

### Working properties

A working property describe how a material responds to use in a certain environment or in a certain way.

#### Strength

The ability of a material to withstand a force such as pressure, tension or shear without breaking.



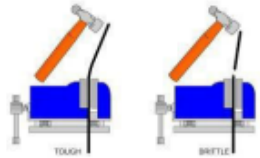
#### Hardness

The ability to resist abrasive wear and indentation through impact.



#### Toughness

The ability to absorb energy through shock without fracturing (break or snap).



#### Malleability

The ability to deform under compression without cracking, splitting or tearing.



#### Ductility

The ability to be stretched out or drawn into a thin strand without snapping.



#### Elasticity

The ability to return to its original shape after being compressed or stretched.



### Key Questions

- Why is it important to consider the working and physical properties when selecting materials?
- List the common working properties of natural timbers and manufactured boards.
- List the common working properties of metals and alloys.
- List the common working properties of papers and boards.
- List the common working properties of polymers
- List the common working properties of textile based materials.
- As you need to know these properties, come up with an mnemonic to help memorise the properties.

When selecting materials for making into a product or prototype it is essential to know how those materials will react and cope in different conditions.

The physical and working properties on this page need to be considered so the correct selection is made.

The physical and working properties of materials can often be adapted and modified using different processes and techniques.

### Physical properties

A physical property is an inherent property of a material.

#### Absorbency

The tendency to attract or take on an element, usually a liquid such as water or moisture, but could include light or heat.



#### Density

The mass of material per unit of volume; how compact a material is.

Formula:  $Density = mass/volume$



#### Fusibility

The ability of a material to be converted through heat into a liquid state and combined with another material before cooling as one material.



#### Electrical conductivity


The ability to conduct electricity.




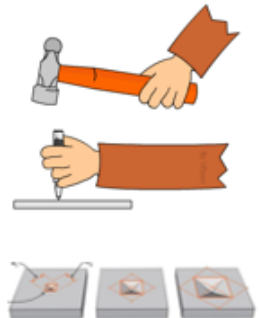
**Thermal conductivity** The ability of a material to conduct heat.

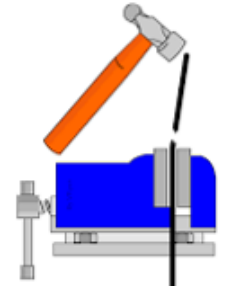


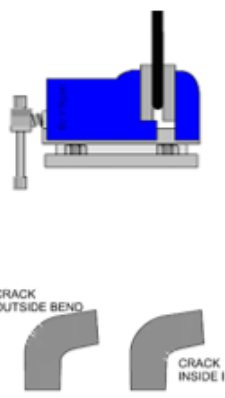
## Year 12 Knowledge organiser— Material testing

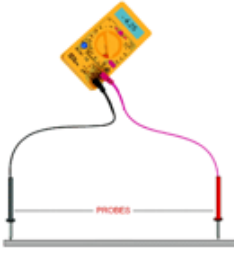
Testing Type	Diagram
<p><b>Tensile Strength</b> (Ability to resist stretching/pulling forces)</p>	
<p>Samples of the material are clamped from the top and weights added to the bottom. The less stretch the more tensile strength the material has. This can be checked using ruler.</p>	


Testing Type	Diagram
<p><b>Thermal Conductivity</b> (How easily heat passes through a material)</p>	
<p>Light a Bunsen burner under one side of the material and place a thermometer at the other. Record, with a timer, how long it takes for the material to reach a set temperature. The shorter the time the more conductive it is</p>	

Testing Type	Diagram
<p><b>Hardness</b> (Ability to resist abrasive wear, indentation and scratching)</p>	
<p>A material is placed on a flat surface and a dot/centre punched is hit with a hammer on top of it. The bigger the indent the less hard it is.</p>	

Testing Type	Diagram
<p><b>Toughness</b> (Ability to resist impact force without fracturing)</p>	
<p>A material is placed in a vice and hit with a hammer. The tougher a material is, the less damage it will show. If the material snaps or breaks it is more brittle.</p>	

Testing Type	Diagram
<p><b>Malleability and Ductility</b> (to be able to withstand deformation and being drawn out without cracking)</p>	
<p>A material is placed in a vice and bent to 90 degrees. If the outside cracks it shows a lack of ductility. If the inside cracks it indicates a lack of malleability</p>	

Testing Type	Diagram
<p><b>Electrical Conductivity</b> (How easily the flow of electrical current passes through a material)</p>	
<p>Probes are places on material, and the distance between them measured. Then the resistance is measured with a multimeter. The higher the resistance the lower the conductivity</p>	

Testing Type	Diagram
<p><b>Corrosion Testing</b> (How well a material can resist corrosion)</p>	
<p>Materials are placed in an outside area, exposed to weather for a certain amount of time. Then visually inspected for corrosion</p>	

### Common papers

Paper is measured in GSM.

Papers	Characteristics	Uses
Bleed proof	70gsm sheet, coated to stop solvent-based markers staining through the page. Deeper colours are achieved as ink stays on the surface.	Used with marker pens for design ideas and final designs.
Cartridge	120-150gsm, completely opaque and more expensive than photocopier paper.	Pencil and ink drawings, sketching and watercolour.
Grid	Usually printed onto 80gsm paper with faint lines often in light blue ink. Lines can be printed darker for use under plain paper as a drawing guide.	Used for graphical, scientific and mathematical diagrams, particularly in conjunction with a lightbox as a drawing guide.
Layout	40-60gsm, semi-translucent, takes pencil and most media well. Some inks can smear heavily coated papers.	Creating sketches and working ideas: copying and tracing images with a variety of media.
Tracing	40-120gsm, translucent, takes pencil and most colour well.	Copying and tracing images. Used with a lightbox, overlays for design adaptations and working drawings.

### Key Questions

- What are papers and boards made out of?
- What does gsm stand for?
- When does a paper become a board?
- If an A4 piece of cartridge paper (120gsm) is 210mm x 297mm what would be the weight of 10 sheets in grams.
- Suggest a paper or board for the following activities:
  - Artist drawing a portrait in charcoal.
  - Creating the walls for an architectural model.
  - Planning the dimensional layout for a scale model of a building.

Papers and boards are usually made from wood pulp and converted to their finished forms at a paper mill.

Other cellulose sources can include textiles such as cotton, where the resulting paper (known as rag paper) can be a very high quality and can last many hundreds of years.

### Common boards

Board thickness is usually quoted in microns or GSM. 1000 microns is equal to 1mm of thickness. The lower the number, the thinner the paper or card.

Boards	Properties	Uses
Corrugated card	1000-5000 microns, strong, lightweight and rigid perpendicular to corrugations. Insulative and easily printed on.	Packaging, boxes and impact protection.
Duplex	200-500gsm, stiff, lightweight, coatings to improve functionality.	Cheaper version of white card used for packaging boxes. Often given a waxy coating and used for food and drinks containers.
Foil lined	200-400 gsm, stiff, foil reflects heat and a water and oil resistant coating enables food and liquid based products to be contained.	Takeaway containers and lids, used to retain heat for longer.
Foam core	3-10mm thick, lightweight and rigid in all directions. Can crease and crack under pressure, expanded polystyrene centre.	Architectural models, model making, prototyping, mounting and framing photographs.
Inkjet card	120-350gsm, medium to thick card treated to hold a high quality photo image. Ink dries on the surface to create deeper colours.	High quality photographic images.
Solid white	200-500gsm, stiff board, holds colour well, easily cut or creased.	Greeting cards, packaging, advertising, hot foil stamping and embossing.

### Key Questions

- What categories are natural woods put into?
- Define the two categories of natural wood.
- What type of tree does a softwood come from? Scientific name
- What type of tree does a hardwood come from? Scientific name
- Define the term manufactured boards.
- What is meant by the term felling?
- How are trees felled today compared to past times?
- What does FSC stand for? Why is this good for manufacturers when giving information to users?

### Softwoods

- Softwood generally has a more porous cell structure than hardwood. If left unprotected from the elements, it can absorb moisture and begin to rot, although some softwoods such as cedar, contain natural oils which protect them and make the suitable for exterior use.
- Softwood is not available in as many colours as hardwood, however, it is easy to add a stain and it is frequently coloured to look like more expensive hardwoods.
- Softwood is relatively cheap and readily available.
- It's the most sustainable wood owing to its faster growth rate and is widely planted.

Softwood	Characteristics	Uses
Larch	Durable, tough, good water resistant, good surface finish, machines well. Issues with loose knots	Exterior cladding, flooring, machined mouldings, furniture and joinery
Pine	Lightweight, easy to work, can split, and be resinous near knots.	Interior construction, cheaper furniture, decking.
Spruce	Easy to work, high stiffness to weight ratio. Variable results when staining.	Construction, furniture, musical instrument.

### Hardwoods

- Hardwoods generally have a less porous and denser cell structure than softwoods. This makes many varieties harder wearing and less prone to rotting.
- Hardwood comes in a variety of colours and has many sought-after aesthetic and physical properties.
- As the value of hardwood is so high, there is much illegal felling of trees, especially in rainforest areas.

Hardwood	Characteristics	Uses
Oak	Tough, hard, and durable, high quality finish possible.	Flooring, furniture, railway sleepers, veneers.
Mahogany	Easily worked, durable and finishes well.	High end furniture, joinery, veneers.
Beech	Fine finish, tough and durable	Children's toys and models, furniture, veneers.
Ash	Flexible, tough and shock resistant, laminate well.	Sports equipment, tool handles
Balsa	Very soft and spongy, very lightweight but can snap in thin sections.	Prototyping and modelling.

### Manufactured boards

- Manufactured boards are usually sheets of processed natural timber waste products or veneers combined with adhesives.
- They are made from waste wood, low-grade timber and recycled timber.

Manufacture d board	Properties	Uses
MDF	Rigid and stable, good value with a smooth, easy to finish surface. Very absorbent, so not good in high humidity or damp areas.	Flat pack furniture, toys, kitchen units and internal construction.
Plywood	Very stable in all directions due to alternate layering at 90°, with outside layers running in the same direction. Thin flexible versions available (flexiply)	Furniture, shelving, toys and construction.
Chipboard	Good compressive strength, not water resistant unless treated, good value but prone to chipping on edges and corners.	Flooring, low-end furniture, kitchen worktops and units.

## Ferrous metals

This group of metals all contain iron (ferrite). A way to remember that ferrous metals contain iron, is that the chemical symbol for iron is Fe. Most ferrous metals are magnetic and will rust if exposed to moisture without a protective finish.

Ferrous	Characteristics	Uses
Low carbon steel	Tough and ductile, easily machined, formed, brazed or welded.	Construction girders, screws, nails, nuts and bolts. Many car bodies and bike frames.
High carbon steel	Less ductile and harder than mild steel due to higher carbon content. Very hard wearing and keeps an edge well.	Garden or workshop tools, blades, scissors, wood and metal cutting tools.
Cast iron	Hard but brittle in thin sections. Easily cast into complex shapes, but some types are hard to machine.	Kitchen pots and pans, machine bases and bodies, vices, manhole covers, post boxes.

## Key Questions

- How do metals impact the environment?
- Define the term galvanise.
- Define the term oxidise.
- Create a moodboard of different products made from ferrous metals.
- Create a moodboard of different products made from non-ferrous metals.
- Create a moodboard of different products made from alloys.
- Explain the steps of separating the metal from an ore using a furnace.
- What is electrolysis?

## Non-ferrous metals

This group of pure metals is generally not magnetic and does not contain iron. Non-ferrous metals do not rust, but they can oxidise.

Non-ferrous	Characteristics	Uses
Aluminium	Lightweight, high strength to weight ratio, ductile but can be difficult to weld.	Pots and pans, sports car body panels, bike frames, drinks cans, foil or takeaway trays.
Copper	Ductile, malleable and a good electrical conductor that is easily joined by soldering.	Plumbing supplies, electrical cables, bespoke roofing and guttering.
Tin	Soft, malleable and ductile; a good electrical conductor.	Can production - used for plating surfaces to preserve contents, soft solder, alloyed with copper to form bronze
Zinc	Fair electrical conductivity, malleability, and ductility; however, all are improved when alloyed.	Mainly use to galvanise steel to prevent rusting, easily die cast or used in alloys.

## Where are metals from?

- Metals are resistant materials and are found in the earth's crust. Some pure metals are mined as a whole metal but many are extracted from an ore.
- The ore is obtained through mining, then the metal is often extracted from the ore using large furnaces.
- The extreme heat of the furnace separates the metal from the ore and it's drawn off as a molten liquid and processed into metals that we commonly use.
- Aluminium ore in the form of bauxite is crushed and the aluminium is extracted via the process of electrolysis.

## Alloys

Alloys are a mixture of at least one pure metal and another element. The alloying process combines the metals and other elements in such a way as to improve the working properties or aesthetics.

	Characteristics	Uses
Brass	A heavy alloy of copper and zinc that is malleable, easy to cast and machine, and has naturally low friction	Musical instruments, bushes, plumbing fittings, ornate artefacts and hardware.
Stainless steel	A ferrous alloy with chromium, nickel and manganese. Hard, very smooth but difficult to weld.	Cutlery, kitchen and medical equipment.
High speed steel	Able to withstand the high temperatures created when machining at high speed, keep its cutting edge well.	Cutting tools such as drill bits, mill cutters, taps and dies.

## Thermoforming plastics

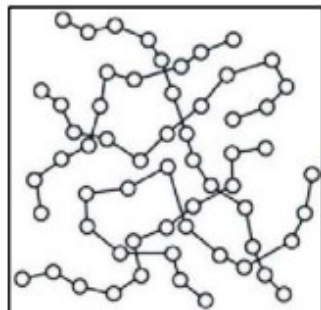
This group, known as thermoplastics, is generally more flexible, especially when heated. They can be formed into complex shapes and many can be reformed multiple times.

Plastic	Characteristics	Uses
PETE	Dimensionally stable, easily blow moulded, chemically resistant and fully recyclable	Bottles, food packaging, sheeting and some food wraps.
HDPE	Lightweight, rip and chemical resistant, premium price paid when recycled.	Milk bottles, pipes, storage crates, hard hats and wheelie bins.
PVC	Flexible, high plasticity, chemically resistant, tough and easily extruded.	Raincoats, pipes, electrical tape, air mattresses and self-adhesive vinyl.
LDPE	Very flexible and tough with a high strength to weight ratio. It is blow mouldable and easily extruded into rolls of film.	Plastic carrier bags, refuse sacks, piping, bottles and some plastic food wraps.
PP	Flexible, tough, lightweight, chemically resistant, easily cleaned and safe with food.	Kitchen, medical and stationery products, rope.
PS	Flexible, impact resistant, can be food safe, sheet used for vacuum forming. Very toxic when burnt.	Vacuum-formed products such as food containers or yoghurt pots.
Acrylic	Tough but brittle when thin. Easily scratched, formed and bonded. Common in school workshops with laser cutting and line bending.	Car lights, display stands, trophies, table tops, modern baths, jumpers, hats and gloves.

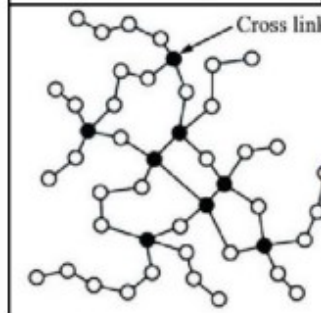
## Key Questions

- How is plastic obtained?
- What impact does plastic have on the environment (from the birth of the product to its death).
- What molecular property allows thermoplastics to have more flexibility when heated?
- Create a moodboard of different products made from thermoforming plastics.
- Create a moodboard of different products made from thermosetting plastics.

## Structure of polymers.



Thermofforming polymer



Thermosetting polymer

## Thermosetting plastics

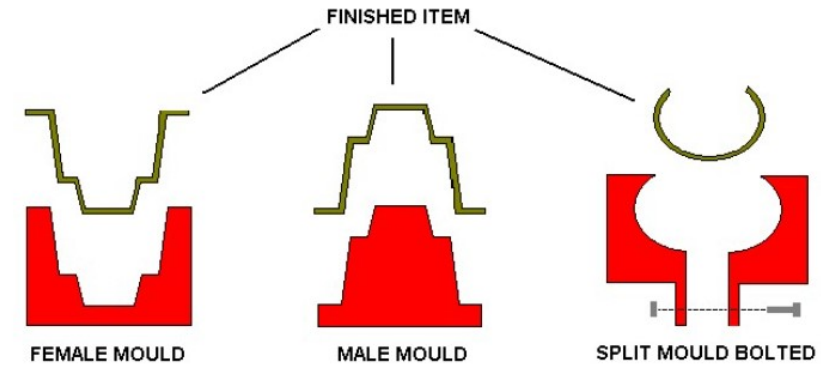
Thermosetting plastics or thermosets are more rigid and, as the name suggests, once they are formed or 'set' they cannot be reformed. They are generally harder and more brittle than thermoplastics.

Plastic	Characteristics	Uses
Epoxy resin	Stronger than other resins, better strength to weight ratio, expensive, heat resistant, and a good electrical insulator. High VOCs when curing.	Bonding different materials together, electronic circuit boards, waterproof coatings, used in fibreglass and carbon fibre lamination.
Melamine formaldehyde	Food safe and hygienic, lightweight, hard, brittle but not microwave safe.	Kitchenware and heat resistant surfaces bonded to worktops and glat packed furniture.
Urea formaldehyde	Heat resistant, very good electrical insulator, hard, brittle, easily injection moulded.	Electrical fittings, casings, buttons and handles. Also used as an adhesive or to treat fabrics to enhance easy-care properties.
Polyester resin	Reasonably strong, heat resistant and a good electrical insulator. High VOCs when curing.	Encapsulation of artefacts, waterproof coatings, flooring, used in the lamination of fibreglass.
Phenol formaldehyde	Formerly known as and early plastic called Bakelite, very rigid, hard and brittle,. An excellent electrical insulator with good chemical resistance.	Electrical components, mechanical parts, casting resin, old bakelite style household artefacts such as clocks, telephones and radios.

# Year 12 Knowledge organiser— Classification of materials 1.1 COMPOSITES

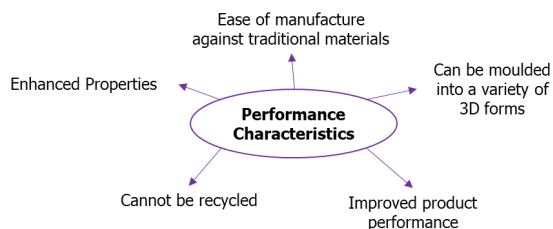
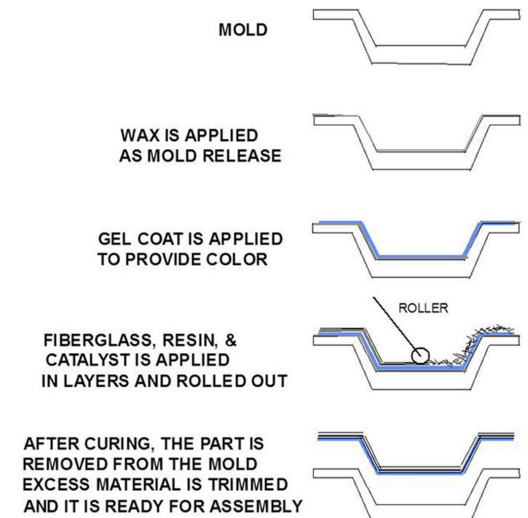
**Composite Materials** are a mix of two or more different materials, making a material with enhanced properties

Name	Key info	Uses/ Examples
CFRP	Lightweight, corrosion resistant and good compressive strength	Sports equipment, racing car bodies and prosthetics
GRP	Lightweight, corrosion resistant, tough and good compressive strength	Boat hulls, kayak shells and sports car bodies
Tungsten Carbide	Hard, tough and resistant to high temperatures	Cutting tools and kitchen knives
Aluminium Composite Board	Lightweight, rigid, malleable and sound insulation	Sound-proofing panels in cars, buildings and boats
Concrete	High compression strength, low tensile strength and easy to mould	Pathways, driveways and building foundations
Reinforced Concrete	High compressive and tensile strength, fire resistant	Buildings, retaining walls
Fibre Cement	Lighter than reinforced concrete, hard, tough and good at low temps	Pathways, complex geometric shapes and suspended floors
Engineered Wood	Good aesthetics, lighter than concrete alternatives and fire resistant	Beams, bridges, decking and room beams



### Key facts:

- Glass is spun to create a fibre that is then coated and bonded with epoxy resin.
- Glass fibres are brittle, but when mixed with polyester resin it becomes tough and hard.
- A mould is required for GRP (can be made from wood, plastic etc)
- The GRP is often sprayed onto a mould and rolled to form the shape.



Composites can be

- Fibre based (CFRP, GRP, Fibre concrete)
- Particle based (tungsten carbide, concrete)
- Sheet based (aluminium, composite board, engineered wood, e.g. glulam)

### Key Questions

- Why have composites come about?
- Explain why reinforced concrete improves the compressive strength of concrete.
- Explain the make up of a cermet
- Why are composites negative for the environment?

**Smart Materials** change in response to external stimuli e.g. light, heat, moisture, etc

Name	Key info	Uses/ Examples
<b>SMA</b> s	Returns to its original shape, in reaction to heat	Braces and glasses
<b>Thermochromic Pigment</b>	Change colour in reaction to heat	Kettles, baby bottles, etc
<b>Phosphorescent Pigment</b>	Absorbs light during the day and 're-emits' it when dark	Exit signs, 'glow in the dark' products
<b>Photochromic Pigment</b>	Change colour in reaction to light	Colour changing glasses, windows, etc
<b>Electroluminescent Wire</b>	Thin copper wire in a phosphorescent material, that glows in response to an alternating current	Glow bracelets, outdoor decorative lighting
<b>Piezoelectrical Material</b>	Gives off a small electric charge when deformed.	Airbag sensors, musical greetings cards and pressure sensors

**Piezoelectric** materials have the ability to generate an electrical charge.

- A mechanical stress is applied to the smart material.
- This causes a small electrical charge to be generated.
- In return, the shape of the solid changes by a small amount.



### Key Questions

- Give an application for Smart memory Alloy and QTC
- Find other examples of piezoelectric materials
- What is 'Smart grease'?

A car's cigarette lighter is a good example of how piezoelectric materials are used in a every day application.

### Thermochromic Pigment

They have many use, for example:

- Plastic strips used as thermometers that are applied to children's foreheads.
- Colour indicators on drinks cans to show whether the contents cold enough to drink.
- Baby spoons that change colour when the food is too hot; these are a safety feature to ensure the child's food is a safe temperature.



### SMAs

- A response to a change in temperature is needed (for example, in fire alarm systems or controllers for hot water valves in showers).
- A damaged product needs to be repaired (for example, if someone bends a glasses frame, it can be returned to its original shape by being heated).

1A.

ORIGINAL WIRE SHAPE

1B.

TWISTED SMA WIRE, HEATED ABOVE 90 DEGREES

1C.

RETURNS TO ORIGINAL SHAPE





## Technical Textiles

Technical textiles are textile materials and products that are manufactured for their technical and performance properties rather than their aesthetic characteristics.



**Conductive fabrics** have either conductive fibres woven into them or conductive powders impregnated into them. They have been built into competitors' jackets for fencing contests. As the sword strikes a panel, it records this, as the metal of the sword has touched the pad with the conductive fabric in it.



**Microfibre** is a very thin synthetic material and is often used for outdoor clothing and sportswear. It is because it's breathable, durable, crease resistant and easy to care for.



**Fire-resistant fabrics** are used on items such as firefighters suits and children's clothing. Nomex is a brand name for fire-resistant fabric made from a polymer called meta-aramid. Nomex thickens when heated, therefore increasing protection.



**Kevlar** is formed by combining terephthaloyl chloride and para-phenylenediamine. These threads woven together create an incredibly strong material. Examples are bulletproof vests.

**Gore-Tex** has been designed to be a waterproof yet breathable textile. It is used in clothing to provide a waterproof product that also releases perspiration vapour, and therefore is comfortable to wear than traditional waterproof materials.



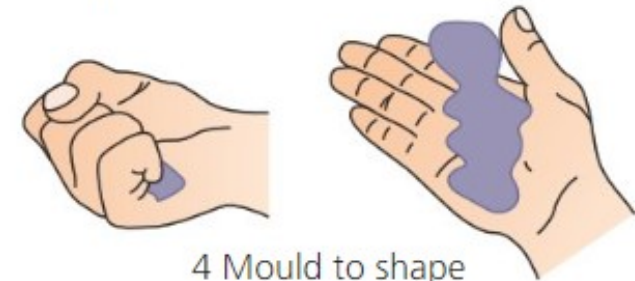
Modern materials are developed through the invention of new or improved processes, for example as a result of man made materials or human intervention.



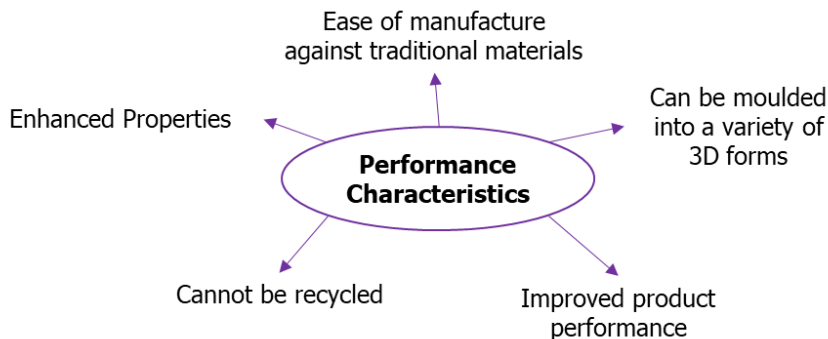
1 Granules of polymorph

2 Add hot water

3 Lift out of water when soft



4 Mould to shape



## Polymorph

Granules which become mouldable at 60 °

Can be heated in water or with a hairdryer. Solidifies at room temperature. Also available in liquid form. Liquid at room temperature and solid at 2 °. Useful for modelling, shaping ergonomic handles,

Plastic Enhancements	
Additive	Purpose
<b>Lubricants</b>	Reduces the viscosity of molten polymers, making them less "sticky". This allows the moulding temp to be lowered, saving energy
<b>Thermal Antioxidants</b>	Prevents the polymer oxidising or discolouring from excessive heat during processing
<b>Pigments</b>	Mixed with the molten polymer to give it colour
<b>Anti-statics</b>	Reduces the likelihood of the polymer building up static charge
<b>Flame Retardants</b>	Reduces the likelihood of combustion or the spread of fire
<b>Plasticisers</b>	Allows polymers to become less hard and brittle at normal temperature use. Also help polymers form more easily at higher temperatures
<b>Fillers</b>	Used to 'bulk' out the polymer, meaning less is required. Some fillers can help increase the thermal conductivity of the polymer
<b>Biodegradable Plasticisers</b>	Makes the polymer more flexible, softer and easier to break down
<b>Bio-Patch Additives</b>	Oxy-degradable, photodegradable and hydro-degradable additives help reduce degradation time
<b>Antioxidants</b>	Helps reduce deterioration of the polymer when exposed to oxygen. Helps prevent brittleness, cracks and discolouration.
<b>UV Light Stabilisers</b>	Prevents the polymer from being broken down by sunlight. UV can cause discolouration and brittleness.

Wood Enhancements	
Method	Purpose
<b>Resins and Laminations</b>	Used in engineering wood to enhance the properties of useful parts of trees. E.g. Chipboard made from compressing wood chips with resin and then laminated
<b>Resin with fire retardants</b>	Resin is impregnated with fire-retardant cladding
<b>Laminations</b>	Veneers are laminated on to the board surface to enhance the aesthetics
<b>Preservatives</b>	Protects woods from fungal and insects
<b>Pigments</b>	Added to preservatives to give different coloured shades to enhance aesthetics
<b>Fire-retardant Preservatives</b>	Use to pressure treat wood. This can make it harder and more resistant to high-wear situations
<b>Modified Natural Polysaccharide</b>	Wood is impregnated to cure within the wood cell structure. Used to increase hardness, toughness and stability
<b>SCL and LVL</b>	Layering strands (SCL) or veneers (LVL) of wood with resin, pressing and heat curing them to produce a stable wood billet

Metal Enhancements		
Heat Treatment	Purpose	Diagram
<b>Work Hardening</b>	'Cold Working' e.g. bending, hammering or rolling. Crystals in the metals are distorted and changed. Leading to improved tensile strength and hardness. However, can become less ductile. Effects can be removed by annealing	
<b>Annealing</b>	Metal is heated and then cooled very slowly, allowing the metal crystals to grow and slowly move into place. This is to make work-hardened metal easier to work with by making it less brittle and more ductile	
<b>Case Hardening</b>	Used for hardening the surface of steels. This produces an outer casing of hardness, improved wear and resistance to indentation. While the core keeps the "softer" properties.	

Wasting Process	Diagram
<b>Die Cutting and Creasing</b>	
Steel cutting dies and creasing rules are used to cut out the net shape.	

Shaping Process	Diagram
<b>Bending</b>	
Sheets of paper are placed onto a folding table. Then bent to the desired angle	

Wasting Process	Diagram
<b>Laser cutting</b>	
A laser is used to cut and engrave into the sheet material. This is often a more quick and accurate process than manual methods, and ideal for one-off and batch production	

Adhesive Name	Description
PVA Glue	Water-based adhesive for attaching wood to wood. Not water-proof
Contact Adhesive	Used for bonding large areas and can be used attaching different materials together e.g. plastics to woods, etc
UV Hardening Adhesive	A clear liquid that "cures" when exposed to UV light. Can be used on metal, glass and plastics
Solvent Cement	Commonly known as dichloromethane and can join polymers to each other. It softens the polymers' surface, making it easier to fuse together
Epoxy Resin	Comes in two parts; a resin and a hardener. One combined, the mix can join different materials together and must be left to "set"
Jigs and Fixtures	These are used to ensure parts or components are made the same when made repeatedly. A Jig holds and guides a tool, and a fixture holds work in place.

Addition Process	Diagram
<b>Traditional Wood Joining</b>	
Different joints are used for purposes, and generally the larger the gluing contact area, the stronger the joint.	

Addition Process	Diagram
<b>Component Jointing</b>	
Knock-down fittings are commonly used for flat-pack furniture. Standard components can also be used e.g., wood screws, coach bolts, etc	

Forming Process	Diagram
<b>Milling</b>	
Can be done using CNC or by hand but uses high speed bits to cut holes and/or channels in wood blocks	

Forming Process	Diagram
<b>Turning</b>	
Turning is done on a wood lathe. The wood is spun at high speed, while either a worker with manual tools or automated tools, cut into the wood to shape it.	

Forming Process	Diagram
<b>Steam Bending</b>	
Heat and steam makes wood strips pliable and can be shaped. Then it is clamped in place and left to dry.	

Forming Process	Diagram
<b>Routering</b>	
Can be CNC or hand controlled. Can be used to make channels, holes, mouldings, etc	

Forming Process	Diagram
<b>Lamination</b>	
Wood veneers or thin man-made boards are bend over a former/jig and glued together. When dried reveals a layered, shaped, sheet	

# Year 12 Knowledge organiser— Forming, redistribution and addition processes METALS



Shaping Process	Diagram
<b>Press Forming</b>	
Shapes sheet metals in 3D forms using a punch. Suitable for mass production	

Shaping Process	Diagram
<b>Rolling</b>	
Can be done hot or cold. Metal is made thinner by the rollers used.	

Addition Process	Diagram
<b>Welding</b>	
Comes in many variations; MIG, TIG, Spot and Oxy-Acetylene. Often pairing high heat with a "fillerrod" to join metals together.	

Shaping Process	Diagram
<b>Spinning</b>	
Turns sheet metal into curved 3D forms by spinning at high speed and shaped using a roller over a mandrel. Suitable for mass or batch production	

Redistribution Process	Diagram
<b>Pressure Die Casting</b>	
Molten metal is stored in a chamber then shot into a die. Used for batch and mass production	

Addition Process	Diagram
<b>Soldering</b>	
Metals solder to join components to PCBs. Can also be used in jewellery making.	

Forming Process	Diagram
<b>Bending</b>	
Sheet metal is bent into shape by a punch. Can be used for small-scale in schools and for mass production in industry.	

Forming Process	Diagram
<b>Cupping and Deep Drawing</b>	
Sheet metal blank is stretched into shape by the punch. Used in mass or continuous production	

Redistribution Process	Diagram
<b>Sand Casting</b>	
Molten metal is poured into a cavity in the sand and cooled. Suitable for one-off production and batch production	

Shaping Process	Diagram
<b>Vacuum Forming</b>	
<p>Heats sheets of thermoplastics around moulds. Moulds need draft angles, air holes and rounded corners to work. Ideal for batch and mass production</p>	

Shaping Process	Diagram
<b>Injection Moulding</b>	
<p>Complex 3D shapes are made quickly for mass or continuous production. Tooling and set-up costs are high</p>	

Shaping Process	Diagram
<b>Extrusion</b>	
<p>Follows same process as injection moulding, but melted polymer goes through a die rather than a mould. Good for continuous production</p>	

Shaping Process	Diagram
<b>Calendering</b>	
<p>Heated rollers squash and stretch polymer pellets to make thinner. Used for continuous production</p>	

Shaping Process	Diagram
<b>Blow Moulding</b>	
<p>Parison stretched to fit a mould, using hot air. High set-up costs but ideal for mass and continuous production of thin-walled components like bottles</p>	

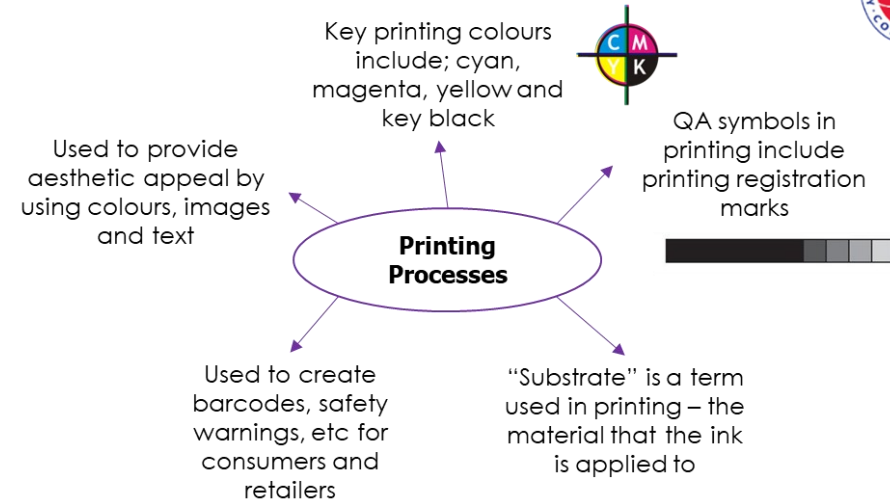
Shaping Process	Diagram
<b>Compression Moulding</b>	
<p>Polymer slug is placed in the lower mould and pressed into shape. Good for large-scale batch production</p>	

Forming Process	Diagram
<b>Line Bending</b>	
<p>Heats along a line, on thermoplastic sheeting. Suitable for one-off and batch production, especially in schools</p>	

Forming Process	Diagram
<b>Rotational Moulding</b>	
<p>Mould filled with thermoplastic granules or powder. Then continuously rotated through heating and cooling chambers. Ideal for batch or mass production</p>	



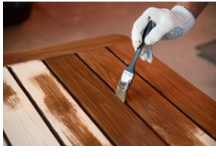




Forming Process	Diagram
<b>Lamination (Lay-up)</b>	
<p>Fibre reinforced composite sheets are rolled into a mould and resin cast over the top.</p>	

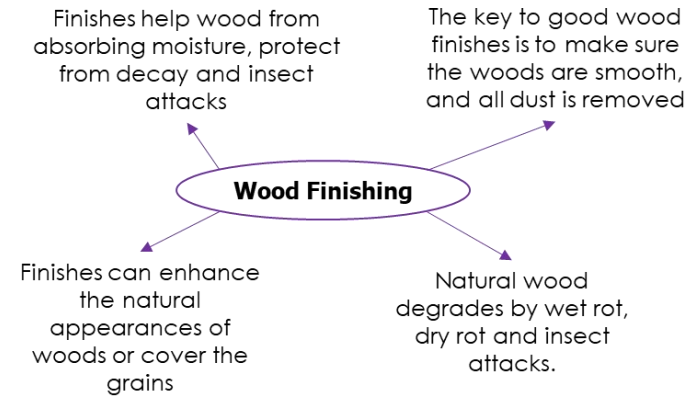
Finish	Key info	Diagram
<b>Lamination</b>	Can be done via encapsulation or via surface coating. Encapsulation used a desktop laminator, and the paper is coated by a plastic pouch Surface Coating uses a liquid for menus and signs.	
<b>Embossing</b>	Creates a raised design on the surface of paper or card. Can be used on business cards, greeting cards, etc	
<b>Debossing</b>	Produces an imprinted depression that sits on the surface on paper or card	
<b>UV Varnishing</b>	Clear non-coloured ink is used on pre-coated papers to enhance the colour and give a layer of protection. UV provides a smooth finish and is abrasion and chemical resistant. Applied using rollers and cured with UV light	
<b>Spot Varnishing</b>	Follows the same process as UV varnishing but is applied to specific areas rather than the whole surface	
<b>Foil Blocking</b>	Heat and pressure is applied to metallic paper (foil) and joins it to paper/card. This helps create depth and texture to improve aesthetics	





Printing Method	Key info	Diagram
<b>Screen Printing</b>	Can be used in one-off and batch production. Different screens are required to print different colours, so can be slow and high-cost. Ideal for posters, t-shirts, and displays.	
<b>Flexography</b>	Uses the 4 main printing colours, and they are printed on top of each other to create the desired colour. The process is simple and least expensive compared to other printing methods. Used for cartons, labels, carrier bags, comics, newspaper, etc	
<b>Offset Lithography</b>	Extremely versatile process that can produce 1 colour, 5 colours (CMYK + metallic) or ten features (CMYK, metallic, varnishing and duplex) Ideal for medium and long runs of products. E.g., books, magazines, etc	

## Year 12 Knowledge organiser— Finishes WOOD

Finish	Key info	Diagram
<b>Varnish</b>	Available in matt, satin, gloss, coloured or clear, etc Applied using a brush and lightly sanded between layers	
<b>Water-based Paints</b>	Available in gloss, satin, matt and metallic. Can be applied with roller, brush or spray. Surface needs to be primed and undercoat added before the main colour	
<b>Stains</b>	Available in colours and types, and can be applied with a brush, roller or spray. Surfaces need to be grease-free prior to application. Stain can be used to enhance and darken grain appearance, making a wood look like a more expensive version	
<b>Colour Wash</b>	Can be applied with a wet sponge and available in a range of colours.	
<b>Wax</b>	Can come in clear and coloured waxes for indoor products. Applied with brush or cloth and once dry buffed in with a clean, dry cloth	
<b>Yacht Varnish</b>	Available in high gloss and satin finishes. Applied with a brush or sprayed directly onto the wood	
<b>Danish Oil</b>	Available in clear and colour tints. Apply with a lint-free cloth, rub the oil into the surface of the wood. Let absorb and then rub away excess oil. Lightly sand down between coats	



Finish	Key info	Diagram
<b>Teak Oil</b>	Available in a clear tint. Apply with a cloth and rub in the oil. Leave to absorb and then rub away any excess oil. This oil is primarily used for outdoor wood products	
<b>Pressure Treating</b>	Wood is placed in a pressure vessel containing a solution consisting of copper sulphate and other preserving salts. Vacuum and pressure are controlled to force the preservative deep into the wood and then steam dried.	



## Year 12 Knowledge organiser— Finishes METAL

Finish	Key info	Diagram
<b>Cellulose and Acrylic Paints</b>	Once the metal is cleaned and degreased the primer is applied. Then a coloured undercoat, then the final paint colour. The colour can be applied using a brush or sprayed. Special effect and texture paints can be added	
<b>Electroplating</b>	The metal product and 'donor' material are placed in a container with an electrolyte solution. Direct current is applied, and the product attracts the donor metal. Examples of 'donors' include; gold, zinc, copper and silver	
<b>Polymer Dip Coating</b>	The metal product is heated to 230 degrees and dipped into a tank of fine polymer powder. The tank has air blowing through to provide an even coating. The heat melts the polymer onto the product, then is left to cool	
<b>Metal Dip Coating</b>	Metal products are dipped into a tank of molten plating metal (a donor metal). There is also tin plating, and zinc plating is known as galvanising.	
<b>Powder Coating</b>	The metal product is (negatively) statically charged. Thermoset polymer resin (positively charged) is sprayed using an airgun. The charging results in a strong attraction and the heat melts the polymer to the metal	
<b>Metal Varnishing</b>	Metal is polished and varnish applied by either spray or with a fine brush	
<b>Sealants</b>	Sealant is applied with a cloth or machine pad to produce a film that is then allowed to cure. Then it is buffed in with a cloth to a shine	

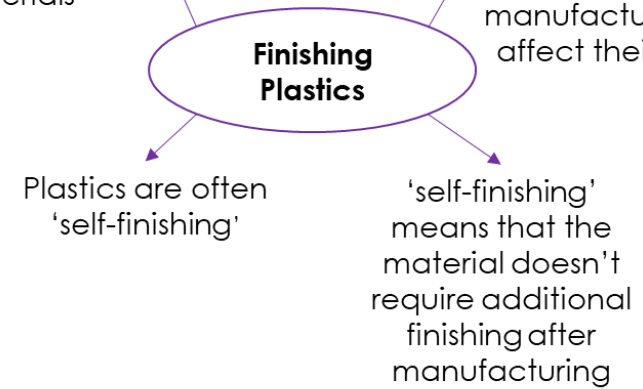
Except steels, most metals have an oxide layer. This provides a slight barrier to environmental effects

Finish	Key info	Diagram
<b>Preservatives</b>	Applied with a cloth, spray or immersion. Silicon sealants can also be classed as preservatives. Often used on moulds and dies for preventing imperfections appearing on surfaces, etc	
<b>Anodising</b>	An electric current passes through sulphuric acid electrolyte solution, from the part to be treated to a negative cathode. As the current flows from the positive to the negative, the aluminium oxide layer builds up on the treated part, producing an anodised finish	
<b>Cathodic Protection</b>	Cathodic protection helps prevent the natural voltage of metals from corroding parts, when exposed to water. There are two methods of cathodic protection – impressed current and sacrificial anodes. Impressed current protects components by flowing a current through any liquid to the component For sacrificial anodes, the electrochemically active metal is joined to a less active metal to provide more resistance to corrosion.	

Finish	Key info	Diagram
<b>Two Injection Moulding - Overmoulding</b>	<p>This is where moulds are used to affect the texture of a final product. One mould is for the product and another for the 'grip' areas.</p> <p>One the product is injection moulded; it is placed into a second mould where the second polymer is injection moulded onto the body.</p>	
<b>Twin-Shot Injection Moulding - Overmoulding</b>	<p>The main mould is used to create the product. Then the mould opens slightly and rotates 180 degrees. The mould closes again, and the second injection applies the second polymer. This would be used for griped sections e.g., razor handles.</p>	
<b>Acrylic Spray Paints</b>	<p>Acrylic spray paint is fast-drying and becomes water resistant when dry.</p> <p>This is commonly used in the automotive industry, as the manufacturer can have a range of colours without having to constantly have to change the coloured pigments during manufacturing.</p>	
<b>Adding Pigments</b>	<p>Pigments can be added during manufacturing or to the stock form. This includes smart material pigments.</p>	

Plastics are often used as finishes on a range of other materials

Additives and pigments can be added to plastics (during manufacturing) to affect their finish



Enhance the aesthetic appeal of the final product – this could enhance the natural finish e.g., on wood grain, or cover a less pleasing appearance e.g., laminating man-made boards

