Materials and their Properties: Timbers & Manufactured Boards

Hardwoods

They are deciduous trees which means that in winter, they lose their leaves.

These trees are broadleaved, bushy and slow growing.

Overall they tend to be harder to work with and more expensive than other types of timbers.

They are less porous and denser cell structure which makes them harder wearing and less prone to rotting.

Types:

Name	Characteristics	Uses
Ash 	Flexible, tough and shock resistant, laminates well. Pale brown/cream.	Sports equipment and tool handles.
Beech 	Fine finish, tough and durable. Dense close grain with an	Children's toys, models and furniture.
Mahogany 	Easily worked, durable and finishes well. Rich reddish brown in	High end furniture and joinery.
Oak 	Tough, hard and durable, high quality finish possible. Light brown with variable grain.	Flooring, furniture, and railway sleepers.
Balsa 	Very soft, and lightweight but can snap. Pale cream/ white in colour. Unusually fast growing	Prototyping and modelling - especially in model aircraft.

Softwoods

They are coniferous trees which means that they keep their leaves in winter = evergreen.

These trees are tall and 'Christmas tree' tree shaped.

Overall they tend to be easier to work with and less expensive than other types of timbers.

They are more porous (holes) and if unprotected will rot. They have cones for leaves and grow quickly.

Types:

Name	Characteristics	Uses
Larch 	Durable, tough and good water resistance. Machines well.	Exterior cladding, flooring, machine mouldings and furniture.
Pine 	Lightweight, easy to work but can split.	Interior construction, cheaper furniture and decking.
Spruce 	Easy to work, high stiffness to weight ratio.	Construction, furniture and musical instruments.
Redwood 	Easy to work and machines well, some rot resistance.	Outdoor furniture, beams, posts and decking.
Cedar 	Easy to work, can blunt tools, finishes well and naturally resistant to rot.	Outdoor furniture, fences and cladding for buildings.

Manufactured Boards

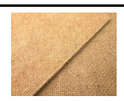
They are sheets of processed natural timber and adhesives - so they are human made boards

These are usually made from waste wood, low-grade and recycled timber.

Can be covered by thin slices of high quality wood known as veneer to make it look aesthetically pleasing.

Cheaper than natural timber. They come in boards and have no grain.

Types:

Name	Characteristics	Uses
MDF 	Rigid and stable, good value with a smooth easy to finish surface.	Flat pack furniture, toys and kitchen units.
Plywood 	Stable in all directions as alternating layers. Flexible versions available.	Furniture, shelving, toys, interior and exterior construction.
Chipboard 	Good compressive strength, not water resistant and prone to chipping on edges.	Flooring, low end kitchen units and worktops.
OSB 	Rigid and even strength, good water resistance.	Construction in interior and exterior house building.
Block board 	Stable, tough and heavy. Finishes well.	Furniture, doors, shelving and indoor construction.
Hardboard 	Flexible, even strength and easily damaged by water.	Furniture and photo frame backing.

Source/Origin

Timber comes from **trees** - this is known as the source or origin of the material. This is how we change into timber.

1. When trees are cut down, this is known as **felling.** This can be through machine or chain saws, just like the image.

2. Branches are cut off and the logs are stored until they are transported to a **sawmill.**

3. When at the sawmill, machines such as **band saws** and **circular saws** are used to create boards/planks.

Environmental Impact

Wood is considered a **sustainable resource** as new trees can be grown to replace those felled. Here are some **issues and positives** surrounding the impact that wood is having on the environment:

- In many places, wood is being used at a greater rate which means it is unsustainable.

- Illegal felling is leading to deforestation as people aren't replanting trees.

- Deforestation helps with global warming.

- To make sure you are buying sustainable timber, you need to make sure it is approved by the **Forest Stewardship Council** or the **Endorsement of Forest Certification.**

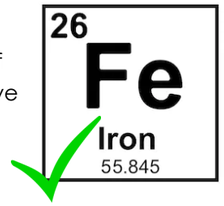
Materials and their Properties: Metals & Alloys

Ferrous

This group of metals all contain iron.

Most of these metals are magnetic and will rust if they are exposed to moisture without a protective finish.

Iron is what causes the metals to rust quicker. They tend to have a higher melting point.



Types:

Name	Characteristics	Uses
Low Carbon Steel (Mild Steel) 	Tough and ductile, easily machined, formed, brazed or welded.	Construction, nails, screws, nuts and bolts. Many car bodies.
High Carbon Steel 	Less ductile and harder than mild steel. Very hard wearing and keeps and edge well.	Garden or workshop tools, blades, scissors, wood and metal cutting tools.
Cast Iron 	Hard but brittle. Easily cast into complex shapes but some are hard to machine.	Kitchen pots and pans, machine bases and bodies, drain covers and vices.

Non Ferrous

This group of metals do NOT contain iron.

Most of these metals are not magnetic and do not rust.

These can **Oxidise**. React with oxygen that causes the surface to change colour.

They include precise metals such as gold, silver and platinum and others such as lead and mercury which are poisonous,

Types:

Name	Characteristics	Uses
Aluminium 	Lightweight, high strength to weight ration, ductile and 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.	Plumbing supplies, and electrical cables.
Tin 	Soft, malleable and ductile, a good electrical conductor.	Used to produce cans and plating surfaces to make them last.
Zinc 	Fair electrical conductivity, malleability and ductility; however, better when alloyed.	Mainly used to galvanise steel to prevent rusting.

Alloys

This group of metals is a mixture of at least one pure metal and another element.

The reason metals are alloyed is so that the added element makes the metal better - it improves it in some way.

These are more difficult to recycle as the metal has been mixed with something else.

Types:

Name	Characteristics	Uses
Brass 	A heavy alloy of zinc and copper that is malleable, easy to cast and machine.	Musical instruments, bushes and plumbing filaments.
Stainless Steel 	Hard very smooth but difficult to weld. A ferrous metal alloyed with chromium, nickel and manganese.	Cutlery, kitchen and medical equipment.
High Speed Steel 	Able to withstand the high temperatures created when machining at high speed, keeps cutting edges well.	Cutting tools such as drill bits, mill cutter, taps and dies.
Duralumin 	Alloy of aluminium, copper, magnesium and manganese. Creates greater hardness and tensile strength.	Aircraft components sports car wheels and casings.

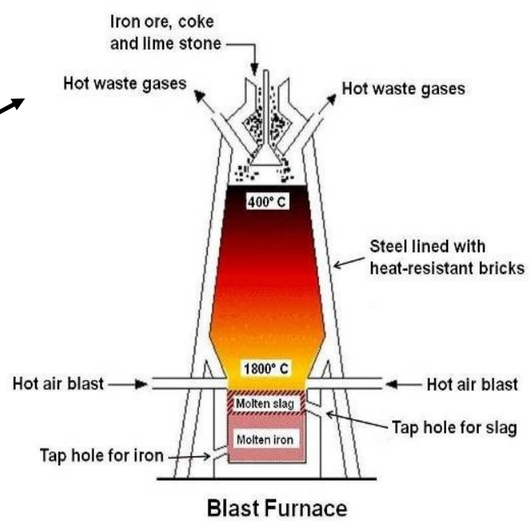
Source/Origin

Metals come from the **ground/rocks** typically the Earth's crust - this is known as the source or origin of the material.

This is how we **extract** (remove) metals from the ground and create **iron ore.**

1. The material is mined using machines - the main two types are **surface mining** and **underground mining.**

2. These rocks are then **transported** to a factory to be separated from waste material.



Blast Furnace

3. To create the **iron ore**, the rocks are placed through the top of the furnace and it is heated.

As it heats, it starts to become a liquid and this sinks to the bottom.

As it becomes a liquid it is carried away from the bottom to be **refined** further into metals.

The waste material leaves in the other direction and is known as the **slag.** Waste material also leaves as gases.

Environmental Impact

Metal is considered a **finite resource** - this means that it will run out eventually as we only have a limited amount. These are some of the impacts that metal has on the environment:

- Finite resource so it will run out eventually.
- Causes **air pollution** from the gases that are released.
- Causes **visual pollution** from the mines that are created to get the raw material.
- Takes a lot of energy to produce.

- Can be recycled over and over again. The quality will always be the same as the original so the material won't weaken over time.
- Lasts a long time and so it won't need to be replaced.
- Most metals can be recycled.

Materials and their Properties: Polymers (Plastics)

Thermoforming

This group of polymers are able to be formed into a different shape over and over again. Known as thermoplastics.

These are generally more flexible, especially when heated.

These are easier to recycle.

Can be formed into complex shapes.

Types:

Name	Characteristics	Uses
Polyethylene terephthalate 	Easily blow moulded and fully recyclable.	Bottles, food packaging, sheeting and some food wraps.
High density Polyethylene 	Lightweight, rip and chemical proof.	Milk bottles, pipes, hard hats and wheelie bins.
Polyvinyl Chloride 	Flexible, high plasticity, tough and easily extruded.	Raincoats, pipes, Electrical tape and blow up mattresses.
Low density Polyethylene 	Very flexible and tough with a high strength to weight ratio.	Plastic carrier bags and black bin bags.
Polypropylene 	Flexible, tough, lightweight, easily cleaned and safe with food.	Kitchen, medical and stationery products.
High Impact Polystyrene (HIPS). 	Flexible, impact resistant, lightweight and can be food safe. Toxic when burned.	Vacuum formed products such as food containers or yoghurt pots.
Acrylic 	Tough but brittle, easily scratched . Common in school workshop for the laser cutter.	Car lights, display stands, trophies, jumpers, hats and gloves.

Polymorph

Non toxic, easily mouldable and re-mouldable when heated. Used for modelling or personalisation of hand grips.

Thermosetting

This group of polymers, once set in shape CANNOT be reformed. Known as thermosets.

These are generally more rigid before and after they've been heated.

These are harder to recycle.

Make excellent electrical insulators.

Types:

Name	Characteristics	Uses
Epoxy resin 	Stronger than other resins, expensive and heat resistant.	Bonding different materials together.
Melamine formaldehyde 	Food safe, hygienic and lightweight.	Kitchenware - but it can't be put in the microwave
Urea formaldehyde 	Heat resistant and very good electrical insulator	Electrical fittings, casings, buttons and handles.
Polyester resin 	Reasonably strong, heat resistant and a good electrical insulator.	Waterproof coatings and flooring.
Phenol formaldehyde 	Very hard and brittle. An excellent electrical insulator.	Electrical components, mechanical parts.

Biopolymers

Newer plastics are made from **vegetable starches** and can be composted - these are great for the environment. Here are some:

PLA - Polylactic Acid

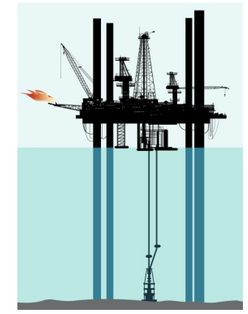
Non toxic, easily shaped and typically used for 3D printers.

Used for pens, phone cases, disposable food and drinks containers.

Source/Origin

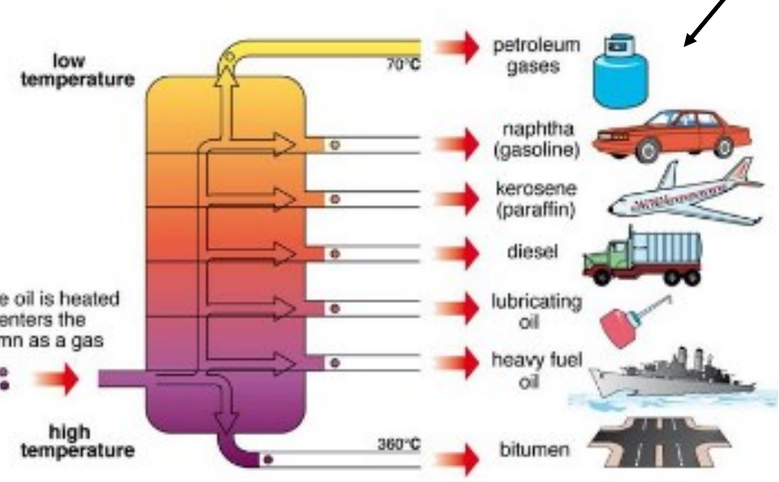
Polymers come from **crude oil.** They can also come from **gas** and **coal.** This can be found beneath the Earth's surface. Below is how we get it and change it into polymers:

1. The oil is **extracted** from beneath the surface and stored. This can be done on land or in the sea.



2. This oil is then **transported** via a **crude tanker** to somewhere called an **oil refinery.**

3. When at the refinery, the oil is heated and at **different temperatures** this creates the different **products.**



Environmental Impact

Polymers are considered a **finite resource** - this means that it will run out eventually as we only have a limited amount. However with development in technology there are some **biodegradable** ones, here are some of the impacts:

✗ - Do not biodegrade easily so release harmful toxins in landfills.

- Causes **air, visual** and **water pollution.**

- Takes a lot of energy to produce.

✓ - Some are able to be recycled so they don't use raw material (brand new e.g. crude oil).

- New technology has given way to fully biodegradable ones - **biopolymers,** so they are non toxic and not from a finite resource.

Materials and their Properties: Textiles

Natural Fibres

Natural fibres come from 2 sources – these are plant based and animal based.

Fabrics from plant based are renewable but take a long time to grow.

Types:

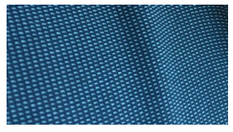
Name	Characteristics	Uses
Cotton **(plant)** 	Soft, strong and absorbent, cool to wear and easily washable. Good thermal properties.	Most clothing and can be used for denim.
Wool **(animal - sheep)** 	Can be fine and thick, naturally warm and crease resistant. Can shrink.	Jumpers, coats, suits and carpets.
Silk **(animal - silk worm)** 	Very soft and fine finish, gentle, warm in winter and cool in summer. Absorbent and strong.	Luxury clothing and bed sheets.

Synthetic Fibres

Synthetic fibres are ones that are man-made.

These can be made from recycled plastic bottles.

Types:

Name	Characteristics	Uses
Polyester 	Tough, strong, hard wearing, very versatile, holds colour well and non absorbent.	Clothing, fleece garments, bedsheets, carpets, backpacks and umbrellas.
Polyamide **(Nylon)** 	Good strength, hard wearing, non absorbent, machine washes well.	Clothing, ropes and webbings, parachutes and sports material.
Elastane **(Lycra)** 	Added to fabric to enhance working properties, to add stretch. Freedom of movement	Sportswear, exercise clothing, swimsuits and general clothing.

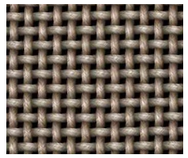
Blended & mixed fibres

These fibres have been blended and mixed together - so natural mixed with synthetic.

Types:

Name	Characteristics	Uses
Poly-cotton 	More durable than pure cotton but not as breathable. Can be produced more cheaply.	General clothing, sheets and bedding. Used as alternative to pure cotton.

Woven fabrics



These are fabrics where they follow a pattern - one piece goes up and over whilst the over does the opposite. Weaving.

Types:

Name	Characteristics	Uses
Plain weave e.g. muslin and calico.	Simple and cheaper to produce, stronger than other weaves.	General clothing, sheets and bedding. Used as alternative to pure cotton.

Non-woven fabrics

These are fibres that haven't been spun into yarn - they have been bonded together through heat or adhesive (glue).

Types:

Name	Characteristics	Uses
Bonded fabric 	Lack strength, no grain so can be cut in any direction and not fray.	Disposable products such as protective clothing
Feted fabric 	Can be formed with moisture and heart - no elasticity when it has dried. Pull apart easily.	Hats, soundproofing and insulation.

Knitted fabrics

This is when yarn is interlocked (connect) with each other.

Weft - hand or machine and loops across the width.

Warp - these interlock vertically and less prone to unravelling and laddering.

Types:

Name	Characteristics	Uses
Knitted fabric 	Warm to wear, different knits have different shapes, stretch and shape retention	Jumpers, cardigans, sportswear and tights.

Source/Origin

Fabric can be sourced from many places as you can see from the table. However they are mainly **animal sources, chemical sources and vegetable sources.** Then when you've got the source this is what happens:

1. This is what some of the **raw fibres** look like, this is once they have all been collected. E.g. you could have a pile of wool or cotton.

2. Then to turn this into **yarn**, the raw material is **spun or twisted** by hand or machine. It is spun and twisted until it becomes useable.

3. So it will look something similar to this once it has been further **processed,** such as being dyed. Some are further processed so they become thinner and smoother.

Environmental Impact

Here are some of the impacts that manufacturing textiles has on the environment:

- They use a lot of water in the processing stages to make sure that they are clean and useable.

- When being processed, they will release **CO2** into the environment causing **air pollution.**

- Throw away culture due to fashion

- Almost all textiles are recyclable or biodegradable.

- Most sources of textiles are considered **sustainable** as they are available such as the cotton plant s and sheep's wool.

- Can be reused or donated.

Materials and their Properties: Papers & Boards

BOARDS

The thickness of boards is measured in microns. 1000 microns = 1mm.

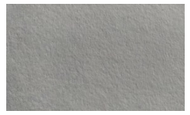
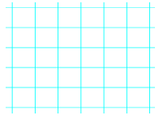
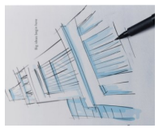
Types:

Name	Characteristics	Uses
Corrugated card 	1000-5000 microns, strong and lightweight. Insulative and easily printed on.	Packaging, boxes and impact protection.
Duplex board 	200-500gsm, stiff, lightweight coatings to improve functionality.	Cheaper version of white card used for packaging boxes. Waxy coating for protection.
Foil lined board 	200-400gsm, 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 board 	3-10mm thick, lightweight and rigid in all directions. Can crease and crack under pressure.	Architectural models, model making, prototyping, mounting and framing of photographs.
Ink jet card 	120-350gsm medium to thick card treated to hold a high quality photo image.	High quality photographic images
Solid white board 	200-500gsm, stiff board, holds colour well, easily cut or creased.	Any uses including greeting cards, packaging and advertising.

PAPERS

Paper is measured by weight in grams per square metre (GSM). This is how heavy it will be.

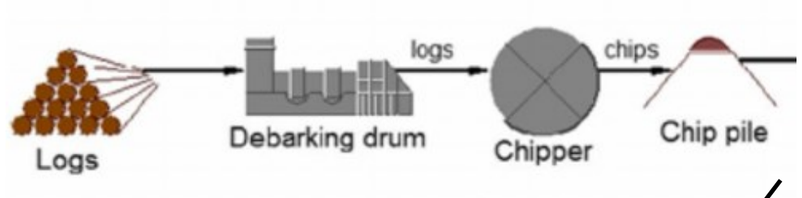
Types:

Name	Characteristics	Uses
Bleed proof paper 	70gsm, coated to stop solvent based markers staining. Ink stays on the surface.	Marker pens when designing and final designs.
Cartridge paper 	120-150gsm, completely opaque and more expensive.	Pencil and ink drawings, sketching and water colour.
Grid paper 	Usually printed onto 80gsm paper with faint lines and often in blue.	Used for graphical, scientific and mathematical diagrams.
Layout paper 	40-60gsm, semi translucent, takes pencil and most media well.	Creating sketches and working ideas.
Tracing paper 	10-120gsm, translucent, takes pencil and most colour well.	Copying and tracing images.

Source/Origin

Paper and boards come from finely shredded wood but has been prepared in a special way to make what you know as paper and boards. This is how they are made:

1. **Pulp** - this is the finely shredded wood. Logs are **debarked** into fine chips. These are added to a chemical solution and cooked under pressure to make them into a paper pulp. These are called **cellulose fibres.** Depending on the colour, the fibrous liquid is then bleached or coloured.



2. **Sizing** - this is a process where chemicals or other additives are beaten into the fibrous liquid. This stops it being so absorbent. This means it can then be photocopied, printed or painted onto.

Papers such as toilet roll or kitchen roll have little sizing so that they can absorb moisture. Otherwise they wouldn't work as toilet or kitchen roll.

3. **Converting Pulp to Paper** - the pulp (so the liquid fibrous) goes on a mesh conveyor belt to drain the excess water. It goes through lots of rollers to squeeze the last of the water out of the paper. Then through **drying rollers,** so it dries and finally through a set of **calender rollers** which give the paper the finish e.g. satin or matt. Here's a picture of the overall process together:

Environmental Impact

Paper is considered a **sustainable resource** which means it is something that can continue going as it can be **replenished** (replaced) for example, you cut down a tree, plant 2 new ones or a new one. Here are some of the impacts on the environment:

✗
- Processing of paper can release chemicals into the environment which is not good for the atmosphere.
- If put into a land fill, it will release methane over time which is bad for the atmosphere.

✓
- Sustainable resource
- Can be recycled over and over again
- Decomposes over time if it does go into a land fill or if left on the ground.