Design Technology Knowledge Organisers

Core Technical Principles **3.1.1 New and Emerging Technologies**

What will I learn?

In this topic you will learn about:

- the impact of new and emerging technologies on the design and organisation of the workplace, buildings and the place of work, tools and equipment
- enterprise based on the development of an effective business innovation
- the impact of resource consumption on the planet
- how technology push/market pull affects choice
- changing job roles due to the emergence of new ways of working driven by technological change
- changes in fashion and trends in relation to new and emergent technologies
- respecting people of different faiths and beliefs
- how products are designed and made to avoid having a negative impact on others
- the positive and negative impacts new products can have on the environment
- the contemporary and potential future use of production techniques and systems
- how the critical evaluation of new and emerging technologies informs design decisions.

KEY WORDS

Computer-aided design (CAD) using computer software to draw, design and model on screen.

Computer-aided manufacturing (CAM) manufacturing products designed by CAD.

Flexible manufacturing system (FMS) a system in which production is organised into cells of machines performing different tasks.

Computer numerically controlled (CNC) machine tools that are controlled by a computer.

Just in time (JIT) a production method that means materials and components are ordered to arrive and the product assembly point just in time for production.

Lean manufacturing focusing on reduction of waste when manufacturing.

Planned obsolescence planning or designing a product to have a short life span.

Technology push where new technology or materials are developed and designers take the opportunity presented by this to design new products.

Market pull where users want a product to be improved or redeveloped to meet their needs.

Sustainability meeting present-day needs without compromising the needs of future generations.

Ecological footprint the impact of a person or community on the environment; the amount of land needed to supply the natural resources they use.

Social footprint the impact a company or organisation has on people and communities.

STRETCH AND CHALLENGE

Write an article that discusses the benefits and disadvantages of automation in the manufacturing industry.

STRETCH AND CHALLENGE

Write an article that discourages manufacturers from producing products that have planned obsolescence.

KEY POINTS

- Automation is the use of computers to control machinery in factories with minimal human involvement.
- Enterprise is a skill where people take risks to bring new products to the market.
- Sustainability is about meeting our own present-day needs without compromising the needs of future generations.
- Culture is the values, beliefs, customs and behaviours displayed by different groups of people.
- Just in time (JIT) production is a method of organising a factory so that materials and components are ordered to arrive at the workplace just in time for production.
- Planned obsolescence is when a product is deliberately designed to have a short life span or to go out of fashion.

1.2 Energy generation and storage

What will I learn?

In this topic you will learn about:

- using fossil fuels for energy generation
- alternative energy sources: their increasing use and different types
- how energy is stored
- batteries and their advantages and disadvantages.

KEY WORDS

Fossil fuels a natural fuel such as coal, oil or gas, formed from the remains of living organisms.

Global warming an increase in the temperature of the Earth's atmosphere caused by the greenhouse effect and increased levels of greenhouse gases.

Fission the process in which uranium atoms are split and produce heat.

Renewable energy energy from a source that is not depleted when used, such as wind or solar power.

Hydroelectricity the process which uses a dam to block a river in a valley and channels water through turbines that are used to turn generators for producing electricity

Biomass growing plants so that they can be burnt, or using decaying plant or animal materials to produce heat.

STRETCH AND CHALLENGE

Produce a short discussion document arguing whether Britain would be better off investing in a new nuclear energy power station or a tidal barrage across either the rivers Severn or Dee.

KEY POINTS

- We rely on energy to power most aspects of our lives, such as light, heat, transport and communication.
- All fuels and biofuels cause pollution when burnt.
- Coal, gas and oil are all fossil fuels, and are finite resources.
- Most renewable sources reduce the risk of pollution.
- Many renewables cannot provide a constant supply, unlike fossil fuel or nuclear-powered power stations.
- Storage systems cannot generate power, but are useful for when extra supply is needed quickly, or if it is not possible to connect to a supply.

1.3 Developments in new materials

What will I learn?

In this topic you will learn about:

- modern materials
- smart materials
- composite materials
- technical textiles.

KEY WORD

Modern material a material that has recently been developed for specific applications.

Smart material a material that changes its properties in response to changes in its environment.

Composite a material that combines the properties of the materials that were used to make it.

Technical textiles textile materials and products that are manufactured for their technical and performance properties.

Microencapsulation very thin fibres hold chemicals in tiny capsules, which break open releasing the chemicals

STRETCH AND CHALLENGE

Write an article for a design magazine explaining how the development of smart materials will affect the work of designers. This should include at least two case studies of products that could be changed to include smart materials.

KEY POINTS

- Graphene is a very new material that is very light and flexible.
- Polymer coated metals can be dip or powder coated depending on the required finish.
- Teflon is used on non-stick pans.
- Corn starch polymers degrade much quicker than oil-based polymers in the right conditions.
- Smart materials change their properties in response to changes in the environment.
- Thermochromic materials change colour at specific temperatures.
- Shape memory alloys (SMAs), if deformed, will return to their original shape when heated.
- Photochromic materials change colour if the level of light changes.
- Composite materials combine the properties of the materials that were used to make them.
- Kevlar is a very light and strong material.
- Gore-Tex is a material used in the manufacture of outdoor clothing as it is breathable and waterproof.

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1.4 Understanding a systems approach when designing

What will I learn?

In this topic you will learn about:

- input devices
- process devices
- output devices.

KEY WORD

System diagram a diagram that breaks down an operation into its three main component parts: input, process and output. More complex systems may have more than one input, process, and output.

Input device electrical and mechanical sensors that use signals from the environment and convert them into signals that can be passed into processing devices and components.

Process devices handle information received and turn outputs on and/or off

Microcontroller a small computer within a single integrated circuit

Output sends out information, heat, light, sound or mechanical movement to the environment the system is operating in.

STRETCH AND CHALLENGE

Analyse and draw systems diagrams for the following products:

- an automatic security light
- a burglar alarm
- an automatic curtain or window blind system.

KEY POINTS

- System block diagrams describe what happens in a system.
- System block diagrams always have a minimum of one input, one process and one output block.
- Input devices provide information from outside into the system.
- Process devices handle information received and turn outputs on and/or off.
- Output devices send out information, heat, light, sound, or mechanical movement to the environment the system is operating in.

1.5 Mechanical devices

What will I learn?

In this topic you will learn about:

- different types of movement
- what levers and linkages are and what they do
- the different orders of lever
- how to convert one type of motion to another
- how diagrams and symbols are used to represent mechanisms
- changing the magnitude and direction of forces in rotary systems.

KEY WORDS

Mechanism a device that changes an input motion into a different output motion.

Lever a mechanism that moves around a fixed point (a pivot).

Linkages mechanisms that transfer force and can change the direction of movement.

Cam a mechanism with a cam, slide and follower. When the cam rotates the follower moves up and down.

Gear train a mechanism for transmitting rotary motion and torque.

Torque the turning force that causes rotation.

Friction resistance of motion when one object rubs against another.

Co-efficient of friction the amount of friction a material has.

STRETCH AND CHALLENGE

Using any modelling materials available to you, see if you can create a mechanism that turns rotary motion into oscillating motion (such as in car windscreen washers). When you have created your model, draw a diagram to explain the operation of this mechanism.

KEY POINTS

- There are four basic types of movement: linear, reciprocating, rotary, and oscillating.
- Levers and linkages are mechanisms used to transfer and alter force, and can change the direction of movement.
- There are three different orders of lever.
- Types of motion can be converted from one type to another by mechanisms.
- Diagrams and symbols are used to represent mechanisms.
- Mechanisms can change the magnitude and direction of forces.

1.6 Materials and their working properties

What will I learn?

In this topic you will learn about:

- the different classifications of papers and boards, their properties and common uses
- the different classifications of natural and manufactured timbers, their properties and common uses
- the different classifications of metals, their properties and common uses
- the different classifications of polymers, their properties and common uses
- the different types and properties of fibres and fabrics, their properties and common uses
- the physical and mechanical working characteristics of materials.

KEY WORDS

Hardwood woods that come from deciduous trees.

Softwood woods that come from coniferous (evergreen) trees.

Ferrous metals that contain iron.

Non-ferrous metals that do not contain iron.

Alloy a material produced by combining two or more elements together to produce a new material with refined properties.

Thermoforming polymers polymers that can be softened by heating, shaped and set over and over again.

Thermosetting polymers polymers that can only be shaped and formed by heat once.

Natural fibres fibres from plant and animal sources.

Synthetic fibres fibres manufactured from oil-based chemicals.

KEY POINTS

- Paper is classed as less than 200 gsm.
- Board is classed as over 200 gsm.
- Other materials can be added to paper and card to make it stronger, waterproof or an insulator of heat, etc.
- Hardwoods come from deciduous trees, softwoods come from coniferous trees.
- Hardwoods take approximately ten times longer to mature than softwoods.
- Manufactured boards come in larger sizes than natural timbers.
- Manufactured boards are more stable than natural timber and won't split or twist.
- Veneers and laminates can be added to manufactured boards to improve their appearance.
- Ferrous metals contain iron and are normally magnetic.
- Non-ferrous metals do not contain iron.
- Alloys are combinations of two or more pure metals with other elements.
- Thermoforming polymers can be repeatedly heated, formed and cooled.
- Thermosetting polymers can only be formed with heat once.
- Thermosetting polymers cannot be recycled.
- Natural fibres can come from plant or animal sources.
- Synthetic fibres are manufactured from oil-based chemicals. Examples of synthetic fibres include polyester, polyamide and elastane.
- Different fibres are blended together to make them better suited to different products and to improve a fabric's properties.
- Plain weave fabrics are strong and hardwearing.
- Non-woven fabrics are made directly from fibres without being woven or knitted, and include felts and bonded fabrics.
- Knitted fabrics have yarns that are looped together to make looser, more flexible fabrics.

2.1 Selection of materials or components

What will I learn?

In this topic you will learn about:

- the influences that have an impact on the design of products
- the factors to consider when selecting materials or components.

KEY WORD

Bulk buying when materials or products are bought in large quantities they usually cost less per unit than buying just a few. This is because the costs of setting up the manufacturing are the same no matter how many are made.

Social factors

Social factors are things that affect our lifestyle and include things such as wealth, gender, family and religion. These can change over time and designers need to be aware of these changes in order to make sure that their products meet the changing needs of consumers. Today, our society is multicultural, with people of many different religions and ethnicities, often with different traditions, which will influence the type of products they will want.

The source of some raw materials can have a big impact on the communities of the people who live nearby. Deforestation to provide land for crops or industrial activity is destroying the Earth's forests on a massive scale. This is thought to contribute to global warming, which can cause flooding of local areas which can have a devastating effect on communities.

Cultural factors

Cultural factors are the values of an individual or a specific community that determine the way that a person behaves. Cultural factors have an important effect on the products that people buy, and a product acceptable in one culture may be looked at as offensive or less desirable in another. The use of colour and colour schemes is a good example of cultural influences on design. Red is associated with good luck in China, but is the colour of mourning in South Africa, therefore, red products would be received very differently in those two countries.

Ethical factors

Ethical factors are things that are seen as being the 'right thing to do' and morally right.

The way that a product is designed and made has an impact on the well-being, safety and comfort of all those people who will be affected by the product.

The world's natural resources are dwindling and designers have a responsibility to use them carefully and to use recycled materials where possible. Manufacturers need to be aware of where materials come from and to purchase them from ethical sources, such as those approved by the FSC, whenever possible. Fair trade methods of manufacture ensure that workers are not exploited and have decent working conditions.

Using land to source raw materials means that less may be available for growing food crops in parts of the world where people do not have enough to eat. Manufacturing activities can cause pollution of land and drinking water, which will affect the health of people living nearby. Building factories and access roads may reduce the land available for housing and schools and also contribute to pollution that affects people's health and well-being.

KEY POINTS

- Timbers, metals and polymers can be manipulated and finished to make them suitable for different products.
- The use of timbers, metals and polymers can deplete the world's finite resources unless carefully managed.
- Many products need to be made from more than one material so that they are functional and aesthetically pleasing.

2.2 Forces and stresses

What will I learn?

In this topic you will learn about the impact of forces and stresses and the way in which materials can be reinforced and stiffened, including:

- the five different types of force that can act upon structures
- how some materials are better at resisting certain forces
- how materials can be enhanced to resist certain forces.

Forces acting on materials and objects

Tension forces are pulling forces that cause an object to be stretched or pulled apart. A rope in a tug of war competition is under tension as each side tries to pull the other side.

Compression forces are pushing forces that squeeze an object. An example might be when you stand on a drinks can and squash it. Table and chair legs are under compression when an object is placed on the table or someone sits on a chair.

Shear forces act across a material by acting near to one another but not directly opposite each other. A shearing force cuts the object by pushing it sideways in opposite directions. Scissors and garden shears have a shearing action that causes paper, grass or garden growth to be cut by making one piece slide across the other and create two pieces.

Bending forces act at an angle to an object and make it bend. Placing too many books or very heavy objects on a shelf can apply forces that make the shelf bend.

When an object bends it is under compression and tension at the same time. As seen in Figure 2.2.4, the top of the beam is experiencing compression and the bottom of the beam is under tension.

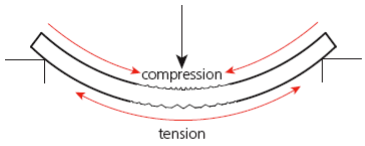


Figure 2.2.4 Compression and tension in a beam that is bending

Torsion forces are twisting forces that are applied to an object. When we twist a screw cap off the top of a bottle we are applying a torsion, or twisting, force. Torsion forces act in the drive shafts in cars. These are the shafts that transmit the rotary motion from the engine and gearbox to the wheels.

Enhancing materials

Materials can be enhanced to resist and work with forces and stresses to improve functionality. A variety of materials are used in many applications to resist tensile forces. Ropes can be made of any long stringy fibrous material, and can be made of natural materials like linen and cotton, or synthetic fibres like nylon or polypropylene. Rope is made by twisting multiple strands or yarns together to form a stronger and more robust material that has good tensile strength.

STRETCH AND CHALLENGE

Create a table that lists materials that have good resistance to tensile, compressive, torsion, shearing and bending loads, to aid designers in material choice.

STRETCH AND CHALLENGE

Describe why metal frame structures can sometimes use steel ropes to increase their rigidity.

KEY POINTS

- There are five main types of force that can act upon any object or structure: tension, compression, shear, bending and torsion.
- Some materials are better at resisting certain forces.
- Materials can be reinforced and stiffened in order to resist certain forces.

2.3 Ecological and social footprint

What will I learn?

In this topic you will learn about:

- ecological issues in the design and manufacture of products
- the six Rs
- social issues in the design and manufacture of products.

KEY WORDS

Mining the extraction of minerals and metals from the ground.

Drilling the process of making a hole in the Earth's surface, usually to extract liquids or gas.

Farming the use of land for growing crops or keeping animals for food.

Eutrophication excessive nutrients in a body of water, often caused by fertilisers.

Deforestation large areas of trees cut down, often due to mining, drilling, farming or logging.

REDUCE – the amount of energy and materials used in the manufacture of a product. This will help to protect valuable resources.

REUSE – the product for something else so you don't need to throw it away.

RECYCLE – take the product apart and separate into the same materials. Convert these materials into another product often by melting the material down. This uses a lot of energy, but considerably less energy than making the material from its raws materials - for example, aluminum uses only 5 per cent of the energy to recycle compared to manufacturing the ore.

RETHINK – products and how we use them. Is there a better way of doing the same job that has less of an effect on the environment?

REFUSE – to buy materials and products that are unsustainable.

REPAIR – products rather than throwing them away. Can you design a product that is easier to repair than throw away?

STRETCH AND CHALLENGE

Write an essay about a country of your choice. Explain your thoughts on their policies relating to farming, mining or drilling.

KEY POINTS

- Deforestation is where large areas of trees are cut down, often due to mining, drilling, farming or logging.
- Mining can damage the environment and causes related problems for local people.
- Farming uses about 70 per cent of the world's useable water supply, which means less is available for other purposes.

2.4 Sources and origins

What will I learn?

In this topic you will learn about:

- the source of timber-based materials
- how timber is converted into planks of wood
- how wood can be seasoned to make it usable and to prevent defects
- the source of metal-based materials
- the different methods of processing ore into metal
- the source of polymers
- how crude oil is processed into polymers
- the use of additives in polymers.

KEY WORDS

FSC the Forestry Stewardship Council.

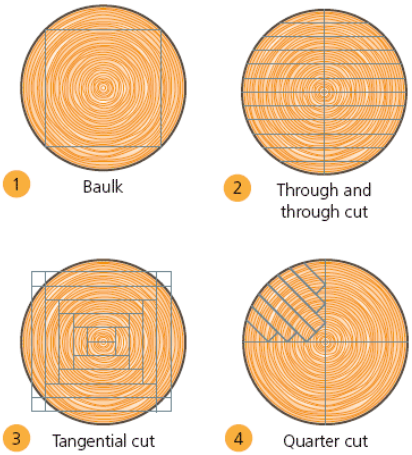
Felling the process of cutting a tree down.

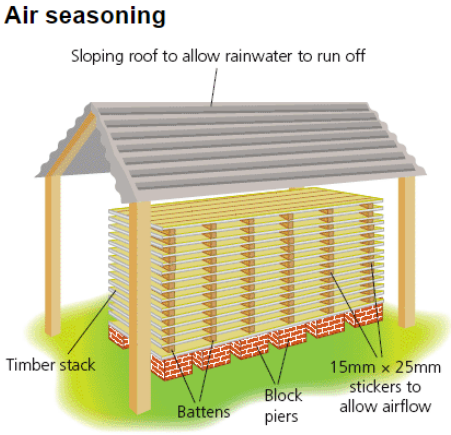
Conversion the process of sawing a tree trunk into planks.

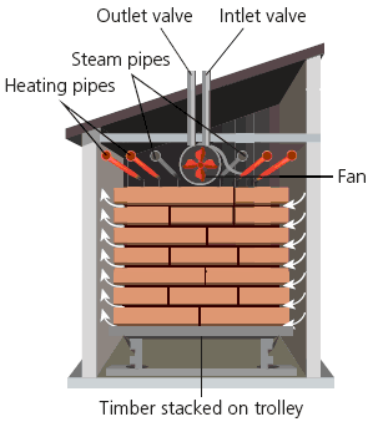
Green timber wood that has not been seasoned.

Air seasoning a natural method of drying out green timber.

Kiln seasoning a relatively quick method of drying out green timber using steam.







KEY POINTS

- Newly felled timber contains a lot of moisture that needs to be reduced before the timber can be used.
- Trees are a renewable source and it is vital that we only use new timber from managed forests.

Check your knowledge and understanding

1 Describe the work of the FSC.
2 Use notes and sketches to describe the four methods of converting timber.
3 Explain why it is necessary to season wood.
4 Draw a cross-section and fully label a seasoning kiln.
5 Why is air seasoning considered to be environmentally friendly?

2.5 Using and working with materials

What will I learn?

In this topic you will learn about:

- how to shape and form materials
- how materials can be modified for a specific purpose
- how a material's properties influence use
- how a material's properties affects a product's performance
- how different properties of materials and components are used in commercial products
- how materials are modified for specific purposes.

KEY POINTS

- Marking out is the process of transferring a design to the material you are working on.
- A template is a profile shape of the part you want to make, like a stencil.
- Tenon saws will cut straight lines in wood.
- Coping saws will cut curved lines in wood.
- Wood joints vary in strength and complexity.

TIMBERS

KEY POINTS

- A centre punch makes a small indent in metal before drilling takes place.
- A hacksaw cuts straight lines in metal.
- Cross filing is a method of shaping metal with a file.
- Draw filing smooths the edges and surfaces of metal.
- Soldering is a method of permanently joining metal.
- Annealing makes metal as soft as possible.

METALS

KEY POINTS

- A spirit-based pen is used for marking out on polymers.
- Most marking-out tools can be used on polymers.
- Most saws will cut polymers.
- Tensol cement is used to glue acrylic (PMMA).

POLYMERS

2.6 Stock forms, types and sizes

What will I learn?

In this topic you will learn about:

- calculating the amount of material needed when using different stock forms
- the stock forms of timber, metal and polymers
- the commonly available sizes of timber, metal and polymers
- the standard components that can be used with various material groups
- a wide range of standard components.

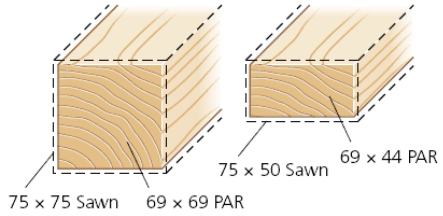


Figure 2.6.2 Typical planed timber sizes

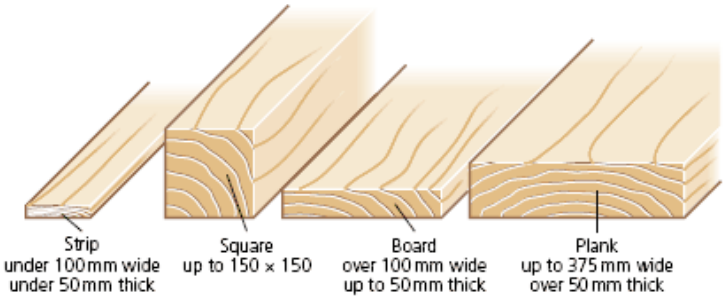


Figure 2.6.3 Timber mouldings

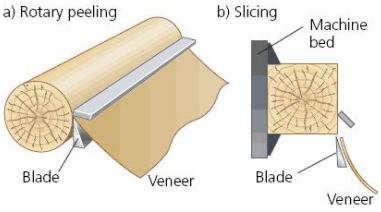


Figure 2.6.4 Producing a timber veneer

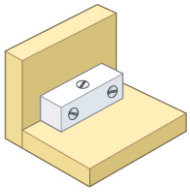
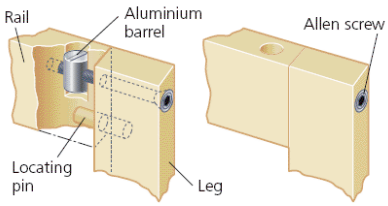
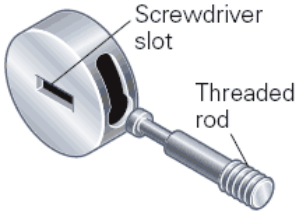
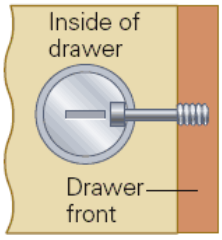


Figure 2.6.12 Corner block







KEY POINTS

TIMBERS

- Natural timber is usually supplied with a planed finish – PAR or PBS.
- Manufactured board can be faced with a more expensive veneer.
- Hinges are versatile, but must be fitted accurately in order to properly function.
- Knock-down fittings can be used in the assembly of flat-pack furniture.
- If you are using a knock-down fitting, a jig or a CNC machine should be used to ensure the accuracy of the holes used.

KEY POINTS

METALS

- Metals are sometimes listed using standard wire gauge (SWG) sizes.
- Rivets can be used to join thin sheet material together.
- Washers can spread the load of a joint when using a nut and bolt.

KEY POINTS

POLYMERS

- Most stock forms of polymers are thermoplastic polymers.
- Thermoset polymers are found in powder form.

2.7 Scales of production

What will I learn?

In this topic you will learn about:

- how products are produced in different volumes
- why different manufacturing methods are used for different production volumes.

KEY WORDS

Batch production when a limited number of the same product is made during a particular period of time.

Down time when a machine has stopped working and no products are being made. This could be for maintenance, because the machine has developed a fault, or the time taken to set the machine up for a new operation.

One-off production when just one complete product is produced.

Prototype an early sample, model, or release of a product built to test a concept or process.

Mass production manufacturing in large quantities over a long period of time. This typically uses a production line.

Continuous production runs constantly and is highly automated.

ACTIVITY

Find examples in your classroom that have been made at different scales of production. Try to get an example from all four categories. Look for things such as past GCSE projects, shoes, furniture, exercise books, pens and anything that uses continuously produced materials such as MDF.

STRETCH AND CHALLENGE

For each of the examples that you found in your classroom, identify how each part or component has been made. Your chair may have been batch produced, but ask yourself about the screws and bolts. Have they been batch produced too or were they mass produced in a different place?

KEY POINTS

- Production can be categorised by the amount that is produced – this is called scales of production.
- One-off production is chosen when a single product is made.
- Batch production is chosen when several of the same product are required before the design of the product needs to change.
- Mass production is used when a large number of the same product are needed. It uses a well-organised production line.
- Continuous production is good when the cost of starting the business and running the necessary equipment is high. The product needs a constant and steady demand.

2.8 Specialist techniques and processes

What will I learn?

In this topic you will learn about:

- production aids used in the manufacture of products
- the tools and equipment used in the manufacture of products
- how to cut and shape materials to a tolerance
- a variety of commercial processes
- how quality control is used during manufacture.

KEY WORDS

Marking out the process of applying a drawing on to a material.

Face side the surface of a piece of wood that is known to be straight and true.

Face edge the surface of a piece of wood that is known to be straight and true.

Template a 2D shape that aids cutting out a shape.

Jig a 3D device that aids a production process.

Dimensional tolerance the difference between the maximum and minimum acceptable size

Moisture content the amount of moisture in a timber.

Laminating a method of bending wood by slicing into thin veneers and gluing back together.

Steam bending a method of bending wood by steaming bending and cooling.

Woodturning a method of making a wood blank round.

Quality control checks put in place to see if the product meets given standards.

STRETCH AND CHALLENGE

Investigate a range of timber based products that have an element of curved construction. Try to correctly identify the forming process that has been used and explain why it was most the appropriate method to achieve the desired shape.

KEY POINTS

TIMBERS

- Accurate marking out is essential if you are to achieve a quality product.
- Jigs and templates will speed up the making process and help achieve consistency.
- There are many saws that will cut wood and it is important to be able to match the saw to the process.
- Chisels and planes help to shape and smooth wood.
- Disc sanders, belt sanders and linishers will mechanically smooth wooden surfaces.
- Wood can be bent by kerfing, steam bending and laminating.
- Wood can by formed into cylinders, spheres and cones by woodturning.

KEY WORDS

Strip heater a machine used to produce bends in thermoplastic sheet.

Vacuum forming a process that uses heat to soften a thermoplastic sheet, then sucks it around a mould.

Press forming a process that forms pre-heated thicker thermoplastic sheet between two moulds.

Yoke the top part of a press-forming mould.

Plug the bottom part of a press-forming mould.

Injection moulding a reforming method of production that involves forcing a molten polymer through a die and into a mould.

Extrusion a reforming method of production that involves forcing a molten polymer through a die to produce a regular cross section polymer product.

KEY POINTS

POLYMERS

- Thermoplastics can be formed by using heat.
- Acrylic (PMMA) can be bent using a strip heater.
- Accurate bends can be produced using a bending jig.
- A sheet of high-impact polystyrene (HIPS) can be vacuum formed using a mould.
- Injection moulding is used to produce high volumes of polymer-based products.
- Extrusion produces long lengths of uniform section polymer.
- Rapid prototyping machines will take a three-dimensional image and turn it into a solid three-dimensional model.

2.9 Surface treatments and finishes

What will I learn?

In this topic you will learn about:

- the range of finishes available for a variety of materials
- how to prepare materials before applying a range of finishes
- how a finish can be used to improve the aesthetic of a material
- how a finish can be used to improve the performance of a material.

There are a huge range of surface finishes available for all material groups. The choice of finish can be influenced by many factors, but most finishes are applied for one of the following reasons:

- to increase the durability of a material or product
- to protect a material from decay
- to improve the aesthetic of a material
- to improve the working properties or performance of a material.

KEY POINTS

- When sanding timber, it is important to always go with the grain.
- The coarseness of glass paper is measured in grit; the lower the number, the more course the paper.
- Stains and paints can change the colour and appearance of a material.
- Oils are generally applied to provide a protective finish.
- Varnish and paint can be matt, satin or gloss.

TIMBERS

KEY POINTS

- Preparation of the metal is the most important factor in successfully applying a surface finish.
- Dip coating provides a thermoplastic coating to a metal.
- Galvanising is the process of coating a metal in zinc.
- Ferrous metals cannot be anodised.
- Powder coating provides an even, durable surface finish.

METALS

KEY POINTS

- Most polymers are self finished and only require edges to be polished.
- Working through files, abrasive paper and then polishing will give you a high-quality finish.
- Flame finishing can be used on the edges of polymers, particularly acrylic.
- Most polymers can be easily printed on.
- Vinyl designs can be cut on a CNC knife cutter.

POLYMERS

3.1 Investigation, primary and secondary data

What will I learn?

In this topic you will learn about:

- how to use primary and secondary data to understand client and/or user needs
- how to write a design brief and produce a design and manufacturing specification
- how to carry out investigations in order to identify problems and needs.

KEY WORDS

Primary research any type of research where you collect new information yourself (for example, through interviews, surveys or observations).

Secondary research gathering existing data that has already been produced (for example, using books, newspapers, magazines or the internet).

Human factors considerations that are concerned with people.

Ergonomics the relationship between people and products, and how they use and interact with them.

KEY POINTS

- Market research is carried out to gain an understanding of the target market for a product.
- Interviews, questionnaires and focus groups are examples of primary research methods that use questions to find out what people are thinking.
- A designer must take into account human factors when designing products, including physiological, psychological and sociological factors.
- Anthropometrics is a record of human measurements that is very useful to anyone who intends to produce something that will be used by a large number of people.
- A design brief describes the problem or situation that needs a design solution.
- When you have completed initial research, you will have answers to many of the questions that you set yourself at the beginning of your project. These answers will influence ideas for your project. You will not necessarily have done all the research at the beginning of the project, and you may not have all the answers. Further, ongoing research may be needed during the design process.
- A design specification is a list of design criteria; it is used to determine the success of your ideas.
- A manufacturing specification contains all the information necessary to make the product.
- As designers work through projects and make attempts to solve the problems, new problems may be found which change how the design brief is understood.
- If further research and testing finds aspects that are critical to the success of the project, and without which the project would not work, changes to the design brief should be made.

3.2 Environmental, social and economic challenge

What will I learn?

In this topic you will learn about:

- how the following might present opportunities and constraints that influence the processes of designing and making:
  - deforestation
  - possible increase in carbon dioxide levels leading to potential global warming
  - the need for fair trade.

KEY WORDS

Deforestation large areas of trees cut down, often due to mining, drilling, farming or logging.

FSC the Forest Stewardship Council.

FAIRTRADE mark the mark that identifies products that have been bought fairly.

STRETCH AND CHALLENGE

Research three products that you feel have successfully considered one of the three topics discussed above; deforestation, global warming or fair trade. Discuss how the designer has addressed these issues.

KEY POINTS

- Designers have the responsibility for choosing their materials and processes carefully, so as to have the least impact on the environment and vulnerable communities.
- Deforestation can be avoided with the correct management of forests. Designers can choose to use FSC materials, which are wood, paper or board that has been taken from sustainable and well-managed forests.
- Fair trade products have been made by communities who have been given a fair price for their goods. This offers some protection to these communities against exploitation.

Designing & Making Principles **3.3.3**

3.3 The work of others

What will I learn?

In this topic you will learn about:
- the work of well-known designers and companies
- how their work can help us with our own designs.

KEY WORD

Design movement a style of design particularly popular with a group of people or within a period of time.

- Describe the work of the designer **Marcel Breuer?**

- Describe:

1. Designed **iconic** 'Wassily' chair
2. Part of the **Bauhaus** movement
3. Use **tubular steel** due to:
4. Its **affordability**
5. Its ability to be easily **mass produced.**
6. He has influenced others to focus on **'Function over Aesthetics'** he designed very simple but functional furniture

- Describe the work of **Charles Rennie Mackintosh?**

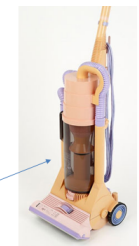
- Describe:

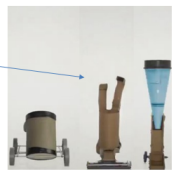
1. **Scottish designer & architect**
2. **Art Nouveau** era circa 1920s
3. Designed **iconic** chairs
4. Used **abstract roses** in his work
5. Design **Glasgow School of Art**

- Describe the work of the company **Dyson?**

- Describe:

1. Set up by James Dyson
2. Produced **first bagless vacuum** cleaner after over **5,000 prototypes**
3. Developed **duel cyclone** technology and had it **patented**.





- Describe the work of the company **Braun?**

- Describe:

1. Set up by Max Braun in Germany
2. Began making **radios** and components
3. Known for **functionality** and **use of colour** during pop art period
4. Clear lines and simple designs
5. **Dieter Rams** produced many **iconic** designs following his **10 principles of good design**

STRETCH AND CHALLENGE

Create a mood board of your favourite designer or design movement. Use this mood board to inspire you, and produce a page of designs for a product of your choice. Use the shapes, colour and style of your chosen designer or design movement's work and create a new design.

KEY POINTS

- Design movements are particular styles popular with a group of people. Within these design movements there were key influential designers.
- Harry Beck is famous for the design of the London Underground map.
- Marcel Breuer was part of the school of design named 'Bauhaus'.
- Norman Foster is a successful architect.
- Sir Alec Issigonis designed the Morris Minor and the Mini.
- William Morris is famous for his furniture and wallpaper designs
- Louis Comfort Tiffany designed the famous Tiffany lamps, which are still manufactured and widely copied today.
- Raymond Templier is famous for his influence in the Art Deco style.
- Gerrit Rietveld designed products for the group De Stijl.
- Charles Rennie Mackintosh is a famous Scottish designer who produced a wide range of products, from posters to furniture.
- Aldo Rossi, Ettore Sottsass and Philippe Starck all worked at some point for the Italian design group, Alessi.
- Braun, Dyson, Apple and Alessi are successful companies that still design products today.

3.4 Design strategies

What will I learn?

In this topic you will learn about:

- coming up with ideas that are imaginative and creative
- collaborating with other people to broaden your ideas and develop them
- understanding the needs and wants of users
- applying a systems approach in complex design situations
- the use of iteration to improve a product or system
- techniques that prevent designers becoming fixated on a single idea
- exploring, developing and evaluating your ideas.

Aethestics	What the product will look like; its colour, finish, etc.
Cost	The price someone will pay for the finished product. Also the total cost of all resources required to make the product.
Customer	Who is going to buy the product and why (the target market).
Environment	The effects the product will have (environmental – the 6 Rs, social, ethical, moral)
Size	The size the product must be (measured in mm)
Safety	To be considered both during and after manufacture (i.e. for the people making the product, and those who buy it)
Function	What the product does; what it includes, holds, etc.
Materials	What the product will be made from.

Evaluation of work to improve outcomes

ACTIVITY

On a piece of softwood try out a range of different finishes, such as wood dye, paint, sanding sealer, varnish or wax. Experiment with different application methods, including a brush, sponge, roller, cloth and spray.

Designing from natural forms: biomimicry

Sketching

User-centred design

A systems approach

Modelling

Iterative design

Testing

Avoiding design fixation

Cultural influences

KEY POINTS

- Negative feedback is used in a system to hold an output at a fixed level, whereas positive feedback is used to make sure that something happens by magnifying a small change.
- Hunting is when a system is trying to achieve something but keeps overshooting the target and tries to correct but overshoots again.
- Flow charts are used to show or plan sequences.
- Complex systems can be split into sub-systems, which simplifies both designing and testing.
- When designing systems, look at the opportunities that incorporating feedback would offer.
- Modelling, whether actual or virtual, allows the system to be tested before committing to manufacture

3.5 Communication of design ideas

What will I learn?

In this topic you will learn about:

- freehand, isometric and perspective sketching to convey design intent
- enhancing sketching using a range of advanced techniques
- rendering techniques to improve communication
- incorporating a range of techniques across a design ideas sheet
- systems and schematic diagrams.

KEY WORDS

Freehand sketching drawing done without the use of rulers or drawing aids. It is a way that a designer can quickly express thoughts and ideas.

Isometric drawing means 'equal measure'. It is a technique of presenting a design sketch in three dimensions.

Rendering the addition of colour, or texture, to enhance a sketch to better communicate design intent.

ACTIVITY: STYLING TWO-DIMENSIONAL FREEHAND SKETCHING

Using the basic shapes and forms shown in Figure 3.5.3, style them into something recognisable.

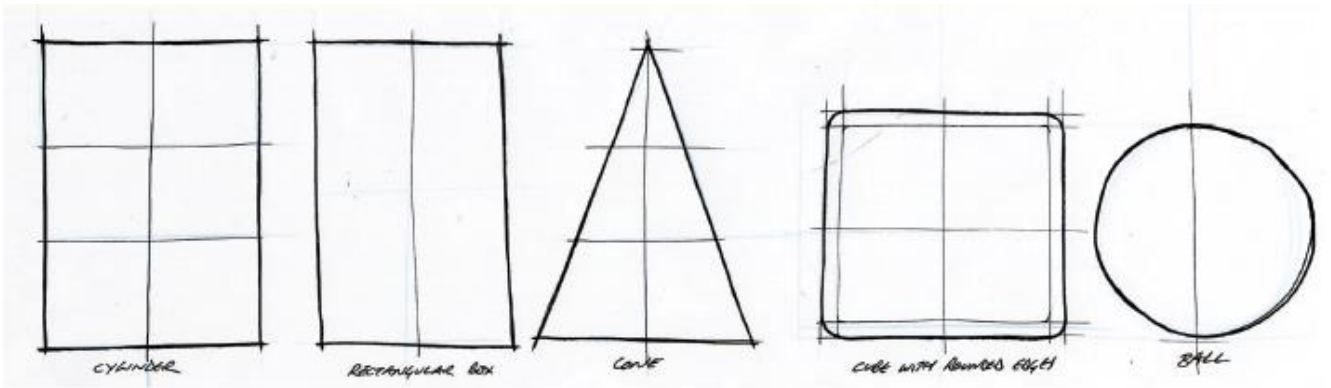


Figure 3.5.3 Freehand two-dimensional sketches of three-dimensional forms – without rendering

KEY POINTS

- Freehand, isometric and perspective sketching techniques are used to communicate design intent.
- A range of enhancement and rendering techniques can improve the communication of design intent.

3.6 Prototype development

What will I learn?

In this topic you will learn about:

- how to design and develop prototypes in response to client wants and needs
- how the development of prototypes:
  - satisfies the requirements of the brief
  - responds to client wants and needs
  - demonstrates innovation
  - is functional
  - considers aesthetics
  - is potentially marketable
- how to evaluate prototypes and be able to:
  - reflect critically, responding to feedback when evaluating your own prototypes
  - suggest modifications to improve them through inception and manufacture
  - assess if prototypes are fit for purpose.

Satisfying the requirements of the brief

Responding to client wants and needs

Demonstrating innovation

Functionality

Aesthetics

Marketability

Evaluation of prototypes

KEY POINTS

- Prototypes are used to test and modify design ideas.
- Prototypes can be physical or virtual models.
- Prototypes often form part of the agreement between a manufacturer and the client.
- Prototypes can be used to show innovative designs and check their viability.
- Rapid prototyping allows small numbers of specialised products to be made economically.
- A rigorous testing and evaluation scheme is important to decide if the product design will be successful.

Check your knowledge and understanding

1 Name three different materials commonly used for making prototypes.
2 Give two reasons why virtual prototyping is used in commercial manufacture.
3 List two commercial uses for rapid prototyping.
4 Give two ways that a virtual prototype can help a client to decide if a new design is right.
5 Identify four ways that a prototype can be evaluated.
6 Give three reasons for making a prototype of a new design.

3.7 Selection of materials and components

What will I learn?

In this topic you will learn about:

- how to select and use appropriate materials and components considering functional need, cost and availability.

KEY POINTS

- When selecting materials for manufacture, functionality, cost and availability are all important issues.

Functional need
Cost
Availability

KEY POINTS

- Wood is an ideal material for producing furniture.
- Different types of wood have very different properties.
- Manufactured boards are available in much larger sizes than natural timber.

TIMBERS

KEY POINTS

- Metal is generally used when strength is important.
- Metals can be permanently and non-permanently joined.

METALS

KEY POINTS

- Polymers have many properties that make them different to wood and metal.
- Polymers have a high environmental cost

POLYMERS

3.8 Tolerances

What will I learn?

In this topic you will learn about:

- how a range of materials are cut, shaped and formed to designated tolerances
- why tolerances are applied during making activities.

Timber-based materials

Timber is one of the most challenging materials to manufacture to accurate tolerances due to the fact that, as a natural material, it is prone to move, split, bow and warp.

In many applications where timber is used as the main material, accurate tolerances are not as vital as with some other materials. If you were manufacturing a large dining table that was 1,500 millimetres long, it would not really matter, or indeed be noticed, if the tabletop's length was actually one or two millimetres longer or shorter than the stated 1,500 millimetres.

If a bespoke piece of furniture was being produced, such as a fitted kitchen or wardrobe, then the accuracy of the dimensions would need to be manufactured with a smaller tolerance, as if the width of the units was too big they would not fit into the intended space.

Manufactured boards are more stable than hardwoods and softwoods, meaning that they are less prone to warp or split. This means that they are easy to machine to accurate dimensions. Hardwoods and softwoods can also be machined accurately, but are less likely to maintain their machined tolerance due to their dimensional instability.

Metal-based materials

Metal is a good material to machine and manufacture to accurate tolerances, especially when produced with the assistance of computer-controlled machinery.

Products with rotating parts, such as wheels or axles that make use of bearings, demand a high level of accuracy in order to be efficient. A skateboard axle is 8-millimetres diameter, therefore the bearing that runs on the axle must be larger than 8 millimetres in order to slide over the axle. If it is too large then the wheel will not run smoothly and the use of a bearing would be redundant.

Metal products that are manufactured by casting are hard to produce to a specific tolerance, as the castings can shrink a little as the molten metal cools, making calculating the finished size tricky. They can be machined once cooled using a centre lathe or milling machine where accurate tolerances can be achieved.

Polymers

Polymers can be manufactured using industrial manufacturing techniques, such as injection moulding, to very accurate tolerances.

Lego bricks are an excellent example of a product where accurate tolerances are vital to the performance of the product. Lego bricks are designed to fit together securely, but also to be able to be removed and rebuilt. The actual tolerance that Lego work to is a closely guarded secret, but if the bricks were too large then they wouldn't be able to fit together, too small and the structures wouldn't stay connected.

KEY POINTS

- Tolerances are the acceptable range of size a product or part can be.
- Tolerances are shown as + or – the acceptable dimension.
- Tolerances are important where components fit together.
- The smaller the tolerance the more accurate the product.
- More accurate tolerances will make a more consistent product, but may also increase manufacturing costs.

3.9 Materials management

What will I learn?

In this topic you will learn about:

- the importance of planning the cutting and shaping of material to minimise waste, for example, nesting of shapes and parts to be cut from material stock forms
- how additional material may be required for a joint overlap
- the value of careful measurement and marking out to create an accurate and quality prototype
- the use of data points and coordinates, including the use of reference points, lines and surfaces, templates and jigs.

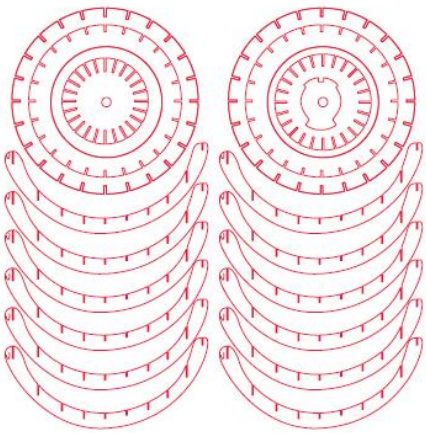


Figure 3.9.1 Nesting of shapes on the laser cutter

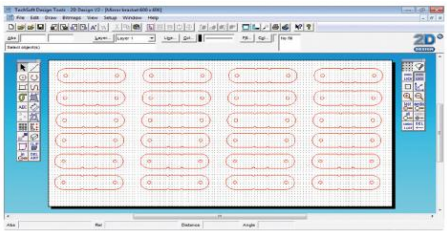


Figure 3.9.5 Wasteful arrangement of designs

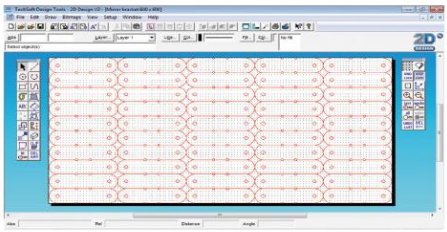
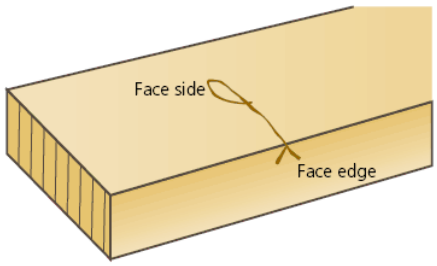


Figure 3.9.6 Efficient tessellated designs



KEY POINTS

- Reduction in material use can reduce environmental impact and helps to reduce cost.
- Nesting is when products are grouped together closely to reduce waste material.

Cut materials efficiently and to minimise waste

Use appropriate marking-out methods

Use of datum points and coordinates

KEY POINTS

- Stock sizes, where possible, should be used to reduce further processing.
- Select the smallest piece of material that is big enough for the job.
- Tessellate designs when marking out to make efficient use of space.
- All waste material should be considered when costing an item.
- A datum point is a position from which an accurate measurement can take place.

3.10 Specialist tools and equipment

What will I learn?

In this topic you will learn about:

- how to use a laser cutter
- how to use a 3D router to machine timber-based materials
- how to use a laser cutter to machine timber-based materials
- how to use a vacuum bag with timber-based materials
- how to use the CNC lathe
- how to use the CNC milling machine
- how to use a plasma cutter
- how to blow mould polymers
- specialist machines and hand tools
- safe use of tools and equipment.

TIMBERS

KEY POINTS

- A 3D router can convert two-dimensional and three-dimensional CAD drawings into three-dimensional products made from timber- or polymer-based materials.
- A laser cutter can cut thin sections of timber-based materials and can etch images onto the surface.
- A vacuum bag can be used as a clamping aid when veneering or laminating.

STRETCH AND CHALLENGE

Most CNC machines in schools and colleges operate on 3 axis. In industry many machines have 5 axis capability. Investigate 5 axis CNC machining and explore the manufacturing opportunities that it offers.

KEY POINTS

METALS

- A CNC machine works from CAD drawings.
- CNC machines are fast, accurate and consistent.
- A plasma cutter can cut thick sections of metal plate.

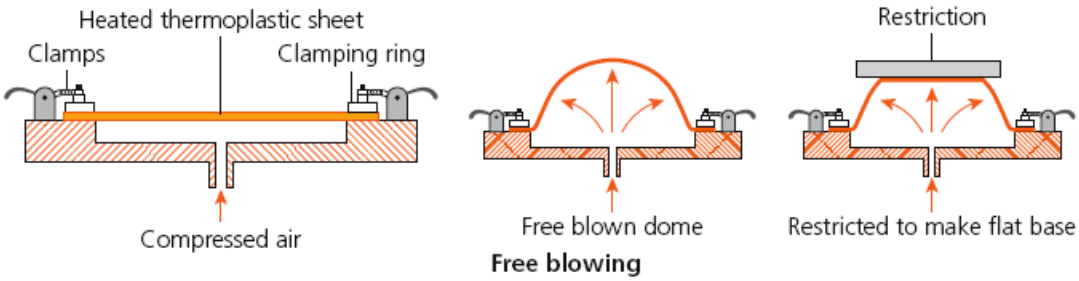


Figure 3.10.8 Blow moulding

POLYMERS

KEY POINTS

- A vacuum former can be used to blow a dome. The polymer sheet is heated in the same way as when vacuum forming, but instead of sucking the sheet over a mould the sheet is blown.

3.11 Specialist techniques and processes

What will I learn?

In this topic you will learn about:

- how to select and use specialist techniques and processes appropriate for the material and/or task and use them to the required level of accuracy in order to complete quality outcomes
- how to use them safely to shape, fabricate and construct a high-quality prototype, including techniques such as wastage, addition, deforming and reforming
- how surface treatments are applied for functional and aesthetic purposes
- how to prepare a material for a treatment or finish
- how to apply an appropriate surface treatment or finish.

Using specialist techniques and processes to the required level of accuracy

Surface treatments and finishes

Preparation

Application

Figure 3.11.1 A cellulose varnish being applied to a softwood floor by hand. The varnish both accentuates the natural grain pattern and protects the timber from wear, increasing its durability.

KEY POINTS

- Timber can be shaped accurately into complex shapes using CNC machinery.
- Laminating can be used to create curved products in timber.
- End-grain is more absorbent than the surface of a piece of timber.
- Finishes for timber can be both protective and aesthetic.
- Thorough surface preparation is key to a high-quality surface finish.

KEY POINTS

- It is hard to achieve high levels of accuracy with hand tools.
- Metals can be shaped into intricate shapes by reforming by casting.
- Corrosion in ferrous metals is known as rust.
- Anodising can be used to add an aesthetic protective finish to aluminium.
- Surfaces must be clean and free of grease for a finish to adhere properly.

KEY POINTS

- Thermoplastic polymers are most commonly in schools and colleges.
- 3D printing and vacuum forming both use heat to shape and form thermoplastic polymers.
- Many polymers are said to be self-finished.
- Pigment can be added before the moulding process takes place.
- Polymers are the same colour from their core through to their surface.