UNIT ONE
WRITTEN PAPER
MATERIALS AND COMPONENTS

Area to Revise	**Revised**
Material Properties	
Woods	
Manufactured Boards	
Metals	
Plastics	
Composite Materials	
Smart Materials	
Nanomaterials	
Sustainability of Materials	
Knock Down Fittings and Fixings	
Mechanical Methods of Joining Materials	
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WRITTEN PAPER
PROCESSES AND MANUFACTURE

Area to Revise	Revised
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UNIT ONE
WRITTEN PAPER
PROCESSES AND MANUFACTURE

Area to Revise	Revised
Levers	
Linkages	
Types of Motion	
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Belt and Pulleys Systems	
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Mechanical Properties:

Mechanical Properties are linked to the way they react to the applied force. Some Mechanical Properties may deform in temporary way, while for different materials it is more permanent. The strength of a material is its ability to hold (withstand) an applying or applied force devoid (withstand) of breaking or permanently being bent. Different types of materials can have different types of strength dependent on how they resist the forces being applied.

Types of strength:

Bending is where you have the ability to withstand forces that are attempting to bend.

Compression is the resistance to forces that are trying to crush or shorten.

Shear is where the resistance to forces sliding in opposite directions.

Tension is where the resistance to forces pulling in opposite directions.

Torsion is where you have the ability to withstand twisting forces.

Physical Properties:

Most of the physical properties of materials are unchanged by the applying forces or by the intensity of heat, as seen in several plastics. Fusibility is where you have the ability to alter the materials into a liquid material at certain temperature. This is extremely important feature in which materials are needed to be melted to carry out a Fabrication process such as soldering, welding, also forming processes such as moulding and casting.

Electrical Conductivity is the capability to tolerate electricity to pass through a material. Good electrical conductivity is seen in most metals, mainly gold, silver and copper. Great electrical insulators are woods ceramics and plastics. Thermal Conductivity is the capability to tolerate heat to pass through a material. Metals have a great thermal conductivity where as non-metallic materials have poor conductivity they are referred to as insulators.

Woods

Materials

Hardwood

Hardwoods grown in the uk tend to be from Broad-leafed, deciduous trees that lose their leaves each autumn. Beach, oak and ash are examples of hardwood trees grown in the uk. Hardwoods grown in the rainforest include teak and mahogany.

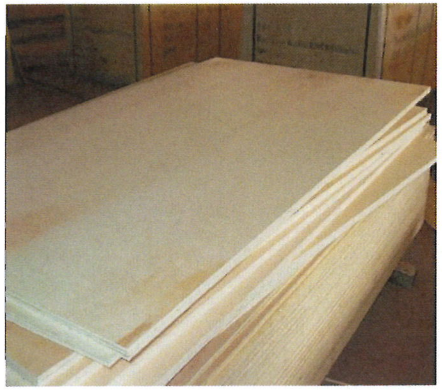
Harwood: is also timber that tends to be from growing , broad-leafed trees.

Examples: Beech, Oak, Ash, Mahogany, Teak.

Softwood

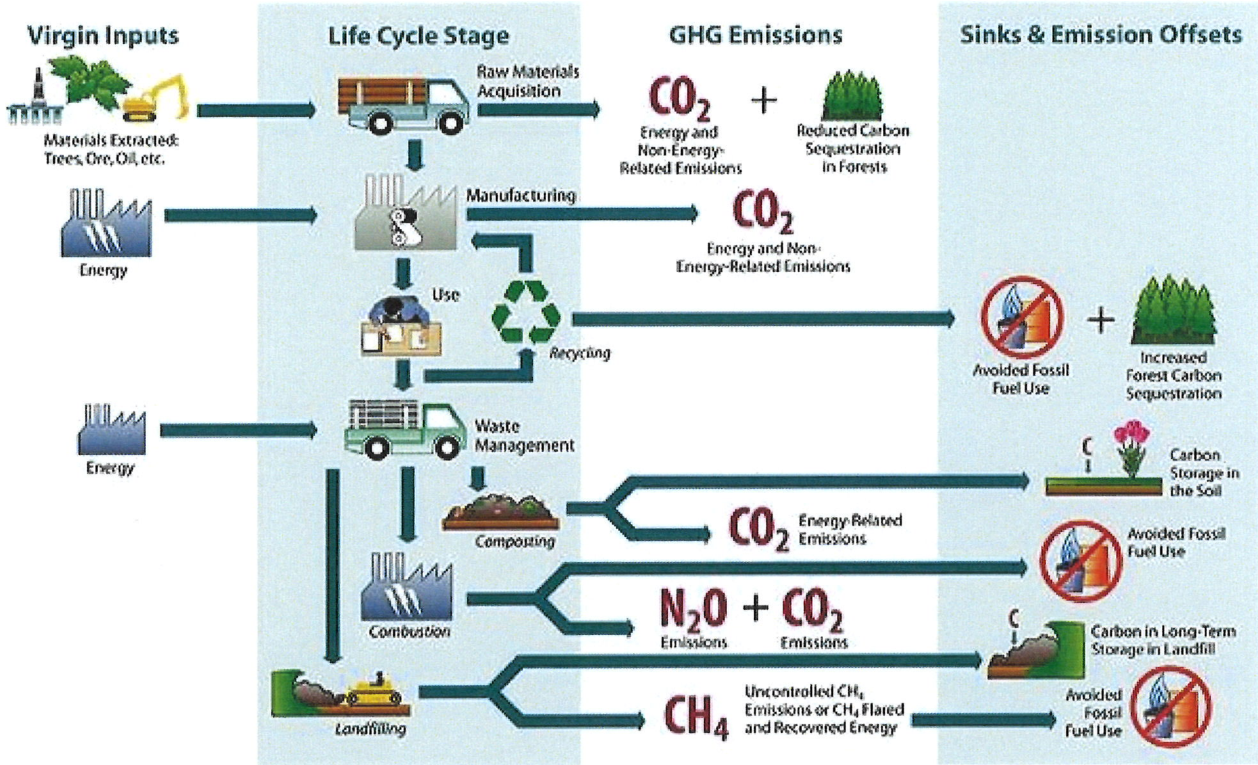
Softwoods come from conifers, which are evergreen trees. Most conifers keep their needles throughout the year. Large amounts of softwoods such as pine and cedar are imported into the uk from Scandinavian countries, while the uk produces about 10 per cent of its own softwood in plantation. Softwood: timber from quick growing conifers

Examples: pine, Cedar.



Manufactured Boards are made by changing logs into a variety of forms and then gluing them together to create sheet materials. The reason for doing this process is to produce large, flat sheets of timber that are stronger and more stable than conventional wide boards of softwood and hardwood. This process often uses more of the trees and therefore can be used to produce large boards of timber more economically.

Examples: plywood, MDF, chip board



Life cycle of Wood: first of all the trees are planted and then the tree is cut then transported by road rail or river. The tree is converted to useful sizes then transported to a factory then it is product manufactured then sold to the retailer which then the retailer sells to the user and then the user after they have used it recycle it back to the place where the product is manufactured or composted or gets left on a landfill.

Environmental consequences: when the wood is transported the transport used causes pollution and where the tree is converted into useful sizes will let off harmful fuels and gasses.

Materials Metals

Ferrous Metals are metals that contains iron and varying amounts of carbon. They are normally magnetic.

Examples: stainless steel

Non Ferrous Metals are metals that do not contain iron.

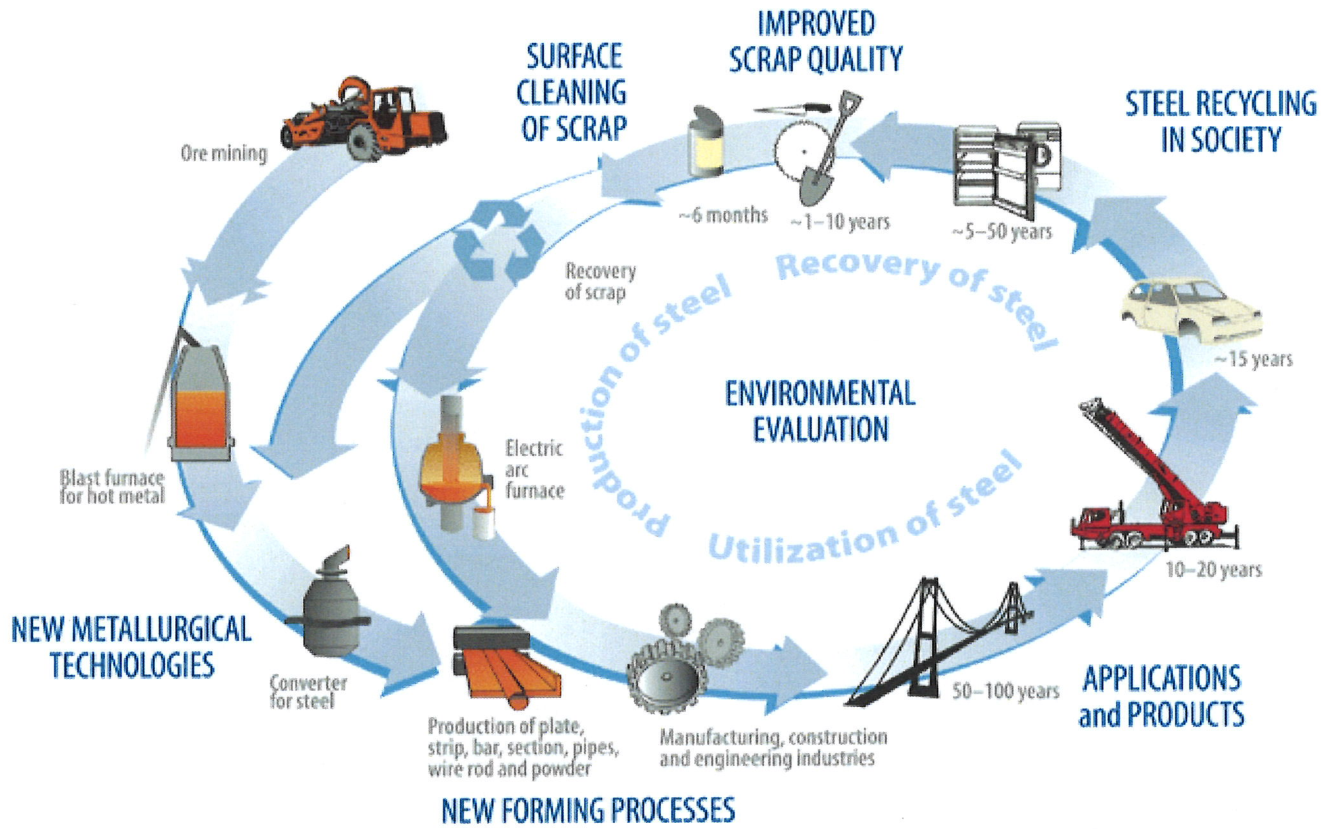
Examples: Aluminium, Copper, Zinc, Gold, Lead and Tin

Alloys are a combination of two or more metals

Examples: Brass, Steel, Bronze and Pewter

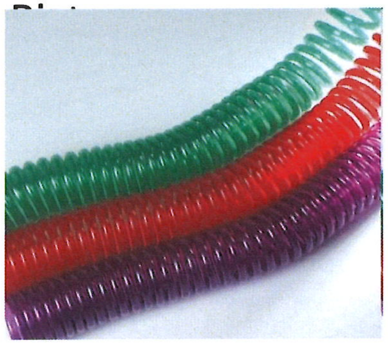
Metals

Sustainability



Life cycle of Metals: The ore is dug from the ground and then transported to where the ore is converted to metal using huge amounts of energy then the product is manufactured and then sent to the retailer which is then sold to the user and then the user disposes the metal and it is either melted down using as little as 5% energy or put in a landfill.

Environmental consequences: when the ore is dug up from the ground it uses a lot of energy and there is a lot of fumes going into the atmosphere and there is also a lot of energy used when they convert it into metal. When it is left in a landfill for a long amount of time it damages the earth.

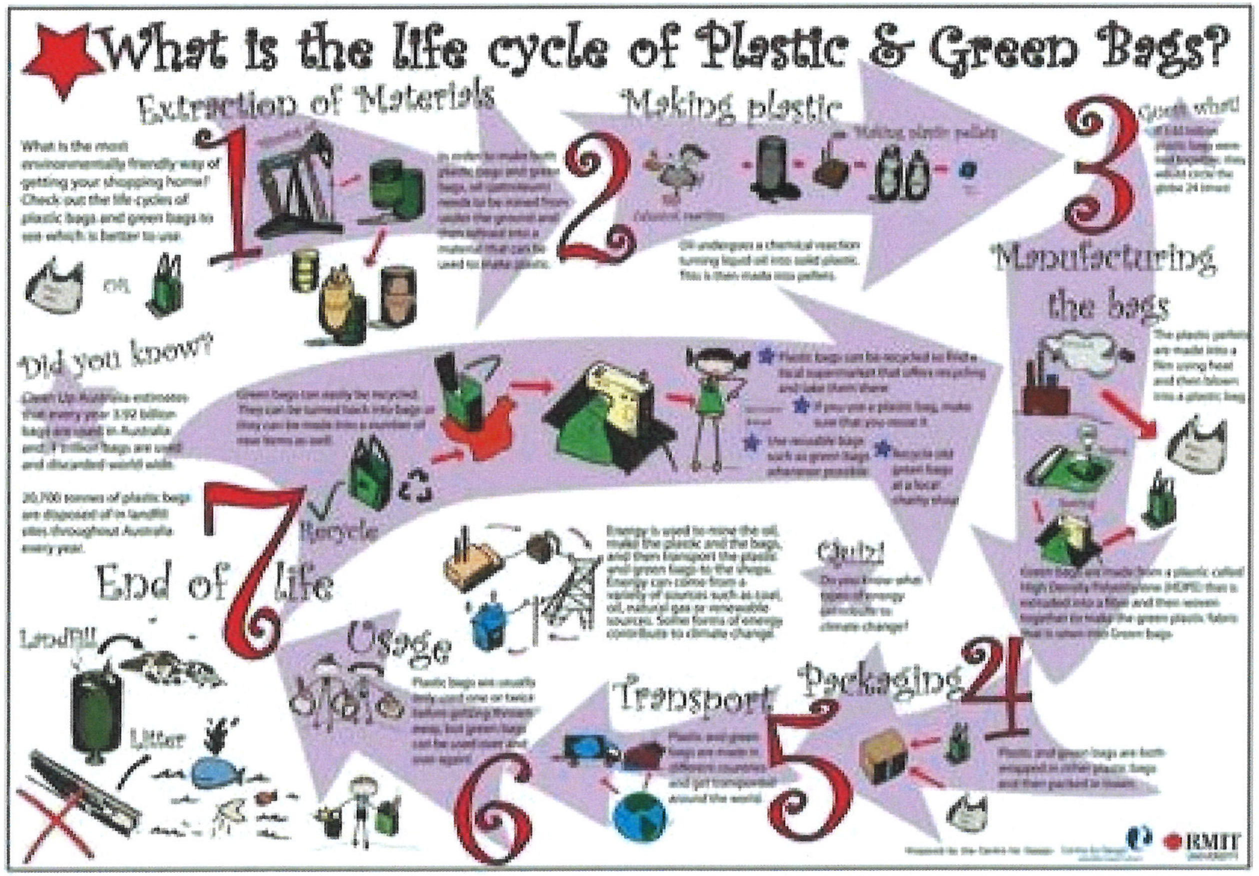


Thermoplastics it is the most common plastic because it can be reshaped when reheated. Common thermoplastic names, PET,HDPE,PVC AND LDPE.

Examples and Common Uses: Bottles, food containers, bowls, buckets, pipes, window frames, flexible hoses, toys and transparent packaging.

Thermosetting Plastics . The chemical polymers that make up these types of plastics bond permanently when heated and set hard as they cool.

Examples and Common Uses: surface coatings (Epoxy resign) laminates for work surfaces, tableware (melamine formaldehyde). saucepan handles and cheap electrical fittings (phenol formaldehyde) car parts, glass reinforcing (polyester resign). adhisives,electrical fittings such as light switches urea (formaldehyde).



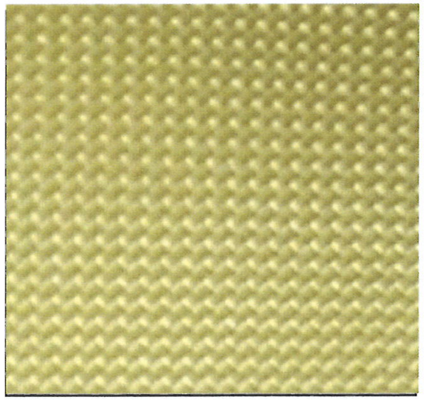
Life cycle of Plastics: Crude oil is extracted from the ground and then shipped or piped then the oil is refined to produce plastic. The product is then made and sent to the retailer and distributed to the shops, when it is disposed it is then recycled and eventually sent to landfill.

Environmental consequences: One of the positive characteristics of plastic is the fact that it is durable. Unfortunately, this is not a positive characteristic when it comes to the environment. The fact that plastic is durable means it degrades slowly. In addition, burning plastic can sometimes result in toxic fumes. Aside from trying to get rid of plastic, creating it can be costly to the environment as well. It takes large amounts of chemical pollutants to create plastic, as well as significant amounts of fossil fuels.

Materials Composites

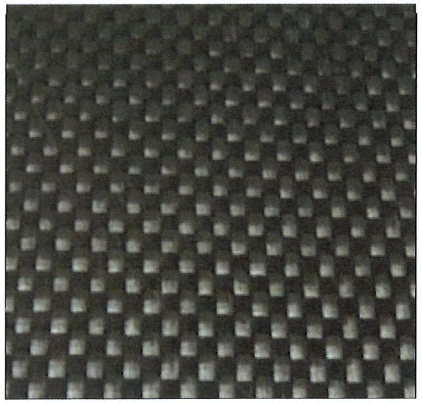
GRP consists of strands of glass fibres that are coated in polyester resin.

Common Uses: sailing boat. Kit car



Kevlar is similar to carbon fibre matting. Very strong plastic material woven to form a mat.

Common Uses: Kevlar is used make items as badminton and tennis rackets, helmets and bullet-proof vests. Body armour



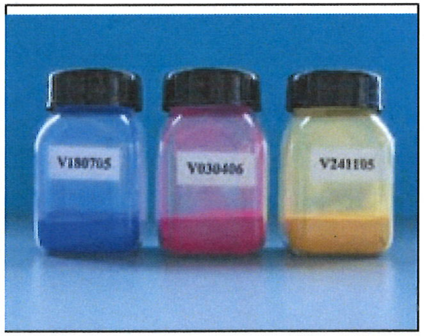
Carbon Fibre is reinforced plastic – similar to GRP. Strands of carbon that are coated in polyester resin – used in high performance products.

Common Uses: track bike tennis racket

Smart Materials

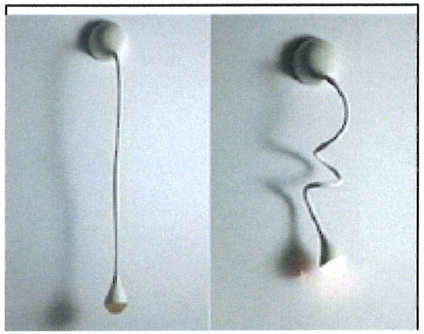
Polymorph

Common Uses: Producing models for ergonomically designed handles.



Thermochromic Pigments

Common Uses: Russle Hobbs make a kettle that changes colour as it boils. Tommy Tippee produce a range of baby feeding products that change colour to warn you if the baby's food is too height.



Shape Memory Alloys

Common Uses: 'Memo flex' spectacles are made from a shape memory alloy and have the ability to return to their original shape even when they have been very badly bent.

Materials

Nanomaterials

Common Uses: because they are light, stiff and strong. A good example is on jet ski hulls. This reduces the weight and also gives a high gloss finish that reduces surface tension on water and increases performance.

Knock Down Fittings:

Knock down fittings is when products are disassembled so that they can be flat packed to be able to fit in some ones car or portable for them to take home and build themselves. They are designed to be built with a screwdriver or a Allen key which is often supplied by the pack. They are useful for joining metal to timber and sometimes plastics.

Examples and Uses:

Cam lock- This is a large thread on the screw is designed to grip well in chipboard and Mdf. Turning the cam, pulls the parts together.

Worktop Connector- Fitted underneath worktop. Tightening the nuts with a spanner pulls the worktops together.

Other Fittings:

This is a variety of fixtures used for moving parts on products.

Examples and Uses:

Magnetic catch- simple to fit but visible when the door is open.

Bolt- often used to fix one pair of doors or keep draws shut.

Mechanical joining methods

Components, adhesives and applied finishes

Nails: nails are easy and quick to use with a hammer. nails are mostly made by steel. other materials stainless, copper and aluminium. some mild steel nails are available with a galvanised finish for use outdoors.

Screws: wood screws are used to join together a variety of materials. There are different shapes and sizes of screws

Nuts and Bolts:

Usually used for fixing metals together. Are non permanent. They come in various shapes and sizes dependant on their task.

Rivets: ways to join metal sheets together without having use of heat

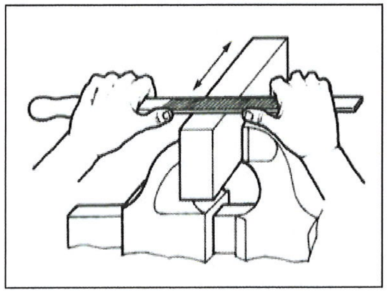
What are they?
A substance used to stick things together

Preparation: All adhesives need the material to be clean, dry and free from oil and dust if they are to achieve their maximum grip. Some areas may need to be covered in masking tape to prevent the glue from spreading.

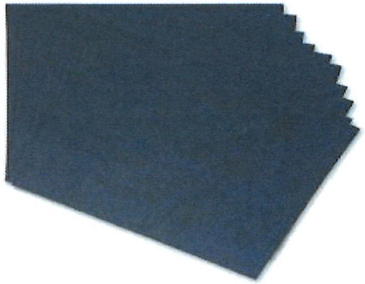
Some adhesives require the joint to be keyed. This means that the joint should be made roughly (usually done with an abrasive paper

Name	Material	Drying Time	Use
Hot Glue stick (glue gun)	Wood, metal, plastic.	On cooling.	Is waterproof but weak, but only suitable for modelling or temporary fixings. It is heated in a special gun and comes out from the nozzle.
PVA	Wood	4-24 Hours	Gives a strong joint. It comes in a liquid form.
Liquid Solvent Cement 'Tensol'	Thermoplastic	10 Minutes	It is waterproof and gives a medium strength joint. It comes in a liquid form. The joint needs to be held together while the glue dries.
Synthetic Resin 'Cascamite' 'Extramite'	Wood	6-8 Hours	Is waterproof and gives a strong joint. It comes in a powder form. The joints must be held together while the glue dries.
Contact Adhesive 'Evostick'	Wood, metal, plastic.	INSTANT	It is waterproof and gives a medium strength joint. Ideal for plastic laminates to chipboard for kitchen worktops. It comes in a liquid form.
Epoxy Resin 'Araldite'	Wood, metal, plastic	½ - 6 hours	Is waterproof and gives a strong joint. Equal amounts of resin and hardener are mixed together and applied with a spreader. Must be held together whilst glue dries.
Cyanocrylate 'super glue'	Wood, metal, plastic	Instant	Is waterproof and gives a medium joint. It comes in a liquid form.

Preparing a Wooden Surface:
Make surface and edges flat (plane and sander)
Work your way through the grades of paper from course to fine.
Remember to sand with the grain.



Preparing a Metal Surface:
Make surface and edges smooth (draw filing)
Clean the surface – emery cloth
Clean with white spirit



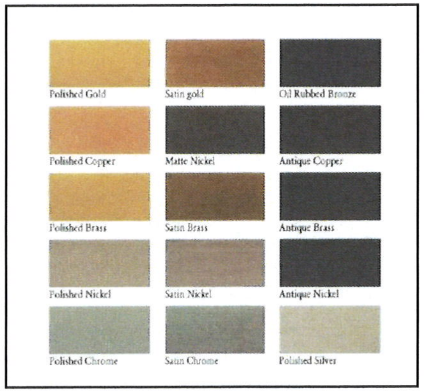
Preparing a Plastic Surface:
Keep on any protective plastic as long as pos
Draw file the plastic
Use abrasive paper – wet and dry

Abrasive Papers:
Abrasive papers are used for finishing all types of materials and come in a variety of grades. The higher the number the finer the grade.

Intro:

Finishes improve the products look.

Protect materials from being damaged.



Finishes for Metal:

Paint: Oil based, water based, solvent based (most common). Primer applied then undercoat then top coat of paint (more if necessary).

Lacquer: Adds clear shine good protection. Solvent based in the form of spray with no brush strokes and fast drying.

Plastic dip coating: Adds colour & excellent protection. Metal is heated to 200 degrees & dipped into a bath of polythene then left to cool.

Oil bluing: Adds bluey/black colour to steel & some protection. Firstly heated to 700 degrees then plunged into an oil bath & cooled.

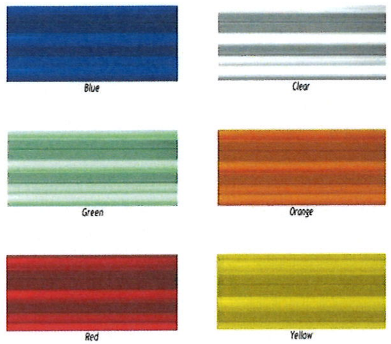
Anodising: An industrial process involving electrolysis. Adds vivid colour to aluminium & excellent protection.

Plating: Coating metal with another metal gives excellent protection also involves electrolysis.

Galvanising: Coats metal with another metal gives excellent protection. Involves dipping steel into molten zinc

Finishes for Wood:

Wax: Beeswax & silicon polish. Adds shine & some protection. Solid, rubbed on & buffed when dried.
Oil: Teak oil, Danish oil, linseed oil (most common). Shine & some protection. Liquid, rubbed on with cloth.
Stain: Changes wood colour & little protection. Added with cloth. When dry it needs to be sealed with sealer or varnish for shine & protection.
French Polish: Adds deep shine & some protection.
Sealer: MDF sealer most common. Shine & good protection. Liquid applied with brush.
Varnish: Polyurethane & acrylic. Shine & good protection.
Paint: Oil based most common. Adds colour (mat, silk, gloss) good protection.



Finishes for Plastic:

They are usually self coloured and finished. They are only required to be polished.

Workshop Safety? Most accidents that in are caused by human carelessness. You must always concentrate on working safely, both for your safety and that of others using the workshop. One brief lapse of concentration could lead to an accident that changes your life, or that of a friend, for ever. It is your responsibility to behave in a mature and correct manor.

Potential Hazards: wear goggles when sawing, sanding or drilling. Wear heat proof gloves Handling hot or sharp materials. Wear apron for General workshop

Operation	PPE	Hazard	Safety Symbol
Drilling, sanding, welding	Goggles, welding visor	Dust, swarf or sparks	
General workshop activities	Apron	Clothing may get caught in machinery or chemicals can spill onto clothing	
Handling hot/sharp	Heat proof gloves, leather apron steel masks.	Burning hands/ fingers when working with hot materials.	
Using machinery	Ear defenders	Damaged hearing after repetitive or continuous loud noise.	
Sanding, applying a finish, using adhesive	Face mask, latex gloves	Lung damage from inhaled dust or fumes	
Carrying or installing equipment	Stout shoes with toe protection	Damaged or crushed toes and feet caused by falling materials or equipment.	

COSHH: A set of regulations that ensure hazards are controlled so as not to affect someone's health (e.g. – hazardous substances)
If these hazards such as ones you may find in a workshop are not controlled properly then effects such as skin irritation, lung damage, cancer etc may effect the users.

Reducing Risks with control measures: Replacing high risk substances with safer alternatives, using substances in a safer form (gels instead of liquids) providing ventilation, storing substances in secure locations.

Symbol	Meaning	Hazard	Control Measure
	Flammable	Catches fire easily	Use with care in ventilated areas. Keep away from naked flames.
	Toxic	Poisonous – if inhaled, swallowed or if penetrates the skin	Only use with PPE and in very small quantities. Dispose with care.
	Harmful	Less dangerous than toxic but can cause inflammation.	Only use with PPE and in very small quantities. Dispose with care.
	Corrosive	Will attack and destroy living tissue including the skin and eyes.	Avoid large quantities. Use with correct PPE in a tray to avoid spills
	Irritant	Not corrosive but can cause reddening, irritation or blistering	Avoid large quantities. Use with correct PPE in a tray to avoid spills

Hand Tools: many of the hand tools you use in the school workshop have evolved over hundreds of years. Craftspeople through the centuries have developed the ability to use these simple tools to create both beautiful furniture and buildings. Only some hand tools are covered on these pages but they should help you understand the importance of using common tools safely and correctly.

Sawing: there are a number of saws available that are used for wasting and shaping materials. The teeth of the saw are slightly bent outwards, which provides the necessary clearance to prevent jamming but consequently the width of the cut is wider than the thickness of the blade.

Tool	Material	Process
Tenonsaw	wood	The blade is stiffened to make straight cuts. It is used to cut pieces of wood to the correct length and wasting unwanted material.
Coping saw	Wood and Plastic	The thin blades allow you to make curved cuts. The blade is held in tension by spring steel frame with the teeth pointing backwards towards the handle.
Hack saw	Metal and Plastic	Hacksaws have finer teeth and are mainly used cutting metals. The blade of the hacksaw has the teeth pointing towards the front and is tensioned by the screw at the front of the hacksaw.
Junior Hacksaw	Metal and Plastic	This is a smaller version of the hacksaw with both a smaller blade and lighter metal frame.

Shearing: materials can be shaped using a variety of hand tools that use some form of cutting action to remove material. Keeping tools sharp is important, as well as using them correctly, if a quality finish is to be achieved on the material. Wood and metal chisels use a basic wedge cutting action while planes use a similar action but the blade is held at a particular angle. Files use tows of teeth to remove small particles of material called filings.

Processes and Manufacture

Tools and Equipment

Shaping: Materials can be shaped by a variety of hand tools that use some form of cutting action to remove material. Keeping tools sharp is important as well as using them correctly.

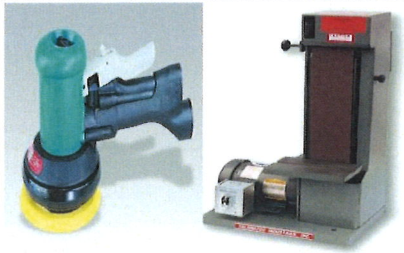
Tool	**Material**	**Process**
Wood Chisel	Wood	Used for removing waste as well as shaping.
Cold Chisel	Metal	Much harder than wood chisel. Always wear safety goggles
File	Metal, Plastic	Used for shaping metals and some plastics. Used in 2 actions – cross and draw filing.
Plane	Wood	Used to reduce the size of the material by shaving the wood. Planing across the grain can cause splitting of the wood.

Drilling: As well as making holes in materials, drilling can also be a quick way of removing waste materials quickly.

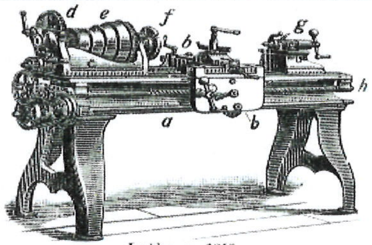
Holding: There are many tools designed to hold materials securely and safely. They allow you to concentrate on working with tools with greater control and to avoid coming into contact with sharp cutting edges. It is important to use holding tools such as clamps and vices for your own safety.

Power Tools: A power tool is a tool powered by an electric motor, an internal combustion engine, a steam engine, compressed air, direct burning of fuels and propellants, or even natural power sources like wind or moving water.

Pillar Drill: a pillar drill is a fixed style of drill that may be mounted on a stand or bolted to the floor or workbench.



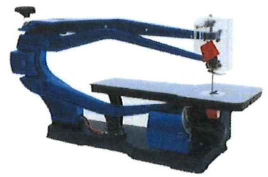
Belt sander and disc sander: A belt sander is a machine used to sand down wood and other materials for finishing purposes. A sander is a power tool used to smooth wood and automotive or wood finishes by abrasion with sandpaper.



Lathe, p. 1218.

A lathe is a machine tool which rotates the work piece on its axis to perform various operations such as cutting, sanding, knurling, drilling, or deformation with tools that are applied to the work piece to create an object which has symmetry about an axis of rotation.

Band Saw: A band saw is a power tool which uses a blade consisting of a continuous band of metal with teeth along one edge to cut various work pieces.



Scroll Saw: used to cut intricate curves. Use blades similar to coping saws. Different blades are available for a selection of different materials and tasks.

Milling Machine: use rotating multi toothed cutter to shape materials using a high level of precision. The bed can be moved in three separate directions.

Mortising Machine: Less common in schools but is a quick and accurate method of producing multiple mortise joints. The machine uses a drill bit held inside a specialist square and hollow chisel. The drill bit removes most the materials while the chisel ensures all the edges are straight and clean.

Hand Held Power Tools:

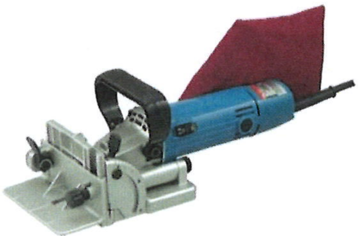
Cordless Drill: Easy to use and lightweight. Can be used as a screwdriver due to them having a clutch setting.
Most drills are now designed more ergonomically with better balance and soft grip handles.

Hand Held Power Tools:

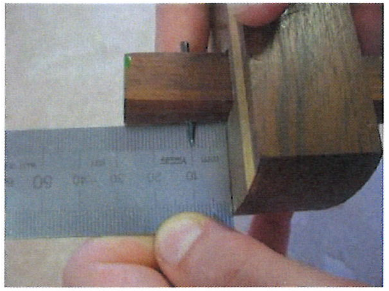
Jigsaw: can be used for making straight cuts or for curved shapes. There are various types of blades which are suitable for most cutting materials. Work must be held securely due to vibrations caused.

Palm Sander: Many have quick change facility for the abrasive pad which comes in various sizes and grades. Ergonomically designed to fit the users hand and often come with soft grip handles.

Router: with the help of a guide they can be used to produce slots, cut shapes following a template or to produce an edge decoration on wood. Can be mounted in a specialist table – like the one we have in the workshop.



Biscuit Jointer: provides an easy way of joining two pieces of wood together. Works by cutting crescent shaped slots into both items and then bringing the two pieces around a elliptical shaped piece of wood which creates a joint.



Marking Out: majority of marking out is completed by placing lines directly onto the surface of the material. Very important as makes work accurate and stops materials being wasted.

Marking Tools: Choice of marking tools is determined by the material.

Tool	Notes	Material
Pencil	Best tool to use on a variety of materials. Softer the pencil – the more easier it is rubbed out. The harder the pencil – the more accurate the lines.	Wood, Acrylic, paper, card
Chinograph pencil	Lines can be easily removed but lack crispness	Plastics
Marking knife	Make a small cut into the material and can give a clean edge when sawing or chiselling. Mistakes can be difficult to remove.	Wood, Card
Scriber	Used when a thin an accurate line is required. To help see the line they are used with engineers blue.	Metals
Spirit pen	Markers come in different thicknesses, Thin pens should be used where accuracy is required. Aluminium sheet is often marked out using a marker as it can be removed by solvents.	Plastics, Aluminium

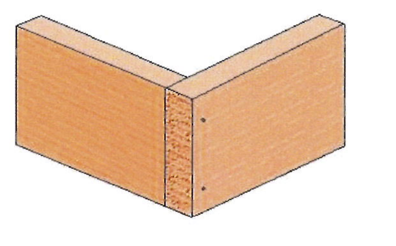
Straight Lines: placed onto materials will be parallel to, at an angel to, or square (90) to an edge.

Curves and Circles: Marking circles and curves accurately dependant on the tool you are using not moving or slipping on the surface.

Templates: and stencils are normally used to mark out odd or complex shapes, particularly if the process is to be repeated several times.

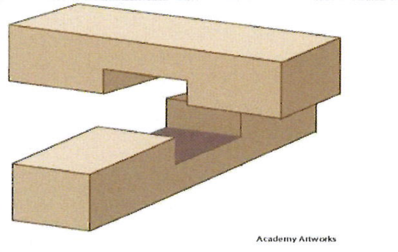
Tool for Making Straight Lines	**Notes**	**Material**
Ruler	Available in different lengths – have a zero end to measure easier.	Wood, Metal, Plastic, Card and Paper
Try Square	Used to mark right angles to an edge.	Wood, Plastic, Metal
Adjustable Bevel	Can mark lines at different angles	Wood, Plastic, Metal
Mitre Square	Used to measure 45 degrees angles	Wood, Plastic, Metal
Marking Gauge	Used to mark parallel lines on wood. Its is adjustable and used along the grain.	Wood
Odd-leg callipers	Similar function to a marking gauge	Metal, Plastic
Tool for Making Curves and Circles	**Notes**	**Material**
Spring Dividers	Used to make accurate circles and arcs	Metals, Plastics
Compass	Different versions allow a selection of pens and pencils to be used	Wood, Paper, Card, Plastics
Centre Punch	Used to make a dot for a drill to sit accurately into the material so it doesn't move on impact.	Metals and Some Plastics

Joining Wood:



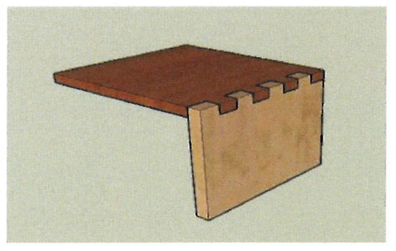
Butt joints:

The **butt joint** is a very simple joint to construct. Members are simply docked at the required angle (usually 90) and required length. One member will be shorter than the finished size by the thickness of the adjacent member.

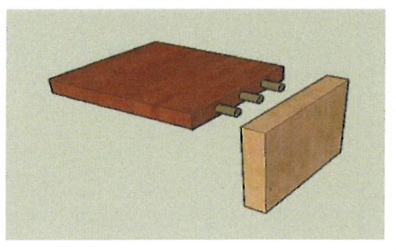


a **lap joint** is a technique for joining two pieces of material by overlapping them

A **mitre** joint sometimes shortened to mitre, is a joint made by sawing each of two parts to be joined, usually at a 45 angle, to form a corner, usually a 90 angle

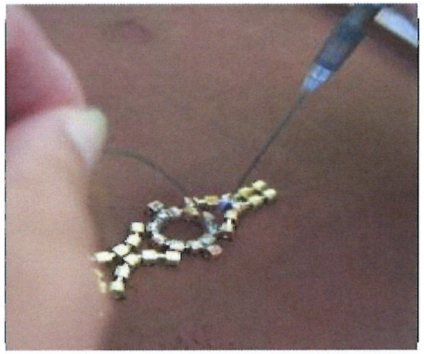


The **finger joint** (also known as a comb joint) is a woodworking joint made by cutting a set of complementary rectangular cuts in two pieces of wood, which are then glued.

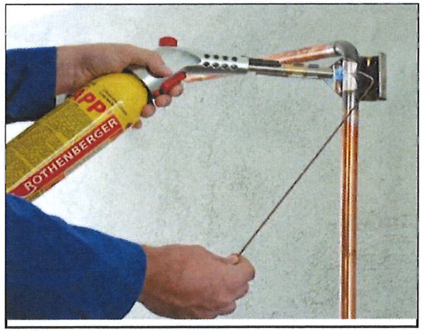


A **dowel** is a solid cylindrical rod, usually made of wood, plastic or metal.

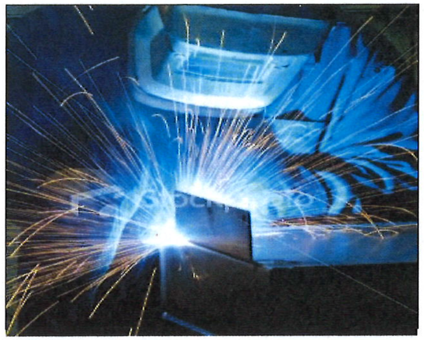
Joining Metals:



Soft Soldering: this is used as a quick method of joining copper, brass and tinplate when little strength is required in the join. It is also used for fixing electronic components into a circuit. The filler rod or solder melts at a relatively low temperature and traditionally was mixture of tin and lead but due to the health risks of using lead has now been replaced by an alloy of tin.



Hard Soldering: hard soldering, also know as silver soldering, uses a filler rod that is and alloy of silver mixed with copper and Zink and melts at temperatures between 600c to 800c this range of temperatures enables work to be joined in several stages with the highest melting point being used first through to the lowest melting point solder called 'easy-Flo' this prevents earlier joint coming apart when Appling heat for later joints .

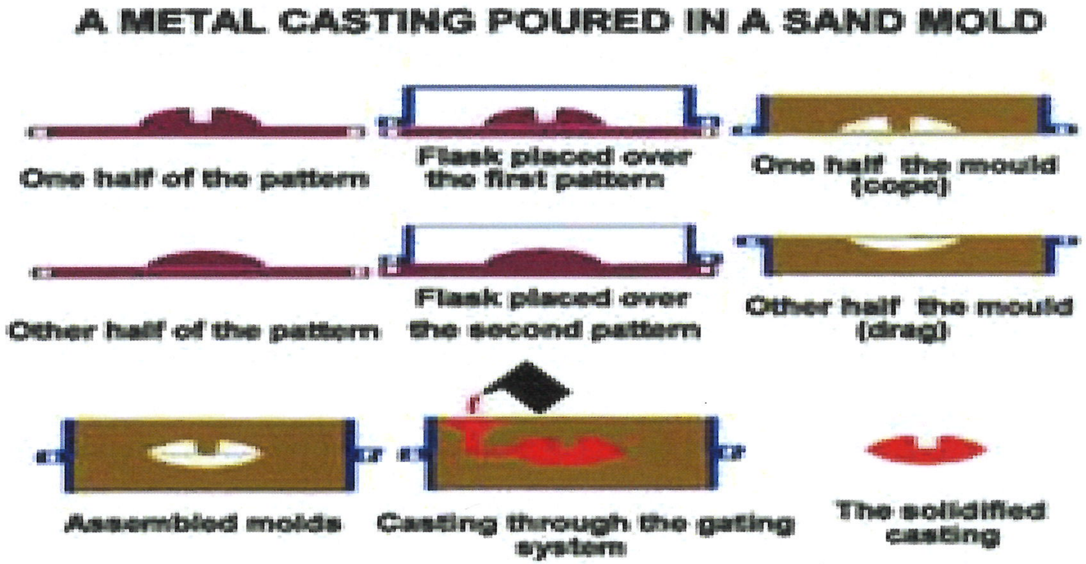


Welding: Welding is a process for joining similar metals. Welding joins metals by melting and fusing. Oxy-acetylene and electric arc. Both of these fuse steel together to produce a very strong joint oxy-acetylene welding sues acetylene burn in oxygen to produce a flame at approximately 2,500 c using the heat of the flame on the joining edges melts the metals and a filler rod is introduced to help fuse the materials together by melting into a pool that sets on cooling. In electric arc welding the heat required to melt the metals is provided by a current passing through a gap (arc) between the filler rod (electrode) and the metal. The electrode is coated in a flux to prevent the joint becoming oxidised

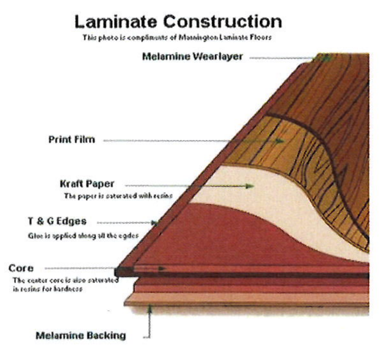
Casting is a process that involves pouring molten meta into a shaped mould. This is used to produce a range of shapes that would normally be difficult to make from a single piece of material. Plastics and concretes can be cast but is more suited to metals.

Aluminium Casting: Sand moulds are usually used to produce complex metal shaped castings. Wide variety of formers but usually flat backed – simplest and/or split pattern – complex shapes. **See stages Below**.

Pewter Casting: Alloy with a melting point that is low enough to melt in school. Moulds can be made out of MDF. Due to low melting point Pewter sets quickly too.

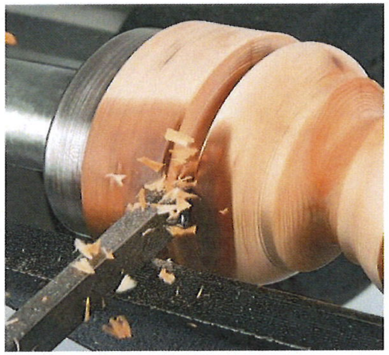


Forming Woods:



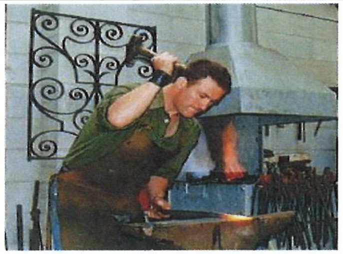
Laminating: Apart from creating a material that is often longer or thicker than what is available, laminating is used to produced shaped materials with improved properties – or to obtain shapes that cant be cut from one piece of material. Thin strips of wood are deformed and bent into curved shapes using a former and then they are glued together.

Formers: are used to produce laminated shapes. The surfaces of the former must be smooth and there must be an allowance for the thickness of the laminates. The former can be lined with rubber or cork to help with slight irregularities. The former would be help together with sash clamps until set.

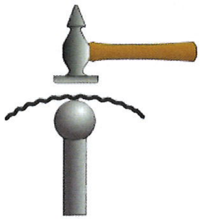


Wood Turning: Usually uses a lathe to create objects such as chair legs, bowls, lamps and patterns for either sand casting or vacuum forming.

Deforming Metals: Forming or forging shapes in metal is often considered to be both quicker and more economical than machining metals. Most are carried out hot to avoid the risk of work hardening and to ensure that they are easier to work into the required shape. Forging is a highly skilled process that has been used for centuries.

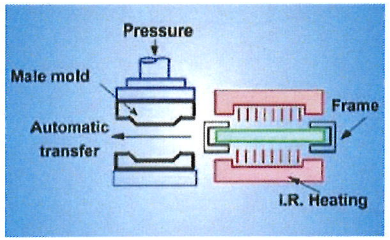


Hot Forming Metals: used to produce very strong components due to the structure of the material that is being refined. The most common metals that are hot formed are mild and tool steel. Process carried out with a hammer and anvil by hand.



Cold Forming Metals: Requires a material that has a high degree of malleability. Copper, brass and aluminium are usually used. Constant hammering causes work hardening and therefore needs regular annealing.

Cold Working Sheet Metals: using aluminium allow you to produce complex shapes such as cones, boxes and trays. Before starting your work you should practice with card to establish sizes, position of joining flaps and bend sequence.

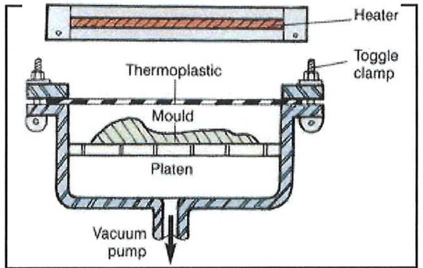


Press Forming: used to make strong everyday components such as car panels, components of an Ipod by pressing thin sheets of metal into a shell shape. Material is annealed and placed in a giant die with loads of pressure applied.

Moulding Plastic

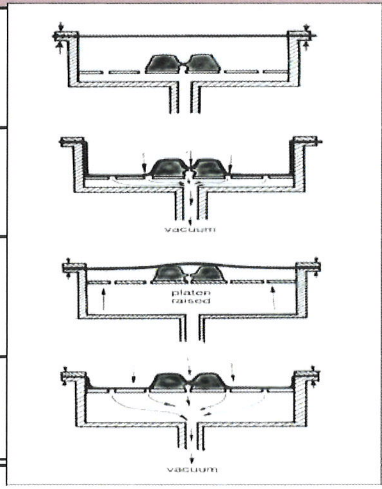
Vacuum Formed Products:

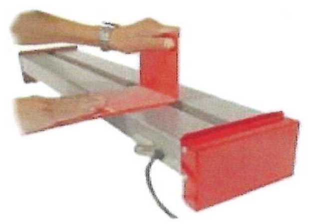
Most thermoplastics soften and become pliable at around 160 C, this makes it easy to mould into the required shape using fabrication techniques. There is no loss or gain when deforming plastics. Expensive moulds are used for large scale production.



Vacuum Forming:

This is a method of forming plastic that is common in schools used to produce trays, cartons, lids ect. This is used in batch or mass production to make food packaging within the packaging industry. It is done by heating a clamped sheet of thermoplastic until soft, ait is then extracted so that the plastic is sucked down forming a mould. The mould must be shaped so that it easily comes off it is then tapered so that it has a smooth finish and smoothed edges.

Description	Illustration
Mould is placed inside a machine where the plastic sheet is clamped to the top of the box using a toggle clamp. The heater is moved into position to heat the plastic until it softens.	
The heater is pushed back and the mould located on, the platten is then lifted into the hot plastic before the vacuum pump is turned on.	
The air between the mould and the softened thermoplastic is sucked out by the pump. The plastic will be forced down over the mould, creating a sharp definition.	
The sheet is unclamped from the frame and the mould is removed. Excess material around the moulding is trimmed off.	



Line Bending:

Simplest method of forming thermoplastics. A strip heater that has a narrow opening allows heat to escape in a restricted area. This then heats and softens the plastic in a concentrated line. Acrylic is popular within schools it can be line bent but must be heated carefully as it can be blistered from overheating and might snap as its bent. By using formers or jigs you can increase the accuracy of bending certain angles, they also help to hold work still as it cools..

Computer Aided Manufacture (CAM):

Vinyl Cutters: cut out complex shapes out of a variety of thin materials and are available in a range of sizes. Used to carry out work such as card modelling, packaging, and sigh writing. They work in 2D and are easy to set up.

CNC Milling Machine: produce a variety of 2D and 3D components – commonly in materials such as brass, steel and alloys. Materials are held in a small vice or with double sided tape.

CNC Lathe: accurately manufactures a wide range of complex turned components from steel, brass and alloys and also plastic materials. Good for producing quantities of identical pieces.

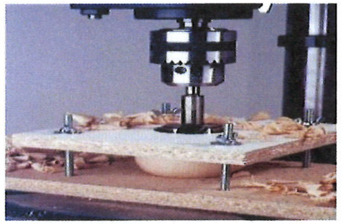
Laser Cutter: Used for cutting and engraving in schools on materials such as paper, wood and plastics. Very accurate and easy to operate. Quite expensive to buy and must have sufficient extraction.

3D Router: Used to accurately manufacture a range of 2D and 3D components in wood MDF, Foam and Plastics. Easy to set up and operate. Do require dust extraction to prevent fire and dust becoming air bourne.

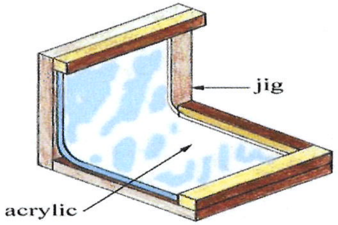
Quantity Production:
Dependant on demand

Level Of Production	Description	Example	Equipment and Tooling cost	Labour Costs	Skill Level	Production Costs	Efficiency
One - off	**Most hand made**	**A sculpture – your own work**	↓	↑	↑	↑	↓
Batch	**Jigs used to create small batches**	**Table , stools**					
Mass	**Specialist equipment and workers for high volume**	**Car, light bulbs, nuts, screws, plastic containers**					
Continuous	**Not many are continuous**	**Various food items, steel, petrol.**					

Scale of Production: Dependant on demand products are made in a range of quantities from large scale mass production (screws, light bulbs etc) to one off product (bespoke furniture etc) Each level has advantages and disadvantages.



Drilling Jig: When a number of holes in identical places / components a drilling jig saves time and increases accuracy. The number of repeated operations determines what material that the jig will be made from.



Bending Jig: used to make bends in a number of materials to improve accuracy and speed of operation. The material being bent and the temperature will determine the material the jig will be made from.

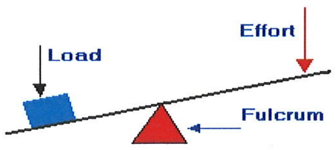
Templates: These should be easy and simple to use and can be made from paper, card or sheet materials. It should save time and be made from a material that is hard enough for repeated use.

Vacuum Forming Mould: can be made from a wide variety of materials that are resistant from a low heat and provide a required level of surface finish (wood, card, clay) Complex shapes must taper slightly for ease of removal.

Mechanical Systems are a vital part of our everyday lives. The spoon that you ate your cereal with this morning is a very simple example of a mechanical component. The bus that may have brought you to school is an example of a very complex mechanical system.

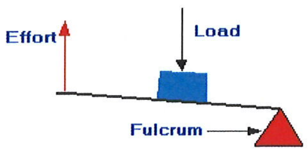
Levers:

A lever is a bar that can be used to provide mechanical advantage. Levers are classified depending upon where the pivot point is placed. This also affects how the lever works.



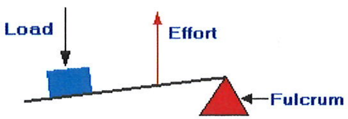
Class 1 Lever

First Class Lever: The pivot is placed between the effort and the load. The further the effort is away from the pivot point the greater the mechanical advantage.
E.g.. See saw



Class 2 Lever

Second Class Lever: The pivot point is placed at one end of the lever and the effort is at the other, leaving the load in the middle.
E.g. A wheelbarrow – the longer the handles the easier to use



Class 3 Lever

Third Class Lever: The pivot point is placed at one end of the lever and the load is at the other leaving the effort in the middle.
E.g. A spade.

Systems and Control

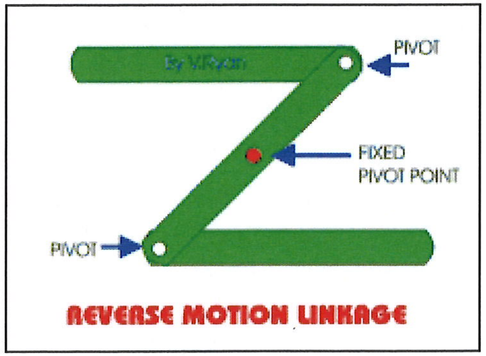
Mechanical Systems

Mechanical System: An assembly of mechanical components that form a machine

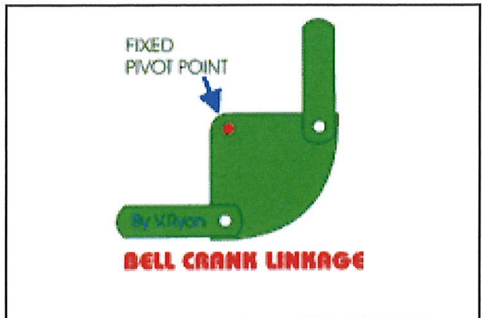
Mechanical Component: A mechanical part of a larger system or product.

Mechanical Advantage: The way in which a machine makes things physically easier to do,

Linkages:
A linkage consists of a number of levers connected together to form a mechanical system.



Reverse motion linkage:
When the top lever is pulled to the left the bottom lever is pushed to the right. The direction is reversed.

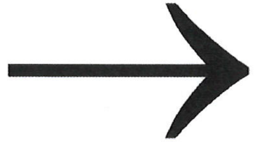


Bell crank linkage:
When the bottom lever is pulled to the left the top lever moved down. The direction has been turned through 90 degrees.

Types of motion:

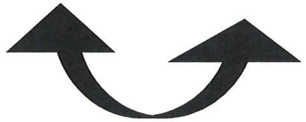
Rotary Motion: Easiest to understand – Moving in a circle like a wheel of a bike.

Linear Motion: When a component is moving in a straight line – Like a train on a track.

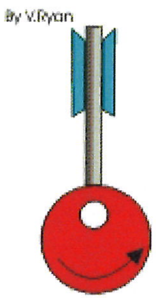


Reciprocating Motion: When a component is moving backwards and forward in a straight line – think about a blade on a fret saw or jigsaw.

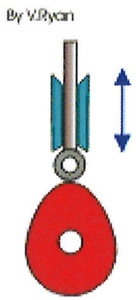
Oscillating Motion: When a component is moving backwards and forwards in an arc. Think about a swinging pendulum on a grandfather clock.



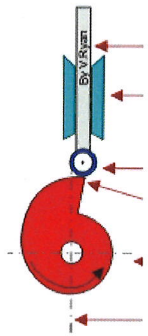
Cams: A shaped disc that rotates on a shaft. As it moves a follower moves up and down responding to the shape of the cam.



Circular Cam



Pear Cam



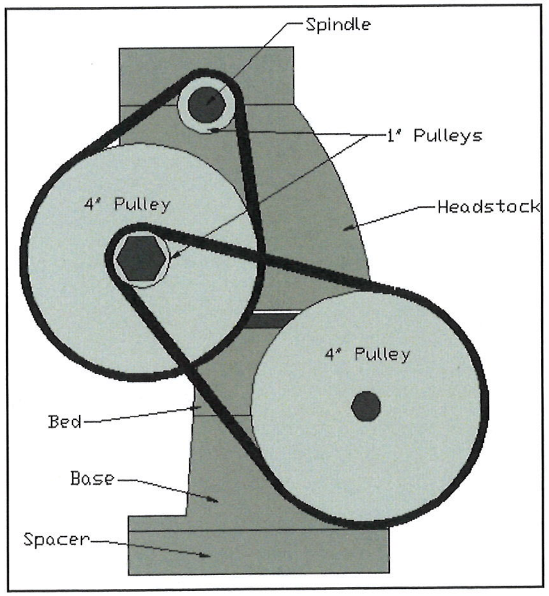
Snail Cam

Transferring power and movement

Is very common in many mechanical systems. Electric motors generate rotary motion and this movement needs to be controlled and transferred to where it is required.

Belt and Pulley System: transfers rotary motion from one shaft to another. A pillar drill will have a belt and pulley system. Using different sized pulleys you can alter the speed that the shafts rotate. Small pulley driving a large pulley will decrease the speed.

Chain and Sprocket system: is another method of transferring rotary motion from one shaft to another. A bicycle has a chain and sprocket system. Using different sized sprockets you can alter the speed. They are more expensive than belt and pulleys but can transfer greater amounts of force and more reliable,



Belt and Pulley System

Chain and Sprocket System