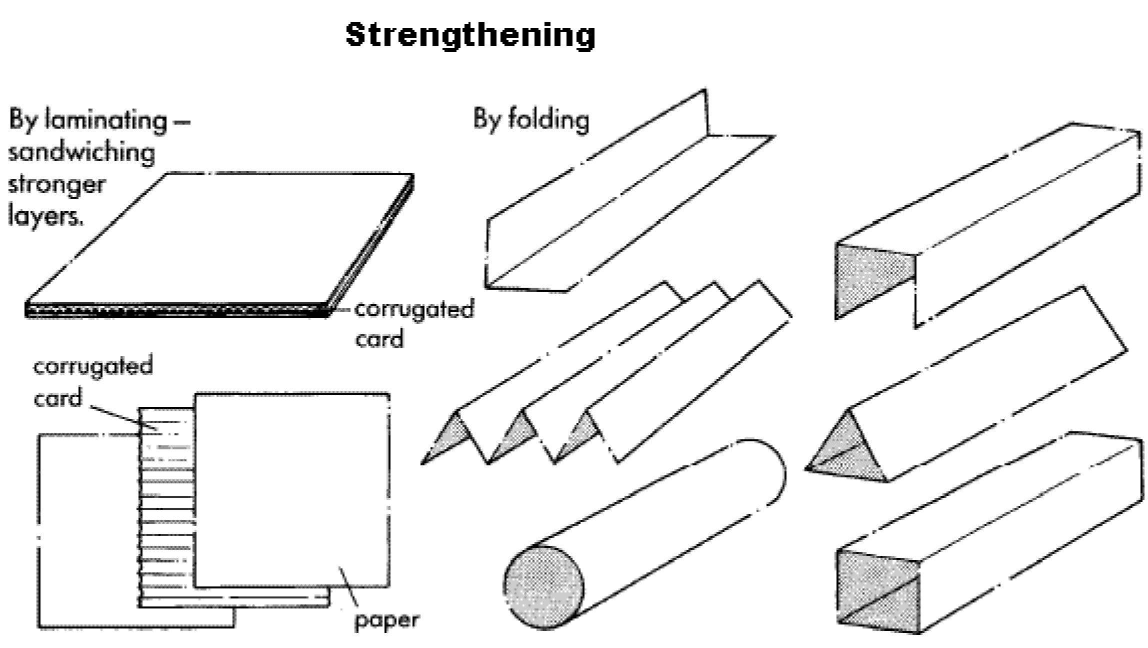
Material which was chosen

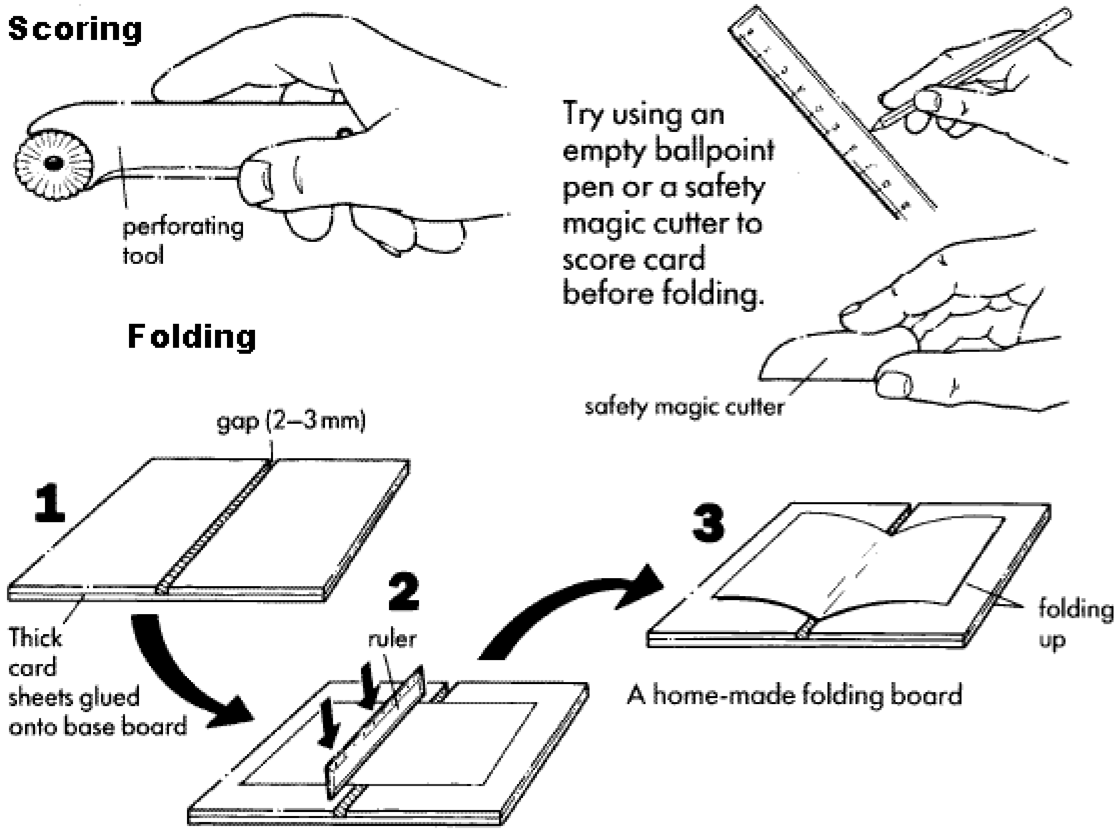
Laminated cardboard boxes. The lamination consisting of:
- paper on the outside, since it can be printed and keep its shape.
- Polyethylene layer on the inside, because it is waterproof.
- Alumnium foil between the polyethylene and paper, because it does not let oxyten of light through.
- The cardboard is light, relatively cheap and can be shaped into a cube, which will take up little space when transported and on shelf displays.

The making of cardboard packaging

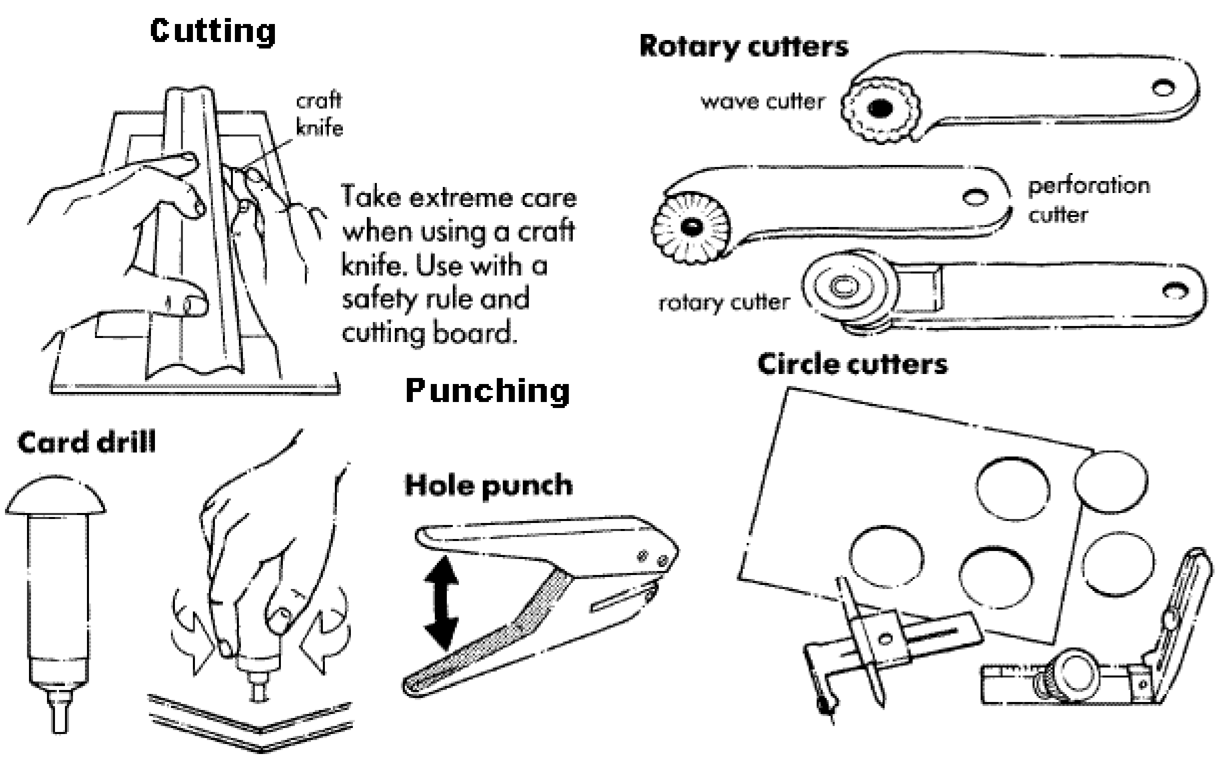
Cardboard packaging is usually made from a single sheet of cardboard which is then cut according to a pattern. Tabs are also cut out to attach the parts to one another. The shape is determined by scoremarks according to which the cardboard is folded.

Help with projects





From S.T.E.P. © Cambridge University Press, 1992. *http://www.sln.org.uk/d&t/Datafile/*



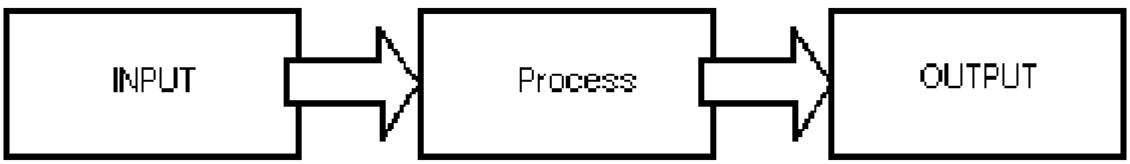
From S.T.E.P. © Cambridge University Press, 1992. *http://www.sln.org.uk/d&t/Datafile/*

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 flow of information or energy from input through the process stage to the output is often called a ***signal.***



The ***energy source*** for 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),*

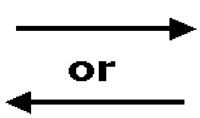
Oil/water under pressure - *(hydraulic systems),*

Air under pressure - *(pneumatic systems),*

Electricity - *(electrical or electronic systems).*

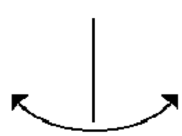
Mechanical Systems

Movement
There are four basic kinds of motion, or movements:

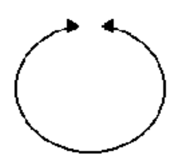


Linear motion
movement in a straight line and in one direction

Reciprocating motion
movement backwards and forwards in a straight line



Oscillating motion
a swinging back and forth



Rotary motion
a circular motion.

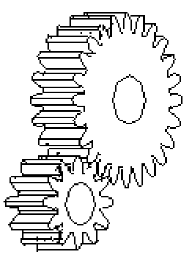
Gears

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 gear . 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.

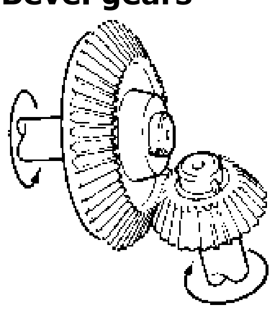
Types of gears

Spur gears

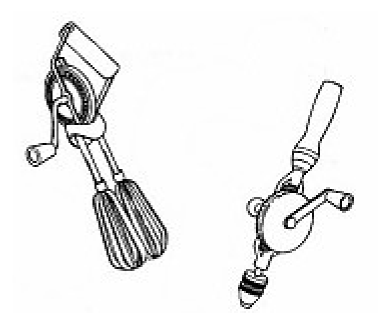


Multiple gears can be connected together to form a gear train. If there are an odd number of gears, the output rotation will be the same direction as the input. If there are an even number, the output will rotate in the opposite direction to the input. Note that for the simple type of gear train shown, 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.

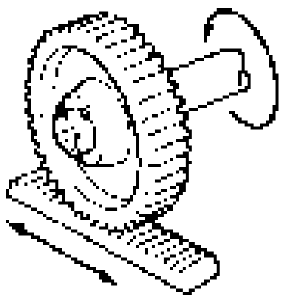
Bevel gears



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



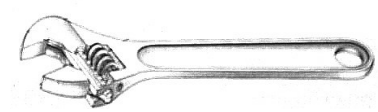
Rack-and-spur gears



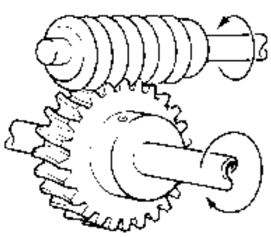
The rack-and-spur gear is used to convert between rotary and linear motion. Often the spur rotates in a fixed position and the rack is free to move - this arrangement is used in the steering mechanism of most cars. Alternatively, the rack may be fixed and the spur rotates moving up and down the rack.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

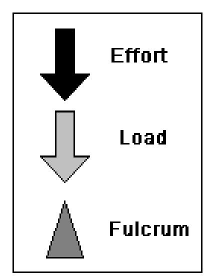


Worm-and-spur gears



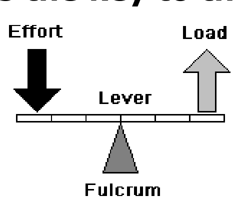
A worm-and-spur gear is often used when a large speed reduction is required and not much power is needed. Unlike ordinary gears, the motion is not reversible, a worm can drive a gear to reduce speed but a gear cannot drive a worm to increase it. The velocity ratio of two adjacent cogs can be calculated 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

Levers



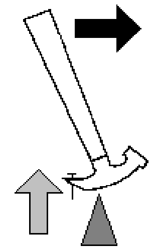
A lever helps you do more work with the strength you already have.
A lever is a simple machine. All tools are combinations of the simple machines. Simple machines are things like: a wheel, a screw, an incline, a pulley or a lever. All levers have 3 parts, or 3 things we can find on them. The fulcrum,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

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

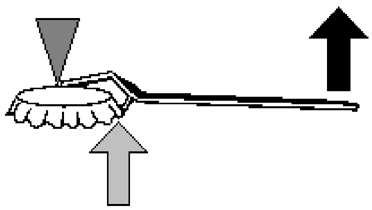


The fulcrum is the place a lever rocks back and forth. You could call it a pivot. When it's right in the middle of the lever, the amount of effort you push down equals exactly the amount of load you can lift with the other end.

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.

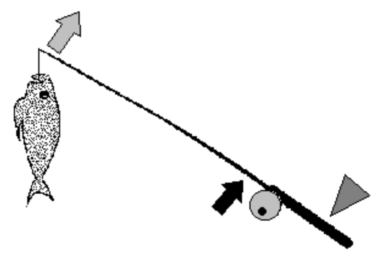


△ L E **Second Class Lever**

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.



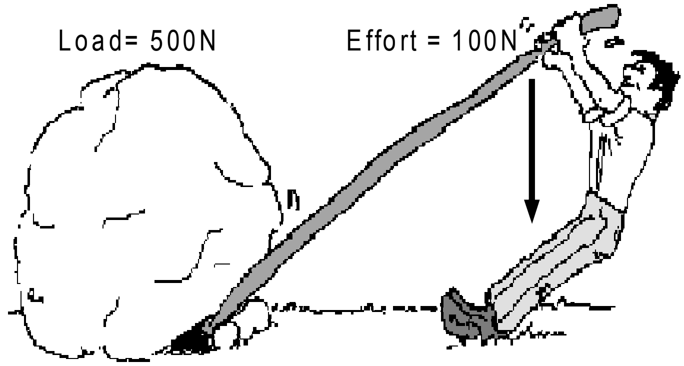
Mechanical Advantage (MA)

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)

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

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

$$= 5$$

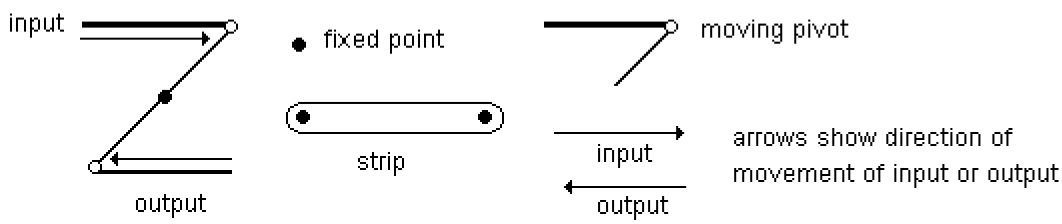


The greater the mechanical advantage, the more help the lever gives you.

Linkages

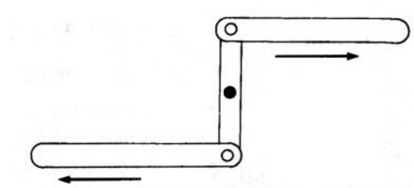
Sometimes a number of different levers are connected together to do certain jobs. A mechanism that is made by connecting levers is called a linkage. A linkage is a system of levers that is used to transmit motion (e.g., nail clippers, back-hoe, and pedal garbage can).
The levers in a linkage are connected at fixed pivots or moving pivots. (Remember, a pivot is another word for fulcrum.) A fixed pivot is one which turns around one point. A moving pivot is one which can move away from its original position.
Linkages are often used to change the direction of force or movement: a push can be changed to a pull, or a pushing movement can be changed to a turning movement. Linkages can also change the distance of movement.

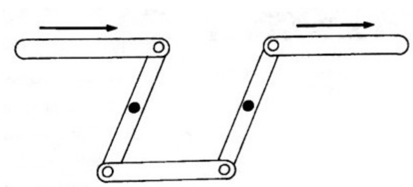
How to draw linkages



Different kinds of linkages

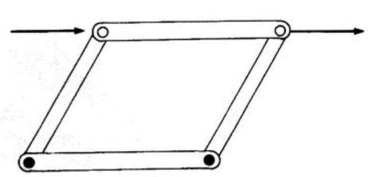
Reversing linkages, reverse the direction of a force or movement. A **push-pull linkage** is used to get an output movement which is in the same direction as the input movement. This type of linkage connects two rods with two fixed pivots. The linkage makes sure that both levers move at the same time in the same direction.

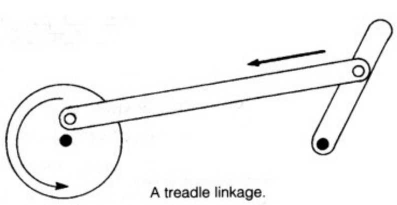

This linkage turns a pull into a push.


A push-pull linkage has centred, fixed pivots.

Linkages can also be used to make objects move together in a line at a fixed distance apart, or to make objects stay parallel to each other.

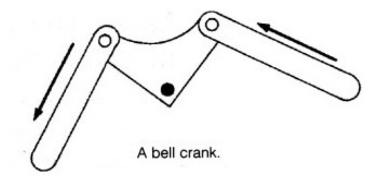
Parallel linkages are used in things such as a tool box. Parallel linkages can also be used to copy or repeat movement, for example folding security doors.

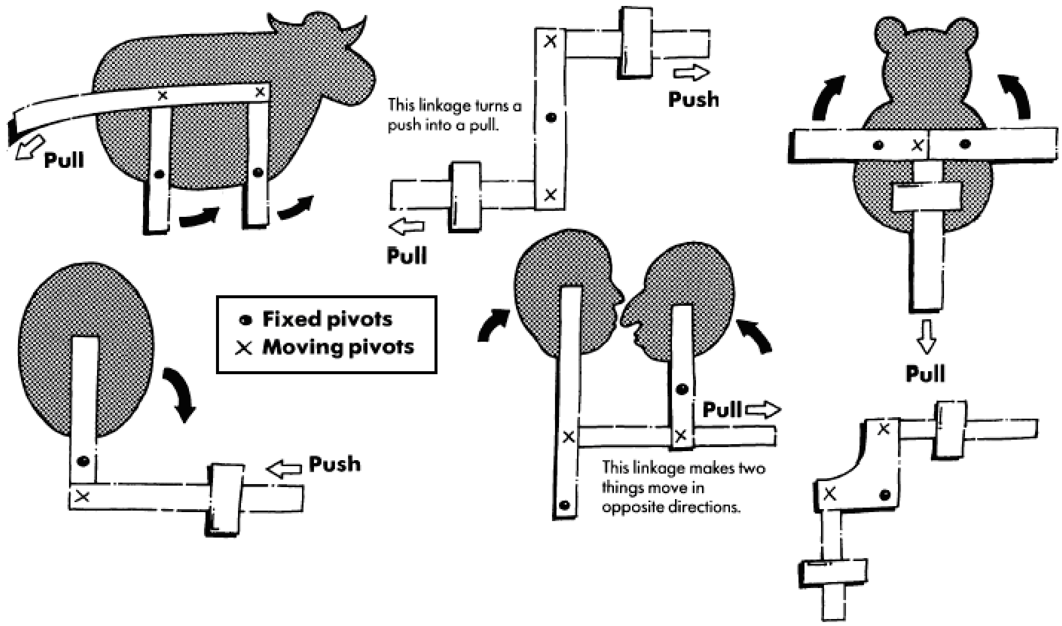

A parallel linkage.


A treadle linkage.

Some linkages changes rotary movement into a to-and-fro movement. Treadle linkages can also change a to-and-fro movement into a rotary movement. Rotary describes something that turns in a circle around a centre point.

Another linkage which rotates around a fixed pivot is a **bell crank**. A bell crank changes the direction of movement through 90°.



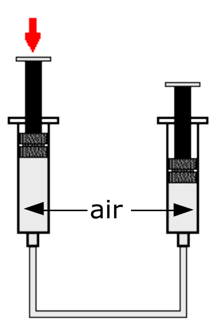


Hydraulics and pneumatics

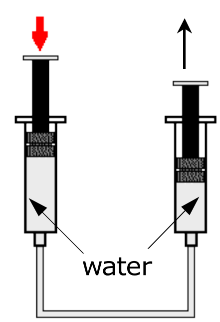
Hydraulics and pneumatic systems basically work in the same way. The only difference is that **hydraulic** systems use an **incompressible liquid** to operate, while **pneumatic** systems use **compressed air** to operate.

How do these two systems really work?

In a **pneumatic system** the second syringe will stay in place to a certain extent when the first syringe is pushed down because air is compressible.



In a **hydraulic system** the second syringe will move upwards, when the first syringe is pushed down, even though it is held down because liquid can not be compressed.



Pneumatic systems

Any machine that uses compressed air to do work is a pneumatic system. Compressed air is air that has been forced into a small space. You compress air every time you pump up a bicycle tyre or blow up a balloon. In industry, air is compressed by machines called compressors.
Bus doors are opened and closed using a pneumatic system. The piston in the system moves in and out in a straight line, but is connected to a lever system that makes the door swing open and closed. The hissing sound you hear when the doors open and close is the movement of compressed air. **Car hoists** that lift cars in workshops are also operated by pneumatic systems. **Pneumatic wheel spanners** and **jackhammers** are also examples of pneumatic systems.

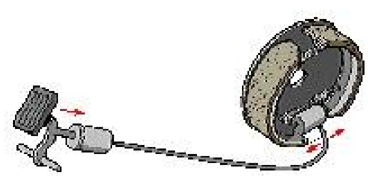
Components of a pneumatic system:

- A supply of compressed air, usually from a compressor
- Air lines containing the compressed air
- Cylinders with pistons for producing force and movement
- Valves that control the flow of compressed air

Hydraulic systems

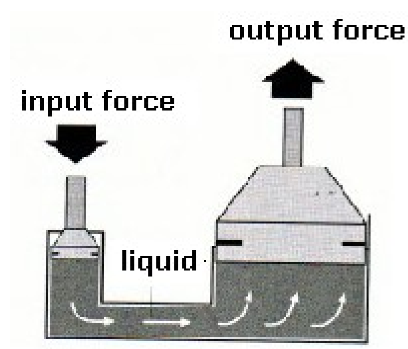
Principles of hydraulics
Hydraulics is based on the principle that a force is transmitted through a liquid. This means that if a liquid, such as water or oil, is in a cylinder or tube, a force applied to the liquid at one end will be passed through the liquid. The force will then be exerted by the liquid at the other end. This happens because a liquid cannot be compressed.

Brakes on many vehicles make use of hydraulic systems. To slow down the car, the driver steps on the brake pedal. This pedal pushes a piston into the hydraulic system, which is filled with brake fluid, this causes pressure in the brake fluid. The force is then transmitted equally to all the wheels. This exerts a force on the brake pads in each wheel which press against the rotating disc inside the car's wheels. The wheel slows down and the car eventually stops.



Syringes of different sizes

If the area of the disc of the output piston or pistons is the same size as the area of the input piston, then the output force is equal to the input force. But if the area of the output pistons is larger (say three times larger) than the input piston, then the output force is also larger (in this case three times larger). If the area of the output piston is half of the area of the input piston, then the output force is half of the input force.



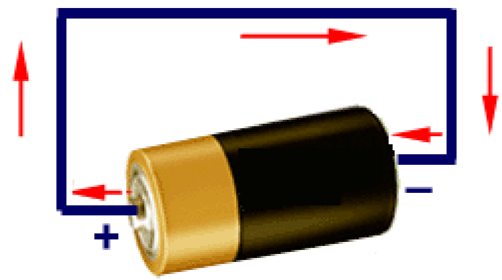
Electricity

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.

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**.



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.

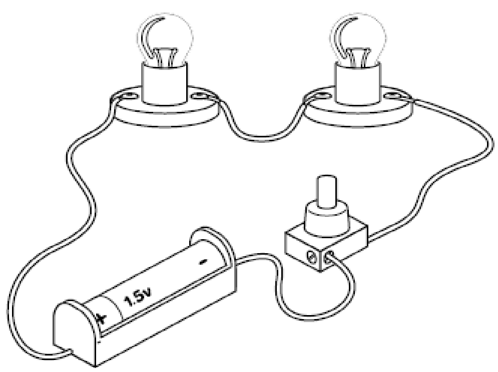
Types of current

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.

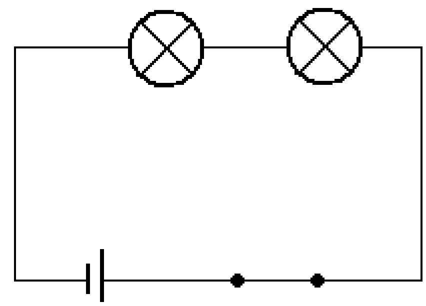
Direct current (DC) is electrical current which flows consistently in one direction. The current that flows in a flashlight or another appliance running on batteries is direct current.

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

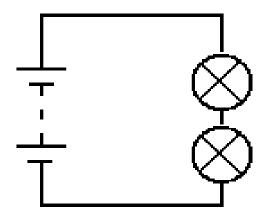


Circuit diagram

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.

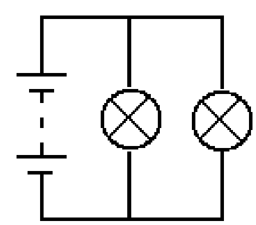
Series circuit

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.

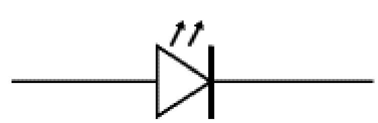
Resistance

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**.

Electrical Components

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.



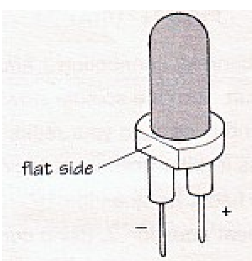
How to connect an LED in a circuit

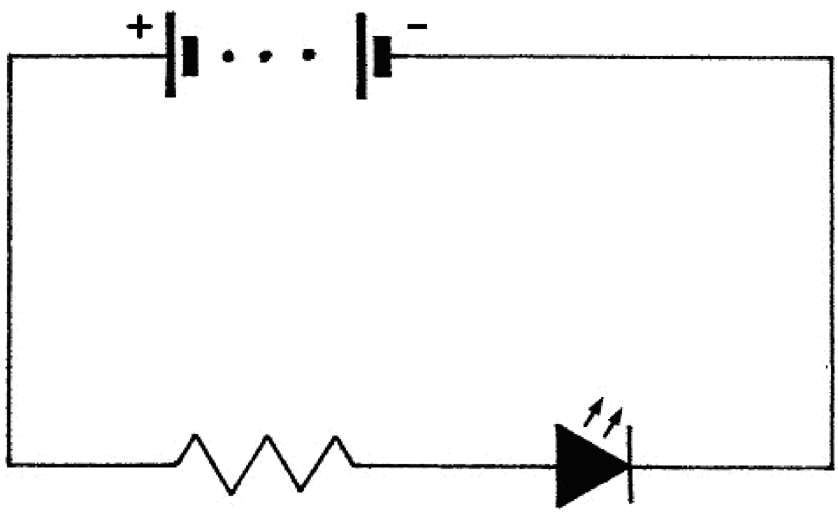
Take care

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.

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.

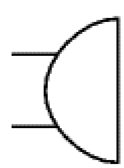
1. An LED has a flat side to indicate which way round it should be connected. The flat side must be facing the negative terminal of the battery.
2. The circuit diagram below shows how to connect an LED in a circuit.



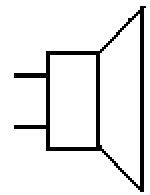


Buzzer

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 (+).



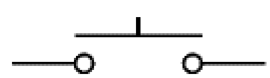
Loudspeaker
Speakers convert an electrical signal to sound



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.



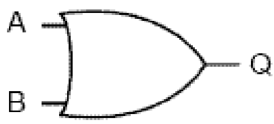
Using switches to control electric current

Switches are used to control electric current. For example, a radio broadcaster in a studio uses switches to change from one sound source to another. You use a switch to turn a radio on or off. A switch is designed to break the flow of electric current in a circuit. There are several different types of switches. They all do the same job of breaking the flow of electric current, but they do it in different ways.

Logic Functions

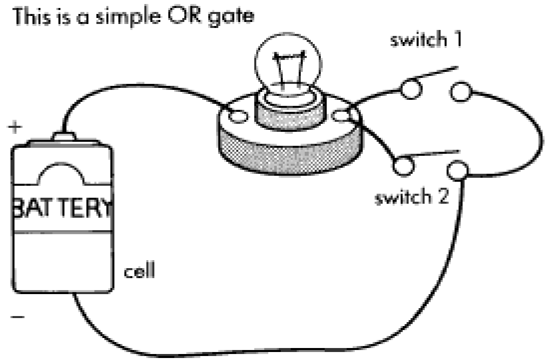
Logic gates are components used to make decisions in circuits. The inputs can be connected to various sensors, and circuits can be designed to operate when certain conditions are met. When using logic, we refer to **ON** as a '1' and **OFF** as a '0'. Each gate has its own rule it follows to produce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

OR gate



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

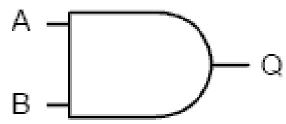
This is a simple OR gate



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

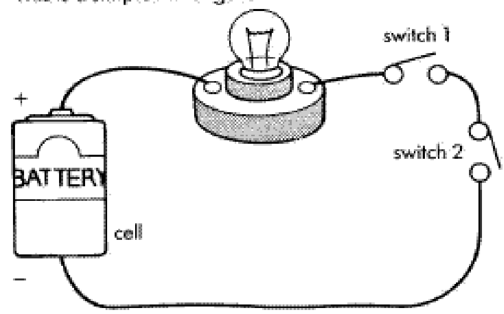
Rule:
Output is **on** if A **AND** B are on

AND gate



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

This is a simple AND gate

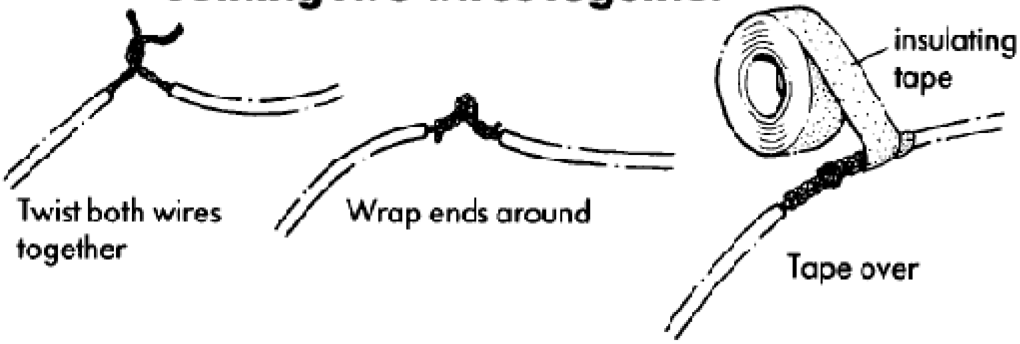


The bulb will light up if switch 1 *and* switch 2 are pressed.

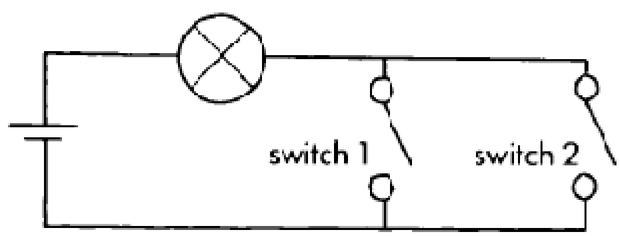
Rule:
Output is **on** if A **OR** B are on

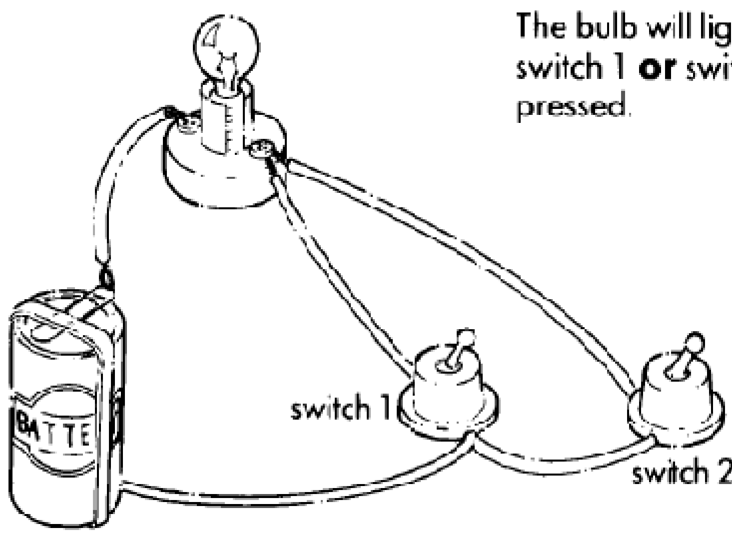
Some tips to help with your project:

Joining two wires together



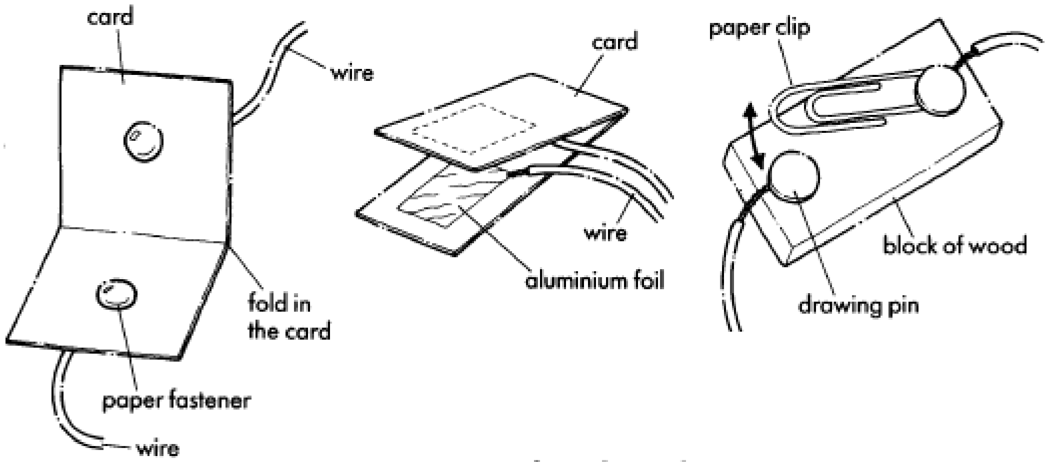
OR gate



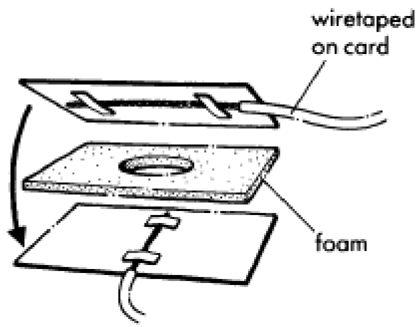


The bulb will light up if switch 1 **or** switch 2 is pressed.

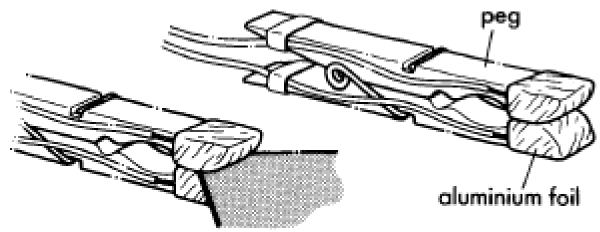
Home-made switches



Push to make switch

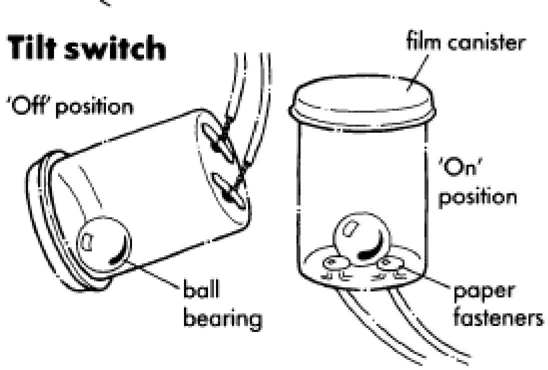


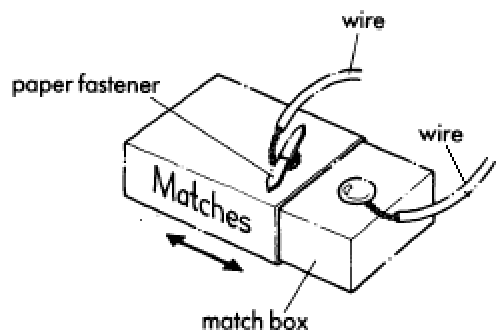
Push to break switch



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 Drawings

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.

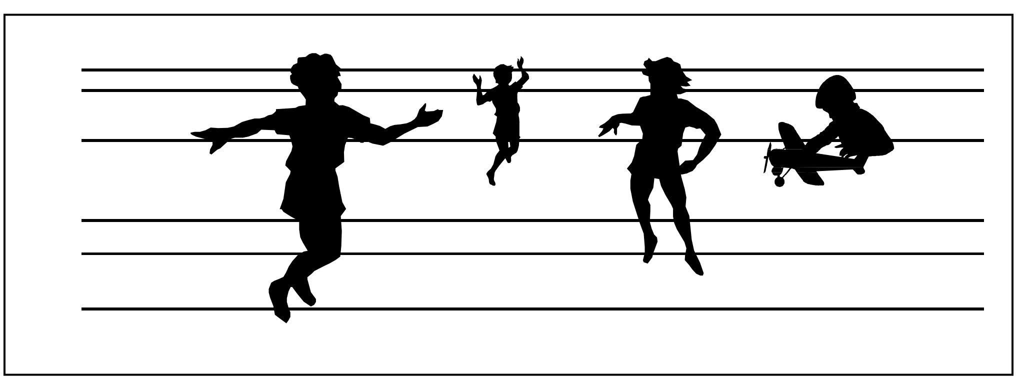
Perspective

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).

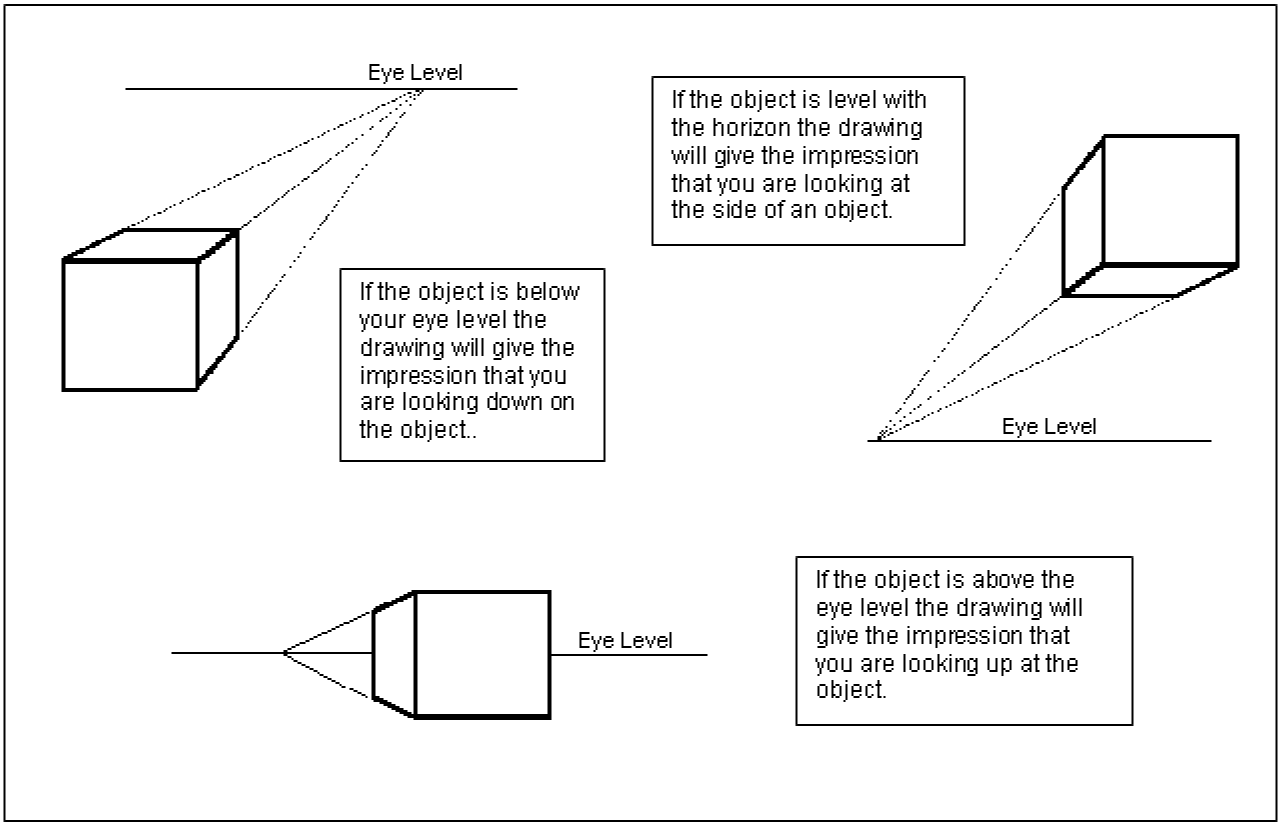
Some points to keep in mind:

- 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.

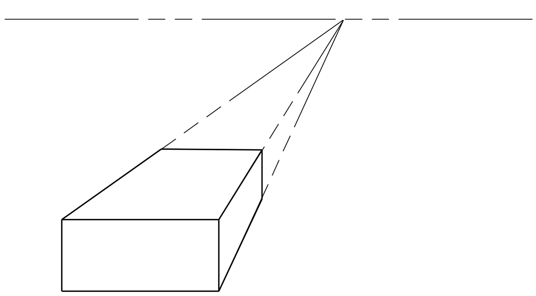
To show depth, all the eyes are on the horizon line and figures decrease in size in relation to the distance from the observer. Sitting figures are placed slightly lower than the horizon line.

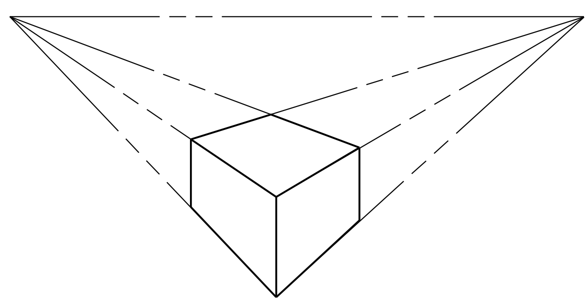


Single point perspective



Two point perspective





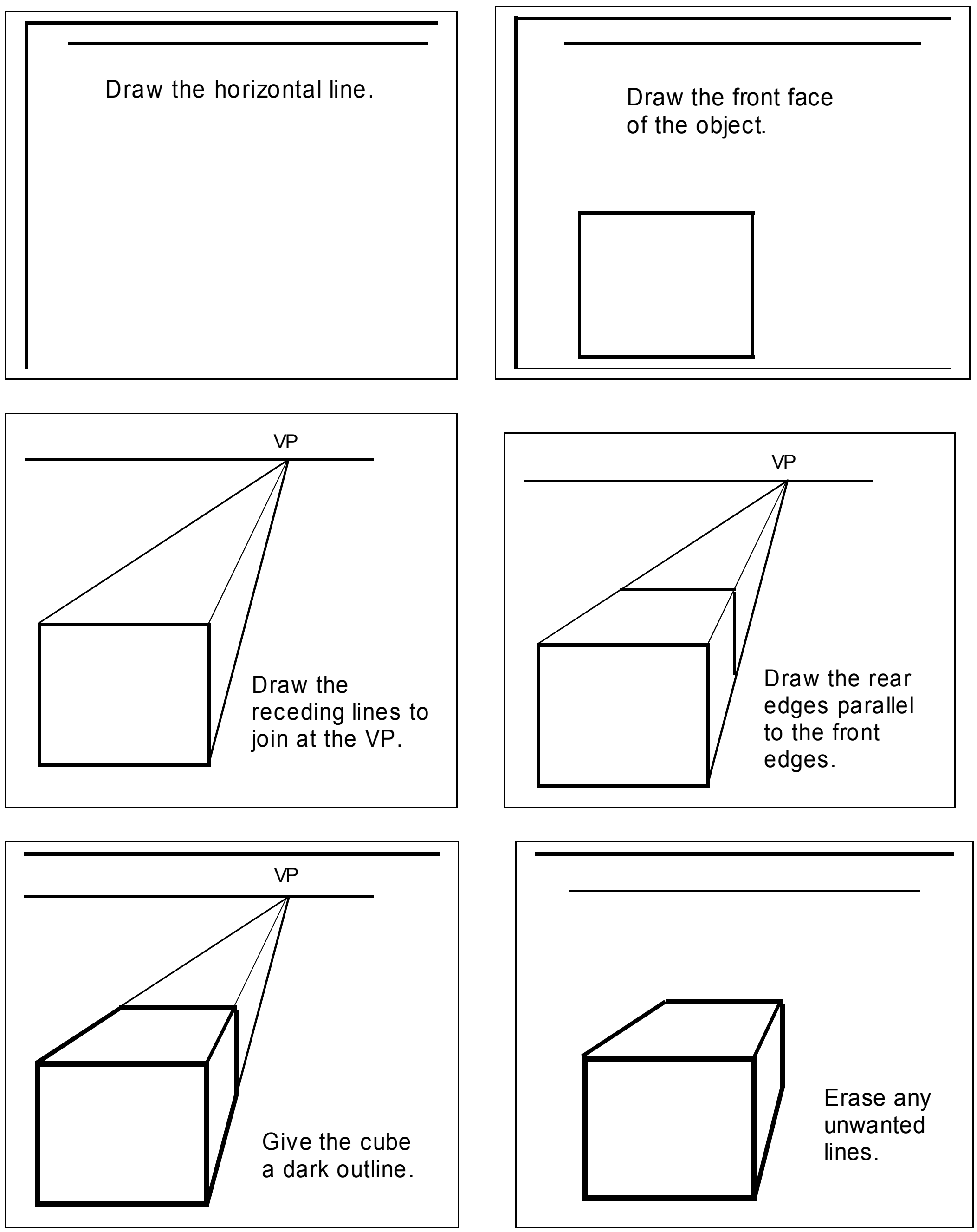
Single point

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.

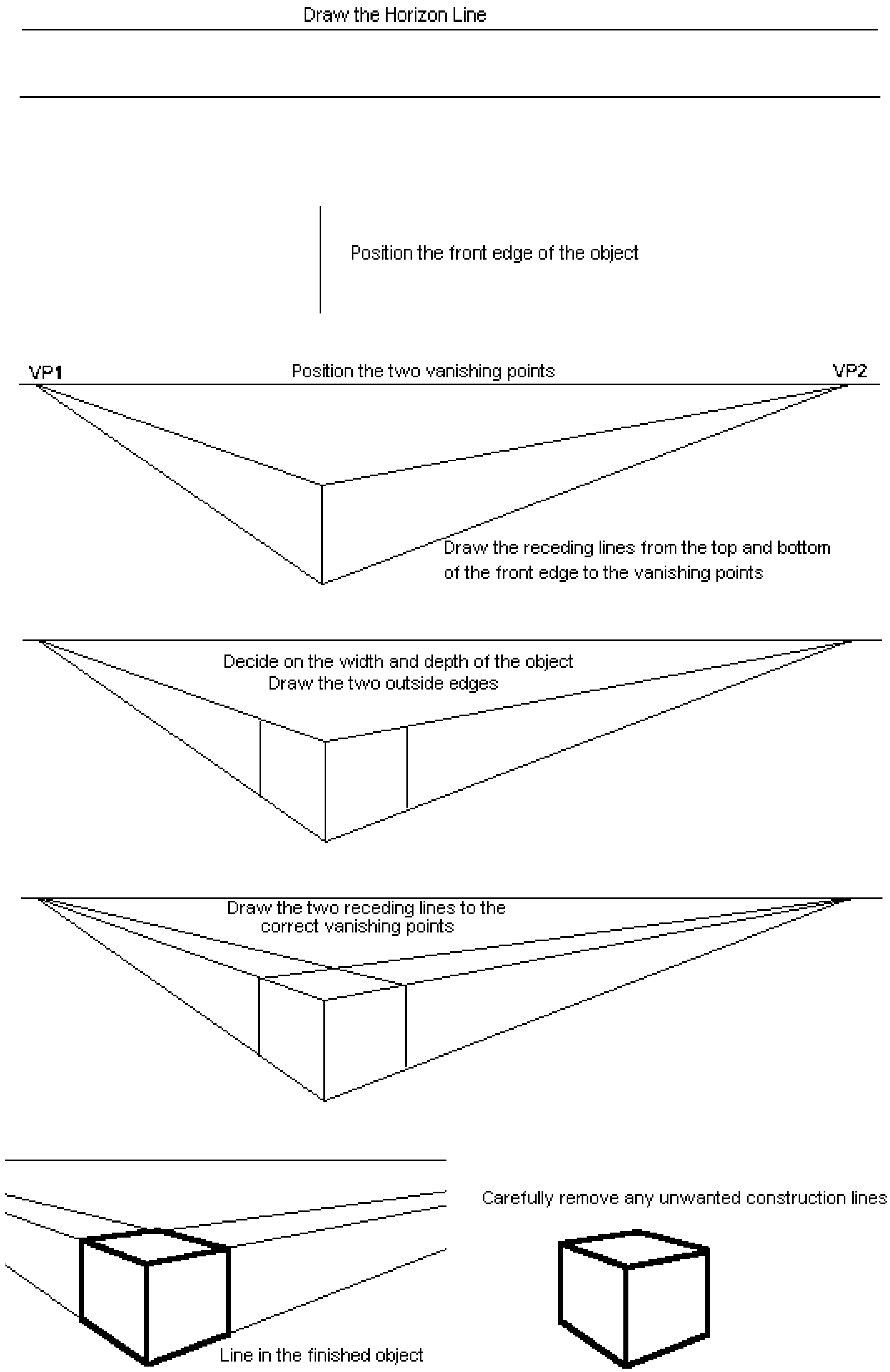
Two point

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 draw in single point perspective:



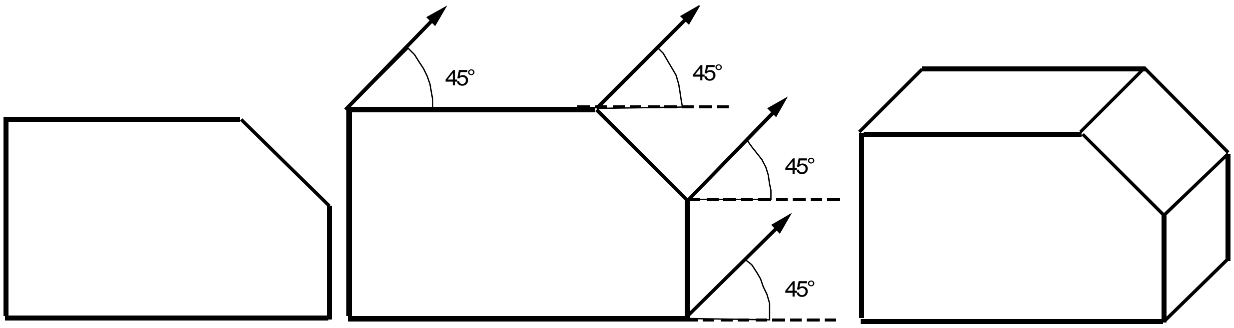
How to draw in double-point perspective:



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.

How to do freehand 3-D drawings

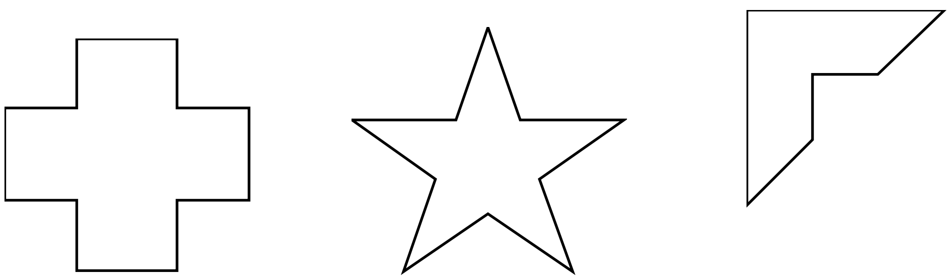


Step1 - Draw the flat front view of the object.

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!

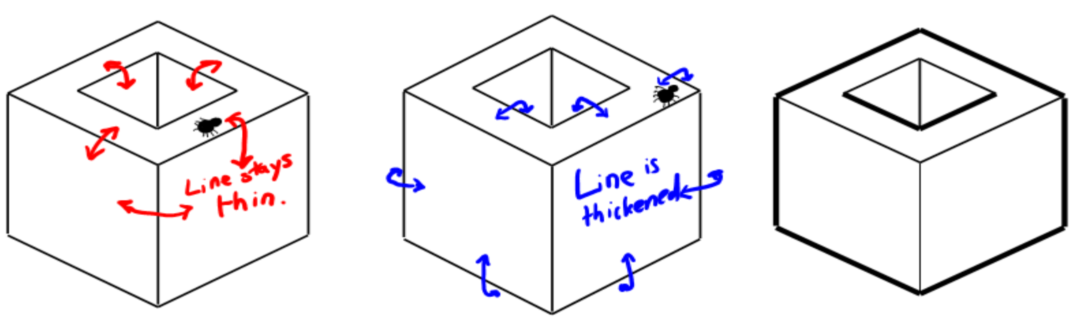
Try drawing these shapes as 3-D objects. Follow the guidelines given above.



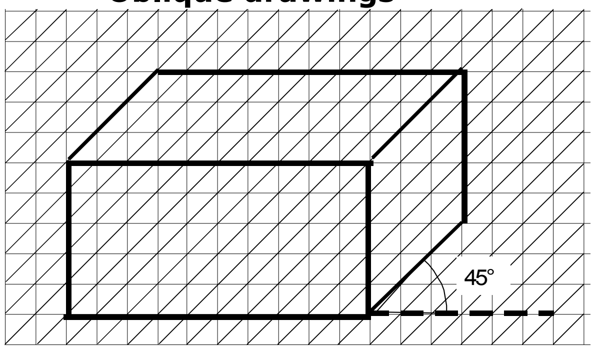
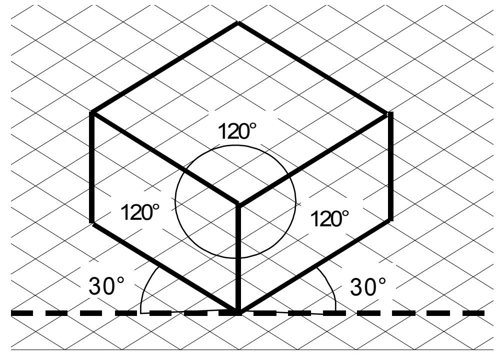
Thick and thin lines

How does it work?

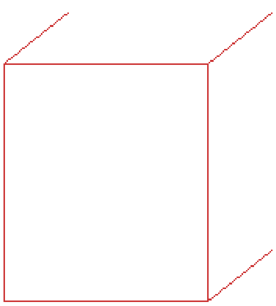
If the spider crawls over the edge and you can still see it, the line is drawn **thin**.
If it crawls over the edge and you can't see it anymore, the line is drawn **thick**.



Oblique and Isometric Drawings

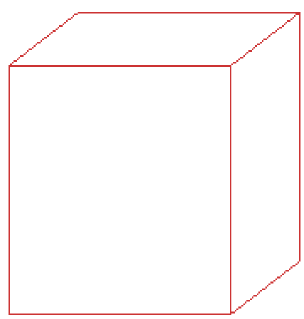
Oblique drawings	Isometric drawings
	
Oblique projection is created by drawing one side of the object facing the observer. This side is always drawn as a true shape. The receding lines are usually drawn at 45° .	An isometric projection is constructed from 3 axes created by dividing a circle into 3 equal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

Oblique projection



Step 1:

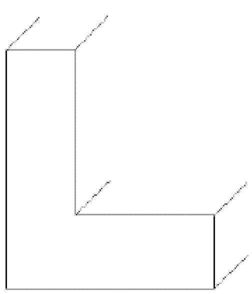
Draw the front view and project 45 degrees lines from each corner

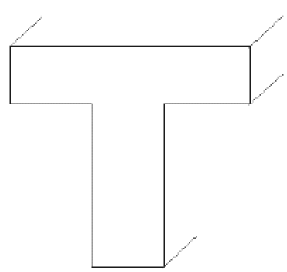


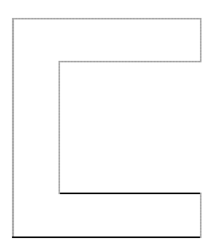
Step 2:

Draw the back two lines of the cube in position.

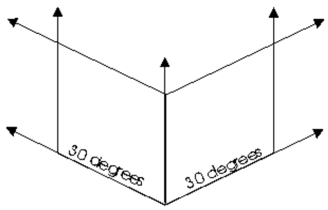
Complete the three shapes shown below - in oblique projection.



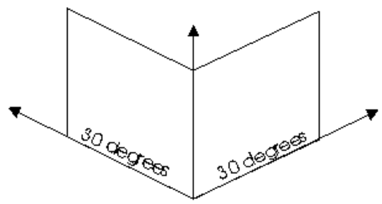




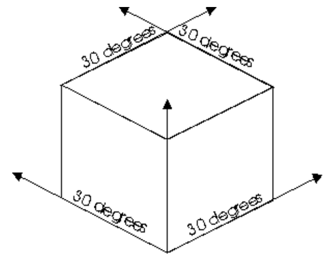
Isometric projection



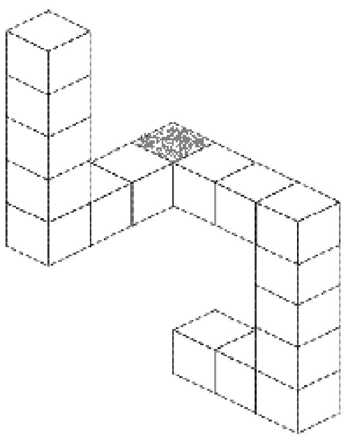
Step 1:
Use the guidelines to draw the left and right sides of the cube.

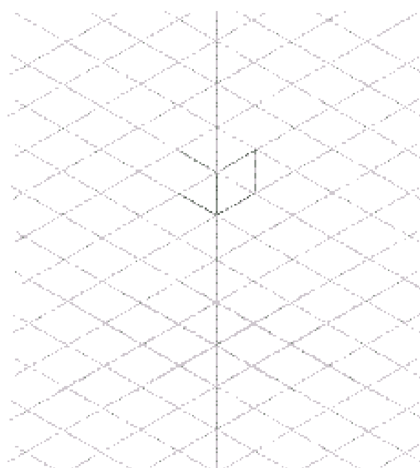


Step 2:
Draw the two sides parallel to the center guideline



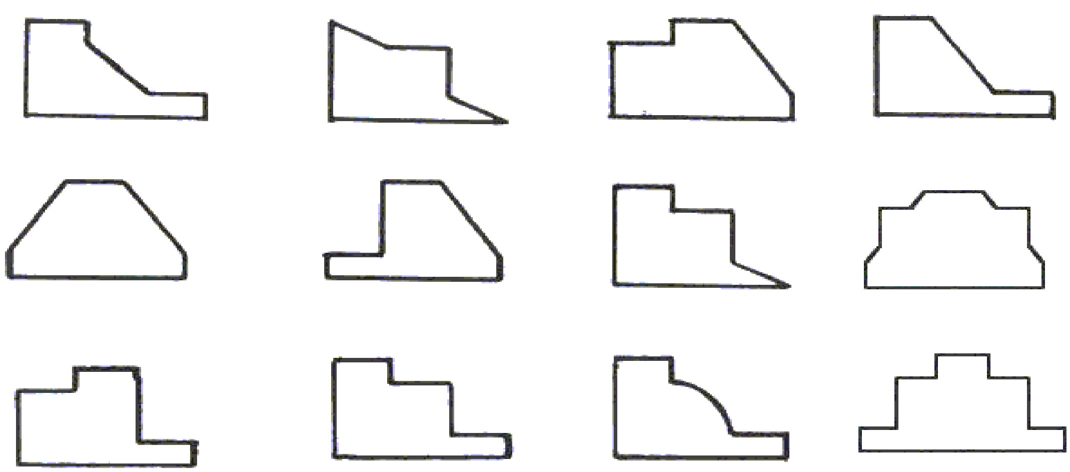
Step 3:
Complete the top of the cube by projecting 30° lines as shown above.





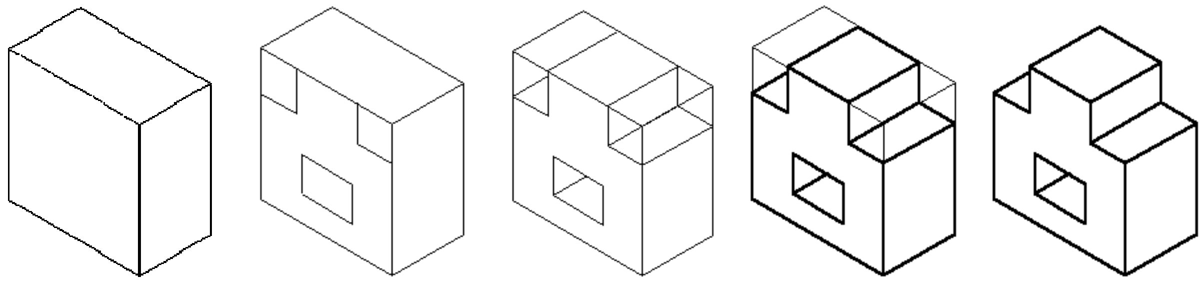
Use the grid to help you draw the isometric shape based on the cube. The first cube (the shaded one) is partly drawn to help you start.

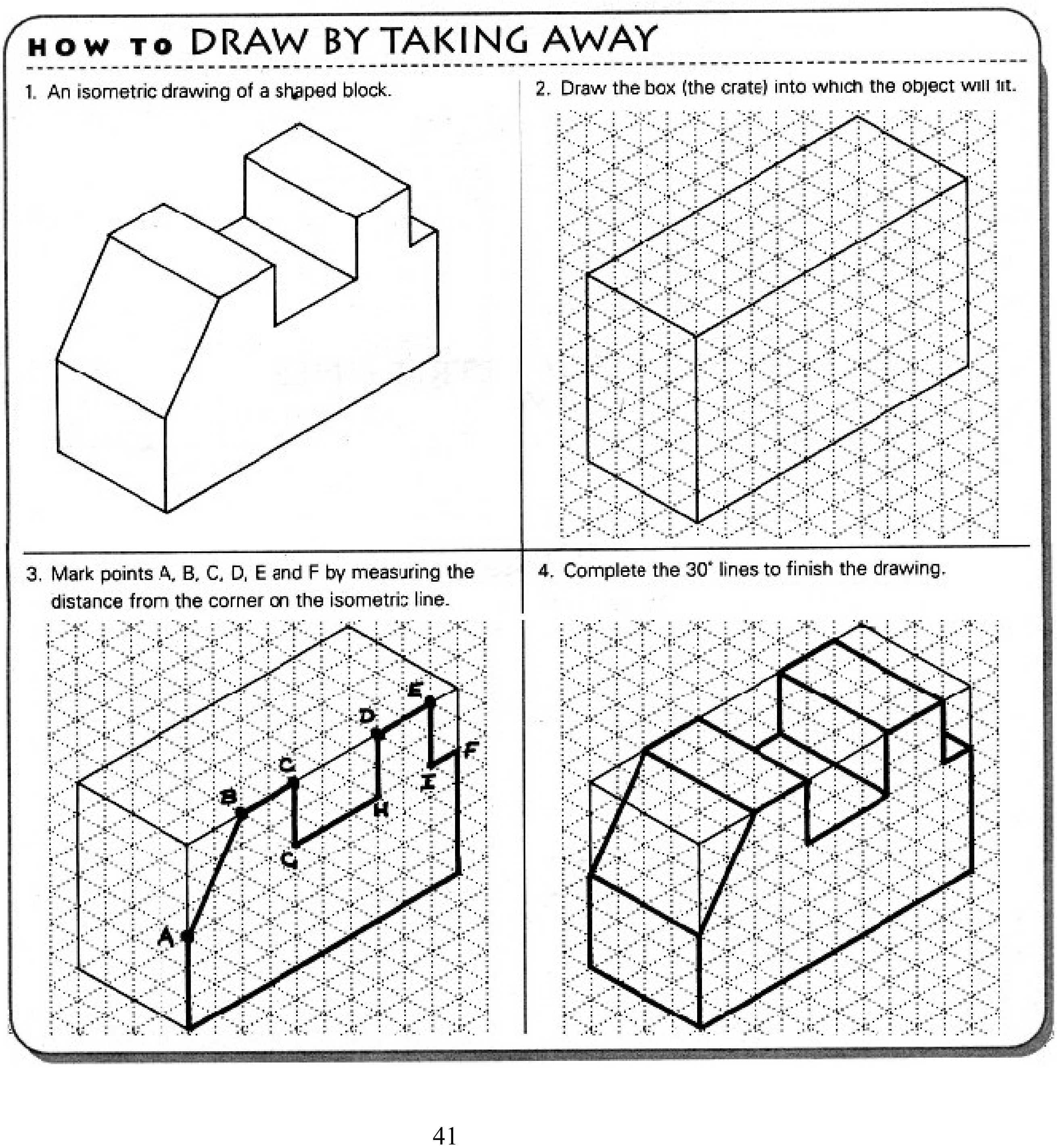
Draw these shapes on oblique and isometric grids.



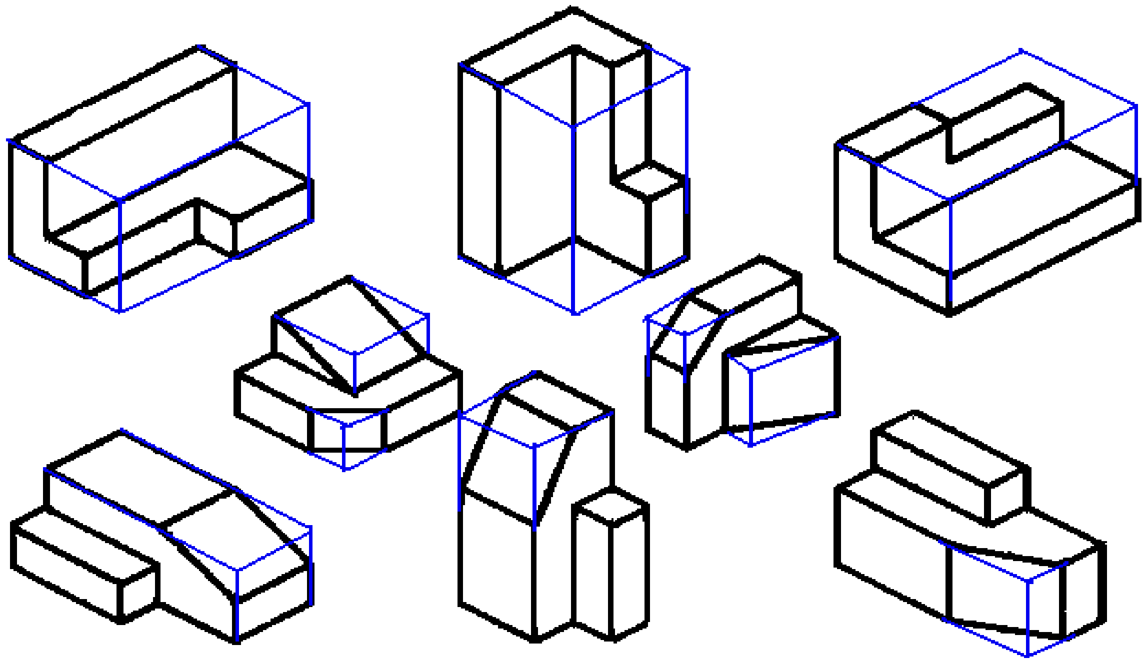
Crating

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.



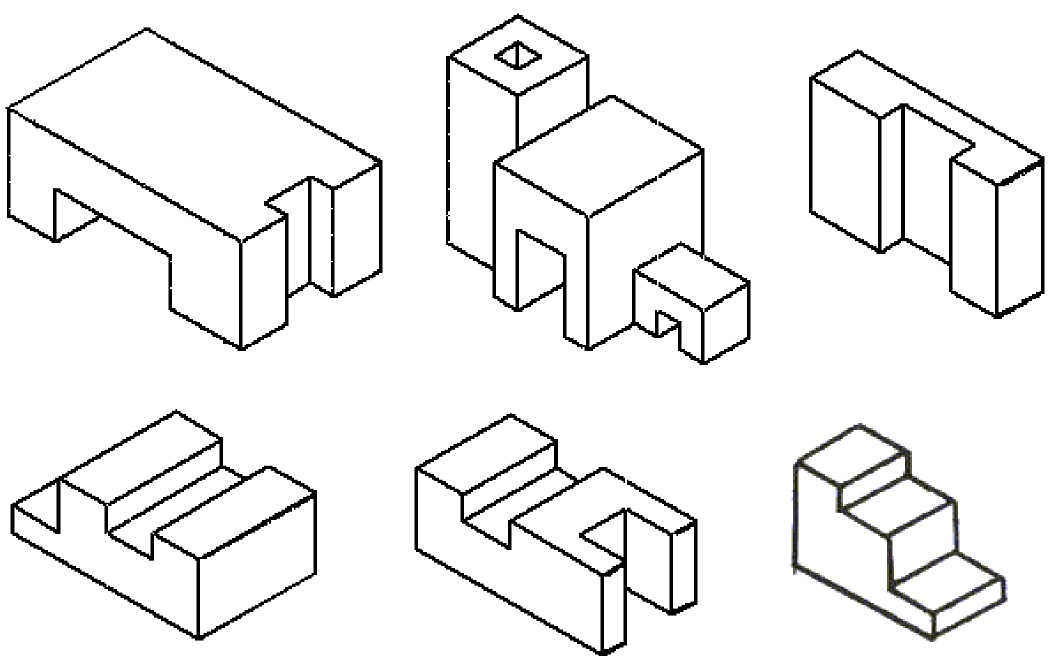


Draw these shapes using the crating method.



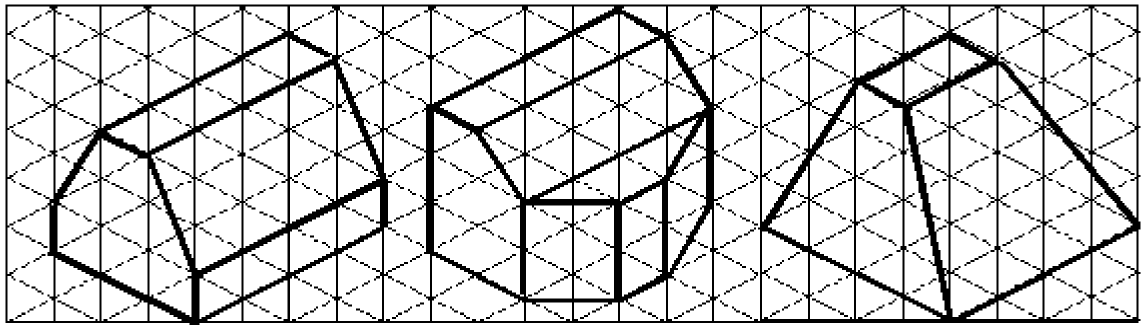
Drawing shapes with straight lines

Draw these shapes on oblique and isometric grids.

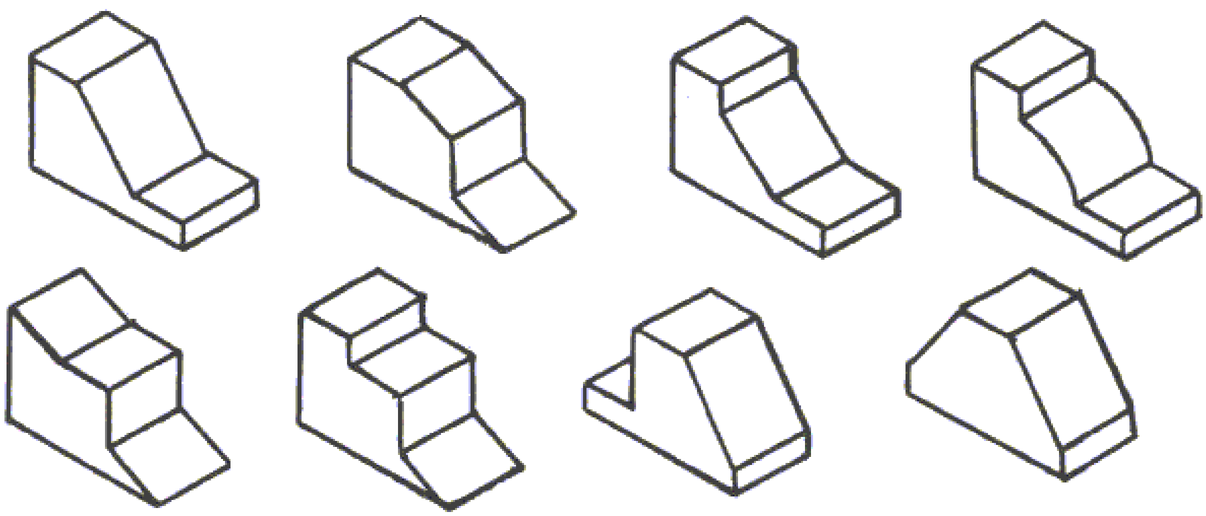


Drawing shapes with slanted lines

Non-isometric lines

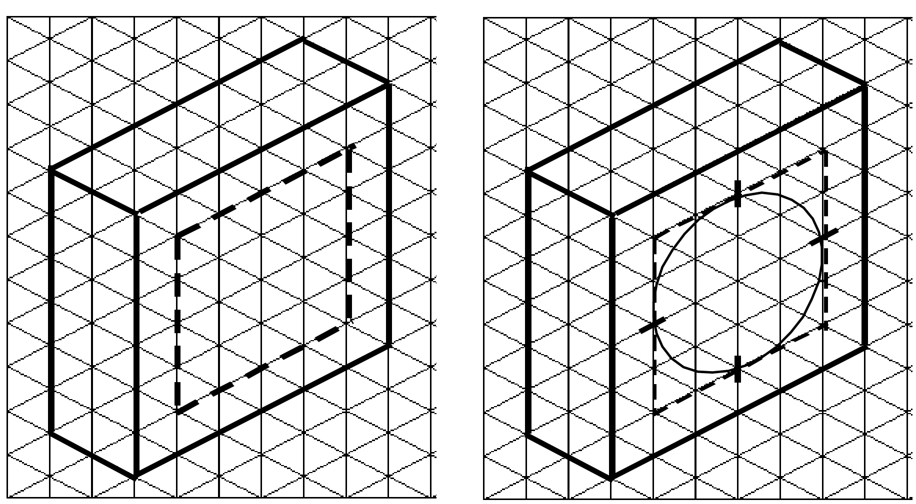


Draw these shapes on oblique and isometric grids.



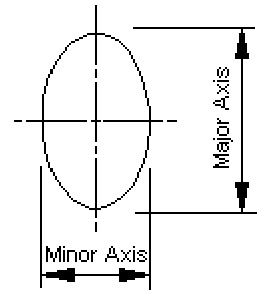
Drawing circles in isometric

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



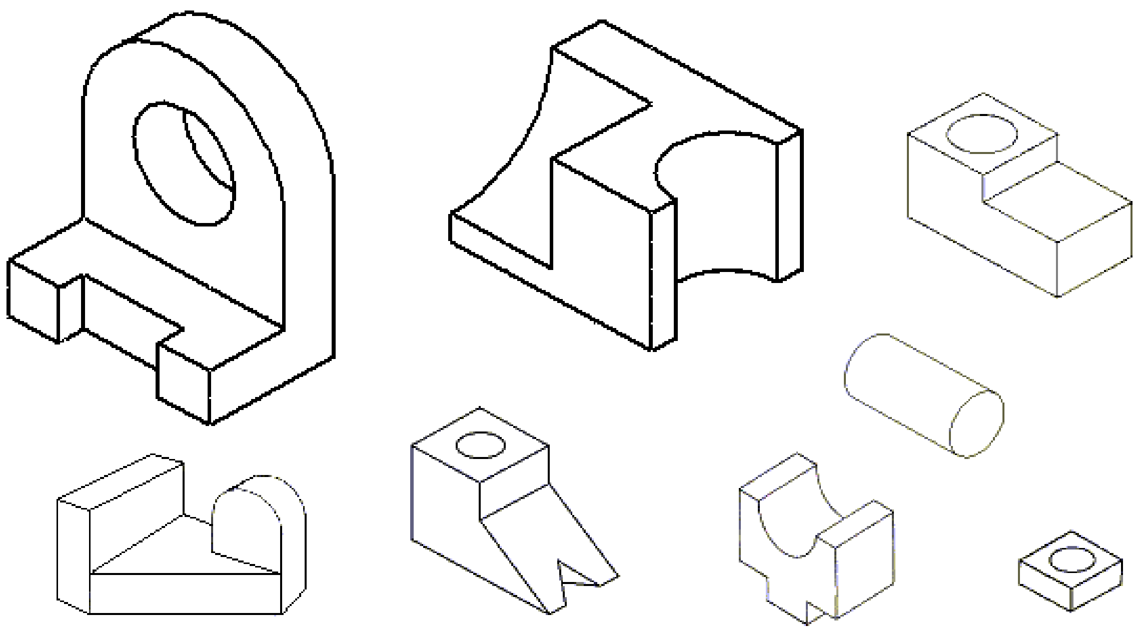
Circles drawn in oblique or isometric views

A circle drawn on a sloping surface in oblique or isometric projection will be drawn as an ellipse.



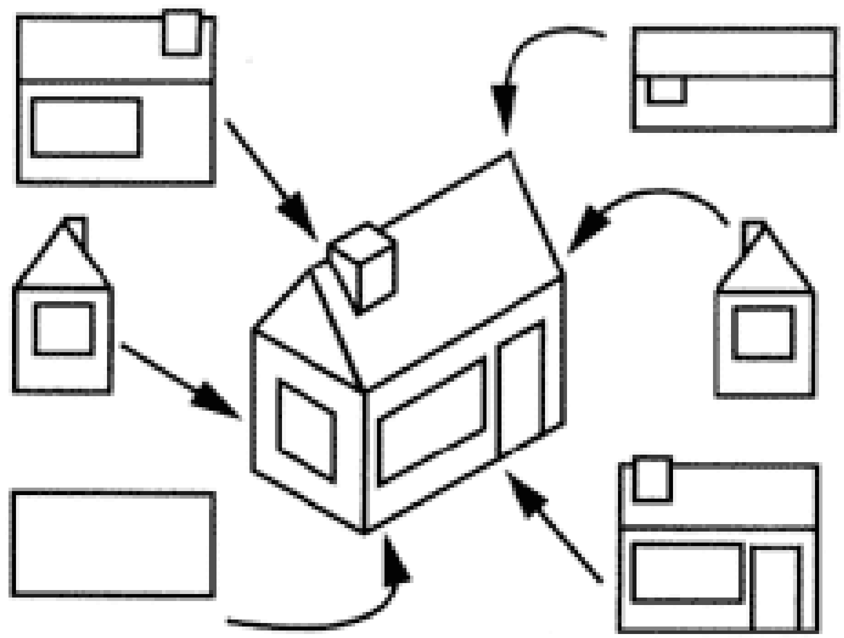
An ellipse is a circle turned through an angle. In order to draw curved surfaces we need to know how to draw ellipses. An ellipse has a major axis and a minor axis. The major axis is the axis about which the ellipse is being turned. The minor axis becomes smaller as the angle through which the ellipse is turned approaches 90^0.

Draw these shapes on oblique and isometric grids.

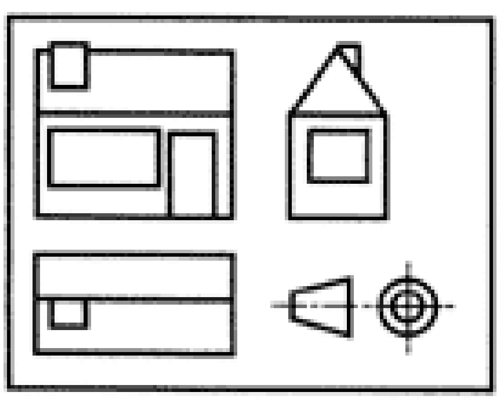


Orthographic

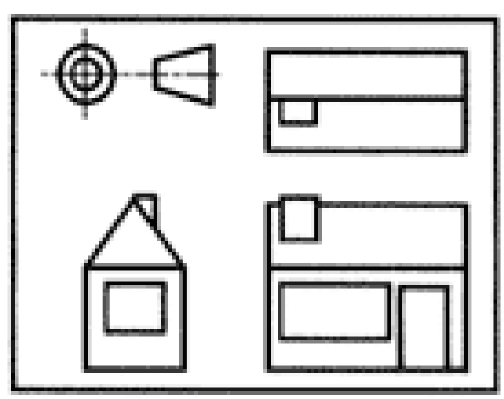
Orthographic Projection is used for accurate scale drawings of your design. You can see from the house design below that we can obtain six flat views of the object. These can be arranged on the paper as **working drawings.**



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.

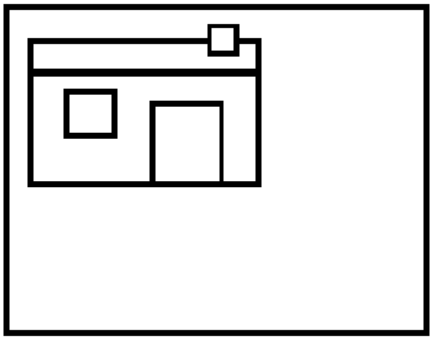


First Angle Projection

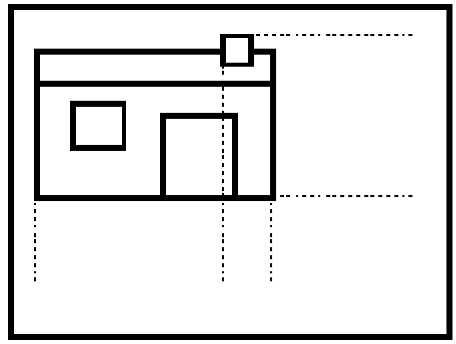


Third Angle Projection

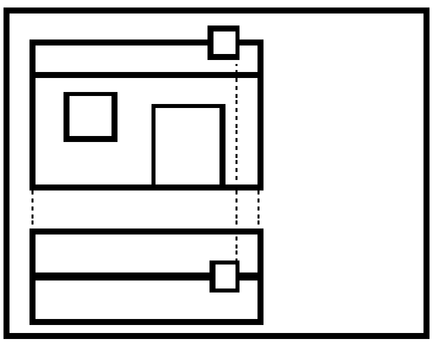
How to make orthographic drawings



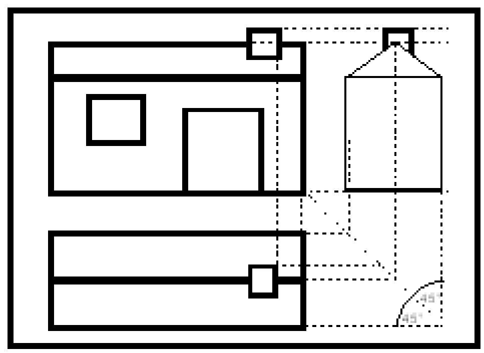
Step 1:
Draw the front view towards the top left of your sheet of paper.



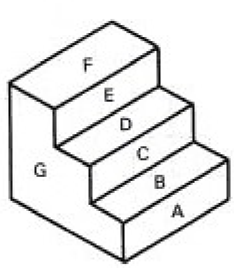
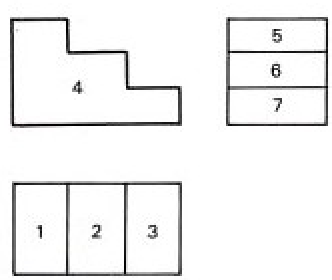
Step 2:
Project faint lines vertically and horizontally from the front view as shown.

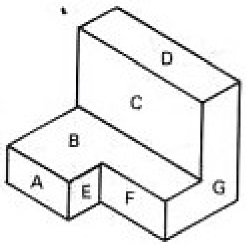
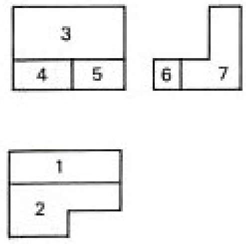
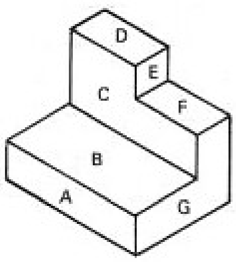
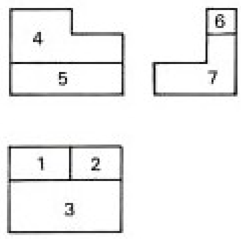


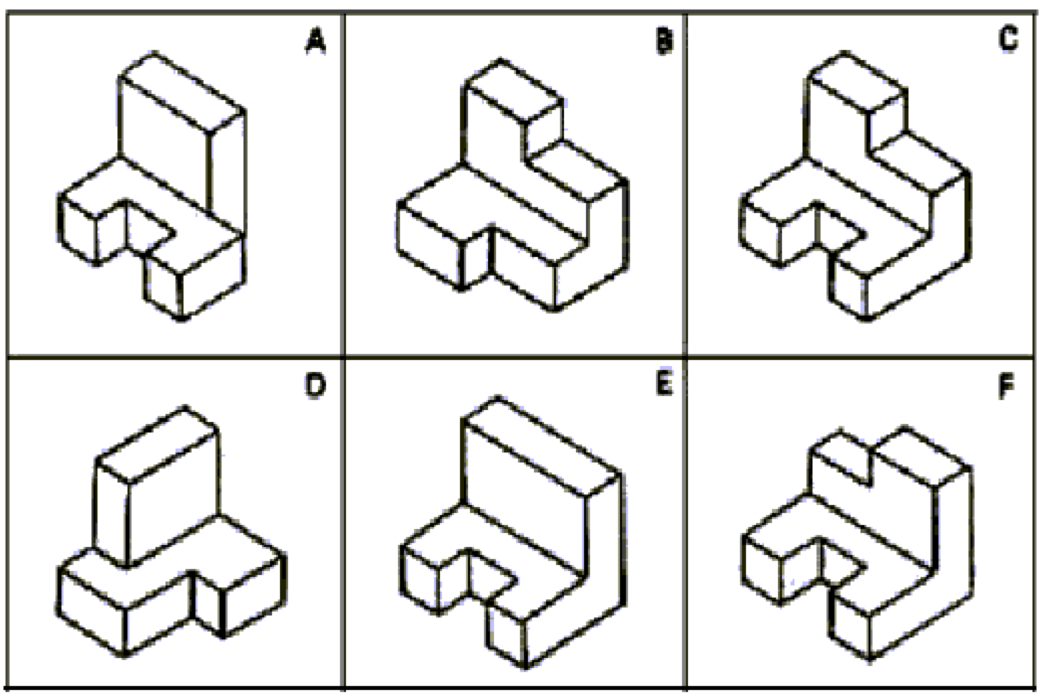
Step 3:
Draw the top view using the faint lines to help you, as shown.

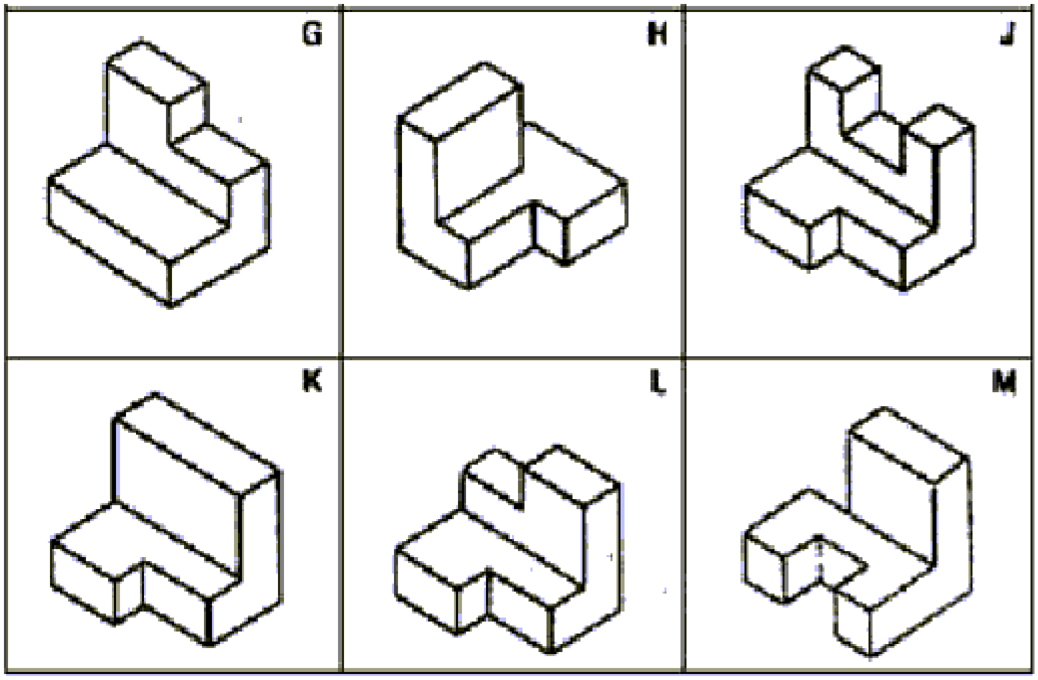


Step 4:
Draw a diagonal line at 45° from the corner as shown. This is used to transfer sizes from the top view to the side view. You then complete the left view using information provided by the other two views.

Isometric Sketch	Orthographic Views	Answers
I 		1. ______ 2. ______ 3. ______ 4. ______ 5. ______ 6. ______ 7. ______

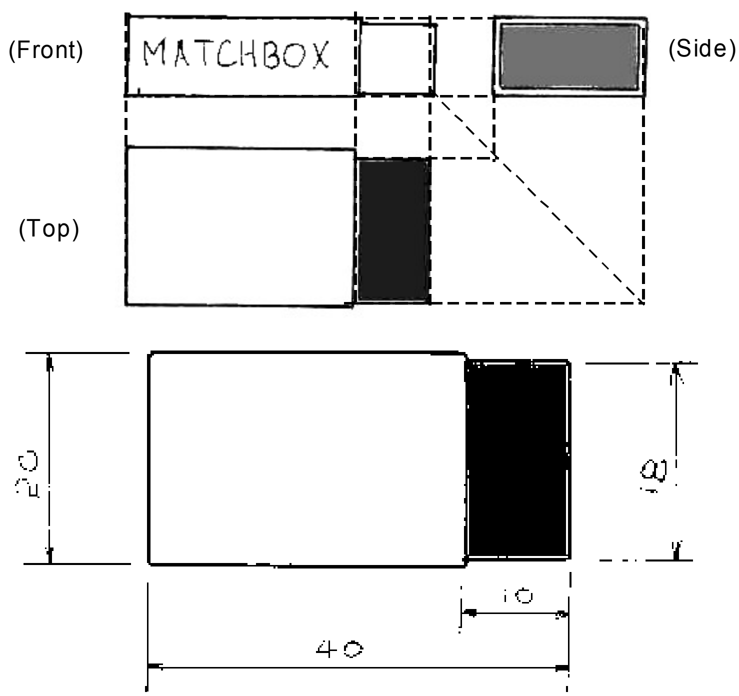
Isometric Sketch	Orthographic Views	Answers
II 		1. ________ 2. ________ 3. ________ 4. ________ 5. ________ 6. ________ 7. ________
III 		1. ________ 2. ________ 3. ________ 4. ________ 5. ________ 6. ________ 7. ________





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:

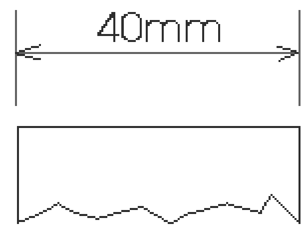
- Don't let measurements clutter the drawing.
- All vertical measurements should be read from the right i.e. turn the drawing 90° (clockwise) to read them.
- Do not repeat dimensions if you already have them or they can be worked out from others you have on the drawing.
- Avoid putting dimensions inside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

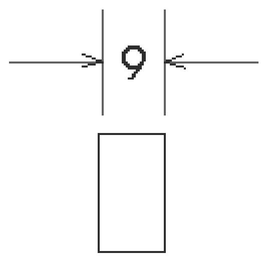
It is very important to add dimensions (measurements) when drawing accurate orthographic or working drawings. An orthographic drawing is usually the last drawing before manufacture and so dimensions must be clearly presented and understood.

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

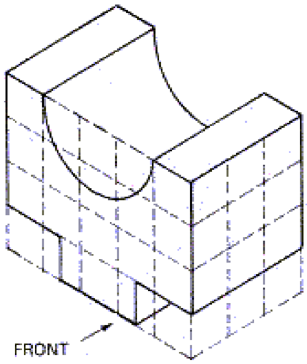
When doing drawings where size and measurements are important, you need to show whether you are drawing the object as its actual size or how many times larger or smaller than this size. This ration between a picture representation and the real size of an object is called the scale of the drawing. A scale 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.

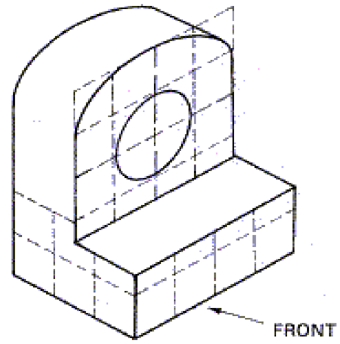
Scaling up and scaling down

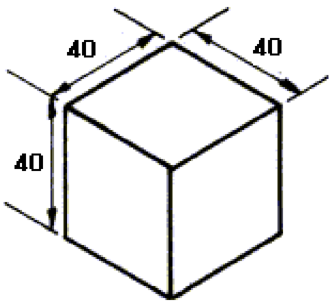
Some objects need to be drawn smaller in order to fit on a page. This is called *scaling down*. An example of this would be drawing a map or house plan. If you wanted to show detail on a very small object, you would have to draw it larger than it's actual size, this is called *scaling up.* Detail on 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.

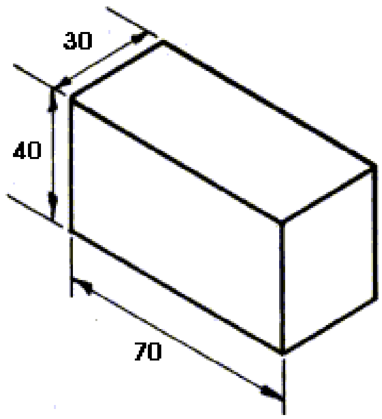
Proportion means keeping the same ratio between length, width and height on your drawing.

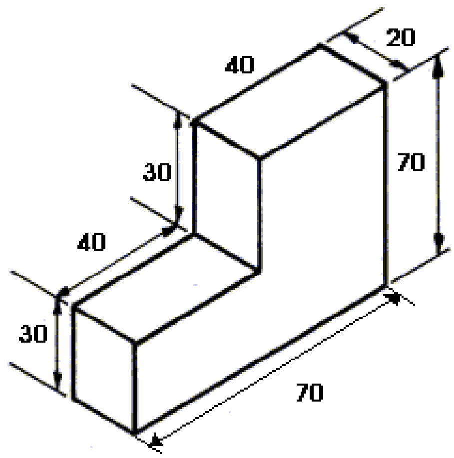
Try to draw these shapes

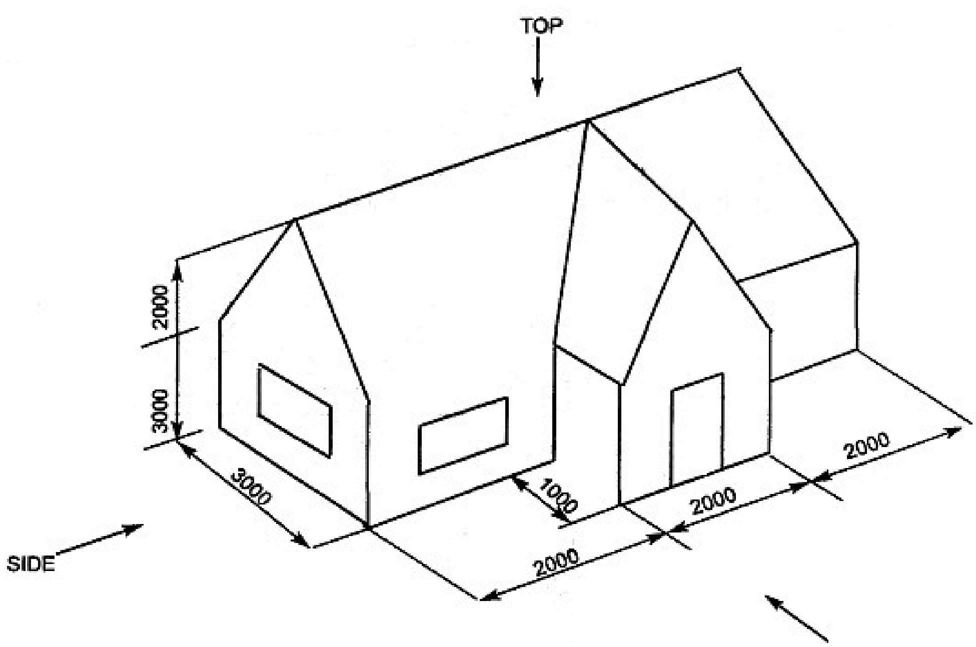












NOTE: Dimensions are in millimetres (mm)