1 Core content

1.1 The impact of new and emerging technologies

1 Automation refers to the use of robots to complete some tasks within a production line (1). This reduces the number of people needed as machinery can operate 24 hours per day, increasing productivity (1). Machinery controlled by computers can achieve higher levels of accuracy and consistency (1), meaning quality is guaranteed (1).

2 Answers could include: crowd funding (1), government loan or grant (1).

3 There is a time limit related to the need for seasonal products, therefore demand is lower and vast quantities are not needed (1). OR Batch production is a more flexible system, so production can be reorganised to suit different products (1). Examples of seasonal products include clothing and decorations relating to specific celebrations or festivals, such as Easter, Christmas and Halloween (1).

4 Factors could include: transportation to point of need [use of finite resources] (1); energy used in manufacturing (1).

5 The Internet of Things allows consumers to link different gadgets via the internet, enabling them to be controlled from a remote source (1). This is convenient for many people and makes life easier to organise (1). It also increases our reliance on technology, however, which could be problematic if things go wrong (1).

1.2 Critical evaluation of new and emerging technologies

1 When a budget is limited, the ability to buy the best materials and components is reduced (1). If cheaper and less-robust materials are used, the overall quality of the product may be impacted (1). Cheaper parts may also affect the useful life of the product as they may fail more quickly (1).

2 Examples could include: the use of the alloy Nitinol in medical implants (1), or 3D printing of synthetic cartilage in joint replacements (1).

3 The sources of the materials (1); the processing/manufacturing of the materials (1); environmental impact during its useful life (1); disposal of the product when no longer needed (1).

4 This refers to 3D printing (1). The print is built up layer by layer – adding layers – to manufacture a product/component (1).

1.3 How energy is generated and stored

1 Burning biomass fuels emits carbon dioxide into the atmosphere, which contributes to global warming (1). Carbon emissions are offset by replanting trees, which absorb carbon dioxide as they grow (1).

2 Advantage: wind power is renewable and freely available (1).

Disadvantage: wind is needed to turn the turbines to generate electricity; if there is no wind, there’s no energy (1).

3 Reasons could include: fossil fuels are a finite resource that is slowly being depleted and cannot be replaced (1). We are currently over-reliant on this resource (1). Burning fossil fuels to provide energy releases gases such as carbon dioxide into the atmosphere, which adds to the threat from global warming (1). The burning of fossil fuels causes air pollution, which can lead to breathing problems in people (1).

4 Photovoltaic cells (1).

5 Batteries have become much smaller [miniaturisation] (1) but their capacity to power devices has increased (1).

1.4 Modern and smart materials, composite materials and technical textiles

1 Plywood comprises several layers of wood (1), each layer being laid on a 90-degree angle to the previous layer. This gives it its strength (1).

2 CFRP is lightweight and has a very high tensile strength (1). A racing bike needs to be robust and strong to stand up to the conditions it will be used in (1), but it also needs to be lightweight so that is does not impede the speed of the cyclist (1).
3 When antibiotics or other medical treatments are micro-encapsulated into dressings (1), they go directly to the point of need to help heal the wound; this can speed up recovery (1).

4 Smart glass is glass that turns from opaque to clear, and vice versa, when activated by a switch (1).

5 Nomex® is resistant to flames and burning, therefore it will protect the wearer when exposed to fire (1). It is also an extremely strong engineered fabric that is resistant to abrasion (1).

1.5 Mechanical devices
1 Movement that turns in a circle (1).
2 A wheelbarrow (1), or any other appropriate response.
3 Knife (1), roller (1), flat (1).
4 To convert rotary motion to reciprocating motion (1) and vice versa (1).
5 To ensure that the gears placed either side of it (1) have the same direction of motion (1).

1.6 Electronic systems
1 Sensor: LDR (1) Output: LED (1)
2 When the voltage at the base reaches approximately 0.6 V (1), current is allowed to flow (1) between the collector and the emitter (1).
3 To reduce the flow of current (1).
4 Door/window alarm (1), electronic child’s toy (1), any other suitable response.

1.7 The use of programmable components
1 Input/output
2
3 Use the compare command (1), then set the threshold value (1) that the analogue input signal must be above or below (1).
4 1 mark for each correctly drawn, labelled and connected symbol (6).

1.8 Ferrous and non-ferrous metals
1 Ferrous metals contain iron, which means that they corrode (1) and they are magnetic (1).
2 A metal mixed with another metal or substance (1) to improve certain properties (1).
3 They allow electricity (1) and/or heat (1) to flow through them easily.

1.9 Papers and boards
1 Making copies of drawings and designs (1), or any other reasonable answer.
2 Answers could include: can absorb knocks and bumps (1) and has good heat-insulating properties (1).
3 Framing work (1), such as paintings and photos (1).

1.10 Thermoforming and thermosetting polymers
1 Thermoforming polymers can be recycled (1) as they can be reheated and shaped into new products (1).
2 Any two from: they do not conduct electricity (good insulator) (1), tough and impact resistant (1), waterproof (1).
3 Any one of:
   – disposable plates, cups (1)
   – model kits (1)
   – food containers (1)
   – trays (1).
1.11 Natural, synthetic, blended and mixed fibres, and woven, non-woven and knitted textiles

1 Natural: wool or cotton, or any other suitable answer [1].
   Synthetic: polyester or acrylic, or any other suitable answer [1].

2 Depending on the type of weave formation, a fabric can be much stronger, for example twill weave or yarns that are not packed tightly can create a less stable fabric [1]. It affects the stability and strength of the fabric [1].

3 Any from: its ability to stretch; it is considered warmer to wear [1].

4 The fibres are meshed together, so they are not strong [1]. This makes them suited to limited-use products as they will not withstand prolonged wear and tear [1].

5 Reason 1: they are biodegradable and will decompose into the ground [1].
   Reason 2: they are sustainable and will not run out [1].

1.12 Natural and manufactured timbers

1 In plywood the layers placed with alternating grains give it strength in both directions [1]. MDF is made from small fibres that can be easily dented or fall apart when exposed to moisture [1].

2 Advantage: knots give an attractive look to the wood [1].
   Disadvantage: knots weaken the strength [1].

3 Any from:
   - Hardwood trees shed their leaves every year [1]; softwood trees are evergreen [1].
   - Hardwood trees grow slowly [1]; softwood trees grow much faster [1].
   - Hardwood trees have thick trunks with branches at the top [1]; softwood trees are tall and thinner, with branches all the way up [1].
   - Hardwoods have a close grain and tend to be dense [1]; softwoods are more porous [1].

1.13 Contexts which inform design outcomes

1 Any four from:
   - compressive strength – resistance to a pushing force
   - tensile strength – resistance to a pulling force
   - durability – resistance to wear, long lasting
   - hardness – resistance to abrasion
   - stiffness – resistance to bending and flexing
   - elasticity – ability to stretch and return to shape
   - impact resistance – resistance to knocks and impacts
   - brittleness – hard but easily broken or shattered
   - water resistance – resistance to water or moisture
   - absorbency – ability to soak up moisture.

2 Any two from: temperature [1], direction or shape of the material [1], age of the material [1].

1.14 Environmental, social and economic challenges

1 Any three from:
   - choose materials that are sustainable, recyclable and non-toxic
   - choose materials that do not require as much energy to process as others
   - design products that are as fuel and material efficient as possible
   - design products to last as long as possible so there is less replacement of parts
   - design products that function to the best of their potential
   - design products that can be fully recycled when they reach the end of their useful life
   - design products that use as much local materials, resources and labour as possible to reduce pollution from transportation (globalisation) and to benefit the local economy
   - consider the needs and wants of all the stakeholders involved.

2 Wood [1] or paper [1] because they come from trees that can be regrown [1].
   Wool [1] or leather [1] because they come from animals that can be bred [1].
   Silk [1] or cotton [1] because they grow naturally and can be regrown [1].

3 Answers could include: old age, illness, life events (accidents).

1.15 The work of past and present professionals and companies

1 Answers could include: they are unusual, fun pieces that invite discussion [1]; they are manufactured to a high quality and with attention to detail [1].

2 Joe Casely-Hayford trained in tailoring in Savile Row. He used his tailoring expertise in his work [1] but combined it with more innovative cutting and tailoring methods to create his own unique style [1].

3 It was the first vehicle to use the latest, cutting-edge battery technology [1].
Now test yourself answers

4 The software allows designers to create photorealistic images (1) in a high-quality, three-dimensional form (1).

5 Zaha Hadid focused on the form and shape of buildings in a more free-flowing style (1). She believed the technical details and how you build the structure could be solved later (1). She was uninhibited by convention (1).

1.16 Design strategies
1 Any one of:
   - By discussing, sharing and working with each other (1), designers can get a different perspective on a problem (1).
   - Designers can bounce ideas back and forth between each other (1) and refine elements (1).
   - It can open new avenues of investigation and design (1) that the designer may not have thought of on their own (1).

2 Putting the user at the ‘centre’ of the design process means less refinement and modifications (1) are needed further along in the design process (1).

1.17 Developing, communicating, recording and justifying design ideas
1 Drawing instruments are not used when freehand sketching (1); freehand sketches do not need to follow formal drawing conventions (1); formal drawings follow conventions (1) and drawing aires are used (1).

2 One point perspective (1) and two point perspective (1).

3 First angle: the front view is drawn above the plan view (1) and the side view is drawn to its left (1). Third angle: the front view is drawn below the plan view (1) with the side view to its right (1).

4 To show a top-down overview of a system (1) in terms of its input, process and output sub-systems (1).

5 High accuracy of drawing (1), easier to modify the drawing (1), or any other appropriate response.

2 Metals

2.2 Sources, origins, physical and working properties, and social and ecological footprint
1 Any two from: excellent tensile strength (1), very tough (1), very durable (1), excellent resistance to corrosion (1).

2 Ferrous metals contain iron whereas non-ferrous metals do not (1).

3 Any two from:
   - excellent strength-to-weight ratio
   - lightweight
   - soft
   - ductile
   - malleable
   - a good conductor of heat and electricity
   - corrosion resistant.

4 Any three from: open cast mining creates scars on the landscape (1); deforestation can occur (1); wildlife can lose its habitat (1); rivers and water courses can be polluted (1).

5 Metal is a non-renewable resource (1); it can be recycled (1); metal uses lots of non-renewable energy when being processed (1).

2.3 Selection of metals
1 Any one of yellow, orange or gold (1).

2 It will rust (1).

3 The price will go up (1).

4 Moral standards will influence the design of a product (1). Products cannot be seen to be offensive towards any particular group of people (1).

5 When a product is designed to become unusable (1) or out of date (1) in a short period of time.

2.4 Forces and stresses
1 It reduces the brittleness of steel (1).

2 It is a force that is acting in opposite directions (1).

3 It would be used as a constructional beam (1) to produce a building (1).

4 It increases the hardness (1) and toughness (1) of steel.

5 Heat the metal with a brazing torch (1) until it is red hot (1). Quench it quickly in cold water (1).

2.5 Stock forms, types and sizes
1 The available shape (1) and size (1) of metal.

2 Plate (1).

3 Sintering (1).

4
2.6 Manufacturing to different scales of production
1 Answers could include: identical products can be made (1); it is cost effective in larger quantities (1); complex shapes can be moulded (1).
2 Any two from: a unique (1), high-quality (1), expensive (1) product is made.
3 Aluminium drinks cans, food cans, water bottles, or any suitable answer (1).
4 A subcomponent of a product is assembled (1) before being fitted to the main product (1).
5 49.5 mm (1) and 50.5 mm (1).

2.7 Specialist techniques, tools, equipment and processes
1 When cross filing, you slide the file across the metal (1); when draw filing, you draw the file along the length of the metal (1).
2 Any three from: tie your hair back (1), wear goggles (1), wear an apron (1), hold the work firmly (1).
3 Either emery cloth or wet and dry paper (1).
4 Any three from: mark out a hole on both pieces of metal (1), drill holes into both pieces of metal (1), place the pop rivet through both pieces (1), attach the rivet gun and squeeze (1).
5 To protect the surface (1) and to spread the pressure over the surface (1).

2.8 Surface treatments and finishes
1 It will rust (1).
2 Aluminium (1).
3 It will protect the car body from rusting (1); it will extend the life of the car (1).
4 Any three from: clean the metal (1), heat the metal (1), apply the powdered polymer via an electrostatic gun (1), heat the powdered metal until it becomes a fluid (1).
5 Any three from: it is a slow process (1), you will get brush stroke marks (1), you may get runs (1), you may get brush hairs (1), it is not as durable as other methods (1).

3 Papers and boards
3.2 Sources, origins, physical and working properties, and social and ecological footprint
1 Heat transfer paper (1).
2 Durable, high-quality paper (1) used for legal documents (1).
3 Each time it is recycled the fibres get shorter (1) and this weakens the paper (1). After five or six times the fibres are too short to bond together (1).

3.3 Selection of papers and boards
1 – Social groups – people with different feelings about the use of certain types of paper and board used (1).
– Trends and fashion – can influence the materials and finishes used so that the product will appeal to the current market and sell well (1).
– Popularity of other products – designer may try to emulate or produce products with similar attributes and properties using similar materials (1).
2 How something looks or feels (1), for example the shape or colour (1).
3 Consumer society (1).

3.4 Forces and stresses
1 An inner `core' (1) sandwiched between two outer layers (1).
2 A sheet of paper or board is fully enclosed (1) within a heat-sealed plastic pouch (1).

3.5 Stock forms, types and sizes
1 The paper has high strength and it needs to last a long time (1).
2 A3 paper is twice the size of A4 (1). Two A4 sheets side by side are the same as one A3 (1).
3 500 sheets (1).

3.6 Manufacturing to different scales of production
1 448 mm (1) and 452 mm (1).
2 Arranging objects on a sheet (1) so the material being cut out is used to its maximum capacity (1).
3 Advantage: any two from: the process is fully automated (1), no labour costs (1); it can run 24/7 (1), cheap unit cost (1), high-speed production (1).
Disadvantage: any two from: requires highly specialised equipment (1), which is expensive (1), high set-up costs (1), storage of products can be difficult due to high volume (1).

3.7 Specialist techniques, tools, equipment and processes
1 Pages can be folded all the way back (1) without damage to the spine (1).
2 Vee cutting (1) and hinge cutting (1).
3 Solvents in the adhesive melt (1) the plastic (1).

3.8 Surface treatments and finishes
1 The application of colour (1) to the edges (1) of paper or boards.
2 UV varnishes dry instantly when exposed to UV light (1); this means they dry much quicker than ‘normal’ varnishes (1).
3 Cold lamination uses film, which has a thin coating of pressure-sensitive adhesive applied to one side (1). The film is placed over the document and passed through the machine’s rollers (1), which press down and smooth out the adhesive, sticking the film firmly to the document (1).

4 Polymers

4.2 Sources, origins, physical and working properties, and social and ecological footprint
1 Any three from: tough (1), good chemical resistance (1), good weather resistance (1), relatively inexpensive (1).
2 Thermoforming polymers can be reheated and reshaped many times (1); thermosetting polymers can only be heated and formed once (1).
3 Acrylic (PMMA) (1).
4 Urea formaldehyde (UF) is a thermosetting polymer (1) that comes from a finite resource, crude oil (1). It cannot be recycled (1). If it goes to landfill it will stay around for many years (1).
5 Crude oil must be extracted from the seabed by drilling (1) and then transported to the oil refinery by ship (1). Spillages can harm sea life, birdlife and beaches (1). The processing of crude oil gives off toxic fumes (1) that pollute the atmosphere (1) and contribute to global warming (1).

4.3 Selection of polymers
1 Transparent – completely clear (1).
2 Translucent – see-through with a hint of colour (1).
3 Opaque – a solid colour (1).
4 To provide grip (1).
5 Answers could include: supply and demand (1), politics (1), conflicts between warring nations (1) and trade wars (1).
6 Any three from: reduces the unit cost of a product (1), fulfils a high demand (1), increases accuracy (1), increases consistency (1), can lead to unemployment of skilled workers (1).
7 Discussion could include four from: biopolymers are a renewable resource (1) therefore we will never run out (1). They are biodegradable (1), therefore they will rot down when they go to landfill (1). They are non-toxic (1), so they will not pollute the land or harm wildlife (1).

4.4 Forces and stresses
1 Tension (1).
2 Any three from: they can be strengthened by adding webs (1), bends (1), ridges (1) and creases (1).
3 Triangulation involves applying diagonal bracing to a structure (1) to form a series of triangles (1).

4.5 Stock forms, types and sizes
1 314.16 mm² (1).
2 Film (1).
3 Polyester resin (1).

4.6 Manufacturing to different scales of production
1 The extrusion process:
   – Polymer pellets are fed from a hopper into a heating chamber (1).
   – The pellets are transported along the chamber via an Archimedes screw (1).
   – The pellets become molten and are then forced through a die, which forms the shape of the cross-section (1).
   – As the extruded polymer emerges from the die, it is cooled and pulled to keep it in tension (1).
2 A strip heater (1).
3 The unit cost of a product is reduced (1), materials can be purchased in vast quantities (1), the accuracy of a product increases (1), the consistency is increased (1).
4 Either vacuum forming (1) or GRP laying up (1).
4.7 Specialist techniques, tools, equipment and processes

1. The vacuum-forming process:
   - Once the mould is ready, it is placed on the platen (table) of the vacuum former and lowered into the machine (1).
   - A sheet of HIPS is then clamped over the top of the machine and heat is applied (1).
   - After a short time, the HIPS sheet will become soft. Care should be taken not to overheat the HIPS sheet as it will not form properly and webbing may occur (1).
   - The mould is then raised up into the hot HIPS sheet and immediately the air is sucked out of the machine by tuning on the vacuum pump (1).
   - Once formed, the sheet should be allowed to cool before being removed from the vacuum former and trimmed (1).
   - Deeper moulds may require the soft HIPS sheet to be blown into a dome before the mould is raised. This gives an even thickness of material around the taller mould (1).

2. They have larger heads to prevent them damaging the surface of the polymer (1).

3. Either it dries clear (1) or it is strong (1).

4. Ensure the surface is clean, dry and free from oil (1). Apply a thin coat to both surfaces (1). Allow time to dry (1). Bring both surfaces together (1).

5. Any three from:
   - it can burn your skin (1)
   - it can blind you (1)
   - it can affect your breathing (1)
   - it is flammable (1).

4.8 Surface treatments and finishes

1. Draw file the edge with a smooth file (1), repeat the process with different grades of wet and dry paper (1), use metal polish and a rag to shine the edge (1), or use a buffing machine (1).

2. A vinyl cutter (1).

3. A coloured pigment (1).

5 Systems

5.1 Design contexts

1. The wider setting in which a design solution for a product or system sits (1).

2. Supporting people with disabilities (1), encouraging more active lifestyles (1), or any other appropriate response.

3. To ensure that the design solution is fit for purpose (1) and fulfils the needs of the end user (1).

5.2 Sources, origins, physical and working properties, and social and ecological footprint

1. Moisture sensor (1).

2. How close the actual resistance is to its stated resistance (1); it is expressed as a percentage (1).

3. China (1), Russia (1), the USA (1).

4. Thermal conductors conduct heat (1); electrical conductors conduct electrical current (1).

5. Children spend less time socialising/playing face-to-face (1) as result of increased time spent using mobile phones and tablets (1), or any other suitable example.

5.3 Selection of systems

1. 8 and 14 pin ICs, or any other appropriate response (2).

2. An element that is difficult to source or obtain (1), such as cobalt (1).

3. Avoiding offence to religious groups (1), ensuring appropriate use of colour (1), or any other appropriate response.

5.4 Forces and stresses

1. Tension is a pulling force (1); compression is pushing force (1).

2. Twisting a plastic ruler between both hands (1), or any other suitable response.

3. Carbon fibre reinforced polymer (CFRP) (1) – it has a high strength-to-weight ratio (1) and high corrosion resistance (1), or any other suitable response.

5.5 Stock forms, types and sizes

1. Components are placed on top of the plastic side of the circuit board (1), with the legs going through the holes to the copper side (1). They are then soldered on to the pads (1).

2. Current – amps (1)

3. Potential difference – volts (1)

4. Potential difference (V) = Current (I) × Resistance (R) (1)

5.6 Manufacturing to different scales of production

1. Place the tip of the soldering iron where the connection is to be made (1) and heat it for a few seconds (1). Apply solder until it flows around the whole joint (1). Remove the unmelted solder
followed by the soldering iron (1). Wait for the joint to cool (1). Cut any excess wire using wire cutters (1).

2 One-off production is making a single prototype (1); batch production is making a small group of identical products (1).

3 Tessellation (1), nesting (1), or any other appropriate response.

5.7 Specialist techniques, tools, equipment and processes

1 Wire strippers (1), which are used to remove the insulation from the end of a wire (1), or any other appropriate response.

2 Prototypes can be made relatively quickly (1), can produce complex parts or shapes (1), or any other appropriate response.

3 To reduce the risk of damage to the cables (1) and to decrease the space needed by them (1).

4 Addition processes add material to the workpiece (1); wastage processes take it away (1).

5.8 Surface treatments and finishes

1 Plating copper contacts with nickel (1) or tin (1), or any other appropriate response.

2 To protect the wire from damage (1), to prevent the wire from touching other conductors that it should not be touching (1), to reduce the risk of electric shocks from people touching the wire (1).

3 Orange, orange, brown, gold (1).

4 To protect them from corrosion/damage (1) and to add aesthetic appeal (1), for example anodising (1) or any other appropriate example.

6 Textiles

6.2 Sources, origins, physical and working properties, and social and ecological footprint

1 Polyester (1), acrylic (1), nylon (1), elastane (1).

2 Regenerated fibres are different because they are extracted from wool pulp using a chemical process (1), so they are not entirely natural (1).

3 Answers could include:
   - Polluted waste water from textile processing finds its way into rivers and streams, impacting on wildlife (1).
   - Intensive farming and overgrazing by sheep for wool production damages the soil (1).
   - Huge quantities of water are needed to grow cotton, taken at the expense of the wider ecosystem (1).

4 Linen is absorbent (1), so any perspiration will be absorbed, leaving the wearer feeling cool (1).

5 **Reason 1**: when fibres are spun the thickness of the yarn will affect the density of the fabric once it has been woven or knitted (1).
   **Reason 2**: the density of the cloth depends on how tightly the fabric has been woven or knitted; a tight weave gives a denser fabric (1).

6.3 Selection of textiles

1 If a product does not look immediately appealing, a consumer may not buy it (1). The style and shape need to be in line with current trends as most people want the latest looks (1). It is important for people's self-esteem that the clothes they wear are aesthetically pleasing (1).

2 **Advantage**: availability of inexpensive/affordable products that are manufactured cheaply (1).
   **Disadvantage**: people who work in the manufacturing industry may be exploited because profit comes first (1).

3 Designers want their latest collections to be successful (1) and on-trend (1).

4 Less waste textiles going to landfill (1), opportunity for a uniquely designed product (1), or any suitable response.

6.4 Forces and stresses

1 Boning provides structural support to a medical corset, keeping the product in place (1). It also restricts movement (1), which aids recovery from spinal or internal injuries (1).

2 Stay stitching helps maintain a shape and prevents the distortion of fabric during manufacture (1).

3 Cuffs (1), collar (1), button/button-hole stand (1).

4 It enhances the properties of the fabrics by improving their functionality or aesthetics (2).

5 A quilted panel could be padded and is thicker (1) and can therefore provide protection, for example on the knee area (1).

6.5 Stock forms, types and sizes

1 Each edge is 40 cm; it has six equal faces (1); surface area for one face is calculated as length x breadth (1).

   \[ 40 \times 40 = 1600 \text{ cm}^2 \]

   \[ 1600 \text{ cm}^2 \times 6 \text{ sides} = 9600 \text{ cm}^2 \]
2 A higher number indicates a thicker fabric (1).
3 It is a double thickness (1) and appears the same on both sides (1).
4 90 cm (1), 137 cm (1), 154 cm (1).
5 It indicates that three threads (1) have been spun together to make the yarn (1).

6.6 Manufacturing to different scales of production

1 Limited numbers are needed for seasonal products as they are only sold for a limited period of time (1).
2 It will be made to the client’s specific measurements (1), so a comfortable/perfect fit can be achieved (1).
3 The worker may only be skilled in one job (1), which can become repetitive and boring (1).
4 Quantity of products needed (1), timescale (1), complexity of product (1), budget/cost (1).
5 Quality control is a series of check points aimed at maintaining standards within production (1). Mistakes can be identified and corrected (1) to ensure the whole production run is of an equal standard (1).

6.7 Specialist techniques, tools, equipment and processes

1 A French seam conceals all raw edges so is a much neater finish (1), especially on sheer fabric as the seam could be seen from the outside (1).
2 – It joins two pieces for fabric and neatens it in one operation (1).
– It cuts the edge as it over-sews it for a neater finish (1).
3 Zig-zag stitch (1), pinking shears (1), overlock stitch (1).
4 Stay stitching prevents fabric from distorting and loosing shape while under construction (1), which leads to a better-quality finish (1).
5 The stitches are not visible so it is a much neater finish (1).

6.8 Surface treatments and finishes

1 Shaped pieces of fabric, usually reinforced with an interfacing, are laid on to a base fabric (1) and stitched in place to create a decorative feature (1).
2 Fabric is folded up and tied securely either with string or clips and immersed in dye (1). The tied parts resist the dye (1) and remain undyed, creating a pattern on the fabric (1).
3 Anti-static (1).
4 The fabric becomes stain resistant and water repellent (1), improving functionality and fabric life (1).
5 Process: biostoning (1).
   Explanation: enzymes react with the dye in the fabric (1) to create a washed-out effect (1).

7 Timbers

7.2 Sources, origins, physical and working properties, and social and ecological footprint

1 Any two from: it is tough (1), durable (1) and does not splinter (1).
2 Any two from: it can be used to make fencing (1), fence posts (1), cladding (1) and sheds (1).
3 It is made up of several veneers of timber (1); each veneer is glued to the next (1) with its grain running at 90 degrees (1).
4 Deforestation occurs when trees are felled and are not replanted (1). It leads to the loss of habitats for wildlife (1) and allows fertile soil to be washed away (1).
5 The FSC® manages forests where new trees are planted for every tree felled (1). It ensures that endangered species of plants and wildlife are cared for (1) and that workers (1) and their communities are looked after (1).

7.3 Selection of timbers

1 Any one from: oak, beech, birch, ash, jelutong (1).
2 Genetic engineering of timber is when the DNA of timber is altered (1) to improve its properties (1).
3 Upcycling is the reuse of a timber product when it has finished its life (1), for example old railway sleepers can be reused to make flower beds (1), or any other suitable example.
4 Planned obsolescence occurs when a product is designed to last only a certain length of time (1). For example, a wooden fork given with a takeaway meal is designed to be used only once and is very likely to break if used again (1), or any other suitable example.

7.4 Forces and stresses

1 A chair leg (1), or any component that is being squashed.
2 A shelf (1), or any wooden component that is resisting a force in two opposite directions.
3 Diagonal brace (1): cut a wooden brace to match diagonal dimension of the frame (1). Glue and/or screw the brace into position (1).
   OR
   Plywood panel (1): cut a plywood panel the same size as the frame (1). Screw, pin and/or glue the panel into position (1).
7.5 Stock forms, types and sizes
1 It speeds up the manufacturing process (1) and it is cost-effective (1).
2 2440 mm × 1220 mm (1).
3 Planed square edge (1).

7.6 Manufacturing to different scales of production
1 Any one from: marking gauge, mortise gauge, try square, sliding bevel, mitre square (1).
2 Any two from: it is quicker than marking out (1), it improves accuracy (1), it provides greater consistency (1), there are likely to be fewer mistakes (1).
3 Either when drilling holes, or when sawing (1).

7.7 Specialist techniques, tools, equipment and processes
1 Coping saw (1).
2 Any one of: palm sander, disc sander, finisher (1).
3 Any three from: PVA is used straight from the bottle (1), it is very strong (1), it dries clear (1), it has ‘slip time’ (1), it is safe to use (1).
4 One mark for each stage, up to four stages:
   – Firstly, a former is produced.
   – Veneers of wood have glue applied to them.
   – The veneers are layered over the former.
   – The veneers are then held in place by clamps until dry.
   – The laminated timber is then removed and trimmed.
5 – A pilot hole is drilled through both the top layer and base layer of timber (1).
   – The top layer is drilled again with a clearance hole (1).
   – A countersink drill bit is used to recess the top layer (1).
   – The screw can now be screwed into the joint with a screwdriver (1).
6 Any three from: knock-down fittings make the cost of the furniture cheaper as the manufacturer does not have to assemble them (1), they are easier to transport home as a flat pack (1), they are easy to assemble (1), they can be taken down when moving to a new house (1).

7.8 Surface treatments and finishes
1 Varnish (1).
2 Paint (1).
3 A high-quality piece of furniture (1).
4 It colours the wood (1) while allowing the natural grain to show through (1).
5 It provides little protection (1) and needs to be reapplied regularly (1).
1 Core content

1 a Sustainable design is about reducing the negative impact of products on the environment (1) by making more informed choices, for example choice of materials, reducing waste, use of renewable resources and building products that last (1).

b The principle of the circular economy is about maximising the use of materials (1) and reducing waste, which puts a strain on natural resources and the environment (1). Keeping materials in the manufacturing system by recycling and reusing materials as much as possible reduces waste going to landfill (1), which in turn reduces pollution and the impact on ecosystems (1).

c Studying a graph that outlines a product’s life cycle helps to identify the success or otherwise of a product (1). If a product continues to sell/remain popular over a long period of time, features of that product could be incorporated into new products to ensure those are equally successful (1). Manufacturers can also identify when products need to be replaced or more need to be manufactured according to demand (1).

2 a Shape memory alloys appear to have a memory, which allows them to return to their original state when heated (1).

b Titanium (1) and nickel (1).

c Thermochroic pigments react and change colour in a reaction to heat (1). Benefits to the user include a warning that something is hot or that the temperature is rising (1).

Reference to a product (1):
- baby bottles, cups, mugs, kettles
- clothing indicating a rise in temperature from external sources or heat from an exercise workout.

3 a Risks or problems could be more easily identified with continual monitoring (1) and would indicate a need for the wearer to seek medical attention (1).

b Example 1: microscopic antibiotics/antiseptics can be encapsulated into medical dressings (1) which are delivered directly on to wounds (1), reducing the need to change dressings quite so often and the risk of infection (1).

Example 2: therapeutic oils or moisturisers can be encapsulated into dressings/clothing to treat patients with severe skin conditions (1). The healing oils are released when in contact with the skin through friction (1) and absorbed by the skin, helping the healing process (1).

c Any two from: Rhovyl® has the ability to wick away moisture (1), it is antibacterial (1), it does not retain odours (1).

4 a 1 mark for each of:
- Natural: plants, animals
- Synthetic: petroleum, fossil fuels

b One of cotton’s most important properties is its ability to absorb moisture (1). This means that if someone is perspiring in hot weather, the fibre will absorb the moisture leaving the wearer feeling cool and comfortable (1). It is a hardwearing fibre, meaning the product should last a long time (1), and it has a smooth feel, which would add to the comfort factor (1).

5 Sensor: light-dependent resistor (LDR) (1) – the resistance of the LDR increases as the light level decreases (1).

Output device: light-emitting diode (LED) (1) – the LED lights up as current flows from the anode to the cathode (1).

6 1 mark for correct formula, 1 mark for working, 1 mark for answer.

Velocity ratio = Diameter of driven pulley ÷ Diameter of driver pulley
Velocity ratio = 100 ÷ 300
Velocity ratio = 1:3

7 Any two from: shows a top-down overview of the system (1), shows the system in terms of its input, process and output subsystems (1) and the signals that flow between them (1).

8 Mild steel contains iron so is ferrous (1) but has small elements of carbon added (1), which makes it an alloy and improves its strength (1).

9 Glass fibre (1) is added, which makes the polymer less brittle or likely to snap (1).

10 Toughness relates to the timber’s ability to resist bending or twisting (1) without splitting (1). Hardness relates to the timber’s resistance to denting or wear (1) on impact (1).
2 Metals

1 It has a good strength-to-weight ratio (1).
2 Either it is malleable, or it is strong (1).
3 It is recyclable (1); it is durable (1).
4 Any three from: it is cost effective (1), it saves time (1), you don’t have to buy machinery (1), they are standard components (1), they are of a high quality (1).
5 It is the standard sizes and profiles (1) that metal can be obtained in (1).
6 Clean the metal (1), heat until the correct tempering colour has been achieved (1), quench in water (1).
7 Six from: mark out the centre of the hole (1), drill a tapping-sized hole (1), insert the taper tap (1), add cutting paste and turn clockwise (1), turn anticlockwise to remove swarf (1), repeat with the plug tap (1), repeat with the bottoming tap (1), check with a bolt (1).
8 Four from: produce a two-part steel mould (1), add the powdered metal (1), heat the mould (1), compress the mould (1), remove the sintered product (1).
9 Advantages: any two from low unit cost (1), high volume of production (1), consistent product (1), high-quality product (1).
Disadvantages: any two from high initial set-up cost (1), requires a high demand (1), no unique products (1).
10 Chemically clean the metal (1), immerse in an electrolytic solution (1), allow an electrical current to flow between the aluminium component and the anodic dye (1), remove and clean the component (1).

3 Papers and boards

1 Tetra Pak is made of three different laminates (1) – card, polythene and foil (1) – which are bonded together (1). This makes them difficult to separate (1), which they must be in order to be recycled (1).
2 Any two from:
   - Good insulation (1) so the pizza will stay warm (1).
   - Rigid (1) so the box protects the pizza from damage (1).
   - Smooth surface (1) so easy to print onto (1).
3 Twice (in half, then in half again) (1).
4 – Material extraction – the trees are cut down and the bark and branches removed (1).
   – The logs are chipped and pulped and made into paper (1).
   – The paper is used to make the paper cups (1).
   – The cups are transported to cafés and restaurants (1).
   – The cups are filled with coffee and drunk out of by the consumer (1).
   – The cup is thrown away and recycled back into pulp to be made into paper again (1).
5 Planned obsolescence is when a product is designed to last only a certain period of time (1) so that consumers will need to buy new products more regularly (1), generating more revenue for the manufacturer (1).
6 Any two from:
   – Varnish (1) gives a high-shine finish and feels like plastic to the touch (1).
   – Hot foil blocking (1) is a metallic finish, such as gold or silver (1).
   – Edge staining (1), the application of colour to the edges of paper or boards.
   – Embossing or debossing (1), which gives paper and card a raised or sunk 3D image (1).
   – UV varnishes (1), which give a highly reflective finish and deepen colours (1).
7 Some paper and card products are difficult and/or time-consuming to recycle (1) which makes it cheaper to use ‘new’ raw materials (1). Laminated products such as drinks cartons are an example of this (1).
8 By knowing what colours, styles, images etc. will be popular in a few months’ time (1) they can design cards that are ‘in fashion’ (1) and will therefore sell well (1).
9 – Print school logo onto heat transfer paper (1).
   – Place paper onto T-shirt (1).
   – Apply heat using a heat press or iron (1).
   – Ink from the paper will be transferred onto the shirt and ‘locked’ into the fibres (1).
10 For every tree that is cut down (1) at least one more is planted (1).

4 Polymers

1 Any two from: lightweight (1), tough (1), impact resistant (1), easily moulded (1).
2 Any two from: high impact strength (1), hard (1), tough (1), durable (1), good surface finish (1), suitable for mass production (1).
3 Either sugar beet or corn starch (1).
4 Any two from: a product with a limited life span (1), designed to fail (1), no opportunities for maintenance (1), ensures the customer will return (1), provides work for manufacturer (1).
5 – A heated parison (tube) is lowered between the two halves of a mould (1).
   – The mould is closed (1) and air is blown into it (1), forcing the hot parison to the outsides of the mould (1).
- The mould is cooled (1), opened and the finished product is removed (1).

6 - A thermoforming polymer sheet is marked out with a bending line (1).
   - The line is placed directly above the hot wire, which is located within the strip heater (1).
   - When the sheet becomes soft it can be bent to any desired angle (1).
   - The sheet must be held until it sets (1).

7 A jig will ensure that the bend is accurate (1), consistent (1) and produced quickly (1).

8 Stock forms reduce the cost of a product (1) as there is less cutting/machining to do (1). Stock forms are readily available, therefore saving time (1).

9 Any six from: thermosetting polymers are sourced from crude oil (1), which is non-renewable (1). The extraction, processing and transportation of thermosetting polymers creates pollution and contributes to global warming (1). They are not recyclable (1) and therefore end up in landfill (1). Polymers that end up in landfill can pollute the land (1), some pollute the sea and can end up in the food chain (1).

10 Crude oil.

5 Systems

1 Sensor: thermistor (1).  
Output: motor (1).

2 Chile (1), China (1), Peru (1).

3 446.5 Ω (1) and 493.5 Ω (1).

4 One mark for each correctly drawn, labelled and connected symbol. Any appropriate flowchart-based programming method can be used. For example:

   ![Flowchart Diagram]

5 Award one mark for each advantage and one mark for each explanation, for example:  
- **Advantage:** decreases size of components/PCBs (1) or increases speed of manufacture (1).  
- **Disadvantage:** smaller size means repairs/soldering is more difficult (1).

6 Textiles

1 a Different types of weave alter the structure of a fabric, changing its properties (1). Different weaves mean fabrics can be used for different purposes, which allow products to function more effectively (1).

   b The main characteristic of knitted fabrics is the ability to stretch, making them far more comfortable to wear as they stretch to fit (1). Knitted fabrics are far less restricting during wear, making them ideal for casual clothing (1).

   c A rib weave has an extra thicker and stronger yarn woven in at intervals (1). This makes the fabric much stronger (1) and resistant to abrasion/tearing (1).

2 a Polyester (1), acrylic (1).

   b Silk is an expensive fibre that feels nice to touch (1) but is also comfortable to wear as it is highly absorbent (1).

3 a Synthetic fibres are not biodegradable (1) meaning they will not decompose if added to landfill. Harmful chemicals from landfill can contaminate the land, which damages delicate ecosystems (1). Toxic gases are released into
the atmosphere during production, increasing pollution levels [1].

b Cotton crops need vast amounts of water to grow [1], which is often taken from land needed for farming for food crops or livestock [1]. Cotton is often in places where water is a scarce commodity [1]. Pesticides, which are sprayed on to cotton to boost growth, also damage the delicate ecosystem [1].

c Fuel derived from fossil fuels provides the energy source used in the transportation of textile goods, whether by air or land freight [1]. Burning this fuel releases the greenhouse gas carbon dioxide [1] into the atmosphere, adding to global warming and to our carbon footprint [1].

d i Workers in developing countries are often paid low wages and work in poor conditions [1], which enables manufacturers to keep costs down in order to provide cheap products that are readily disposed of when new cheap products become available [1].

ii Products that are easily disposed of often end up in landfill, which causes environmental issues including pollution [1]. The materials used to produce ‘throwaway products’ may not be easy to replace, putting a strain on the world’s resources [1].

4 a Scotchguard™ prevents marks from permanently spoiling fabric [1], which in turn increases the life expectancy and aesthetics of the fabric [1].

b The process of brushing raises and fluffs up the surface of the cotton fabric [1]. This creates air pockets on the surface of the fabric that trap heat [1], making the brushed fabric warmer to wear, improving its functionality [1].

5 a Piping can strengthen the edge of a textile product, improving its structural integrity [1]. Piping can be in a contrast colour, which enhances its aesthetic appeal [1].

b i Circumference of a circle is \(2\pi r\) [1].

   The diameter is 70 cm, so the radius is 35 cm [1].
   \(2 \times 3.142 \times 35 = 220\) cm [1]
   \(220 \times 2 = 440\) cm, or 4.4 m [1]

ii The seam allowance needs to be added to both the length and width.

   Length of fabric = Circumference + Seam allowance
   \(220 + 3 = 223\) cm, or 2.23 m [1]

Height of cushion + Seam allowance = 30 cm + 3 cm = 33 cm, or 0.33 m [1]

   The template should be 223 cm by 33cm.

6 a Woollen coats are seasonal products [1] and, being for children, the quantity or demand would be limited [1]. Trends and fashion change so new styles may be needed, which reduces demand [1].

b A bespoke product is made specifically for an individual client [1]. The client can have a direct input into the design, which may be unique [1]. The product will be personalised to fit the client’s measurements [1]. The quality of construction would be much higher than a readily available product [1].

7 Questions beginning with **analyse** require extended writing and should show evidence of reasoning. Content that would gain marks includes:

- Specialist CAD programs are used by manufacturers to organise a lay plan of all the templates needed to make a specific product, which might include multiple sizes.
- CAD programs allow the templates to be moved around on-screen and tessellated to find the most efficient lay plan to maximise the use of fabric and reduce waste.
- As this is a digital process, the plan developed on-screen can be sent directly to the cutting table once the fabric has been prepared. The automated cutting tools will cut the fabric in accordance with the digital lay plan.

8 a **Statement**   **True**  **False**

   Natural dyes work best on synthetic fibres  ✔

   Roller printing is another name for flatbed printing  ✔

   Free machine embroidery allows the fabric to move freely while being stitched  ✔

   Batik involves using hot, melted wax to outline a shape on fabric  ✔

b Questions beginning with **evaluate** require extended writing and should show evidence of appraisal, for example advantages or disadvantages. Content that would gain marks include:

- CAD allows designers to manipulate images more easily, which includes copying and pasting patterns in repeat designs, recolouring designs and resizing. Changes can be made more easily and errors can be rectified quickly. CAD also
facilitates developing co-ordinated ranges. Designs can also be more intricate and detailed.
- CAD designs can be sent directly to a digital printer to be printed straight on to fabric, either as a sample or a short length of fabric. The printed fabric can be evaluated immediately, and improved and reprinted if required.
- The whole process is far more efficient than designing by hand and sending designs off to be printed elsewhere. Changes in trends are facilitated more easily.

9 A flat fell seam has two rows of stitching and looks the same on both sides as raw edges are concealed (1). Two rows of stitching mean the seam is a much stronger construction method (1). When the balloon is fully inflated it will come under extreme shear force (1) but the seams will resist this force and will not break (1).

10 a A dart is a triangular piece of folded fabric pinched out of a section to reduce the length of an edge (1). This creates shape (1), allowing fabric to fit to the contours of the body (1).

b Gathers are formed by bringing in the width of a piece of fabric in gentle folds (1). This allows the waist to be fitted to a set measurement (1) and provide shape to the finished skirt (1).

7 Timbers

1 It is easy to cut and shape (1).
2 It has a good resistance to weathering (1).
3 They have broad leaves that they lose in winter (1), they carry their seeds within fruit (1) and produce hardwoods (1).
4 Manufactured boards are generally less expensive than natural timber (1). They are available in large, flat sheets that have a smooth surface (1) and are generally free from defects such as twisting, warping, splitting and bowing (1).

5 Four from: a layer of glue is applied to a manufactured board (1) then a decorative veneer is placed on top (1). The assembled board is then put into a bag press (1), sealed and left until the glue has dried (1). The board is then removed from the bag press (1), trimmed and sanded (1).

6 Seasoning is the reduction of the moisture content within timber (1). Seasoning turns it into a workable material and helps prevent defects such as twisting and warping (1).

7 Any three from the following:

- **Advantages**: contact adhesive is a medium-strength glue that sticks on contact (1).
- **Disadvantages**: contact adhesive has several health and safety issues; it is flammable (1) and it is an irritant (1) that can affect your breathing (1).

8 French polishing is a highly skilled finishing process (1) that produces a very high-quality finish (1) on expensive furniture (1).

9 Any five from the following: flat-pack furniture can be made from manufactured boards that are less expensive than natural timbers (1) – they are free from defects (1) and highly suited to manufacturing in quantity by CAM (1). Flat-pack furniture is sold ready for home assembly (1), therefore the manufacturer does not need to assemble the furniture (1), which saves time (1), money (1), storage (1) and transportation costs (1).

10 Any five from the following: trees are not being replanted (1), fertile soil is being washed away (1), wildlife habitats are being lost (1), animals may become extinct (1), less carbon dioxide is being converted into oxygen (1), global warming is being accelerated (1), communities are being lost (1).