**Hardwood**

* Easily identifiable by their distinctive colour and grain patterns.
* Organic material which decays over time.
* Can contain knots which causes weakness
* Slow growing
* Dense

**Softwood**

* Very resinous - may leak from timer - sticky and messy
* Less dense
* Prone to water damage
* Quick growing
* Sustainable forests

* Subject to warping, bowing, cupping and splitting

Natural wood is produced naturally when a tree grows! There are many ways in which you can natural categorise woods. You will need to know...
**Aesthetics & properties**

**Mahogany**
- reddish brown
- straight, even grain
- durable, dense
- indoor furniture, window frames
- finishes well, easy to work
- prone to warping, soft

**Pine**
- pale yellow with brown streaks
- lightweight
- constructional woodwork (roof trusses)
- floorboards, toys
- grows quickly, nice colour
- prone to warping, knots can fallout

**Beech**
- light brown
- hard, tough
- workshop benches, chopping boards
- turns & finishes well
- prone to warping

**Oak**
- pale brown with distinctive growth rings
- hard, tough, dense, durable
- high quality furniture, boats
- finishes well
- contains acid which corrodes steel

**Ash**
- creamy white
- good elasticity, tough, flexible
- sports equipment, ladders
- flexible
- can splinter
Manufactured Boards

Advantages

* Waste wood is used to make MDF, hardboard and chipboard.
* Mass produced furniture is almost all manufactured board.
* Can be decorated with veneers or paint
* Available in large sheets
* Sheets of plywood and MDF are flexible and easy to bend over formers.

Disadvantages

* Sharp tools required to cut which can quickly blunt
* Thin sheets will bow if not supported
* Can be difficult to join with traditional methods (finger/ dovetail joints)
* Cutting and sanding can be hazardous due to hazardous dust particles
* Edges must be treated and covered for aesthetic reasons and stop water getting in.
Plywood
Made of layers placed at right angles
Strong in all directions, resistant to splitting
Boats, draw bottoms, construction industry
Available in large sheets, thick sheets don’t warp,
This shapes can be laminated
Thin sheets warp

Medium density fibreboard
Excellent surface finish to veneered or painted
Very dense, not affected by changing humidity levels
Flat pack furniture, kitchen units
Sheets can be formed to make 2d shapes
Not good with water

Chipboard
No grain pattern, surface often veneered
Made from waste products bonded together using strong resin, strong in all directions,
Large floor boards, shelving, flat packed furniture
Makes good use of waste materials
Not good around water, will chip/flake if not protected

Hardboard
Side very smooth, underside textured
Made from compressed fibres, soaked in resin then compressed
Draw bottoms, cabinet backs
Cheapest of manufactured boards
Not string as has no grain
Metals

Ferrous

Composed of ferrite or iron

*Almost all are magnetic
*They develop a surface oxide over time (rust)
*Known for their strength- tensile, compressive or sheer strength

Mild steel (alloy of iron&carbon)
Tough, malleable, magnetic
Structural girders, car body panels
Easily worked & joined, cheap, widely available, can be recycled
Will oxidise if unprotected, can only be case hardened

Stainless steel
Hard, tough, excellent corrosion resistance
Cutlery, sinks, pots & pans
Easily cleaned, needs no surface finishing, can be recycled
Difficult to join and use in school, specialist welding equipment is required

Carbon steel
ductile
Nails, screws, nuts
Can be recycled
Will oxidise if unprotected
Can be easily heat treated
Metals

Non-ferrous

Contain no iron & are non-magnetic

*Good conductors of heat and electricity
*Good or excellent resistance to corrosion

Aluminium
Reflective surface
Lightweight, ductile, malleable, soft
Window frames, drink cans, kitchen foil, used in alloys
Easily drawn into thin sheets or wires
Can be recycled, easily cast
Expensive, difficult to weld as specialist equipment is required.

Zink
Dull blue grey, can have a scaly appearance when galvanised
Excellent resistance to corrosion
Protective coverings for dust bins/railings
Can be recycled brittle

Copper
Over time develops a blue green surface oxide
Malleable, ductile, Electric cables, plumbing fillings
Easily drawn into wires, can be recycled, easily soldered, can be made thinner than aluminium
Expensive, will tarnish over time

Brass (alloy copper & zink)
Goldy-yellow
Good fluidity- casts well
Pluming fittings, marine fittings
Can be polished for a high-lustre finish, tougher than copper, can be recycled, easily cast & turned
Relatively expensive
Using the right words...

DUCTILITY - can be stretched into thinner smaller sections. Like thin aluminium power cables.

MALLEABILITY - can be deformed by compression without tearing or cracking. Mild steel car body panels.

TOUGHNESS - Can withstand sudden shock without fracture like a mild steel nail.

HARDNESS - Can withstand abrasive wear and indentation like a stainless steel kitchen sink.

ELASTICITY - Can return to its original shape after the force has been removed. Like a carbon steel spring!
Using the right words for strength...

TENSION - can withstand being pulled apart. Like carbon steel nails and screws.

SHEAR - the ability for a material or joint to be slid or pulled apart. Like stainless steel security shear nuts.

COMPRESSSION - can withstand being squashed like Mild steel car body panels.
Polymers (plastics)

Plastics: man-made materials, correct name is ‘Polymer’

Thermoplastics (thermoforming) are plastics shaped using heat, they are made up from long tangled chains of molecules.

Thermosetting plastics are also shaped using heat, but their molecule chains are bonded by short cross links.

* Produced with a glossy / shiny surface
  • Impervious (waterproof)
  • Can be used in clothing and upholstery by adding plasticisers during manufacturing process (e.g. PVC)
  • Available in an endless range of colours
  • Cheap & lightweight

Remember!!! Plastic is not a sustainable material! It is man-made from crude oil (a non-renewable energy source), and is one of the fossil fuels!

Some plastics can be recycled, all plastics will eventually end up in a landfill site – biodegrading takes 1000 years!!!!
Thermoplastics (thermoforming)

- Long tangle chain of molecules with no fixed pattern.
- Few cross links between the chains
- Heating allows them to soften & be formed into different shapes
- Once cool they stiffen up again

Advantages!!!
They can be re-heated and shaped many times

THINK ABOUT...
What environmental factors could you link to thermoplastics?

Their ability to return to their original flat shape when re-heated is down to them having a property known as Plastic Memory.
Polymers (plastics)

Thermoplastics

**Acrylic**
- Good impact strength (doesn’t shatter)
- Lightweight, durable, good electrical insulator
- Ornamental fish tanks, baths & bathroom furniture, car indicator covers & reflectors
- Can be recycled, environmental stability, polishes & finishes well, available in lots of colours
- Relatively soft, scratches easily, poor chemical resistance

**Polyethene (PE)**
- Resistant to chemicals
- Tough, soft & flexible good electrical insulator
- Toys, carrier bags, washing up bowls, bleach bottles, buckets, Shampoo bottles
- Can be recycled, but not easily, excellent chemical resistance. Although it can be recycled, most of its waste ends up in landfill sites

**Polyvinyl chloride (PVC)**
- Good chemical resistance
- Lightweight, durable, good electrical insulator, weather resistant, stiff, hard, tough, waterproof
- Pipes, rainwater pipes and guttering, bottles, shoe soles, window frames & fascias, waterbeds, swimming pools toys, electrical cable insulation
- Can be recycled, relatively cheap to manufacture
- Very expensive to recycle, dangerous fumes given off when burnt
Polymers (plastics)

**Thermoplastics**

- **High-impact polystyrene (HIPS)**
  - High Impact Strength
  - Tough, rigid, good electrical insulator
  - Food appliances, toys, cutlery, DVD & CD cases
  - Available in numerous colours, can be machined and painted, can be recycled
  - Expensive, limited flexibility, cannot biodegrade

- **Acrylonitrile-butadiene-styrene (ABS)**
  - High impact strength
  - Lightweight, durable, good electrical insulator, weather, tough, scratch-resistant, good resistance to chemicals
  - Kitchenware, toys, camera cases, car components, telephone cases
  - Available in numerous colours
  - Relatively expensive when compared to polystyrene
Question....

Looking at the examples of the 5 thermoplastics, what industrial forming processes can you identify?
Thermosetting plastics

- Long tangle chain of molecules with cross links
- Rigid structure
- Heating allows them to soften & be formed into different shapes once.
- Once cool they permanently harden

Advantages!!!
Good electrical insulators
Hard & waterproof when solid – idea for external adhesives.
Great for kitchen utensils that come into contact with heat.

You will need to know:
- Polyester Resin
- Urea Formaldehyde
Both are good materials for plugs and sockets, and also make excellent external adhesives

THINK ABOUT...
What environmental impacts can a thermosetting plastic cause?
Polymers (plastics)

Thermosetting plastics

Polyester Resin
- Good electrical insulator
- Hard, brittle, good heat & chemical resistance, resists UV radiation
- Casting, encapsulating biological specimens, boat hulls with fibreglass, model figures, adhesives, filler materials
- Can be mixed with pigments to achieve a range of colours, good resistance to water
- Contracts on curing, can cause excess heat when too much water is catalyst is used.

Urea Formaldehyde
- High tensile strength
- Stiff, hard, brittle, scratch resistant, stain resistant
- Tableware, worktop laminates, buttons, electrical castings
- Can be coloured, high surface hardness
- Toxic fumes given off when it cures
Properties of plastics
Choosing the right polymer to use depends on the properties of:

- Plasticity
- Durability

**Plasticity** (Property)
Ability to change shape without cracking or breaking
Acrylic, ABS
Moulded products such as shampoo bottles, garden chairs

**Durability** (Property)
Ability to withstand weathering, deterioration, or corrosion
Generally all plastics, some will fade in colour over time if exposed to UV to too long
Garden furniture, window and door frames, rainwater pipes and guttering
Composite materials

Carbon Fibre & Glass Reinforced Plastic

These are groups of materials made up from two or more materials in layers or a mixture.
Carbon Fibre

- Material made up of very thin fibres (0.005-0.010mm in diameter)
- Mostly carbon atoms
- Thousands of stands can be twisted together to form threads, these can be woven into fabrics.
- Combined with a resin known as the matrix, usually epoxy resin, to form new materials
- New material has new physical and chemical properties from those originally shown by the two separate materials
Composite materials

Carbon Fibre

**Properties**
- High Tensile Strength
- High strength to weight ration, very strong compared to its weight.
- Stiffness – can be formed to create products & components where great stiffness is required (F1 cars & aircraft industry)
- Golf clubs shafts, skis, bike frames forks and wheels, yacht & powerboat hulls, racket frames, fishing rods, helicopter rotor blades, aircraft fuselages, high quality musical instrument bodies

**Advantages**
- High strength to weight ration
- High tensile strength
- Weave of the cloth can be chosen to maximise strength & stiffness of component
- Can be woven in different patterns to create aesthetically pleasing surface patterns
- Very expensive

**Disadvantages**
- Weak when compressed, squashed, or subjected to high shock or impact
- Small air bubbles or imperfections will cause weak spots and reduce overall strength
Glass Reinforced Plastic (GRP)

- Plastic reinforced with very fine fibres of glass
- Commonly known as fibreglass
- Polyester Resin, or Epoxy Resin are the thermosetting plastics that usually act as its matrix
- The fibreglass and the resin work together to overcome the weaknesses of each other
Composite materials

Carbon Fibre

Properties
Good strength to weight ratio
Resin is strong in compression and weak in tension, whereas the glass fibres are weak in compressive strength but are strong in tension.
When combined, GRP resists both compressive and tensile forces.
Can be formed into any 3D shape
Lightweight & low maintenance

Uses
Architectural mouldings (that would normally be too heavy), boat hulls, canoes, car body panels, chemical storage tanks, septic tanks, train canopies

Advantages
Lightweight, low maintenance, endless colour choice, formed into a wide range of 3D shapes, good strength to weight ratio, surface texture can be added, durable, good resistance to UV light and sea salt

Disadvantages
Difficult to repair, time consuming to make, labour-intensive process, extraction required due to the toxic nature of materials involved, cutting produces fine dust which is dangerous when breathed in, requires production of a mould for shapes to be formed around, resins and catalysts have a limited shelf life
Shape Memory alloys – they remember their original cold formed shape. These use Nitinol.

Unbreakable Glasses

Orthodontic wires - they apply a more gentle pressure over a longer time so you don't need to go to the dentist so often.

Smart Materials

Anti-scalding valves - above a certain temperature the device automatically switches off.

Good elasticity, strong in tension and lightweight. But they are expensive compared to steel and aluminium.
Photochromic paint—changes colour when exposed to UV light or sunlight then reverses back. They can be mixed with paints or polymers.

Smart Materials
Used a lot in the textiles and clothing industry

Have many creative abilities however over time the ability to change will decay (natural fatigue)
British fashion student Georgie Davies, in collaboration with Sony Ericsson, designed and developed a working prototype of a dress that animates and lights up when you receive a call. The dress is designed to wirelessly connect to a phone via bluetooth. When the wearer receives a call, the translucent white scales that embellish the dress move and light up.

I'd love to see the movement of the scales but unfortunately I could not find any video footage. Also from the looks of all the wires coming out of the mannequin, the prototype isn't very wearable considering it needs to be plugged in.

As you may have noticed, tennis star Maria Sharapova modelled off the dress to photographers and a crowd of passers-by from the window of a luxury store in central London.
**Smart Materials**

**Reactive glass** – types of glass that can change colour when exposed to UV light, or has a voltage applied to it.

Most common use is glass in spectacles. It darkens when exposed to UV radiation, so no need for 2 pairs of glasses!

During its manufacture, **silver halide microcrystals** are added – allowing it to react to UV radiation.

**Smart glass / switchable glass** changes from transparent to opaque when a voltage is applied – its most common use is in windows, skylights & offices.

Expensive to manufacture in both cases, and install – the time delay of photochromic glasses can cause difficulty when driving.
Carbon Nanotubes—cylindrical nanostructures made from carbon molecules.

Really useful in the world of electronics, optics and medicine, however, they can be included into clothing & sports equipment & military body armour.

* They are used in the miniaturisation of electrical products.

- 6x lighter than steel, 500x stronger
- Flexible as plastic
- Used to strengthen plastic on cars
- Added to paint to give a hard tough finish

Expensive to manufacture and are toxic, so are restricted in use of medicines. Super tensile strength, good electrical conductors, tough and chemically inert.