A Level
Design and Technology

Topic Guide

Topic Guide

Pearson Edexcel Level 3 Advanced GCE in Design and Technology (Product Design) (9DT0)

Pearson Edexcel Level 3 Advanced Subsidiary GCE in Design and Technology (Product Design) (8DT0)

Contents

Introduction

The information in this document covers content that is not covered in the Pearson Resistant Materials Student Book (ISBN 9780435757786) and the Pearson Graphic Products Student Book (ISBN 9780435757793). This content is part of the Pearson Edexcel Level 3 Advanced Subsidiary and Advanced GCE in Design and Technology qualifications for first teaching 2017.

The combination of this support document and the textbooks will help you in the delivery of the AS and A level qualifications.

Topic 1: Materials

1.1 (b) Softwoods – cedar, larch, redwood

Cedar

Cedar is the common name for a family of evergreen trees that are native to eastern Mediterranean countries and some mountain areas, but are also grown in the UK. It is a distinctive tree as it usually has several trunks and can grow to a height of up to 40 metres. Cedar is often dark yellow in colour, but can vary from almost white to a reddish brown in the heartwood. Cedar has a distinctive straight grain and has a fine and even texture. Due to its fine texture cedar can be easily worked with both hand and machine tools. Different types of cedar can have a wide range of properties although in general they can be finished to a high quality due to their grain and texture. Some softer cedars do not take fixings well, however the majority can be glued easily.

Larch

Larch is a softwood that is often used for applications where a hard wearing and attractive timber is needed. Larch has a very defined grain with bands of narrow white sap highlighting the grain pattern. In general larch is a fairly easy material to work with and it machines and finishes well. Long straight lengths of larch are often available however board widths can be limited. It can be difficult to join larch with nails as it often splits; this can be overcome by pre-drilling holes. Due to its waterproof properties larch is a popular material for use in boat building and also the construction industry where it is used for building frames, exterior cladding and also interior panels. Larch can also be used for fences and posts because it does not rot when it is in contact with the ground.

Redwood

Redwood is a softwood that is known by a number of names including red deal and Scots pine. Various different grades of redwood are available, with knots being common. Redwood often has a high moisture content even when it is kiln dried and can be sourced in a range of widths up to 225 mm. Redwood is a relatively lightweight material but has good strength. Redwood is commonly used in construction for both structural members and internal decorative mouldings such as architraves. Redwood does not react with metallic components and can take mechanical fixings easily and is readily glued.

	Properties	Disadvantages	Applications
Cedar	• Hard • Durable • Resistant to rot • Low density • High quality finish • Straight grain/even texture	• Susceptible to insect attack • Easily damaged, scratched or dented	• Furniture • Ship building • Carving and marquetry • Building
Larch	• Tough • Hard/hard wearing • waterproof	• Can contain knots • Contains high amounts of resin • Prone to warping • Splits if not predrilled for nails	• Exterior cladding of buildings • Veneers • Flooring • Fencing
Redwood (also known as red deal and Scots pine)	• Soft • Lightweight • Good strength to weight ratio • Little shrinkage • Easy to cut and shape	• Often contains knots • Rots if not treated • Warps if gets wet • Coarse texture	• Furniture • Structural construction members • Interior mouldings • Veneer

1.3 (c) Elastomers – rubber

Rubber is a versatile material that has a range of properties that make it suitable for use in a wide range of products such as car tyres, rubber gloves, bouncy balls and wet suits. It has good elasticity, is abrasion, water and chemically resistant. Rubber is an unusual material because unlike many other types of material it contracts when it is heated instead of expanding. Rubber can come from natural sources (natural rubber) or be artificially manufactured from chemicals (synthetic rubber). Common synthetic rubbers include polyvinyl acetate (PVA), neoprene and polyacrylics.

Rubber can be made stronger through a process called vulcanising - this adds additional cross links and produces the type of black rubber used for car tyres.

	Properties	Disadvantages	Applications
Polyvinyl acetate (PVA)	• Non-toxic • Dries clear • Good initial grip/tack	• Susceptible to fungal attack • Slow drying time as an adhesive	• Wood adhesive • Book binding • Primer
Neoprene	• Resistant to cracking • Impact resistant • Flexible	• Relatively expensive • Lacks resistance to chemicals	• Seals • Gaskets • Protective cases
Polyacrylics	• Transparent • Shatter resistant • Light in weight	• Poor chemical resistance • Brittle	• Car light lenses • Windows • Display units

1.4 (c) Hardboard

Hardboard is a manufactured board that is often used for parts of furniture such as drawer bottoms or the backs of cabinets. Hardboard can also be used for door skins and is also available as a perforated board which can be used for decorative effect. As with most manufactured boards hardboard is supplied in stock sizes with standardised thickness. Hardboard has good abrasion resistance and can be treated to be resistant to heat, but it absorbs moisture easily so cannot be used outside. One of the key features of hardboard is that it has one smooth grain less surface whilst the other is textured. Hardboard is manufactured by compressing fibres in a resin between two steam heated plates. Hardboard is a cheap material compared to plywood or MDF however it lacks the strength of either of these materials.

1.5 (c) Foam board

Foam board can be used for a wide range of applications, including mounting work, point of sale displays or making architectural models. The centre of the board is dense foam and the outer layers are made from thin card. This allows a range of finishes to be applied including printed images. The inner foam core gives strength to the board and can be easily and cleanly cut. Foam board is available in a range of standard sizes such as A3 and A2 and also in different thicknesses although 3mm and 5mm are most common.

Foam board is a stiff yet lightweight material as a result of its composite construction; this also means that it is very difficult to recycle and does not biodegrade in the same way as a board made from wood pulp would do.

	Composition	Applications	Properties	Cost
Foam Board	• The centre of the board is dense foam and the outer layers are made from thin card.	• Mounting work, Point of sale displays • Architectural models	• The inner foam core gives strength to the board and can be easily and cleanly cut.	• Relatively expensive

1.6 (a) Natural fibres

Natural fibres are made from plant or animal sources such as cotton, linen and wool.

Any flexible fabric that is made from fibres is classified as a textile. It consists of a network of thin thread-like fibres which are combined in a number of ways such as woven, non-woven and knitted. You need to know about two types of fibres.

Cotton

Cotton is a natural fibre that is produced from cotton plants that grow in tropical climates where the soil is wet. The cotton fibres come from cotton bolls that form after the cotton flower has died. To produce the cotton fibres firstly the boll has all of the seeds, stalks and leaves removed during a process called ‘ginning’. The cotton is then sent to mills to be carded, which uses brushes to draw out the cotton into a thin film which in turn is then drawn into slivers. This process is repeated until the fibres are very fine when they are spun into twisted thread. These threads can be used for sewing or can be woven in to a fabric. Cotton is a versatile fabric and can be used for clothing, towels, and even used for hard wearing materials such as denim. Since cotton can have lots of different types of finish applied to it, care is needed when washing; this is addressed by using specific instructions on the care labels attached to clothing.

Linen

Linen is a strong fabric that is woven from fibres produced from flax. Flax is a plant that grows in cool damp climates, mostly in the northern hemisphere. To produce the fibre flax plants are harvested then laid out in fields for a number of weeks to allow micro-organisms to attack the gum that holds the fibre to the stem. The flax is then processed through gathering, drying and scutching (a rolling and scraping process) to obtain the fibres. Fibres that are 30cm to 50cm long are then spun into yarn which can then be used to produce linen.

Linen is an expensive fabric and has a smooth texture that is produced by calendering with heavy rollers. Linen is available in a range of weights, with light weight linen such as lawn and cambric being used for shirts and blouses, whilst heavier weights can be used for embroidery. Linen absorbs water well which makes it ideal for tea towels and bed linen.

Wool

Most wool that is used in the production of clothing and fabrics comes from the fleece of sheep, although hair from camels, llamas, goats and angora rabbits are also used. In order to be used the wool first needs to be washed. It then goes through a process called carding that brushes the wool. Wool has short fibres can be used for two types of cloth - worsted and woollen. Worsted fabric is produced from fibres that are combed to make them all parallel resulting in an even texture. This produces a high quality yarn that is used for fine cloths such as gabardine and barathea.

Wool yarn is produced from very short fibres which run in lots of different directions - this is why wool feels fluffy. It also helps to keep air trapped that in turn means wool is warm to touch and can be used for clothing that is a good insulator. Wool is spun into different types of yarns including various thicknesses for knitting (ply), or for weaving.

	Properties	**Disadvantages**	**Applications**
Cotton	• Good conductor of heat • Absorbs water well • Able to be dyed or printed on • Strong and hard wearing	• Creases easily • Flammable • Damaged by exposure to sunlight	• Sewing • Clothing • Denim
Linen	• Withstands high temperature • Good conductor of heat • Absorb water well	• Creases easily • Difficult to dye • Frays easily • expensive	• Shirts • Blouses • Lace • Embroidery • Bed linen
Wool	• Warm • Resilient • High absorbency • Able to be dyed	• Can shrink when washed at high temperatures • Easy to scorch • More expensive than synthetic fibres	• Knitting wool • Clothing, including flannel, cashmere, tweed

1.6 (b) Manmade Fibres

Manmade fibres are made from coal, oil or petrol based chemicals such as nylon, polypropylene, and polyester.

Nylon

Nylon forms as a long filament when it is produced, although this can be cut into short fibres. These fibres are very light and smooth with some silk like properties and importantly good strength. These properties make nylon a very useful fibre to work with and can be woven into a very close weave making it windproof and water repellent. There are two types of nylon, nylon 6 and nylon 6.6 - these are produced using different methods, nylon 6 through a chemical reaction and nylon 6.6 is produced from a single compound. These two types of nylon have slight differences, however both tend to be produced from oil.

Polypropylene

Polypropylene is the lightest of all synthetic fibres which means that it is good for clothing that needs to provide warmth without adding excessive weight. It also retains heat well and does not absorb liquids easily making it ideal for outdoor clothing, often being considered to be warmer than wool. Unlike other synthetic manmade fibres polypropylene does not generate static electricity

Polyester

Originally known by the name Terylene, polyester was developed in the 1950s as a by-product of the petrochemical industry. Polyester can be easily dyed which is one of the reasons why it is popular in the fashion industry. Furthermore it is resistant to shrinkage, wrinkling and stretching which makes it very easy to look after, whilst its quick drying properties make it a good choice for clothing that will be worn outdoors. Polyester can feel silky to the touch and fabrics can be produced by weaving or knitting which makes it a versatile alternative to natural fibres. Polyester is a synthetic material which mostly comes from non-sustainable sources, although increasingly plastic bottles are being recycled to produce polyester fabric.

	Properties	**Disadvantages**	**Applications**
Nylon	• Excellent abrasion resistance • Range of finishes are possible • High levels of durability • Lightweight	• Low absorbency • Can shrink • Poor resistance to UV light • Can create static	• Clothing • Carpets • Parachutes, umbrellas and kites • Rope • Stockings
Polypropylene	• Moth proof • Lightweight • Good abrasion resistance • Very good chemical resistance • Quick drying • Resistant to staining	• Cannot be dyed once it is spun • Specialist dry cleaning is required • Poor resistance to UV light	• Ropes • Luggage • Table cloths • Face masks
Polyester	• Good strength • Resists rubbing • Polyester is easy to care for and resists creasing and stretching • Resistant to chemicals, mould, rot and sunlight	• Non-absorbant • Does not feel warm to wear • Needs a hot iron to remove creases • Causes static electricity to build up	• Often mixed with cotton for clothing • Car seat belts and safety belts • Duvet and pillow fillings • Sportswear • Non-iron fabrics

1.6 (c) Textile treatments – flame resistant, polytetrafluoroethylene (PTFE)

Flame resistant

Although many natural fibres have some flame resistant properties the same cannot be said for synthetic fibres. As a result there is a growing need for textiles to be treated to increase their fire resistance. There are a number of different ways in which textiles can be made flame resistant; one method involves using phosphine gas, formaldehyde and a mineral acid such as hydrochloric acid.

Flame resistant treatments slow down the combustion process at different stages such as heating, ignition or spreading of flame. Different treatments are used depending on the type of fabric and the application that it is used for be that furniture, soft furnishings or clothing. Some flame resistant treatments deteriorate when they come into contact with liquids so they need to have specialist cleaning otherwise they will need to have the treatment reapplied time and time again.

Polytetrafluoroethylene (PTFE)

Polytetrafluoroethylene (PTFE) can be used for many different applications, however for textiles it often used to provide a protective surface to a fabric. This can result in a fabric that does not stain or get damaged by spills. PTFE works well on wool and cotton and does not change its look, feel or colour. PTFE can be used to apply a protective coating to clothing, upholstery, bedding and indoor furnishings. When a liquid is spilt on to a fabric that has been treated it tends to form into droplets that can then roll off or be wiped up easily – the PTFE coating prevents the liquid from soaking in.

Topic 2: Performance characteristics of materials

Performance characteristics of woods, metals, polymers, smart and modern materials, papers, boards, textiles and composites in order to discriminate between materials and select appropriately.

2.1 (a) Conductivity

There are two types of conductivity - thermal and electrical. In each case the definition is very similar. Conductivity is the ability of a material to allow energy (electricity or thermal energy) to pass through it. Some materials are very good electrical conductors, for example gold and copper, whilst others are good thermal conductors such as steel or aluminium. If a material has very poor conductivity it is known as an insulator.

2.1 (b) Strength

In its widest meaning, strength is the ability of a material to withstand a force or pressure without failing. However this is a rather simplistic approach; strength can be classified in a number of different ways including tensile, compressive and shear strength. Tensile strength is the ability of a material to withstand being stretch, whilst compressive strength is the ability of a material to withstand being squashed when a load or pressure is imposed on it. Shear strength is a little more complex as it relates to the ability to withstand failure along the line of a force. When a piece of card or fabric is cut with scissors it fails in shear, if the material is harder to cut through this is an indication that it has a higher shear strength.

2.1 (c) Elasticity

Materials can be stretched. The elasticity of a material is the amount that you can stretch it with a force and then its ability to go back to its original shape when the force is removed.

2.1 (h) Toughness

Toughness is the ability of a material to withstand a sudden impact or shock. If a material is hit repeatedly by a hammer, the number of hits the material can take without it breaking is linked to its toughness, so the more hits that are needed to break a material, the tougher it is.

2.1 (i) Durability

A durable material is one which is able to withstand wear and tear from use. A durable material tends to be long lasting, and durability is an important consideration when selecting the materials to use for a product that is going to have a lot of use, for example a chair, a pair of shoes or a mobile phone.

Topic 3: Processes, techniques and specialist tools

3.1 (a) Case hardening

Case hardening is a heat treatment process that can be used to prevent steel or iron from becoming brittle, increase its wear resistance or make it more durable. It is achieved by adding carbon to produce a hardened outer skin while the core of the metal remain relatively soft. The process involves heating the metal until is it a bright red colour, it is then dipped or coated in a carbon compound that covers the outer surface. Depending on the thickness required, this may be repeated many times. The metal is then reheated before being quenched in water which completes the hardening process.

Case hardening is used a range of products and components including self-tapping screws, beams, vices and chains. The process is carried out once all forming and machining processes have been completed.

3.1 (b) Alloying

An alloy is a metal that is produced by combining metals and other substances, for example carbon, together to form a new metal that has much improved properties for its intended application. Some alloys have been considered earlier, and you may be familiar with stainless steel, bronze and brass, each of which is an alloy. The process of producing an alloy is not overly complicated, however having the correct proportions of base metals is very important. Each of the metals is heated until it becomes a molten liquid; at this point the metals are mixed, along with any other elements that might be added. It is usual for the metal that makes the largest proportion of the alloy to be melted first, with the other metals and elements added in to the mix. When mixing is completed, the newly produced alloy is allowed to cool in a mould.

3.1 (d) Casting – sand (to include investment), resin, plaster of Paris (including use of specialist tools)

Casting can be used to produce solid items from a range of materials including metals, polymer resin or plaster of Paris. In each case the principles are the same, with a mould first being made which is then filled with a liquid that then solidifies. There is one variation of this which is investment casting, which is also known as lost-wax casting. This particular process requires a wax pattern to be made in the shape of the required casting which is then surrounded by sand. As the molten metal is poured in to the mould, the wax melts and is replaced by the metal. The benefits of this are that the wax can be reused and the resultant casting requires little further work.

Similarly sand casting can be used for low volume production. A pattern is made, often from wood, which is placed in the sand to make a mould. The pattern is then removed, and molten metal poured in to the space that has been left behind. Once cooled, the mould is broken apart and the casting removed. Both resin and plaster of Paris can be cast using flexible silicone or rubber moulds in to which the liquid is poured.

Type of casting	Applications	Advantages	Disadvantages	Specialist tools / materials needed
Sand casting	• Engine parts • Fan blades	• Sand can be reused	• Energy intensive	• Cope & drag
Investment casting	• Jewellery • Complex components	• Little further processing needed	• Energy intensive • Long cooling time	• Cope & drag • Casting sand • Parting powder
Resin casting	• Jewellery • Toys • Small-scale production	• Low set-up cost • No cooling time • Reusable mould	• Castings are easily scratched • Castings may not be shiny	• Rubber/silicon mould
Plaster of Paris casting	• Models • Medical castings	• Low set-up cost • Few specialist tools required • Has a hard outer surface	• Takes a long time to solidify • Incorrect mixture can result in brittle castings	• Rubber/silicon mould

3.1 (e) Stamping, pressing

There are many ways that a piece of sheet metal can be cut to produce a blank or a net. One of these is stamping where a die is used with a stamping press to cut, emboss or bend the metal. The sheet can either be in the form of individual sheets or coils. Stamping is used to produce many items from aluminium, stainless steel along with copper and zinc which are in the form of a flat blank. Stamping is often linked with pressing where these flat pieces of metal are formed into more complex products, for example pans. Panels for cars are also often produced using a stamping and pressing process; the limiting factor is the thickness of the metal sheet.

3.1 (h) Marking out techniques – woods, metals, polymers, paper and boards (including use of specialist tools)

Marking out techniques and tools

The approaches to marking out woods, metals, polymers and papers and boards differ to an extent, although there are some similarities in the approaches. The key points when marking out include making sure that the marking out is accurate and that also it is clear to interpret so whoever is going to be cutting the material is able to complete it correctly.

Woods

When marking out wood you must make sure that you mark out both across the width of the piece and also the depth, this makes sure that any cuts through the wood are correct as once the top surface has been cut through the marks will no longer be visible.

When marking out it is important to identify where all measurements will be taken from; these are the called the face side and the face edge. All measurements and markings should be taken from these. It is good practice to mark these on the workpiece using the conventions shown.

Techniques that are used for marking wood include the use of marking, cutting and mortice gauges (which will be covered later), along with squares, bevels and measuring equipment. In most cases the measuring of wood will be done using a steel ruler, however for longer pieces of work a metal tape measure should be used. A carpenters rule can also be used; this is a ruler that is hinged so that it does not take up much space but can extend to up to two metres. Circles can be marked out using a pair of compasses, whilst irregular shapes are marked using a template.

To mark a line at right angles to the face edge you should use a try square. This makes sure that the angle is correct.

Sometimes you need to mark out a line at 45º to the face edge. For this you would use a combination square. As with a try square you should always use a sharp pencil for marking out and to begin with you should place your pencil at the start of where you want to mark out and move the square to meet the pencil. This makes sure that the line will be drawn in exactly the right place. A combination square is a useful tool when you need to mark a piece of wood to cut a mitre.

Sometimes the angle that needs to be marked out is specific for a piece of work and is not 45, 90 or 135 degrees. For such angles a specialist tool known as a bevel (or sliding bevel) needs to be used. These are used by setting the required angle and then tightening up a wingnut or lock screw that locks the blade in place. The stock, or handle, is usually made from hardwood or plastic and this is held firmly against the face edge to produce an accurate marking on the wood.

For marking out on metals and polymers similar techniques and approaches can be used to those used for wood. However, instead of using a pencil a scribe (or scriber) is used for metals and a spirit pen for polymers. In some cases a fluid called Engineers' Blue is used with a scriber when marking out metal as this increases the contrast between the marking out and the metal. Dot punches (or centre punches) are also used to mark points, for example the centre of a circle. Since compasses cannot be used with these types of material, dividers are used to mark out circles. Some tools have slightly different names, for example an engineers square is used instead of a try square to mark a line at 90º to an edge.

Papers and boards can usually be marked out using a pencil. Tools that need to be used to mark out accurately include a pair of compasses to produce circles, set squares to produce lines that are at angles of 30, 45, 60 or 90 degrees to an edge or line. As with most materials if an irregular shape needs to be marked out this would be done using a template, although for paper and board a pencil would be needed.

Marking type	Wood	Metal	Plastic	Paper and board
Lines	• Pencil	• Scriber	• Spirit pen or felt tip pen	• Pencil
Lines at right angles to an edge	• Try square	• Engineers square	• Engineers square	• Set square
Lines at angles to an edge	• Marking gauge	• Odd-leg callipers	• Odd-leg callipers	
Marking a circle	• Pair of compasses	• Dividers	• Dividers	• Pair of compasses
Marking the centre of a circle	• Pencil	• Centre punch	• Spirit pen	• Pencil
Irregular shape	• Template and pencil	• Template and scriber	• Template and spirit pen	• Template and pencil

3.2 (a) Marking, cutting and mortise gauges

Marking gauges and cutting gauges

A marking gauge is used to mark a straight line parallel to an edge on a piece of wood. In most cases the stem and the stock are made from beech, often with a brass insert in the stock to reduce wear and tear when the gauge is being pushed against the edge of the piece of wood being marked. A thumbscrew is used to tighten the position of the stock once the required distance has been set. Using a steel ruler, a sharp hardened steel point (called a spur) is used to mark a line on the surface of the wood at the distance set.

The stem and stock are made from beech and the thumbscrew from clear yellow plastic. The better quality gauges have brass inserts at the front of the stock. These help reduce the wear on the stock as it is pushed against the surface of the wood - to be marked. The marking gauge is an extremely important tool for marking parallel lines and preparing for cutting joints.

The steel spur can be replaced by a small knife that is used for cutting lines parallel to an edge as part of the preparation for inlaying or adding a veneer. This type of tool is called a cutting gauge.

To use either a marking gauge or a cutting gauge the piece of work that is being marked needs to be held firmly, either by clamping or using a bench hook. The distance between the spur and the stock is set and then the stock pushed firmly against the edge closest to where the line needs to be marked. Only a small amount of pressure is needed to mark out wood, but if the line needs to be clearly seen it is good practice to repeat the process two or three times as putting a lot of pressure on the spur will cause it to dig in to the wood and the marking will lack accuracy.

Mortise gauges

A mortice gauge is similar to a marking gauge, however instead of having one spur there are two, one of which is fixed and the other adjustable. The stock again features brass strips to maintain accuracy, and can be set using the thumb screw. In this case the distance between the stock and the fixed spur is set to the distance between the edge of the wood and the closest side of the mortice to be cut. An adjustable brass thumb screw is used to adjust the position of the adjustable spur. The distance between the two spurs should match the width of the chisel to be used.

A mortice gauge is used in the same way as a marking gauge, with the stock being pushed against the edge of the piece of wood and then pushed along the wood with the spurs making marks.

3.2 (b) Odd leg, internal and external callipers

Odd leg callipers

Odd leg callipers perform a similar function to a marking gauge, but in this case for use with metal or plastics. They can also be used to mark the centre of both square and circular sections of metal, for example a length of bar. One leg is offset (not straight) and has a point that can be adjusted and works like a scriber, the other leg is straight and instead of having a point there is a locating lug that is held against the edge of the piece of plastic or metal that is being marked out.

Internal and external callipers

Callipers are used to measure either the internal or external dimensions of a component. Often associated with circular sections they can be used either to take measurements from an object or can be used for marking out and checking dimensions.

When using callipers for making out, one leg is held against the end of a steel ruler and the other leg moved until it is set to the required dimension; the process is similar for both internal and external callipers. The reverse is done when measuring an object, one leg is placed at the end of the scale and the dimension read off a steel ruler from the other leg.

Callipers are also used to check the diameter of pieces of work that are being turned on a lathe; if the callipers are set to the desired diameter then they can be used to quickly check if the correct dimension has been achieved.

Both internal and external callipers are available as spring joint callipers. These have legs that are pivoted on a roller, with the distance between the two legs being controlled accurately by an adjusting nut and a spring.

3.2 (c) Squares (set, try, engineers and mitre)

Set squares

Set squares are most often used for marking out papers and boards, but can also be used for pattern making and marking out textiles. Usually available with 30, 60 and 90 degree angles, or 90, 45 and 45 degree angles, they are very useful to draw lines perpendicular to a straight line, or for constructing isometric, orthographic or planometric drawings due to the angles that they are available in. Adjustable set squares are also available which can be set to any angle that is needed. The majority of set squares are made from transparent plastic, and are available in a range of different sizes depending on what they will be used for.

Try squares

A try square is used for marking out lines perpendicular to the face edge of a piece of wood. The try square has a hardened steel blade and a wooden stock often made from rosewood. Higher quality try squares have a brass face to make sure they move freely along the wood and are accurate.

To be used with accuracy the stock needs to be firmly held against the edge of the piece of wood and either a marking knife or pencil used to mark across the wood. The pencil or marking knife should be held at the correct position and the try square slid against it to make sure the position is correct. The line is often marked all the way around the piece of wood to make sure an accurate cut is made.

Try squares can also be used to check that the end or edge of a piece of wood is square by holding the stock against the piece of wood and looking for any gaps between the blade and the piece of wood.

Engineers Squares

An engineers square is very similar to a try square both in its shape and its uses, except that it is used for marking metal and plastic and the stock is made from bright mild steel instead of rosewood. They are often smaller but are available in a range of different sizes.

They are used in exactly the same way however, with the stock pushed firm against the edge of the piece of metal or plastic to be marked out and either a scriber (metal) or spirit pen (plastics) used to mark a line at 90º to the edge. As already stated, Engineers Blue can be used to make markings clearer to see on metals. An engineers square also has a small notch at in the stock where it meets the blade to stop it getting damaged by burrs on pieces of metal.

Mitre squares

Mitre squares have the blade and stock at an angle of 45º and 135º to each other to allow for accurate marking out of mitre joints. The blade is again made from hardened and tempered steel with a rosewood stock. They are used in the same way as a try square with either a pencil or marking knife.

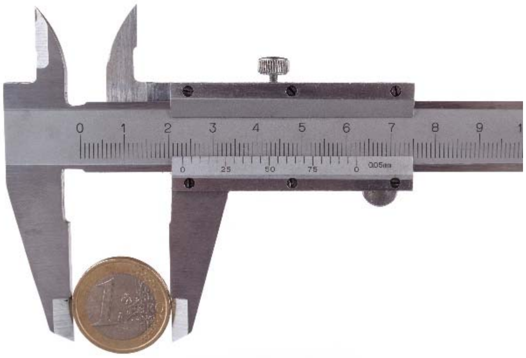
Micrometer

Micrometers are used to take exact measurements from small and intricate components or products. One face of the micrometer is fixed, this is called the anvil. The other is called the spindle and is attached to a ratchet that moves the spindle 0.5 mm for each full rotation. The part to be measured is placed between the anvil and the spindle; when the ratchet starts to make a clicking noise the measurement can be read from the scale. It can be quite complicated to read the scale.

A depth micrometer is a similar measuring instrument used to find the depth of a 'blind' hole (one that stops part way through a piece of material). Turning the ratchet moves the spindle down until it reaches the base of the hole. The depth can be read off using the same technique as a conventional micrometer.

Vernier callipers

If you need to find an accurate value for the either the internal or external measurement of an item then you should use a Vernier calliper. These can be either manual but digital callipers are also available. These are much easier to read as the measurement is shown on a digital display. Manual versions have scales that are shown in both metric and imperial values. The measurement is read by using the sliding scale and noting where the vertical lines align fully.



Densitometer

A densitometer is used to check the quality of printed images such as magazines, posters and labels for packaging. They work by measuring the reflection from the colour bar that is printed on the products for quality control purposes. The densitometer measures the saturation of the printed image and does this through light-sensitive photoelectric eyes that use red, blue and green filters to measure the amount of light that is absorbed by the printed image.

Dividers

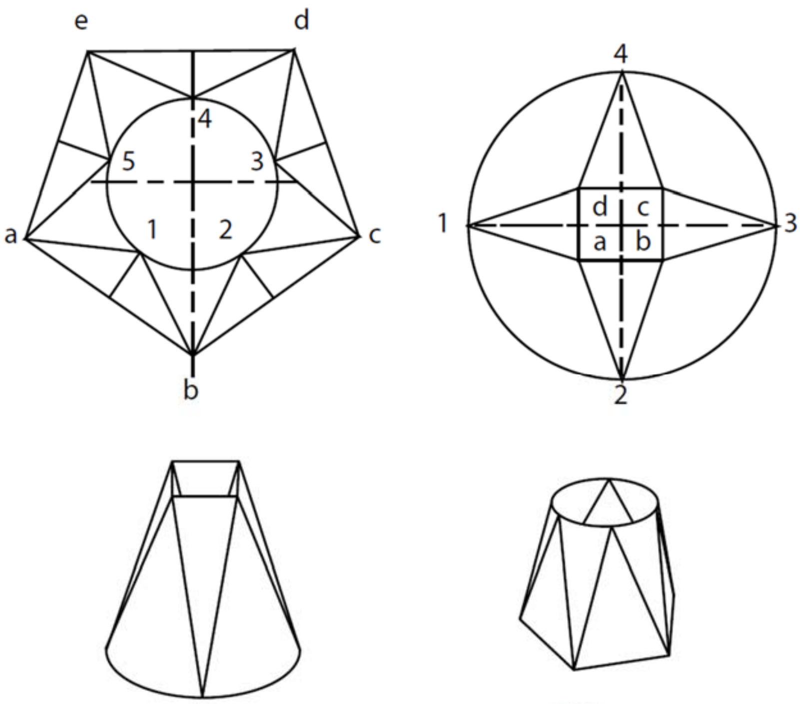
Dividers can be used for a range of different purposes in a similar way to callipers. They can be used for measuring internal or external dimensions, for transferring measurements from one component to another, or for marking off distances that are repeated, such as marking a hexagon inside a circle. They have two hinged legs, both of which have sharp points. Dividers can be used for many similar uses as a pair of compasses, indeed compasses are effectively dividers that have one point and a pencil instead of the other point.

Go and no-go gauges

Often used in engineering, a go no-go gauge is an efficient method of checking whether or not a component or part is within tolerance. If it is too short it will pass directly through, whilst if it too long it will not fit inside the gauge. If neither of these are the case, then the component or part is in tolerance. A similar type of gauge is a plug gauge which is used to see if holes are of the correct dimensions.

3.3 (b) Triangulation

Triangulation can be used for a number of purposes when communicating 2D information. One use of a triangulation technique is to produce developments for parts and components that form a transition between a square/rectangular piece and a circular part. In other words surface developments for something that has a square base but a circular top, such as that shown below.



(a) (b)

The second use of triangulation is for either copying or changing the scale of a given drawing. The drawing is divided into a series of triangles with key features being measured from corners of the triangles. This measurement is then transferred to the new drawing (or scaled up or down if necessary) and the point plotted. This is repeated until all the key points have been identified and plotted, then the points are linked together, like a big dot-to-dot, to reproduce the drawing.

Triangulation can also be used for creating computer generated landscapes by joining together points with xyz co-ordinates and then rendering them with a shell or skin. Some CAD packages use this approach to produce the transitions between squares and circles described earlier.

3.3 (e) Report writing

Although it may sometimes be appropriate to keep a logbook or diary of activities that you carry out, there will be times when you need to produce a more formal report. When writing a report it is important that the structure is logical and flows correctly. In most cases a report will have a number of sections - a summary, a list of contents, the main body of the report, conclusions, recommendations and appendices. You will also need to include references and a bibliography with any report. The summary section is just that, a brief overview of the report as a whole. This will include information about why the report was completed, the outcomes of the report and a brief account of the conclusions and recommendations. The main body if the report is where the main findings of the report will be included. For a design project this could include information about the target user group, the design specification, the approach taken to solve the problem along with supporting research. These should then be drawn together as part of the conclusion, with recommendations being based on the conclusion. Recommendations could relate to the process or the outcome, or a combination of both. Next you should include references to the sources you have used, preferably using a recognised referencing system such as Harvard, and a complete list of books, websites and other materials in a bibliography. Finally any research data or technical drawings can be included in appendices at the end of the report.

3.4 (a) Cyanoacrylate (superglue)

Like many inventions, the common use of cyanoacrylate as an adhesive was discovered by accident during the development of other materials. Cyanoacrylate has a wide range of applications in design and technology and is often used to join dissimilar materials together, especially ones that are not very absorbent. A range of forms are available that are designed for specific types of material. In some cases cyanoacrylate is used as an alternative to stitches for medical use. There are many advantages of cyanoacrylate, because it is a liquid it will flow along a joint. It also dries very quickly so there is no need to clamp pieces together. It is difficult to break apart a joint glued with cyanoacrylate. However, because it dries quickly if you make a mistake it is difficult to either reposition or separate parts. Similarly if you get it on your fingers it is difficult to separate them, although acetone does dissolve cyanoacrylate.

3.4 (b) Press forming

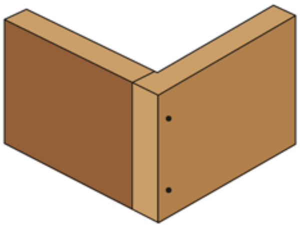
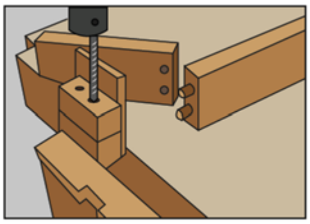
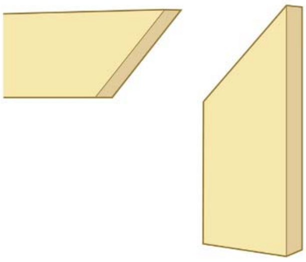
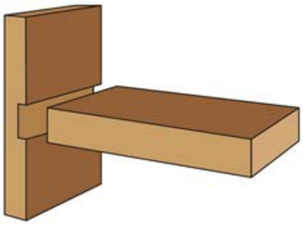
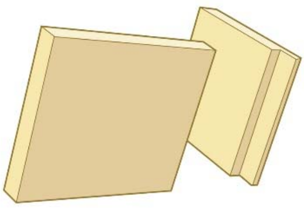
Press forming uses a two-part die that is fitted inside a press. The material to be formed is placed between the two parts of the die before very high pressures are used to force the two halves together. The material that is being formed is bent or stretched to match the shape and size of the die. Once formed, the material will retain its new shape.

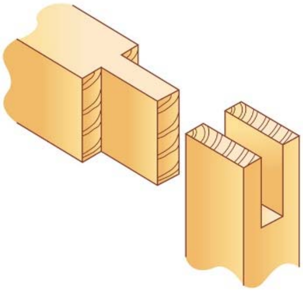
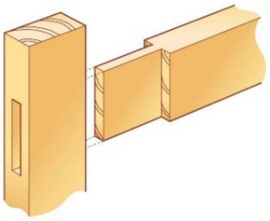
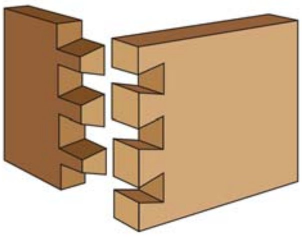
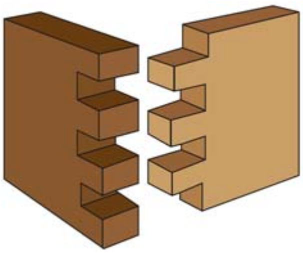
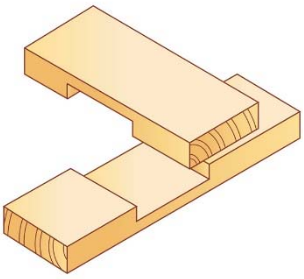
Press forming is a rapid process that has high repeatability. Products such as body panels for cars are generally press formed, however the process can be used for kitchen appliances, television casings and even small electronic components.

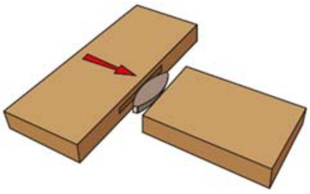
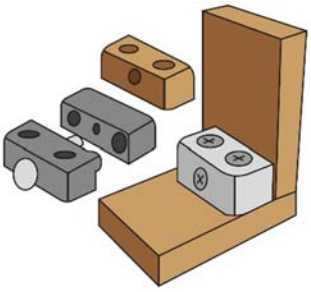
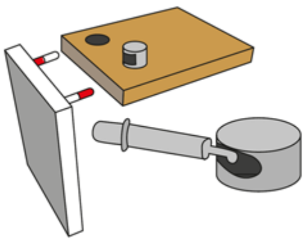
3.4 (c) Soft soldering

Soft soldering can be used to join metals using an alloy of tin and lead, although more modern solders contain no lead. The solder is heated using either a soldering iron, or in some cases a gas torch. Many metals can be joined by soldering, including copper, brass, tin and steel, although some are harder to join including aluminium. Soft soldering is mostly used for constructing electronic circuits, where electronic components are joined to the circuit board. When soldering it is important to make sure that everything is cleaned to remove grease or any form of corrosion. A soldering iron is placed on the point where the two components are to be joined, and then as these heat up solder is applied to the joint. The solder will melt quickly and flow around the joint creating a permanent connection. Sometimes if larger parts need to be joined a gas torch can be used.

3.4 (d) Jointing – traditional wood joints, knock-down fittings (including use of specialist tools)

Type of joint	Applications	Advantages	Disadvantages	Tools needed
Butt joint 	• Simple boxes and frames	• Easy to construct without specialist tools	• Lacks strength • Easily broken/ damaged	• Tenon saw
Dowel joint 	• Frameworks • Flat-pack furniture	• More strength than a butt joint	• Accuracy is needed when drilling holes for the dowels	• Tenon saw • Drill • Dowels
Mitre joint 	• Picture frames • Window frames	• Allows grain pattern to be continuous around the frame • No exposed end grain	• Very difficult to construct with accuracy • Lacks strength	• Tenon saw • Mitre block
Housing joint 	• Shelves in cupboards	• Provides strength to the joint	• Needs to be cut with accuracy	• Tenon saw • Try square • Chisel
Lap joint and half-lap joint 	• Frameworks • Drawers	• Provides a flush joint between pieces	• Relatively low strength • Accuracy needed when cutting the rebate for the joint	• Marking gauge • Tenon saw • Try square • Chisel

Type of joint	Applications	Advantages	Disadvantages	Tools needed
Bridle joint 	• Door frames • Furniture	• Very strong joint	• Can be hard to cut with accuracy	• Marking gauge • Tenon saw • Try square • Chisel
Mortice and tenon joint 	• Doors • Furniture	• High strength joint • No end grain shown • High quality finish	• Difficult to cut with accuracy	• Mortice gauge • Try square • Tenon saw • Chisel • Can also be cut using a mortiser
Dovetail joint 	• Drawers • Furniture	• High quality joint • Good strength • Looks attractive	• Very difficult to cut with accuracy by hand	• Dovetail saw • Dovetail Jig • Chisel • Marking gauge • Try square
Comb or finger joint 	• Furniture • Boxes	• Good strength • Can be made to be a decorative feature	• Requires accuracy in marking and cutting	• Marking gauge • Tenon saw • Try square
Halving joint 	• Frameworks • Window frames	• Provides a flush joint between pieces • Good for right angle joints	• Not suitable for chipboard • May not be visually attractive	• Marking gauge • Tenon saw • Try square

Type of joint	Applications	Advantages	Disadvantages	Tools needed
Biscuit joint 	• Table tops • Large panels made from individual boards • Furniture	• Allows large areas of solid wood to be produced • Can also be used to strengthen butt joints	• Slots can be difficult to cut with consistency	• Router • Chisel • Beech 'biscuits'
Knock-down (KD) fittings 	• Flat pack furniture	• Simple to use • Only need limited tools • Can be dismantled	• Might not look attractive • Can be unstable	• Screwdriver
Cam locks 	• Flat pack furniture	• Can be used with all types of wood • Provides a secure and strong joint • Can be dismantled	• Holes must be predrilled • Can damage the wood if overtightened	• Drill • Screwdriver

3.5 (a) Finishes – paints, varnishes, sealants, preservatives, anodising, electro-plating, powder coating, oil coating, cathodic protection

Paints

There are a number of different types of paint that can be used within design and technology. These include gloss paints which often leave a shiny finish; acrylic paints that can provide a level of wear resistance and usually come in bright colours but are also sometimes used for painting pictures; enamel paints also give a wear resisting surface but are usually only used on metals. Other paints that may be used include aerosol based spray paints, emulsion paint and, for design work, watercolour paint. Paints can be used on many surfaces, including polymers and textiles, although it is important to first check that the paint is suitable for the material you are using. When using aerosol paints you should make sure you use the correct personal protective equipment (PPE) and only work in well ventilated areas.

Type of paint	Applications	Advantages	Disadvantages
Acrylic	• Can be used with most materials	• Durable finish • Vivid colours • Flexible when dry	• Pigments can contain toxins • Harmful to the environment
Emulsion	• Can be used on most materials including ceramics	• Water based • Easy to apply • Quick drying	• Can be expensive
Enamel	• Metals	• Durable finish • Dries quickly	• Gives off fumes when in use
Gloss	• Wood • Metals	• Durable • Wide range of colours	• Might need an undercoat
Spray paint	• Can be used on most surfaces	• Faster to apply than using a brush • Does not leave brush strokes	• Toxic fumes • Lack of accuracy when painting • Limited range of colours
Fabric paint	• Most fabrics and fibres	• Range of finishes available • Does not need to colour the whole piece of fabric • Can add an additional texture to the fabric	• Less durable than dying fabric • Can alter the feel and flexibility of the fabric

Varnish

Varnish is similar to paint, but is generally only used on hardwoods or softwoods. Varnish can be clear of have some form of stain included, for example to make the wood look older than it actually is. Varnish enhances the grain of the wood and can provide a very durable protective coating to the wood, including making it water resistant.

Sealants

Some absorbent materials, such as MDF or Styrofoam, need to be sealed before they can have a further paint finish applied to them. The sealant often includes adhesives which prevent the paint from soaking into material which would leave an uneven finish.

Preservatives

Wood is a natural material that over time will lose strength and degrade as it is attacked by rot, decay and insects. Preservatives help to improve the resistance of wood to such attack and increase the life span of the timber. Preservatives can be used on many types of wood to change its properties, for example making softwood more durable. Preservatives can have different finishes to improve the aesthetics of the wood whilst also enabling the wood to be used in water, underground and also for above ground applications. Preservatives are however toxic and are more effective if they are used to pressure treat wood.

Anodising

Anodising is a process that can be used to add a coating to aluminium. This coating improves resistance to wear and can also be decorative. It is possible to anodise aluminium in a range of different colours. To anodise aluminium the piece that is going to be treated is made in to an anode and placed in to an acid solution. When the component is brought out of the solution it begins to oxidise and the coating is formed. Machining and joining processes should be completed before anodising the metal.

Electro-plating

To electroplate a metal an electric current is passed from one terminal through an electrolyte liquid to another terminal. As electricity flows through the electrolyte the metal atoms within it separate and form a thin layer on one of the electrodes.

Electro-plating can be used with a wide range of metals including gold, silver, tin, zinc, copper, chromium, nickel, platinum, and lead. The choice of electrolyte is important, for example to achieve silver plating the electrolyte must contain silver. As with many processes, it is important to make sure the electrodes you want to plate are completely clean.

It is also possible to electroplate plastics to give them the appearance of a metallic component, for example small portable electronic products. To do this a very thin coating of copper or nickel is applied to the plastic component and then it is electroplated in the same way as metallic components would be. Electroplating can be used to make something decorative, for example a gold or silver plating, or to protect it, such as applying zinc to iron or steel to galvanise it.

Powder coating

Powder coating has historically been used on metals such as aluminium alloys to provide them with a tough outside finish that offers more protection than paint. Modern technologies have however made it possible to powder coat other materials. The process is carried out by using an electrostatic charge that attracts the thermosetting plastic powder to the surface that is going to be treated and then heating this so that the plastic melts and flows to form the coating which cures at a higher temperature. Thick protective coats can be applied, and the coating does not run (unlike paint), whilst because no solvents are involved the hazards to health and the environment are lower than alternatives. To apply a powder coating the workpiece must be cleaned of all grease and dirt otherwise the powder will not bond. The workpiece is grounded and an electrostatic spray gun is used to spray positively charged powder. The charge attracts the powder to the workpiece. Once covered, the workpiece is heated so that the powder melts to form a film. Sometimes the workpiece itself is heated before applying the powder, which can give a higher quality finish. The final stage, curing, involves raising the temperature to 200ºC for around 10 minutes. This causes chemical reactions within the thermoset powder and causes crosslinks to form.

Oil coating

Adding a layer of oil to a ferrous metal prevents it from rusting. This is because the oil prevents air coming in contact with the surface of the metal and therefore stops it oxidising. Oil coatings can be applied to metals in store to keep them free from rust, and also to metals that are in use, for example motorbike chains or hinges, where any form of rusting will prevent correct operation and can lead to long term damage or failure.

Cathodic protection

Cathodic protection is a very good way of preventing metals from corroding (CP) and is one of the most effective methods for preventing most types of corrosion on a metal surface. In some cases, CP can even stop corrosion damage from occurring. Metals, especially ferrous metals, corrode in the presence of oxygen, water, and other impurities such as sulfur. Without CP, metals act as the anode and easily lose their electrons and thus, the metal becomes oxidized and corroded. CP simply supplies the metal with electrons from an external source, making it a cathode.

Galvanic Cathodic Protection

Galvanic cathodic protection involves protecting a metal surface that is either underground or under water by adding another metal that is more reactive. This additional metal is given a negative charge from an external power supply. The reason for using cathodic protection is so that the additional metal oxidises and corrodes rather than the metal surface that needs to be protected.

Galvanised steels have a zinc coating that protect them from corrosion, however they do not need to be connected to a cathode to provide protection.

Topic 5: Factors influencing the development of products

5.1 (a) User needs, wants and values

It is important with user centred design that any design proposals and solutions are based on a clear understanding of the needs of the user, their wants, their values, as well as the tasks that will be used with the product and the environment in which it will be used.

An iterative approach needs to be followed with the end user at the centre of the process, with on-going evaluations being used to assess the user experience as a whole. When thinking about the user needs, wants and values, it is important to profile the users so that they remain central to the project. The needs, wants and values of the potential user need to be considered at all times, with the development of the product addressing each of these. Often specialists from a range of different areas will be drawn together in order to ensure that designs and products are fit-for-purpose.

5.1 (b) Purpose

The purpose of a product should be central to the design as failing to meet this would result in a product that does not meet the specification. Whilst the user centred approach should ensure that the end user is at the heart of decision making, the design should nonetheless fulfil its intended purpose, be that to keep somebody warm, safe or entertained. When considered alongside user-centred design, questions that need to be answered will include those related to the functionality, use and environment within which the product will be used.

5.1 (c) Functionality

How will the product be used? What functions does it need to perform? When considering functionality it is important that aspects of the design related to ergonomics and anthropometrics are evaluated. The ease of use of the product will need to be considered, with prototyping and user opinion being useful tools at this stage to check that products function as intended.

5.1 (d) Innovation

Innovation can be achieved in a number of different ways, but it does not always mean that a design has to be completely new. When first launched, smart phones were considered to be innovative as they brought together a range of existing types of product including cameras, telephones, calculators and music players in to one pocket sized package. This is one example of innovation, other approaches could include taking a different approach to solving a problem by taking inspiration from something not usually associated with such problems; considering different materials or processes or developing a completely new approach to addressing the problem.

5.1 (e) Authenticity

When following a user-centred design approach it needs to be authentic, in other words it needs to be seen to run through the entire process and be seen to the focus of the design process. By making sure that all aspects of the process are being valued and the user is indeed the true focus of developments then all involved are more likely to contribute positively. Products will be seen as being truly designed with the user in mind, rather than being an afterthought.

5.4 (c) Bauhaus Modernist - Marianne Brandt

Marianne Brandt was a former student of the Bauhaus who later became the deputy head of metal who was responsible for developing many of the metal objects and products that are typically Bauhaus. After leaving the Bauhaus, Brandt continued to have a major impact in product design, firstly as designer for a number of German companies, and then later she was appointed a lecturer in Dresden.

Brandt is often considered to be one of the major forces behind modern industrial design, designing lamps, household objects and tea and coffee services whilst at the Bauhaus. Other work at the Bauhaus included working in the architecture practice where she designed furniture that could be mass produced, or was of modular design. This was in line with the Bauhaus principles of ensuring the function of a product was considered along with the aesthetics, although decorative features were omitted. This became known as the International Style. Bauhaus is probably most remembered for the modernist design style where designs were produced with simplified form, their functionality and limited use of materials. This allowed for products to be mass produced using industrial approaches. Standardised parts and components were features of the modernist approach, as were clean lines and the use of modern materials such as steel and raw concrete.

5.4 (g) Memphis – Ettore Sottsass

Ettore Sottsass was an Austria-born designer who, along with other designers, formed the Memphis Group in 1981. He was one of the important and influential designers of the 20th Century, also being renowned for his contributions to architecture. The Memphis Group was at the forefront of post-modernism design, producing bright, colourful and abstract designs for metalware, glassware and furniture. Many designs made use of simple geometric forms that were combined to produce asymmetrical products. Designs were often inspired by popular culture, including Pop Art, along with previous design styles including Bauhaus and Art Deco. Modern materials featured within many of the design, including metals and plastic laminates.

Topic 8: Features of manufacturing industries

8.1 (f) Standardised parts, bought-in components

For most design and technology projects some component parts will need to be bought in. These could include fixings such as nuts, bolts, screws, paper fasteners, zips, buttons, or electronic components. These are also sometimes known as standardised parts as they are available 'off the shelf' from suppliers and are usually manufactured by more than one company. Not all bought-in components are standardised; sometimes a manufacturer may need to have parts specially made for a product that they do not have the equipment or expertise to produce themselves. Examples of this could be a furniture manufacturer that has hinges made to a specific size that would only fit their cupboards, or a clothing manufacturer that has embroidered badges produced for them that are then sewn onto jackets.

Topic 9: Designing for maintenance and the cleaner environment

9.2 (a) Cost implications to the consumer and manufacturer of using cleaner technologies

Clean technologies often have some financial benefit to the consumer in the long term, however the initial cost implications can be severe. Cleaner technologies will usually need some form of investment in designing and manufacturing, with more efficient and less polluting machinery commonly needed.

Topic 10: Current legislation

10.1 (a) Consumer Rights Act (2015)

One of the key features of the Consumer Rights Act (2015) is that it is designed to ensure that all products must be of satisfactory quality, that they are fit for purpose and as described by the retailer. The legislation applies to all products including those that are provided digitally such as downloaded software or are web based. The legislation protects the consumer by requiring goods to be in full working order when bought, although the expected standard of products is often linked to the price paid. Similarly, products should be suitable for their intended use, i.e. be 'fit for purpose'. An example of this could be a waterproof jacket that does not keep the wearer dry when it rains. This would not be fit for purpose, whereas a table that provides a level and flat surface can be considered to be fit for purpose. This can be linked to the product being 'as described', so if you buy a storage box advertised as being made from aluminium, then it must be made from aluminium.

The legislation also allows consumers to have products repaired or replaced if they fail to meet the above criteria. In some cases the consumer can ask for a refund, but this is not an automatic right and depends on whether repair or replacement is possible, timescales and levels of inconvenience for the customer. Some of these rights also extend for the first 6 months of ownership.

10.1 (b) Sale of Goods Act (1979)

This has largely been replaced by the Consumer Right Act (2015), however still applies to any products bought before 2015. As with the Consumer Rights Act, goods need to be as described, of satisfactory quality, and be fit for purpose. This means that not only must products be suitable for everyday use, but also, for example, if a customer asks for a power supply for a specific type of laptop computer and this is agreed with the seller, then it must be suitable.

Topic 11: Information handling, modelling and forward planning

11.1 (a) Marketing

Marketing analysis

Businesses use a marketing analysis to examine the potential of the market they are operating in. They do this by carrying out a SWOT analysis which looks at the strengths, weaknesses, opportunities and threats that will help the company focus on when making decisions. The marketing analysis could consider factors such as competitors, innovation, approaches to advertising and manufacturing capabilities.

Research techniques

There are many different research techniques that can be used by designers. Depending on the nature of the data that needs to be collected the type of research to be used will differ. In some cases raw data will be collected and used, whilst in others data will need to be analysed to encourage enterprise.

Interviews

These can be used, either individually or in groups, where opinions of concepts and designs can be sought during the development of a new product. However this approach is unlikely to result in any form of data that can be analysed other than functional testing.

Desk top research

This can be in a number of forms, using both internet resources and books or references. This could result in market trends being able to be analysed to see if there are gaps in the market, or where customer satisfaction for a competitor product is low which could allow for marketing to try and gain more market share.

Data analysis

This can be applied to raw which can be investigated to find out specific details, such as the potential market for a new product, or the amount customers would be willing to pay for an updated version of an existing design. Such data can be obtained from surveys, which although can sometimes seem to be of little worth, providing the correct questions are asked and suitable multiple choice options are given, the information and data obtained can be very useful when considering new products.

11.1 (b) Innovation management

By using innovation management a designer, or company, can introduce new products, ideas or processes using creativity. Innovation management draws together two strands - imitation and invention, both of which can help to develop products.

Innovation can be achieved by using lots of different approaches including prototyping, as part of an iterative approach. Innovation can be 'push' or 'pull' driven. If it is push driven then this will make best use of existing technologies and processes, or ones that have recently been developed, whereas a pull driven approach may lead to new technologies being developed. Innovation management brings together all of the departments involved with design and development of products throughout the whole process to introduce a strategy for innovation. As products develop faster, and new products are introduced more often, innovation management is a tool that can be used to generate new business, improve employee engagement and also increase customer satisfaction levels.

Cooperation between management, designers and production engineers

All employees must be able to work together for innovation management process to be successful. Some companies and designers use social media to get feedback, while others use some of the research techniques covered elsewhere. Whichever approach is taken, innovation needs to be organised and managed, with a range of proposals being narrowed down to a short list which can be trialled to see how they work. For this to be effective designers, managers and engineers need to be able to cooperate. Managers need to make sure that processes are effective by encouraging designers and engineers to work together as the introduction of an innovative design can be a very complex process. Each will bring knowledge and ideas, from which large scale innovations can often result.

The encouragement of creativity

To be innovative designers need to be creative which can use many of the processes that you could be familiar with, such as brainstorming or design workshops. Sometimes designers need to step back and refocus on ideas after a short break to allow thoughts to become clearer. Part of the creative process could involve a design company giving all employees an opportunity to come up with ideas for new approaches to solve a problem, rather than limiting suggestions to the designers. Team work can be a good way for a company to encourage new ideas, with ideas from a number of designers often being better than those produced by an individual. Some organisations encourage staff to change rolls frequently to keep them 'fresh' and to be able to experience different jobs.

Creativity can be developed if designers are encouraged to look at different methods of working, if their ideas are taken seriously, no matter how off-the-wall they may be. Consider the conversations that took place in the Victorian era when many of the technologies we take for granted were being developed; if the horseless-carriage had not been taken seriously then, would the car have become the everyday form of transport it is now? It is important to remember that part of innovation is making mistakes in the same way as success is, however for innovation management creativity should be rewarded with no penalty for mistakes. Often mistakes can lead to a different approach being adopted that is more successful in the long run.

11.1 (c) The use of feasibility studies on the practicability of proposed solutions

When a solution to a problem has been arrived at it is a good idea to carry out a feasibility study to analyse and justify manufacturing the design. The study may consider technical aspects of the design, as well as whether the product will be profitable to manufacture or not. When the study is finished, it is usual for a report to be produced that includes a summary of the study and recommends if the particular project is realistic and practical. A feasibility study will look at the costs related to the project, whether the project is sustainable and viable, and whether or not the design is technically possible. Feasibility studies will also provide areas that need to be focussed on during the development of a solution, they will study materials and manufacturing options and the scale of production most likely once commercial manufacturing begins.

11.2 (a) Budgets – undertake financial forecasts

For any manufacturer it is key to their success that they have accurate financial forecasts. This will allow them to decide if a project is viable or not. They will use information from past and current projects to try and project what is likely to happen in terms of income and outgoings. Some consideration will also be made of market trends, government policies and the long term aims and objectives of the manufacturer. In many cases both short term and long term forecasts will be carried out, with reviews taking place regularly based on sales, stock held in inventory and to an extent manufacturing activities. Financial forecasts can help a manufacturer to make decisions related to production levels, retail prices and also the potential for investment.

11.3 (a) Patents

A patent is something that a designer can apply for when they produce a new invention. The purpose of a patent is to prevent others from copying how something is made, the processes used, and the technologies involved with making the invention work. The owner of the patent can stop other people making the product without their permission. The rules for being granted a patent are quite strict; the design must be new, it must be inventive in some way, and it must be capable of being manufactured or used in industry.

11.3 (b) Copyrights

Copyright is a way in which both published and unpublished works, such as books, magazines, films, music and video games can be protected. This means the holder of the copyright, which can be the person who has created the work but this is not always the case, can decide what they do with their work such as where it can be displayed or performed. Copyright laws can be used by the original author of the work if somebody is either using their work without permission or has made unauthorised copies of it.

11.3 (c) Design rights

Design rights are similar to patents, however they only cover the shape and form of a design. Design rights are automatic and protect the design for 10 years following publication. To further protect the design, it can be registered. This is especially the case for 2D designs such as graphics, textiles and wallpaper.

11.3 (d) Trademarks

There are many forms of trademark, many that you will be familiar with from clothing designers through to household brands. A trademark can be either a symbol, a word, a name or a device that is instantly recognisable as belonging to a particular company or product. Trademark rights do not prevent other companies from making a very similar product, they do however stop other companies from copying the trademark and using something that is very similar to it.

Topic 12: Further processes and techniques

12.1 (a) User-centred design

Framework process

When following a user-centred design approach it is important that there is some form of structure, or framework, to the process. This will involve considering the overall goals of the organisation, the information that is already available, and the user needs, to create designs that have the user experience at their centre. There should be a clear framework for the process which begins with specifying what the users' needs are, and the context that the product will be used in. This is followed by considering the requirements of the business. Ideas and designs are then developed before being evaluated by users to see if they are suitable. If the outcome is positive, then production can begin and products sold. Finally the needs of the user need to be monitored in case they change, with the product being continuously evaluated when in production.

Problem solving

User-centred design provides designers with clear information about the user, the environment in which a product will be used, and the purpose of the product. This allows the manufacturing company to put together a team that is able to solve the problem through an iterative design approach. Through the use of feedback during the design and development phases, the solutions to problems can be refined and improved. Collaborative working also helps with the development of designs, with designers and engineers being able to share ideas to produce innovative user-centred design solution.

User needs, wants and values

We have already considered the overall approaches to user centred design, however it is important to remember the importance of user needs, wants and values throughout the entire design, create and evaluate process. These should be central to all aspects of the process, and designers need to make sure that they remain the focus throughout development.

Limitations of end user consideration

It is important that when considering the end user that the methods of seeking their opinions is appropriate and will provide feedback that is developmental. End users can be used for product testing to see which parts of a design work for them, and which do not. However it is important to remember that this is the views of a small proportion of the potential market, therefore caution is needed. This is where the iterative approach is important, small changes can have a big impact on the success of a design, and feedback from end users should lead to refinements not large scale revisions.

12.1 (b) Circular economy

Through using a circular economy system it is possible for a manufacturer to reduce the waste and pollution that they produce. This can be used through a combination of approaches including the 5Rs (Reduce, Reuse, Refurbish, Repair and Recycle), maintenance, improvements to designs, remanufacturing and upcycling. The focus of a circular economy is to reduce waste, including energy waste, and emissions through processes which slow, close or narrow the material or energy loops. It is a regenerative approach that aims to design out waste and pollution, regenerate natural systems and try to keep product and materials in use rather than disposing of them. Circular economies are based on biological systems that use natural materials such as wood and cotton that are biodegradable which then feeds back in to the cycle through biodegradation. Introducing a circular economy requires a change in the way things are designed, but should ensure that what is produce is 'made to be made again'.

12.1 (c) Systems thinking

One of the key principles of systems thinking is that each part of a product is a part of something bigger, and that the overall function and purpose of the product can be understood by analysing each of these smaller systems in order to explain how it works. As with a number of other design approaches, systems thinking relies on different people within an organisation working together, including designers and managers. A systems thinking approach requires all those involved to understand how components and parts are related to each other, and that if changes are made this can impact on other parts of the system. Typically systems thinking can involve the use of flow diagrams and feedback loops. With systems thinking, small changes can lead to major improvements, and the use of feedback is important to identify where changes can be made to refine a system or improve an outcome that will have the greatest overall effect. Everyone involved with manufacturing that involves systems thinking has their part to play in making sure the outcome is as expected.

12.2 (a) Critical path analysis

Although many projects can be broken down into small stages, many of these stages are dependent on each other and to an extent time sensitive. By using a critical path analysis it is possible to calculate the shortest time that a project will take as well as the earliest and latest times that an activity can begin. The activities that determine the length of the project are the ones that are on the critical path, whilst other activities can have an element of 'float' which means they are less time sensitive. Using a critical path analysis shows the activities that have the greatest impact on meeting deadlines and allows resources to be focussed on these. However they are only as accurate as the estimations used to produce them, therefore it is very important that any assumptions are accurate and are based on experience and prior knowledge from other projects.

Scrum

Scrum is a design approach that revolves around team work. The approach should be goal driven, with the ultimate outcome of the project being the aim and all activities should really work towards that goal. Different members of the scrum team, especially designers, will interpret what the users of products need to inform their designs. They will think about how the new product should work and what it will be like. There may be a need to work with engineering designers who will be able to make sure any systems function correctly. At all times it is important that the goals are defined before work begins on designs, and developments focus on both current project needs and also the long term goals. This results in an iterative design process that is agile and takes in to account feedback based on development and user needs. Teams should be made up of enough members to bring all the skills that are needed together.

Six Sigma

Six Sigma usually involves a project that concentrates on improving one or more key areas, which are often cost, schedule and quality. The project will often have a short time scale of only three or four months during which staff work together to meet the goals that have been set. For projects to be successful they need to have the support of management, enough resources to be implemented correctly, use data to inform decision making and have measurable performance characteristics that can be fed back into the project.

Six Sigma incorporates the DMAIC (Define, Measure, Analyse, Improve, Control) methodology which has 5 stages:

Define Stage

This is when the scope of the project is set, along with goals and objectives. The function of the process will also be defined and a team assembled who will have all of the skills needed to understand the project and the expected benefits.

Measure Stage

At this stage the process is looked at in detail to identify decision points. Baseline estimates are also taken and factors that are critical to cost, critical to quality and critical to schedule are considered to see which are customer focussed and can be collaboratively developed by the team.

Analyse Stage

The process is analysed by considering the value stream for the process and identifying those stages that add value for the customer or end user. If there are differences in the value added then the reasons for variation need to be identified.

Improve Stage

During the improve stage the project team will determine any new processes that will replace existing, less efficient, methods. They will also estimate benefits that will be achieved by the improvements whilst also investigating potential for failure and faults within the new process. Once these have been completed, the new processes will be implemented and the improvements verified.

Control Stage

The final stage involves making sure the new and improved processes become standard. The processes are then monitored, along with the financial returns from the improve approaches. During the control stage records are kept of lessons which have been learned which can then be used to inform the next DMAIC cycle.

Six Sigma approaches can be used to improve a manufacturing activity in a range of different ways:

Reduce process cycle time

One way to reduce process cycle time is reducing non-value added activities. Often there will be some unnecessary stages in production, for example inefficient layout of productions lines or paperwork being completed that is not needed. Reducing errors can also improve cycle time as products do not need to be reworked or replaced.

Reduce pollution

Reducing the distance that materials and products need to travel is one way of improving work activities that also has the benefit of reducing pollution. Similarly, reducing the amount of work that goes to waste due to faults is also a method of reducing pollution. More efficient processes which can produce more items at once can also assist in reducing pollution per unit.

Reduce costs

Most aspects of the improvement to any process will have some impact on the reduction of costs, with these also being linked to other improvements such as reducing process cycle time or pollution. In many manufacturing processes costs can be reduced by simplifying the steps needed, for example by redesigning components. Similarly using a common manufacturing process for a number of different products which reduces the time for setting up offers cost reductions that are related to standardisation.

Increase customer satisfaction - increase profits

Although it may seem to be obvious, the more satisfied customers are with a product or service, profits should increase. If a product or service meets customer satisfaction levels, for example by having a long service life, performing correctly or being manufactured to a high standard, then customers are likely to return or make recommendations to friends or family. This in turn can increase profits when other improvement techniques are also included.

12.3 Product life cycle

All products have a life cycle. This consists of four main stages which can vary in length depending on the type of product. An item of clothing may have a very short life cycle as market trends change quickly, whilst an item of office furniture could have a long life cycle as functionality of the product is often more important than the look of it. A designer and manufacturer will consider where a product is along its life cycle when deciding if they should improve what they already produce or launch a new product.

Introduction Stage

At this stage of the life cycle the manufacturer tends to make only a small profit as they need to not only manufacture the product but they also need to market it through a range of advertising methods. Sales can also be slow at this stage which also impacts on profitability.

Growth Stage

Once a product begins to become popular, more and more people will buy the product which in turn increases the profits for the manufacturer. As a product continues through the growth stage the market share will often increase, with competitor products losing market share. The costs of development have also generally been met at this point, so each sale adds more profit for the manufacturer.

Maturity Stage

With many products there will reach a point in time where everybody who wants to own the product will own it, and the designer and manufacturer will need to consider how to keep their share of the market. They could do this by redeveloping the existing product, maybe introducing a different model. This is an approach often used by car manufacturers who make improvements to their existing product for many years as the investment in a new design is very high. Alternatively a new product could be launched, an approach taken by many mobile phone manufacturers, which has new features and will be attractive to new customers as well as existing ones.

Decline Stage

As sales drop, profits will become less however the only costs now needing to be met are the direct and indirect costs associated with manufacturing and retail. There will come a point though where continued manufacture is no longer profitable, and this will be the stage when the product is withdrawn from the market.