The English Martyrs Catholic School and Sixth Form College

Year 11 Knowledge organiser

Product Design

A Member Of Bishop Hogarth Catholic Education Trust

Name:

WJEC GCSE D&T Core knowledge and understanding 2.1.1 (c):

How energy is generated and stored

Renewable and non-renewable energy sources

There are two types of energy sources – **renewable** and **non-renewable.**

- Renewable energy sources include wind, solar, tidal, geothermal, biomass and hydro-electric.
- Non-renewable energy sources include coal, oil, gas and nuclear.

Renewable energy sources are often referred to as 'clean' or 'green' energy sources, because they come from a natural supply that is continuously replaced.

Non-renewable energy sources are often called 'dirty' and 'fossil fuels'. Coal, oil and gas are available in different parts of the world, but in limited amounts. Non-renewable energy sources often need to be extracted from the earth and sometimes processed, which can give off pollution and be very damaging. We currently depend highly on non-renewable energy sources, so a shift to 'greener' sources is underway and developing more and more.

Wind farms use turbines.

Coal fired power stations create lots of pollution.

Advantages and disadvantages of renewable energy

Wind power has relatively little impact on the environment, although some people consider turbines to be unsightly, or 'visual pollution'. They are expensive to install, and reliable when there is wind. Turbines can affect wildlife, particularly birds.

Solar energy is expensive to set up, and is very dependent on sunny weather conditions to be at its most productive, although some electricity will be generated on cloudy days. Home owners fitting solar panels to their roofs can find them space-consuming too. Storing solar energy can also be difficult and expensive.

Tidal systems are expensive to set up and can damage ecological coastlines and harm marine life. Tidal power generates power for around 10 hours per day. It is around 80% efficient, better than solar or wind-based systems.

Geothermal energy uses 'hot spots' where molten rock close to the earth's crust generates hot water. In some locations, geothermal systems involve drilling into the earth's surface to reach deeper geothermal resources, allowing broader access to geothermal energy. This is a very high-cost resource and also risks triggering earthquakes.

Manufacturing using renewable energy

Industrial and commercial manufacturing plants and factories around the world are implementing alternative methods of power generation from renewable energy sources, in order to increase production and reduce their energy usage.

Currently, about 66% of the energy used by the industry and manufacturing sector is fossil fuels, with a small percentage of renewable energy and biofuels.

Government targets

The UK government has made a commitment for the UK to be net zero emissions by 2050.

This includes increasing clean wind energy, slashing carbon emissions and increasing offshore wind capacity.

Fossil fuel powered road vehicles

By 2030, the UK will ban the production of petrol- and diesel-powered cars. Some hybrid vehicles that use both electricity and petrol or diesel will still be allowed to be produced until 2035.

In addition to some cities having congestion charges to help reduce congestion and pollution, electric vehicles and hybrids are becoming a more popular choice for motorists. There is often reduced or no road tax, as these vehicles are very clean and some produce zero emissions. Lots of car manufacturers are now producing fully electric cars, however battery technology and charging facilities remain problematic.

WJEC GCSE D&T In-depth knowledge and understanding 2.1.2:

Product design (c) ferrous and non-ferrous metals

Ferrous metals

- **Metals that contain iron and are magnetic are ferrous metals.**
- **They are prone to rust and require a protective finish to prevent corrosion.**

Cast iron is brittle if thin, can be cast in a mould, has strong compressive strength, good electrical and thermal conductivity, but poor resistance to corrosion. It is used for gates, manhole covers, drains and vices.

High carbon steel, also known as tool steel, is hard and brittle, less malleable than mild steel and is a good electrical and thermal conductor. Uses include tools, screwdrivers, and chisels.

Low carbon steel or mild steel is ductile and tough, easy to shape, braze and weld, a good conductor of heat and electricity, but again corrodes easily. Popular for nuts and bolts, screws, bicycle frames and car parts.

Alloys

An alloy is a mixture of metals with an element to improve its working properties or aesthetics.

- Brass is an alloy of copper and zinc.
- Bronze is an alloy of copper, aluminium and/or nickel.
- Stainless steel is an alloy of iron and chromium, nickel and magnesium.

Non-ferrous metals

- **Metals that do not contain iron and are not magnetic are non-ferrous metals.**
- **They are metals that do not rust.**

Aluminium is lightweight, malleable and strong. A good conductor of heat and electricity. Used in drinks cans, cycle frames and saucepans.

Copper is very malleable and an excellent conductor of electricity and heat – perfect for plumbing and central heating applications. It is orange/brown when polished, but will oxidise green.

Silver is a precious metal used in jewellery, it is soft and malleable when hot, highly corrosion-resistant and a good conductor.

Alloys: properties and uses

Brass is a non-ferrous alloy that is strong, ductile and a good conductor of heat. It works well when cast, is golden in colour but darkens with age. Used for taps, door fittings, hinges, locks and door handles. Due to its workability and durability, brass is commonly used for musical instruments.

Bronze is another non-ferrous alloy. It is hard and corrosion resistant, making it useful for bearings (due to its low friction) and outdoor mechanical components and monuments. Darker than copper, it is more reddish-brown. Bronze is also used in nautical applications due to its corrosion resistance.

Stainless steel is a ferrous alloy that is shiny silver when polished. It is hard and tough with good resistance to stains and corrosion. Used extensively in kitchen sinks, cutlery and hospital equipment. Stainless steel is also used in architecture, aerospace and general transport.

Properties of metals

- **Hardness –** a metal's ability to withstand friction and abrasion.
- **Toughness –** how well a metal can resist fracturing when force is applied.
- **Elasticity –** the rate at which a metal distorts in size and shape under stress.
- **Conductivity** – how well a metal allows electricity or heat to flow through it.
- **Ductility –** the ability of the metal to be drawn or deformed without fracture.
- **Tensile strength** – the amount of load a metal can withstand before failure.
- **Malleability** – the metal's ability to be bent or shaped easily.

Finishing metals

Metal finishing is the process of placing a coating onto a metal for cleaning, polishing or improving the surface in a functional or visual context. Finishing is the last step in the manufacturing process to provide environmental protection and improve aesthetic qualities. Popular finishing processes for metals include electroplating, anodising, powder coating, hot blackening, brushing, sand blasting and buff polishing.

WJEC GCSE D&T In-depth knowledge and understanding

2.1.2: Product design (e) modern and smart materials

Modern materials

- **These are materials that are relatively new and have specific working properties and performance characteristics.**

Carbon fibre is a material that has several advantages including high stiffness, high tensile strength, low weight, high temperature tolerance, high chemical resistance, low thermal expansion and resistance to corrosion. Carbon fibre is created when carbon atoms are bonded together in crystals and can be woven into fabric. Carbon fibres are usually combined with other materials to form a composite. Commonly, fabrics or matting made from woven carbon is bonded in layers to create complex shapes for performance products like racing bicycles, Formula One cars, aerospace vehicles and many sporting products where strength, lightweight properties and speed are essential.

Kevlar is another newer material with special performance characteristics. Kevlar is a heat resistant and strong synthetic fibre with the ability to stop bullets and knives form penetrating it. Kevlar is often described as being five times stronger than steel for its weight. It can be woven into different shapes and remains lightweight and flexible, which is ideal for protective vests.

GRP or Glass Reinforced Polymer is also called fibreglass. Fibre strands are embedded into a polymer resin matrix, resulting in high compressive and tensile strengths in the finished products. Many products are made from fibreglass including fun water slides, jacuzzis, car body panels, boats and roofing products.

Smart materials

- **Smart materials can display a physical change due to external stimuli.**

A smart material is a category of materials that react when something triggers them. It can be a change in temperature or light for example.

QTC or **Quantum Tunnelling Composite** is a black rubbery material which is an electrical insulator, but when placed under compression, it becomes a conductor. It is used in clothing, smart phones and outdoor equipment, normally as a material to make an electrical switch.

Photochromic pigments or film are used to change colour in ultraviolet (UV) light. This is used in spectacles that automatically darken as the sunlight gets brighter. It is useful in high-rise buildings and office blocks to prevent strong sunlight penetrating inside.

Thermochromic pigments are useful when used in baby products like spoons, bottles and bath toys. This allows the product to change colour to indicate temperature.

Shape memory alloys or **SMAs** are materials that change their shape when heated. Spectacle frames made from Nitinol can be returned to their original shape easily. Also, dental braces made from Nitinol can help straighten teeth.

Polymorph is a polymer that becomes malleable at 62°C.

Differences between modern and smart materials

Modern materials are designed to have specific properties and characteristics, so that they can be used to improve existing materials used in products. Smart materials have unique changes that occur in response to external stimuli, making the smart material react in a clever way.

Styrofoam

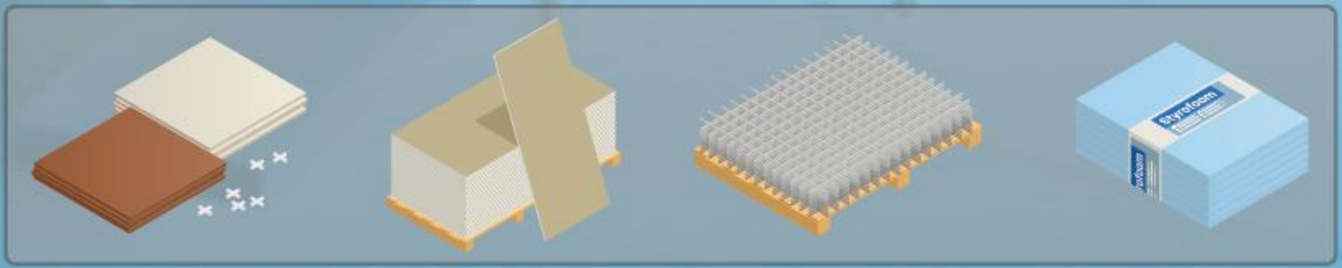
Styrofoam is a trade name for expanded polystyrene foam also called blue modelling foam. It can be purchased in a variety of sheet sizes and thicknesses. It is easy to cut, shape and work, and has excellent insulation properties.

Modelling foam board

Modelling foam board or white foam board is an eco-friendly versatile material used for framing, mounting design work and creating scale architectural models.

Available in different thicknesses, foam board is a dense layer of foam sandwiched between two thin card faces. It will take ink, print, paint and toppers. It is completely non-toxic and acid free, with anti UV finishing to resist yellowing over time.

Modelling foam board is easy to cut, leaving a clean finish in this sturdy material. It can also be laser cut.



WJEC GCSE D&T In-depth knowledge and understanding 2.1.2:

Product design (b) natural and manufactured timber

Hardwoods

- This wood comes from trees that lose their leaves during autumn.
- Hardwood trees are slow-growing and therefore less amounts are available, which makes it more expensive.

Oak is a moderate brown colour with close, straight grain. Oak is a tough and durable hardwood, it polishes well and is used for high quality furniture, doors, skirting and staircases.

Beech is a pink-tinted, closely grained hardwood. Beech is a very tough and durable material and is smooth to finish. It is popular with products that require a hard-wearing and robust material.

Mahogany is a dark red/brown hardwood with very close grain. It cuts and polishes easily, and gives a deep finish, popular for furniture and cabinet making.

Natural timber availability

Hardwoods and softwoods are available in a variety of forms including plank, board, strip, square and dowel. Natural timbers need to be cut at the sawmill and seasoned before use. Many are planed and cut to standard sizes ready for sale.

Softwoods

- This wood comes from trees that are evergreen, possibly bearing pinecones and needles, not leaves.
- Softwood trees grow quicker and in more locations. They are readily available and less expensive.

Pine is a pale-yellow coloured wood with darker brown grain. It is lightweight, easy to work, used for construction and furniture products.

Cedar is lightweight, pale with even texture. It is more expensive than pine but not as strong. Good for outdoor use, fencing, decking and shed construction.

Larch is a darker shade with brown grain, used for exterior cladding and boats, as it is water resistant and durable. It is **more expensive than other softwoods.**

Manufactured board

Man-made boards like MDF (medium density fibreboard), plywood and chipboard are all manufactured boards. They are made from wood fibres, normally collected from recycled wooden materials, bonded together with resins to form sheets.

MDF is made from small fibres which are mixed with a wax and resin, then heated and compressed into the desired thickness. MDF has no grain, and is easy to work. It is popular for interior DIY furniture.

Chipboard is made from small 'chips' of timber bonded together to produce a dense sheet. Kitchen worktops can be made using chipboard with an additional veneer applied for aesthetic and functional purposes.

Plywood is made from layers of wood, bonded together at an angle of 90 degrees to increase strength and rigidity. Sometimes, the facing layers can be high quality, e.g. birch, to provide a better aesthetic finish.

Finishes for hardwoods and softwoods

Surface finishes can be aesthetic and functional. High-traffic areas like floors might require a hard-wearing and sealing finish like polyurethane, which can be oil or water based, and matt, semigloss or high gloss finish.

Waxes and oils are popular to provide enhancement of the natural grain in the wood.

Stains and varnishes help to add colour to natural wood, and even change colours to match colour schemes. Preservatives are sometimes used to provide protection and ensure the wood is long-lasting.

Finishes for manufactured boards

Man-made boards like plywood are often finished depending on the visibility of the veneers. Plywood can have natural grain on the face veneers, so a spray-on lacquer or a paint-on varnish might be best.

MDF can be stained to match other natural woods, or it can be painted. However, as MDF is very porous, it is best to seal any exposed edges first to avoid paint being absorbed.

Chipboard can look unattractive and is normally finished with a veneer. On kitchen worktops, this is a melamine layer that provides heat, scratch and water resistance, and a variety of colours and patterns that can enhance the look of the user's kitchen.

WJEC GCSE D&T Core knowledge and understanding 2.1.1 (b):

New and emerging technology, ethics and environment

Life Cycle Analysis (LCA) includes:

- the source of materials for the product or component
- the energy used and pollution caused when manufacturing
- the energy used and pollution caused during a product's useful life
- the disposal of the product at the end of its useful life.

Designers and consumers consider these before purchasing a product. These factors can often influence purchasing decisions.

New or emerging materials, manufacturing methods or energy sources can often provide opportunities for greener products. This could be a more eco-friendly material or a self-repairing material. For example, the inner tube in the tyre below, which contains a sticky liquid that hardens when it contacts air – a perfect cure for punctures.

The Six Rs of Sustainability

Designers can often improve products by using the Six Rs. **REDUCE, REUSE, RECYCLE, REPAIR, RETHINK REFUSE** can often provoke innovation in products.

Better build quality can improve a product's performance during its expected life – designers can ensure that products are easy to service, maintain and repair.

Planned obsolescence is producing a product that is intended to last for a specific time span. This allows newer products to be introduced to succeed previous versions.

'Cradle to cradle' is a concept of taking a product from start to finish. 'Cradle to cradle' looks at putting a product to good use at the end of its life to create a new product.

Ecological footprint

Ecological design can be defined as solving problems alongside minimising environmental damage. Designers must solve problems without creating other problems. Eco is about nature, living things, cycles and patterns.

Eco-efficiency refers to moving towards sustainable development – creating goods, products and services to satisfy user needs and wants while reducing ecological impacts and resource depletion. After all, any natural resources that we use will eventually run out!

The footprint of a product is a measurement of the environmental impact from cradle to grave.

Fair trade

This is an arrangement to help producers in developing countries to achieve trade relationships with other countries. It promotes sustainable development by improving trading conditions, including the rights for the workers.

Worker exploitation

Different countries have different laws about employment for workers. Sometimes workers can be exposed to unfair working conditions including poor or unfair levels of payment. This includes child labour.

Social, cultural, economic and environmental responsibilities

Designers and manufacturers have a duty to ensure that their decisions do not infringe certain codes and laws.

Social – products must not have an unforeseen side effect on a group of people.

Cultural – ensuring that a product is acceptable and not offensive for a specific group.

Economic – ensuring that financial decision making is good for the product. This could relate to material selection, profit margins, running costs or energy efficiency.

Environmental – recently, a lot of legislation and laws have been passed to enforce certain conditions. Many manufacturers now have to comply with targets on lowering CO_2 (carbon dioxide) emissions.

WJEC GCSE D&T In-depth knowledge and understanding 2.1.2:

Product design (a) papers and boards

Categories of papers and boards

Papers and boards are made from wood pulp which originates from trees. Wood pulp is rolled out into thin sheets at an industrial setting called a papermill.

- Paper density is measured by weight in grams per square metre (gsm).
- Paper comes in standard sizes, A0 is the largest, down to A10 (postal stamp size). In schools, A4 and A3 are very common paper sizes.

Types of paper

- Tracing paper (40 – 90 gsm) – translucent, smooth and strong, non-absorbent. Used for copying sketches and drawings, used as an overlay.
- Layout paper (50 gsm) – smooth, translucent and cheap to purchase. Great for designing, sketching and developing ideas.
- Copier paper (80gsm) – smooth, opaque, clean white finish. Uncoated and finishes well when printed on. Also used for photocopying.
- Cartridge paper (80 – 140 gsm) – thick, textured surface finish, a creamy off-white colour. Works well with paints, watercolours, pastels and inks.

Boards

Board is categorised by weight as well as thickness. The thickness of board is measured in microns, with one micron equal to 1/1000th of a mm.

Corrugated cardboard (3000 microns) – strong and lightweight, with two or more layers of wavy 'fluted' sheets to provide additional rigidity. Corrugated card is available in different thicknesses, making it perfect for packaging various items. It is fully recyclable, but not water-resistant.

Mounting board (1400 microns) – has a rigid and smooth surface, normally black and white in colour but available in other colours. It is popular for framing mounts, scale architectural modelling and concept designs.

Folding boxboard (300 – 1699 microns) – This is a stiff board normally made from recycled paper. It scores and folds well, bending without splitting, perfect for packaging supermarket foods.

Laminating papers, cards and boards

Some materials can be coated to add thickness, weight and strength for specific purposes. This additional layer is known as laminating. Many food containers and drinks cartons are laminated to ensure food and drinks are retained effectively and hygienically, and to keep produce fresh. Laminated cardboard is also good for book binding.

Adding surface finishes to papers, cards and boards

Surface finishes can be aesthetic and functional. Varnish can be added to card to give a glossy finish. Sometimes, part of a logo or brand name is varnished so that it stands out to the customer from the rest of the detail. Edge staining is another finishing process where dye is applied to the edge of a book to improve visual quality. UV (ultraviolet) varnishing produces a high-gloss finish on card, which is great for marketing materials like business cards. Embossing is a process that can create raised patterns or shapes in card and paper, usually by stamping. This is popular in greetings cards, perfume boxes and invitations.

Folding ability and absorbency

Some uses require materials to remain rigid, and to resist folding or creasing, such as corrugated cardboard coffee cups. These need to insulate heat, retain hot liquid, and must not leak. Other products, like sandwich containers, are die cut, flat packed items that erect easily to provide display, packaging and keep food stuffs fresh. These have crease lines, fold easily, and are again waxed inside to resist absorbency.

Greener solutions

A lot of paper-, card- and board-based packaging is designed to be easily fully recycled. This provides a 'cradle to cradle' approach and reduces waste and the need for new materials. Reusability is also high, where containers can be washed and used again for the same or similar purposes.

WJEC GCSE D&T Core knowledge and understanding 2.1.1 (e):

Ecological and social footprint of materials and components

Changing society's views

There are many ways in which society is encouraged to reduce waste and recycle more, because:

- 90% of waste is dumped or burned, mostly in low income countries
- lots of poorly managed waste contaminates the world's oceans
- waste causes clogging of drains, flooding, the spread of disease and harm to wildlife.

Recycling – with economic development and population growth, the generation of waste will also increase. High income countries provide nearly universal waste collection, and more than one third of waste in high income countries is recovered through recycling and composting.

Low income countries collect about 48% of waste in cities, but only 26% in rural areas, and only 4% is recycled.

Overall, only 13.5% of global waste is recycled, and 5.5% is composted.

The circular economy refers to society putting waste back into a good use and continuing this cycle. This means that once a material, component or product comes to the end of its useful life with the owner, it is disposed of and becomes re-usable in some way. This prevents new materials being required, saving resources and reducing waste.

Designers need to build this kind of thinking into products!

Living in a greener world

Being kinder to the planet should be on everyone's minds, but especially designers who are producing products for users in today's world.

- Waste food is a problem in most households, so portion control and re-using leftovers will help.
- Cutting down on packaging is a great way of reducing unnecessary waste that is not really an essential part of the product we purchase.
- Reducing plastics where possible will be a massive gain. Plastics can be difficult to recycle and biodegrade, so finding an alternative would be very helpful.
- Recycling waste correctly is another area for improvement.
- Repairing products or choosing not to upgrade when a newer version becomes available can be beneficial.
- Green energy should be used where possible.
- Greener travel options, car sharing, or cycling should be chosen instead of driving, where possible.
- Economise your home – optimise your 'white goods' to operate correctly. Set your fridge and freezer to eco settings if possible, turn off lights when not needed, and try to lower the central heating thermostat – wear another layer instead.

Before purchasing a product, think about its Life Cycle Analysis (LCA). Consider where the material comes from, how the product has been made, running costs and eventual disposal.

Opt for sustainable design

Whether you are a designer or consumer, making the right choice is critical. **Sustainable, eco or greener alternatives** are much better for the environment. They have been designed and manufactured with minimising damage and promoting sustainability at the core.

Average life of a mobile phone

Research reveals that the average life of a mobile phone is two and a half years, and 15 to 18 months for a smart phone. Often, this short life is because the user has damaged the device, dropping or breaking the screen for example, which requires replacement. Using a protective cover is one option to improve the life of the phone. Mobile phone manufacturers often release new models frequently to replace previous versions. This is known as 'incremental' development and can help ensure consistent sales.

Products using 'greener' power supplies

Solar power can often improve energy consumption for users and also makes the product more flexible and less reliant on 'plugging in'. Photovoltaic (PV) cells can be used as power supplies and 'trickle chargers', converting free sunlight into electricity.

Wind-up technology offers far more opportunities for designers. A wind-up torch uses the mechanical movement provided by turning the handle of the device. This can then operate without the need for batteries.

WJEC GCSE D&T In-depth knowledge and understanding

2.1.2: Product design (f) sources, origins, physical and working properties of materials, components, systems

Metals

- **Ferrous metals contain iron.**
- **Non-ferrous metals do not contain iron.**
- **Alloys are combinations of a base metal with other metals or non-metals.**
- **Metals are sourced from ores, which are a natural resource and will run out.**

Metals can be conditioned and finished using heat treatments. These include:

Annealing – heating then slowly cooling the metal to remove stress, make softer and refine structure.

Normalising – heating and then cooling the metal at room temperature, reducing hardness and increasing ductility.

Case hardening – This hardens an alloy's surface by adding carbon, heating and quenching.

Tempering – applied to steel and cast iron, increasing toughness and reducing hardness and brittleness. Tempering involves heating to a high temperature and air-cooling.

Hardening – heating and then cooling the metal rapidly by submerging into a liquid or oil.

Ferrous metal	**Melting point**
Mild steel	1300˚C
Cast iron	1200˚C
Non-ferrous metal	**Melting point**
Aluminium	660˚C
Brass	900˚C
Copper	1100˚C

Natural and manufactured timber

- **Natural timber is grown on trees!**
- **Manufactured timbers are man-made.**
- **Timbers are categorised into hardwoods and softwoods.**

Hardwoods come from trees that shed their leaves in colder months. These trees take longer to grow, and these woods are more expensive. Common hardwoods are oak, beech, balsa and jelutong.

Softwoods come from coniferous trees that are green all year round and often have pinecones and needles. They are faster-growing than hardwoods and more easily available, which makes them less expensive. Scots pine, western red cedar and Parana pine are all common softwoods.

Manufactured boards are normally made from recycled wooded waste, mixed with additives including adhesive. Popular man-made boards are MDF (Medium Density Fibreboard), chipboard, hardboard and plywood.

Hardwoods and softwoods must be **seasoned** before use. This could be by kiln drying or air drying, to ensure all moisture is removed to **prevent shrinkage.**

Hardwoods tend to have close grain and are normally polished to enhance their natural aesthetic. Beech has a pink tint, and oak light-mid brown. Balsa is pale with widely spaced grain as it is a fast-growing hardwood (even though it is soft and lightweight).

Softwoods tend to be yellow/pale with contrasting grain, and sometimes knots.

Polymers

- **Polymers that can be heated and shaped repeatedly are called thermoplastics/ thermoforming.**
- **Thermosetting polymers (or thermosets) can only be heated and shaped once.**
- **Some polymers are natural, some are synthetic.**

Common thermoplastics include acrylic, polythene, polypropylene, Styrofoam, polystyrene and nylon.

Common thermosets include melamine, urea formaldehyde and epoxy resins.

Papers and boards

- **Paper is made from wood pulp.**
- **Paper is fully recyclable, reducing the need for wood fibres from trees.**

Paper is used for sketching, printing, and newspapers. It is measured in **gsm** (grams per square metre).

Card is thicker and is measured in **microns.** Card can be reinforced by adding a 'wavy' layer between two flat layers, to make **corrugated card.** It is brilliant for packaging. Paper and card need to be scored before bending.

Papers and boards can be textured, embossed, and have specialist coatings and finishes applied for specific purposes. Most papers and boards are printed on, some are laminated to ensure they retain a liquid and are not absorbent.

2.1.2: Product design (k) appropriate surface treatments

Metal surface treatments – these can be for:

- functional reasons, to improve the performance of the material/product
- aesthetic reasons, to improve the visual appearance of the material/product.

Metals

The following finishes are commonly applied to metals:

- powder coating
- galvanising
- enamelling
- oil and wax finishing
- primer/paint
- electroplating.

Surface preparation for finishing metals

The removal of dust, grease and rust is critical before applying a finish to a metal surface. Some finishes need grip to adhere to some metals, so it is important to key the surface to accept the finish.

Surface treatment of timbers

Timbers are finished with both functional and aesthetic applications, depending on the location of the product/timber and the desired outcome. Timber finishes are varied and include:

- varnishes
- wood stains
- oils
- polishes
- preservative finishes
- paints.

Applying finishes to timbers

Painting provides a colourful finish but also protects the timber. Glossy, matt or silk paints can be applied with a brush, roller or sprayer. Some include a primer too.

Wood stain is applied to enhance the appearance of the wood. Stains can also provide some protection but normally a coat of varnish is used to seal the stain.

Oil and wax soak into the timber and can enhance its appearance, whilst repelling moisture and water.

Varnish provides a shiny coat, usually applied in layers to make it more durable. Glossy and matt style varnishes are common.

Dip-treating timber protects the surface of the material, but outdoor timber fences tend to be made from pressure treated timber, which is far more long-lasting.

Self-finishing polymers

Some plastics are called self-finishing. This means that once they are formed into their desired shape using a mould, their surface will require no further finishing.

Vacuum forming will allow a flat, glossy sheet material to take the shape of the mould or former, and the outcome will be a duplicate of the surface of the mould or former used.

Finishing processes applied to paper, card and board products

Sometimes, a finishing process when manufacturing a paper, card or board product can be:

- stamping the shape out of a sheet (die cutting)
- a specialist finishing process like UV varnishing e.g. on a business card
- a texturing process like embossing or debossing, which creates a raised or lowered surface finish e.g. in a greeting card or wedding invitation.

Folding process

Some paper, card or board products, such as greetings cards, menus, or invitations need to be folded in order to be posted, delivered or to stand up once in use.

To fold a paper, card or board, normally a crease would be applied so that the material bends without breaking, tearing or weakening. Sometimes a perforated line or score is applied so that the material bends or folds in exactly the right place.

Binding products

When a book or pamphlet is bound, it needs to open without any of the separate pages falling out or becoming removed. Hand stitching is a skilled and time-consuming process that fixes pages together, but comb binding is a less specialist and more common method. This is when holes are punched so that a plastic bind can hold the pages in order.

Other finishing processes to bind products include stapling and using split pins.

Thermosetting and thermoforming polymers

There are two different types of manufactured / synthetic polymers:

- Thermosetting polymers
- Thermoforming polymers

Keyword: polymer

◊ *A scientific term for a fibre that has a molecular structure made up of smaller units bonded together.*

- Thermosetting and thermoforming polymers are used throughout textiles but for different purposes.
- The classification of these polymers are the same ones listed under synthetic (or manufactured) fibres.

Thermosetting polymers

◊ These polymers can be heated and formed into a specific shape – often complex shapes.

◊ On cooling these polymers cannot be reheated or reshaped.

◊ This makes thermosetting polymers difficult to recycle.

◊ Textile components such as plastic clips and buckles, can be made from thermosetting polymers.

◊ Plugs on sewing machines and other electrical equipment are made from a thermosetting polymer.

◊ Polyester resin is a thermosetting polymer used to bind the fibres in CFRP (carbon fibre reinforced polymer).

Thermoforming polymers

- These can be softened by heating and formed or moulded into a required shape – in pleating or moulding fabrics for example.
- On cooling, thermoforming polymers retain the new shape.
- Polyester, nylon, polypropylene and acrylic are all thermoforming polymers.
- Thermoforming polymers can be reheated and reshaped making recycling possible.
- Polyester and nylon work well in the process of pleating as they are pliable above a certain temperature but will not melt.
- Polythene, polystyrene and polyvinyl chloride (PVC) are also thermoforming polymers but are not as widely used in fashion garments.

Pleated polyester satin fabric – a thermoforming polymer

Electric 3-pin plug — a thermosetting polymer

Working properties of fibres and fabrics

- **Tensile strength**: refers to the force needed to break a fibre.
- **Strength**: the higher the number of interlacing yarns, the stronger the fabric. Twill weave is stronger than plain weave for example.
- **Elasticity**: the extent a fibre will stretch before breaking and how well it recovers after stretching.
- **Absorbency**: the fibres' ability to take in or soak up moisture without feeling wet.
- **Durability**: refers to the fibre or fabrics ability to withstand wear and tear when subjected to friction.
- **Insulation**: the ability to trap air (gaps in between fibres or yarns) and retain heat allowing the fabric to act as an insulator, for example knitted fabric.
- **Flammability**: how easily a fibre or fabric burns. An open structure on a fabric will burn more easily. Cotton is highly flammable.
- **Water repellence**: the ability to repel water; wool has a natural grease (lanolin) on its surface which repels water.
- **Anti-static**: static refers to the electrostatic charge that builds up through friction in some fabrics. Some fabrics do not give off a static charge.
- **Resistant to acid and bleach**: the ability to resist damage through exposure to acid or bleach.
- **Resistant to sunlight**: ability to reflect UV rays to prevent damage to the fibre or fabric.
- **Weight**: fabric construction and thickness of yarn affect the weight of the fabric. Densely woven cloth like denim is heavy, chiffon is lighter.