Year 11 Knowledge organiser— Material properties

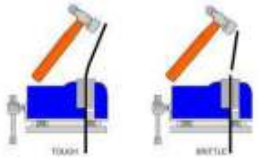
Working properties

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 11 Knowledge organiser— 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 11 Knowledge organiser— 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 11 Knowledge organiser— 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 11 Knowledge organiser— POLYMERS

Thermoforming plastics

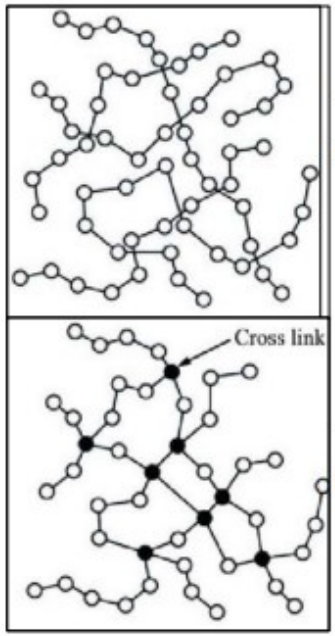
This group, known as thermoplastics, is generally more flexible, especially when heated. They can be formed into complex shapes and many can be reformed multiple times.

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.



Thermoforming 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 11 Knowledge organiser— TEXTILES

Natural fibres

Name	Characteristics	Uses
Cotton	Soft and strong, absorbent, cool to wear and easily washable. Cotton fabrics can be given a brushed finish to increase their thermal properties.	Most clothing, especially shirts, underwear and denim can be made from cotton. Also used for towels and bedsheets.
Wool	From fine and soft to thick and coarse, it is warm and naturally crease resistant. Can shrink. Often blended to add functionality.	Jumpers, coats, suits and accessories worn for warmth. Specialist wools are very soft and expensive. Felt products and carpets.
Silk	Very soft and fine finish, gentle on skin, can feel cool in summer yet warm in winter, drapes well, absorbent, strong when dry (weaker when wet), tricky to wash, can crease easily and is usually expensive.	Luxury clothing including nightwear and underwear, soft furnishings, bed sheets, silk paintings and wall hangings.

Woven fabrics

Name	Characteristics	Uses
Plain Weave	SImple and cheaper to produce than more complicated weaves, stronger than other weave patterns.	Used on textiles such as cotton calicos, cheesecloth and gingham, found on table cloths, upholstery and clothing.

Key Questions

- **Define the term non-woven fabric.**
- **What is felting?**
- **Define the term woven fabric.**
- **What is the warp and weft?**
- **What does a fabric that has a plain weave in it look like?**
- **What are blended and mixed fibres?**
- **Give an example and its characteristics of a bended or mixed fibre.**
- **Define the term knitted textiles.**
- **What is weft knitting?**
- **What is warp knitting?**
- **What are the two categories of natural fibres?**

Non-woven fabrics

Name	Characteristics	Uses
Bonded fabric	Fabrics lack strength, they have no grain so can be cut in any direction and do not fray.	Disposable products such as protective clothing worn for hygiene purposes, tea bags, dish cloths and dusters.
Felted Fabric	Can be formed with moisture and heat; once dry it has no elasticity or drape, and can pull apart easily. Woolen varieties can be expensive.	Hats, handicraft, pads under furniture to prevent scratching, soundproofing and insulation.

Synthetic fibres

Name	Characteristics	Uses
Polyester	Tough, strong, hard wearing, very versatile, holds colour well, non-absorbent so quick drying, machine washes well. Often blended with other fibres. Easily coloured.	Clothing, fleece garments, bedsheets, carpets, wading, rope, threads, backpacks, umbrellas and sportswear.
Nylon	Good strength, hard wearing, non absorbent, machine washes well, easily and frequently blended.	Clothing, ropes and webbings, parachutes and sports material. Used as a tough thread on garments.
Lycra	Added to fabric to enhance working properties, particularly to add stretch. Allows freedom of movement, quick drying, holds colour well, machine washable.	Sportswear, exercise clothing, swimsuits, hosiery, general clothing, surgical and muscular supports.

Knitted textiles

Name	Characteristics	Uses
Knitted Fabric	Warm to wear, different knits have different properties such as stretch and shape retention. Weft knits ladder and unravel more easily than warp.	Jumpers, cardigans, sportswear and underwear fabrics, socks, tights and leggings, craft items such as soft toys.