DT Curriculum Overview Year 10 (Sept-Feb) 2024-25

Unit Title	**Half term 1** **Polymers and manufacturing methods**	**Half term 2** **Production of Metal.**	**Half term 3** **How power is generated and Positive and negative impacts new products have on the environment. How nuclear power is generated. Arguments for and against the selection of nuclear power.** **Printing processes.**
Number of lessons	7 lessons	7 Lessons	7 Lessons
Curriculum content	**Thermosetting** • Made up of lines of molecules which are heavily cross-linked. • Very rigid molecule structure. • **They can be heated for first time and shaped (moulded).** • **Permanently stiff after heating.** • **They cannot be reshaped again.** • Thermosetting are very strong. **Thermoplastic** • **Soften when heated and when cools and sets it can be reheated and reshaped again.** • Soften when heated which means it can be formed into different shapes easily. • Suitable for Vacuum Forming, Injection Moulding, and Blow Moulding. • Very easy to mass produce. • Strong material and well-priced generally. • Does not react to heat very well (finished product).	Introduction to why metals are used in the world of design: Basic meaning: Metallic elements found naturally here on earth. Examples of Natural Found Metals: • **Gold** • **Silver** • **Tin** • **Lead** • **Iron** • **Zinc** • **Copper.** **There are several promotional advantages for using metals for commercial packaging:** • Added security: this can be sealed cans, that cannot be tampered with without causing obvious visible signs. • All containers can be made in a variety of sizes and shapes.	**How power is generated and Positive and negative impacts new products have on the environment.** **How power is generated from:** • coal • gas • oil. Arguments for and against the selection of fossil fuel • **Discuss the possible environmental impact of using metal to manufacture products.** • **What is meant by the term 'sustainability'. Give examples of products where sustainability has been considered during their design, manufacture or use.** • **Discuss the possible environmental impact of using plastics (polymers) to manufacture products.** • **Energy conscious: How can this be more energy conscious**

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	Recall written notes and answering question regarding the thermoplastics, the properties and applications of the following: • acrylic (PMMA) • high impact polystyrene (HIPS • high density polythene (HDPE) • polypropylene (PP) • polyvinyl chloride (PVC) • polyethylene terephthalate (PET). Thermosetting the properties and applications of the following: • epoxy resin (ER) • melamine-formaldehyde (MF) • phenol formaldehyde (PF) • polyester resin (PR) • urea–formaldehyde (UF). How products are produced in different volumes. The reasons why different manufacturing methods are used for different production volumes: • prototype • batch • mass	• Packaging can also be embossed or debossed this can provide texture or styling to the product. • Another advantage of metal it can be directly printed on to or have stickers applied to the product. **Ferrous metals** are metals which contain **iron**. They will corrode if unprotected. Ferrous metals will be attracted by a magnet. **Non-ferrous** are metals which do not contain iron. Pure metals such as aluminium, copper, tin and lead are non-ferrous, and do not rust. **Alloys** are metals which are a **mixture** of two or more metals, benefiting from the properties of both. For example, brass is an alloy of copper and zinc. Students should have an overview of the main categories and types of metals and alloys: ferrous metals including: • low carbon steel • cast Iron • high carbon/tool steel.	• **6 r's.** How nuclear power is generated. Arguments for and against the selection of nuclear power How power is generated from: • wind • solar • tidal • hydro-electrical • biomass. Arguments for and against the selection of renewable energy. All pupils should know about the following different printing processes: • Photocopying • Off Set Lithography • Flexography • Gravure Screen printing.

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	• continuous. By using Just In Time (JIT) production methods, manufactures are able to respond to customer demands more effectively. JIT manufacturing ensures that customers get the right product at the right at the right price. A customer's order triggers the production process and the manufacturer makes the product specifically to meet the order. Many companies now seek to make constant improvements to their systems and they reward employees if they ways to cut waste even further.		
Links to prior learning	Understanding of properties of material and why they are suitable for certain applications.	Science and Geography: Finite and Non- Finite. Understanding of properties of material and why they are suitable for certain applications.	Science and Geography: renewable and non-renewable energy.
Cultural capital opportunities	**JIT** https://www.youtube.com/watch?v=AH5Bn8iguNM https://www.youtube.com/watch?v=wot9DFzFRLU **Plastics** Log the plastics/ one use you use in a week. Pick up plastic rubbish at your local park or beach. Watch the following: https://www.youtube.com/watch?v=IW3jEIYBFzg https://www.youtube.com/watch?v=EjlUp6A7GRU https://www.youtube.com/watch?v=I4QNolP7Khc	**Metals** https://www.youtube.com/watch?v=iQen-uq3eUk https://www.youtube.com/watch?v=f6WYxkhum-s Log the metals you use in a week in your recycling bin **Architecture** https://www.youtube.com/watch?v=N08XW9wNRYc	https://www.youtube.com/watch?v=w16-Uems2Qo https://www.bbc.co.uk/iplayer/episode/m000t2t3/bill-gates-on-the-environment https://www.theguardian.com/uk/environment

DT Curriculum Overview Year 10 (Sept-Feb) 2024-25

Assessment focus	All learners will complete exam type questions throughout topics covered. Assessment to be covered will be regarding; polymers and manufacturing methods	All learners will complete exam type questions throughout topics covered. Assessment to be covered will be regarding; Ferrous metals, Non-ferrous, Alloys, low carbon steel, cast Iron and high carbon/tool steel.	Assessment to be covered will be regarding; 6 r' s, nuclear power, sustainability, renewable energy's.

DT Curriculum Overview Year 10 (Feb-June) 2024-25

Unit Title	**Half term 4** **Printing processes, adhesives, Natural and manufactured timbers, Ethics and moral issues in the design and manufacturing sectors.**	**Half term 5** **CAD/ CAM, Composites and Smart Materials.**	**Half term 6** **NEA (coursework)** **Section A: Identifying and investigating design possibilities (10 marks)** **Section B: Producing a design brief and specification (10 marks)**
Number of lessons	7 lessons	7 lessons	7 lessons
Curriculum content	**All students should know about the following different printing processes:** • Photocopying • Off Set Lithography • Flexography • Gravure • Screen printing **http://www.technologystudent.com/designpro/drawdex.htm** **Students should have an overview of the main categories and types of natural and manufactured timbers:** hardwoods including: • ash • beech • mahogany • oak • balsa	**CAD/ CAM** • To understand that computers now play a major role in developing and testing new products within product design. • To be able to use CAD software to create 2D and 3D designs. • To recognize the advantages and disadvantages of CAD and CAM. • To know how CNC machines are programmed and to be familiar with a range of CNC machines including milling machines, routers and cutters. **Composites** • Combinations of different types of materials. • Final material has all the best characteristics of each original material. • Composites normally have excellent strength to weight ratios.	**Section A:** Identifying and investigating design possibilities (10 marks) By analysing the contextual challenge students will identify design possibilities, investigate client needs and wants and factors including economic and social challenges. Students should also use the work of others (past and/or present) to help them form ideas. Research should be concise and relate to their contextual challenge. Students are also advised to use a range of research techniques (primary/secondary) in order to draw accurate conclusions. Students should be encouraged to investigate throughout their project to help inform decisions. **Success criteria:** • Design possibilities identified and thoroughly explored, directly linked to a contextual challenge demonstrating excellent understanding of the problems/opportunities. • A user/client has been clearly identified and is entirely relevant in all aspects to the contextual challenge and student has undertaken a comprehensive investigation of their needs and wants, with a clear

	softwoods including: • larch • pine • spruce manufactured boards including: • medium density fibreboard (MDF) • plywood • chipboard. **Ethics and moral issues in the design and manufacturing sectors.** • Fairtrade • Moral issues – throwaway society • Sweatshops • COSHH • Safety symbols. **Adhesives** To understand that different adhesives are used with different materials and for different purposes. **PVA** **Cascamite:** **Contact adhesive** **Epoxy resin adhesive**	**Smart Materials** • LCD • Phosphorescent pigments • Thermochromic Materials (ink) Piezoelectric Crystals.	explanation and justification of all aspects of these. • Comprehensive investigation into the work of others that clearly informs ideas. • Excellent design focus and full understanding of the impact on society including; economic and social effects. • Extensive evidence that investigation of design possibilities has taken place throughout the project with excellent justification and understanding of possibilities identified. **Section B:** Producing a design brief and specification (10 marks) Based on conclusions from their investigations students will outline design possibilities by producing a design brief and design specification. Students should review both throughout the project. • Comprehensive design brief which clearly justifies how they have considered their user/client's needs and wants and links directly to the context selected. Comprehensive design specification with very high level of justification linking to the needs and wants of the client/user. Fully informs subsequent design stages.

	Tensol cement **Hot glue** **Health and safety** • If you are using adhesives, be aware of the possibility of **fumes**. • Wipe up any **spillages**. • Some adhesives are **skin irritants**, so wear gloves when working with them. • Reading the instructions on the tins is a useful starting point for finding out about each adhesive. • All adhesives need to be stored and used appropriately. • **COSHH regulations cover the storage and use of these substances**.		
Links to prior learning	Properties of materials such as; timber and manufactured boards from mechanical toy and Art Deco project in KS3	Should reinforce some smart materials content covered in Science GCSE.	Content has been covered in KS3: target markets, design briefs and specification. This will give foundation for all learners to progress to a deeper level.
Cultural capital opportunities	https://www.vam.ac.uk/collections/posters https://designmuseum.org/exhibitions/past-exhibitions	https://www.bbc.co.uk/news/science-environment-56096888 https://www.bbc.co.uk/news/technology-32517996	https://www.vam.ac.uk https://designmuseum.org https://www.youtube.com/watch?v=_uzSMAI5AuE
Assessment focus	All learners will complete exam type questions throughout topics covered. Assessment to be covered will be regarding; **adhesive, printing processes, natural and manufactured timbers, Ethics and moral issues in the design and manufacturing sectors.**	All learners will complete exam type questions throughout topics covered. Assessment to be covered will be regarding; **CAD/ CAM, Composites and Smart Materials**	**Section A: Identifying and investigating design possibilities (10 marks)** **Section B: Producing a design brief and specification (10 marks)**

Year 10 GCSE DT Knowledge Organiser

Year 10 GCSE DT Knowledge Organiser Sept - Feb

Some slides are from AQA

- aqa.org.uk/

Sept- Feb

Thermosetting

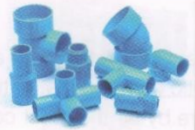
- Made up of lines of molecules which are heavily cross-linked.
- Very rigid molecule structure.
- **They can be heated for first time and shaped (moulded).**
- **Permanently stiff after heating.**
- **They cannot be reshaped again.**
- Thermosetting are very strong.

Thermoplastic

- **Soften when heated and when cools and sets it can be reheated and reshaped again.**
- Soften when heated which means it can be formed into different shapes easily.
- Suitable for Vacuum Forming, Injection Moulding, and Blow Moulding.
- Very easy to mass produce.
- Strong material and well-priced generally.
- Does not react to heat very well (finished product).

Common thermoforming plastics

The following table gives the properties of the most commonly used plastics. Most have similar properties but they all have slight variations and some have specific applications.

Name	Appearance	Image	Characteristics	Example uses
Polyethylene terephthalate 1 PETE	Clear, easily coloured with a smooth finish		Dimensionally stable, easily blow moulded, chemically resistant and fully recyclable	Bottles, food packaging, sheeting and some food wraps
High density Polyethylene 2 HDPE	Opaque, takes colour well and can be textured		Lightweight, rip and chemical resistant, premium price paid when recycled	Milk bottles, pipes, storage crates, hard hats and wheelie bins
Polyvinyl chloride 3 PVC	Good range of colours with a high gloss finish. Available in sheets or shaped as rigid PVC		Flexible, high plasticity, chemically resistant, tough and easily extruded	Raincoats, pipes, electrical tape, air mattresses and self-adhesive vinyl
Low density Polyethylene 4 LDPE	Clear, thin to medium thick film with a smooth finish that takes colour well		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
Polypropylene 5 PP	Available in sheets or shapes that are easily coloured		Flexible, tough, lightweight, chemically resistant, easily cleaned and safe with food	Kitchen, medical and stationery products, rope
High Impact Polystyrene HIPS 6 PS	Flat, clear or coloured sheets for vacuum forming		Flexible, impact resistant, lightweight, can be food safe, sheet used for vacuum forming. Very toxic when burnt	Vacuum-formed products such as food containers or yoghurt pots.
Acrylic (Poly-methyl Meth Acrylate – PMMA) 7 OTHER	Thick to thin sheets, bars and tubes in huge colour ranges with a smooth finish. Can be spun into thread and woven. Very versatile		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

Common thermosetting plastics

The properties of the most commonly used thermosetting plastics are similar to each other but most are quite easily distinguished from thermoplastics. They are rigid but brittle and they are all better at withstanding heat.

Name	Appearance	Image	Characteristics	Example uses
Epoxy resin (ER) Araldite™	Supplied as two liquids: a resin and a hardener (catalyst), which when mixed, sets clear with a very smooth finish. Can be coloured		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 (MF)	Formed and moulded into a variety of shapes, smooth, available in many colours and can be printed		Food safe and hygienic, lightweight, hard, brittle but not microwave safe	Kitchenware and heat resistant surfaces bonded to worktops and flat packed furniture
Urea formaldehyde (UF)	Very smooth finish, mainly white, limited colours available. Very versatile		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 (PR)	Similar to epoxy resin, it is supplied as two liquids, a resin and a hardener (catalyst). Sets very clear, very smooth and can be coloured		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 (PF)	Frequently injection moulded, it has a limited colour palette with high gloss finish achievable		Formerly known as an 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

Introduction to why metals are used in the world of design:

Basic meaning: Metallic elements found naturally here on earth. Examples of Natural Found Metals:

- **Gold**
- **Silver**
- **Tin**
- **Lead**
- **Iron**
- **Zinc**
- **Copper.**

There are several promotional advantages for using metals for commercial packaging:

- **Added security: this can be sealed cans, that cannot be tampered with without causing obvious visible signs.**
- **All containers can be made in a variety of sizes and shapes.**
- **Packaging can also be embossed or de-bossed this can provide texture or styling to the product.**
- **Another advantage of metal it can be directly printed on to or have stickers applied to the product.**

Ferrous metals are metals which contain iron. They will corrode if unprotected. Ferrous metals will be attracted by a magnet.

Non-ferrous are metals which do not contain iron. Pure metals such as aluminium, copper, tin and lead are non-ferrous, and do not rust.

Alloys are metals which are a mixture of two or more metals, benefiting from the properties of both. For example, brass is an alloy of copper and zinc.

Students should have an overview of the main
categories and types of metals and alloys: ferrous metals including:

- **low carbon steel**
- **cast Iron**
- **high carbon/tool steel.**

Common ferrous metals

Name	Appearance	Image	Characteristics	Example uses
Low carbon steel (Mild steel) Carbon content 0.05 – 0.3%	Bright grey with a smooth texture that quickly oxidises if not protected		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 (Tool steel) Carbon content 0.6 – 1.5%	Very similar to mild steel but does not rust as readily, very smooth texture		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 Carbon content 2.4 – 4%	Dull, varying shades of grey depending on type, rough texture unless machined, less prone to rust		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

Common non-ferrous metals

Name	Appearance	Image	Characteristics	Example uses
Aluminium	Light grey, can be polished to a mirror finish but often has brushed matt finish		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 take-away trays
Copper	Light reddish brown, polishes well, oxidises to an attractive green-grey shade		Ductile, malleable and a good electrical conductor that is easily joined by soldering	Plumbing supplies, electrical cables, bespoke roofing and guttering
Tin	Silvery white, often plated onto steel with a shiny finish achievable		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	Silvery grey with bluish-white hue, matt finish		Fair electrical conductivity, malleability and ductility; however, all are improved when alloyed	Mainly used to **galvanise** steel to prevent rusting, easily die cast or used in alloys

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.

Name	Appearance	Image	Characteristics	Example uses
Brass Copper 65% Zinc 35%	Yellowish gold, polishes well and oxidises to a dark antique brown		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 Low carbon 0.03 – 0.08% Chromium 10.5 – 26%	Silver hue that can be polished to mirror finish. Resists rust well		A ferrous alloy with chromium, nickel and manganese. Hard, very smooth but difficult to weld	Cutlery, kitchen and medical equipment
High speed steel Alloys can include: Chromium Molybdenum Tungsten Vanadium Cobalt Carbon	Varies depending on the combination of metals alloyed with steel		Able to withstand the high temperatures created when machining at high speed, keeps its cutting edge well	Cutting tools such as drill bits, mill cutters, taps and dies

Scale of production	Applications	Advantages	Disadvantages
One-off	Prototype and architectural models, shop signage, vinyl stickers for commercial vehicles, etc.	• Made to exact personal specifications. • High-quality materials used. • Highly skilled craftsperson ensures high-quality product.	• Expensive final product in comparison to larger scales of production. • Generally labour intensive and can be a relatively time-consuming process.
Batch	Commercially printed materials, e.g. magazines and newspapers.	• Flexibility in adapting production to another product. • Fast response to market trends. • Identical batches of products produced. • Efficient manufacturing systems can be employed. • Very good economies of scale in bulk buying of materials. • Lower unit costs.	• Poor production planning can result in large quantities of products having to be stored, incurring storage costs. • Frequent changes in production can cause costly re-tooling, reflected in retail price.
Mass	Electronic products, e.g. mobile phones and games consoles, commercial packaging, etc.	• Highly automated and efficient manufacturing processes. • Specialisation of workforce to specific tasks. • Rigorous quality control ensures identical goods. • Excellent economies of scale in bulk buying of materials. • Increased production means that set-up costs are quickly recovered. • Low unit costs. • Reduced labour costs.	• Low-skilled workforce – low wages, repetitive nature of tasks leading to job dissatisfaction. • Ethical concerns of manufacturing in developing countries i.e. 'sweat shops'. • High initial set-up costs due to very expensive machinery and tooling needs. • Inflexible – cannot respond quickly to market trends.
Continuous	Packaging, e.g. cans and bottles for the drinks industry.	• As mass production. • Extremely low unit costs. • Runs continuously 24 hours, 7 days a week.	• As mass production. • Very little flexibility at all as production set up 24/7.

Just In Time and lean manufacturing

Lean manufacturing is based on an ethos of eliminating waste in manufacture, overburden and bottlenecks. A growing number of responsible manufacturers now adopt this principle to save money and resources. It was first witnessed in Japan during the 1990s and has grown in popularity as manufacturers across the world are cutting down on the waste that they produce. To do this, they have had to change the way they operate.

By using **Just In Time** (JIT) production methods, manufacturers are able to respond to customer demands more effectively. JIT manufacturing ensures that customers get the right product at the right time at the right price. A customer's order triggers the production process and the manufacturer makes the product specifically to meet the order.

Many companies now seek to make constant improvements to their systems and they reward employees if they find ways to cut waste even further.

Advantages of just in time:

- Products are made to order, so no products need storing whilst waiting to be sold, thus saving on storage costs
- Money is not tied up in unsold stock
- Orders are often secured on a deposit or full payment, so money is in the bank before outlay is needed on materials and production costs
- Materials and components are supplied just when needed, saving financial outlay on unused materials and additional storage (very low stock levels are maintained)
- Improved competitiveness results from minimal waste of materials and time
- Stock does not become old, out of date or obsolete
- High reliance on making sure products are 'right first time' means less time is spent correcting mistakes, or money wasted on faulty products
- Almost all waste is reused or recycled, meaning there is little or no landfill waste produced

Disadvantages of just in time:

- Relies on high quality, fast and reliable supply chain for raw materials and components
- All production could stop if the supply chain breaks down
- Stock is not ready to be purchased off the shelf; some consumers prefer not to wait at all and some sales could be lost
- Usually a deposit or the whole cost of the product needs to be paid upfront which could be offputting for some consumers
- Discounts from suppliers for bulk purchasing of materials may be not available

Just In Time and lean manufacturing

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Advantages of CAM	Disadvantages of CAM
Faster than traditional machines and tools	Expensive set up costs for equipment
More accurate than traditional methods	Training costs and time
High repetitive accuracy	CAM machines need specialist engineers when they need maintaining or repairing
Machines can run 24/7	CAM machines can do work that is traditionally done by skilled workers and has led to unemployment in many manufacturing sectors
Can produce work directly from CAD files	

Flexible manufacturing systems

A **flexible manufacturing system** (FMS) is a collection of automated machines that are adaptable and are used in production lines where the products that are being made may change on a regular basis. This allows manufacturers to respond quickly to fluctuations in the market and consumer demands, which may be influenced by trends and fashion.

If a manufacturer was making only one product, like an aluminium can, machines could be dedicated to that task and therefore not have to be recalibrated or retooled. FMS machines are flexible and adaptable and therefore better equipped for batch production, although the need for flexibility may incur additional setup costs.

CNC machines are frequently used in FMS as they are easily reprogrammable, making changes quick, simple and cost effective.

Robot arms are also used because they can be programmed to perform many tasks. They can even perform multiple tasks while on one production line, making the FMS capable of real-time changes and even greater manufacturing flexibility.

Technology push

When a new scientific discovery becomes public it is never long before designers, engineers and technologists use it or turn it into a product, despite there being no consumer awareness or demand for such a product. This is called **technology push**, as it drives forward current thinking and creates new and exciting developments. Large manufacturing companies employ teams of designers to work in their research and development (R&D) departments.

R&D is one of the most important areas for a company, as they need to produce new and exciting products to ensure they keep their market share. Being the first to market with a new technology can be the difference between success and failure.

Market pull

Market pull describes consumer demand as the driving force behind new products. Analysis of the consumer market, along with an understanding of human needs and desires, enables the 'gap in the market' to be filled. Market pull also puts pressure on companies to constantly improve their products so that they keep their share of the market through brand loyalty as well as attracting new customers.

The smartphone is a good example of market pull. Consumers once carried numerous bits of electronic equipment with them; a phone, a pager, a diary, a camera, an MP3 player, a SatNav and so on. This was bulky, inconvenient and very expensive.

The technologies for all of these products already existed, and so through demand the smartphone was developed. Improved battery technology and the miniaturisation of electronic components also helped.

The next market pull for smartphones seems to be around flexibility and wearability, and there is an increasing demand for very low power consumption and fast wireless charging.

This market pull combined with the technology push of new discovery (for example **graphene**, a flexible and incredibly strong, conductive material) should continue to bring some very interesting and exciting products to market.

Planned obsolescence

As consumers we expect some products to last a long time and others we throw away after only one use. A sofa would be expected to last for many years, if not decades; a pair of headphones perhaps a year or two at best; many ball-point pens will be disposed of once they run out of ink, as they are not designed to be refilled. Ensuring a product only performs its task for a certain length of time is known as **planned or built-in obsolescence** and is something designers and manufacturers need to consider for a number of reasons.

Appropriately engineered quality – If a product only needs to last for a short period of time then it would be a waste of materials and energy to ensure that it is robust enough to last a long time. A disposable razor has a plastic handle instead of a metal one because the non-replaceable blade will be blunt after a few uses. Therefore, an appropriate polymer, e.g. polystyrene, is the best material as it is much cheaper to produce.

GCSE DT Knowledge Organiser (Feb- June)

Advantages of CAD	Disadvantages of CAD
Designs can be altered easily	CAD software is complex to learn
It can be faster to draw designs and complex shapes, saving labour costs and development time	Software can be very expensive
Designs are easily saved and historic versions kept or archived	Compatibility issues with software
Designs or parts of designs can be easily copied or repeated	Security issues - risk of data being corrupted or hacked
Designs can be sent by email for approval and manufacture	Software often subject to regular updates
Designs can be worked on by whole teams simultaneously	Ever increasing demand on computer memory, RAM and graphics capabilities
Designs can be rendered to look photo-realistic to gather public opinion in a range of finishes	Data can be lost in power cuts / outage
Designs can be simulated to judge ease of manufacture	
CAD software can process complex stress testing and associated calculations to predict the behaviour of a product before production	

The most frequently used CAM equipment used in schools are laser cutters, vinyl cutters, computerised sewing and embroidery machines, CNC milling and engraving machines, CNC routers and CNC lathes.

Advantages of CAM	**Disadvantages of CAM**
Faster than traditional machines and tools	Expensive set up costs for equipment
More accurate than traditional methods	Training costs and time
High repetitive accuracy	CAM machines need specialist engineers when they need maintaining or repairing
Machines can run 24/7	CAM machines can do work that is traditionally done by skilled workers and has led to unemployment in many manufacturing sectors
Can produce work directly from CAD files	

Modern materials

This chapter covers a small selection of the many modern materials available to designers. Technology is constantly progressing and new materials, as well as new ways of working with materials, continue to be developed. A good designer will utilise and exploit these materials where appropriate and keep up-to-date with the latest developments.

Corn starch polymers

This sustainable branch of polymers has been around for some time but has only become commercially viable since the recent drive towards more sustainable design. Our dependency on fossil fuels and the ever-increasing amounts of synthetic plastic waste in our oceans and natural environments are causing harm to our planet. Corn starch polymers are becoming an attractive option to the manufacturing and retail industries. The plastics listed are made from vegetable starches and are fully **biodegradable** if composted. The natural bacteria in the soil break down the plastic very quickly and unlike petrochemical based polymers, they are not toxic to the environment. Corn starch polymers cannot be recycled because they so readily decompose. Small amounts of these plastics mixed in with other recyclable thermoplastics can render a batch unusable.

Name	Appearance	Image	Characteristics	Uses
Polylactic acid PLA	Smooth or textured finish, dependent on the production method, easily coloured		Widely used in 3D printers as reels of filament, it is non-toxic, easily moulded and fully biodegradable	Bottles, pots, disposable food and drink containers, pens, phone cases and 3D printed items
Polyhydroxy-butyrate PHB Biopol™	Smooth or textured finish, easily coloured		Stable, stiff, quite brittle, non-toxic, easily processed and moulded, has limited chemical resistance, fully (but slowly) biodegradable	Bottles, pots, household items, disposable food containers

Smart Materials

Name	Appearance	Image	Characteristics	Uses
Liquid Crystal Display	Monochrome versions have solid areas that are placed in predetermined positions and appear dark when a voltage is applied. Colour versions have RGB pixels that offer full screen images		Low power consumption compared to older style CRT monitors, crisp sharp image, thin, compact, flat, colour LCD screens which can be very bright. However, the contrast is not so good and they can have a restricted viewing angle	Small low-powered electronic devices, watches, clocks, microwave ovens, satellite navigation systems, in-car entertainment, flat computer and TV screens

Liquid Crystal Display (LCD)

Liquid crystal displays are commonplace in many of today's modern electronic appliances. They offer a low-cost and low-power method of displaying information. There are two varieties, monochrome and full colour. The liquid crystals in the displays are organic molecules which align in a predetermined way when a voltage is applied to them. LCDs use a combination of polarising filters and electrodes to make the crystals appear solid and visible. Early monochrome varieties, as seen on digital watches, show just a single colour which is usually black. These are backlit to enable viewing in poor light, as the LCD display itself does not emit light. The full-colour versions, commonly found on flat-panel computer screens, have separate red, blue and green pixels which are filtered by applying varying voltages to them.

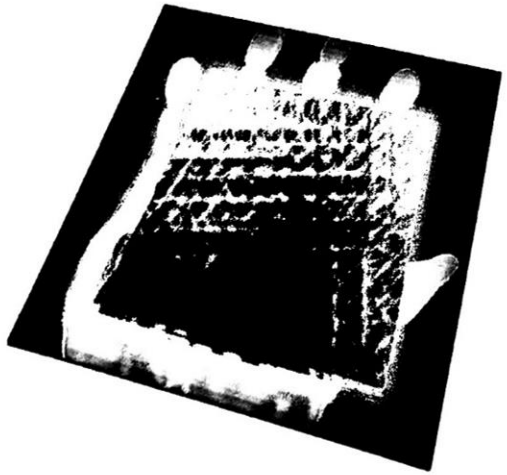
Polymorph

Although sometimes described as a smart material, **Polymorph** is a non-toxic and fully **biodegradable** polymer which comes in small plastic granules. When it is heated to 62°C the granules fuse together to become a mouldable substance. It can be shaped by hand and becomes solid when cooled. When it is reheated it will soften and become re-mouldable, making it a great material for **prototyping** and for making repairs. It is also available in a lower temperature version called Coolmorph™ which is formed at 42°C.

Name and stimulus	**Appearance**	**Image**	**Characteristics**	**Uses**
Polycaprolactone PCL Polymorph 62°C Coolmorph™ 42°C Heat	An off-white mouldable translucent pellet which can be hand shaped. Can be coloured with pigments		Easily mouldable and remouldable at low temperature in hot water, non-toxic, reusable, fully biodegradable	Repairs, hand shaped artefacts, jewellery, modifications and personalisation of products, prototyping and modelling.

Thermochromic pigments

These pigments, inks and dyes react to heat by changing colour at specific temperatures. A colour change can indicate that a particular temperature has been reached. For example, a product could turn red when it becomes hot to signify danger or a need for caution. These pigments are used in applications such as room and paediatric thermometers, spray paints and children's cutlery.



Irreversible versions of the pigment are available which can be used to indicate that a critical temperature has been reached. This is very useful to warn someone if heat sensitive products, such as medical supplies, have been poorly stored or transported.

Name and stimulus	**Appearance**	**Image**	**Characteristics**	**Uses**
Thermochromic pigments Heat	The pigment is a powder that is added to a variety of materials such as fabrics, plastics and paints		Pigments embedded into the thermochromic material respond to temperature changes by changing colour. They normally change as they heat up and cool down, but some versions are irreversible	Flexible thermometers, temperature indicators, clothing, novelty goods, over-heating or over-cooling indicators

Photochromic pigments

Photochromic pigments, inks and dyes react to levels of light by changing colour. It is the **ultra violet** (UV) rays that effects the change in the pigment and in most applications, the longer it is exposed to the UV light, the darker it becomes until it reaches its maximum. This is caused by the reaction of light sensitive particles embedded in the pigments. There are several different organic and inorganic compounds that can be used to create the photochromic reaction and they vary depending on the required effect and the material used. These pigments are mainly used in novelty goods such as colour-changing nail varnish, vehicle spray paint, clothing, party items and beach products.

Name and stimulus	**Appearance**	**Image**	**Characteristics**	**Uses**
Photochromic pigments UV light	The pigment is a compound that is added to a variety of materials such as fabrics, plastics, and paints. It can be bonded on to glass		The pigments that are embedded into the photochromic material respond to changes in the UV light levels by changing colour or darkening. Once the UV light is taken away they change back or lighten	Novelty goods, paints and clothing that change colour in UV light

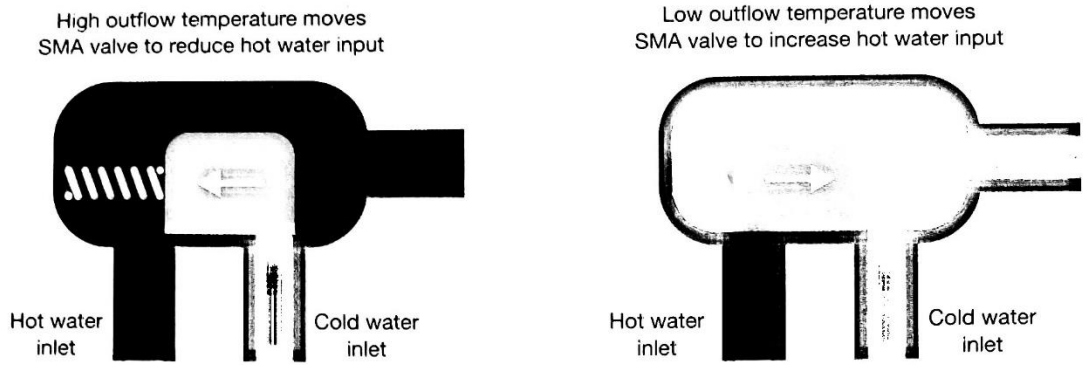
SMA used as a self-expanding surgical stent

Nitinol can also be used as **muscle wire**. The wire is first stretched and then, when an electrical current is passed through it, it will contract approximately 5% of its length. This is used in dental braces.

Name and stimuli	Appearance	Image	Characteristics	Uses
Shape memory alloy (Nitinol) Heat or electricity	Mid-grey metal wire of varying thickness. Also available in sheets		A shape can be programmed when heated to 540°C; it can be deformed and will return to the memory shape when reheated to 70°C	Frames for glasses, dental braces, self-expanding stents used in surgical procedures to open capillaries, fire sprinklers

Shape memory alloy

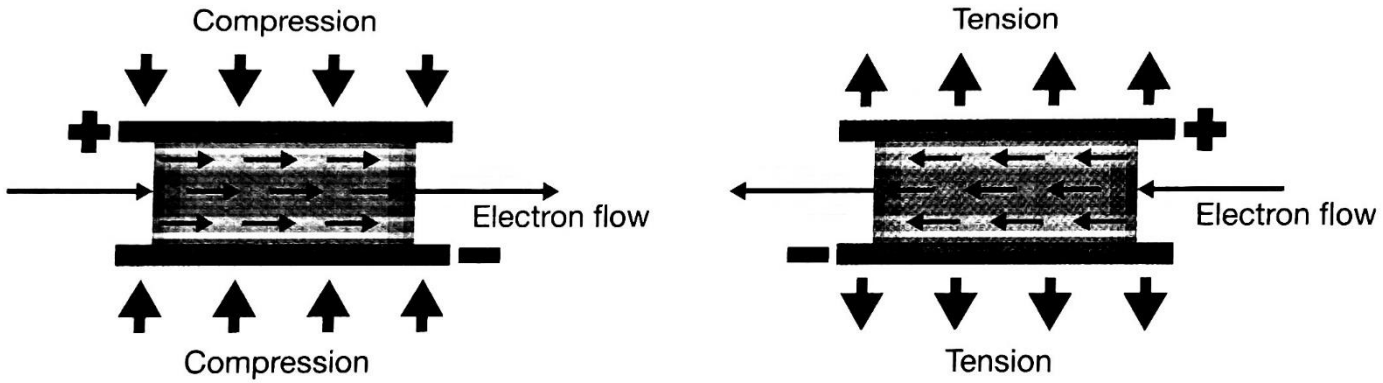
Most materials have some form of memory, meaning that they will try to resist deformation or spring back to their original shape. **Shape memory alloys** (SMA) take this a step further; they can remember a preset shape and return to it despite being dramatically reshaped. The stimulus for returning to the preset shape is heat or electricity.



Nitinol, an alloy of nickel and titanium, is the most commonly used SMA. To program its shape memory, the nitinol must be held in the desired position and heated to around 540°C, then allowed to cool. It can then be deformed to a different shape. When it is heated to around 70°C, it will spring back to its programmed shape. This can also be achieved by passing an electric current through it. It can be re-programmed by reheating it to 540°C.

Piezoelectric material

Although it is not a conductor, a **piezoelectric** material produces an electrical voltage when squeezed or put under pressure. It is commonly used in gas lighters to create a spark that ignites the gas. **Quartz** is a natural piezoelectric material, and some polymers and ceramic materials have the same effect.



If a voltage is applied to the piezoelectric material it causes it to change shape. It is this principle that allows for its use in speakers. The electrical signal makes the metallic diaphragm move, which creates sound. A microphone receives soundwaves which move the diaphragm, creating an electrical signal.

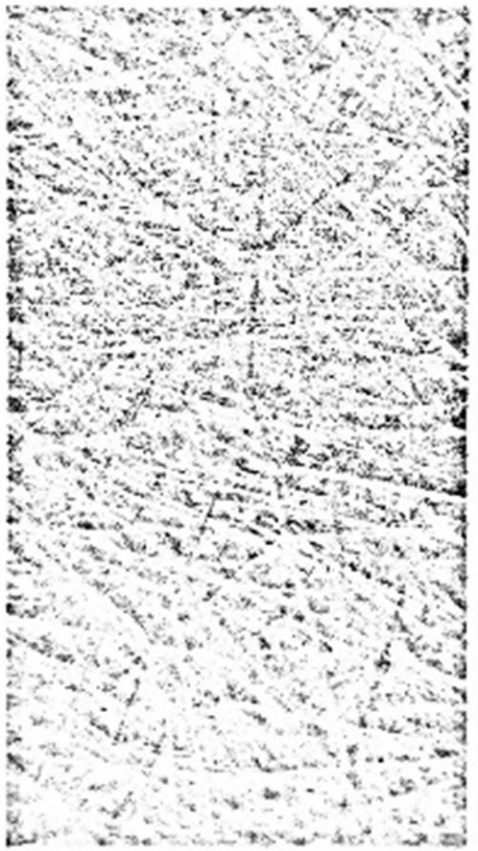
Name and stimuli	**Appearance**	**Image**	**Characteristics**	**Uses**
Piezoelectric material Movement, stress or electricity	Can be a quartz crystal, a polymer or ceramic, normally embedded into components		Stress or movement of the material produces an electrical signal, and an electrical signal applied to the material results in a change of shape in the material	Mobile phone speakers and microphones, gas lighter ignition spark, circuits in quartz clocks, inkjet printers

Litmus paper

This special paper changes colour depending on PH levels. It utilises dyes found in different varieties of lichen.

Name and stimulus	Appearance	Image	Characteristics	Uses
Litmus paper PH	Strips of yellow, red or blue paper that change colour according to the level of PH of the substance being tested		The active ingredients from the lichen dyes react to the acidic or alkaline content of the substance, turning red in acid and blue in alkaline. The PH scale is 0-14, 0 being most acidic, 7 neutral and 14 the most alkaline	Used in scientific experimentation to accurately test PH levels of substances. Also used in soil testing for gardeners and testing chemical balance in swimming pools, wildlife ponds and fish tanks

Composite

Name	Appearance	Image	Characteristics	Uses
Glass reinforced plastic (GRP)	Glass fibre matting is covered with smooth plastic resin (gel coat) which sets hard with high gloss finish. It is easily coloured and complex shapes can be formed		Lightweight, good strength-to-weight ratio, good corrosion, chemical and heat resistance, waterproof, high VOCs / resins used. Can be trimmed with rotating blade. Labour intensive to produce	Boat hulls, car and truck body parts, liquid storage tanks, pipes, helmets, seating

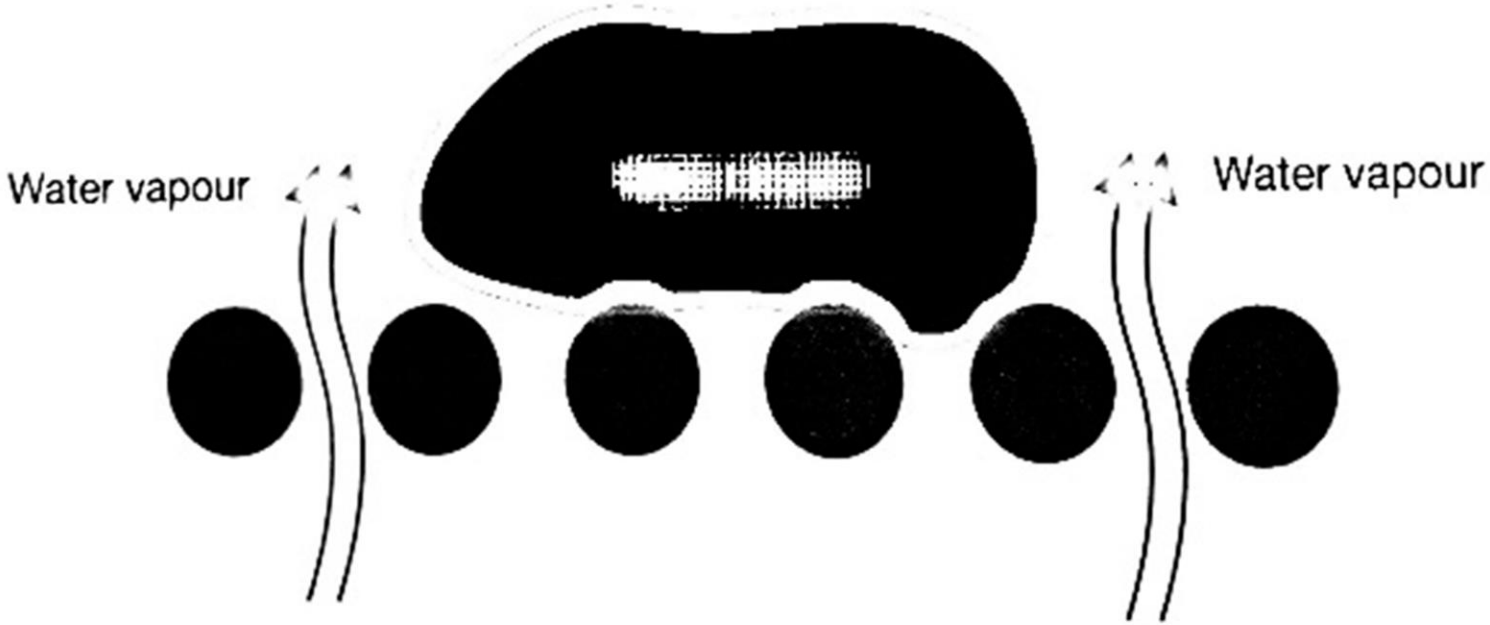
Name	Appearance	Image	Characteristics	Uses
Carbon-fibre reinforced plastic (CRP)	Carbon-fibre is a cloth woven from individual strands, the interlacing provides an interesting and modern aesthetic, available in different patterns, can be coloured but frequently left natural, vinyl decals can be added for decoration		Very high strength-to-weight ratio, good tensile strength but not good compressive strength, stiff and rigid, very expensive, high VOCs / resins used, waterproof and resistant to chemicals. Manufacture is a labour-intensive and skilled process	Supercars and sports cars, top-end sports equipment, bespoke boats and musical instruments, increasingly developed for prosthetic uses

chnical textiles

Technical Fabrics

Gore-Tex® fabric

A wide range of clothing products now come with a Gore-Tex® membrane sewn between layers of other fabrics. This creates a waterproof yet breathable garment which is commonly used in a variety of outdoor clothing including, jackets, gloves, walking boots and trainers. The specific benefit of Gore-Tex® over other waterproof materials is that it is breathable. This means that the Gore-Tex® layer not only stops water coming in, but also allows airborne moisture to escape. This reduces the build-up of **condensation** inside a jacket or a pair of boots, making the wearer much more comfortable.



Name	Appearance	Image	Characteristics	Uses
Gore-Tex®	A very thin membrane sandwiched between a liner and outer material		Waterproof, wind proof, breathable fabric; moisture vapour can escape	Outdoor clothing from skiwear to mountain wear, walking boots, cross country trainers, gloves, sportswear

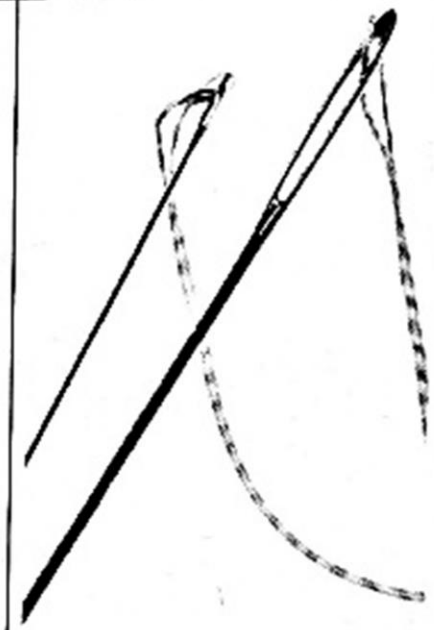
Kevlar®

Kevlar® is a fibre developed by DuPont™ that has high tensile strength, has great heat resistance and is extremely hard-wearing. It is a flexible and lightweight synthetic fibre from the class of fibres known as **aramids** which are modified polyamide (nylon) fibres. Kevlar® is used for many applications including body armour and personal protective equipment for use in hazardous situations. It has also been found to have useful acoustic properties and is used in the production of quality loudspeakers and some musical instruments.

Name	Appearance	Image	Characteristics	Uses
Kevlar® by DuPont™ Poly-paraphenylene terephthalamide	Natural yellowish-gold material which also comes dyed in many colours. Woven texture from fine to course weave		Extremely strong and hard-wearing, excellent cut and tear resistance, high thermal protection, non-flammable, good chemical resistance	Personal armour, helmets, bullet-proof vests, motorcycle safety clothing, extreme sports equipment, audio equipment, musical instruments

Conductive fabrics

Also known as **e-textiles**, these highly conductive threads and fabrics allow an electrical signal to pass through them with very little resistance. The fabric can be used in strips so as to create paths for electricity to flow along, connecting components such as LEDs, headphones and microphones. It is even possible to remotely connect a smartphone in an inside coat pocket to controls on a cuff or a pair of gloves. Connective thread is effectively single strands of conductive material that can be sewn onto or into non-conductive fabrics to create an electrical pathway or circuit; handy for connecting individual components.

Name	Appearance	Image	Characteristics	Uses
Conductive fabrics and threads	A silvery, fabric or thread that can be sewn or woven. Can be layered between other fabrics		The thread or fabric can pass an electrical current along its length, linking electronic components. It allows for flexible and wearable control of electronic products for entertainment, safety, health and fitness	Connecting wearable inputs, processes and outputs such as switches, lights, Bluetooth connectivity and speakers in technical clothing, children's soft electronic toys, wearable electronic sports equipment and anti-static clothing

Fire resistant fabrics

Heat and flame resistant fabrics such as **Nomex®** and **Kevlar®** have been developed to withstand high temperatures and reduce combustion when exposed to a naked flame. There are many different brands of fabric that have differing levels of heat and flame protection. Most of these fabrics are based on a group of synthetic fibres known as **aramid** fibres. They are generally very strong and heat-resistant.

Flame retardants are different and can be applied to a range of regular fabrics, in particular, curtains and sofa fabrics. They are designed to produce a chemical reaction that slows down and even stops ignition taking place.

Name	Appearance	Image	Characteristics	Uses
Fire resistant fabrics	Varies from brand to brand but usually a closely woven texture. Most can be dyed a range of colours		Resists heat and ignition from naked flame to protect the wearer	Fire blankets, firefighting or safety clothing such as gloves, aprons and boiler suits. Protection for racing car drivers

Microfibres and microencapsulation

Microfibres are a group of **synthetic** fibres that are less than one denier thick. This means that they are about five times finer than a human hair.

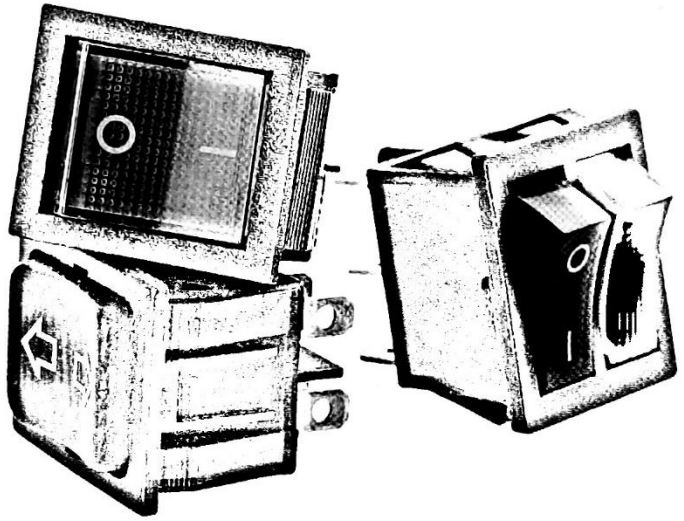
Microencapsulation traps liquid or solid substances within the fibres of the material. This has led to the development of smart fabrics. When microencapsulated textiles are rubbed or in some applications, heated, the walls of the fibres open up allowing the encapsulated substance to be released. Uses for this technology include insect-repellent clothing, where insecticide is slowly released; anti-bacterial clothing for sports and medical applications and phase-change micro-encapsulation (PCM) which enables textiles to regulate the wearer's body temperature. Microencapsulation is also used for trapping thermochromic dyes used in colour-changing clothing.

Name	Appearance	Image	Characteristics	Uses
Microfibres and micro-encapsulation	A very fine synthetic fibre woven into many different products, can be dyed for aesthetics		Vary depending on the specific textile, can be statically charged to pick up dust and filter particles, can be absorbent yet fast drying	Medical textiles, fabrics, cloths, and towels. High-tech clothing which can be anti-bacterial, heat-regulating or insect-repelling

Electronics

Inputs

For a system to be controlled it usually needs to be manually triggered or it needs to sense an environmental change such as heat, sound, movement or light. To do this it needs an input component or sensor. The most common input component is a switch.

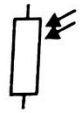
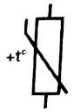
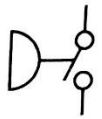


Some electronic components have **polarity**. This means that they have a positive and negative side to them and therefore it matters which way around they go in a circuit. Most switches do not have polarity but they do have a **pole** and a **throw**. Electricity in a circuit will only travel from the pole to the throw or vice-versa.

The simplest form of switch is a single pole single throw (SPST) which is perfect as an on-off power switch, as it can make (connect) or break (disconnect) a circuit. The single pole double throw (SPDT) has two options for the throw. This could be used to control two outputs such as a red bulb for stop or a green bulb for go. Momentary switches (push switches) only operate for as long as they are pressed. There are two types; push to make (PTM) and push to break (PTB). These are frequently used to trigger circuits such as that used for a door bell.

Other input devices include thermistors to detect heat and cold, light dependent resistors (LDR) to detect light or dark and pressure sensors to detect changes in force.

Common input components

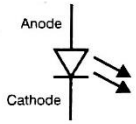
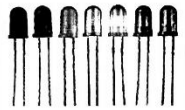
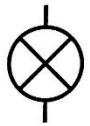
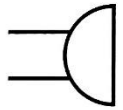
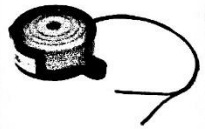
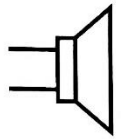
Name and symbol	Appearance	Image	Characteristics	Uses
Toggle switch (latching) 	Available in a variety of shapes, sizes and switching positions depending on the task		Off and on positions, once switched they stay on (latched) until switched again	Lighting, power switch, control panels
Push to make (PTM) switch normally open 	A wide variety of shapes, colours and sizes		The legs of the switch are only connected when the switch is pressed (momentary); it is normally open, no polarity	Door bell, intercoms, keyboards
Push to break (PTB) switch normally closed 	They are identical to PTM switches so you may need to check the connectivity		The legs are only disconnected when the switch is pressed (momentary); it is normally closed, no polarity	Alarm systems, control systems
Light dependent resistor (LDR) 	Small light sensitive panel often in plastic shroud, two wires for mounting to circuit		Resistance increases in the dark and decreases in the light, no polarity	Street lights, solar garden lights, security and child night lights, low-light meter for sporting events
Thermistor 	Small coloured disc, two wires for mounting to circuit		Resistance changes with a change in temperature, no polarity	Thermostats on central heating systems, fridges and freezers, digital thermometers
Pressure switch 	Come in all different shapes, sizes and colours.		Detects pressure from being pressed, can perform on/off tasks or detect gradual pressure being applied	Burglar alarm systems, video game floor mats, sensing fluid pressure in pipes

Outputs

Output components are used to give off a stimulus such as light, heat, movement or sound. Some output components such as light emitting diodes (LEDs) require very little power to drive them but others, such as heating elements, require a lot of energy. Output components sometimes need to be connected to devices called **transducer drivers** which increase the power available and help a circuit to perform correctly without overheating.

Most output components (excluding lamps) have polarity.

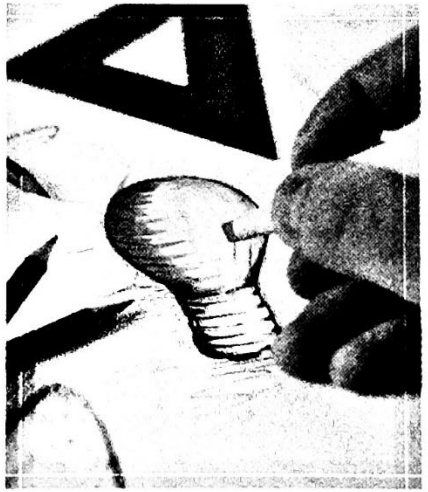
Common output components

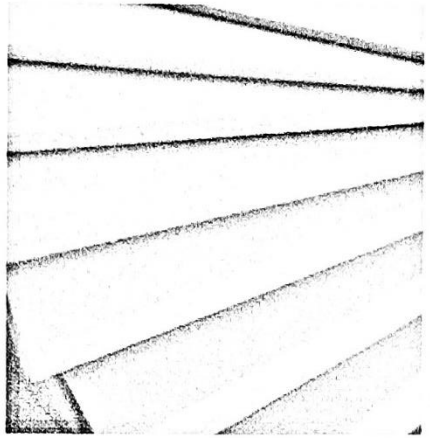
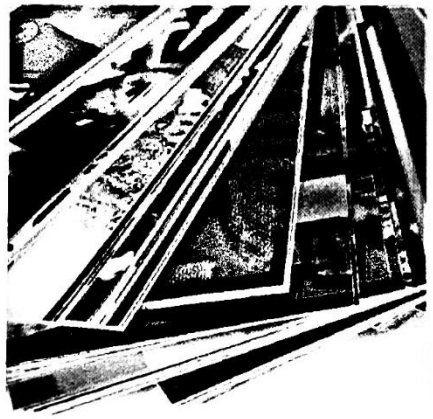
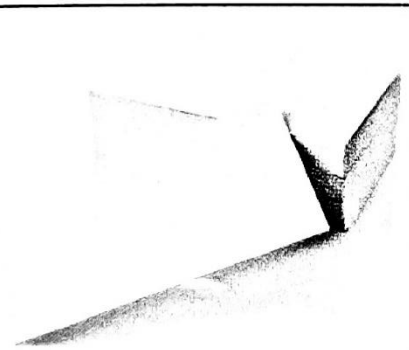
Name and symbol	Appearance	Image	Characteristics	Uses
Light emitting diode (LED) 	Available in a variety of sizes, shapes and colours, most commonly 5mm round		Produces light, connected by an anode (+ve) and cathode (-ve), has polarity. Low voltage, low power consumption, long-lasting, can be hard to change if broken	Low power lighting, torches, TV screens, power indicators
Lamp 	Available in a variety of sizes, shapes, colours and levels of power (wattage) or brightness (lux)		Produces light, can be brighter than LEDs, less economical due to the heat produced. Not long-lasting but easy to change	Household lamps, car headlamps, street lights, floodlights and security lights
Buzzer 	Small compact units in plastic casing, available in a variety of sizes and sounds		Mid- to high-pitched buzz created by fast oscillating electromagnetic parts, has polarity	Alarm systems, door entry systems, children's toys, electronics games
Speaker 	Speaker cone shaped into magnetic coil at base, available in a wide variety of sizes		Full range of sound available, variety of power ratings (wattage), variety of frequency responses (treble to bass)	Headphones, music systems, intercoms, radios

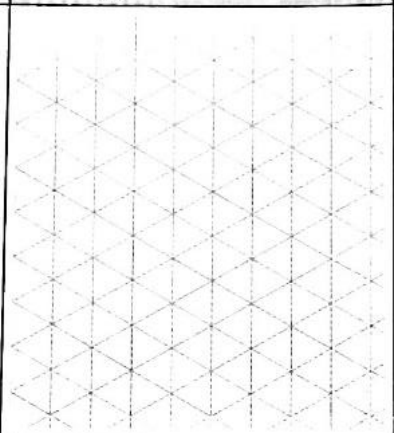
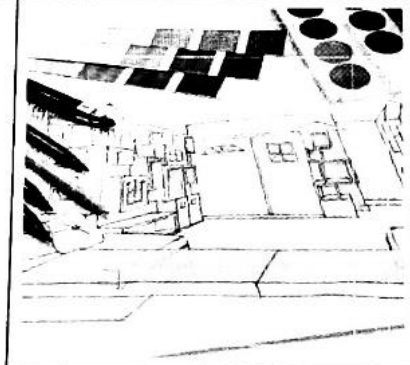
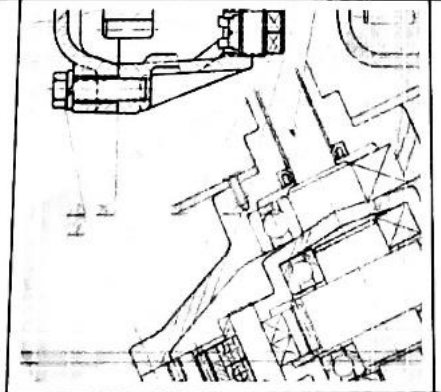
Paper and Board

Common papers

Paper is measured by weight in grams per square metre (**GSM**). Weights and measurements of paper and board are covered in more detail in Chapter 25.

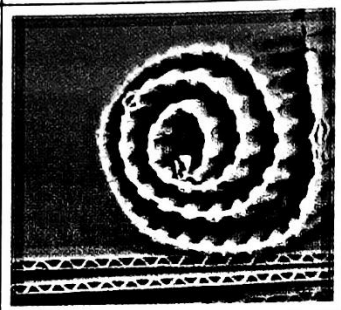
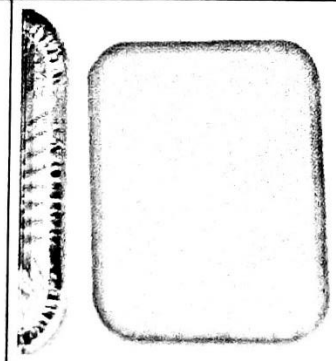
Name	Appearance	Image	Characteristics	Uses
Bleed proof paper	Coated white cartridge-like paper that can be slightly textured		70gsm sheet, coated to stop solvent-based markers staining through the page. Deeper colours are achieved as ink stays on the surface	Used with marker pens for design ideas and final designs
Cartridge paper	Thick white paper with a slightly rough surface texture		120-150gsm, completely opaque and more expensive than photocopier paper	Pencil and ink drawings, sketching and watercolour

Name	Appearance	Image	Characteristics	Uses
Foam core board	Smooth board surface front and back, foam inner core, limited variety of colours and thicknesses		3-10mm thick, lightweight and rigid in all directions. Can crease and crack under pressure, expanded polystyrene centre	Architectural models, model making, prototyping, mounting and framing of photographs and art work
Ink jet card	Brilliant white card treated for a smooth finish		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 board	High quality card, brilliant white smooth finish on both sides		200-500gsm, stiff board, holds colour well, easily cut or creased	Many uses including greeting cards, packaging and advertising, hot foil stamping and embossing

Name	Appearance	Image	Characteristics	Uses
Grid paper	White paper with a printed grid of squares, isometric lines or other patterns		Usually printed onto 80gsm paper with faint lines often in a 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 paper	Off white, medium opacity sheet with a smooth finish. Translucency decreases as gsm increases		40-60gsm, semi-translucent, takes pencil and most media well. Some inks can smear on heavily coated papers	Creating sketches and working ideas; copying and tracing images with a variety of media
Tracing paper	Off white, low opacity sheet. Translucency decreases as gsm increases		40-120gsm, translucent, takes pencil and most colours well	Copying and tracing images. Used with a light box, overlays for design adaptations and working drawings

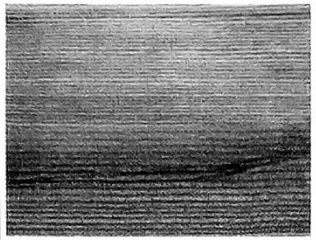
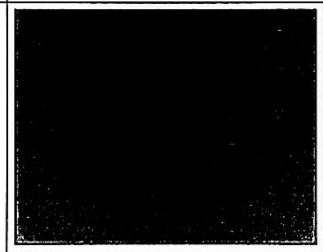
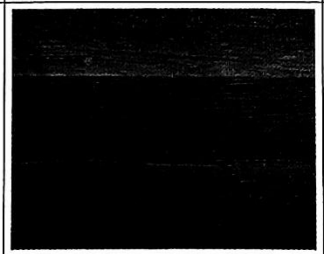
Common boards

Board thickness is usually quoted in **microns** or grams per square metre (**GSM**). 1000 microns is equal to 1mm of thickness. The lower the number, the thinner the paper or card. Weights and measurements of board are covered in more detail in Chapter 25.

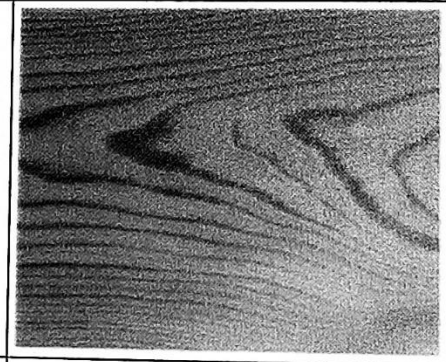
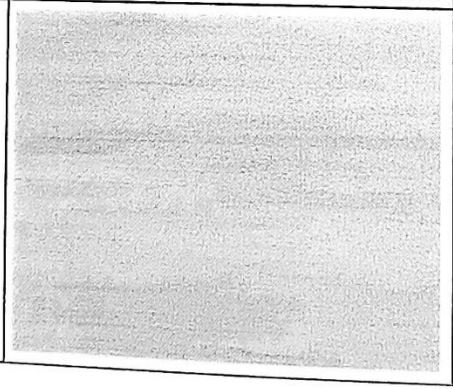
Name	Appearance	Image	Characteristics	Uses
Corrugated cardboard (fibreboard)	Natural brown board finished on one or both sides with bonded paper		1000-5000 microns, strong, lightweight and rigid perpendicular to corrugations. Insulative and easily printed on	Packaging, boxes and impact protection
Duplex board	Two layers of card bonded together, often with a white external layer		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 board	White card, usually coated or laminated with aluminium foil bonded on one side		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

Timber

Common hardwoods

Name	Appearance	Image	Characteristics	Example uses
Ash	Pale brown/cream		Flexible, tough and shock resistant, laminates well	Sports equipment and tool handles
Beech	Dense/close grain with an attractive pink hue		Fine finish, tough and durable	Children's toys and models, furniture and veneers
Mahogany	Rich reddish brown		Easily worked, durable and finishes well	High end furniture and joinery, veneers
Oak	Light brown with an interesting and variable grain		Tough, hard and durable, high quality finish possible	Flooring, furniture, railway sleepers and veneers
Balsa	Pale cream/white. An open grained, large and unusually fast growing hardwood tree		Very soft and spongy, very lightweight but can snap in thin sections	Prototyping and modelling - especially model aircraft

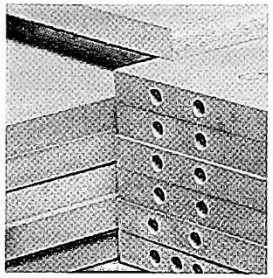
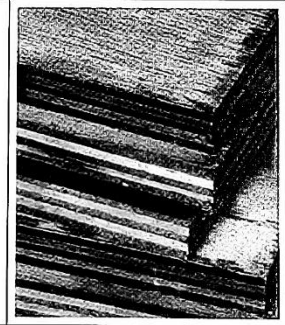
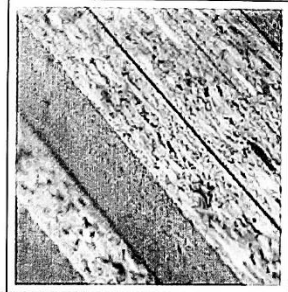
Common softwoods

Name	Appearance	Image	Characteristics	Example uses
Larch	Pale to reddish brown with a contrasting grain		Durable, tough, good water resistance, good surface finish and machines well. Issues with loose knots	Exterior cladding, flooring, machined mouldings, furniture and joinery
Pine	Pale yellow to pale brown, attractive grain that darkens with age		Lightweight, easy to work, can split and be resinous near knots	Interior construction (and exterior if treated), cheaper furniture, decking
Spruce	White/cream with a fine even grain		Easy to work, high stiffness to weight ratio. Variable results when staining	Construction, furniture and musical instruments

Manufactured Boards

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 boards have a pale brown natural finish, but can be covered with thin slices of high quality wood to give the appearance of solid wood. This covering is called a **veneer**. Veneers are produced by taking thin slices of a natural wood from the trunk of a tree. They are then bonded to the surface of cheaper sheet materials, such as medium density fibreboard (MDF) or plywood. The veneering process is covered in Chapter 27.

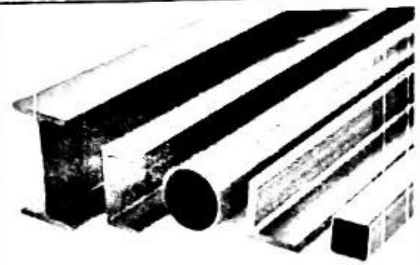
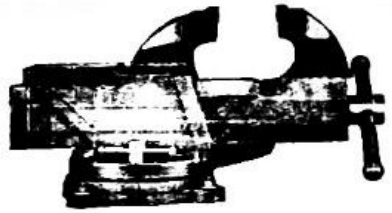
Name	Appearance	Image	Characteristics	Example uses
Medium density fibreboard (MDF)	Smooth, dull, light brown finish available in many veneered options. Edges can be hard to finish well		Rigid and stable, good value with a smooth, easy to finish surface. Very absorbent so not good in high humidity or damp areas	Flat pack furniture, toys, kitchen units and internal construction
Plywood	Alternating layers of natural grain veneers with the outer material usually of a higher quality for aesthetics		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. Interior, exterior and marine grades available for greater water resistance
Chipboard	Pale grey/brown with no natural grain. Frequently covered with a laminate such as melamine formaldehyde (Formica®)		Good compressive strength, not water resistant unless treated, good value but prone to chipping on edges and corners	Flooring, low-end furniture, kitchen units and worktops

Metals

Ferrous metals

This group of metals all contain iron (**ferrite**). Most ferrous metals are magnetic and will rust if exposed to moisture without a protective finish. Common examples include mild steel, carbon steel and cast iron. Very small amounts of other compounds or metals can be combined with non-ferrous metals to enhance their properties. **Carbon** is a common additive used to increase the hardness of the iron.

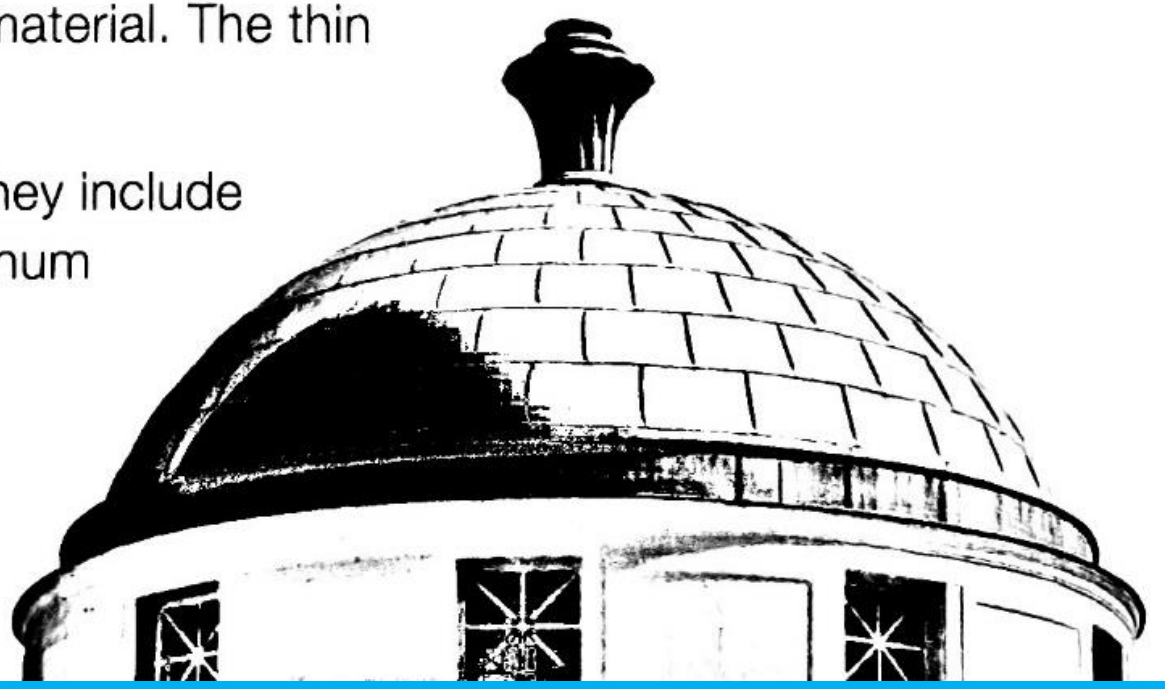
Common ferrous metals

Name	Appearance	Image	Characteristics	Example uses
Low carbon steel (Mild steel) Carbon content 0.05 – 0.3%	Bright grey with a smooth texture that quickly oxidises if not protected		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 (Tool steel) Carbon content 0.6 – 1.5%	Very similar to mild steel but does not rust as readily, very smooth texture		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 Carbon content 2.4 – 4%	Dull, varying shades of grey depending on type, rough texture unless machined, less prone to rust		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

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**. Oxidisation causes the surface of the metal to change colour and dull with time. This rarely affects the working properties of the metal and is used by some designers as an aesthetic benefit. Copper, for example, turns a deep turquoise called **verdigris** and is used as a bespoke roofing material. The thin oxide layer is known as **patina**.

Non-ferrous metals come in many colours. They include precious metals such as gold, silver and platinum and others including lead and mercury, that are poisonous.

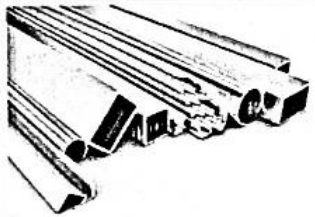


Common non-ferrous metals

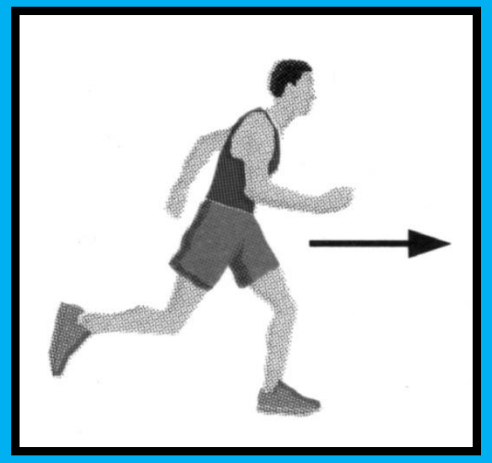
Name	Appearance	Image	Characteristics	Example uses
Aluminium	Light grey, can be polished to a mirror finish but often has brushed matt finish		Lightweight, high strength to weight ratio, ductile but can be difficult to weld	Pots and pans, sports car body panels, bike frames, drinks cans, foil or take-away trays
Copper	Light reddish brown, polishes well, oxidises to an attractive green-grey shade		Ductile, malleable and a good electrical conductor that is easily joined by soldering	Plumbing supplies, electrical cables, bespoke roofing and guttering
Tin	Silvery white, often plated onto steel with a shiny finish achievable		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	Silvery grey with bluish-white hue, matt finish		Fair electrical conductivity, malleability and ductility; however, all are improved when alloyed	Mainly used to **galvanise** steel to prevent rusting, easily die cast or used in alloys

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.

Name	Appearance	Image	Characteristics	Example uses
Brass Copper 65% Zinc 35%	Yellowish gold, polishes well and oxidises to a dark antique brown		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 Low carbon 0.03 – 0.08% Chromium 10.5 – 26%	Silver hue that can be polished to mirror finish. Resists rust well		A ferrous alloy with chromium, nickel and manganese. Hard, very smooth but difficult to weld	Cutlery, kitchen and medical equipment
High speed steel Alloys can include: Chromium Molybdenum Tungsten Vanadium Cobalt Carbon	Varies depending on the combination of metals alloyed with steel		Able to withstand the high temperatures created when machining at high speed, keeps its cutting edge well	Cutting tools such as drill bits, mill cutters, taps and dies

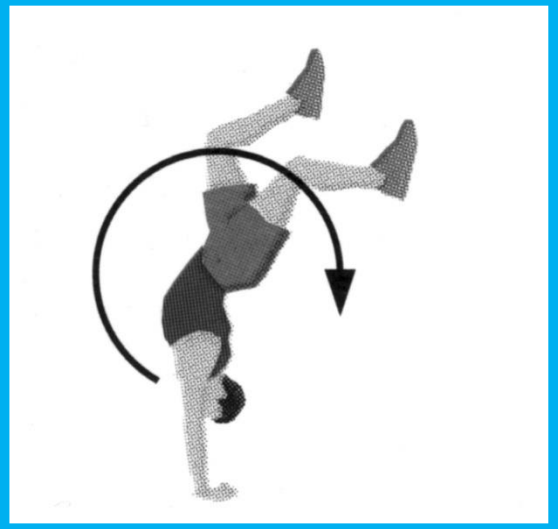
Motions



Linear Motion:

This is when something completes a movement in a straight line. When you walk down the street you are enacting a linear motion.

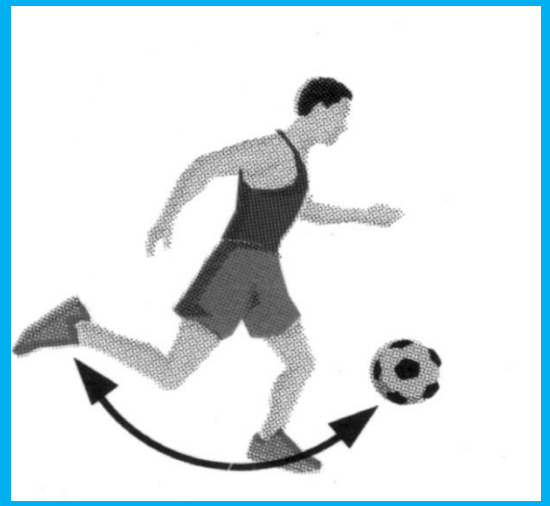
Examples may be to pull a cord, wind up a rope and a zip mechanism.



Rotary Motion:

This motion involves moving in a complete circle.

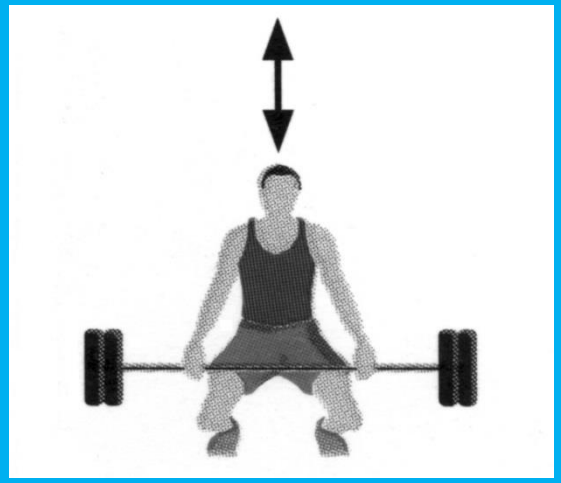
Examples may be a gear, wheel and a cam.



Oscillating Motion:

This is a swinging motion which does not go round in a full circle.

Examples including a swing, pendulum and a metronome.



Reciprocating Motion:

This motion involves moving to and fro in one complete movement.

Examples of this are a bicycle pump and a keyboard key.

Forces

Tension

Tension occurs when a pulling force is applied to either end of a material. The object becomes stretched as it tries to resist being pulled apart. For example, a rope being pulled in a tug-of-war competition, or chains supporting a swing are under tension.

Tensile strength is the ability of a material to resist being pulled apart.

Compression

Compression occurs when a pushing force is applied to either end of a material. The object becomes compressed as it tries to resist being squashed. For example, a spring in a suspension system or a clove of garlic in a garlic press are being compressed. Air in a balloon and spray deodorant in a can are also being held under compression.

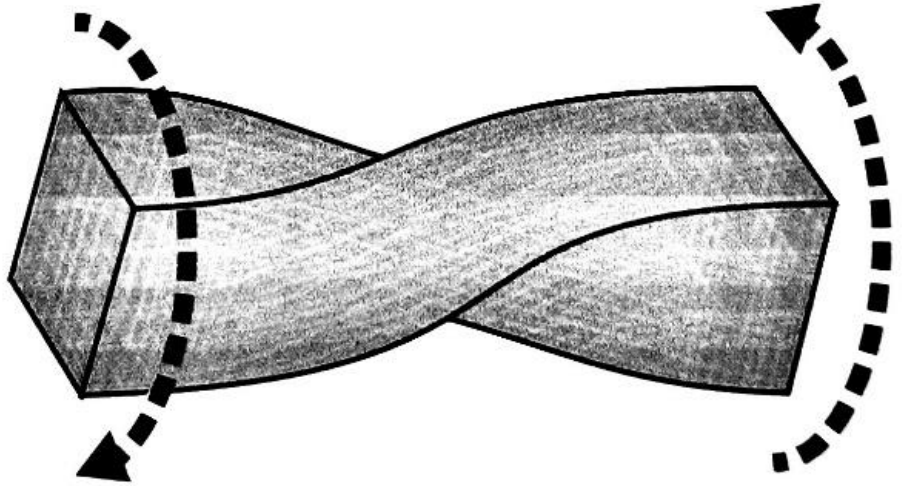
Holding liquids and gasses under compression is an economical way of storing them. They take up less room and their release can be easily controlled through valves and other devices.

Compressive strength is the ability of a material to resist being compressed or squashed.

Torsion

Torsion forces occur when a material is being twisted. The two ends of the material rotate in opposite directions creating a twist, like wringing out a wet towel.

Many structures and objects, including cars going over uneven road surfaces and boats riding over waves, are subject to torsion.



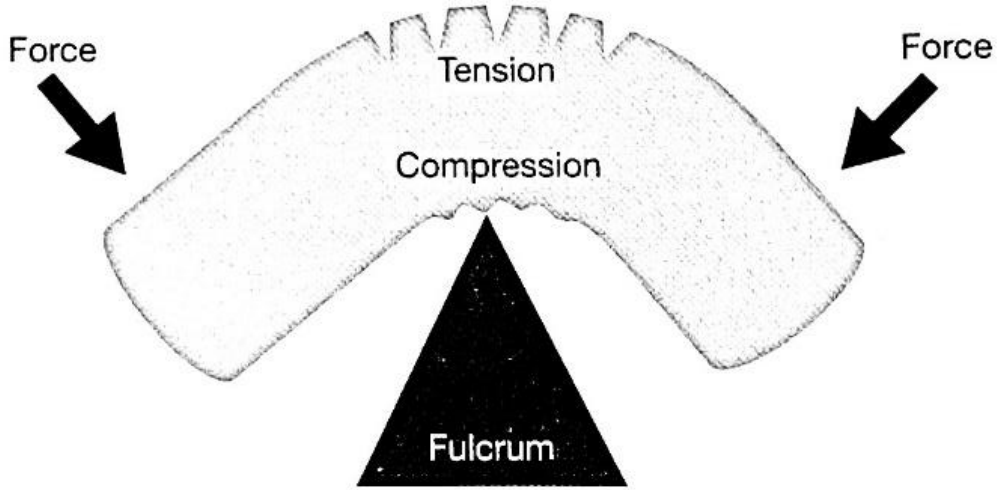
Torsional strength is the ability of a material to resist being twisted out of shape.

Bending

A **bending** force results in both tension and compression either side of its neutral axis. When two people are sitting on opposite ends of a seesaw, the beam will bend over the fulcrum. The top of the beam will be stretched and the underside will be compressed.

The pressure to make a material bend is applied at either end with an upwards or downwards pressure. Pressure could also be applied in the middle whilst it is supported at both ends.

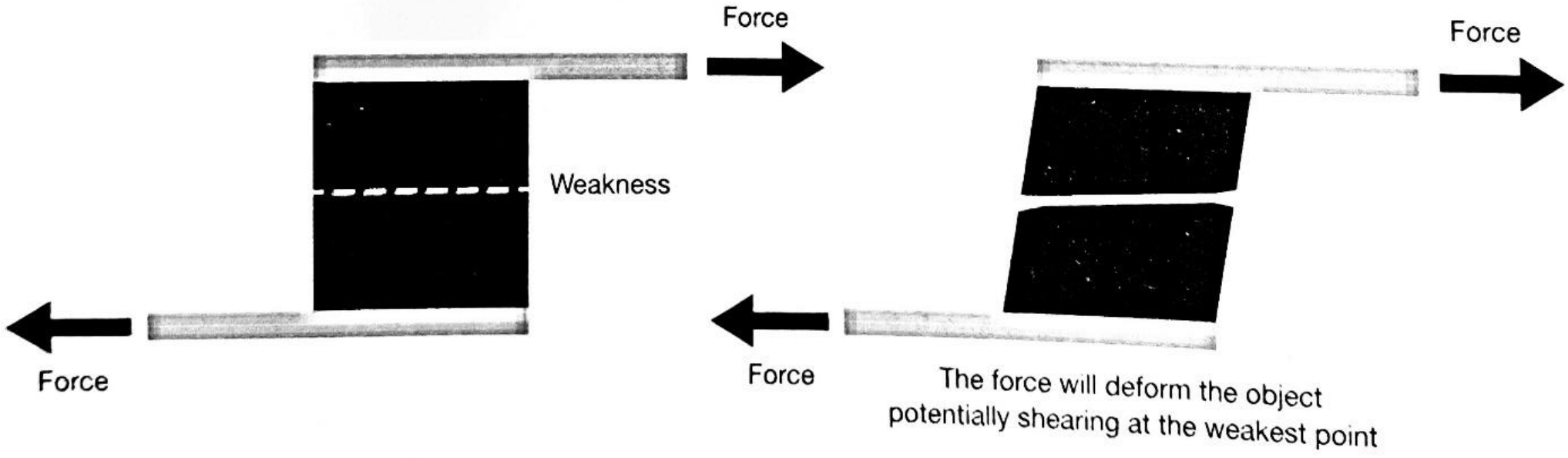
Stiffness is the ability of a material to resist being bent out of shape.



Shear

Shear force is a force that acts on an object in a direction perpendicular to its length. For example, wind pushing against a tree is a shear force. The object experiences shear stress, and may eventually snap or break.

Shear forces also occur when a material or a joint between materials is being pulled apart along different planes or lines (tension is similar but in only one plane i.e. a straight line). The two forces will travel in opposite directions from different planes or lines. Imagine fabric shears cutting a cloth.



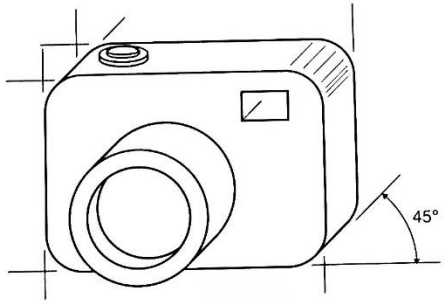
Other Thermoplastics

Name	Appearance	Image	Characteristics	Uses
ABS Acrylonitrile butadiene styrene 7 OTHER	Very smooth finish, can be textured, easily coloured		Tough, hard, good chemical resistance, good impact resistance, can be 3D-printed, easily injection moulded and extruded	Electronic casings, 3D printed products, hard-hats, Lego™
Nylon Polyamide 7 OTHER	Smooth, easily coloured, available in various thicknesses of sheet, bar, film or thread		Self-lubricating, very low friction, hard wearing, easily machined, can be woven in to fabrics	Clothing, tights, rope, cogs, gears, bushes, pipes, tents, parachutes

Drawing techniques

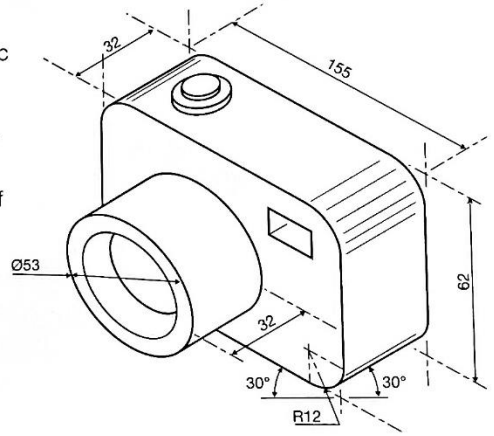
There are three main types of 3D drawing styles that you are likely to use within your portfolio. These vary in their level of complexity to produce and have different advantages and disadvantages.

Oblique projection uses a 45-degree angle to draw lines that represent the depth of the side (end) and the top (plan) of the drawing. The front of the drawing is face on to the viewer which actually creates a visual lie. It is impossible to see the front of a cuboid straight on and also see the side and the top.



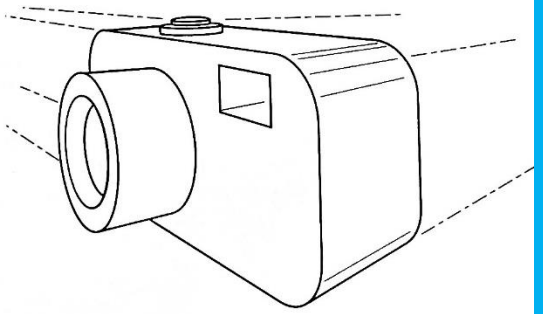
Oblique projection is a technique that can get an idea across quickly and simply. It can be very useful in the early stages of developing ideas.

Isometric projection uses a 30-degree angle and is much more realistic. For a basic cuboid, all of the height, width and depth lines follow the 30-degree isometric grid lines. Dimensioning can be done accurately and, by using simple techniques, complex shapes can be constructed or carved out of the main cuboid.



Isometric projection is very good for design ideas that have a geometric shape. With some practice, it is also good to convey ideas quickly and to show where components and parts fit in relation to others.

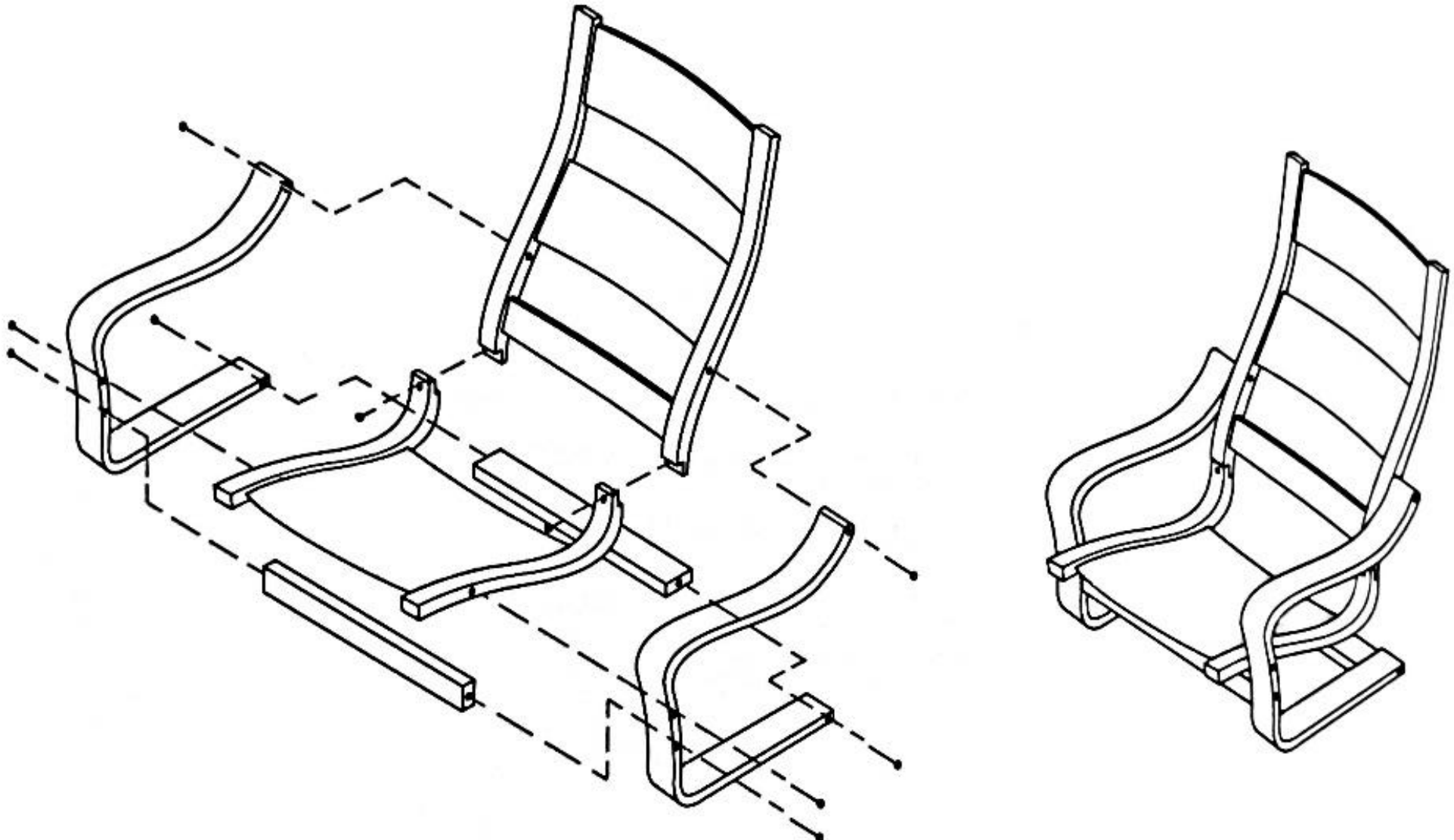
Two-point perspective uses two **vanishing points** that are set to the outer edges of the page. The main **construction lines** that create the width and depth are all projected back to the two vanishing points.



Two-point perspective gives the most realistic view as it emulates the way the viewer's eye sees perspective, meaning that things get smaller the further away they are. It is great technique to give a realistic view of what a product or prototype might look like. It is not so easy to add dimensions, in comparison to isometric projection.

Exploded drawings

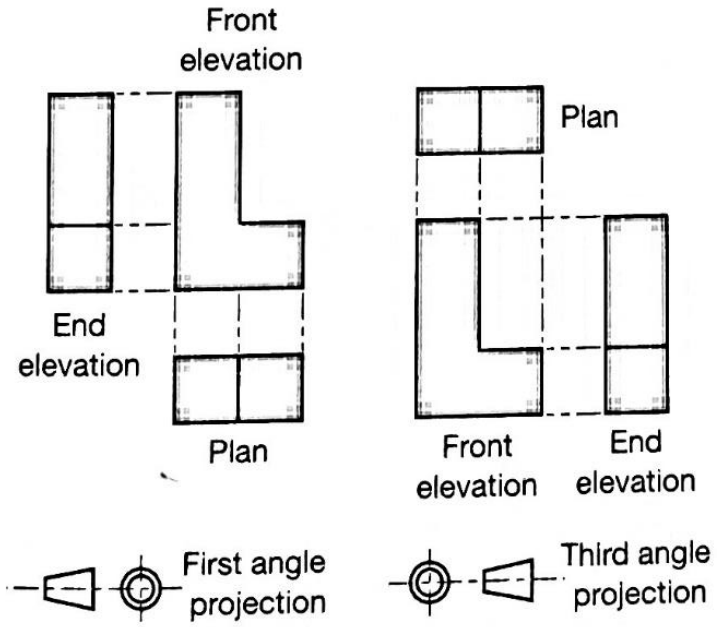
An **exploded drawing** can be very helpful to show how the component parts of a product fit together. The parts are drawn as if they are separated from each other, but using paths that represent the way they are assembled. Exploded drawings are a good way to show separate components that would normally be hidden in a solid drawing.

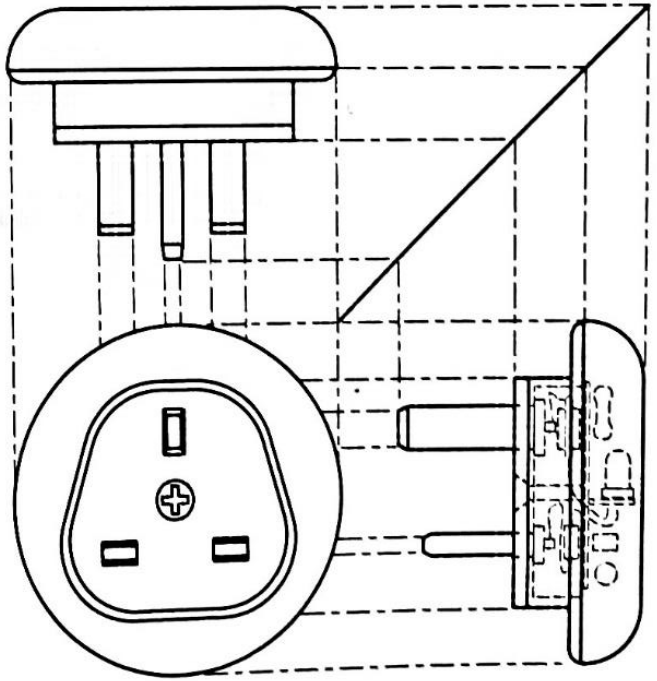


Working drawings

To enable enough detail for prototype or product manufacture to take place, a working drawing needs to be produced. This normally needs to include a front, end and plan view (elevation) of the design. A textiles pattern may simply include a front and back view. Drawings could also include other elevations if not all of the important detail has been shown. Some very detailed products require a **sectional view,** which enables you to see inside a design as if part of it had been removed or if it had been cut through.

Working drawings are best presented in **orthographic projection**. The two types used are first angle and third angle orthographic projection. Third angle projection places the plan elevation above the front elevation; the right end elevation is placed to the right and so on. First angle differs in that the plan elevation is projected below the front elevation and the left end elevation is positioned to the right.





Printing Processes

Offset Lithography

Applications:

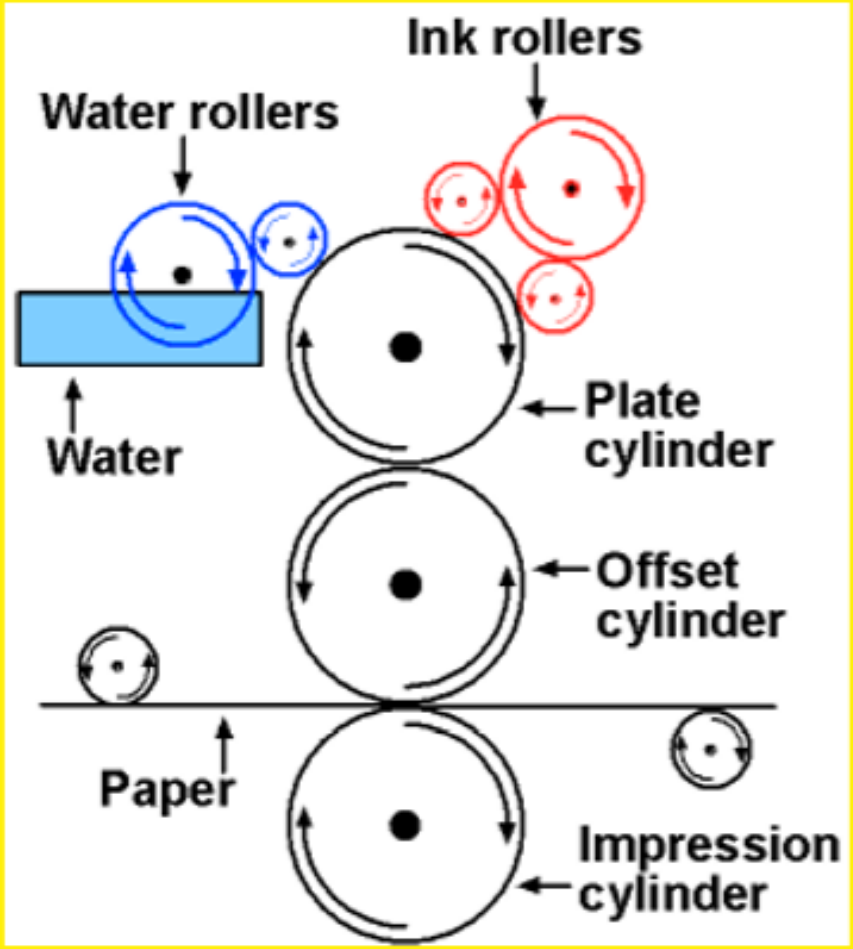
Business stationery;
Brochures;
Magazines;
Newspapers.

Offset Lithography

How it works:

Plates (aluminium or polymer) are made up with the images & type. Water covers the blank areas to repell the inks. The plate rolls against the rubber blanket cylinder (offset). This then transfers from the cylinder to the stock (paper).

This is known as indirect or offset printing.



Advantages

- Good reproduction quality, especially photography.

- Inexpensive.

- Able to print on a variety of papers and stocks.

- High printing speeds.

- Widely available.

Disadvantages

- Colour variation due to water/ink mixture.

- Paper can stretch due to dampening.

- Set-up costs make it uneconomic on short runs.

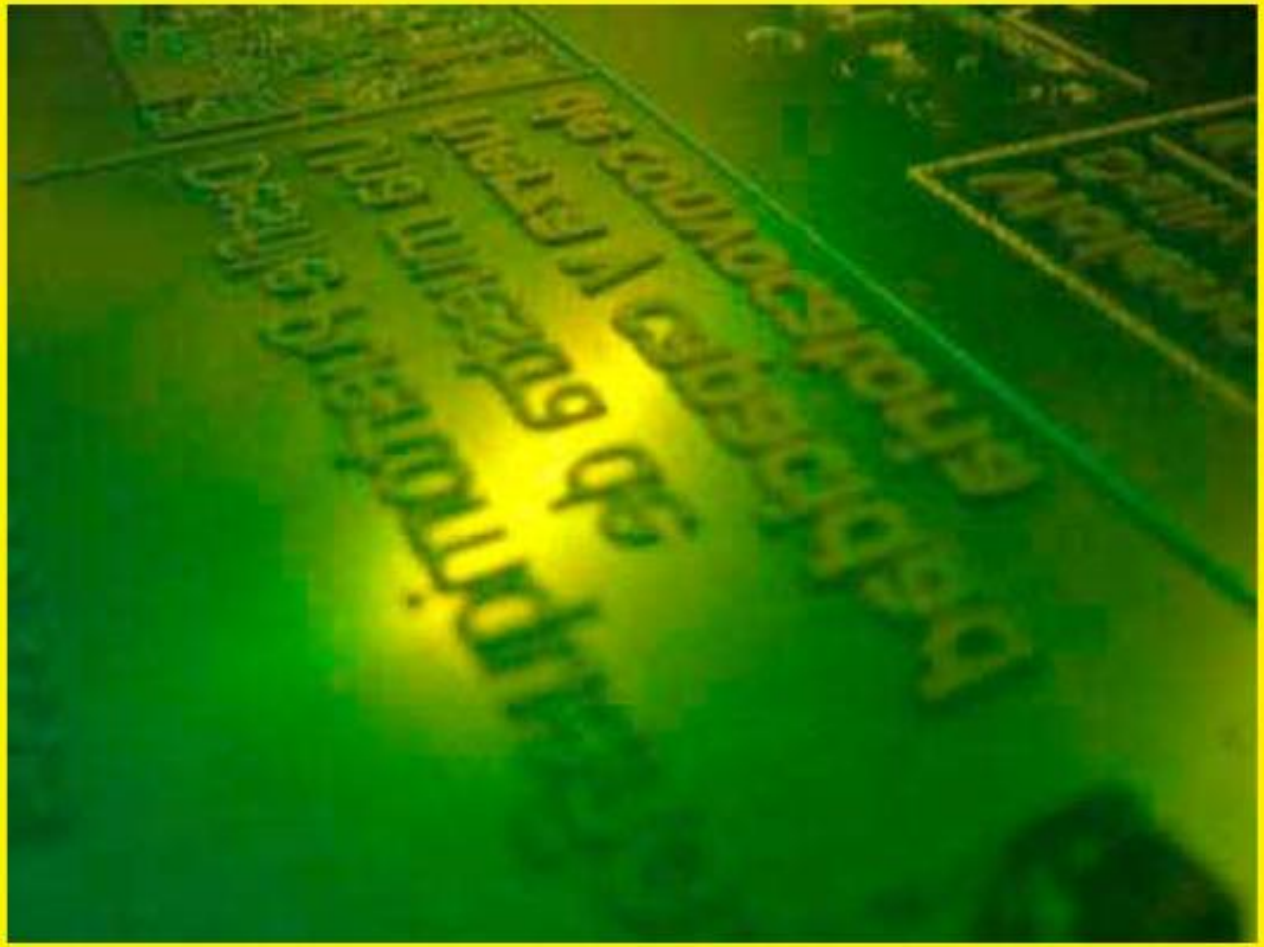
- Can only be used on flat surfaces.

- Requires a good quality surface.

Flexography

Applications:

Packaging;
Less-expensive magazines;
Paperbacks;
Newspapers.

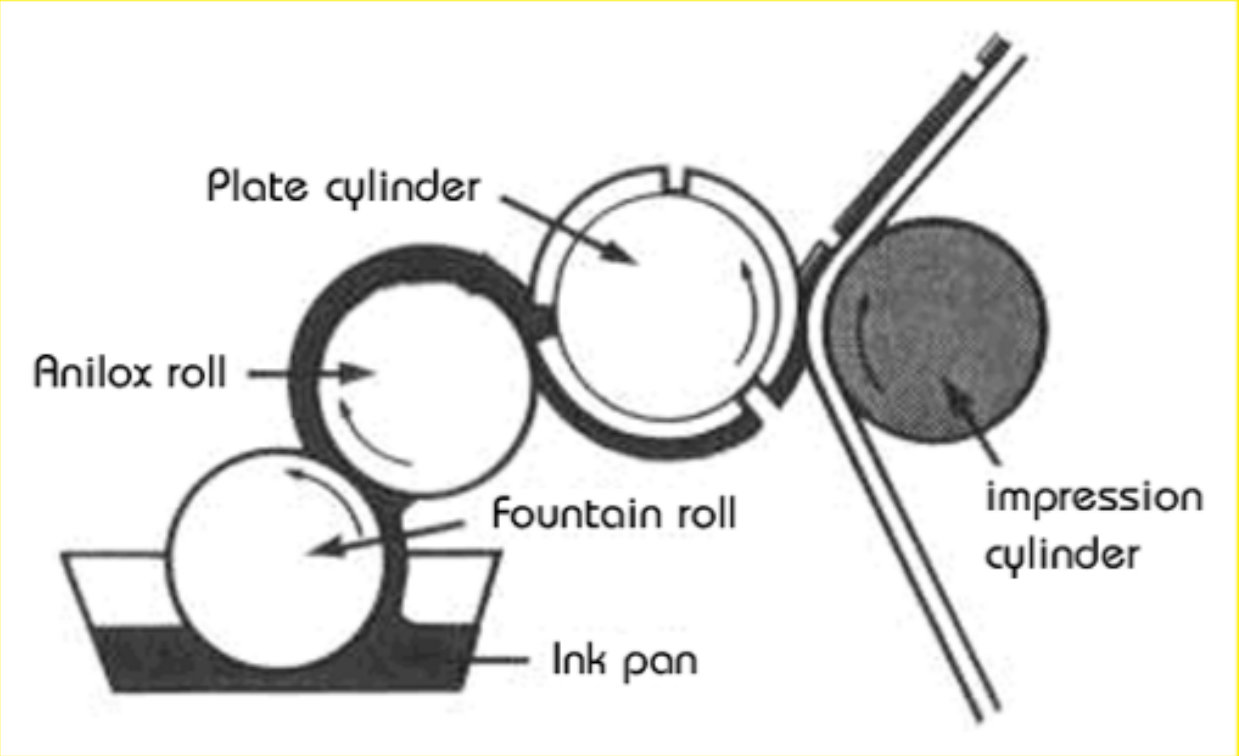


Flexography

How it works:

Using rollers and a plate which this time has raised images, ink feeds through the rollers applies to the plate then to the stock.

This is known as direct printing.



Advantages

- High speed printing process.

- Fast-drying inks.

- Can print on the same presses as letterpress.

Disadvantages

- Difficult to reproduce fine detail.

- Colour may not be consistent.

- Set-up costs high and would rarely be used on print runs below 500,00.

Screen Printing

Applications:

T-shirts;
Posters;
Plastic/Metal signage;
POS displays;
Promotional items.

Screen Printing

How it works:

Using a stencil or photo emulsion and a screen ink passes through the open spaces of the screen and onto the paper or fabric.

This is known as direct printing.

Advantages

- Stencils easy to produce using photo-emulsion technique.

- Versatile, can print on virtually any surface.

- Economical for short, hand produced runs.

- Fully automatic methods capable of producing large volumes.

Disadvantages

- Generally difficult to achieve fine detail (photogrpahic screens able to reproduce fine detail).

- Print requires long drying times.

Gravure

Applications:

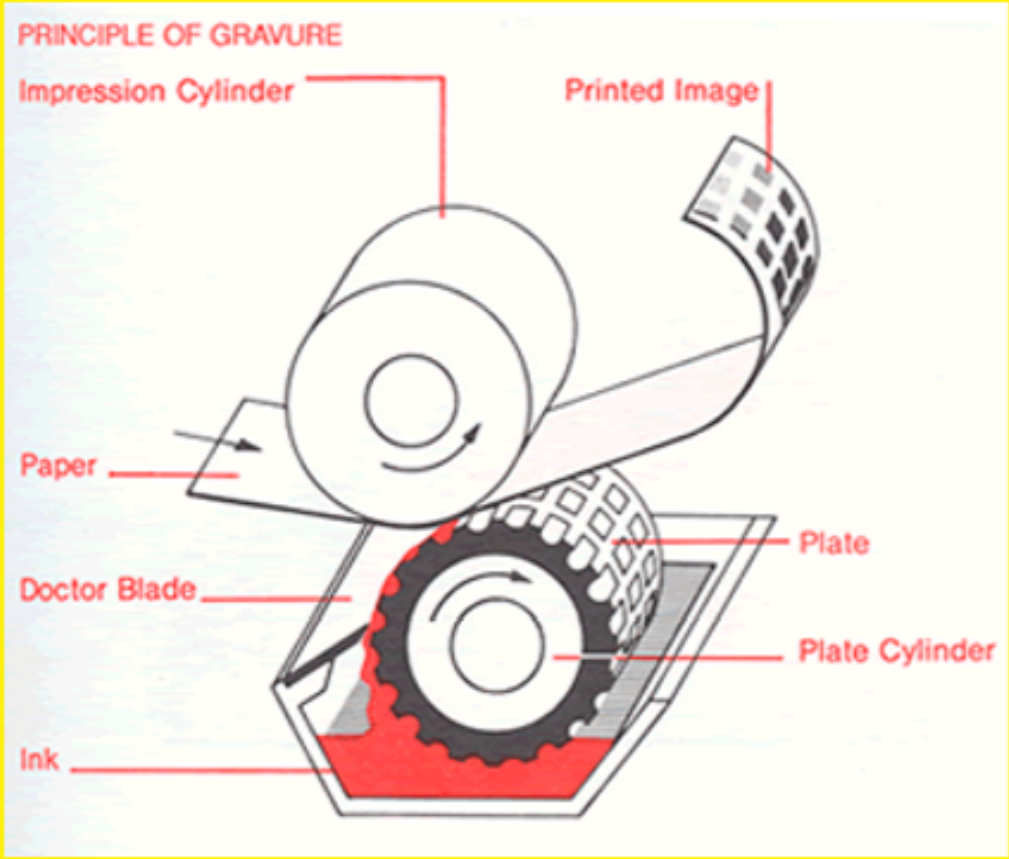
High-quality art and photographic books;
Postage stamps;
Packaging;
Expensive magazines.

Gravure

How it works:

An image is engraved onto a copper plate which has small indents which act as ink wells. In the printing press, like litho and flexography, the rollers rotate over the plate, printing the image on to the stock.

This is known as direct printing.



Advantages

- Consistent colour reproduction.

- High-speed printing processes.

- Widest printing presses.

- Ink dries upon evapouration.

- Good results on lower-quality paper.

- Variety of in-line finishing operations available.

Disadvantages

- High cost of engraved plates and cylinders.

- Only efficient for long print runs.

- Image printed as dots which can be visible to the naked eye.

- Very expensive set-up costs, so only used on large print runs.

Scale of Production

Table 2.11 *Applications, advantages and disadvantages of scales of production.*

Scale of production	Applications	Advantages	Disadvantages
One-off	Prototype and architectural models, shop signage, vinyl stickers for commercial vehicles, etc.	• Made to exact personal specifications. • High-quality materials used. • Highly skilled craftsperson ensures high-quality product.	• Expensive final product in comparison to larger scales of production. • Generally labour intensive and can be a relatively time-consuming process.
Batch	Commercially printed materials, e.g. magazines and newspapers.	• Flexibility in adapting production to another product. • Fast response to market trends. • Identical batches of products produced. • Efficient manufacturing systems can be employed. • Very good economies of scale in bulk buying of materials.	• Poor production planning can result in large quantities of products having to be stored, incurring storage costs. • Frequent changes in production can cause costly re-tooling, reflected in retail price.

Mass	Electronic products, e.g. mobile phones and games consoles, commercial packaging, etc.	• Highly automated and efficient manufacturing processes. • Specialisation of workforce to specific tasks. • Rigorous quality control ensures identical goods. • Excellent economies of scale in bulk buying of materials. • Increased production means that set-up costs are quickly recovered. • Low unit costs. • Reduced labour costs.	• Low-skilled workforce – low wages, repetitive nature of tasks leading to job dissatisfaction. • Ethical concerns of manufacturing in developing countries i.e. 'sweat shops'. • High initial set-up costs due to very expensive machinery and tooling needs. • Inflexible – cannot respond quickly to market trends.
Continuous	Packaging, e.g. cans and bottles for the drinks industry.	• As mass production. • Extremely low unit costs. • Runs continuously 24 hours, 7 days a week.	• As mass production. • Very little flexibility at all as production set up 24/7.

Good Luck!