Year 12 Knowledge organiser— Material properties

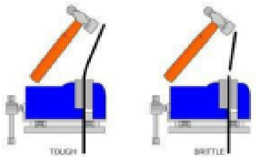
Working properties

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.

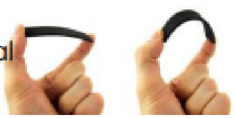
Toughness
The ability to absorb energy through shock without fracturing (break or snap).



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

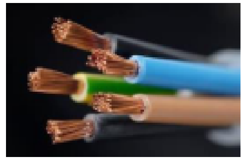
A physical property is an inherent property of a material.

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

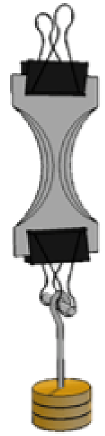
Fusibility
The ability of a material to be converted through heat into a liquid state and combined with another material before cooling as one material.

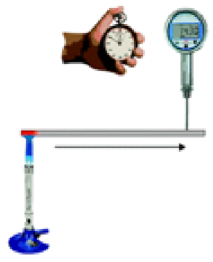
Electrical conductivity
The ability to conduct electricity.

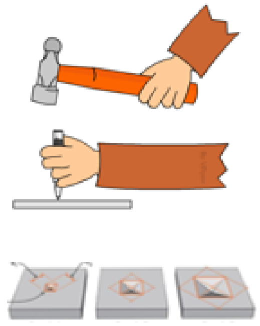


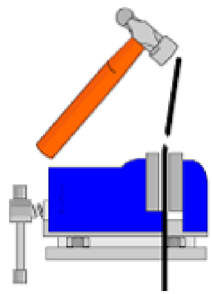
Thermal conductivity The ability of a material to conduct heat.

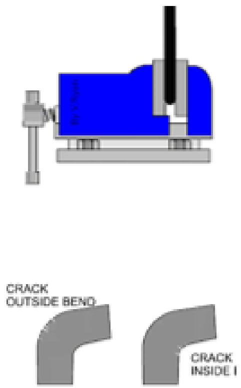
Year 12 Knowledge organiser— Material testing

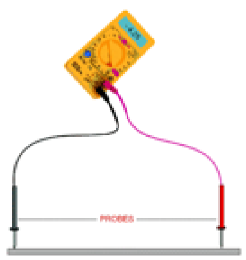
Testing Type	Diagram
Tensile Strength (Ability to resist stretching/pulling forces)	
Samples of the material are clamped from the top and weights added to the bottom. The less stretch the more tensile strength the material has. This can be checked using ruler.	

Testing Type	Diagram
Thermal Conductivity (How easily heat passes through a material)	
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	

Testing Type	Diagram
Hardness (Ability to resist abrasive wear, indentation and scratching)	
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.	

Testing Type	Diagram
Toughness (Ability to resist impact force without fracturing)	
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.	

Testing Type	Diagram
Malleability and Ductility (to be able to withstand deformation and being drawn out without cracking)	
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	

Testing Type	Diagram
Electrical Conductivity (How easily the flow of electrical current passes through a material)	
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	

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

Year 12 Knowledge organiser— Classification of materials 1.1 PAPERS AND BOARDS

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 that 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 to 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 direction. 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.

Year 12 Knowledge organiser— Classification of materials 1.1 WOODS/MANUFACTURED BOARD

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.

Manufactured 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.

Year 12 Knowledge organiser— Classification of materials 1.1 METALS

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 thee 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 fitments, 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.

Year 12 Knowledge organiser— Classification of materials 1.1 POLYMERS

Thermoforming plastics

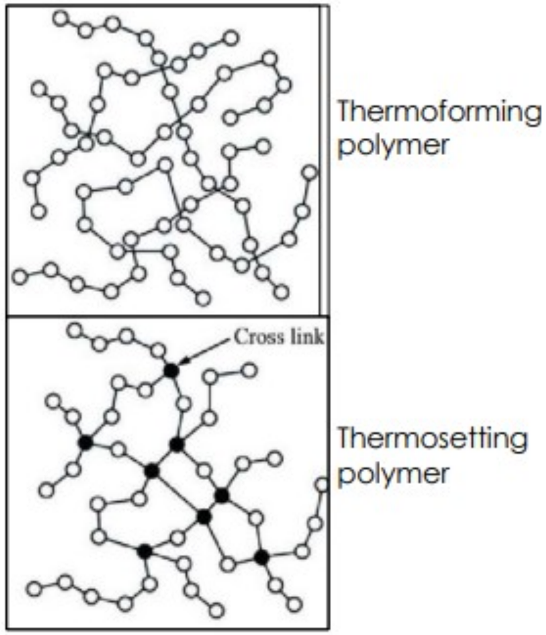
This group, known as thermoplastics, is generally more flexible, especially when heated. They can be formed into complex shapes and many can be reformed multiple times.

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, aire 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.



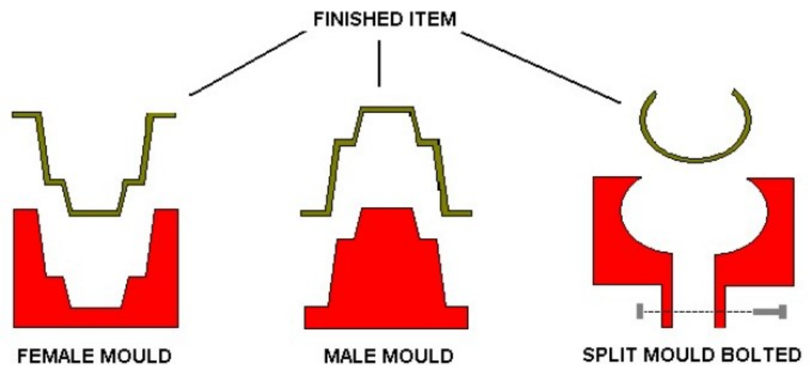
Thermosetting plastics

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.

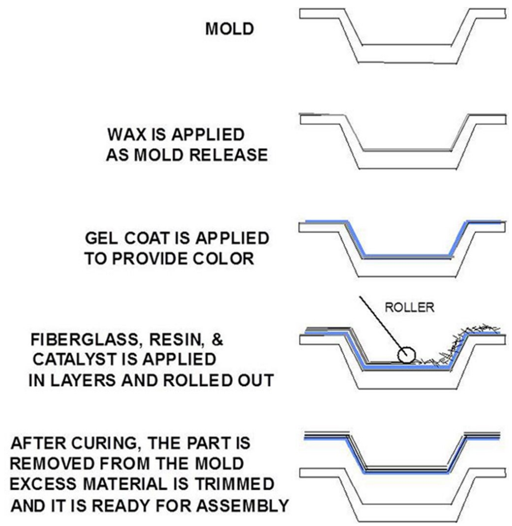
Year 12 Knowledge organiser— Classification of materials 1.1 COMPOSITES

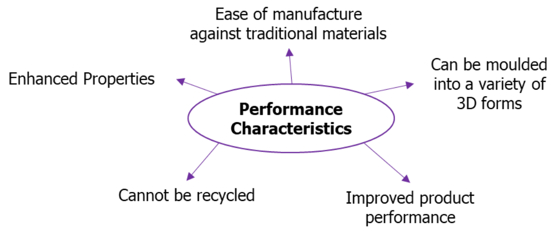
Composite Materials are a mix of two or more different materials, making a material with enhanced properties		
Name	**Key info**	**Uses/ Examples**
CFRP	Lightweight, corrosion resistant and good compressive strength	Sports equipment, racing car bodies and prosthetics
GRP	Lightweight, corrosion resistant, 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 environ-ment?

Year 12 Knowledge organiser— Classification of materials SMART MATERIALS

Smart Materials change in response to external stimuli e.g. light, heat, moisture, etc		
Name	**Key info**	**Uses/ Examples**
SMAs	Returns to its original shape, in reaction to heat	Braces and glasses
Thermochromic Pigment	Change colour in reaction to heat	Kettles, baby bottles, etc
Phosphorescent Pigment	Absorbs light during the day and 're-emits' it when dark	Exit signs, 'glow in the dark' products
Photochromic Pigment	Change colour in reaction to light	Colour changing glasses, windows, etc
Electroluminescent Wire	Thin copper wire in a phosphorescent material, that glows in response to an alternating current	Glow bracelets, outdoor decorative lighting
Piezoelectrical Material	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.

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

Key Questions

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

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).

Year 12 Knowledge organiser— Classification of materials MODERN 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.

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

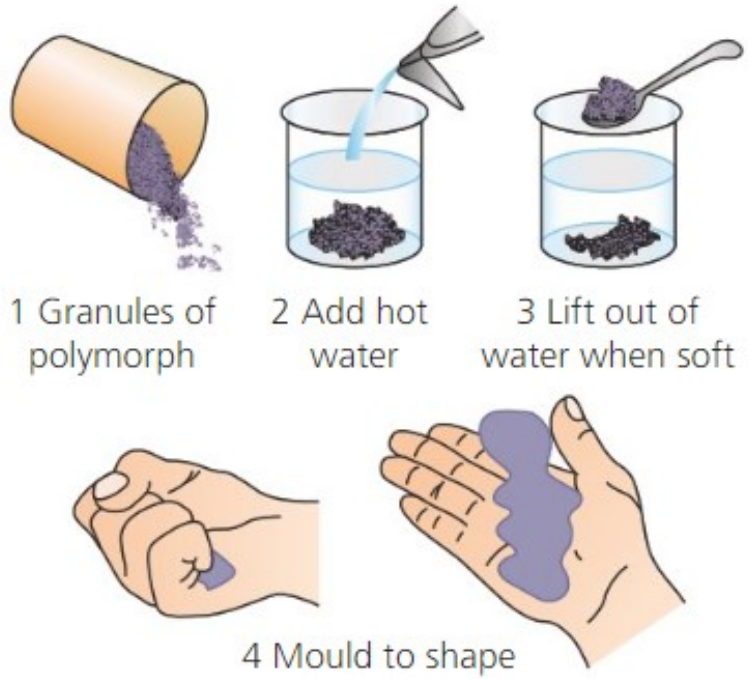
Conductive fabrics have either conductive fibres woven into them or conductive powders impregnated into them. They have been built into competitors' jackets for fencing contests. As the sword strikes a panel, it records this, as the metal of the sword has touched the pad with the conductive fabric in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

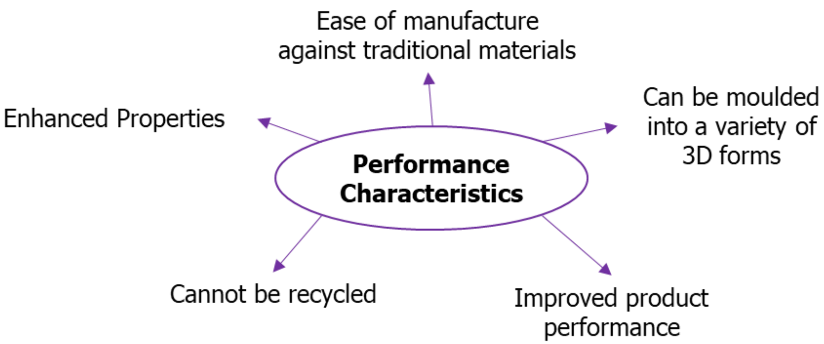
Fire-resistant fabrics are used on items such as firefighters suits and children's clothing. Nomex is a brand name for fire-resistant fabric made from a polymer called meta-aramid. Nomex thickens when heated, therefore increasing protection.

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.

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.





Polymorph

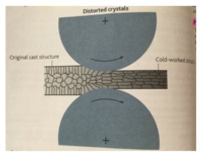
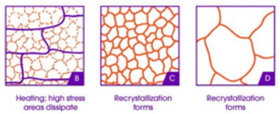
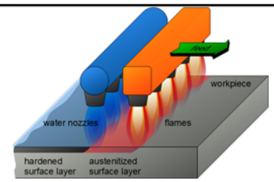
Granules which become mouldable at 60 °

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,

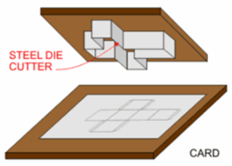
Year 12 Knowledge organiser— 1.3 ENHANCING MATERIALS

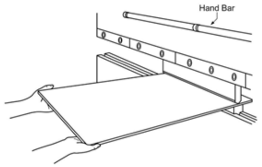
Plastic Enhancements	
Additive	**Purpose**
Lubricants	Reduces the viscosity of molten polymers, making them less "sticky". This allows the moulding temp to be lowered, saving energy
Thermal Antioxidants	Prevents the polymer oxidising or discolouring from excessive heat during processing
Pigments	Mixed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

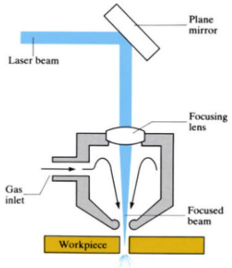
Wood Enhancements	
Method	**Purpose**
Resins and Laminations	Used in engineering wood to enhance the properties of useful parts of trees. E.g. Chipboard made from compressing wood chips with resin and then laminated
Resin with fire retardants	Resin is impregnated with fire-retardant cladding
Laminations	Veneers are laminated on to the board surface to enhance the aesthetics
Preservatives	Protects woods from fungal and insects
Pigments	Added to preservatives to give different coloured shades to enhance aesthetics
Fire-retardant Preservatives	Use to pressure treat wood. This can make it harder and more resistant to high-wear situations
Modified Natural Polysaccharide	Wood is impregnated to cure within the wood cell structure. Used to increase hardness, toughness and stability
SCL and LVL	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**
Work Hardening	'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	
Annealing	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	
Case Hardening	Used for hardening the surface of steels. This produce an outer casing of hardness, improved wear and resistance to indentation. While to core keeps the "softer" properties.	

Year 12 Knowledge organiser— Forming, redistribution and addition processes PAPER & BOARD

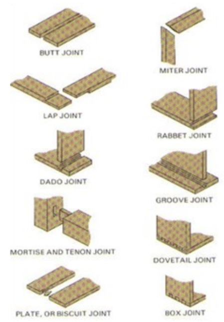
Wasting Process	Diagram
Die Cutting and Creasing	
Steel cutting dies and creasing rules are used to cut out the net shape.	

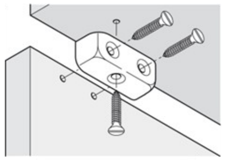
Shaping Process	Diagram
Bending	
Sheets of paper are placed onto a folding table. Then bent to the desired angle	

Wasting Process	Diagram
Laser cutting	
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	

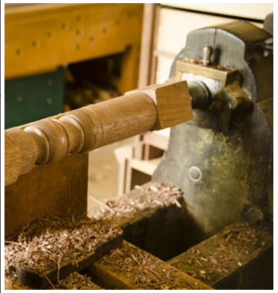
Adhesive Name	Description
PVA Glue	Water-based adhesive for attaching wood to wood. Not water-proof
Contact Adhesive	Used for bonding large areas and can be used attaching different materials together e.g. plastics to woods, etc
UV Hardening Adhesive	A clear liquid that "cures" when exposed to UV light. 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.

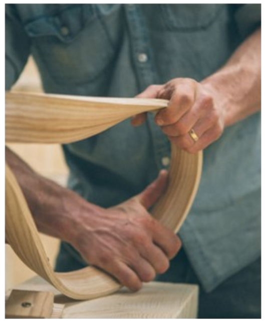
Year 12 Knowledge organiser— Forming, redistribution and addition processes WOOD

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

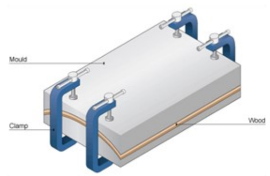
Addition Process	Diagram
Component Jointing	 
Knock-down fittings are commonly used for flat-pack furniture. Standard components can also be used e.g., wood screws, coach bolts, etc	

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

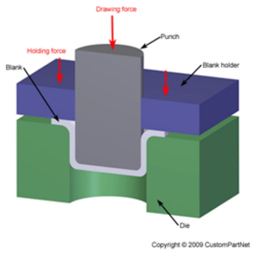
Forming Process	Diagram
Turning	
Turning is done on a wood lathe. The wood is spun at high speed, while either a worker with manual tools or automated tools, cut into the wood to shape it.	

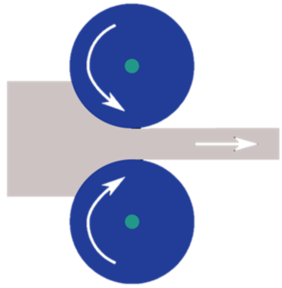
Forming Process	Diagram
Steam Bending	
Heat and steam makes wood strips pliable and can be shaped. Then it is clamped in place and left to dry.	

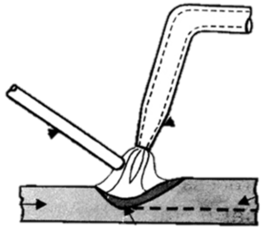
Forming Process	Diagram
Routering	
Can be CNC or hand controlled. Can be used to make channels, holes, mouldings, etc	

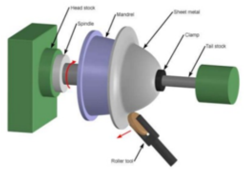
Forming Process	Diagram
Lamination	
Wood veneers or thin man-made boards are bend over a former/jig and glued together. When dried reveals a layered, shaped, sheet	

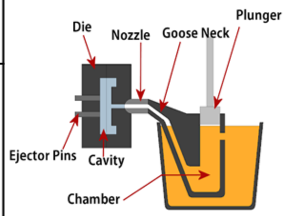
Year 12 Knowledge organiser— Forming, redistribution and addition processes METALS

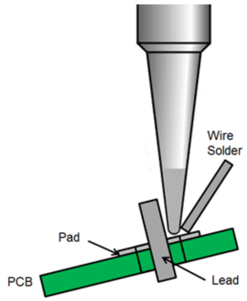
Shaping Process	Diagram
Press Forming	
Shapes sheet metals in 3D forms using a punch. Suitable for mass production	

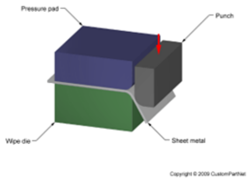
Shaping Process	Diagram
Rolling	
Can be done hot or cold. Metal is made thinner by the rollers used.	

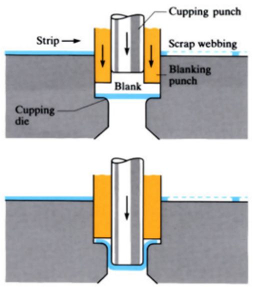
Addition Process	Diagram
Welding	
Comes in many variations; MIG, TIG, Spot and Oxy-Acetylene. Often pairing high heat with a "filler rod" to join metals together.	

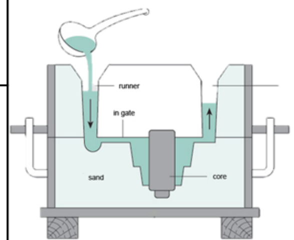
Shaping Process	Diagram
Spinning	
Turns sheet metal into curved 3D forms by spinning at high speed and shaped using a roller over a mandrel. Suitable for mass or batch production	

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

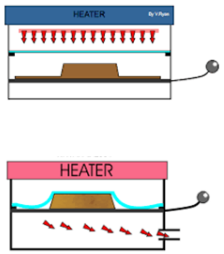
Addition Process	Diagram
Soldering	
Metals solder to join components to PCBs. Can also be used in jewellery making.	

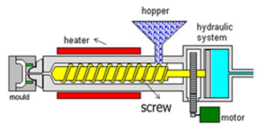
Forming Process	Diagram
Bending	
Sheet metal is bent into shape by a punch. Can be used for small-scale in schools and for mass production in industry.	

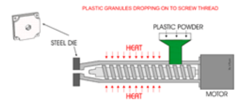
Forming Process	Diagram
Cupping and Deep Drawing	
Sheet metal blank is stretched into shape by the punch. Used in mass or continuous production	

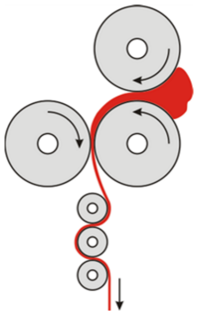
Redistribution Process	Diagram
Sand Casting	
Molten metal is poured into a cavity in the sand and cooled. Suitable for one-off production and batch production	

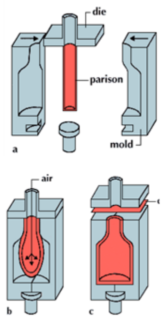
Year 12 Knowledge organiser— Forming, redistribution and addition processes POLYMERS

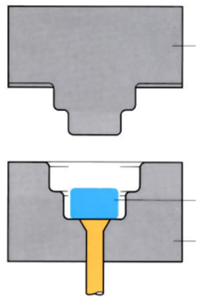
Shaping Process	Diagram
Vacuum Forming	
Heats sheets of thermoplastics around moulds. Moulds need draft angles, air holes and rounded corners to work. Ideal for batch and mass production	

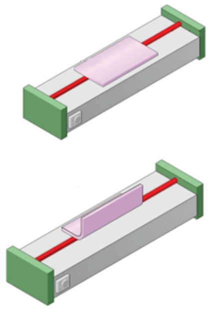
Shaping Process	Diagram
Injection Moulding	
Complex 3D shapes are made quickly for mass or continuous production. Tooling and set-up costs are high	

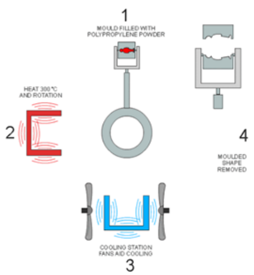
Shaping Process	Diagram
Extrusion	
Follows same process as injection moulding, but melted polymer goes through a die rather than a mould. Good for continuous production	

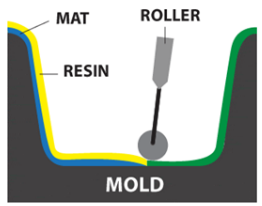
Shaping Process	Diagram
Calendering	
Heated rollers squash and stretch polymer pellets to make thinner. Used for continuous production	

Shaping Process	Diagram
Blow Moulding	
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	

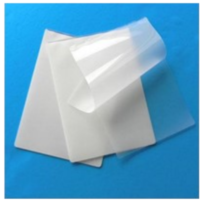
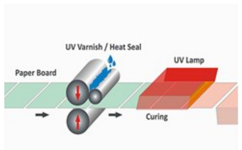
Shaping Process	Diagram
Compression Moulding	
Polymer slug is placed in the lower mould and pressed into shape. Good for large-scale batch production	

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

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

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

Year 12 Knowledge organiser— Finishes PAPER AND BOARD

Finish	Key info	Diagram
Lamination	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.	
Embossing	Creates a raised design on the surface of paper or card. Can be used on business cards, greeting cards, etc	
Debossing	Produces an imprinted depression that sits on the surface on paper or card	
UV Varnishing	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	
Spot Varnishing	Follows the same process as UV varnishing but is applied to specific areas rather than the whole surface	
Foil Blocking	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 Processes

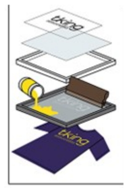
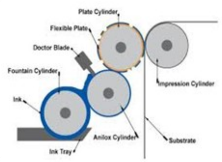
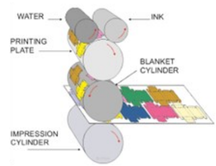
Key printing colours include; cyan, magenta, yellow and key black

QA symbols in printing include printing registration marks

Used to provide aesthetic appeal by using colours, images and text

Used to create barcodes, safety warnings, etc for consumers and retailers

"Substrate" is a term used in printing – the material that the ink is applied to

Printing Method	Key info	Diagram
Screen Printing	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.	
Flexography	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	
Offset Lithography	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

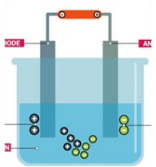
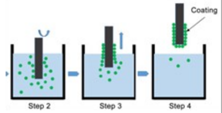
Finish	Key info	Diagram
Varnish	Available in matt, satin, gloss, coloured or clear, etc Applied using a brush and lightly sanded between layers	
Water-based Paints	Available in gloss, satin, matt and metallic. Can be applied with roller, brush or spray. Surface needs to be primed and undercoat added before the main colour	
Stains	Available in colours and types, and can be applied with a brush, roller or spray. Surfaces been 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	
Colour Wash	Can be applied with a wet sponge and available in a range of colours.	
Wax	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	
Yacht Varnish	Available in high gloss and satin finishes. Applied with a brush or sprayed directly onto the wood	
Danish Oil	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	

Wood Finishing

- Finishes help wood from absorbing moisture, protect from decay and insect attacks
- The key to good wood finishes is to make sure the woods are smooth, and all dust is removed
- Finishes can enhance the natural appearances of woods or cover the grains
- Natural wood degrades by wet rot, dry rot and insect attacks.

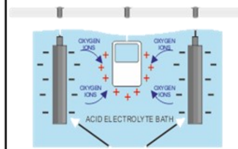
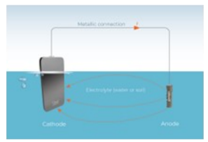
Finish	Key info	Diagram
Teak Oil	Available in a clear tint. Apply with a cloth and rub in the oil. Leave to absorb and then rub away any excess oil. This oil is primarily used for outdoor wood products	
Pressure Treating	Wood is placed in a pressure vessel containing a solution consisting of copper sulphate 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

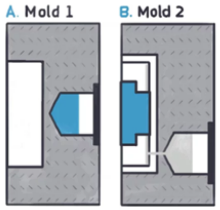
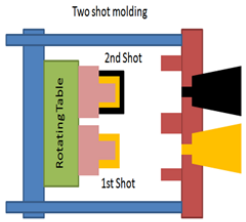
Finish	Key info	Diagram
Cellulose and Acrylic Paints	Once the metal is cleaned and degreased the primer is applied. Then a coloured undercoat, then the final paint colour. The colour can be applied using a brush or sprayed. Special effect and texture paints can be added	
Electroplating	The metal product 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	
Polymer Dip Coating	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	
Metal Dip Coating	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.	
Powder Coating	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	
Metal Varnishing	Metal is polishes and varnish applied by either spray or with a fine brush	
Sealants	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	

Metal Finishing

- Except steels, most metals have an oxide layer. This provides a slight barrier to environmental effects
- Copper's oxide layer turns it form a reddish colour to a greenish colour
- Steels have a porous oxide later which lets moisture through. This is what causes rust

Finish	Key info	Diagram
Preservative s	Applied with a cloth, spray or immersion. Silicon sealants can also be classed are preservatives. Often used on moulds and dues for preventing imperfections appearing on surfaces, etc	
Anodising	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	
Cathodic Protection	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.	

Year 12 Knowledge organiser— Finishes POLYMERS

Finish	Key info	Diagram
Two Injection Moulding - Overmoulding	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. One the product is injection moulded; it is placed into a second mould where the second polymer is injection moulded onto the body.	
Twin-Shot Injection Moulding - Overmoulding	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.	
Acrylic Spray Paints	Acrylic spray paint is fast-drying and becomes water resistant when dry. 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.	
Adding Pigments	Pigments can be added during manufacturing or to the stock form. This includes smart material pigments.	

Finishing Plastics

- 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
- Plastics are often 'self-finishing'
- 'self-finishing' means that the material doesn't require additional finishing after manufacturing

Why are finishes generally used?

- 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
- Protect against insects and pests – this is especially important for woods and boards
- Can help protect against decay and corrosion