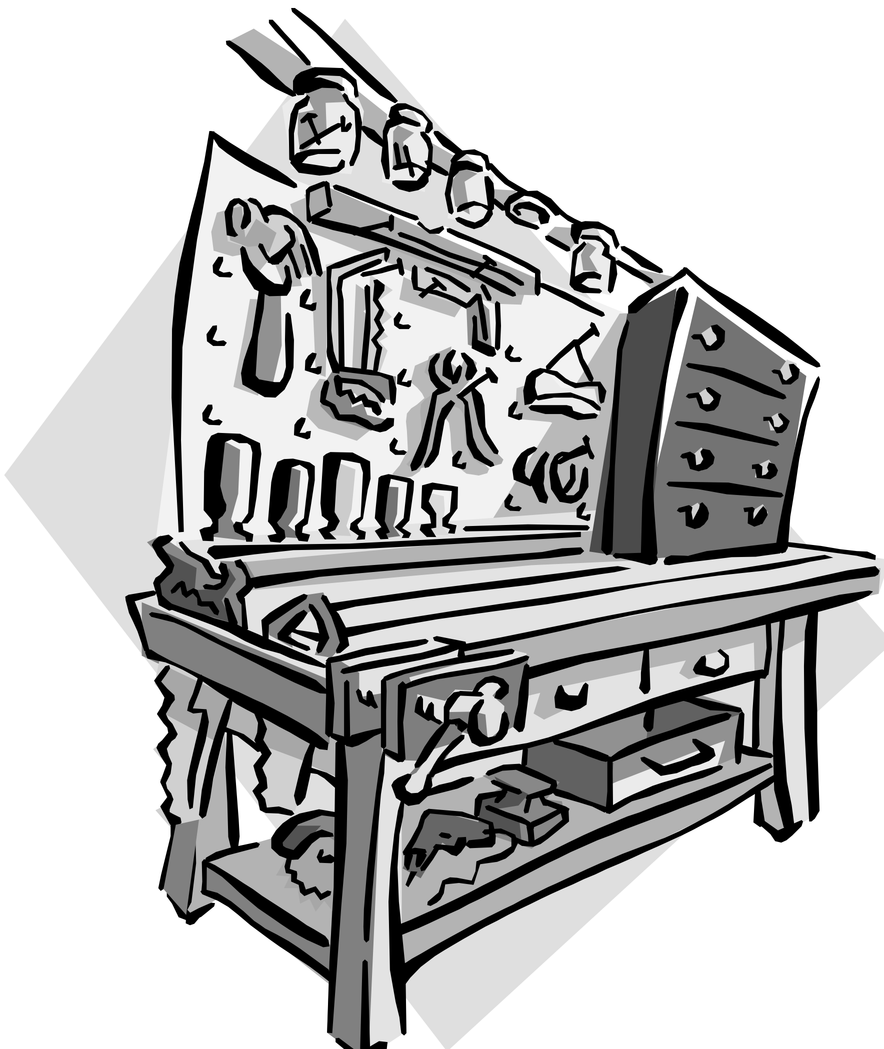
TECHNOLOGY

GRADE 7



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Contents

Learning outcomes explained

Learning Outcome 1: Technological Processes and Skills

The learner will be able to apply technological processes and skills ethically and responsibly using appropriate information and communication technology.

Assessment standards
We know this when the learner:

Investigates

- Investigates the background context, the nature of the need, the environmental situation, and the people concerned when given a problem, need or opportunity set in a local context.
- Examines existing products relevant to a problem, situation or need based on the following key aspects of design:
  - people;
  - purpose;
  - appearance;
  - environment;
  - safety;
  - cost.
- Investigates by performing simple practical tests relating to aspects of the technological knowledge areas (Structures, Processing, and Systems and Control).
- During investigations, plans a strategy for collecting data and information that includes:
- identifying technologies and methods;
- considering the source, resources and copyright laws;
- uses search techniques;
- extracts relevant data for specific purposes;
- produces meaningful summaries.

Designs

- Writes or communicates a short and clear statement or a design brief for the development of a product or system related to a given problem, need or opportunity.
- Lists product and design specifications and constraints for a solution to a given problem, need or opportunity based on some of the design key words:
  - people: age, target market, human rights, access;
  - purpose: function, what the product will do;
  - appearance: colour, shape;
  - environment: where the product will be used or made, impact on the environment;
  - safety: for users and manufacturers;
  - cost: cost of materials, wastage, cost of manufacture, maximum selling price.
- Generates at least two alternative solutions and annotates the ideas.
- Chooses possible solutions, gives sensible reasons for choice, and develops a chosen idea using graphics or modelling techniques.

Makes

- Develops a plan for making that details all of the following:
  - resources needed (e.g. materials lists, tools, people, costs);
  - dimensions (e.g. lengths, breadths, depths, widths);
  - steps for making the product (e.g. annotations, simple flow diagrams).

- Chooses and uses appropriate tools and materials to make products by measuring, marking, cutting or separating, shaping or forming, joining or combining, and finishing different materials with some accuracy.
- Uses safe working practices and shows awareness of efficient ways of using materials and tools.

Evaluates

- Evaluates the product or system based on criteria linked directly to the design brief and some of the specifications and constraints, and suggests improvements or modifications.
- Evaluates the efficiency of the plan of action followed and suggests improving future plans.

Communicates

- Presents ideas (in a project portfolio) using two-dimensional or three-dimensional sketches, circuit diagrams or systems diagrams that include most of the following features:
  - notes to communicate design reasoning;
  - dimensions;
  - quantities;
  - enhancements of significant sketches (e.g. colour, texture, shade, thick and thin lines, shadow).
- Chooses and uses appropriate technologies (e.g. computers, photocopiers, stencils, audio-visual recordings)to present a combination of graphics and text in order to record and communicate progress.

Learning Outcome 2: Technological Knowledge and Understanding

The learner will be able to understand and apply relevant technological knowledge ethically and responsibly.

Assessment standards
We know this when the learner:

Structures

- Demonstrates knowledge and understanding of structures in terms of:
  - specific properties and use of materials (e.g. water resistance, thermal insulation, fire resistance);
  - stability (e.g. base size, centre of gravity);
  - strengthening (e.g. corrugation, laminating, reinforcing);
  - joining techniques.

Processing

- Demonstrates knowledge and understanding of how materials can be processed to change or improve properties (e.g. strength, fire resistance, waterproofing, taste, volume, texture).

Systems and Control

- Demonstrates knowledge and understanding of mechanical systems that change a direction of movement using components (e.g. cams, pistons, pivot and slider, eccentric wheels), and/or the value of force in systems (e.g. lever systems, linked lever systems, pneumatic or hydraulic systems), and represents them using systems diagrams.
- Demonstrates knowledge and understanding of electrical circuits with more than one output device in the circuit (series and parallel), and represents them using systems diagrams.

Learning Outcome 3: Technology, Society and the Environment

The learner will be able to demonstrate an understanding of the interrelationships between science, technology, society and the environment.

Assessment standards
We know this when the learner:

Indigenous Technology and Culture

- Explains how indigenous cultures in South African history have used specific materials to satisfy needs and the main reasons for the differences.

Impact of Technology

- Expresses some reasons why products of technology affect the quality of people's lives positively and negatively.

Bias in Technology

- Expresses an opinion that explains how certain groups of society might be favoured or disadvantaged by given products of technology.

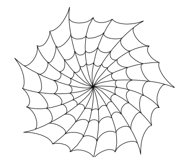
STRUCTURES

WHAT IS A STRUCTURE?

- A structure is something that will support an object or a load.
- A structure must be strong enough to support its own weight and whatever load is put on it.

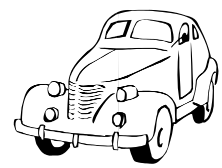
TYPES OF STRUCTURES

✳ Natural Structures



Structures are not new, nature produced the first structures long before humans were able to. A leaf is a natural structure. Its veins provide support and carry nutrients. A tree has to carry the weight of its own branches as well as resisting strong winds.

✳ Manufactured structures



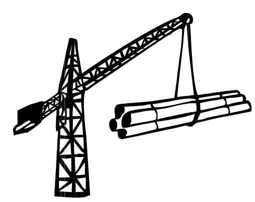
A manufactured structure is quite simply a structure built by human beings. Many of Nature's structures have been copied by humans. The shell of a snail and the body of a modern car are both shell structures designed to protect their occupants.

Natural and Manufactured structures can be divided into:

➢ Mass Structures

Mass Structures are solid structures which rely on their own weight to resist loads. A single brick is a mass structure but so is a large dam wall.

➢ Frame Structures



Frame structures are made from many small parts (called members), joined together. Bridges cranes and parts of this oil rig are just a few examples.

➢ Shell structures

Shell structures are made or assembled to make one piece. Tin cans, bottles and other food containers are often good examples of shell structures, but larger things such as car and airplane bodies are examples of more complicated shell structures. Most shell structures are made from thin sheet material (which makes them light) and most have ridges or curves molded into them (to make them strong).

APPLY YOUR KNOWLEDGE

Organise the following structures in the correct categories:

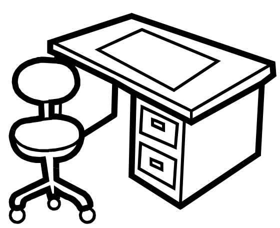
crayfish, chair, cave, skeleton, glass, bird cage, shopping bag, mountain, brick, tree, cardboard box, egg, roof trusses, wall, cupboard, umbrella, igloo

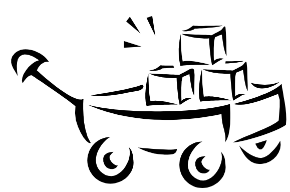
	Shell	Mass	Frame
Manufactured			
Natural			

FUNCTIONS OF STRUCTURES

Supporting a load

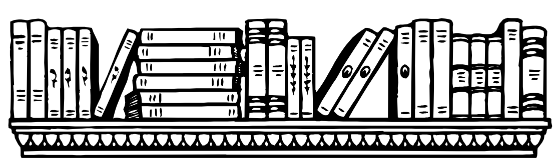
A structure must be able to support its own weight and the load it has to carry. A load can be a person, an object or a force. A moving load is known as a dynamic load. A stationary load is known as a static load.





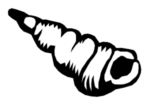
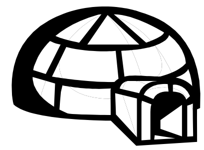
Spanning a gap

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.

APPLY YOUR KNOWLEDGE

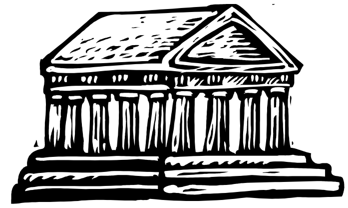
Organise the following structures in the correct categories:

crayfish, chair, cave, skeleton, glass, bird cage, shopping bag, mountain, brick, tree, cardboard box, egg, roof trusses, wall, cupboard, umbrella, igloo

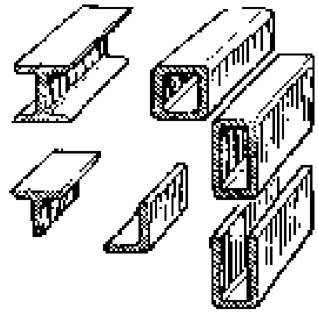
Support a load	Span a gap	Enclose or contain

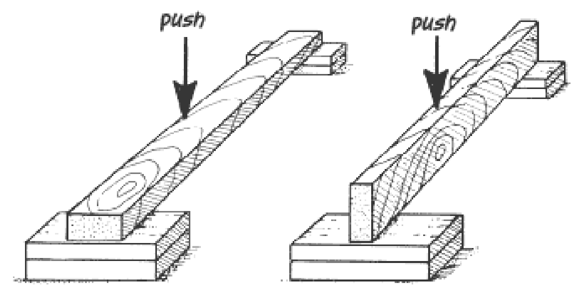
STRUCTURAL MEMBERS

Columns are vertical structural members.

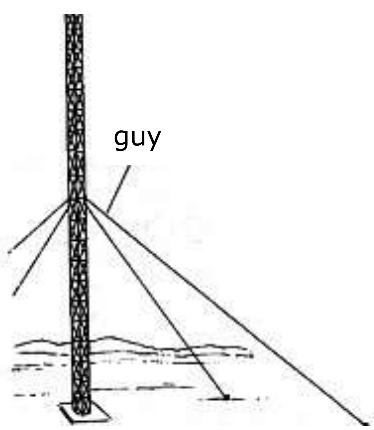


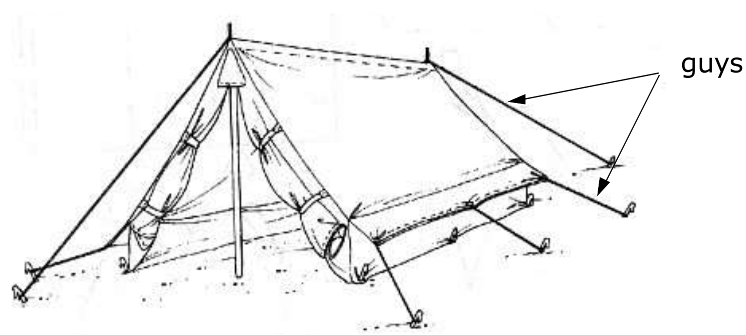
Beams are horizontal structural members. Beams often spread a load across two or more columns. How well the beam works depends the material it is made from and its shape. If you lay a beam flat and push down at the center, t gives easily. If the beam is on its side and you push down at the center, the beam is much more rigid. 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.





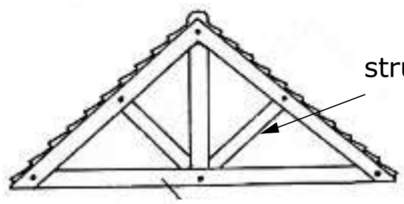
Structures like high towers and tents can also be made stable by anchoring it to the ground with guys. **Guys** are ropes, cables or chains (flexible members) that hold a structure firmly in place by pulling on it.

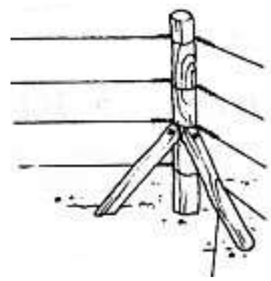




STRUTS and TIES

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 that do not bend.





Do you understand?

Answer the following questions in your exercise books:

1. What is the function of ties, guys and struts?
2. A ____________ has a tensile force acting on it.
3. A ____________ has a compressive force acting on it.
4. Ties and struts are flexible / inflexible.
5. Guys are flexible / inflexible.
6. Guys and ties hold members in place by pulling on / pushing against them.
7. Struts hold members in place by pulling on / pushing against them.

PROPERTIES OF STRUCTURES

DEFINITIONS:

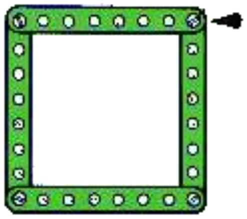
Rigidity - the ability not to buckle or distort. The strength and rigidity of a structure depend on its ability to resist force. Framed structures achieve most of their strength and rigidity from the way they are assembled.

Stability - the ability of a structure to remain or return to its original position; being in balance. A structure is stable when it will not topple over easily when acted upon by a force.

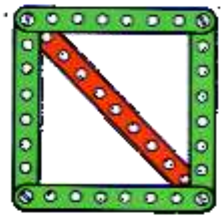
Strength - the capacity to withstand forces that tend to break an object or change its shape; it is an object's ability to hold its shape without collapsing.

RIGIDITY

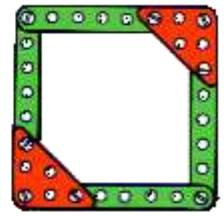
If you look at some pictures of familiar **frame structures** like cranes, electricity pylons or roof supports you may notice that triangulation is used to make them rigid.



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.

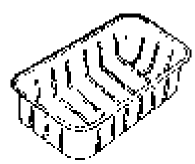


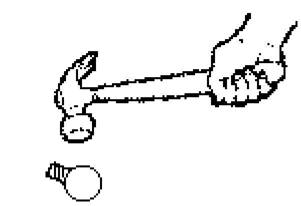
By adding an extra bar or member (usually a strut) corners A and B are prevented from moving apart. The structure then cannot be be forced out of shape, and is said to be rigid. Notice that the additional member has formed two triangles in the structure. Triangles make very strong and rigid structures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



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.

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.

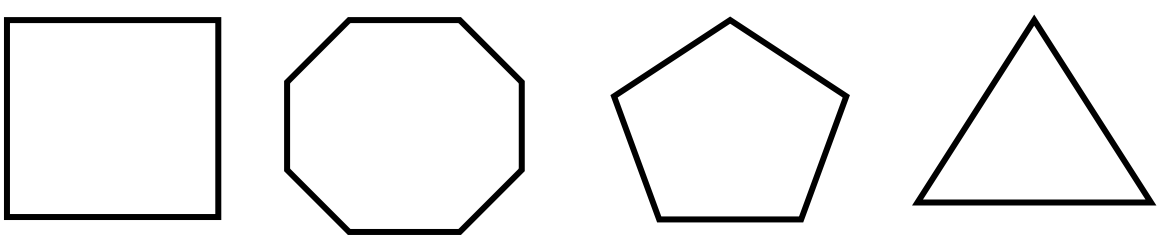




APPLY YOUR KNOWLEDGE

How would you strengthen each of the following frames to make it **rigid**?

Use your pencil and draw lines in each of the frames to indicate where you would add more strips. (Use the least amount of lines possible)

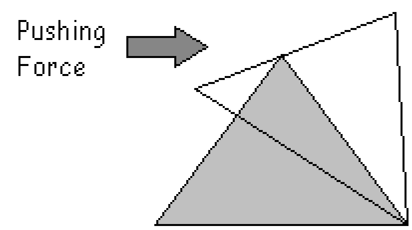


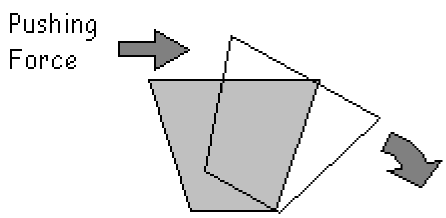
STABILITY

How stable a structure is, depends on the relationship between the base, the height and the weight of the structure.
An object has weight 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 centre of gravity is low and lies well inside a large base area, the object is 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 very high, and therefore can more easily be moved outside the base area by external loads. The center of gravity is the specific point where all of the mass of the structure is evenly distributed around. The force of gravity acts on all parts of the structure and if all parts are evenly distributed around the center of gravity, then the structure will be stable.

The concept of stability

If a force is applied to the triangle it will tip up as shown. When the force is released, the triangle falls back down to its original position. The behaviour of this structure is said to be stable.

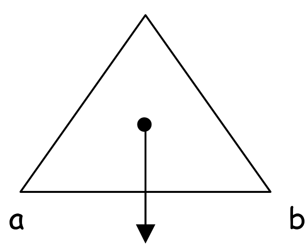


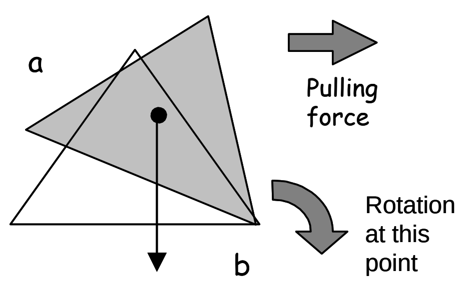


When the process is repeated on this structure it will tilt over then topple. The behaviour of this structure is said to be unstable.

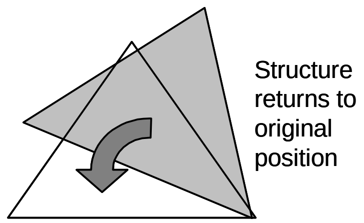
The relation between stability and centre of gravity

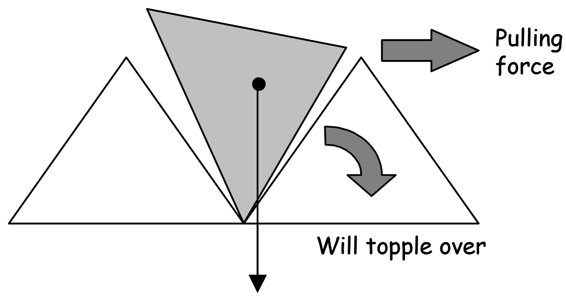
The stability of a structure is related to the position of the centre of gravity for that structure. As indicated in the diagram below, as the structure is tilted, its centre of gravity rises. It is rotated about point b, caused by the pulling force.

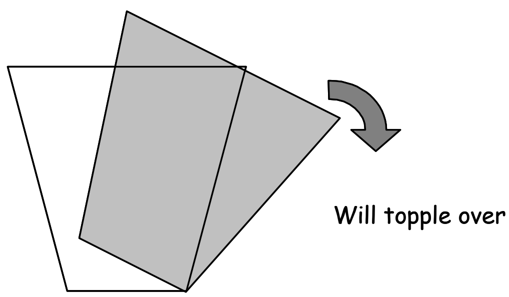




If the structure is stable, on release of the pulling force the structure will return to its original position.



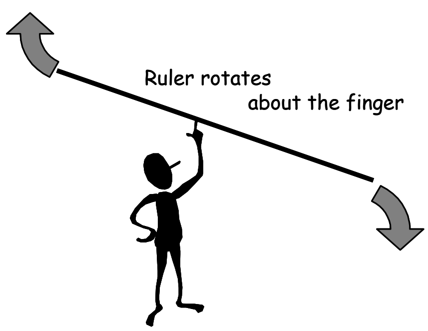




However, it must be noted that this will only be the case if the centre of gravity remains inside the base of the structure. When the structure is tilted to such a degree that its centre of gravity is outside its base, then the structure will become unstable as gravity acts on it and causes it to topple 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.

LET'S TRY IT !

To fully understand stability you must first have an understanding of the principles of centre of gravity.



Centre of gravity

Balance a ruler on your finger as shown below with more of the ruler on one side of your finger than the other.
You will observe that it topples off your finger. This is because there is more material to the left of your finger than to the right.

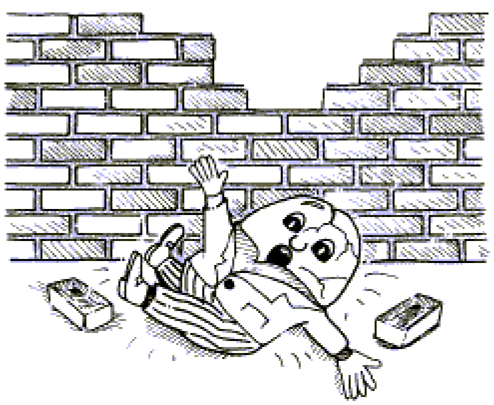
Gravity has an effect on the material at each side of your finger, and since there is not an equal amount on either side the ruler is unbalanced and thus topples over. The pull of gravity acting on the ruler is what gives it its weight and causes the ruler to tilt.

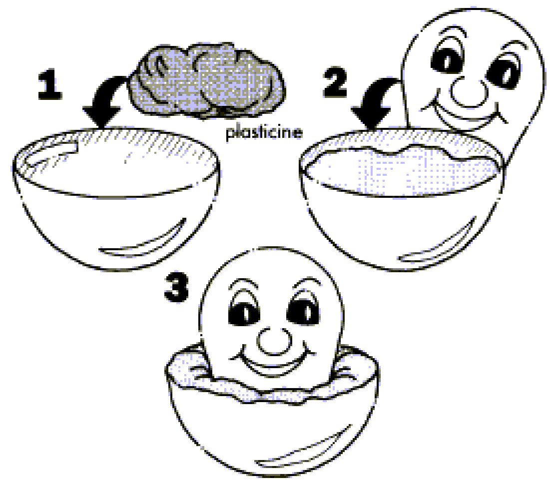
In order to balance the ruler on your finger, you must position it so that the point at which the pull of gravity acting to the right and left of your finger is equal. When you position the ruler on your finger so that it is perfectly balanced, then you have found the centre of gravity. You can apply this principle to any shaped object.
Once the object is perfectly balanced you have found the centre of gravity.

Some rules for stability:

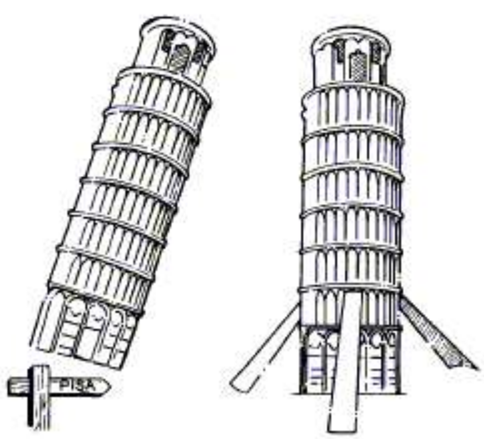
- A low centre of gravity.
- A wide base is generally more stable than a structure with narrow base.
- The weight at the top of the structure should by less that the weight at the bottom.
- Using struts and guys to hold it.
- Using a foundation

Using a heavy base

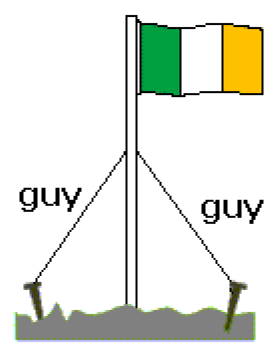




Using a wider base



Using guys



STRENGTH

Forces acting on structures

> The strength and rigidity of a structure depend on its ability to **resist force**.

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.

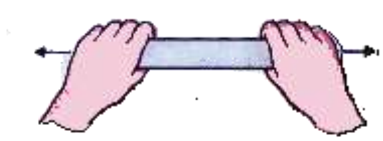
Dynamic forces are caused by things such as wind, waves, people, and vehicles. Dynamic forces are usually much greater than static forces and are very difficult to predict. These are the most common reason for structural failures.

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.

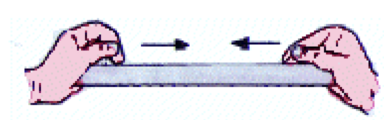
External forces or loads cause internal stresses to be set up in a structure. Not all forces or loads act in the same way. This year we will only deal with tension and compression.

Tension



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

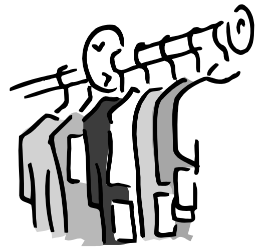
Compression

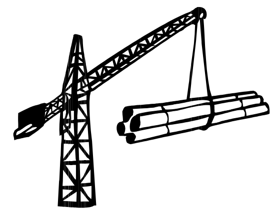


Is a force which tries to **squash** something together. A structural member in compression is called a strut. A strut resists compressive stress.

APPLY YOUR KNOWLEDGE

Name the **forces** acting on each of the following structures





a)_______________ b)_______________ c)_______________ d)______________

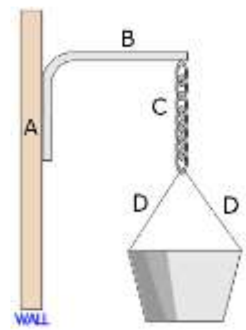
Determine the forces exerted on each part in the picture?

A: ____________________________

B: ____________________________

C: ____________________________

D: ____________________________



REINFORCEMENT

In order to make structures stronger, they can be reinforced.

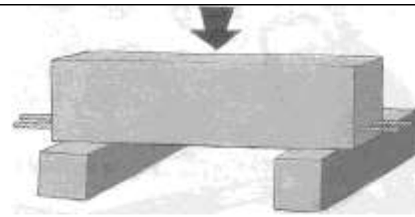
Reinforcing concrete

Concrete is a processed material made with cement, sand, stone and water. When we add sand and water to the concrete powder, we get mortar; in South Africa it is called "dagha". As the ingredients are mixed a chemical reaction takes place and the mixture hardens. If we should add stones (aggregate) to the mixture, we get concrete. The strength of the concrete depends on the amount of each ingredient in the mixture and the time allowed to cure (dry out). Good and strong concrete should ideally cure slowly. When concrete floors are laid, the floor is wet each day so that it does not dry out too quickly.

Concrete is the most used construction material in the world. It is used for constructing dams, tunnels, walls, bricks, roads and many other things.

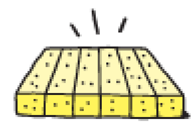
Concrete is very **strong in compression** but it is very **weak in tension**. To counteract this problem, concrete is reinforced. Steel rods, are put inside the concrete mixture before it dries.

A solution to the problem above is to reinforce (make it stronger) the concrete. Concrete is reinforced with steel rods (called rebar) to withstand tension forces.

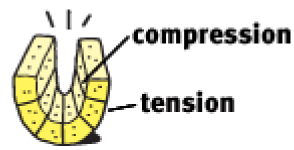


Why is the rebar at the bottom of the concrete?

Do the following experiment:



With a permanent marker, draw a series of lines crosswise on the top and bottom of a soft kitchen sponge.



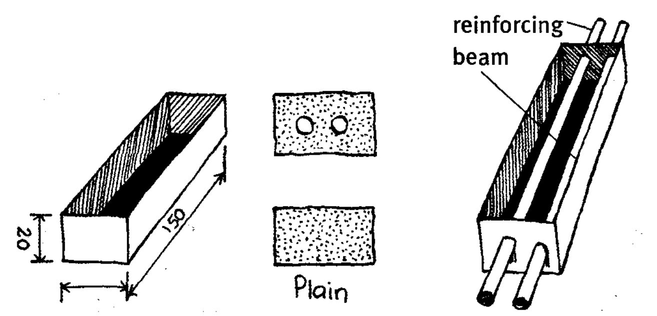
Bend the sponge into a U-shape, and observe what happens to each set of lines. (The lines inside the U get closer together and the lines on the outside spread farther apart.)
Where is this sponge in compression? (On the inside.)
Where is it in tension? (On the outside.)
Bending is common in structures; for example, a horizontal beam that supports a floor or a bridge deck experiences bending. Reinforced concrete tension because the rebar is more towards the bottom of the concrete.

How to make a reinforced concrete beam

	CEMENT	SAND	STONE	WATER
				
mortar	1	4	nil	enough water for a workable mix
concrete	1	3	3	

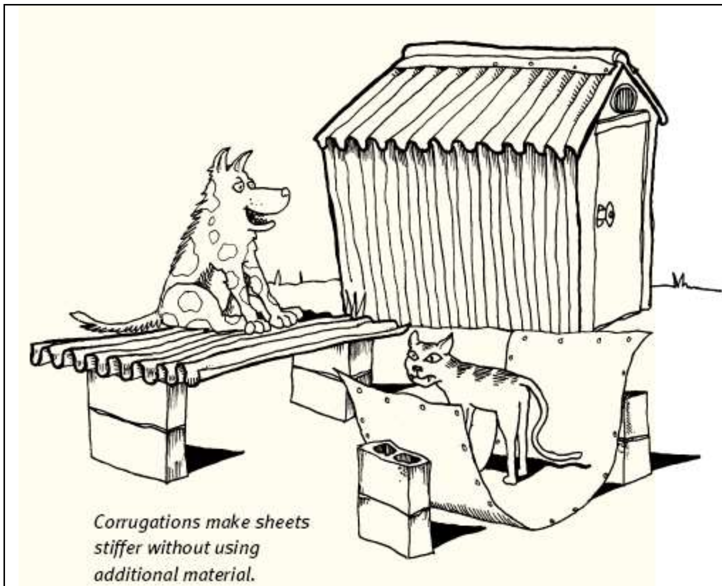
The mixing table above is for medium strength concrete and normal strength mortar. The numbers represent units, so for 1 measure of cement you need 3 measures of sand, etc.

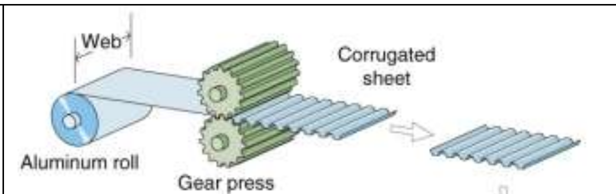
- Cut a cardboard mold and insert steel rods into it, from the one end to the other.
- Put the rods reasonably low in the mold, since tension acts on the bottom part of a beam.
- Mix your concrete and mortar, fill the mold and wait till it has dried before you remove the mold.



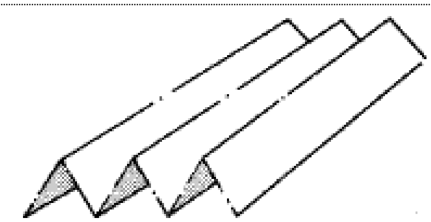
Reinforcing with corrugation

Corrugations add rigidity to paper. The paper is not stronger, but stiffer or more difficult to bend. A similar principal is used in corrugated iron roofs.


Corrugations make sheets stiffer without using additional material.



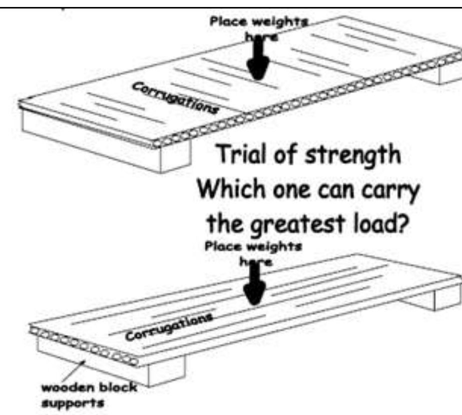
Look at the picture below and test the concept by folding a piece of paper like this and see if it will hold more weight than a flat sheet of paper.



Test your knowledge

Look carefully at the two drawings to the right and say which one do you think will be able to carry the greatest load. Look at the "grain" of the corrugation.
Write your answer below:

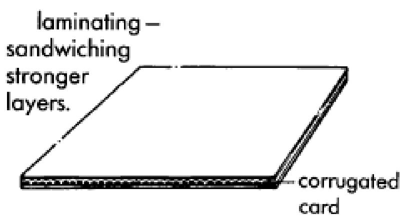
____
____
____

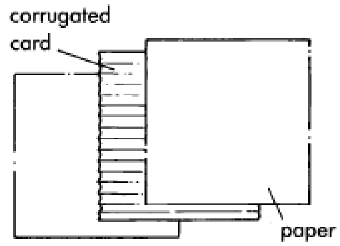


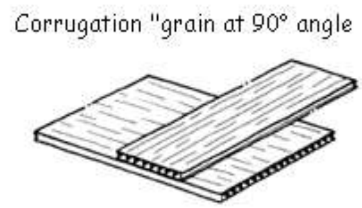
Reinforcing by laminating

Laminating is a way of strengthening materials using layers to cover and protect. Laminating machines are used to cover paper of cardboard with a plastic layer on each side. A simple way of laminating paper is to use cellotape or DC-fix.

Plywood is made by laminating thin sheets of wood. The wood grain of each layer runs at a 90° angle to the layer above and below it. This makes plywood very strong. Plywood is used to make wooden toys because it can be cut into any shape without losing its strength.





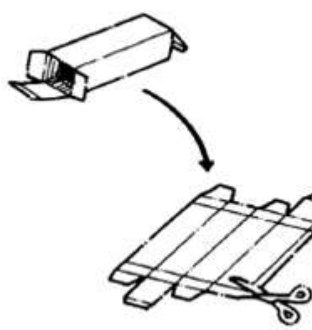


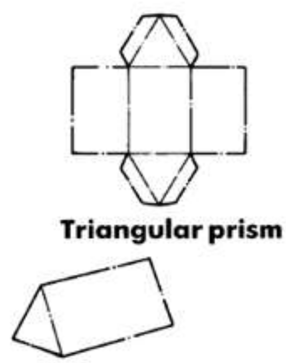
Reinforcing with nets

Cardboard boxes are made using nets. If you carefully open up an existing box you would see the tabs or flaps – these are the parts of the box which are stuck to the rest of the box and they make the box stronger.

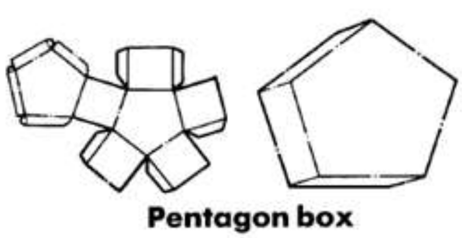
Using existing boxes:

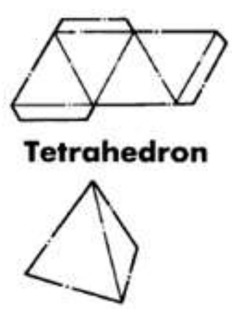
- Use found cardboard boxes.
- Find out where they are stuck together.
- Don't cut apart.
- Pull apart gently along the place where it is stuck.
- Open out the box.
- Use the opened box as a template.

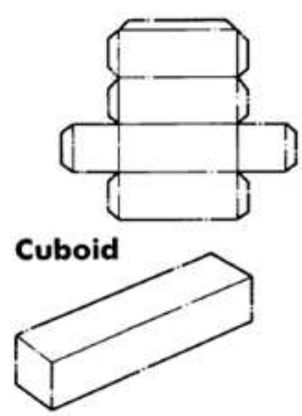




Box shapes:





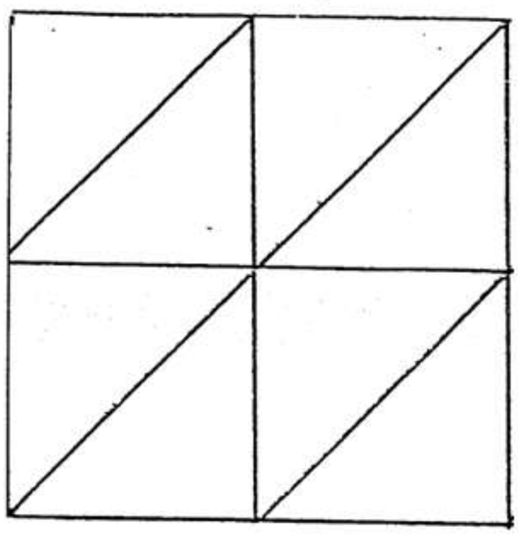


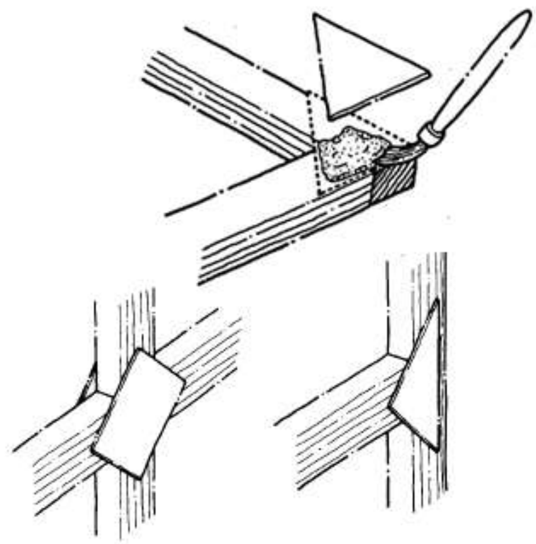
Reinforcing frame structures using corner joints

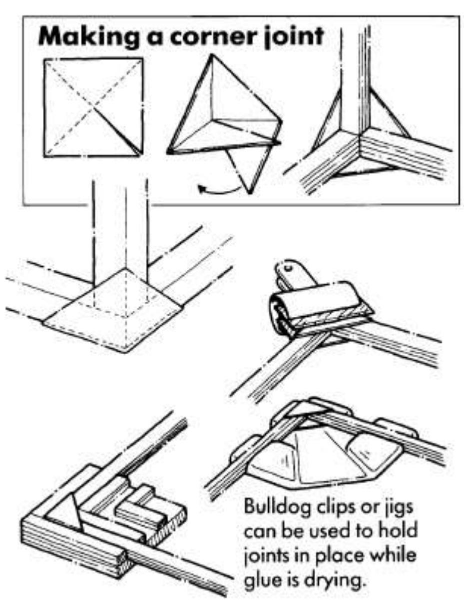
Cut corners like these from scrap cardboard and glue on corners of 2-D and 3-D structures to reinforce corners of frame structures. T-sections and cross sections can also be reinforced this way. For cross sections, cut a square and turn it to resemble a diamond.

Copy the templates below to make your own corner joint reinforcements.

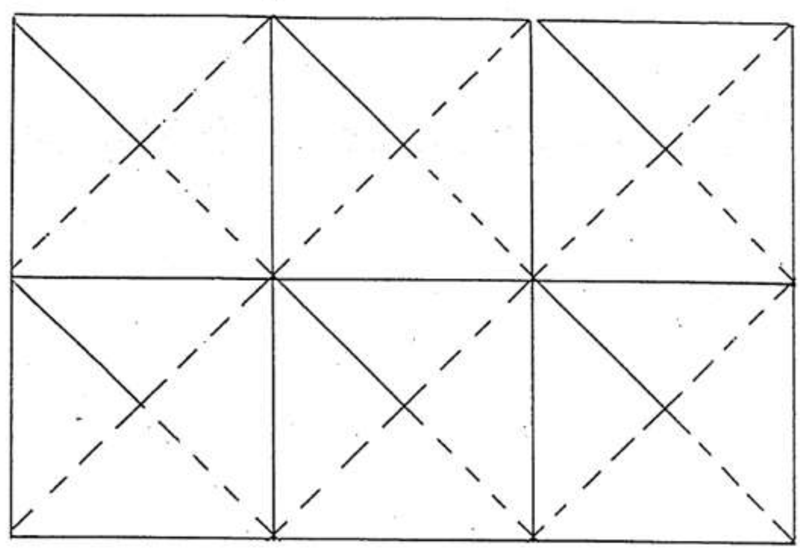
2D corner joints





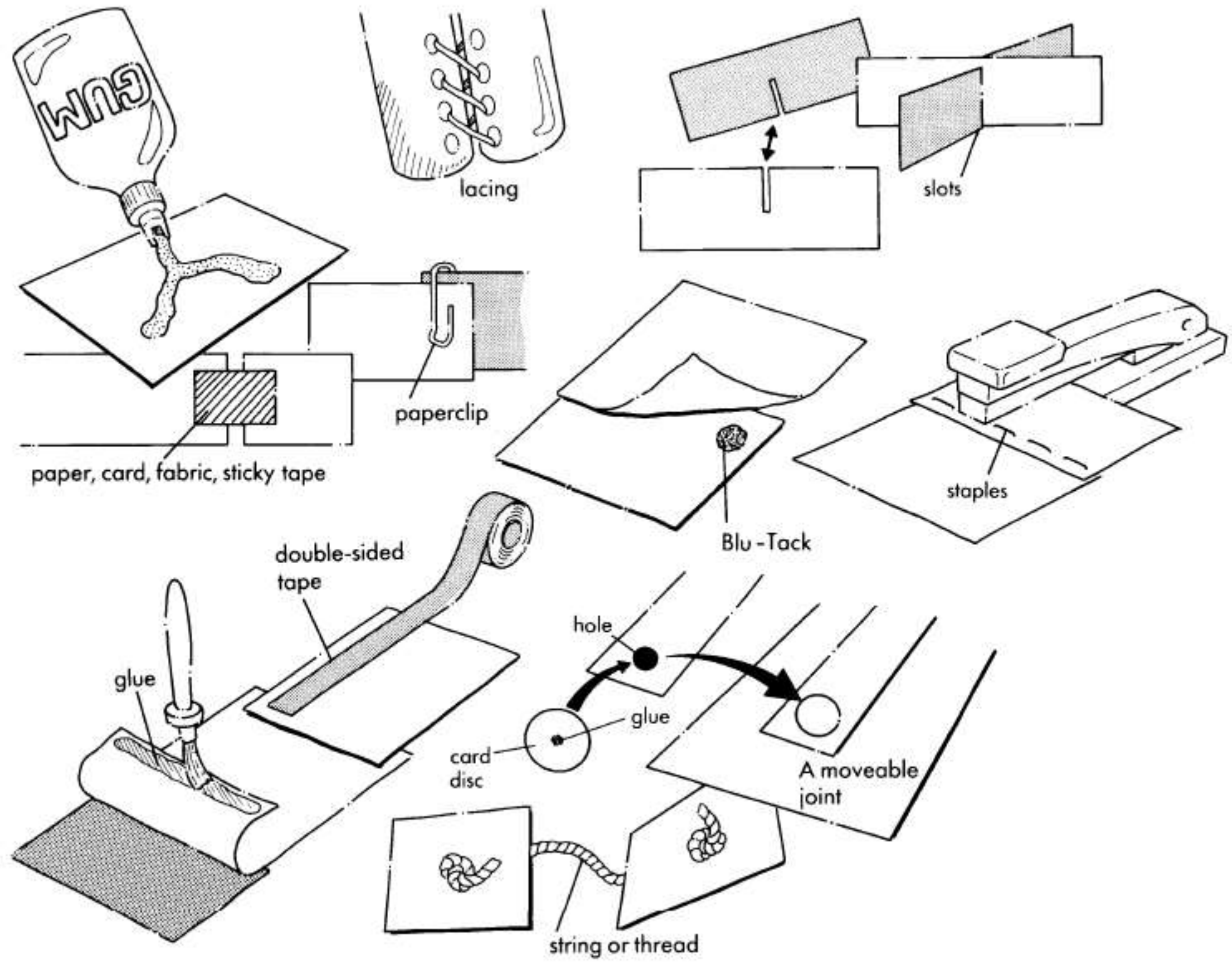


3-D corner joints

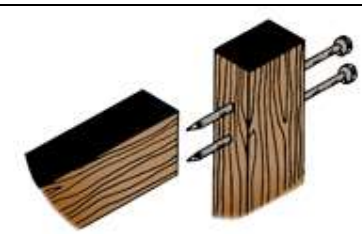


JOINING METHODS

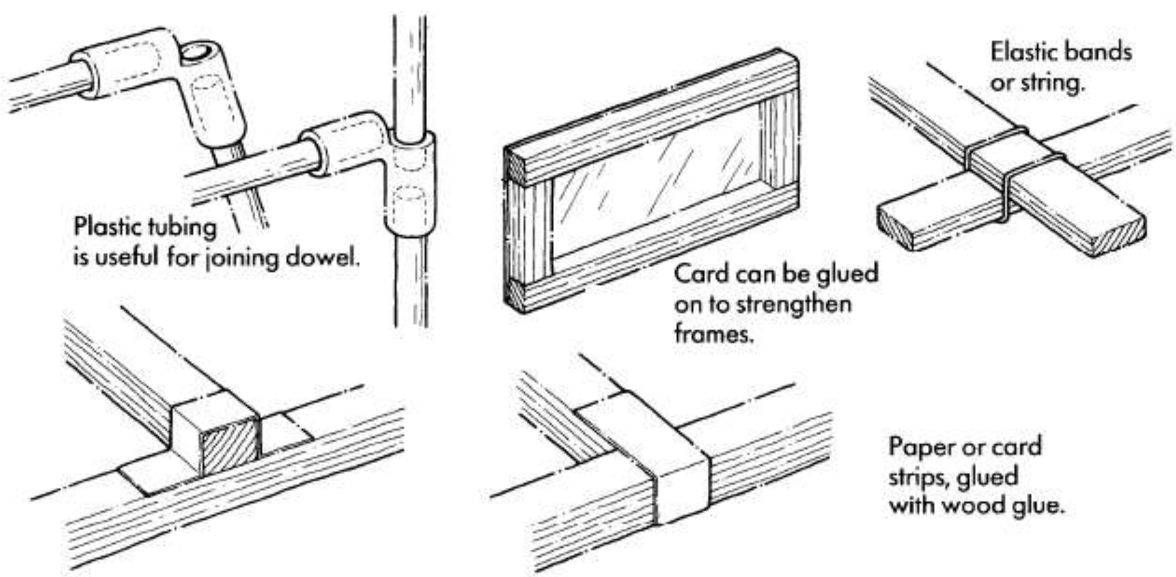
Paper and cardboard



Wood

The simple butt joint is most commonly used. This joint is formed by nailing or screwing the end of one piece of wood to the end of the other. While this is simple, fast and effective, the butt joint cannot be used on many types of end joints.	 A simple butt joint is formed by nailing or screwing two ends together.
The dowel joint is basically the same as the butt joint except dowels are used to hold the two pieces of wood together instead of screws and nails.	 Use a drill to start the holes for a dowel joint.

A newer version of the spline is a biscuit, a football-shaped spline. The biscuit requires a power biscuit jointer tool that is easy to use and produces excellent results. Biscuits can be used on almost any type of joint	 Biscuit joints can be used in any number of applications.
The through mortise and tenon joint is easy to make with a power saw and a dado head. A through mortise and tenon joint is suitable for various woodworking jobs.	 The through mortise and tenon joint is easy to make with a power saw and a dado head.
The half-blind dovetail joint is used almost exclusively for making drawers. Don't undertake this joint without some experience and good power tools.	 The half-blind dovetail joint is used almost exclusively for drawers.



Demonstrates knowledge and understanding of mechanical systems that change a direction of movement using components (e.g. cams, pistons, pivot and slider, eccentric wheels), and/or the value of force in systems (e.g. lever systems, linked lever systems, pneumatic or hydraulic systems), and represents them using systems diagrams.

MECHANISMS

What is a machine?

a device used to perform a task (or to do work).

What is a mechanism?

Mechanisms are devices (lever, wheel, wedge, ramp, pulley, screw etc) that have been designed to make jobs easier. They all have certain things in common:

- They involve some kind of *motion*.
- They involve some kind of *force*.
- They must have some kind of *input* to make them work.
- They produce some kind of *output*.

What is work?

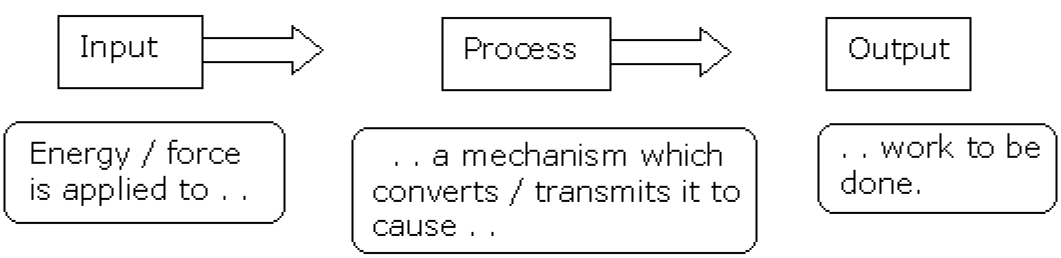
The use of force to move something. In order for work to take place, a Force must be exerted through a distance.
Work is defined by a force times distance (Work = Force x Distance)

What is a mechanical system?

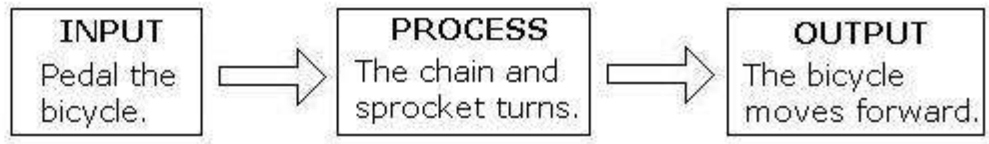
If we connect mechanisms together we can build mechanical systems called machines.

How do mechanisms work?

All mechanical systems have an input, a process and an output.



Machines cannot do work on their own. They need energy and someone or something to operate them, eg. Pedalling a bicycle. The energy, which is used by the machine, is called the **INPUT**. The result of this energy input is called **OUTPUT**.



What do mechanisms or machines do?

Mechanisms control **force** and **motion** so we have to do less work. When work is done, energy is converted.

- They increase power so that a bigger load can be moved

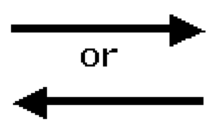
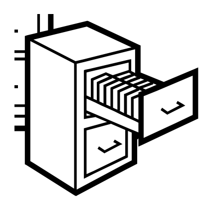
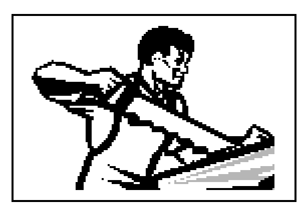
  or

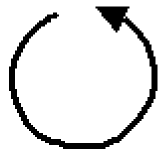
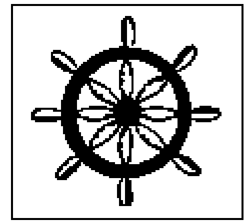
- They increase the distance so an object can move

Forces

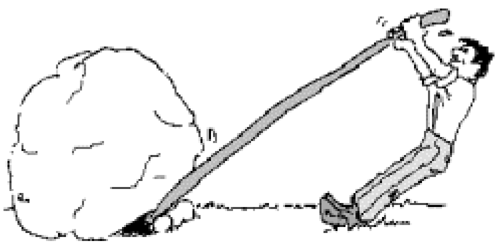
Forces are pushes or pulls that make things start or stop moving, move faster or slower, change shape or direction.

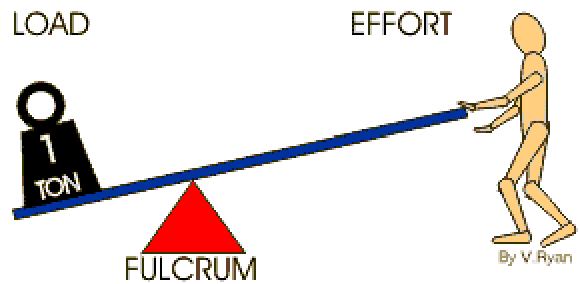
Types of motion

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 in an arc.		

rotary motion a circular motion around an axle or a center point.		

THE LEVER





Levers are used to lift heavy weights with the least amount of effort. In the example, the heavy weight on the left hand side is been lifted by the person because of the lever. A lever consists of a rigid arm, which is free to turn about a fixed point called the **fulcrum**. The longer the 'rod' the easier it is to lift the weight. Under normal circumstances the person would not be able to lift the weight at all. The fulcrum is the place where the rod pivots (or rotates). The **effort** is exerted upon one lever arm, and the other lever arm will go up or down in the opposite direction. The resisting load is exerted upon the lever arm, which tends to move the lever in the opposite direction to the applied force. The **load** is the scientific name for the weight. The effort is quite simply the amount of effort used to push down on the rod in order to move the weight.

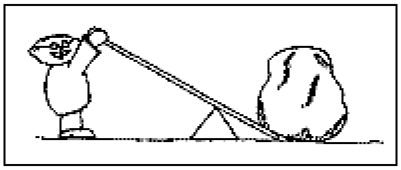
With levers, the force is applied at a different point from the load. The closer the fulcrum to the load, the less force needed to lift the load. The force will move a greater distance, and the load will move a shorter distance. The closer the fulcrum to the force, the greater the force needed to lift the load. The force will move a shorter distance, and the load will move a greater distance.

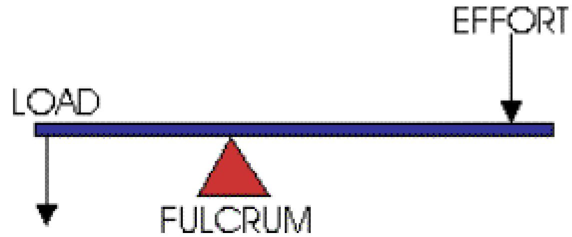
Classes of levers

Levers are divided into three classes, according to the way the load and force arms are arranged around the fulcrum.

- **First Class Lever**

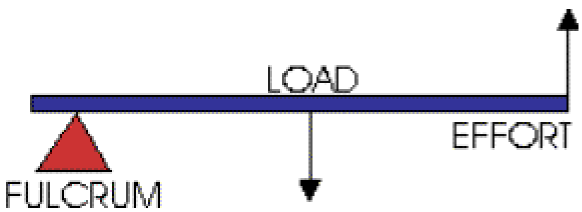
When the fulcrum lies between the force arm and the lever arm, the lever is described as a first class lever. When the fulcrum is midway between the force and the load, there is no change in force, speed or distance. First class levers include: a see-saw, a car jack, a pair of pliers, a pair of scissors, a balance or pair of weigh scales, a crowbar, a claw of a hammer taking out a nail, or a lever with a rock as its fulcrum trying to lift another rock.





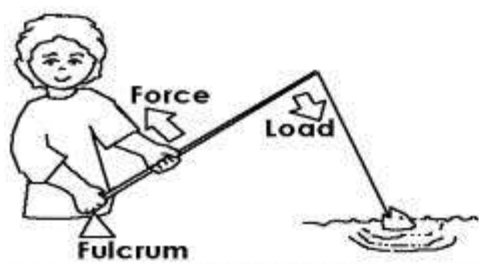
- **Second Class Lever**

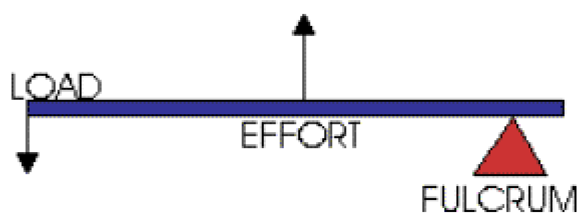
In the second class lever, the load arm lies between the fulcrum and the force arm. A good example of this type of lever is the wheelbarrow. The axle of the wheel serves as the fulcrum, the handles are the force arm, and the load is carried between the two in the bucket part of the wheel barrow. In the second class lever, the fulcrum is usually closer to the load, which reduces the force needed to accomplish the work. Some other examples of the second class lever are: a pair of nutcrackers, and a bottle opener.

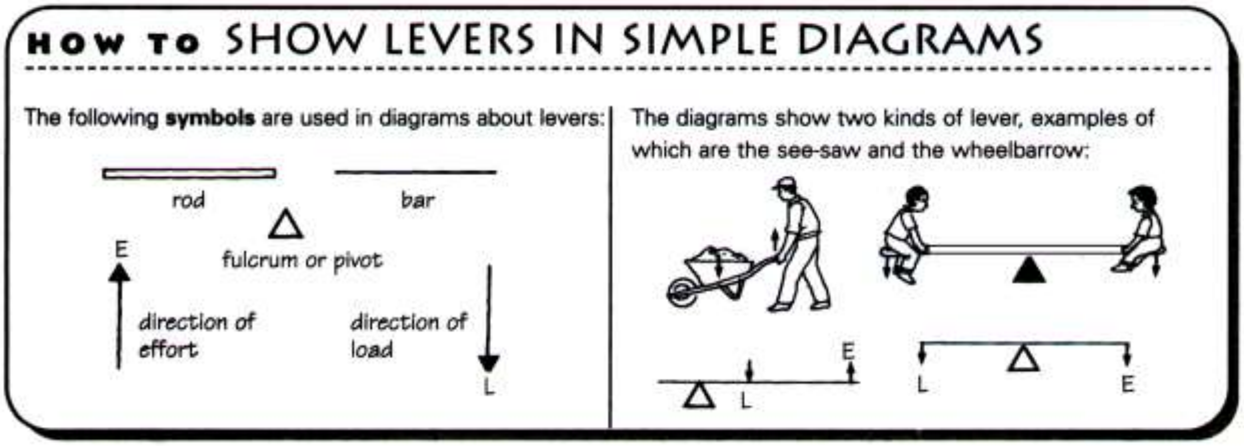


- **Third Class Lever**

In this class of levers, the force arm lies between the fulcrum and the load arm. Because of this arrangement, a relatively large force is required to move the load. This is offset by the fact that it is possible to produce movement of the load over a long distance with a relatively small movement of the force arm. Think of a fishing rod! In a third class lever there is usually a loss in force needed to accomplish the work, but a gain in speed or distance. Example of third class levers are: a fishing pole, a pair of tweezers, an arm lifting a weight, a pair of calipers, a person using a broom, a hockey stick, a tennis racket, a spade, or a shovel.



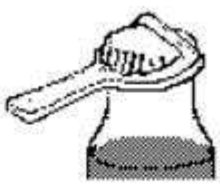
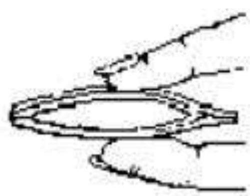
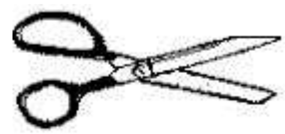




APPLY YOUR KNOWLEDGE

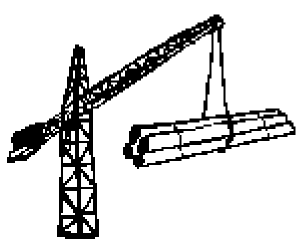
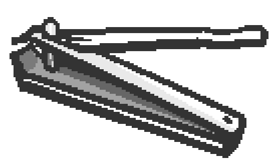
1) Explain where the fulcrum, load and effort are in these levers by using simple diagrams and symbols.
2) Identify the class of each lever.

___________ class ___________ class ___________ class

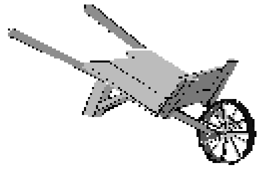
_____________________ _____________________ _____________________

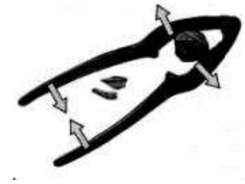
___________ class ___________ class ___________ class

_____________________ _____________________ _____________________

___________ class ___________ class ___________ class





____________________ ____________________ ____________________

What Is Force and How Is It Measured?

A force is a push or a pull that causes an object to accelerate or decelerate (i.e., a change in speed and direction). It can be applied to an object in two ways. It can be applied directly, through the contact of two objects. For example, when a baseball bat is used to hit a baseball, the bat exerts a force on the ball, causing it to accelerate in the direction it was hit.

Using the international system of measurement, force is measured in newtons (N), named after the English physicist and mathematician Sir Isaac Newton. You will do calculations using measurement in newtons. The force needed to hold up a mass of 100 g using a spring scale is about 1 N. One newton (1 N) refers to the amount of force required to move an object with a mass of 100 g. (against the force of gravity).

Mechanical Advantage

Always convert mass into force ?kg x 10 = ?N

What is "mechanical advantage"?

So far, we've found out that mechanisms (and the machines they combine to make) can make our lives easier. We can calculate how much easier things become. We call this MECHANICAL ADVANTAGE. So how do we work out mechanical advantage?
We've already said that the energy (or force) that goes into a mechanism is called the EFFORT. If your job is going to be made easier, you want to get more output for your effort. In other words, you want to be able to move the biggest load possible. If you write this as an equation, you get:

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

If the mechanical advantage is greater than 1, your effort is less than the output of the machine. In other words, the machine has increased your strength. The load, however, will only move a small distance.

If the mechanical advantage is less than 1, your effort is greater than the load. So the machine has decreased your strength. The load however will move a greater distance.

What does this mean? There is always as trade-off between strength and distance. When the mechanical advantage is greater than 1, the effort has to be sustained for a longer time and over a greater distance.

The amount of energy used will always be the same for a particular task.

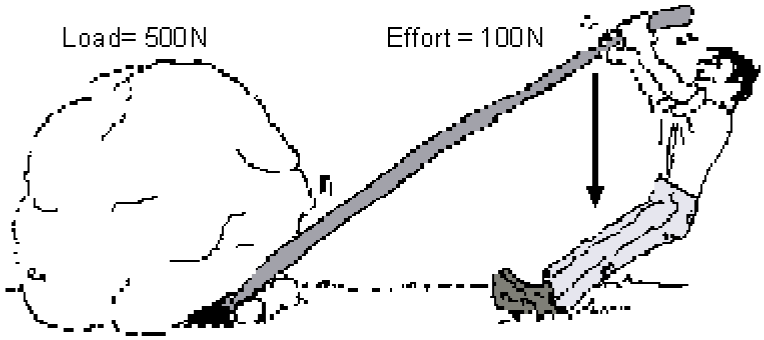
The acting force times the distance it moves equals the work put into the machine. This work is called the input force. The resisting weight times the distance it moves equals the work accomplished by the machine. This work is called the output force.

Here is an example: a machine has a mechanical advantage of 5, if an applied force (effort) of 100N can counterbalance a weight (load) of 500N.

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

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

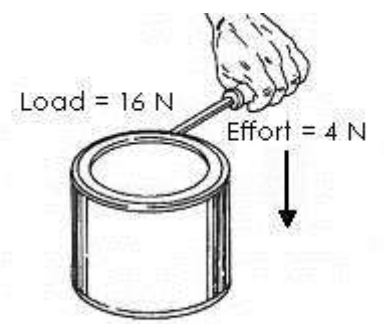
$$MA = 5$$

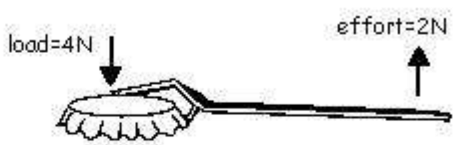


The greater the mechanical advantage, the more help the lever gives you.

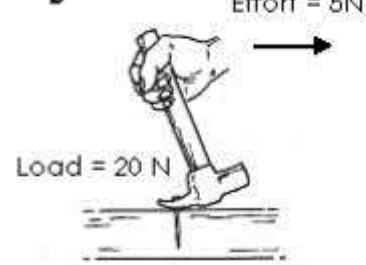
APPLY YOUR KNOWLEDGE

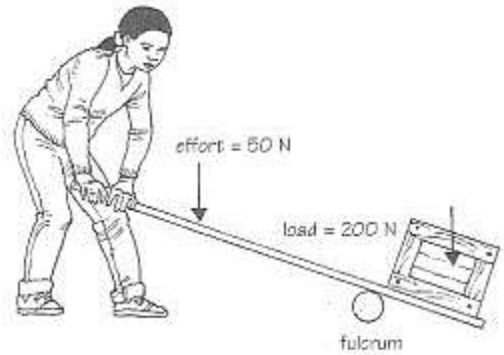
Determine the mechanical advantage of each lever below.

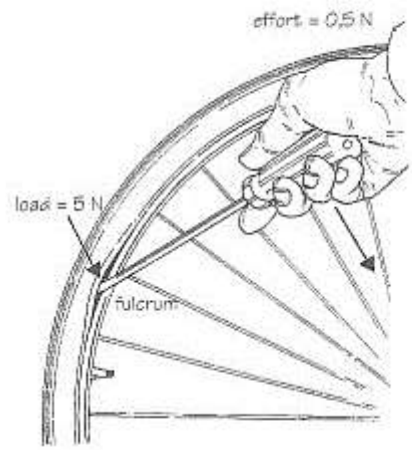




B







<u>Moment of Force</u> (also called **torque**)

You may have noticed when using a first order lever that little effort is needed to move the load if you are further away from the fulcrum than the load. In fact the further you are the less effort is needed.

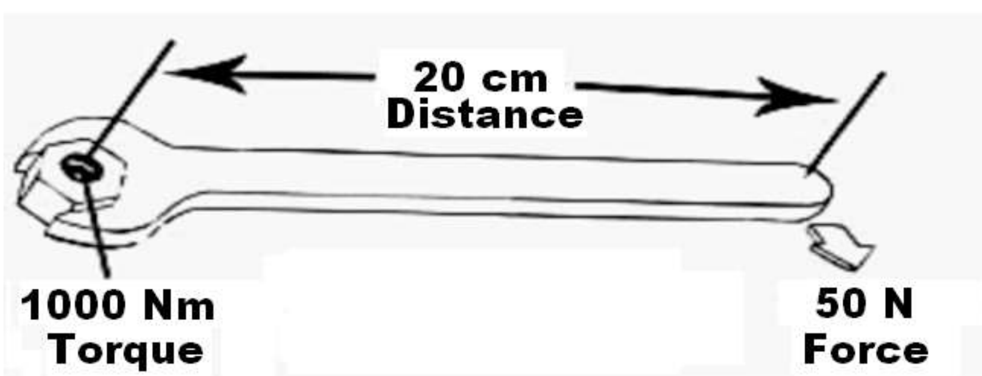
The mechanical advantage gained by a lever can be explained by the principle of ***moments.*** A moment is the **turning effect** generated when a force is applied to a lever to rotate it about the fulcrum. The moment depends upon the size of the force and its distance from the fulcrum according to the expression below:

moment = force X distance

or

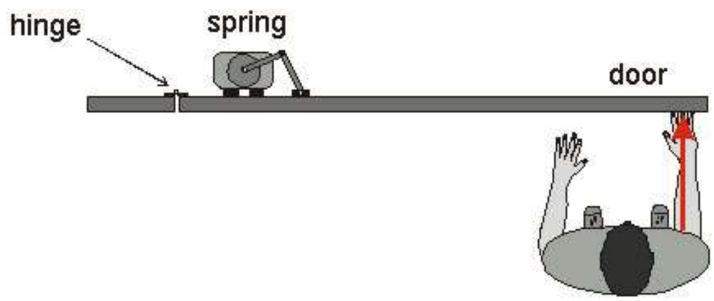
torque = force x distance

The answer is written as **Nm** which is **Newton metre**.



APPLY YOUR KNOWLEDGE

Consider a person trying to open a door, by applying a force, as shown below.



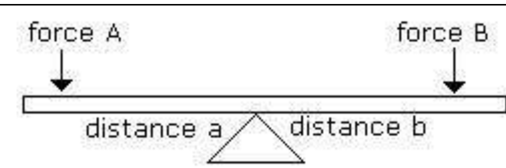
1. The force you apply on the door is 50N. The door is 1.0m wide. What is the **torque** on the swinging door?

2. The force applied to a spanner is 20N. The distance to the fulcrum is 0.25m. What is the **moment of force**?

3. If a door handle is 0.20m long and the moment of force on the door handle is 2Nm, what **force** was applied?

4. The width of a swinging gate is 0.80m and the torque on it is 40Nm. What **force** was applied?

In a simple balanced see-saw, the forces acting on the left- and right-hand sides of the pivot are the same. This is known as balancing moments. Moving the load at one end will cause the see-saw to become unbalanced. To regain balance, the load on the opposite side must either be increased or its position changed. This is known as the principle of moments. To determine the balancing moments, we multiply the force by the distance from each side of the fulcrum. When a see-saw is balanced the moments of the forces on each side of the fulcrum are equal.

The rule for a see-saw to balance is: **A x a = B x b**	

APPLY YOUR KNOWLEDGE

Both these see-saws are balanced. Use the above rule to determine the missing distance in Figure A and the missing force in Figure B.

Fig. A

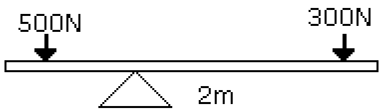
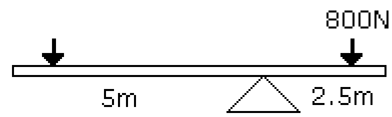
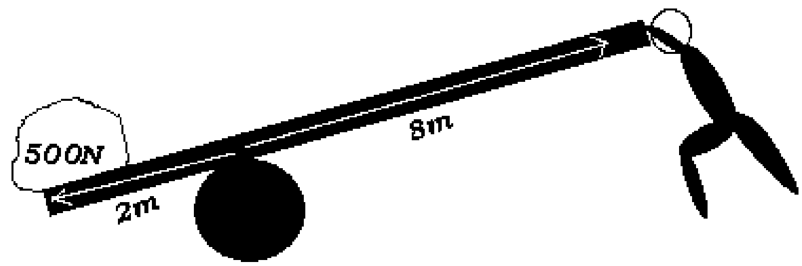
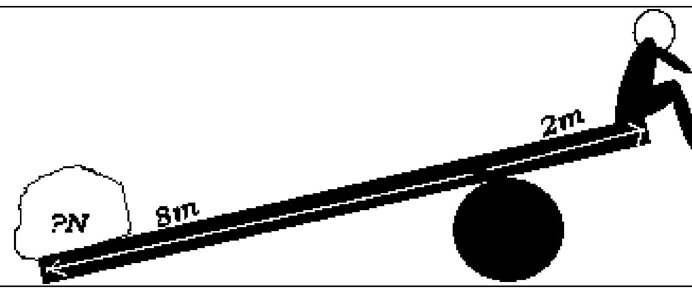
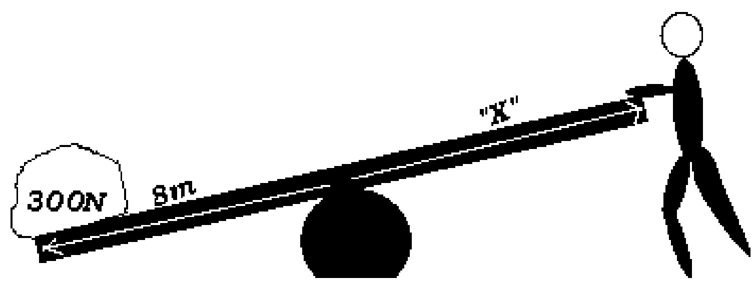


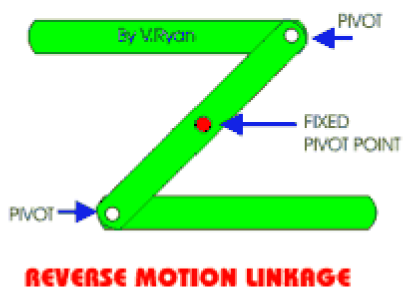
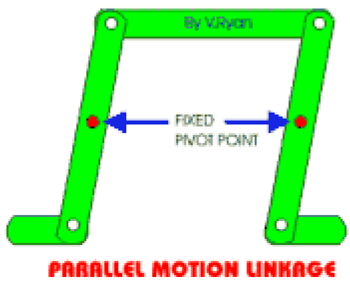
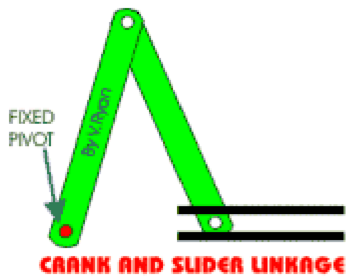
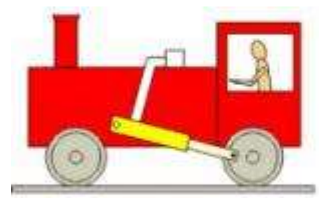
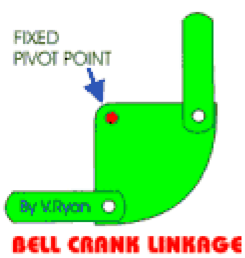
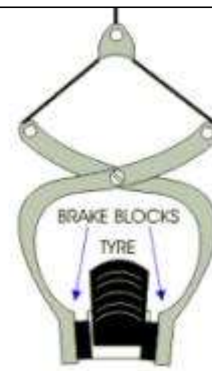
Fig. B

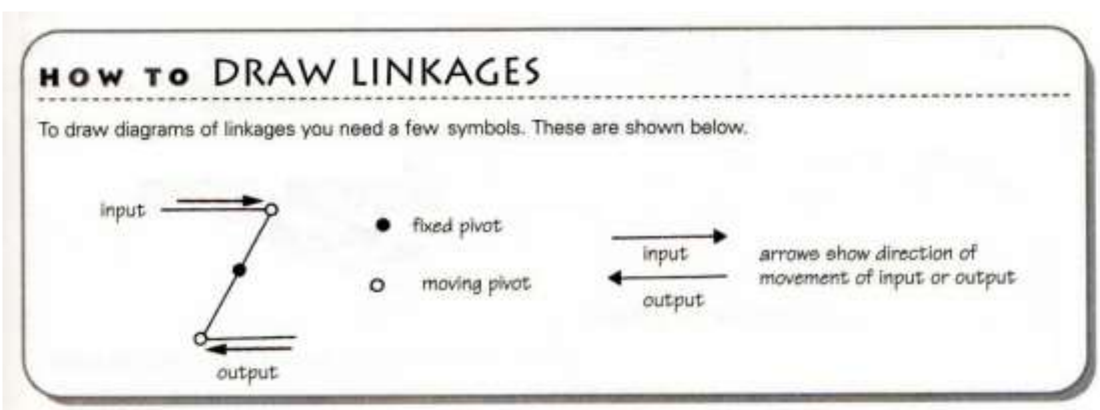


What is the force that must be applied to just lift the rock pushing down with a force of 500N?	
What is the maximum force that can be opposed if the person can apply a force of 300N ?	
What distance must a person be from the fulcrum to apply a force of 60N in order to lift a 300N load.	

Linkages

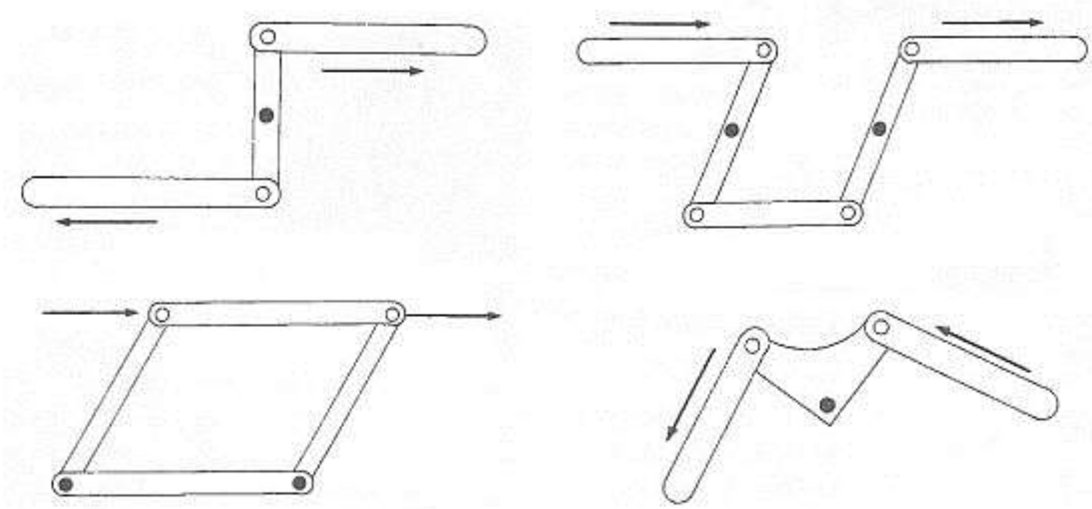
Sometimes a number of different levers are connected together to do certain jobs. A mechanism that is made by connecting levers is called a linkage. The levers in a linkage are connected at fixed pivots or moving pivots. A fixed pivot is one which moves around one point, but does not move away from that 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.

	**REVERSE MOTION LINKAGE**: As the top rod moves to the left the bottom rod moves to the right. The bars move in opposite directions. Another way of describing this linkage is the direction of movement in one rod is reversed in the other rod. The fixed pivot is the centre of rotation.	
	**PARALLEL MOTION LINKAGE**: As the large rod at the top of the diagram moves to the left the two small rods at the bottom move to the right. All the rods are parallel to each other.	
	**CRANK AND SLIDER LINKAGE**: The rods move forwards and backwards in slider. The fixed pivot anchor the linkages to one place.	
	**BELL CRANK LINKAGE**: This linkage allows horizontal movement to be converted to vertical movement. It also works the opposite way round. A practical example of this is the brake mechanism on a bicycle.	

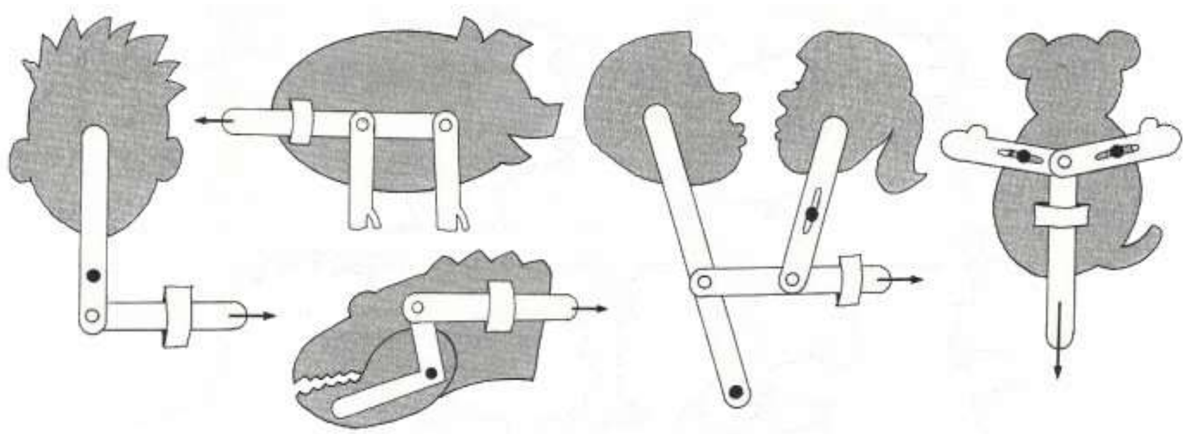


APPLY YOUR KNOWLEDGE

Draw diagrams of the following linkages:



Use cardboard and split pins and try to build the following figures. Make sure you use moving and fixed pivots where indicated.



WHEEL AND AXLE

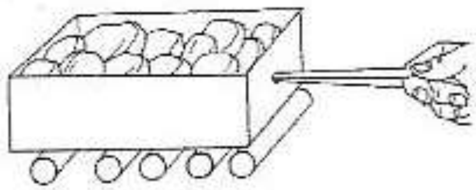
Resistance

When forces act against one another, we say that there is resistance. When you are trying to move an object across a surface, the amount of resistance depends on three things:

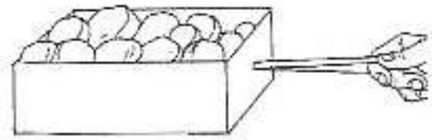
- the weight of the object you are trying to move,
- the amount of contact the object has with the surface, and
- the roughness of the surfaces which are pressing against each other.

TRY THIS:

Load a box with stones, tie a rubber band to the one end. Pull the rubber band. How far does the rubber band stretch?



Now put wooden dowels under the box and pull the rubber band. How far does the rubber band stretch?

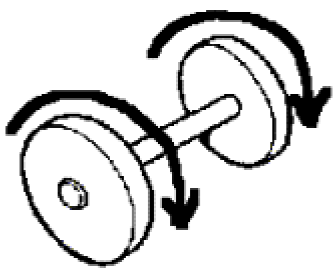


Wheels, unlike rollers, are joined to a vehicle with an axle. A wheel and axle help us turn something more easily or move something across a surface more easily. In other words: with a wheel and axle, you use less force.

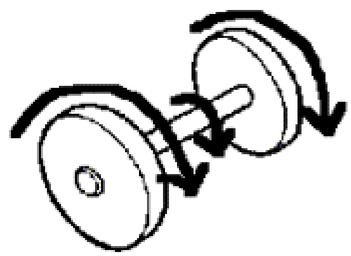
Some examples of a wheel and axle are: a crank, gears, pulleys

Different kinds of axles

Some axles are fixed to vehicles so that the axle does not move. The wheels turn around the axle. This kind of axle that cannot move is called a fixed axle.



Sometimes the axle and the wheels turn together. As the axle turns, the wheels turn as well. This kind of axle is called a moving axle. A moving axle has to be connected to a vehicle in a way that allows the axle to turn.

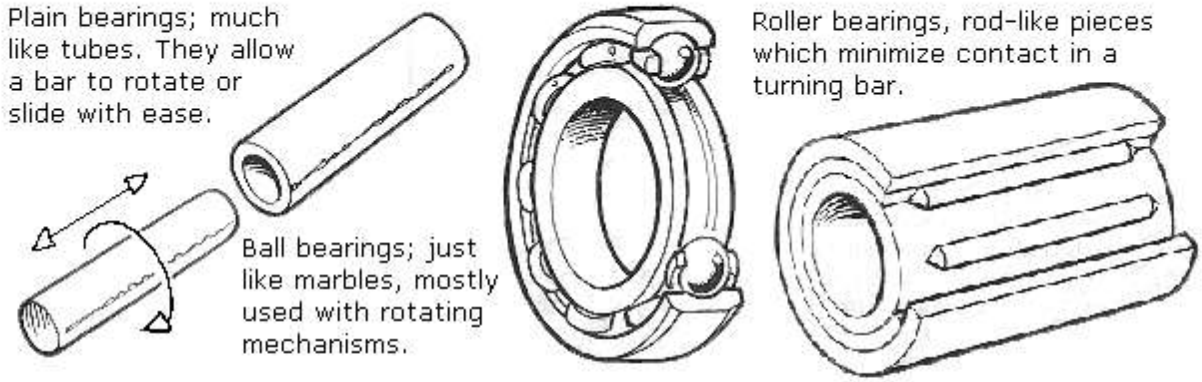


Friction

When one thing rubs against another like a wheel against the axle, we say that there is friction between them. The friction makes the wheel harder to turn.
Friction is a direct force which is applied when two objects are in contact with one another, which occurs in one form or another when any machine is being used. Friction can be described as the resistance to motion when two objects are in contact.

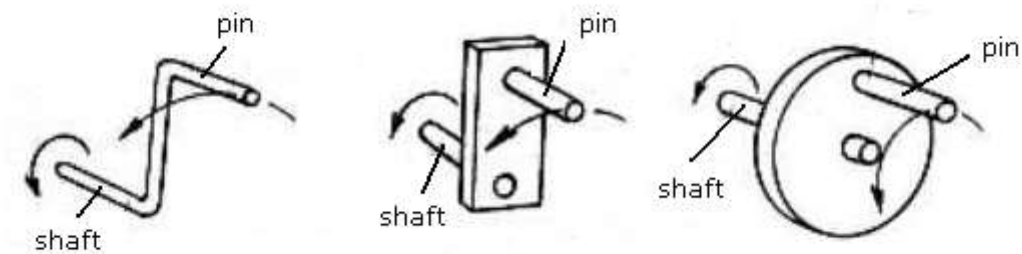
Reducing Friction

- Streamlining shapes (e.g., race cars) to reduce friction between an object and air or water.
- Bearings, can be used to create rolling friction rather than sliding friction. For example, it is easier to move a desk on wheels than it is to move one without.

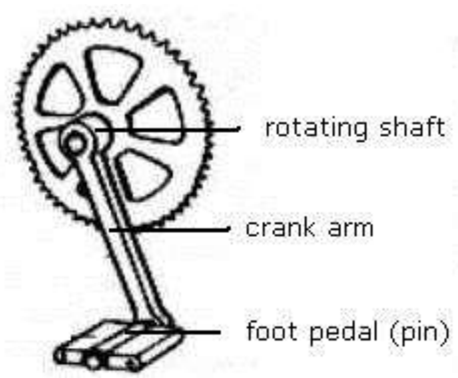


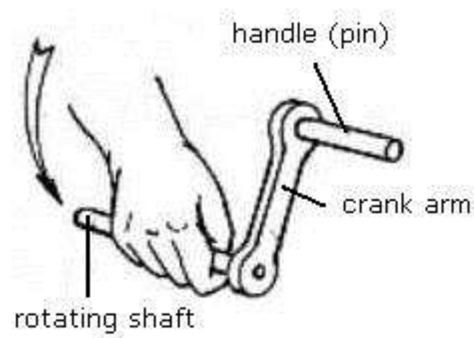
- Finished surfaces can be made smoother (e.g., polishing, sanding), thereby reducing resistance.
- Surfaces can be lubricated (e.g., oil, grease, graphite), yielding a slippery layer over which solid objects can more easily move because the lubricant reduces the amount of contact between objects.

The Crank



A crank is made up of a arm or lever attached at one end to a shaft (axle) that can rotate. The arm or lever is at a right angle (90°) to the shaft. At the other end of the arm there is a pin which is parallel to the shaft. (Although this part of the crank mechanism is called a 'pin', it is usually a handle or pedal.)





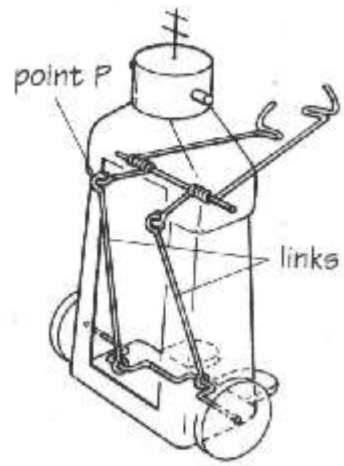
What does it do?

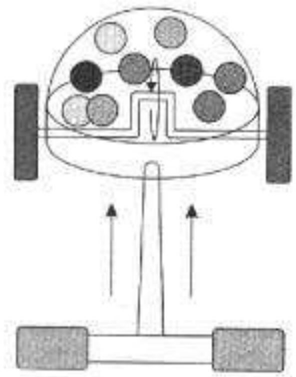
- The crank acts like a lever, **increasing mechanical advantage** (the distance between the handle and the central shaft is increased - this makes it easier to turn).

- A crank is a mechanism that **changes reciprocating motion into rotary motion**. It can also work the opposite way around and change rotary motion into reciprocating motion.

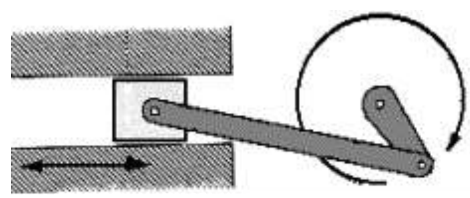
Crank shaft

When a shaft has two or more cranks it can be called a crankshaft. A typical example of a crank shaft can be found on small mechanical vehicles made for young children. As the child peddles the crank shaft rotates the wheels and the vehicle moves forward.





The crank and slider mechanism
The crank and slider mechanism is composed of three important parts:



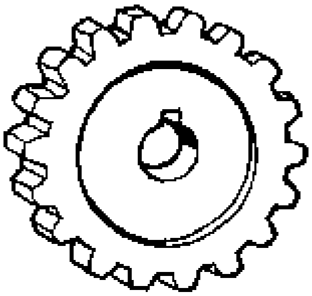
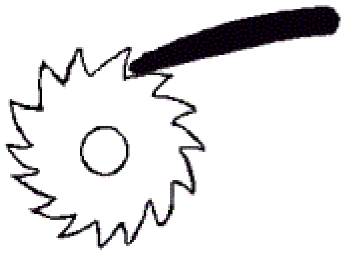
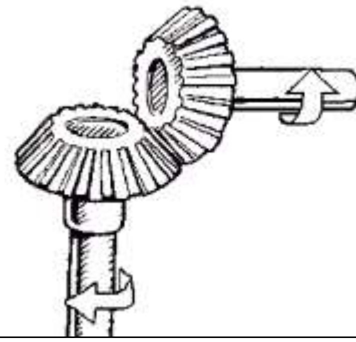
- The crank which is the rotating disc,
- the slider which slides inside the tube and
- the connecting rod which joins the parts together.

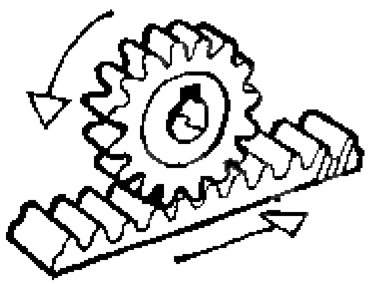
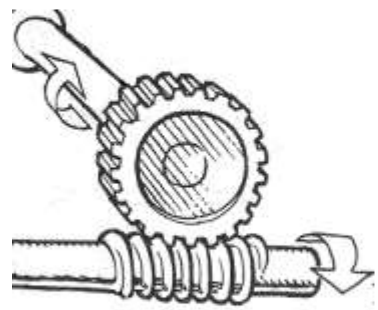
As the slider moves to the right the connecting rod pushes the wheel round for the first 180 degrees of wheel rotation. When the slider begins to move back into the tube, the connecting rod pulls the wheel round to complete the rotation.

The gear

Gears are wheels with teeth that can be used to **gain force or speed** or **change direction**.

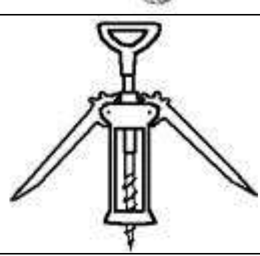
The **spur gear** is the simplest kind of gear. It is a wheel with teeth around its circumference.	A **ratchet gear** has slanted teeth. A pawl fits into the teeth in a way which only allows the ratchet to turn in one direction.	The **bevel gear** has its set of teeth fixed at an angle, this way, it can change the direction of the rotary motion from one axis to another.

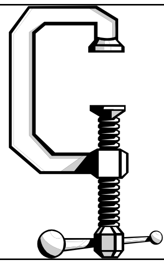
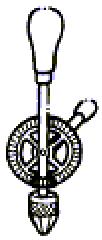
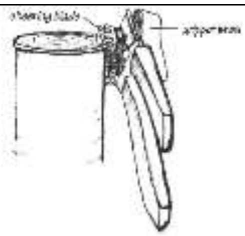
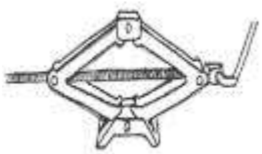
		

A **rack and pinion** gears system is also composed of two gears. The pinion is the normal round gear and the rack is straight or flat. The rack has teeth cut in it and they mesh with the teeth of the pinion gear. 	With the **worm gear**, the worm, only has one tooth but it is like a screw thread. The wheel, is like a normal spur gear. The worm always drives the worm wheel round. 

APPLY YOUR KNOWLEDGE

Find and name the mechanisms in these everyday machines.

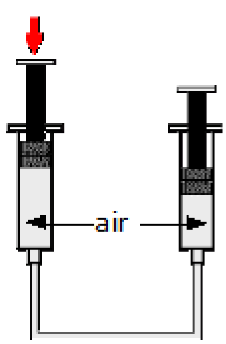
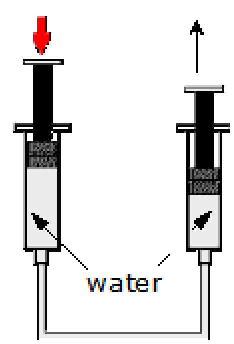
Machine	Mechanisms
	
	

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.	

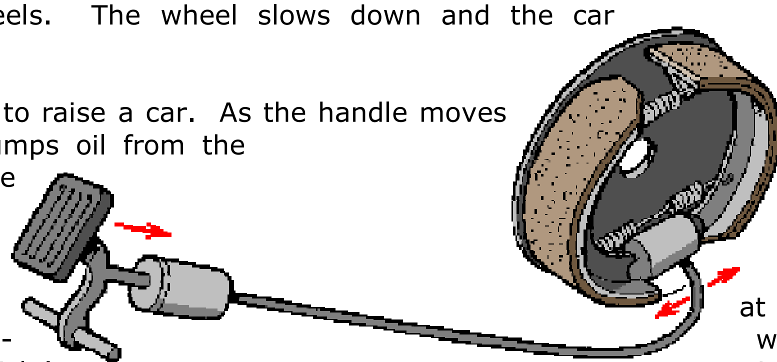
Hydraulic systems

Open and closed hydraulic systems

Hydraulics is about the flow of liquids in pipes and channels, and the pressure the liquids exerts. In an open hydraulic system, a fluid flows from one point to another if there is a difference in pressure. In a closed hydraulic system the fluid does not leave the container it is in. The pressure of the fluid in the container does the work.

Uses

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.

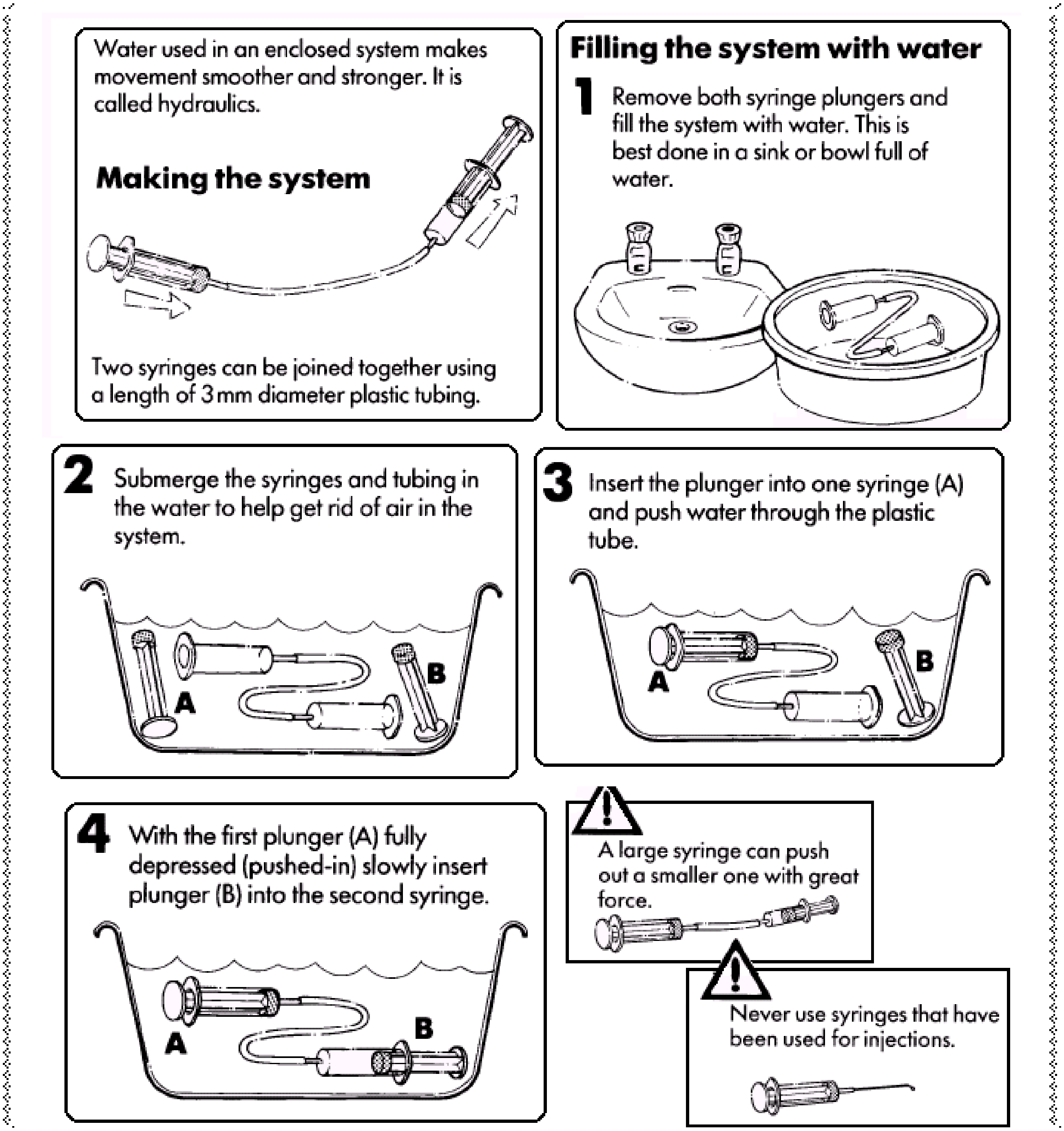


A hydraulic jack has to be pumped to raise a car. As the handle moves up and down, the input piston pumps oil from the reservoir through a one-way valve into the main cylinder. Each movement of the handle pumps only a small amount of oil and raises the car only a small distance at a time. To lower the vehicle the one-way valve is released, and the vehicle's weight forces the oil back into the reservoir.

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.
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.

HOW CAN WE MAKE IT WORK?



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.

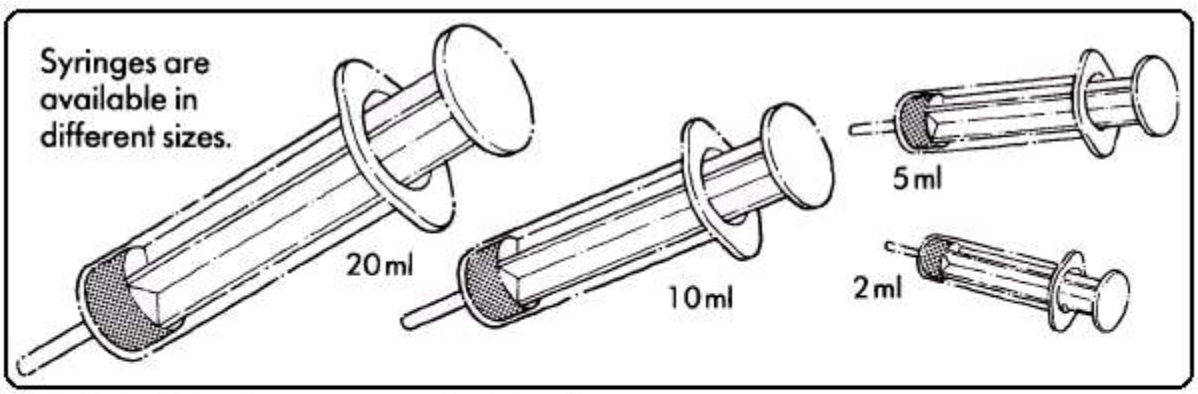
Uses

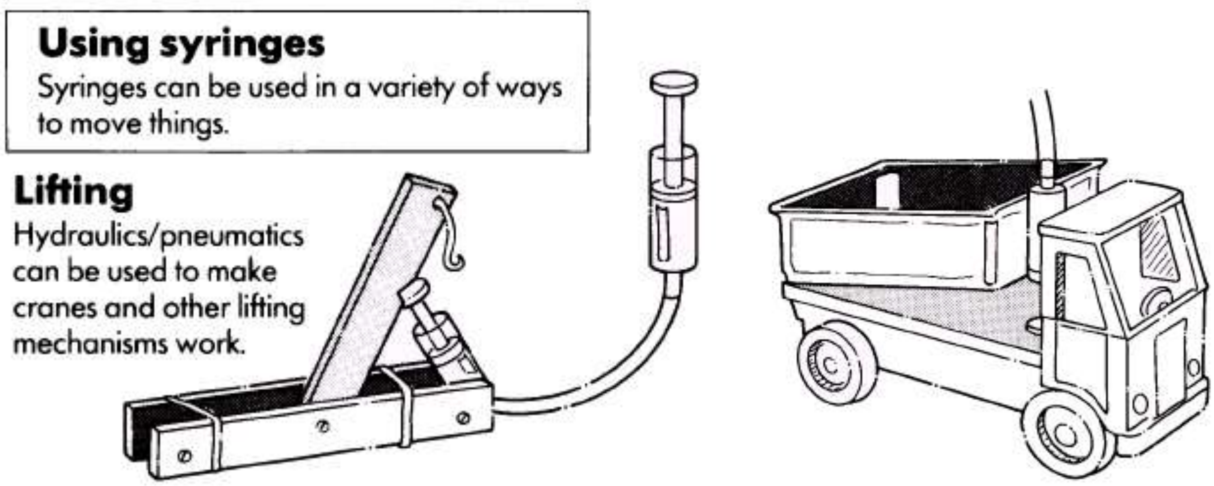
Bus doors are opened and closed using a pneumatic system. The piston in the system moves in and out in a straight line, but is connected to a lever system that makes the door swing open and closed. The hissing sound you hear when the doors open and close is the movement of compressed air. **Car hoists** that lift cars in workshops are also operated by pneumatic systems. **Pneumatic wheel spanners** and **jackhammers** are also examples of pneumatic systems.

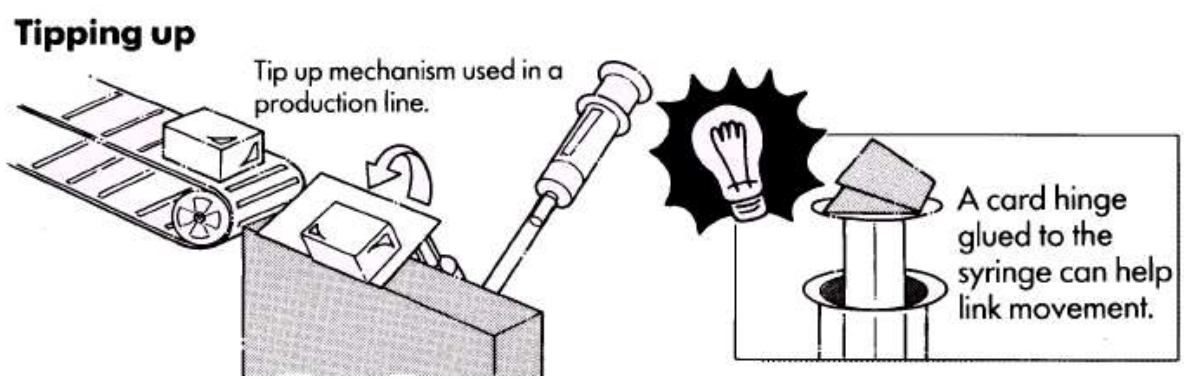
Components of a pneumatic system:

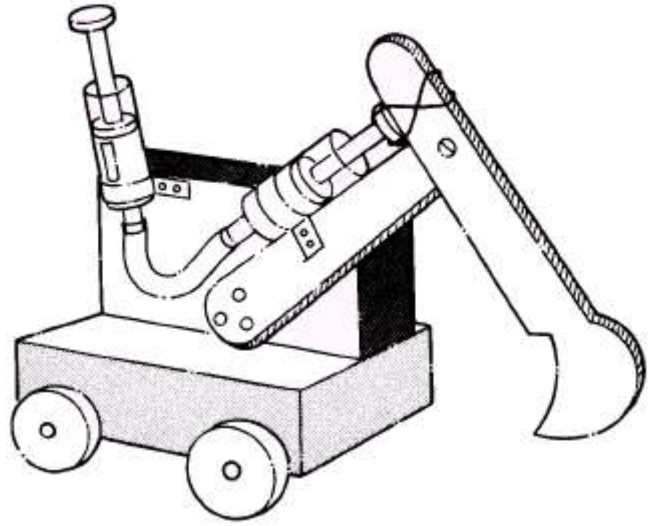
- A supply of compressed air, usually from a compressor
- Air lines containing the compressed air
- Cylinders with pistons for producing force and movement
- Valves that control the flow of compressed air

EASY IDEAS USING HYDRAULIC & PNEUMATIC SYSTEMS

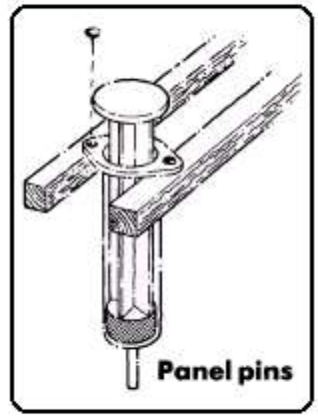






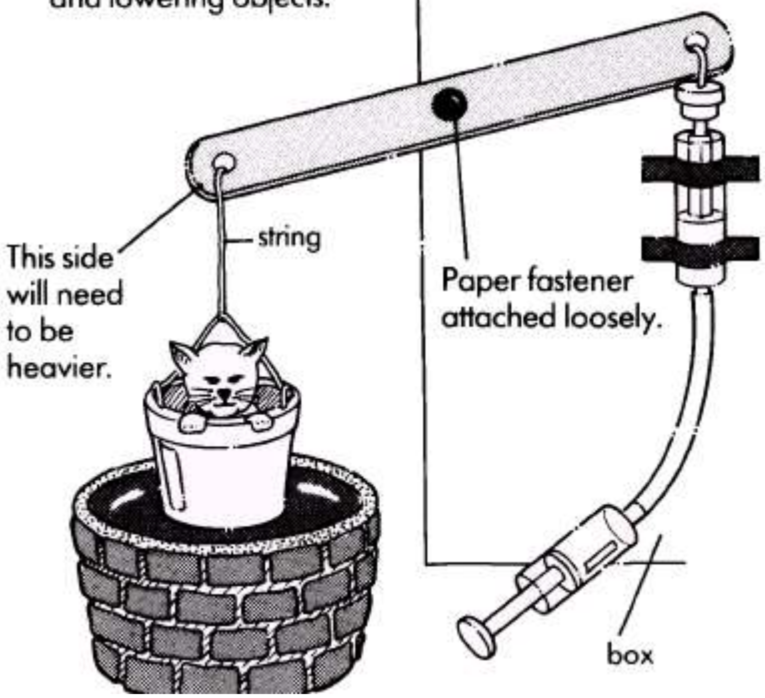


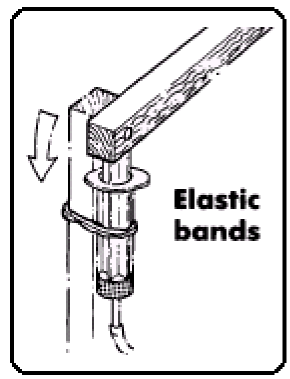
attaching syringes



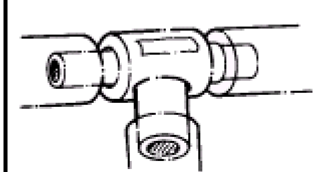
Lifting and lowering

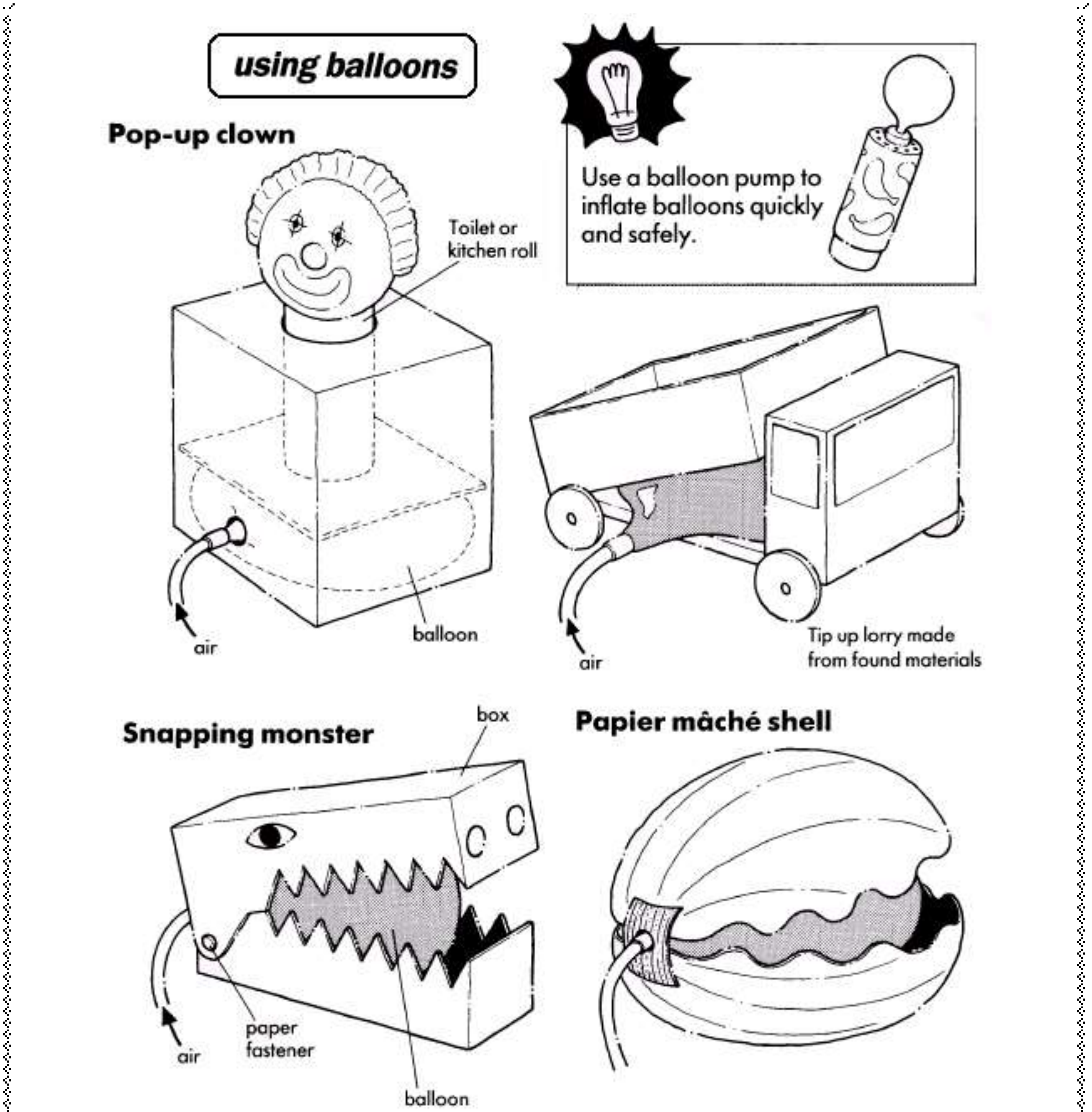
This type of mechanism can be used for lifting and lowering objects.





Connectors are useful to share out movement.

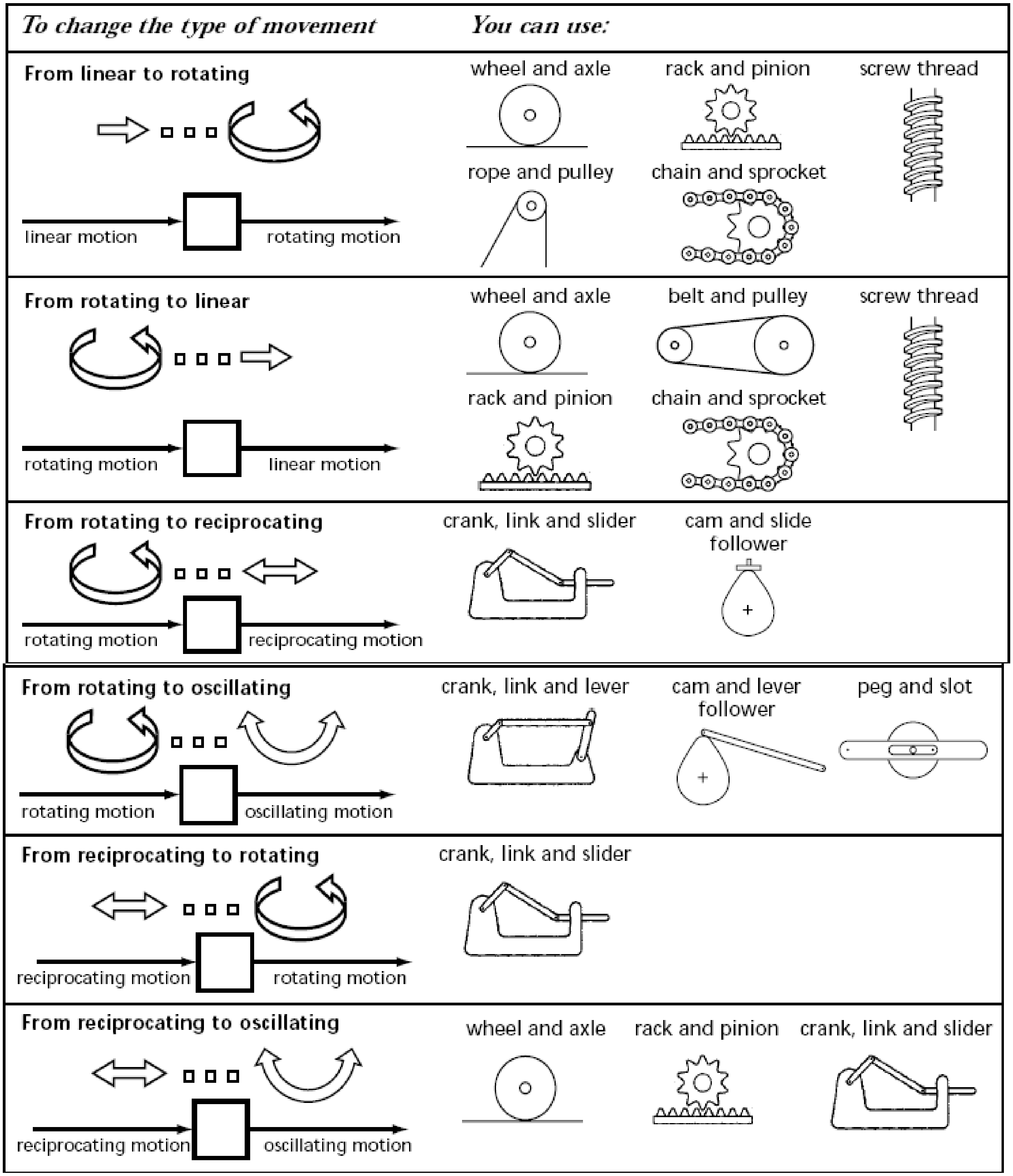


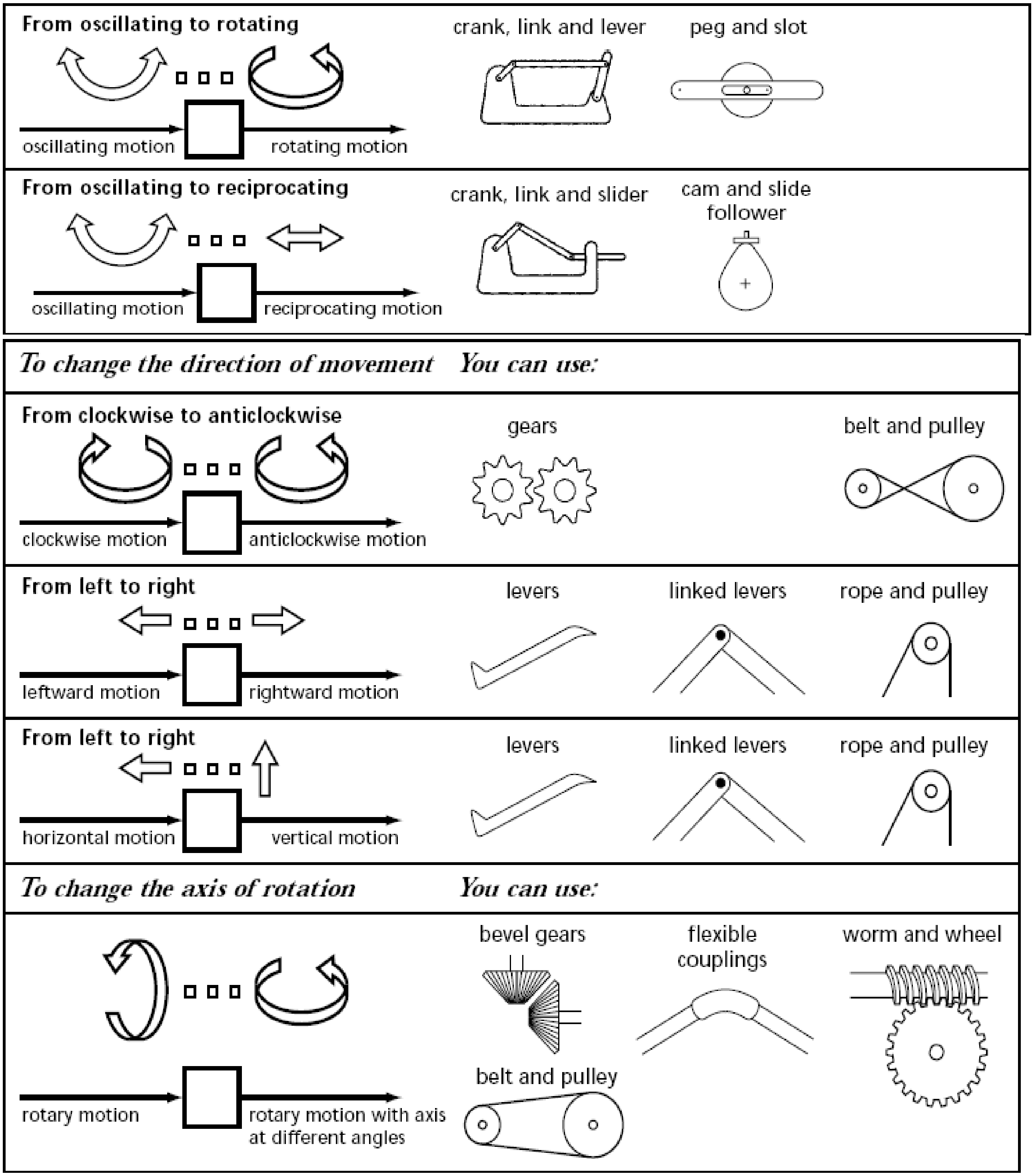


Apply your knowledge

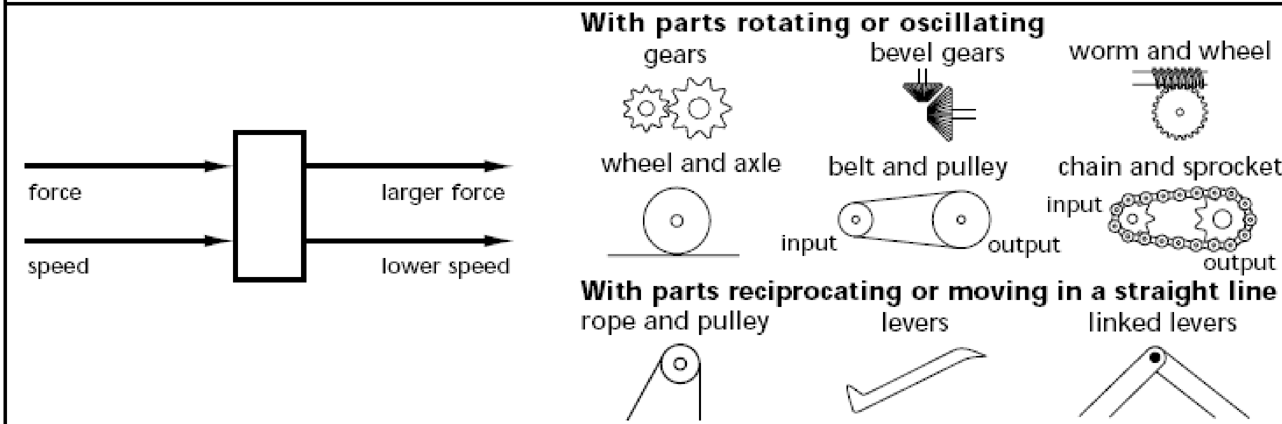
Look at the toys shown above and then make your own hydraulic or pneumatic toy by using syringes or balloons.

Mechanisms Chooser Chart

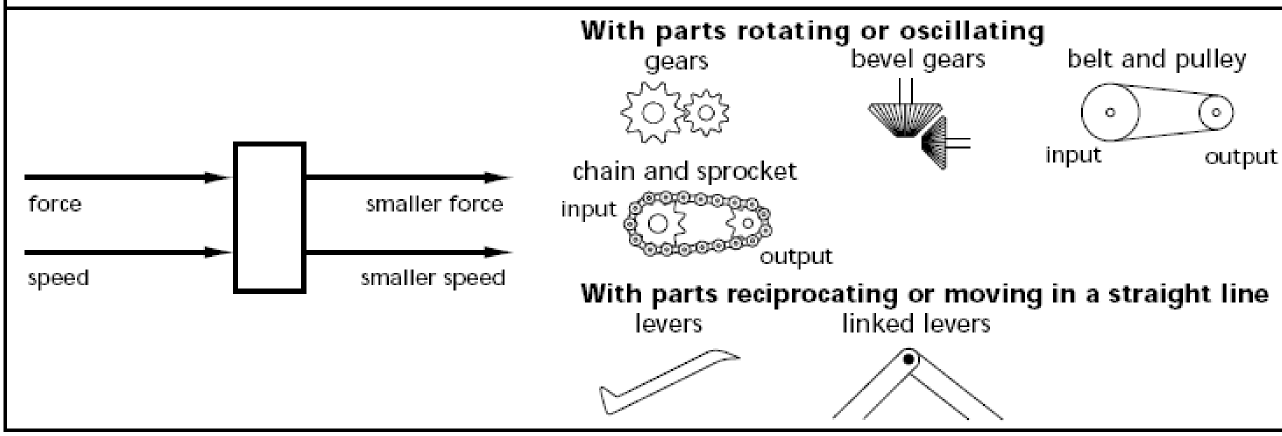



From oscillating to rotating
oscillating motion
rotating motion
crank, link and lever
peg and slot
From oscillating to reciprocating
oscillating motion
reciprocating motion
crank, link and slider
cam and slide follower
To change the direction of movement
You can use:
From clockwise to anticlockwise
clockwise motion
anticlockwise motion
gears
belt and pulley
From left to right
leftward motion
rightward motion
levers
linked levers
rope and pulley
From left to right
horizontal motion
vertical motion
levers
linked levers
rope and pulley
To change the axis of rotation
You can use:
rotary motion
rotary motion with axis at different angles
bevel gears
flexible couplings
worm and wheel
belt and pulley

To increase output force and decrease speed	*You can use:*



To increase output speed and decrease force	*You can use:*



ELECTRICITY

Demonstrates knowledge and understanding of electrical circuits with more than one output device in the circuit (series and parallel), and represents them using systems diagrams.

Different kinds of electricity

- **Static electricity**, is a collection of positive (+) or negative (-) charges on the surface of a non-conducting material such as rubber or plastic.

- **Direct current** or DC is electricity that directly flows through a conductor, from a negatively charged area to one that has positive charges, such as a metal wire. This movement of electrons through a conductor is called Direct Current (DC) electricity, because the electricity is traveling directly through the wire from (-) to (+). You usually get DC from batteries, although DC generators is another source of this form of electricity. The characteristics of DC electricity in a circuit are voltage, current and resistance.

- **Alternating current** (AC) electricity is the type of electricity commonly used in homes and businesses throughout the world. The current in AC electricity alternates in direction. The back-and-forth motion occurs between 50 and 60 times per second, depending on the electrical system of the country. AC is created by an AC electric generator, which determines the frequency. What is special about AC electricity is that the voltage in can be readily changed, thus making it more suitable for long-distance transmission than DC electricity.

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.

APPLY YOUR KNOWLEDGE

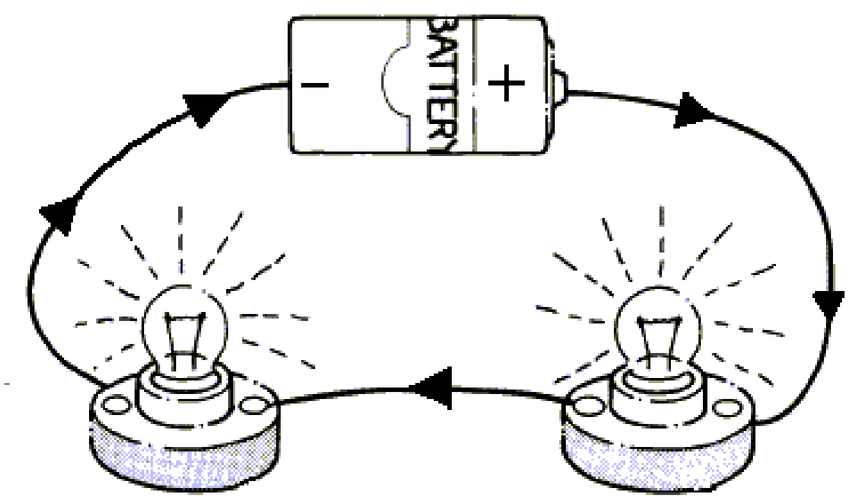
Make a tick next to the **conductors** in the following list.

Paper clips		Paper-clips		Copper wire	
Pencils		Rubber bands		Iron nail	
Erasers		Pieces of wood		Salt water	
Aluminum foil		Foam pieces		Distilled water	

Electric current

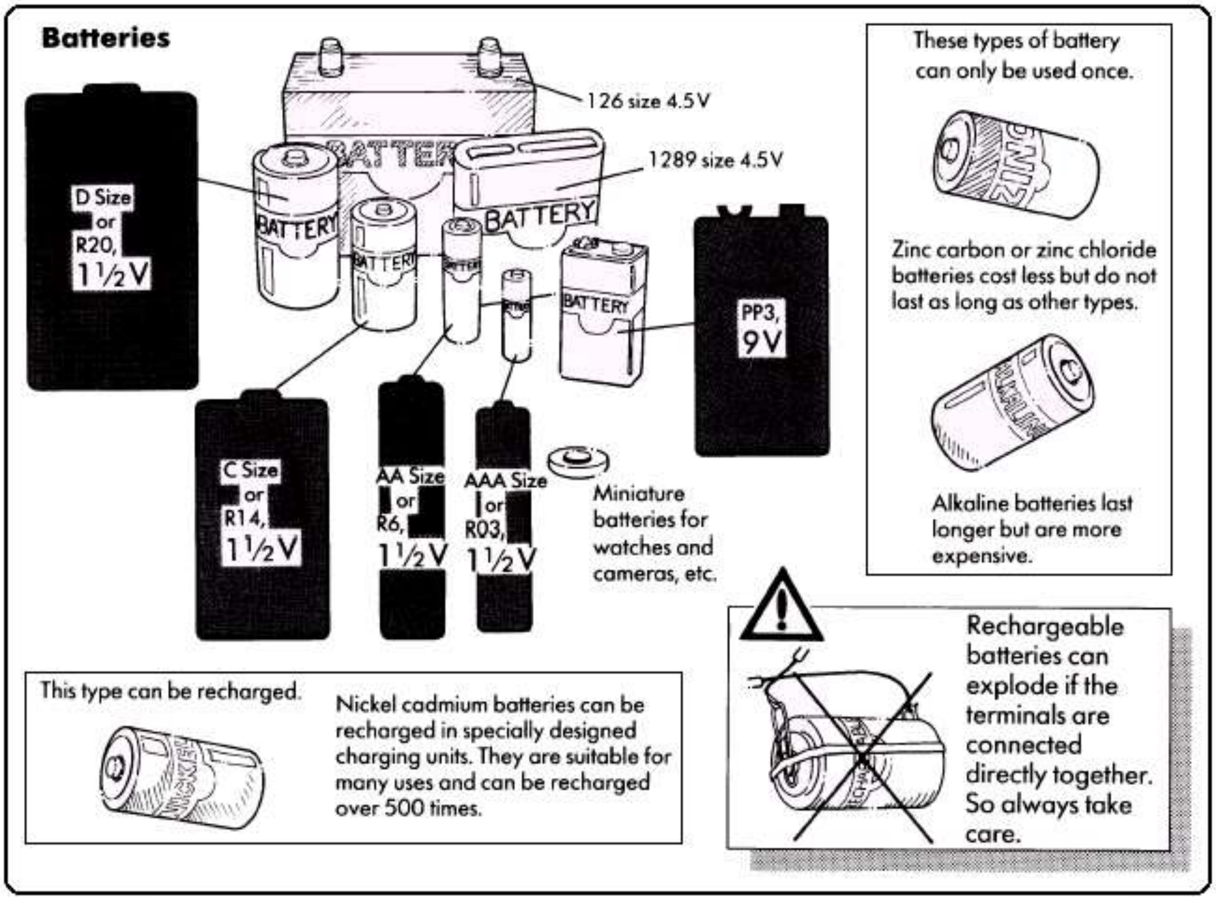
An electric current is a flow of positive charges moving **from positive to negative** around a circuit.

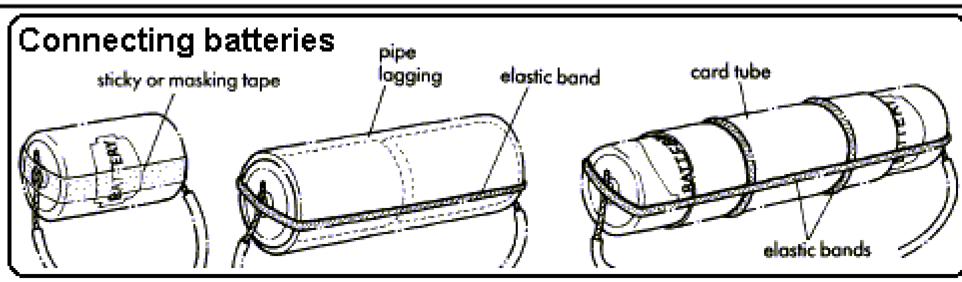
- When the switch is open, no current can flow.
- When the switch is closed, the circuit is complete and the current flows.

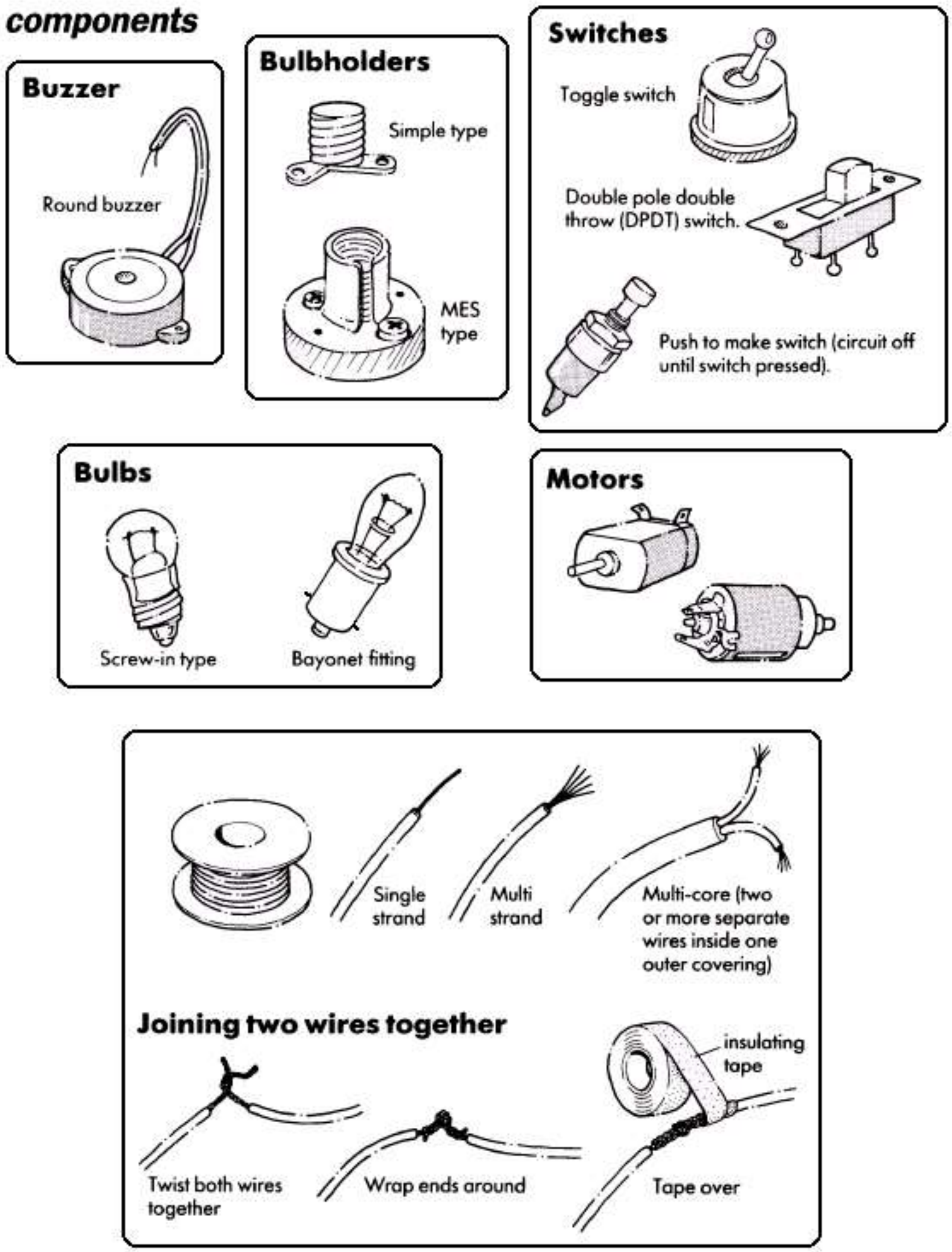


Batteries and cells

A cell has two ends, labeled + (positive) and – (negative). Cells must be connected the right way round if their voltages are to add up. If a cell is the wrong way around, it is shorted, and we have to subtract its voltage.
The bigger the voltage, the stronger the current.

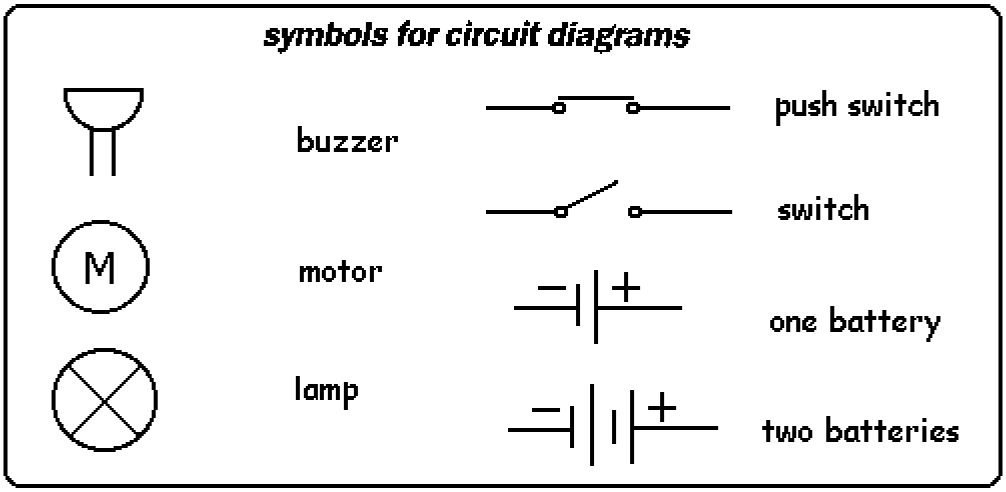

Batteries
126 size 4.5V
1289 size 4.5V
D Size or R20, 1½V
C Size or R14, 1½V
AA Size or R6, 1½V
AAA Size or R03, 1½V
PP3, 9V
Miniature batteries for watches and cameras, etc.
These types of battery can only be used once.
Zinc carbon or zinc chloride batteries cost less but do not last as long as other types.
Alkaline batteries last longer but are more expensive.
This type can be recharged.
Nickel cadmium batteries can be recharged in specially designed charging units. They are suitable for many uses and can be recharged over 500 times.
Rechargeable batteries can explode if the terminals are connected directly together. So always take care.


Connecting batteries
sticky or masking tape
pipe lagging
elastic band
card tube
elastic bands

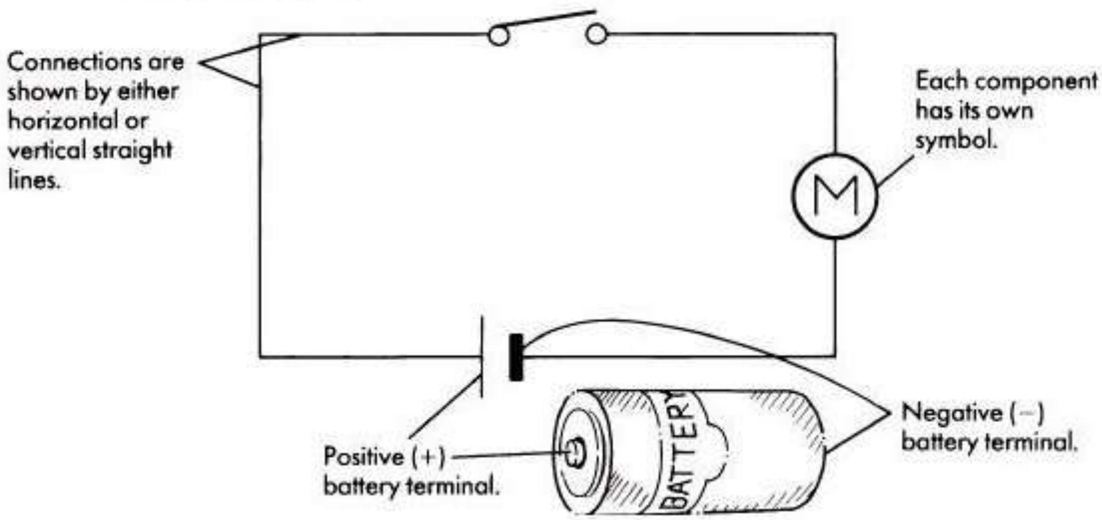


Circuit diagrams

We use circuit diagrams with symbols to show electrical circuits. Electricians and engineers draw circuit diagrams to help them design the actual circuits. The important thing to note is what each symbol stands for.

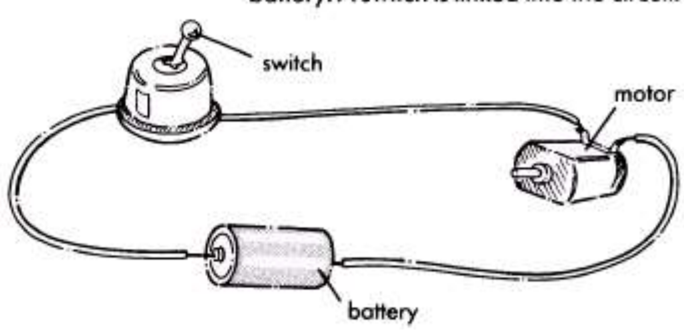


Circuit diagram



The circuit

This circuit shows a motor connected to a battery. A switch is linked into the circuit.

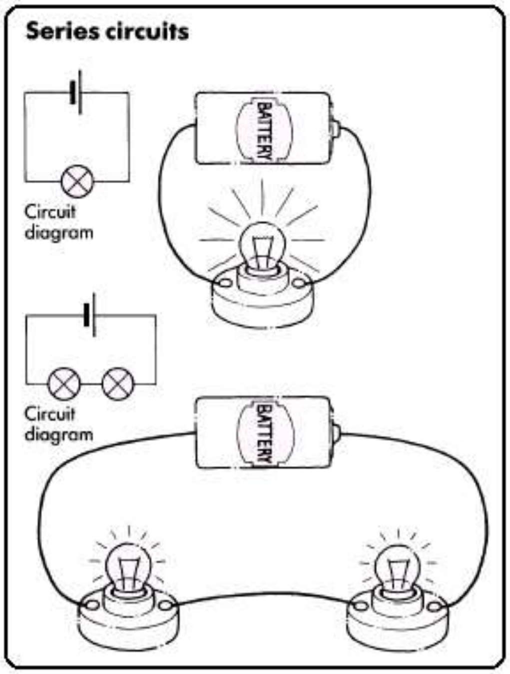


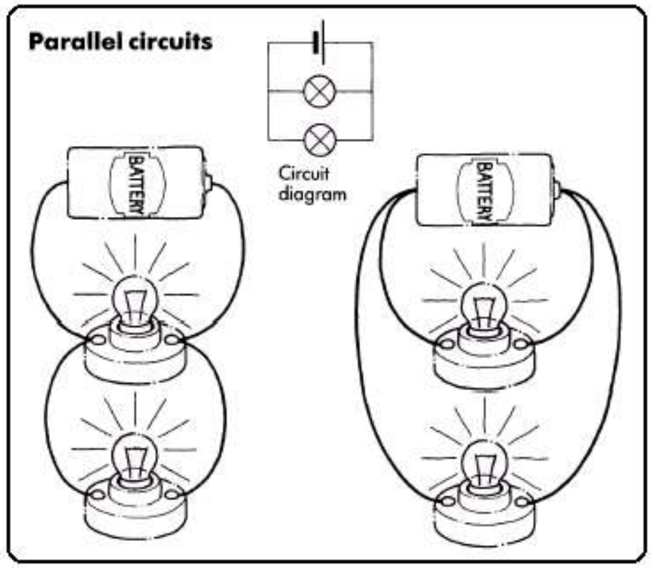
Series and Parallel circuits

There are two important ways of connecting components in a circuit. We can connect components in series or in parallel.

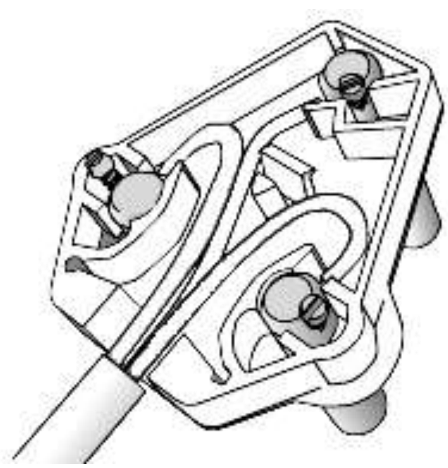
- In a **series circuit** the whole electric current passes through each of the components.
-

- In a **parallel circuit** the current splits so that only part of the current pass through each of the components.





Wiring of a plug



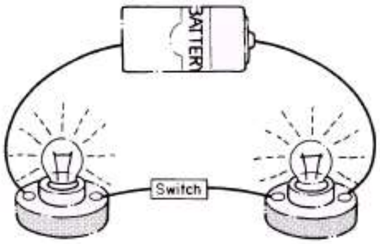
Top pin: Earth (E) - green and yellow wire

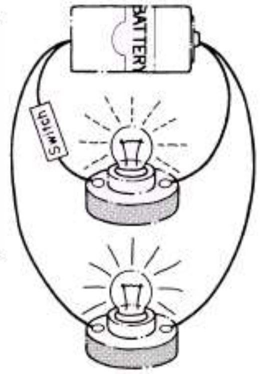
Left pin: Neutral (N) - blue wire

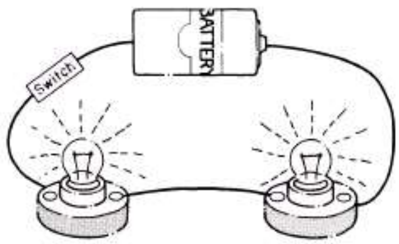
Right pin: Live (L) - brown wire

APPLY YOUR KNOWLEDGE

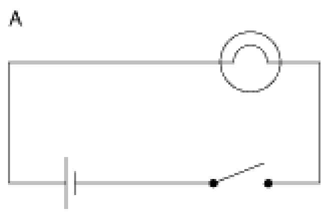
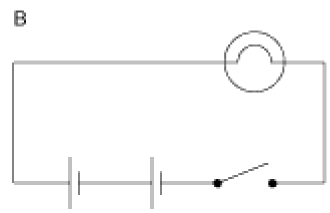
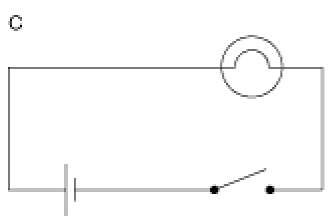
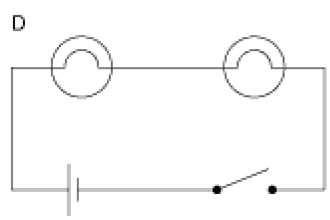
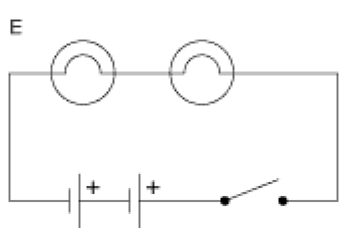
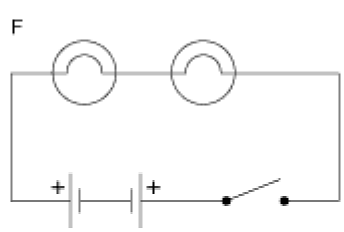
Draw the following circuits diagrammatically in the boxes provided

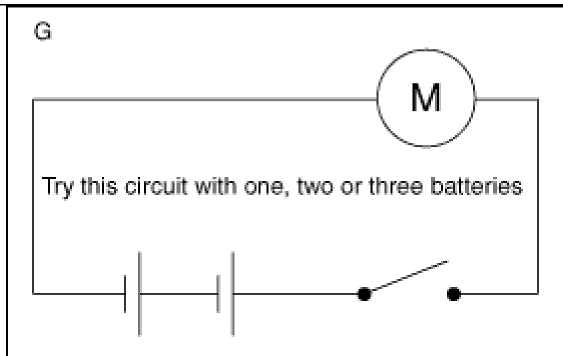
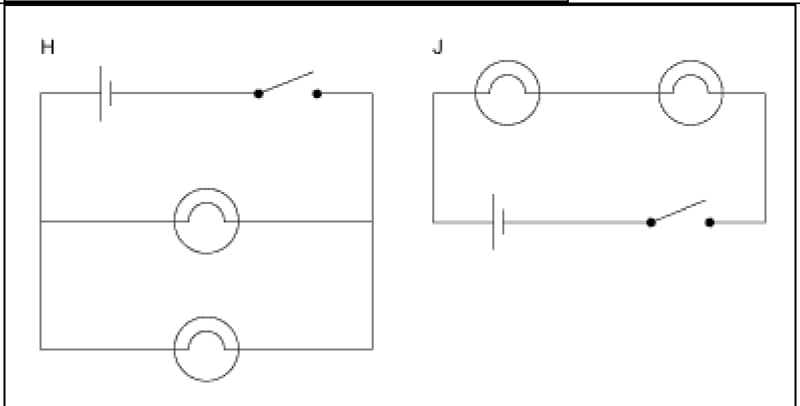
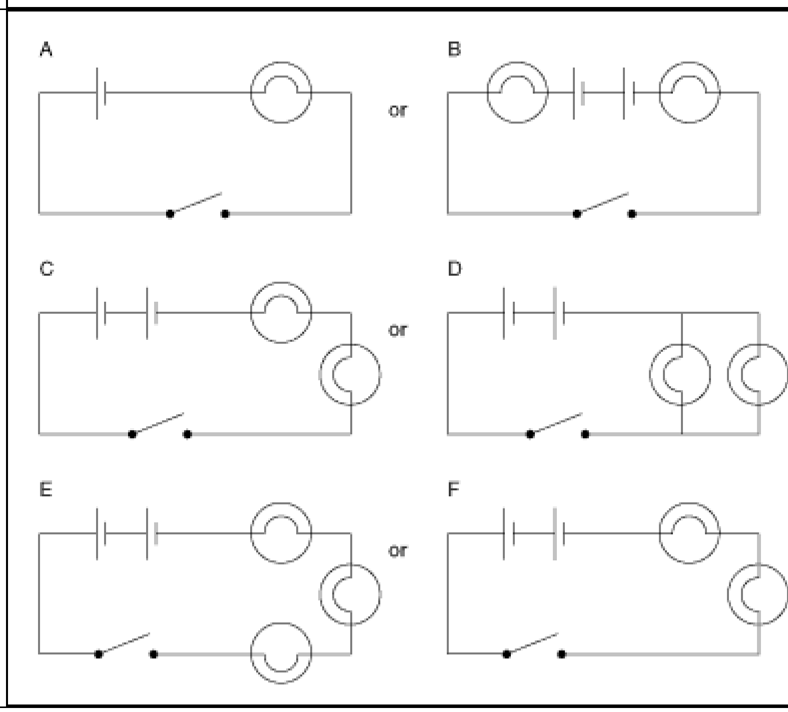






APPLY YOUR KNOWLEDGE

Which circuit has the brighter globe? Why do you think this occurs?	 
Which circuit has the brighter globe(s)? Why are they brighter?	 
Which circuit has the brighter globes? Why do you think this happens?	 

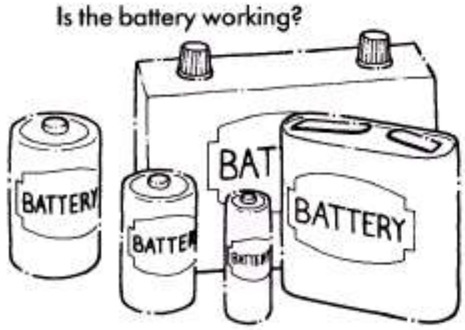
How is the speed of an electric motor affected by the number of batteries in the circuit?	
If you wanted to light up two globes as brightly as possible using one battery, which circuit is the better way to do it?	
Predict which of each pair of circuits in the diagram will have the brighter globes.	

circuit fault finding

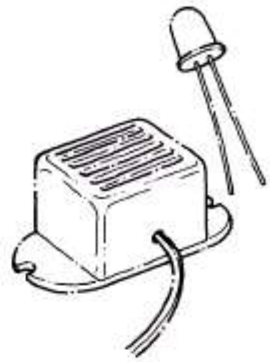
Has enough insulation been stripped away where connections have been made?

Is there a short circuit? (Are connections touching?)

Is the battery working?

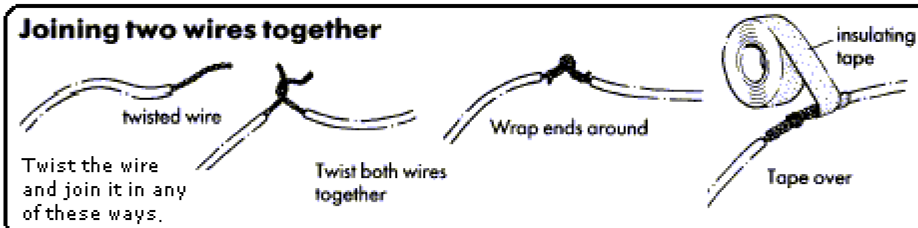


Is the component connected the wrong way round? (Buzzers and most LEDs will only work connected in one direction.)



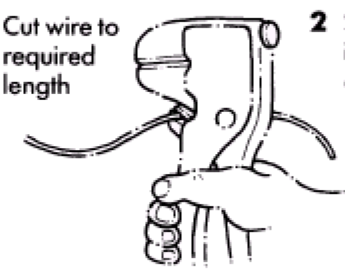
Is the battery strong enough? (Some components such as buzzers require a certain voltage before they will work.)

Joining two wires together

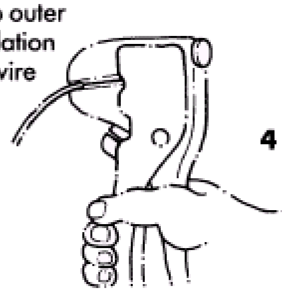


Connecting wires to components

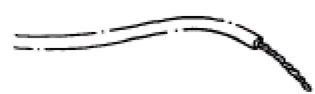
1 Cut wire to required length



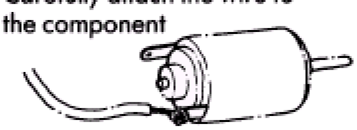
2 Strip outer insulation off wire



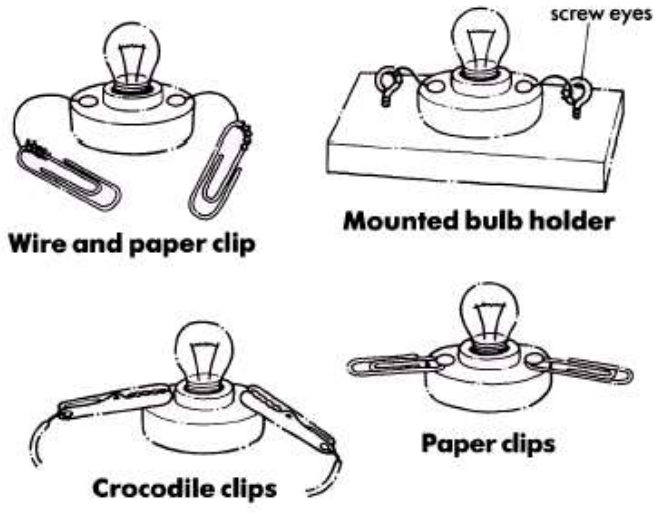
3 Carefully twist strands together



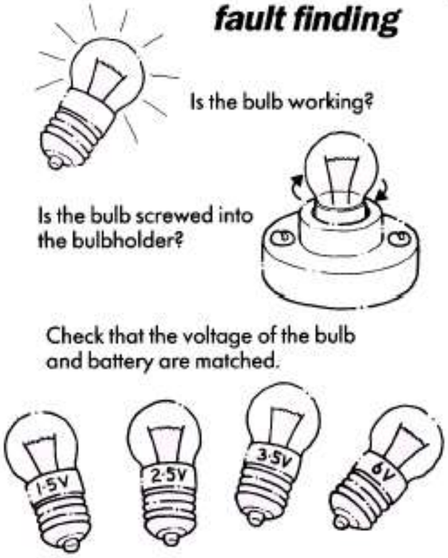
4 Carefully attach the wire to the component



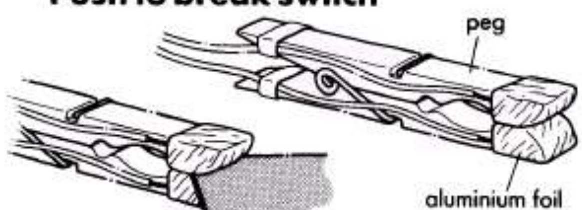
connecting bulbs



fault finding

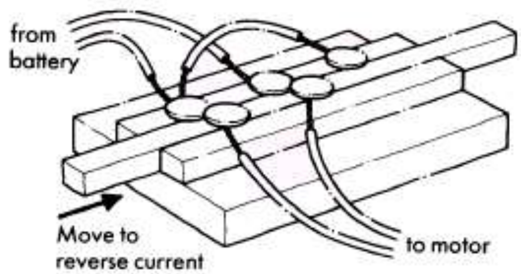


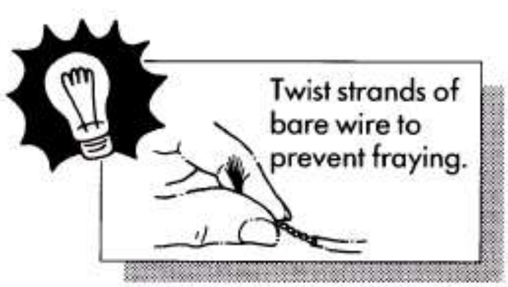
Push to break switch



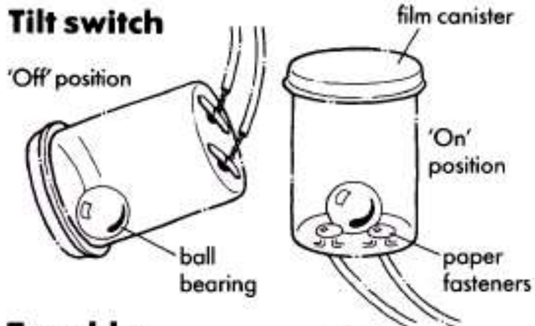
Card can be used to keep the electrical contacts apart. Salt crystals could be used as a moisture sensor as they will conduct electricity when wet.

Reversing switches

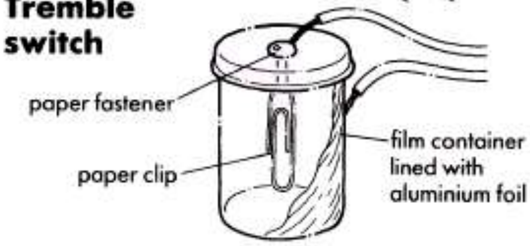




Tilt switch

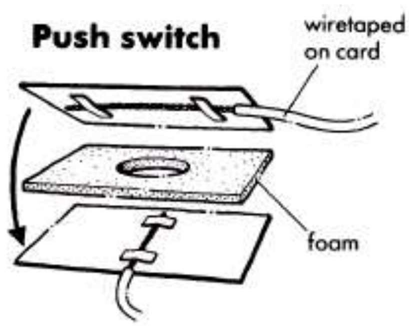


Tremble switch



Will only work intermittently unless 'locked' in some way.

Push switch



1. What is alternating current?

a) Current that alternates in direction within the wire

b) Current that alternates between on and off

c) Current that alternates between AC and DC

2. What happens when a light burns out in a series circuit?

a) The other lights remain lit

b) The voltage increases dramatically

c) The circuit is broken

3. Why is a parallel circuit used in your house?

a) To reduce the electric bill

b) So you can turn things on independently

c) To use one switch for all appliances

4. What is a common way to create direct current electricity?

a) Atomic energy

b) Use a battery

c) Lightning

More questions:

1. Why are symbols used to describe electric circuits?
2. How is the amount of electricity flowing through a circuit affected by the number of batteries in the circuit?
3. How is the amount of electricity flowing through a circuit affected by the number of globes in the circuit?
4. How is the amount of electricity flowing through a circuit that contains two globes affected by the way in which the globes are connected?

PROCESSING AND MATERIALS

Demonstrates knowledge and understanding of how materials can be processed to change or improve properties (e.g. strength, fire resistance, waterproofing, taste, volume, texture).

There are two main groups of processing technology:

Construction technology

Making use of materials to build different structures like bridges, houses, shopping centers, towers, etc.

Manufacturing technology

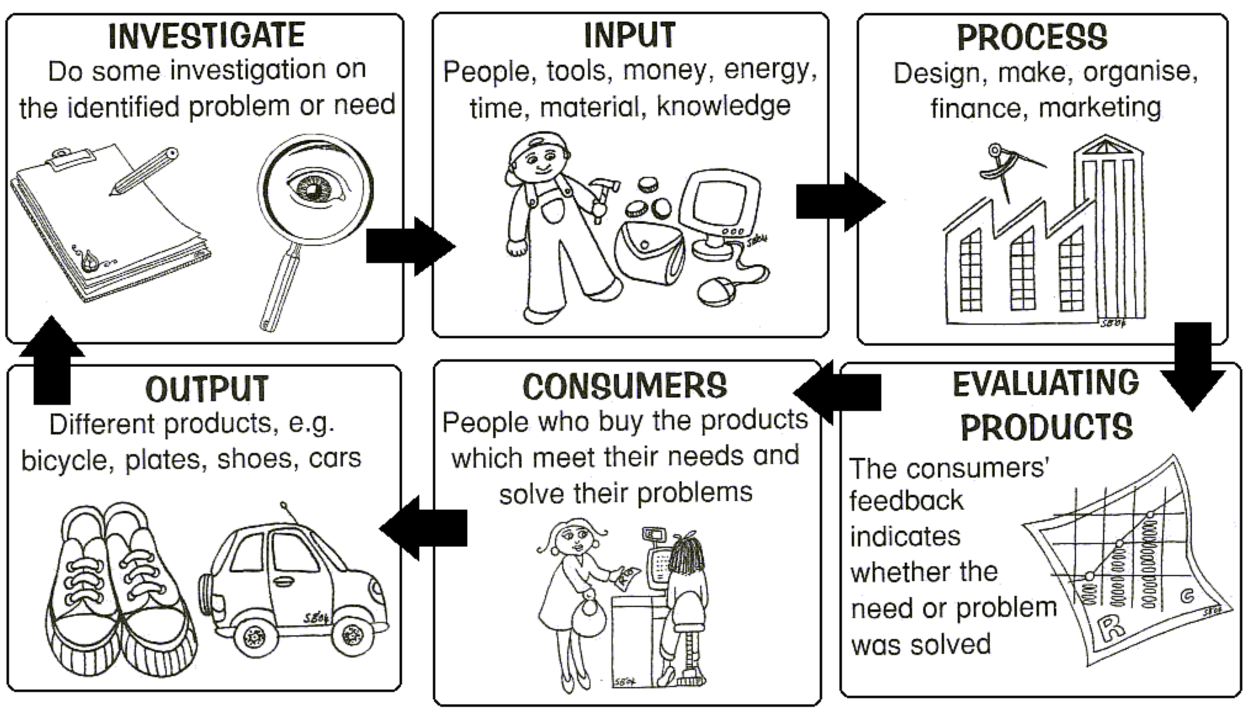
Making use of materials to make different products in factories, e.g. electrical appliances, food, cars, clothing, furniture, etc.

So……

Processing is about using tools and machines to change raw **materials** into useful products. We can illustrate this with the following simple flow diagram:

Input ⇒ Process ⇒ Output

Now let's take a closer look at the **technological process**:



Materials

Materials can be natural or manufactured.

Raw materials are materials which we find in their natural state, such as materials that we get from plants, animals and the earth. Examples include fibers from the flax plant that are used to make linen and cotton, which is a processed, natural material that is made from the seeds of cotton heads. We also get raw materials from animals, such as silk that is produced by silk worms. From the coats of animals such as sheep and goats, we get fibres to make wool. Wool is a processed, natural material.

Processed natural materials can be made from minerals. A mineral is a non-living thing that comes from the earth. Iron ore is a rock that contains iron. Before we can use the iron, we have to find ways to separate the iron from the ore. Natural processed materials from minerals include iron, salt, diamonds, granite, marble and copper.

People make **synthetic** or artificial materials. These are materials that are not found in nature. People use special chemical processes to make artificial materials. People use coal and oil to make nylon, polyester and acrylic. They use crude oil to make petroleum that we use as fuel in our cars. We use many synthetic materials, for example perspex for CD covers and vinyl for floor coverings and the dashboards of vehicles.

Apply your knowledge

Look around you and list 7 objects in the first column and then decide what they are made of and whether they are natural or synthetic.

Object	**Plastic**	**Wood**	**Metal**	**Fabric**	**Glass**	**Natural**	**Synthetic**

Properties of materials describe the way materials feel when we touch them, their appearance when we look at them and the way they smell. We can describe the materials with specific words, such as "shiny", "fluffy", "dry", "cool" and "sour". But properties also describe the way materials behave when we use them. We call these working properties. Here are some words that we use to describe the working properties of materials:

- **strong** - it does not break when very big forces are applied to it.
- **tough** - it does not crack or break easily and it is very hard.
- **hard** - it cannot be scratched or dented easily.
- **brittle** - it breaks easily if you hit it or bend it.
- **stiff** - it does not stretch or bend.
- **flexible** - it bends easily and goes back to its original shape.

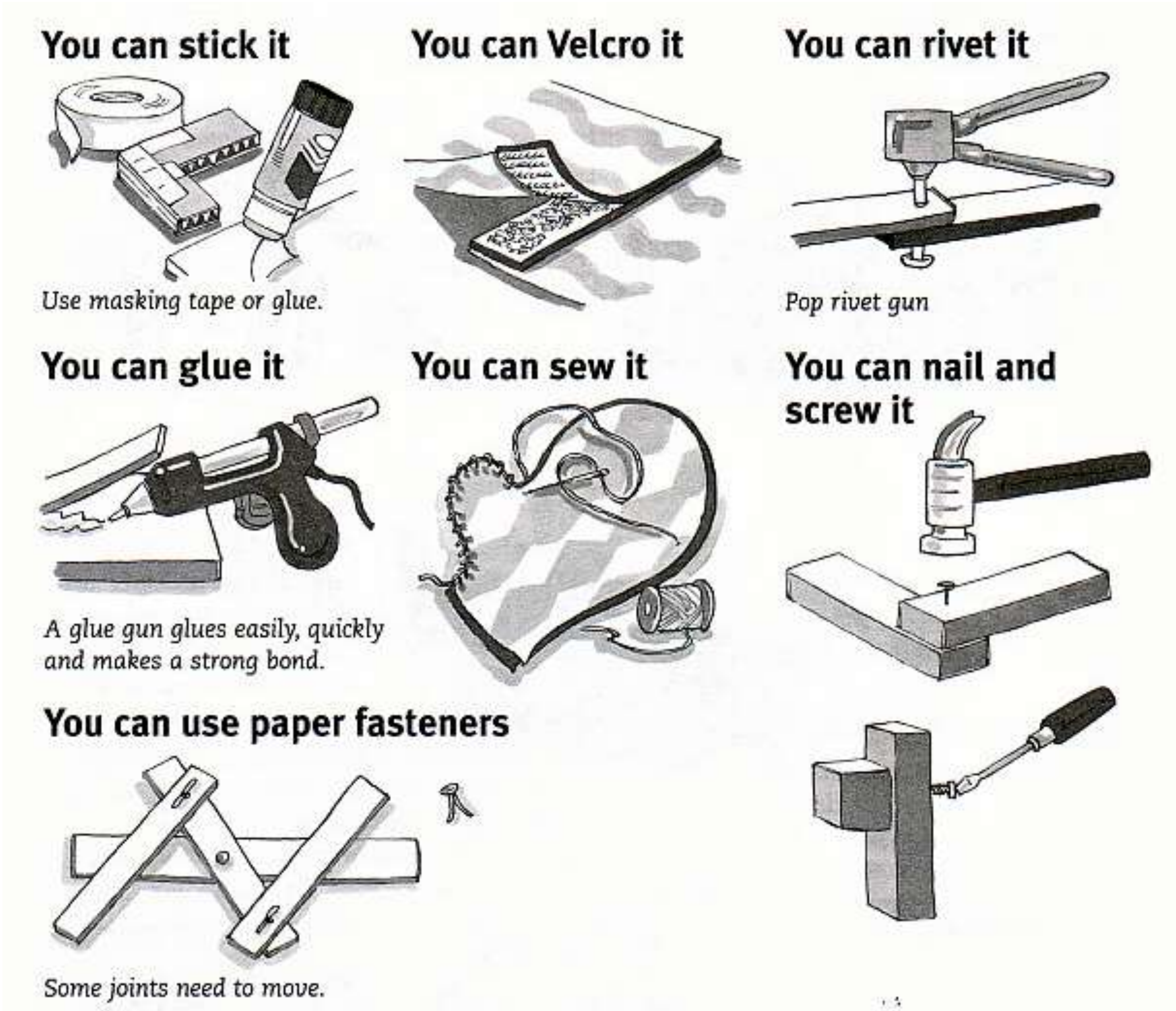
- **elastic** - it stretches and goes back to its old shape.
- **plastic** - it changes shape when you press or squash it; it will stay in the new shape and will not go back to its old shape.

Testing the working properties of materials will help us to decide if a material will be able to do the job for which we require it.

Try this:

Material	Apply a force				
	Stretch or deform	**Press or squash**	**Bend or stretch**	**Hit or drop**	**Scratch, dent or cut**
	It is elastic?	**Is it plastic?**	**Is it stiff or flexible?**	**Is it brittle or tough?**	**Is it hard or soft?**
Chalk					
Copper wire					
Foil					
Prestik/clay					
Plastic bag					
Paper					
Stone					
Wood					
Glass					

Joining Techniques



Improving materials

Materials can be **improved** through:

- chemical conditioning
- coating
- mechanical conditioning.

Materials can be **processed** in three ways:

- shaping (material is removed)
- forming (all of the material is used) or,
- conditioning (the internal properties of the materials are changed).

Sometimes a combination of processing techniques is used. Materials are also processed with temperature treatment, coating, mixing, combining, extracting, dehydrating, and so on.

Chemical conditioning

A **chemical reaction** takes place when materials are chemically conditioned. For example, when you add lemon juice to fresh milk, something happens chemically and the milk curdles and turns sour.

Chemical conditioning can also be used to enhance flavours. When you stir a teaspoon of sugar into a glass of water, you make the water taste sweeter. When the sugar and the water mix, a **reaction** takes place and the taste of the water is changed. The sugar dissolves in the water.

Coating

Another way in which materials are conditioned is by **coating** them. There are different reasons for coating, including protection (rust proofed burglar bars), increased value (gold-plated jewellery), improved feel (velvet coating in gift boxes feels soft to the touch), and safety (non-slip flooring). Coatings are usually applied onto the surface of objects, although sometimes the coating soaks through.

Waterproofing materials

A material that already has many uses can be enhanced by being made waterproof or water resistant. This can be done easily by coating the material with accessible (easy to get) materials such as varnish, nail polish, silicone, and so on.

Fire resistant

Fires cause enormous damage. There are many fire-retardant materials in industry. An easy way to process wood to make it fire retardant is to mix river or sea sand with wood glue and then coat the wood with the mixture. Note that this is not fire proof, but it can delay the burning process.

Magnetizing

When a piece of steel is magnetized, the molecules (which are usually arranged in a random way) are lined up in a particular direction. Certain steels can be magnetized, as you can see in the illustration. This is an example of a material that has been processed by conditioning: its internal structure has been altered.

Hardening

Have you heard of toughened glass? Regular glass is fragile and it breaks easily. Glass can be hardened and tempered: the glass is heated to a particular temperature, which is near to its melting point (when it becomes soft). Depending on the type of glass, the temperature at which it starts to become soft ranges from 500°C-1 650°C. Once the glass has been brought to this temperature, it is cooled rapidly with a blast of cold air, or it may be immersed in water. This controlled heating and cooling makes the glass tougher.

Hardening and tempering

When a metal like a wire coat hanger is bent, the point that is bent becomes brittle. It can eventually break. This is an example of mechanical conditioning. It has been changed mechanically.
The process of heating and cooling silver or copper is called **annealing**. This is what jewelers do when they make metal objects. When you hammer copper or silver it becomes hard. Heating it and dipping it in water softens it.

Metals

Where does metal come from
Rock consist of elements, including metal elements such as iron, copper, aluminium and gold. Rocks that contain a large amount of a particular metal element are called ores, for example iron ore. Ore is mined and then the metal is extracted from the ore. Metals are divided into **three groups**:

- **Ferrous** metals: which contain iron. Almost all ferrous metals are magnetic.
- **Non-ferrous** metals which contain no iron, for example copper, tin and lead.
- **Alloys** which are mixtures of two or more metals that give a new metal with improved properties. For example, brass is an alloy of copper and zinc, and stainless steel is an alloy of iron, chrome, nickel and magnesium. Alloys are not found naturally.

People have been making metal things for thousands of years because of their special properties, such as their strength and their special appearance. Gold, silver and platinum have a wonderful shine and are used to make jewellery. People use metal to make parts of aircraft, cars, cans, pots and pans. They also use metals in construction for pipes, roofs and window and door frames.
There are two groups of metal: ferrous metal and non-ferrous metal. The properties of metals can be changed by mixing them with other metals or chemicals. Iron is taken from iron ore and mixed with carbon and other metals to make it stronger and less likely to corrode, tarnish or rust. There are many different types of metal, each with their own specific properties.

Properties of Metals

Malleability is the ability of a material to resist compressive loading from all directions without breaking or fracture. A malleable material can be hammered into shape. Heating a metal increases its malleability.
Ductility is the ability of a material to be drawn out longitudinally to a reduced cross section. A ductile material must have a high plasticity. Copper is very ductile. Processes such as wire making rely on ductile materials. Ductility is decreased on heating as its tensile strength is reduced.
Brittleness is a term given to a material that has few ductile, toughness or malleable properties. A material that does not deform before fracture is said to be brittle. Cast iron is brittle.
Tensile Strength - a material's resistance to a stretching force. Some materials resist the force very well for example tungsten and steel while others, for example aluminium and lead, fail.
Compressive strength is the ability of materials to withstand pushing or compressive forces
Torsion strength - is a material's ability to resist twisting forces. Materials such as copper and mild steel will twist without breaking, whereas cast iron will break quickly. Therefore, brittle materials will break quickly under torsion.
Bending strength - a ductile material will bend easily without cracking. Tests are done on cold materials. The material is examined for cracks to assess performance. Copper, brass, lead and tin can all be easily bent, while steels, cast iron are harder to bend.

Examine metal products or objects

Collect metal objects such as drinking cans, cake tins, a door handle, hinges, milk or juice bottle tops, tart cases, keys, screws, springs, pens, tools and objects from your kit.

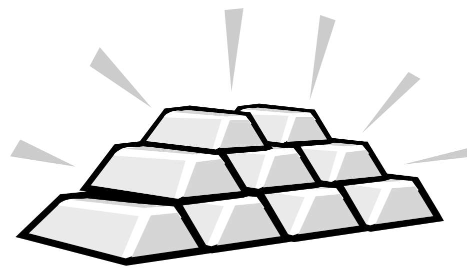
Answer the following questions:

1. What are metals and where do they come from?

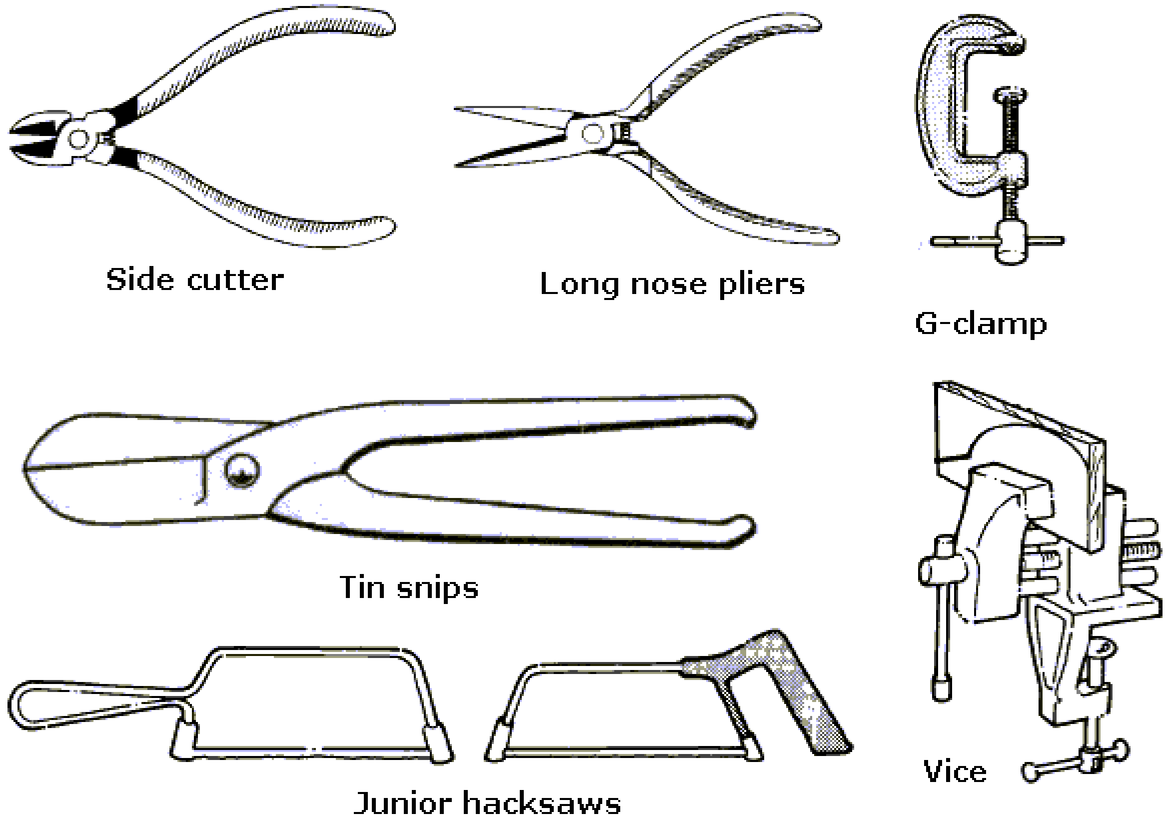
2. Classify 10 metal objects from the collection according to their appearances and then according to their uses.
3. Evaluate each metal product as follows:
    a) What is it used for?
    b) What types of material were used to make it?
    c) What colour is the metal?
    d) How does it appear?
    e) Does the product have different parts?
    f) If so, how are they joined?
    g) Are there any seams? How are they folded? How was the product finished off?
    h) How suitable is the product for its purpose?
    i) How do the properties of the material contribute to the suitability of the product?
4. Can one use different types of metal for the same object? Motivate your answer.

Changing the appearance and texture of metals

Metals and any other materials can be changed by processing them. Manufacturers process material and make the best use of the properties of the material for the proposed product. The type of material and the properties of the materials determine the techniques and tools that will be used. Wood, metal, plastic and textiles all have different properties. That is why the tools and equipment that are used to process the various materials, differ.



Tools



> **Tip:**
>
> Side-cutters should only be used to cut soft wire, because hard wire will damage or break the blades. Use pliers to cut harder wire.

Activity

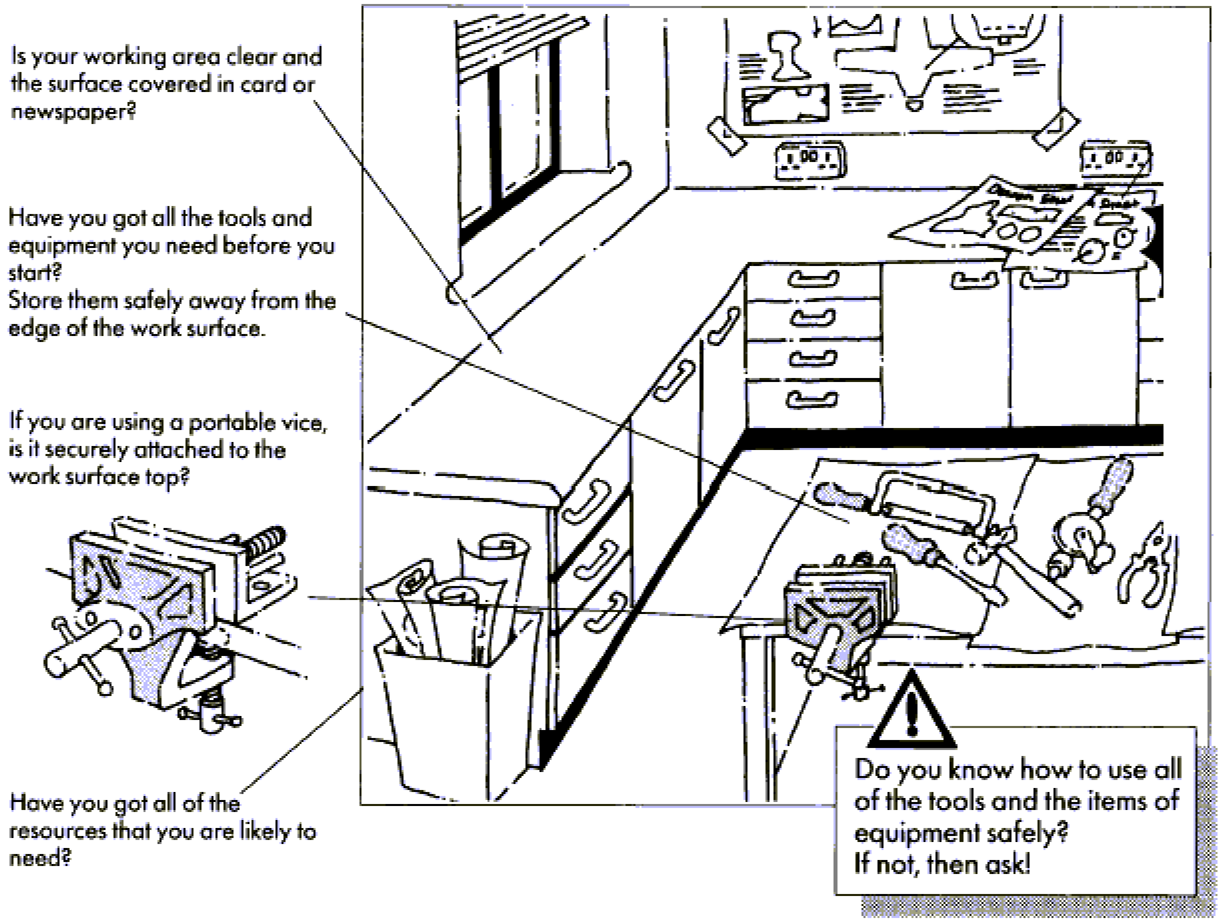
Collect round-nose pliers, ordinary pliers or a side-cutter, a hammer, scissors, wooden dowel or an empty pen, and a sharp nail. Waste metal materials: foil of various thickness; thin metal from a drinking can; off-cuts of soft wire, a paper clip and a wire hanger.

1. Use the different metal materials from your collection. For each material experiment say:

   a) How you can mark out a shape on the metal?
   b) How you can join another piece of the same metal to it?
   c) How you can join another type of metal to it?
   d) How you can change the texture of the metal material?
   e) How you can add anything to the metal material to change its appearance?

2. Think about what safety precautions you have to consider and apply when you work with metal?

Working area



Metal cleaning tips:

GOLD - *Cold Water and Ammonia*: Make a solution out of 50% cold water and 50% household ammonia in a cup. Soak the pieces for 30 minutes. Lift out gently clean with an eyebrow brush or toothbrush. Swish in the solution once more and let the jewelry drain on tissue paper.

COPPER - *Lemon Juice and Salt*: This trick is my favorite. I make a paste of lemon juice and salt and use an old paint brush to brush it over the entire surface. Any particularly dirty areas, I soak in a lemon juice and salt solution. Then I buff with a very fine steel wool. Many people also dip half of a lemon in the salt and use the lemon as the buffer, directly on the copper.

BRONZE - *Salt, Vinegar, and Flour*: Dissolve 1 teaspoon salt in 1 cup white vinegar. Add enough flour to make a paste. Apply paste to bronze and let sit for 15 minutes to 1 hour. Rinse with clean, warm water, and polish dry.

Working with metal foil

Metals like aluminum and tin, are made into thin sheets called foil. Heavy aluminum foil can be used to make fancy photo frames. You can cut heavy foil with ordinary scissors, and it is thin enough to fold and bend.

HOW TO MAKE A FRAME USING METAL FOIL

You will need:

- a photo or other small picture
- thick cardboard
- scissors
- a ballpoint pen or pencil
- a felt-tip pen
- heavy metal foil
- sticky tape
- paper
- a pencil
- a ruler
- a craft knife

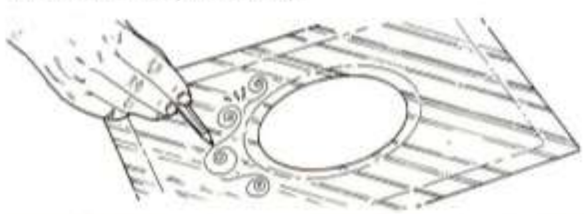
1. Measure the photo or picture that you want to frame. Then draw a bigger rectangle on a piece of thick cardboard. Inside the rectangle, draw a circle, oval or heart shape.

2. Cut out both cardboard shapes with a sharp knife. This will be your frame.

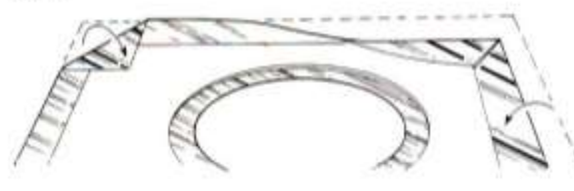
3. Place the cardboard on a piece of heavy metal foil. Trace the rectangle and the inner shape onto the foil. Press softly with a felt-tip pen to make lines, as foil tears easily.

4. On the foil, mark out another rectangle, about 3 cm bigger. Then mark out another inner shape, about 1 cm smaller. Cut along this second set of lines.

5. Use a ballpoint pen or blunt pencil to draw patterns on the dull side of the foil. Or you can change the texture of the foil in any other way.

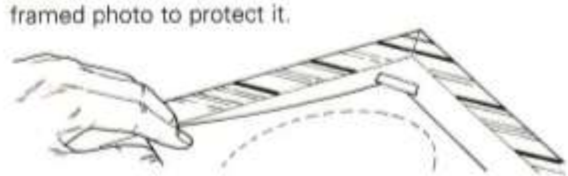


6. Put the cardboard frame onto the dull side of the foil. Fold the corners of the foil over, then fold the sides over.



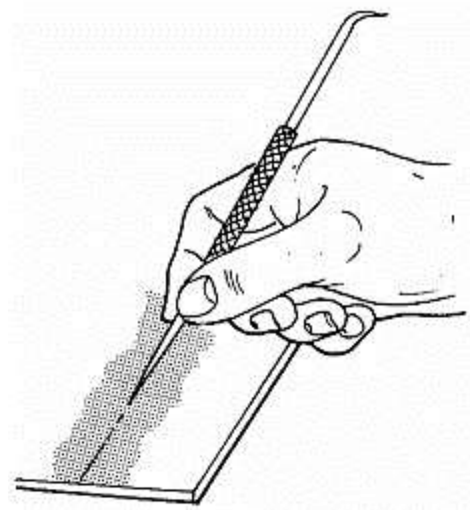
7. Cut small slits in the foil from the small inner shape to the larger inner shape. Fold the foil over.

8. Stick the photo onto the frame with sticky tape so that the picture shows through the inner shape. You can stick another piece of cardboard onto the back of the framed photo to protect it.



Working with thin sheet metal

Another form of metal that you can use to make jewellery is sheet metal. Sheet metal is metal that has been rolled or beaten into thin sheets. Sheet metal from cooldrink cans is thin enough to cut with ordinary scissors. If you have tin snips at school, these will cut sheet metal more easily than scissors. Use short cuts when cutting metal, because it is hard to make the cutting line go where you want it to go if you use longer cuts. A scriber can be used for marking lines on metal.



HOW TO RE-USE METAL FROM COOLDRINK CANS

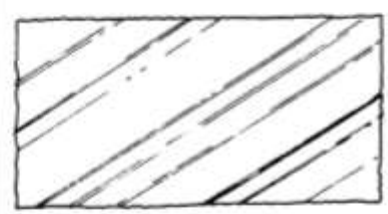
You will need:

- cooldrink cans
- tin-snips

1. Cut the top and bottom off the can.

2. Cut the can down the middle.

3. Flatten the sheet of metal. Now you can use this thin metal to make any object you want to.



Take care:

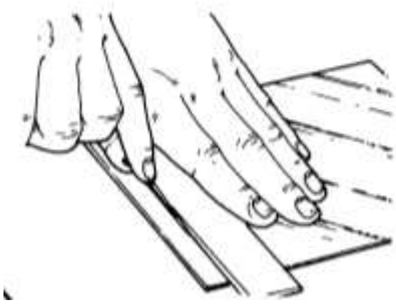
The edges of sheet metal are sharp and can cut you badly.

HOW TO MAKE EDGES SAFE ON SHEET METAL

You will need:

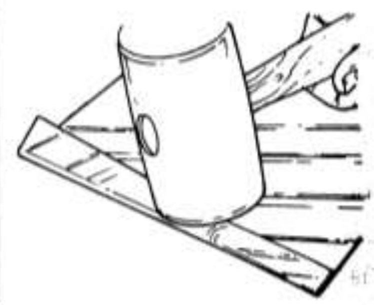
- sheet metal
- a scriber or sharp nail
- a vice
- a steel rule
- a mallet

1. Mark off a line 5 mm from the edge of the sheet of metal. Score a line using a scriber or sharp nail.



2. Place the metal in a vice and fold it over as far as you can, on the line you have made.

3. Using a mallet, flatten the turned over piece by tapping gently.

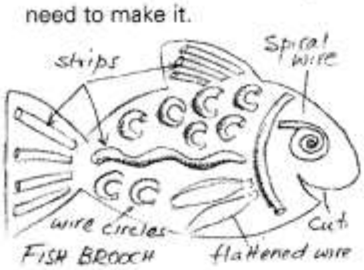


HOW TO MAKE A BROOCH OR BADGE

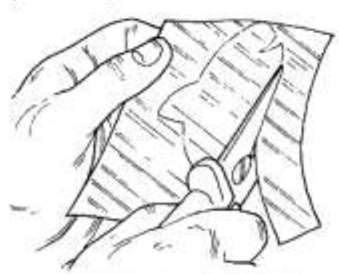
You will need:

- materials of your choice to decorate your brooch or badge
- a large safety pin
- sheet metal
- metal epoxy glue or other strong glue
- a small strip of strong cotton fabric

1. Design your brooch or badge. Draw a life-size picture of it and label the different materials you need to make it.



2. Take a small piece of sheet metal and shape it to make the base of your design.



3. Arrange your decorative objects on the sheet metal. Glue them on to the base. Leave the base to dry for a day.

4. Fix a strong safety pin to the back of your badge or brooch like this:

Cut a small strip of strong cotton material.

Put the badge or brooch face down. Hold the safety pin sideways on the back of the brooch.

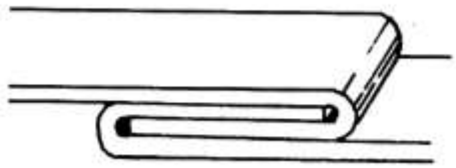
Stick the piece of material over the back of the safety pin with glue. Leave it to dry completely.

HOW TO JOIN THIN SHEET METAL

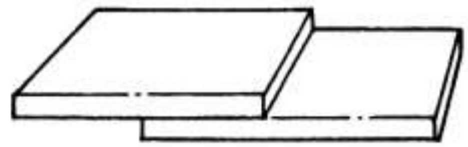
You will need:

- metal from cooldrink cans
- pliers or a vice or a mallet
- soldering iron and solder, or metal epoxy glue

1. You will need pliers or a vice or a mallet to make this kind of folded seam strong and neat.



2. The joint shown here needs soldering or glueing with metal epoxy glue. Hint: Cleaning or scratching the metal surface before applying the glue will improve your joint.



Making Christmas decorations with wire

Wire is available in different thickness and is easy to find or buy. You can use thin galvanized wire for making decorations. Thin wire is easy to bend and join without using special machinery. You can cut thin wire with small pliers or side-cutters.

New word:

When a metal such as iron is coated with zinc to prevent rust, it has been galvanized.

HOW TO STRAIGHTEN WIRE

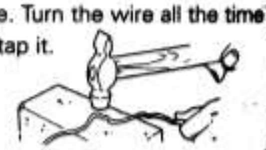
You will need:

- wire
- pliers
- a brick or other hard, flat surface
- a small hammer

1. Unwind the wire and cut off the length you need.

2. Straighten the wire as much as possible by hand. If the wire is stiff and hard, use pliers to help.

3. Hold any twisted or bent parts of your wire on the brick. Use gentle taps of the hammer to straighten the wire. Turn the wire all the time as you tap it.



HOW TO MAKE A FLAT SPIRAL FROM WIRE

You will need:

- round-nosed pliers
- soft wire (but not too thin)
- ordinary pliers or a small hammer

1. Start by rolling the wire around the nose of the round-nosed pliers.

2. Use ordinary pliers or a small hammer to flatten the spiral.