Eduqas GCSE D&T Technical Principles Core Knowledge and Understanding 2.1.4

Smart Materials

Modern materials

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.

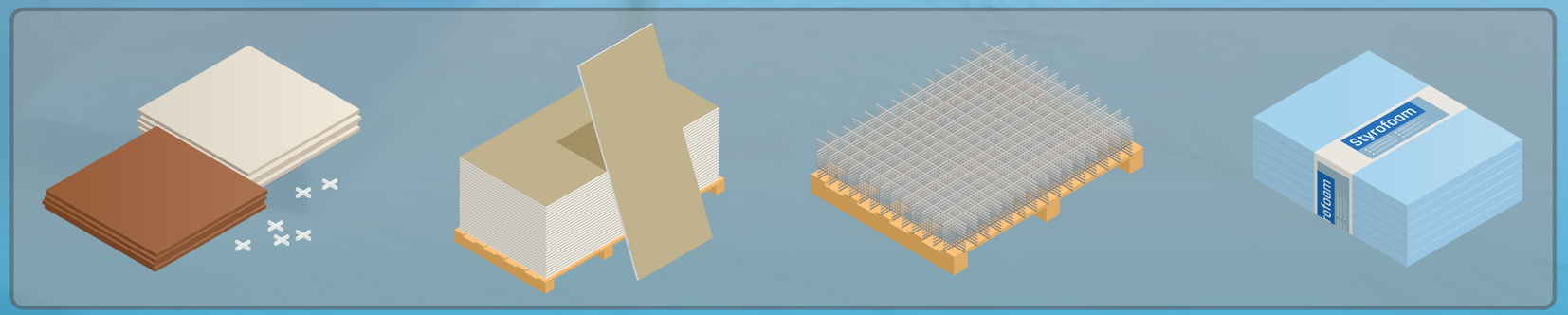
Smart materials

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.

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.



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Materials 2

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.**

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). Paper is available in standard sized sheets ranging from A10, which is the size of a postage stamp through to 4A0. The most common sizes used in a school environment are A4-A2.

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 the paper cannot absorbent liquid and can therefore be wiped clean.

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Scales of Production

Scales of production

- **One off production** – single products made as prototypes or concepts, or bespoke custom-made items are manufactured.

  Advantage – the user or owner will have an original product unlike any other.

  Disadvantage – lots of manual labour will be used because no production line would be set up for one product.

- **Batch production** – products made in limited numbers at any one time, although this may be repeated.

  Advantage – small numbers of similar items are made at one time to satisfy demand.

  Disadvantage – there may be a delay until the next batch is produced.

- **Mass production** – identical products made in large volume, normally thousands, with some use of automated machinery to achieve accuracy, efficiency and identical outcomes.

  Advantage – more profit for the manufacturer as materials are bought in bulk, and automated machinery is set up so less workers required.

  Disadvantage – initial set up costs are high, and not much flexibility once production line is set up.

- **Continuous flow production** – identical products constantly being produced 24 hours per day, 7 days per week without stopping. There will be heavily automated production lines in use for speed, accuracy and quality control purposes.

  Advantage – huge numbers produced identically, efficiently and quickly, saving time, energy and need for manual workers.

  Disadvantage – one single fault can stop the whole production process and be very costly.

Jigs and repeating activities

Sometimes a process needs to be repeated several times in order to make one or more products. Manufacturers will often use devices to help complete this task and ensure accuracy and consistency.

Jigs – a jig is a device used to hold or secure material and guide cutting or drilling tools to ensure accuracy and repeatability.

Pattern – a pattern is a shape attached to the surface of the material to help to shape it.

Template – a template is a tool for marking out a shape repeatedly, so it is exactly the same each time.

Computer aided manufacture (CAM)

Machines that are controlled by a computer offer many benefits when manufacturing. They are:

- faster than working by hand
- far more accurate and precise than what manual workers could achieve.

They can:

- repeat tasks consistently and identically
- support production by making difficult components or parts while others are produced simultaneously
- produce multiple items in one go
- save material and reduce waste
- work without supervision or lunch breaks!

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New and Emerging Technologies 2

Global manufacture

- This is when parts of products are made in different locations.
- The benefits include cheaper labour and investing in poorer countries' economies.
- However, this can result in child exploitation and unfair conditions!
- Fair Trade tries to ensure that everyone benefits.

Biodiversity and deforestation

- We must avoid damage to natural habitats and source materials sustainably.
- The Six Rs help!
- FSC and managed forests supply sustainable timbers.
- Select recycled materials over virgin materials.
- Protect wildlife and natural eco systems.

Cost of a prototype

Making a prototype involves more costs than just materials:

- energy costs to power machinery
- labour costs – prototypes can be one off, hand-made items
- CAD/CAM CNC are very expensive
- intellectual property to protect that brilliant invention.

New materials are constantly being developed to improve current materials. Take 3D printing PLA – a reel of inexpensive, bio-degradable material, sourced from nature and melts at 210˚C. It is available in lots of colours, finishes and sizes.