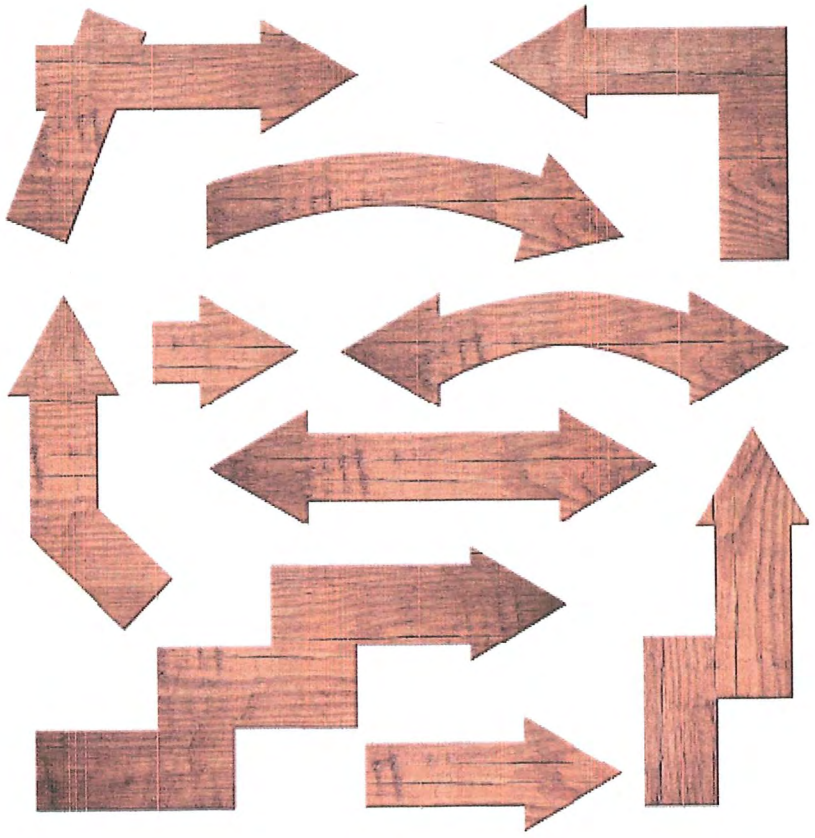
AQA
Realising potential

Revision

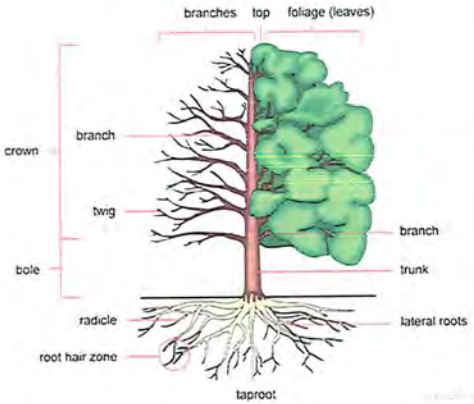
GCSE
DESIGN AND TECHNOLOGY
(8552)

Specification
For teaching from September 2017 onwards
For GCSE exams in 2019 onwards

Version 1.2 6 June 2022



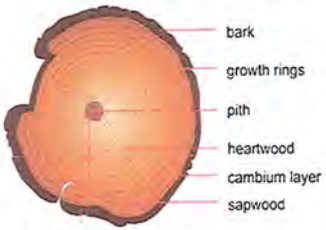
STRUCTURE OF A TREE



Trees come in all shapes and sizes. They produce many different types of wood that can be used for many different jobs. All trees grow relatively slowly, some take 20 – 30 years to reach full size and others 300-400 years. A few can live for thousands of years. And reach over 120 meters in height.

The bark of the tree is there to protect the living part of the tree from the weather and insects. The heart wood is the strongest part of the tree.

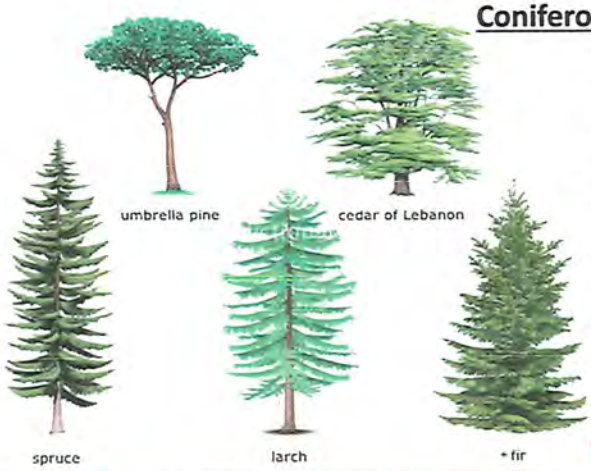
CROSS SECTION OF A TREE TRUNK AND STUMP



wood (xylem)

stump

Coniferous trees



Coniferous trees are also know as 'Evergreens'. This group of trees keep their leaves all year . They tend to have tall, flexible trunks to allow them to bend in heavy winds and under the weight of snow. They are generally found in milder, temperate climates such as northern Europe, Russia and North American

The wood produced from Coniferous trees is known as **softwood**. This does not necessarily mean it is 'soft'. 80% of the worlds production wood is softwood.
Some coniferous trees are very fast growing reach maturity in 25 years.

Thin needle like leaves.

Farming Trees???

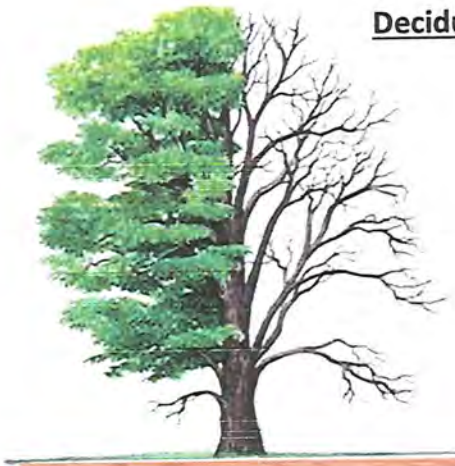
Due to the amount of time it takes a **deciduous tree (hardwood)** to grow there is little point in landowners planting these and hoping to make a return (profit) in a short amount of time. Because of the speed they grow, hardwood is expensive

Conifers (softwood) mature much quicker and as a result landowners plant these with the aim of cutting them down to sell. You often see these growing in neat, straight rows. Because of the speed they grow, softwood is cheap

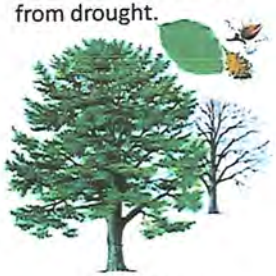
Once the trees have been cut down, they need to be converted into planks and boards that we can use. However at this point 80% of the trees weight is water, this has to be reduced before we can use it. This process is know as seasoning. Wood that isn't dried is known as '**Green**' wood

Once cut down the timber is cut into workable planks. This is either done by 'slab' sawing or quarter sawing. Both have advantages and disadvantages. Once cut the timber needs to dry out before it can be used.

Deciduous trees



Deciduous trees are the group of trees that loose their leaves during the winter seasons. They tend to have rigid trunks with visible branches. These trees loose their leaves during changes in climate to protect themselves. This is usually to protect from freezing and snow, but it can be to protect from drought.



Broad leaves

The wood produced from Deciduous trees is known as **Hardwood**. This does not necessarily mean it is 'Hard'. 20% of the worlds production wood is hardwood.
Most deciduous trees are slow growing and take over 100 year to reach maturity.

Mr E 2011

Trees can be split into two main groups – Coniferous and Deciduous

Coniferous trees; tall single trunk, generally small needle like leaves.

Deciduous trees; large trunk with large visible branches and broad leaves.

Seasoning is the name given to the methods of drying timber
There are two methods by which timber can be dried:
(i) natural drying or air drying,
(ii) artificial drying.

Air drying
Air-drying is the drying of timber by exposing it to the air. The technique of air-drying consists mainly of making a stack of sawn timber (with the layers of boards separated by sticks) on raised foundations, in a clean, cool, dry and shady place. This can take up to 18 months to dry the timber.

Artificial or Kiln drying
The process of kiln drying consists basically of introducing heat. In this process, deliberate control of temperature, relative humidity and air circulation is provided. For this purpose, the timber is stacked in chambers, called wood drying kilns, which are fitted with equipment for manipulation and control of the temperature and the relative humidity of the drying air and its circulation rate through the timber stack. This process is quick and can dry the wood in 48 hours

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The Forest Stewardship Council (FSC) helps take care of forests and the people and wildlife who call them home.

FSC is an international, non-governmental organisation dedicated to promoting responsible management of the world's forests.

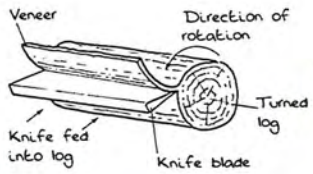
The FSC are an independent organisation that check that managed forests meet internationally and nationally agreed standards of responsible forest management.
Forest products like timber can then carry the FSC label, guaranteeing that it comes from a well-managed forest and enabling you to pass on the benefits of certification to your customers.

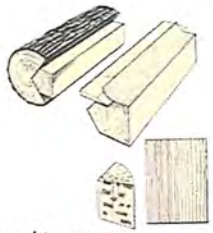
Manufactured Woods - veneers

Occasionally logs are used to create **veneers** (very thin sheets of wood)

This can range from 4 mm down to 0.5mm in thickness.

Veneers are cut in a number of different ways, these are the main methods; Rotational or Sliced





Veneers are used to cover cheaper woods to give a more appealing finish, to decorate ornate furnishings or to produce plywood.

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MDF - Medium Density Fibreboard

Medium-density fibreboard (MDF) is an manufactured wood product formed by breaking down hardwood or softwood residuals into wood fibre, combining it with wax and a resin glue, and forming panels by applying high temperature and pressure. MDF is denser than plywood.
It is made up of separated fibres, (not wood veneers) but can be used as a building material similar in application to plywood. It is stronger and much more dense than normal particle board.

MDF like plywood is known as a sheet material. It comes in large sheets normally 2440mm x 1220mm (8ftx4ft). It is very stable and will not normally twist or bend. Dust extraction should be used when working with M.D.F.

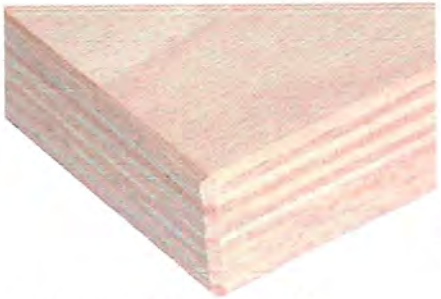
https://www.youtube.com/watch?v=qitenYvpSx4

Mr E 2011

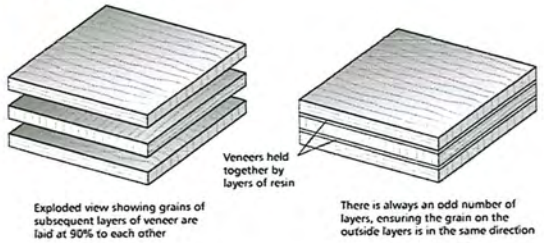
Blockboard is a manufactured board that has a central core of solid wooden strips. These strips of wood are glued together to form a single piece of wood. This collection of wooden pieces is then covered with a wood veneer to give a much more aesthetically pleasing appearance as well as providing strength and support. Without the veneer the solid wood would be weak along the grain.

Mr E 2011

Chipboard is an engineered wood product manufactured from wood particles, such as wood chips, sawmill shavings, or even saw dust, and a synthetic resin or other suitable binder, which is pressed and extruded. Particleboard is a composite material. It is considerably weaker than both MDF and Plywood. Due to the chemicals (thermosetting glues) used to bond the particles disposing of chipboard can present problems for the environment.

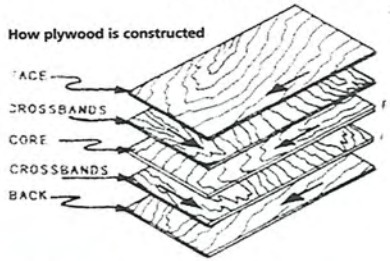


Plywood is a manufactured board made of a layers of Veneers, these are LAMINATED together to form a single sheet



Advantages of Plywood

1. High uniform strength
2. Freedom from shrinking, swelling and warping
3. Non-splitting qualities
4. Availability of relatively large sizes
5. Economical and effective utilisation of figured wood:
6. Ease of fabrication of curved surfaces
7. Reduction of waste



https://www.youtube.com/watch?v=WsJR7hoZRRE

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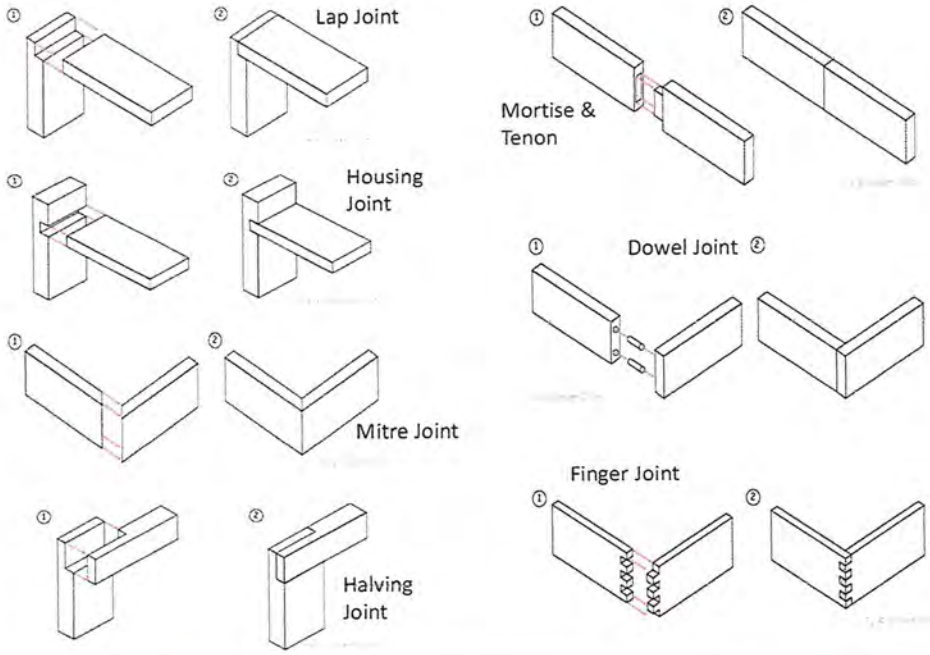
Beech

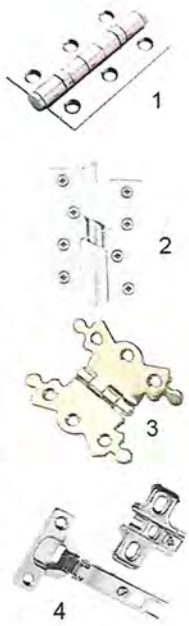


Panel pins are used for holding small pieces together, normally as glue is drying.

Nails are used as a fixing, they have a flat head to prevent it being driven below the surface.

Dowels are a fixing that takes a little more preparation. Holes need drilling in both pieces before hand and then glue applied to fix.

Hinges come in many various shapes and sizes and fulfil many different jobs. The most common type are the plain Butt Hinge (1). A variation of this is the rising hinge, which lifts the door as it opens (2). Decorative hinges are for surface mounting (3). Kitchen cupboards are often fixed using concealed hinges, these are occasionally called self closing(4)



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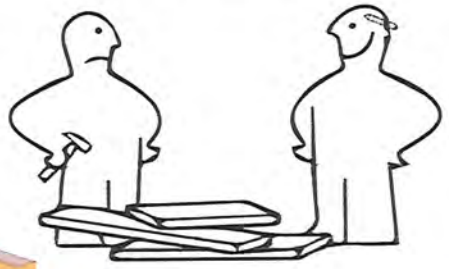
Knock Down Fittings

(KD Fittings)

If you have ever assembled a piece of flat pack furniture some of these fittings might be familiar – frustrating but familiar

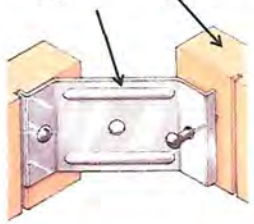
Cross Dowel – used to join pieces where an upright needs to have a piece joining it – where traditionally a mortise and tenon might work

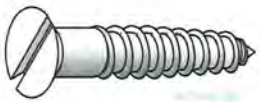


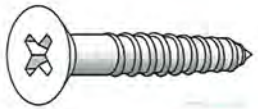
Corner block – used to join pieces at a right angle

Cam lock – used to join pieces at a right angle. The cam pulls the pieces tightly together.

Corner plate – often used on tables to attach the frame to the legs







The most common method of fixing pieces of wood together is usually to screw them together. Screws offer a strong semi permanent fixing. Due to modern screws being coated in moisture resistant material the screws will now last a very long time without decaying.

There are many varied designs of screw the most common are the countersink variety. These are normally either slotted or Phillips (crosshead).

Coach bolts are a type of screw used for heavy duty fixing in wood.

It is normal when putting screws into wood to drill a pilot hole, this will stop the wood splitting as the screw pulls through the wood.

Mr E 2011

Joinery is a part of woodworking that involves joining together pieces of wood, to create furniture, structures, toys, and other items. Some wood joints employ fasteners, bindings, or adhesives, while others use only wood itself.

Joints can be designed to hold without the use of glue or fasteners; a pinned mortise and tenon is an example of this. Glue is highly effective for joining wood when both surfaces of the joint are edge grain. A properly glued joint may be as strong or stronger than a single piece of wood.

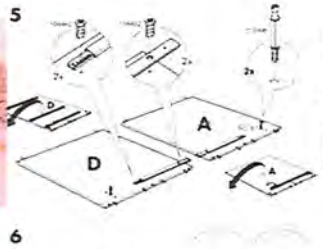
<u>Traditional woodworking joints</u>

Butt joint; the end of a piece of wood is butted against another piece of wood. This is the simplest and weakest joint.
Miter joint; similar to a butt joint, but both pieces have been cut at a 45 degree angle.
Lap joints; one piece of wood will overlap another.
Box joint, also called a **finger joint**, used for the corners of boxes. It involves several lap joints at the ends of two boards.
Dovetail joint; a form of box joint where the fingers are locked together by diagonal cuts.
Housing joint; a slot is cut across the grain in one piece for another piece to set into; shelves on a bookshelf having slots cut into the sides of the shelf, for example.
Mortise and tenon; a stub (the tenon) will fit tightly into a hole cut for it (the mortise)

6R's and party bags

RACTICAL ACTION

- Rethink: What could you do differently? Do we need party bags at all?
- Refuse: Are there materials you would choose not to use?
- Reduce: Can you reduce the packaging?
- Reuse: Can the bag or its contents be used again for another purpose?
- Recycle: Have you used materials that area easy to recycle when its finished with?
- Repair: It is possible to mend any of it or will it go to landfill if broken?



Flat packed furniture and <u>knock down fittings</u>

•They're much cheaper than ready-to-use furniture. Their price is so low it compensates for the lower durability.
•They're easy to dismantle and transport. This means companies can reduce the amount of trucks/lorries they use to transport goods and customers can take them apart when they need to, e.g. if they are moving house.
•They are easier to carry into your house as they are in boxes and flat packed instead of being an awkward, fixed shape.
•Manufacturers can carry more products in a single truck, which reduces the cost, journeys, amount of trucks used and fuel consumption.
•The retailer can store the products on flat shelves, maximizing the storage space.
•The products can be produced using a CNC milling machine. This means they are not made by craftsmen which reduces the labour costs as the company doesn't have to pay for skilled labour.

Petroleum and natural gas formation

Tiny marine plants and animals died and were buried on the ocean floor. Over time, the marine plants and animals were covered by layers of silt and sand.

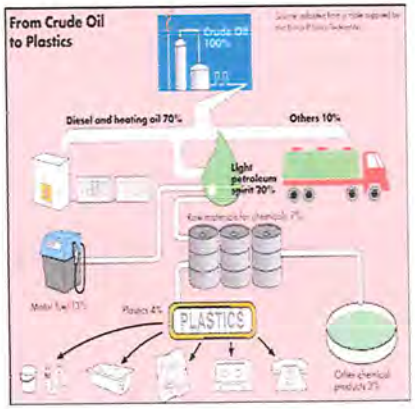
Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned the remains into oil and natural gas.

Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and natural gas deposits.

Source: Adapted from National Energy Education Development Project (public domain)

Oil is thought to have formed over **millions of years** from the break down of tiny **dead creatures.** Natural gas is formed alongside oil. The dead organisms sank to the bottom of lakes or seas and became **trapped** in muddy sediments. As the sediments built up, the lower layers were under pressure. They eventually turned to rock. If there was no oxygen in the sediments, **heat and pressure** turned the remains of the organisms into oil and natural gas.

The large majority of plastics we use today are formed from oil. Crude oil is separated into separate batches of different compounds by heating it in a process called fractional distillation



Oil and pollution

There are many risks involved with the extraction and processing of oil. Oil spills from oil rigs, pumping stations and oil tankers can cause huge environmental problems for both marine and land habitats.

Airborne pollution from oil refineries contributes towards both acid rain and increasing carbon dioxide in the atmosphere. This can impact on peoples health, have a negative effect on the environment, damage habitats and contribute towards climate change.

Thermoplastics are a group of plastics (polymers) that as they are heated become soft and **CAN be moulded** over and over again. These plastics then harden as they cool. The Polymers in Thermoplastics do not form strong bonds so they can move over each other and be reshaped when subjected to heat.

Advantages
- Highly recyclable
- Aesthetically-superior finishes
- High-impact resistance
- Remolding/reshaping capabilities
- Chemical resistant
- Eco-friendly manufacturing

Disadvatages
- Generally more expensive than thermoset
- Can melt if heated

Thermoset plastics are a group of plastics that once they have been moulded and set **CANNOT be remoulded.** Once moulded, they do not soften when heated and they cannot be reshaped. Its polymer chains are joined together by cross-links, so they cannot slide past each other easily.

As a result of this resistance to heat **Thermosetting plastics** are suitable where a degree of heat resistance is required, such as engines, electrical components and fittings, saucepan handles etc.

Advantages
- More resistant to high temperatures than thermoplastics
- Highly flexible design
- Excellent aesthetic appearance
- Cost-effective

Disadvantages
Cannot be recycled
More difficult to surface finish
Cannot be remolded or reshaped

Tips for exams

- If it's a **drinks bottle its PET.**
- If it's a **chemical** container its probably **HDPE.**
- If it's a **thin film** its probably **PVC** or **LDPE** – both would be accepted.
- If its **safety** equipment its **PC.**
- If its **anything else** it could be **ABS** because they cant prove otherwise.
- If its **packaging** it is **expanded polystyrene.**
- If its around **food** it will be **PET, HDPE, LDPE**

There are many types of plastics that are used for a huge variety of different tasks. These plastics can be divided into two main groups; Thermosetting plastics and Thermoplastics. Plastics are made up of long strings of monomers that bind together to form **polymers.**

Thermoplastics are a group of plastics (polymers) that as they are heated become soft and CAN be moulded over and over again. These plastics then harden as they cool. The Polymers in Thermoplastics do not form strong bonds so they can move over each other and be reshaped when subjected to heat.

Thermoplastic

Common Thermoplastic Polymers

Some of the most commonly found thermoplastic polymers include polyethylene, polypropylene (PP), polyvinyl chloride (PVC), polystyrene, polytetrafluoroethylene (PTFE, commonly known as Teflon), Acrylonitrile butadiene styrene (ABS plastic), and polyamide (commonly known as nylon).

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Thermoset

As a result of this resistance to heat Thermosetting plastics are suitable where a degree of heat resistance is required, such as engines, electrical components and fittings, saucepan handles etc.

Common Thermoset Polymers

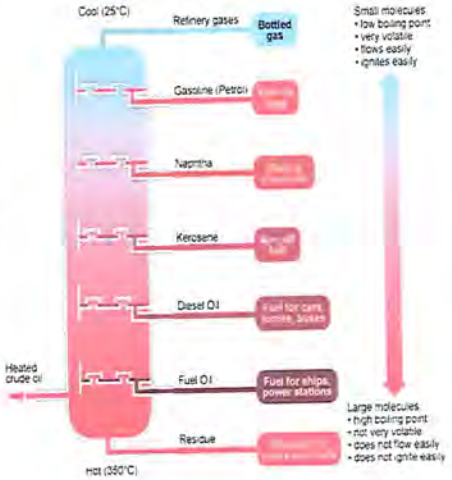
Some of the most commonly found Thermosetting polymers include Epoxy Resin, Melamine Formaldehyde, Polyester Resin and Urea Formaldehyde

Fractional distillation of crude oil

Crude oil is a **mixture** of many thousands of different compounds with different properties. They are called **hydrocarbons** because they only contain the elements hydrogen and carbon.

To make crude oil useful, batches of similar compounds with similar properties need to be sorted. These batches are called **fractions** and they are separated by **fractional distillation.**

The theory behind this technique is that some of the compounds in crude oil are easily vaporised, for example, they are volatile due to their low boiling points. Others are less volatile and have higher boiling points.



Tips for exams

- **If its electrical - it Urea Formaldehyde**
- **If its worktop or flooring – it Melamine Formaldehyde**
- **If its GRP or carbon fibre – Its Polyester Resin**

Thermoplastics

The majority of plastics that are used each day are Thermoplastics. Due to the fact they are easy to mould, can be recycled and have a wide variety of uses.
A large proportion of plastics can be identified by their **Resin Identification Code.** This is normally stamped on the product so we can identify the type of plastic it is made from.

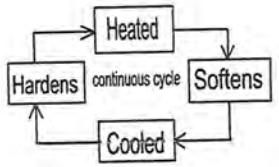
Look on the bottom of your bottle of water, you will see this symbol. It is made up of the recycling symbol we are all familiar with, a number and sometimes letters.
The number and letters identify plastic in the picture as 1 (PET) **Polyethylene terephthalate.** PET is fine in all exam situations!!!!

Resin identification codes

These were introduced in 1988 to help identify the main groups of plastics to help with recycling. They identify 6 named types of plastic and all others are grouped as number 7

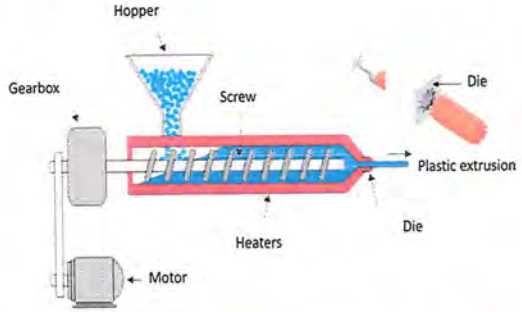
7 – OTHER

These days we use such a wide variety of different plastics that a large proportion of products will fall into the 'OTHER' category. For example Other **acrylic, nylon, polycarbonate (PC), and Acrylonitrile Butadiene Styrene (ABS)**



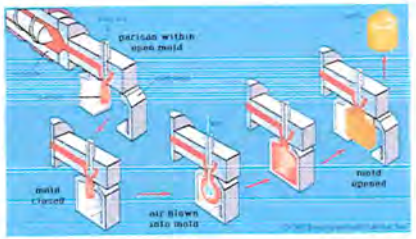
Extrusion

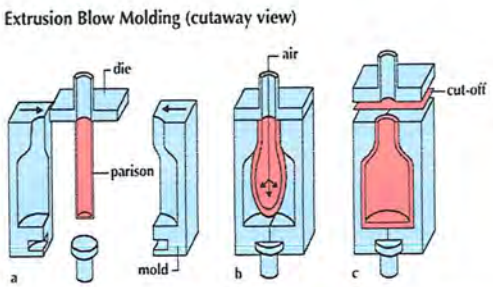
Extrusion is the starting point for other forms of plastic moulding as will be seen later. Extrusion is generally used to form of plastic moulding. It is used to form pipes, moulded sections and trunking. Plastic granules are fed into the screw barrel by a hopper, as they pass along they are heated and for a semi liquid homogenous mass. This is then forced out under pressure through the DIE, what ever the shape of the die the plastic adopts. It is then cooled rapidly in water baths to stop it deforming and cut to the required length.



Blow Moulding

Blow moulding is a plastic moulding process that is often used to form hollow products such as bottles. A plastic tube is extruded following the extrusion process discussed earlier. This tube is known as a **parison**. The parison is clamped between two halves of a mould and air is blown in through one end. The hot, flexible plastic is blown out and takes on the shape of the mould. The steel mould helps the plastic cool rapidly. When cooled the mould opens and the bottle falls out.



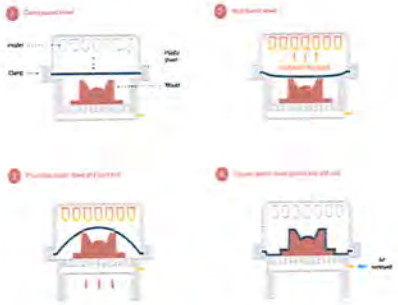


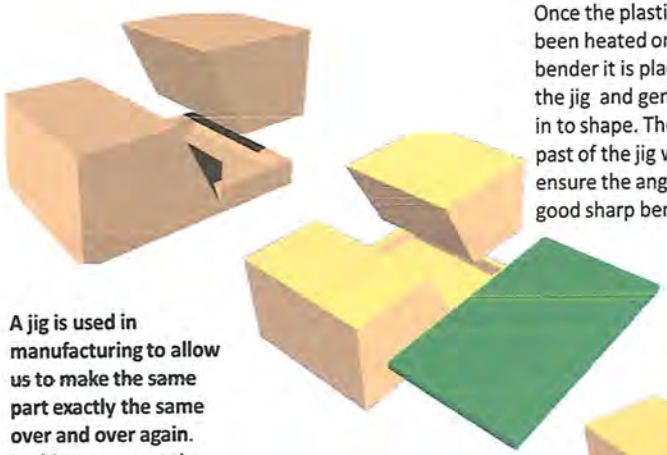
Products that are blow moulded often have a visible line down them on opposite sides, this is where the mould opens, it is known as a split line.

Vacuum Forming

The vacuum forming process involves heating a plastic sheet until soft and then dropping it over a mould. A vacuum is applied sucking the sheet into the mould. The finished sheet is then taken from the mould.
The table that moves the mould up in to the soft plastic sheet is called the plattern. As the plattern is pushed up and the plastic starts to form the shape of the mould the vacuum is turned on actually sucking the plastic tight over the mould.

All moulds must have a **DRAFT** angle to allow them to be removed from the formed plastic. The sides must have an angle of around 5° to allow the parts to separate.





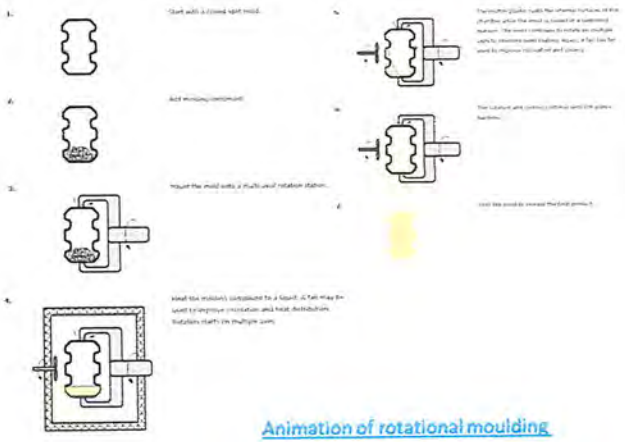
A jig is used in manufacturing to allow us to make the same part exactly the same over and over again.
In this case to put the first bend in a piece of plastic. This is a two part jig.

Once the plastic has been heated on the line bender it is placed into the jig and gently bent in to shape. The second past of the jig will help ensure the angle is a good sharp bend

After a short time the plastic will have cooled. The top part of the jig can be removed to allow the plastic to be removed.

Rotational Moulding

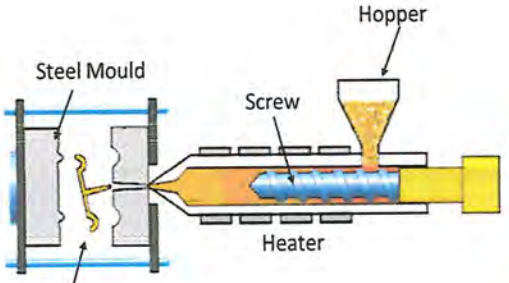
Rotational moulding is a plastic moulding process commonly used to make large, hollow products.
Plastic powder or granules are loaded into an open mould. The mould is then sealed and heated. The mould then spins around 3 axis so the plastic sticks to the cooling metal mould. Layers are built up by adding more plastic following each cooling process.

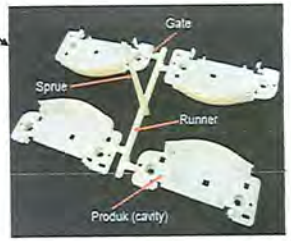


Animation of rotational moulding

Injection Moulding

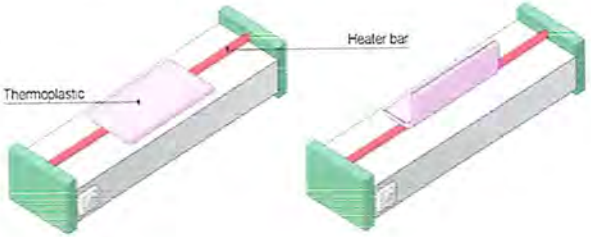
Injection Moulding along with extrusion ranks as one of the main processes for producing plastics articles. It is a fast process and is used to produce large numbers of identical items from high precision engineering components to disposable consumer goods.
The process is similar to the extrusion process in terms of the hopper and screw, how ever rather than the plastic being pushed through a die it is injected under pressure into a steel mould.





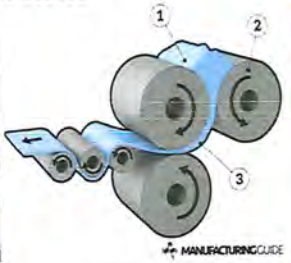
Line Bending/Strip heating

Line bending/strip heating is a simple process often used with ACRYLIC to bend a straight line in the plastic.
The acrylic is heated slowly over a heated bar or wire. This softens the plastic which then allows it to be reformed (bent) along the heated line.
Simple angles can be completed easily and with some planning some more complex shapes can be achieved. To ensure accurate bends a jig should be used to hold the soft plastic at the desired angle until it has hardened.



Calendaring

Calendaring is the process of squeezing a soft (melted) plastic between several rollers. The careful control and space between thee rollers will determine the eventual thickness of the plastic film.
The original plastic is extruded from the same as we looked at in the extrusion process. This melted extrusion is then dropped onto the first few sets of rollers to position and start the cooling process. The other rollers in the process stretch and adjust the thickness of the desired film.



Laser cutter

Although technically not a moulding process the laser cutter is often used in schools and industry to shape plastic.
The laser cutter is a 2 Dimensional cutting machine that can also engrave on to a range of materials.
In schools laser cutters are used to cut a variety of materials, but acrylic is widely used. This **CAM (Computer Aided Manufacture)** process is quick, easy and produces a finished edge when cutting acrylic.

A design is produced in a **CAD (Computer Aided Design)** package and sent to the laser cutter. A popular CAD program would be **2D Design.** This CAD design would identify which parts of the plastic are to be cut and which engraved. If multiple products are needed the designs should be collected together in a tessellation (sometimes called NESTING) to save material.

As discussed previously the majority of plastics are made from oil. This causes problems fom the environment through the process of extracting oil from the ground or under the sea. There are also problems with the processing of oil into compounds we can use as plastics and the pollution these produce.

Plastic also creates problems following our use and its **final disposal**. Plastic is generally not biodegradable, meaning it is not easily broken down naturally by animals and enzymes digesting it. Plastics have only been around for about 70 years. So microorganisms simply haven't had much time to evolve the necessary biochemical tool kit to latch onto the plastic fibres, break them up into the constituent parts and then utilise the resulting chemicals as a source of energy and carbon that they need to grow.

Disposing of plastic

According to National Geographic only 9% of plastic is recycled.
The vast majority—79%—is accumulating in landfills or discarded in the natural environment as litter. Meaning: at some point, much of it ends up in the oceans, the final sink.

Environmental impact of disposal.

- Most plastic ends up in landfill, land that cannot be used again as plastic does not natural degrade.
- A large proportion is simply litter damaging habitats.
- Much will finally end up in the ocean as small pieces where it is ingested and will enter the food chain.

Can plastics be environmentally friendly?

If we recycled 100% of all plastic produced then there is every chance the use of plastics would become sustainable, but we don't. Alternatives are needed to allow us to continue to use this versatile material.

I order to make plastic more environmentally friendly we need to look at:

- **Bioplastics** made from natural materials such as corn starch
- **Biodegradable** plastics made from traditional petrochemicals, which are engineered to break down more quickly
- **Eco/recycled plastics**, which are simply plastics made from recycled plastic materials rather than raw petrochemicals.

Bioplastics
The theory behind bioplastics is simple: if we could make plastics from kinder chemicals to start with, they'd break down more quickly and easily when we got rid of them.
The most familiar bioplastics are made from natural materials such as **corn starch** and sold under such names as *EverCorn™* and *NatureWorks*. Some bioplastics look virtually indistinguishable from traditional petrochemical plastics. **Polylactide acid** (PLA) looks and behaves like polyethylene and polypropylene and is now widely used for food containers.

Biodegradable plastic is **plastic** that decomposes naturally in the environment. This is achieved when microorganisms in the environment metabolize and break down the structure of **biodegradable plastic**. The end result is one which is less harmful to the environment than traditional **plastics**

Some supermarkets now use what are described as **photodegradable**, **oxydegradable**, or just **biodegradable bags** (in practice, whatever they're called, it often means the same thing). As the name suggests, these biodegradable plastics contain additives that cause them to decay more rapidly in the presence of light and oxygen (moisture and heat help too). Unlike bioplastics, biodegradable plastics are made of normal (petrochemical) plastics and don't always break down into harmless substances: sometimes they leave behind a toxic residue and that makes them generally (but not always) unsuitable for composting

Eco/recycled plastics
One easy solution to the problem of plastic disposal is to recycle old plastic materials (like used milk bottles) into new ones (such as items of clothing). A product called ecoplastic is sold as a replacement for wood for use in outdoor garden furniture and fence posts. Made from high-molecular polyethylene, the manufacturers boast that it's long-lasting, attractive, relatively cheap, and nice to look at.

Metals are found in the Earth's crust and have been mined extensively for many years. Of the 70 different types of metal a select few are used for the majority of applications. Metals very rarely occur in their pure metallic state in the ground (the only exceptions are gold, silver and copper)

Metals account for about two thirds of all the elements and about 24% of the mass of the planet. Metals have useful properties including strength, ductility, high melting points, thermal and electrical conductivity, and toughness. From the periodic table, it can be seen that a large number of the elements are classified as being a metal. A selection of various metals can be seen below

From ore to metal

What are "ores"?

An **ore** is a type of rock that contains minerals with important elements including metals. The ores are extracted through mining; these are then refined to extract the valuable element Aluminium, for example, is the most common metal in the Earth's crust, occurring in all sorts of minerals. However, it isn't economically worthwhile to extract it from most of these minerals. Instead, the usual ore of aluminium is bauxite - which contains from 50 - 70% of

Bauxite – the ore from which Aluminium is extracted

Iron ore – the ore from which Iron is extracted.

An open cast gold mine. Huge areas of land are removed to get access to the valuable metals.

Metals like all materials come in a large variety of standard shapes and sizes. We will look at the standard **stock forms**.

Sheet metal is commonly sold in flat sheets, however large industrial users will by roles of steel sheet if it is thin enough to be placed on a role.

Bar is shaped lengths of metal in a variety of shapes in the cross section.

It is solid in its cross section and is often comes as round bar, flat section and hex bar (hexagonal)

It would be available in many different sizes and is often sold in both metric and imperial sizes

Turning Metal

A lathe is used to change the sizes and shape of metal. It is a versatile tool that has many applications. The work piece is held in the chuck that the spins. The cutting tool is then carefully moved against the tool as the work spins cutting the metal away slowly to shape the metal.

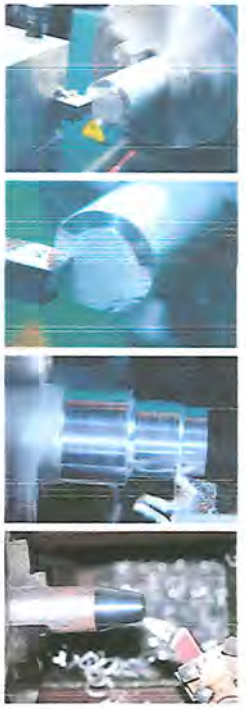
Facing Off

This operation involves moving the cutting tool along the end of the spinning work piece. This cleans the metal, removing cutting marks and ensuring the end of the material is cut 'square'

Turning down

This operation involves moving the cutting tool down the length of the metal, this has the effect of reducing the diameter.

By turning the tool holder on its mount and repeating the turning down process you can cut a taper on the metal.

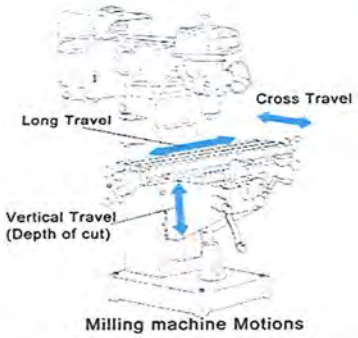


Milling

Milling is a process of removing metal using a spinning cutting tool. The machine looks similar to a drill but the work can be moved using the 'Cross' travel and 'Long' travel. This allows the metal to be shaped, cut or a surface finished.

1

Cutting on a flat sheet using the miller. The tool stays in position, it is the work that moves under control of the operator.



Milling machine Motions

CNC (computer numerical controlled) millers can produce some extremely detailed pieces of work.

https://www.youtube.com/watch?v=GRL9Pf7STSM

Blanking

Blanking is an industrial process of stamping shapes from metal sheet. Flat shapes are punched from metal sheet. The moulds and shapes of the punch determine the shape of the final product.

Polishing

Polishing involves fast spinning cloth wheels being applied to the surface of metal along with a hard wax polish this can produce a highly polished surface.

You should always use separate mops (the cloth wheels) for ferrous and non ferrous metals as well as different polishes.

There are many different types of polishing wheel/mop for different finishes or materials.

Casting – simple pewter casting

The easiest form of pewter casting is often done between pieces of MDF/plywood laminated together. The middle piece has a shape cut out to form the void into which the pewter is poured. More complicated moulds would have details engraved onto the other surfaces.
This process was demonstrated in the workshops.

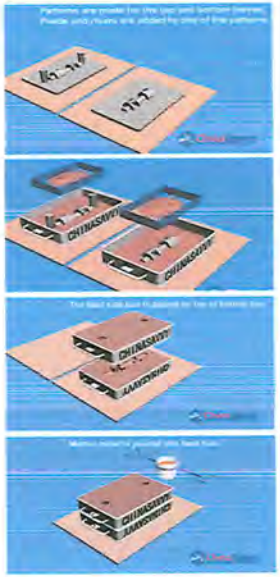
Pewter is a malleable metal alloy that is made from tin and copper. Pewter has a low melting point, around 170–230 ° and therefore is much easier to cast in a school than other metals. The pewter is heated in a low temperature system or by torch (not recommended) and poured into a mould. The pewter sets rapidly to form the desired shape.

Casting – sand casting

Casting is the process of pouring liquid metal into a mould and allowing it to set. These moulds are often made in sand and use either a removable, reusable mould or a sacrificial mould like one made from wax, that will be destroyed during the process.

The process of making a mould and preparing for pouring the metal is quite long. Below is the basic step by step guide.

The mould (pattern) is placed on a flat board. The **drag and cope** (metal of wooden frames) are placed around them and these are then filled with a type of sand known as **Green Sand.** This sand is packed tightly around the moulds and is compacted to form a prefect copy of the mould.
The drag and the cope are then turned over so they now meet and the two haves of the mould line up.
After any excess sand is cleaned away from the mating surfaces the molten metal is poured in through the feed hole. Air and gases escape through the riser hole to allow the metal to reach all parts of the void. When it is cool the sand is removed leaving a metal duplicate



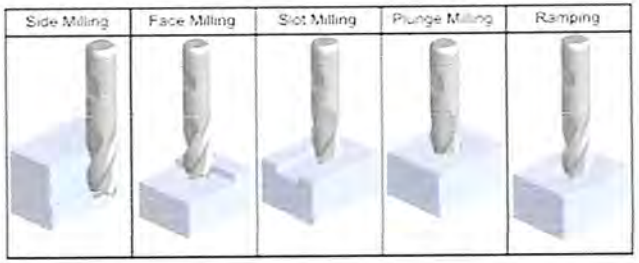
https://www.youtube.com/watch?v=K8SYhISGxN4 https://www.youtube.com/watch?v=jWyBtF5si_4

Milling tools

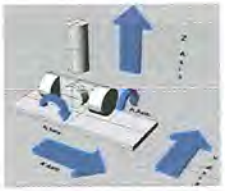
At first glance a milling tool looks similar to a drill but there are different types for different jobs.

An end mill normally has 4 cutting edges and is used for cleaning or cutting the edge of a piece of work or the surface of a piece of work

A slot cutter is used to cut slots in the metal and cut holes.



5 axis CNC milling machines are very versatile and can produce extremely complicated products by moving beyond the X,Y,Z axis and using A and B as well giving access to the underside of work and even the interior



https://www.youtube.com/watch?v=jbIU7l_8pR8

Welding – Gas and Electric

Oxy acetylene welding is using two gases (oxygen and acetylene) mixed together to produce a very hot, but controlled flame. As the metal is melted a handheld filler metal rod is fed into the pool of molten metal.

Correct and safe oxygas welding station

MIG (Metal Inert Gas) welding melts the metal by using an electric arc. The work being welded is connected to the welder by a clamp that is the negative side of the circuit. The metal that passes through the middle of the welding un has a positive charge, when they touch the arc is produced which intern melts the metal. The joint is protected from the air by the gas that is fed through the torch (stops rusting and air getting into the weld).

Correct and safe electric welding station

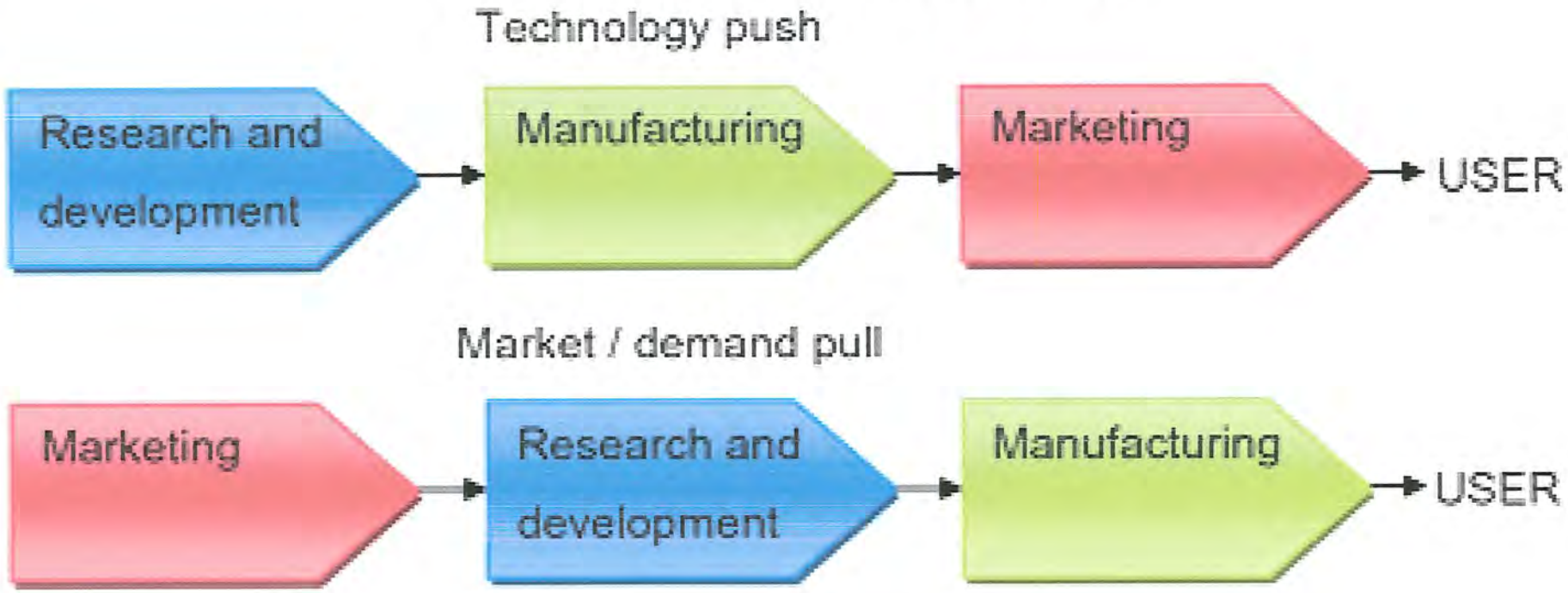
Technology 'push and pull'

Technology push

Technology push is when products are re-designed because of changes in materials or manufacturing methods. This might mean that new materials have become available, with improved properties; or that improvements in manufacturing processes mean a manufacturer can make the product cheaper or more efficiently, which reduces manufacturing costs

Market pull

Market pull is when product ideas are produced in response to market forces. Examples of market influences include:
A demand from consumers for new or improved products.
A competing product is launched by another manufacturer.
A manufacturer wants to increase their share of the market



Benefits of automation

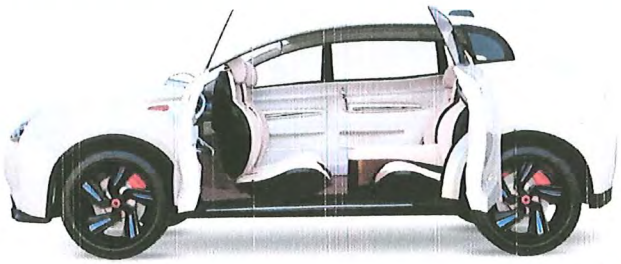
- Robots and automated systems often replace manual jobs, and can therefore save labour costs
- What other benefits are there of automation to:
  - Product manufacturers or service suppliers?
  - Consumers?
- What products are still handmade?
  - Why would manufacturers prefer to make things by hand?

Making a sphere out of resin by hand

4

Automated guidance systems

- Some companies including Google are developing autonomous self-driving vehicles
  - How might this improve the lives of the elderly or impaired?
  - What ethical considerations might developers need to make?



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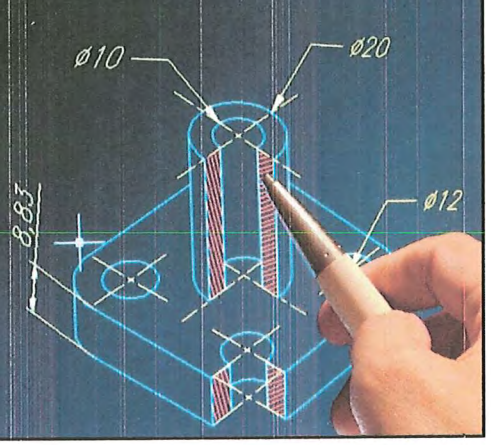
Computer Aided Design (CAD)

- CAD software is used to create precision 2D or 3D drawings, models or technical illustrations
- It is commonly used by designers, architects, engineers and artists
  - What are the advantages of CAD over hand drawn designs?
  - Many designers still prefer to start sketching by hand
  - Why?



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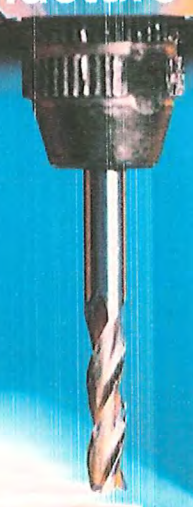
Advantages and disadvantages

Advantages of CAD	Disadvantages of CAD
Designs can be created, saved and edited easily, saving time	CAD software is complex to learn
Designs or parts of designs can be easily copied or repeated	Software can be very expensive
Designs can be worked on by remote teams simultaneously	Compatibility issues with software
Designs can be rendered to look photo-realistic to gather public opinion in a range of finishes	Security issues - Risk of data being corrupted or hacked
CAD is very accurate	
CAD software can process complex stress testing	

9

Computer Aided Manufacture

- Automated machinery is controlled by software to manufacture physical parts
- CAM uses Computer Numerical Control (CNC) and CAD files to generate 3D tool paths for the machinery to follow
  - CAM machinery includes laser cutters, embroidery machines, CNC milling machines, routers and lathes
  - Where is CAM currently used?



10


Production techniques and systems
Unit 1 New and emerging technologies
CNC milling
• CNC milling machines work in three dimensions to produce intricately and accurately machined objects such as this jet engine turbine wheel
• Digital designs are converted into a series of x, y, z coordinates for the machine to follow
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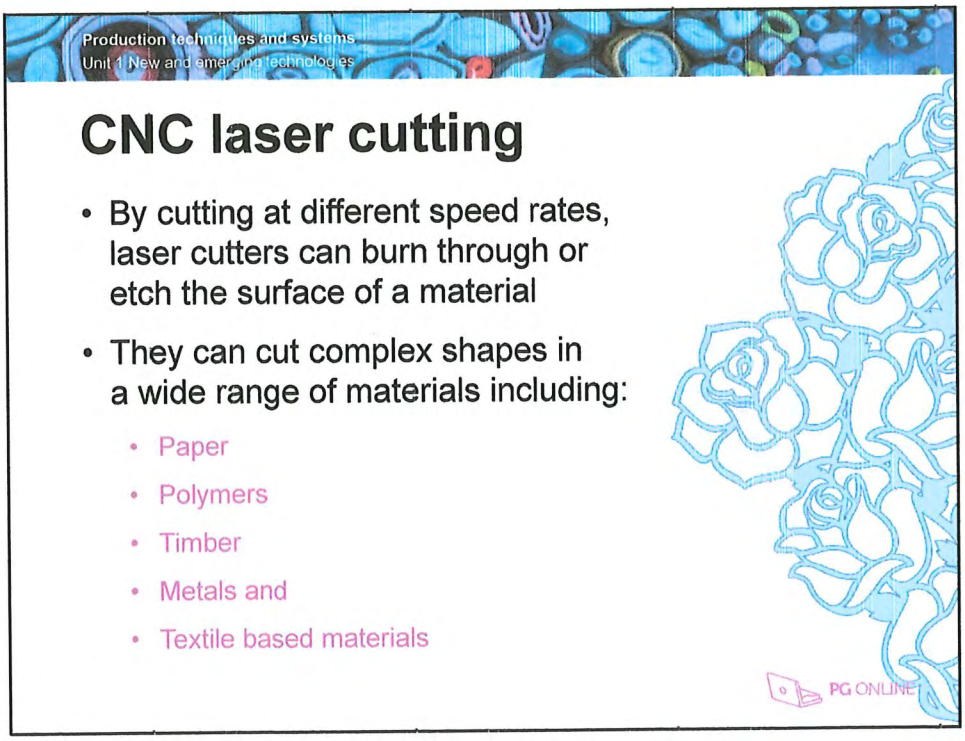

Production techniques and systems
Unit 1 New and emerging technologies
CNC laser cutting
• By cutting at different speed rates, laser cutters can burn through or etch the surface of a material
• They can cut complex shapes in a wide range of materials including:
• Paper
• Polymers
• Timber
• Metals and
• Textile based materials
PG ONLINE

12

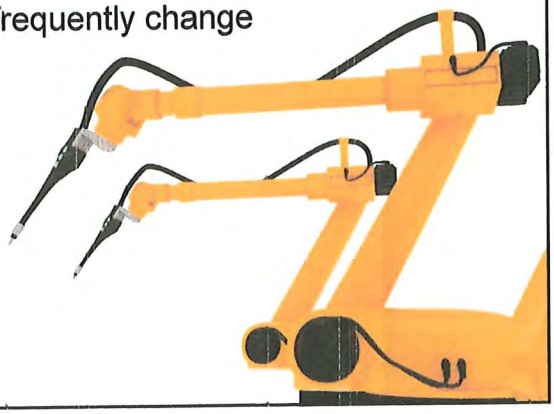
Why use CAM?

- Why are CAM systems becoming increasingly used in industry?
- What are the drawbacks of using CAM to:
  - The organisation?
  - Staff within the organisation?

13

Flexible Manufacturing Systems (FMS)

- FMS involve an assembly of automated machines commonly used on short-run batch production lines where the products frequently change
- They can be easily:
  - recalibrated
  - reprogrammed
  - retooled



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Lean Manufacturing

- 'Lean' is a Japanese philosophy created by Toyota
- It aims to manufacture products just before they are required to eliminate areas of waste including:
  - Overproduction
  - Waiting
  - Transportation
  - Inappropriate processing
  - Excessive inventory (Storage)
  - Unnecessary motion
  - Defects

15

Just In Time (JIT) production

- Items are created as they are demanded
- No surplus stock of raw material, component or finished parts are kept
  - What are the benefits of holding no stock?

16

Advantages and disadvantages

Advantages of JIT	Explanation
No warehousing needed	Reduced costs for construction, maintenance and running costs.
Orders secured before outlay on parts is required	Making it more economical. No storage or waste of unused parts
Stock does not become obsolete, damaged or deteriorated	Cuts down on wastage

17

Manufacturing techniques

- Complete **Task 3** of **Worksheet 4**

18

Ethics and the environment

- Companies are increasingly aware of the need for social responsibility
  - This includes sustainably sourcing components and materials, ethical production methods, reducing waste, recycling and considerate end-of-life disposal
  - What are the benefits of social responsibility to companies?
- How might ethical factors inform design decisions?

Evaluating the use of new technologies

- The success of new technologies and products are frequently evaluated according to the following points:
  - Cost
  - Reliability
  - Longevity
  - Sustainability
  - Recyclability
- What other factors might you consider?

3

Informing design decisions

- If you are designing a new product, you will need to gather opinion and facts in relation to:
  - Successes and shortfalls of similar available products
  - Available technology
  - The size of the market
  - The market need

4

Planned obsolescence

- Should all products last for your lifetime?
- How long would you expect the following to last?
  - School chair
  - iPod
  - Shoes
  - Newspaper
  - Plastic fork

5

Determining product lifespan

- Why should designers of a new product consider:
  - Fashion and trends?
  - The requirements to maintain market share?
  - New technologies?
  - Upgradeability and function?
- Once the expected lifespan is determined, manufactures need to appropriately engineer the product in order to last as long as expected
  - What are the consequences of over- or under-engineering product parts?

6

Disposability

- Some products are planned with deliberately short lifespans
- What are the advantages and disadvantages of short product lifetimes to:
  - Manufacturers?
  - Consumers?
  - The environment?

7

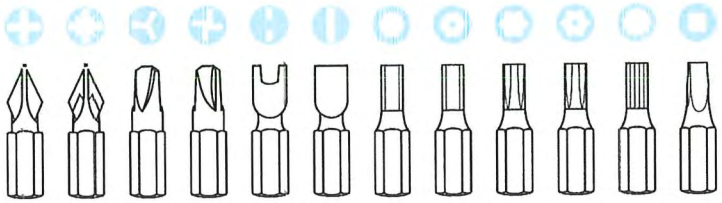
Design for maintenance

- Should all products be repairable?
  - What scope for maintenance and repair should designers allow?
  - Are repairs expected to be carried out at home or sent to professionals?
  - How easily are modern products repaired?

8

Specialist repairs

- Some products are manufactured to be too complex to be repaired at home
  - Knowledge is required to fix electronics or mechanical parts
  - Specialist tools are required
  - Specialist replacement parts may be required



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Case study: Swedish repairs

- The Swedish government is offering to halve VAT on repairs to encourage owners to make do and mend
- They will also offset half the labour cost through income tax benefits
  - This will significantly reduce the cost of repairs to clothes, shoes, bikes and large kitchen appliances such as washing machines and dishwashers
  - Products will last longer and the consumption of materials will be reduced

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10

Recycling

- What products are designed to be recycled or reused?
  - What makes them suitable for recycling?
  - What products are easily upcycled?
- What are the benefits of recycling to:
  - The company?
  - The customer?
  - The planet?
- How much recycling does your household produce each week?

11

End of life

- Responsible end of life design should include:
  - as few materials as possible
  - recycled and recyclable materials where possible
  - easy-to-separate materials avoiding permanent bonding methods
  - built-in reusability where possible

12

Low oil supplies

- The depletion of oil reserves is hastening change and development of replacement technologies to fuel our industries, homes and transport
- New technologies include:
  - Harnessing natural resources
  - Hydrogen power
  - Battery technology

8

Electric vehicles

- The EV market is expanding rapidly
- Success is dependent on:
  - national and international charging networks
  - battery technology
  - a change in driver mindset

9

MATERIALS AND THEIR MECHANICAL PROPERTIES.

Conductivity: The ability of a material to conduct heat and electricity.

Strength: The ability of a material to withstand a force without breaking or bending.

Elasticity: The ability of a material to bend or distort and return to its original form.

Plasticity: The ability of a material to permanently change its shape or form.

Malleability: The ability of a material to permanently deform in any direction without cracking or splitting.

Ductility: The ability of a material to be drawn out along its length, twisted or stretched without splitting or breaking

Hardness: The ability of a material to withstand wear, scratching and indentation.

Toughness: Is the ability to withstand sudden shocks, blows, impacts etc without breaking

Durability: The ability of a material to withstand wear and tear especially from weathering.

Fusibility: Is the ability of a material to change into a liquid or molten state when heated.

Stability:

The ability of a material to resist changes in size and shape due to environmental factors.

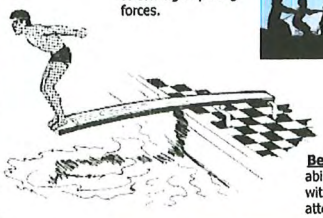
Many timbers are not very stable because they shrink and swell along their width due to temperature and humidity changes.

10

MATERIALS AND THEIR MECHANICAL PROPERTIES.

Tensile strength: Is the ability of a material to resist stretching or pulling forces.

Compressive strength: is the ability of a material to withstand crushing or pushing forces which attempt to crush or shorten the material.



Bending strength: Is the ability of a material to withstand forces which attempt to bend the material.

Shear strength: Is the ability of a material to resist sliding forces acting against each other like a scissor action.

Torsional strength: Is the ability of a material to withstand twisting forces when torque and torsion are applied.

11

Environmental issues

Making a product uses resources, such as raw materials and energy. This has an impact on the environment.

There are a number of things that a designer might think about to reduce environmental impact:

- **The material used to make the product.**
- **The life of the product.**
- **What happens to the product at the end of its life.**

Wood

Timber is a renewable resource, which means that if forests and woodlands are carefully managed, we will never run out of it. Timber is easy to reuse and can be burnt to produce heat when at the end of its natural life. It is also biodegradable.

Metals

Most metals are relatively easy to recycle and reuse, and there are advantages for manufacturers. It is 20 times more efficient to recycle aluminium cans than to make new ones.

Plastics

Although most plastics are not biodegradable, they can be recycled and reused. Polystyrene vending cups can be recycled to make items such as pencils and rulers, and plastic carrier bags can be reused

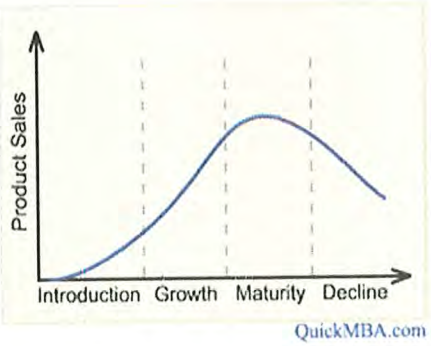
1

Product life

Most products have a limited life. This means that eventually they stop working, are worn out or are thrown away. Designers have to consider how long a product will last and what will happen when it is no longer needed.

A product with a long life uses less material than several short-lived replacements. This is good for the environment. However, a longer life also means that the manufacturer will sell less replacement products.

One way of extending product life is using better materials – like stronger materials or materials that resist corrosion. Another way is through design to allow their life to be extended by maintenance.



2

Design for maintenance

Maintenance means any activity which allows the product to have a longer life. It can include anything from repairing worn out parts to replacing batteries.

Designing a product to allow maintenance may mean including features such as access panels and standard screws. These help to allow parts to be replaced.

Alternatively, products might be made from a series of standard modules. This would mean that if it went wrong, only the faulty module would need to be repaired or replaced.

Using modular design also makes it easier to upgrade and improve products as there are new developments and improvements in technology.

3

Disposal

At the end of their useful life, most products are disposed of in some way. How this is carried out can have a significant effect on their impact on the environment.
A large proportion of products that we use currently end up in landfill – this means that they are buried in underground rubbish dumps. This is one of the least environmentally friendly methods of disposal.

Recycling

Recycling means reprocessing a material so that it can be used again. This helps to reduce damage to the environment by reducing the need for new materials. For example, this might mean melting plastic parts so that they can be shaped into new products. Symbols are used on plastic products to show the type of plastic used, so that it can be sorted into different types and recycled.

Biodegradability

If it is essential to dispose of a product in landfill, ideally the material should be biodegradable. This means that it will decompose (naturally break down) relatively quickly into naturally-occurring substances - as opposed to non-biodegradable ones that take many years to decompose.

4

As discussed previously the majority of plastics are made from oil. This causes problems fom the environment through the process of extracting oil from the ground or under the sea. There are also problems with the processing of oil into compounds we can use as plastics and the pollution these produce.

Plastic also creates problems following our use and its **final disposal**. Plastic is generally not biodegradable, meaning it is not easily broken down naturally by animals and enzymes digesting it. Plastics have only been around for about 70 years. So microorganisms simply haven't had much time to evolve the necessary biochemical tool kit to latch onto the plastic fibres, break them up into the constituent parts and then utilise the resulting chemicals as a source of energy and carbon that they need to grow.

Disposing of plastic

According to National Geographic only 9% of plastic is recycled.
The vast majority—79%—is accumulating in landfills or discarded in the natural environment as litter. Meaning: at some point, much of it ends up in the oceans, the final sink.

Environmental impact of disposal.

- Most plastic ends up in landfill, land that cannot be used again as plastic does not naturally degrade.
- A large proportion is simply litter damaging habitats.
- Much will finally end up in the ocean as small pieces where it is ingested and will enter the food chain.

Can plastics be environmentally friendly?

If we recycled 100% of all plastic produced then there is every chance the use of plastics would become sustainable, but we don't. Alternatives are needed to allow us to continue to use this versatile material.

In order to make plastic more environmentally friendly we need to look at:

- **Bioplastics** made from natural materials such as corn starch
- **Biodegradable** plastics made from traditional petrochemicals, which are engineered to break down more quickly
- **Eco/recycled plastics**, which are simply plastics made from recycled plastic materials rather than raw petrochemicals.

Bioplastics

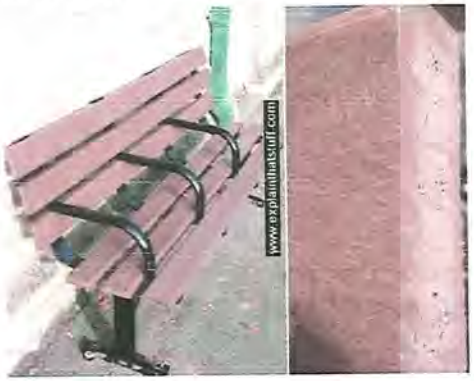
The theory behind bioplastics is simple: if we could make plastics from kinder chemicals to start with, they'd break down more quickly and easily when we got rid of them.
The most familiar bioplastics are made from natural materials such as **corn starch** and sold under such names as *EverCorn™* and *NatureWorks*. Some bioplastics look virtually indistinguishable from traditional petrochemical plastics. **Polylactide acid** (PLA) looks and behaves like polyethylene and polypropylene and is now widely used for food containers.

Biodegradable plastic is **plastic** that decomposes naturally in the environment. This is achieved when microorganisms in the environment metabolize and break down the structure of **biodegradable plastic.** The end result is one which is less harmful to the environment than traditional **plastics**

Some supermarkets now use what are described as **photodegradable**, **oxydegradable**, or just **biodegradable bags** (in practice, whatever they're called, it often means the same thing). As the name suggests, these biodegradable plastics contain additives that cause them to decay more rapidly in the presence of light and oxygen (moisture and heat help too). Unlike bioplastics, biodegradable plastics are made of normal (petrochemical) plastics and don't always break down into harmless substances: sometimes they leave behind a toxic residue and that makes them generally (but not always) unsuitable for composting

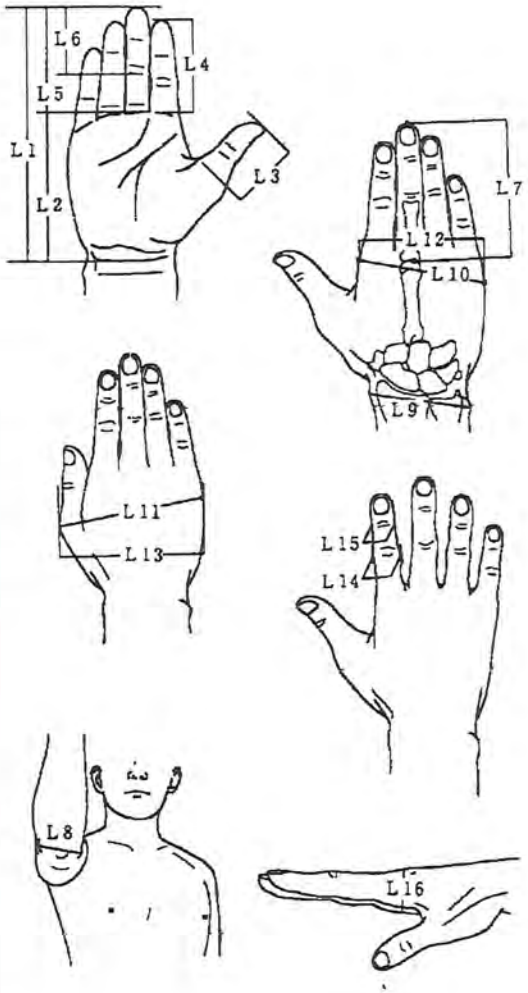
Eco/recycled plastics

One easy solution to the problem of plastic disposal is to recycle old plastic materials (like used milk bottles) into new ones (such as items of clothing). A product called ecoplastic is sold as a replacement for wood for use in outdoor garden furniture and fence posts. Made from high-molecular polyethylene, the manufacturers boast that it's long-lasting, attractive, relatively cheap, and nice to look at.



Anthropometrics

- Anthropometrics is the study of measurements of the human body.
- It is used in product design, architectural design and clothing design.
- Nothing that is designed for humans to use can be designed before considering the anthropometric data.



Ergonomics is the study of designing equipment and devices that fit the human body, its movements, and its abilities making them comfortable.

Many products are designed to be used by people for long periods of time, such as computer keyboards and mice, ergonomics are used to make sure they can be used safely and efficiently.

Repetitive strain injury (rsi) can be caused by badly designed products or by incorrect use of them for long periods of time.