A-level
DESIGN AND TECHNOLOGY: PRODUCT DESIGN
7552/1

Paper 1 Technical Principles

Mark scheme

June 2020

Version: 1.0 Final

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Glossary for maths

If a student uses a method which is not explicitly covered by the mark scheme the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

[a, b]	Accept values between a and b inclusive.
For π	Accept values in the range [3.14, 3.142]
Their	Accept an answer from the candidate if it has been inaccurately calculated but is subsequently used in a further stage of the question.

Questions which do not ask students to show working

As a general principle, a correct response is awarded full marks.

Qu	Part	Marking Guidance	Total marks	AO
01		Give **three** reasons why polymorph may be used in the modelling of an ergonomic grip. **1 mark per relevant point**. **Indicative content**: • Polymorph is a thermoplastic that can be easily shaped and formed when softened by heating in water to 62ºC. The low temperature allows it to be moulded by hand. • It can be reheated and remoulded enabling the shape of the grip to be refined. • It can be machined and shaped with hand tools when cooled. • It can be formed around an existing handle. • It comes in a range of colours or can be painted in order to enhance the aesthetics of the grip. **This list is not exhaustive.** **Accept any other valid responses.**	**3 marks**	AO4 1a

Qu	Part	Marking Guidance	Total marks	AO
02		Define the following material properties: • malleability • elasticity **One mark** per correct definition of the material properties. • **Malleability** A material's ability to be permanently deformed or shaped by impact, rolling or pressing without cracking. • **Elasticity** A material's ability to be deformed and return to its original when the force is removed.	**2 marks**	AO4 1a

Qu	Part	Marking Guidance	Total marks	AO
03		State **three** ways that manufacturers are improving sustainability throughout product manufacture. **1 mark per relevant point**. **Indicative content**: Sustainability can be improved by reducing: • the number of manufacturing processes used • the volume or quantity of raw materials used • the use of finite materials by choosing a more environmentally friendly alternative • the use of toxic materials or materials that can be damaging or harmful to the environment • the use of finishes that may be harmful to the environment • the amount of energy used in factories or manufacturing facilities by installing low energy lighting etc • the amount of energy used that is generated from finite resources by seeking alternative sustainable sources. **This list is not exhaustive.** **Accept any other valid responses.**	**3 marks**	AO4 1a

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>04</td><td></td><td>Explain why high speed steel would be a suitable material for a metal drill bit.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>Detailed understanding why HSS would be a suitable material for a metal drill bit. Response should make reference to the physical and mechanical properties of HSS and be specifically related to the metal drill bit context. Not all indicative content needs to be included in order to access the top mark band.</td></tr>
<tr><td>3–4 marks</td><td>Good understanding of why HSS would be a suitable material for a metal drill bit. Response may make reference to the physical or mechanical properties of HSS and its suitability for the metal drill bit context.</td></tr>
<tr><td>1–2 marks</td><td>Basic understanding of why HSS is used for a metal drill bits.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• HSS is an extremely hard material that resists abrasion and wear, maintaining a sharp cutting edge on the drill bit.
• HSS is capable of withstanding the high temperatures caused by the friction of cutting, without losing its hardness.
• Its resistance to wear allows it to drill other metals at high speeds.
• HSS is an alloy containing chromium that is highly resistant to corrosion allowing HSS drill bits to be used with a variety of lubricants and cutting compounds.
• HSS can be coated to improve its performance. A titanium nitride coating can be used to further reduce friction and improve performance.

This list is not exhaustive.

Accept any other valid responses.</td><td>6 marks</td><td>AO4 1c</td></tr>
</table>

Qu	Part	Marking Guidance	Total marks	AO
05				
05	**1**	**Figure 1** shows the dimensions of the components required to produce **Figure 2**. The component parts are cut from a 90 mm × 70 mm × 3 mm sheet of acrylic. Calculate the percentage (%) of waste from the acrylic sheet. Show your working. **Area of component A** 57 × 33 = 1 881 − (3 × 27) = 81 − (3 × 15) × 2 = 90 = 1 710 **Area of component B** 57 × 33 = 1 881 − (3 × 15) × 2 = 90 − (3 × 6) × 2 = 36 − (3 × 3) × 2 = 18 = 1 737 **Or** 57 × 30 = 1 710 + (27 × 3) = 81 − (3 × 6) × 2 = 36 − (3 × 3) × 2 = 18 = 1 737 **Area of component C** $30 \times \frac{30}{2} = 450$ + 3 × 3 = 9 + 6 × 3 = 18 + 15 × 3 = 45 = 522 **Area of 1 component correct** 1 mark (M1) **Area of 2nd component correct** 1 mark (M1) **Area of all component parts** 1 710 + 1 737 + (522 × 2) = 4 491	**4 marks**	AO4 1c

		Percentage waste **Percentage waste** Where no working has been shown but final answer is accurate	$1 - \frac{(\text{their } 4\,491)}{6\,300} \times 100 = 28.7$ Or $\frac{6\,300 - \text{their } 4\,491)}{6\,300} \times 100 = 28.7$ = 28.7 % or 29 % = 28.7 % or 29 %	1 mark (M1) 1 mark (A1) 4 marks		

Qu	Part	Marking Guidance	Total marks	AO
05	**2**	The product shown in **Figure 3** has been laser cut and fabricated. An alternative method is to form it in one piece using injection moulding. Compare and evaluate the suitability of each manufacturing method for this product.	**6 marks** 3 marks 3 marks	AO3 2a AO3 2b

Marks	**Description**
5–6 marks	The response includes detailed analysis, and compares the two processes in detail with reference to factors such as ease of manufacture and use of material. The response provides detailed evaluation of the suitability of each process to fabricate the acrylic part.
3–4 marks	The response includes good analysis and evaluation of both manufacturing processes and draws some comparison with reference to factors such as ease of manufacture and use of material.
1–2 marks	The response includes basic analysis and tends to be descriptive rather than evaluative.
0 marks	No response worthy of credit.

Indicative content:

Fabrication method – Laser cut and joined with solvent cement

		• Each component could be accurately cut out to an accurate tolerance using a laser cutter, providing flat, smooth surfaces to then be joined. • The laser cutting process would provide a reliable, repeatable manufacturing process. • The design can be fairly well tessellated to reduce the volume of material used although waste will be created. • Laser cutting the design would be appropriate for small flexible production runs. • The shape provides ample surface area for joining with a solvent cement. • The shape of the component means that no gluing jigs would be necessary. **Redistribution method – Injection Moulding** • The component would be a one piece moulding therefore requiring no assembly. • The size of the component means that several could be easily moulded simultaneously, increasing the volume of production. • The redistribution process means that material can be used efficiently with little or no waste. • A large volume of products would need to be required to justify the expensive initial set up costs of mould manufacture. **This list is not exhaustive.** **Accept any other valid responses.**		

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>06</td><td></td><td>Describe the main stages in the process of soft soldering.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>The response shows a detailed knowledge of the process of soft soldering with a clear understanding of all main stages of the process. The response covers in detail the required stages in a logical sequence to produce a successful soft soldered joint.</td></tr>
<tr><td>3–4 marks</td><td>The response shows a good level of knowledge of the process of soft soldering. The response describes most of the main stages of the process which if followed would achieve a successful soft soldered joint.</td></tr>
<tr><td>1–2 marks</td><td>The response shows basic understanding of the process of soft soldering.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• The components should be clean and free from grease or impurities.
• Flux may be used to help the solder flow and prevent oxidisation when heating. The flux can be added separately or may be present in the core of the solder itself.
• The components should be held in place while being heated to approximately 200º
• Heating can be undertaken with a soldering iron, small gas blow torch or hot air gun depending on the application.
• The solder should be added to the joint.
• The heat source should be removed and the component or join allowed to cool in order for the solder to return to a solid state.
• Any excess flux should be removed to prevent corrosion.
• An electrical circuit may be tested after soldering as part of effective quality control.
• A solder bath may be used to solder several components to a complete circuit board at one time.

This list is not exhaustive.

Accept any other valid responses.</td><td>6 marks</td><td>AO4 1a</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>07</td><td></td><td>Explain how the data gained from Electronic Point Of Sale (EPOS) systems can be used.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>The response shows a detailed understanding of the range of data that an EPOS system can gather from consumers. The response also demonstrates an understanding of the wide range of methods in which the data gathered can be used to manage stock and monitor consumer purchasing patterns.</td></tr>
<tr><td>3–4 marks</td><td>The response demonstrates a good understanding of the range of data that can be gathered by an EPOS system and an awareness of the methods in which the data gathered can be used.</td></tr>
<tr><td>1–2 marks</td><td>The response offers a basic understanding of how the data gained from EPOS systems can be used.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

EPOS – Electronic Point of Sales systems

Stock Management
• Volume of sales are recorded which in turn monitor stock levels and management. If reorder limits are exceeded, stock is automatically ordered from distributors or manufacturers.
• EPOS data can ensure that a satisfactory level of stock is maintained.
• Shopping patterns such as regional purchasing, seasonal trends, popular brands, colours and models can be recorded and used for planning and interpreting consumer demand.

Purchasing Patterns
• Product sales can be monitored and patterns or decline in sales may trigger manufacturers to redevelop products or limit production.
• Data gained may influence the timing of product launches based on spending patterns.

Customer Data
• Buying trends, brand selection, sizing and styles can be gathered to then be used for focused marketing.
• EPOS systems can be linked to customer accounts and email addresses in order to reduce the need for printed receipts.
• Customer data such as contact details can be obtained and monitored in order to target marketing and promotional materials.</td><td>6 marks</td><td>AO4 1b</td></tr>
</table>

		• Shopping patterns can be recorded to then focus digital communication or suggest future potential online purchases. **This list is not exhaustive.** **Accept any other valid responses.**		

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>08</td><td></td><td>Explain why silicone is an appropriate material for the manufacture of the oven mitt shown in Figure 4.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>A detailed explanation of why silicone is an appropriate material for the manufacture of an oven mitt, with a wide range of clear and appropriate reasons that are directly related to the context.</td></tr>
<tr><td>3–4 marks</td><td>A good explanation of why silicone is an appropriate material for the manufacture of the oven mitt. The response makes reference to several appropriate reasons that are related to the context.</td></tr>
<tr><td>1–2 marks</td><td>The response offers a basic explanation of why silicone is used for the oven mitt, but tends to be provided generic material properties.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• Silicone is a flexible material that can be deformed under pressure and will return to its original shape when the pressure is released. This allows the user to easily grip pans, trays or tins of different shapes and sizes.
• The non-slip surface texture of the material enables hot items to be securely held.
• Additional texture or surface pattern can be added during the moulding process.
• The elastomer is an insulator and it is heat resistant to approx. 250^{o}C, protecting the user from being burnt by hot pans.
• The upper temperature range of 250^{o}C makes is suitable for use with most domestic ovens.
• Silicone can be injection moulded, allowing for the shape of the oven mitt to be easily produced.
• Silicone has good chemical resistance and is impermeable to water meaning that it will not be damaged by grease associated with cooking and can also be cleaned by detergents.
• Silicone is food safe meaning it will not cause an issue if contact with food is made.
• Silicone is a suitable material to be used in a dishwasher allowing for the mitt to be easily cleaned.
• Silicone can be easily pigmented so can be manufactured in a wide range of colours allowing consumers to match the mitt to other kitchen products.

This list is not exhaustive. Accept any other valid responses.</td><td>6 marks</td><td>AO4 1b</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>09</td><td></td><td>Analyse and evaluate the suitability of phosphorescent pigment for use in indoor emergency signage.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>The response shows a detailed analysis of the specific context and how the properties of phosphorescent pigment make it a suitable material for emergency signage. It provides detailed evaluation of the material’s performance in direct relation to the context of indoor emergency signage.</td></tr>
<tr><td>3–4 marks</td><td>Response shows good analysis and evaluation of the suitability of phosphorescent pigment. Responses provide some evaluation with reference to emergency signage.</td></tr>
<tr><td>1–2 marks</td><td>The response focuses on the properties of phosphorescent pigment, but response tends to be descriptive rather than evaluative with little specific links to the context of emergency signage.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• The phosphorescent pigment will glow in the dark or low light making the signage visible in a power cut or smoke filled environment.
• The pigment absorbs both natural and artificial light so is appropriate for indoor use.
• There is no need to permanently light the sign with electricity which may be isolated in the event of a fire.
• The location of the sign is not restricted by the need for a power supply.
• The signage can be relocated without damage to structures or rewiring.
• The intensity of the light emitted is low, so is only visible in close proximity limiting the speed of locating an exit or fire extinguisher point.
• The sign must be exposed to a light source in order to absorb the energy needed for the phosphorescent pigment to function.
• The phosphorescent pigment will only glow for a limited period of time when the light source is removed.

This list is not exhaustive.

Accept any other valid responses.</td><td>6 marks

3 marks
3 marks</td><td>AO3 2a
AO3 2b</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>10</td><td></td><td>Describe the purpose of risk assessment in a manufacturing environment.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>The response demonstrates a detailed and thorough understanding of the purpose of risk assessments and how they are used to minimise risk and provide a safe working environment.</td></tr>
<tr><td>3–4 marks</td><td>The response demonstrates a good understanding of the purpose of risk assessments and how they impact the work place.</td></tr>
<tr><td>1–2 marks</td><td>The response offers a basic understanding of the purpose of a risk assessment.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative Content:

• To identify both the likely frequency and potential of harm, injury or risk measured.
• To identify when activities or actions that are deemed too risky, or where the severity of injury is great. Ensures that they are either removed, or an increased level of scrutiny is adhered to in order to provide a safer working environment.
• To identify specific PPE that a worker may need to be equipped with for a specific activity.
• To ensure that the manufacturing company is fulfilling its obligation and duty of care for employees.
• To help employers identify and minimise risk to the workforce.
• To provide guidance for all employees to help reduce accidents or injuries.
• To ensure that annual reassessments take place and new guidance or directives are implemented.
• To ensure that all new staff are properly trained and aware of the manufacturer’s H&S safety policy and guidance.
• To ensure that all employees, from cleaning and maintenance staff, machine operators and office workers are all aware of any dangers or risks that may occur.

This list is not exhaustive.

Accept any other valid responses.</td><td>6 marks</td><td>AO4 1b</td></tr>
</table>

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>11</td><td></td><td>Explain why concrete is a suitable material for the manufacture of the outdoor table tennis table shown in Figure 5.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>Detailed understanding of why concrete is used in the manufacture of an outdoor table tennis table.
Response may make reference to the material properties, the fabrication or construction of the table and environment in which it is sited.</td></tr>
<tr><td>3–4 marks</td><td>Good understanding of why concrete is used in the manufacture of an outdoor table tennis table.
Response may make some reference to aspects such as material properties and the fabrication or construction of the table.</td></tr>
<tr><td>1–2 marks</td><td>Limited understanding of why concrete is used for an outdoor table tennis table.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• Concrete is a hard material that can be polished to provide a smooth, hardwearing playing surface.
• Concrete can be reinforced with a high tensile steel frame to provided additional strength for the unsupported table.
• Concrete can be easily poured into a simple mould to create the shape of the table.
• Concrete can be moulded on site removing the need to transport and lift the table.
• Concrete is a stable material that can withstand weathering and changes in temperature making it suitable for outdoor use.
• Concrete is hard and rigid providing an appropriate surface with no flex.
• Concrete requires little maintenance.
• Concrete is a durable material that will withstand potential inappropriate use or vandalism.
• The use of concrete provides a flat playing surface.

This list is not exhaustive.

Accept any other valid responses.</td><td>6 marks</td><td>AO4 1c</td></tr>
</table>

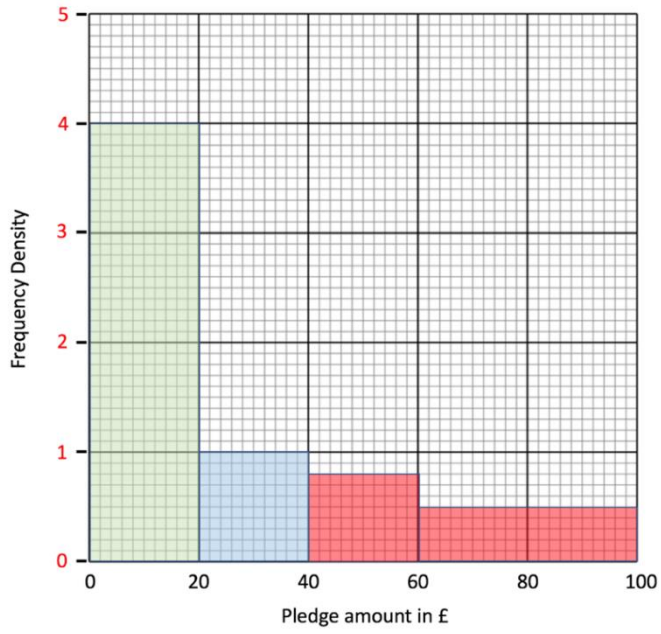
12	**1**	**Table 1** shows information on the number of pledges and funds raised by a crowd-funding campaign for a new product. Using the data provided in **Table 1**, complete the histogram in **Figure 6**.	**4 marks**	AO4 1c

Table 1

Backer's pledge (£*p*)	**Number of backers**
$0 < x \leq 20$	
$20 < x \leq 40$	20
$40 < x \leq 60$	16
$60 < x \leq 100$	20

Establishing the Scale of Frequency Density (y axis) Using provided data in £20 − £40	Area of £20 − £40 data is 20 Width = 20 Therefore height = 1	1 mark (M1)
Height of £40 − £60	$\frac{16}{20} = 0.8$	1 mark (M1)
Height of £60 − £100	$\frac{20}{40} = 0.5$	1 mark (M1)
Completing Graph	Data transposed successfully to the graph (See the completed example). Red areas represent required additions.	1 mark (A1)

Worked example:



Qu	Part	Marking Guidance			Total marks	AO
12	**2**	Calculate the percentage (%) of people who supported the campaign with a pledge of £20 or less.			**2 marks**	AO4 1c
		Calculation of number of people who pledged £0 − £20	Area of £0 − £20 20 × 4 = 80 people	1 mark (M1)		
		Percentage of people who pledged £0 − £20	80 + 20 + 16 + 20 = 136 $\frac{80}{136} \times 100$ = [58.8, 59] %	1 mark (A1)		
		Percentage of people who pledged £0 − £20 Where no working has been shown but final answer is accurate	= [58.8, 59] %	2 marks		

Qu	Part	Marking Guidance	Total marks	AO
13		Explain why bio-batch may be added to a polymer used in the manufacture of single-use carrier bags. **1 mark** for a simple statement. **1 further mark** for a justified explanation. **Indicative content**: • Carrier bags are single-use products so a bio-batch additive will help accelerate the breakdown of the carrier bag after it has been disposed of. • Carrier bags generally have an oxy-degradable additive where the breakdown will begin with exposure to oxygen limiting their contribution to landfill. • The inclusion of a bio-batch additive means that the carrier bag can decompose in between 3 and 6 months leaving no toxic residue or plastic particles. **This list is not exhaustive.** **Accept any other valid responses.**	**2 marks**	AO4 1b

Qu	Part	Marking Guidance	Total marks	AO
14		State **two** reasons why Danish oil is used as a surface finish for timber. **1 mark per relevant point**. **Indicative content**: • Danish oil dries to a clear, transparent finish that maintains the natural appearance of the timber. • Danish oil is a suitable finish for interior and exterior use. • Danish oil penetrates the surface of the timber creating a hard wearing and durable finish. • Danish oil is a suitable finish for use on food preparation surfaces. • Danish oil is water and moisture resistant. **This list is not exhaustive.** **Accept any other valid responses.**	**2 marks**	AO4 1a

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>15</td><td></td><td>
Describe how physical and virtual prototypes can be used during the development of a product.

Include the benefits of each kind of prototype to the designer in your answer.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>7–9 marks</td><td>A detailed and thorough understanding of how both physical and virtual prototypes can be used by designers. The response clearly identifies a wide range of relevant benefits that each technique offers the designer throughout the development of a product.</td></tr>
<tr><td>4–6 marks</td><td>The response demonstrates a good understanding of how both physical and virtual prototypes can be used by designers throughout the development of a product. Several benefits of each technique are provided.</td></tr>
<tr><td>1–3 marks</td><td>The response offers a basic understanding of the benefits of prototyping and may focus on one technique only.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative Content:

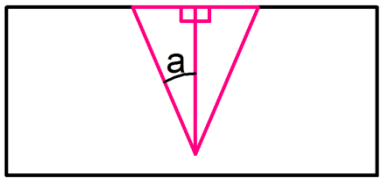
Physical prototypes

• Physical prototypes can be quickly realised through styrofoam modelling or rapid prototyping without huge expense to the designer.
• Ergonomic features can be modelled and tested with target user groups, gaining direct feedback which can then help further development and refinement of the design.
• The function of mechanisms and dynamic features such as hinges or buttons can be tested.
• Observations of how potential user groups interact with the product can be made.
• Designers can use the physical model to test the aesthetic form and appearance of the product, developing and adjusting the design where necessary.
• Physical prototypes can be finished to represent the aesthetics of the final product allowing users or clients to provide detailed feedback that can be used by the designer.

Virtual prototypes

• Manufacturing methods can be explored and tool paths simulated identifying issues before manufacture or financial investment in tooling or machining.
</td><td>9 marks</td><td>AO4 1b</td></tr>
</table>

		• Virtual prototypes can be used by CFD programs to test and simulate fluid and air flow. Data can be used by designers to improve aerodynamics. • Financial savings will be made by negating the need for specialist testing of the physical model. • Assembly of components can be tested to ensure compatibility with larger systems. • FEA modelling can take place to simulate stresses of the physical product in use, saving time and money on physical modelling. • Virtual prototypes can be quickly edited and materials and textures easily applied to represent a physical product. • Virtual prototypes can be quickly shared with clients and manufacturers around the world. **This list is not exhaustive.** **Accept any other valid responses.**		

Qu	Part	Marking Guidance		Total marks	AO
16		A student wishes to route a symmetrical V-shaped channel in a piece of timber to the dimensions provided in **Figure 7**. Calculate cutter angle a. Show your working.		**4 marks**	AO4 1c
		Establishing that the V groove is two 90º angled triangles	Establishing that the V groove is two right angled triangles. 	1 mark (M1)	
		Calculating the internal angle	$\tan a = \frac{\text{opposite}}{\text{adjacent}}$	1 mark (M1)	
			$\tan a = \frac{10}{30}$ $= 18.43^{o}$	1 mark (A1)	
		Calculating 'a'	2×18.43^{o} $= 36.87$ $= 36.9$	1 mark (M1)	
		Calculating 'a' Where no working has been shown but final answer is accurate	$a = 36.9^{o}$	4 marks (A1)	

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>17</td><td></td><td>
Figure 8 and Figure 9 show children’s toys.

Analyse and evaluate the suitability of the materials and manufacturing methods used for each of the children’s toys.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>9–12 marks</td><td>The response shows a detailed analysis and evaluation of the suitability of the chosen material and manufacturing process of both child’s trains. The response clearly evaluates how the properties of the material and the way in which the trains are manufactured affect the suitability for target audience and intended function.</td></tr>
<tr><td>5–8 marks</td><td>The response shows good evaluation and analysis of the suitability of the chosen material and manufacturing process of both toy trains with appropriate reference to the trains’ target audience and intended function.</td></tr>
<tr><td>1–4 marks</td><td>Basic evaluation of the suitability of the chosen material and manufacturing process of each of the toy trains, but response tends to be descriptive rather than evaluative or focuses on one material or manufacturing process only.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

Beech

• Beech is a hardwood with a tight grain meaning that it will not easily chip or splinter during use.
• Beech is a durable material. Children’s toys can be subject to a huge amount of use and abuse, meaning that the chosen material must be hard-wearing and long lasting.
• Beech can be stained or painted to change the colour of the surface.
• Staining provides a hard-wearing finish that won’t chip or peel.
• Beech is hard, meaning that the surface will resist scratching and abrasion.

Hand shaped

• The shape of the train is fairly simple and can be easily cut out using widely available hand tools
• The train has no intricate details or patterns that would be hard to reproduce accurately by hand
</td><td>12 marks

6 marks
6 marks</td><td>AO3 2a
AO3 2b</td></tr>
</table>

		• The raw material Beech is widely available and could be planed from an appropriate stock size to reflect the height and width of the train • The size of the train is small enough to allow cutting and shaping using a bandsaw, cross cut saw and bandfacer or linisher • The train could be easily batch produced by using a template to mark out the length of each train body or a stop could be set and a bandsaw or cross cut saw be used. • A jig could be used to drill the holes for the funnel and the axles for the wheels, allowing for a consistent quality of product. • The product can be easily sanded using abrasive papers giving a smooth surface ready for the application of a surface finish. **Acrylonitrile Butadiene Styrene** (**ABS)** • High impact strength providing durability to the product that is likely to be played with roughly. • Scratch resistant allowing the train to maintain a high quality surface finish. • ABS can be easily coloured with the addition of a pigment allowing for a variety of coloured models to be produced. • ABS is a lightweight material which makes it suitable for use in a child's toy. • ABS can have decals applied easily by screen printing. **Injection moulded** • A variety of surface textures can be achieved by different mould surfaces allowing for the high gloss body and textured roof component. • Small intricate details can be achieved making it possible to represent the shape of the train. • Injection moulding provides consistently accurate mouldings essential for each component part to easily click together. • Injection moulding is the most suitable manufacture method for high volume output, appropriate for the worldwide market of the toy train. • Injection moulding is an ideal redistribution process for use with thermoplastics making it appropriate for moulding the ABS train. **This list is not exhaustive.** **Accept any other valid responses.**		

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>18</td><td></td><td>Explain why polypropylene (PP) is an appropriate material for the manufacture of an ice cream container.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>The response demonstrates a detailed and thorough understanding of why polypropylene is a suitable material for the manufacture of an ice cream container with specific reference to how its properties make it appropriate for the specific application and environment of use.</td></tr>
<tr><td>3–4 marks</td><td>The response demonstrates a good understanding of why polypropylene is a suitable material for the manufacture of an ice cream container with some reference to how its properties make it appropriate for the specific application.</td></tr>
<tr><td>1–2 marks</td><td>The response offers a basic explanation of the properties of polypropylene with limited reference to the ice cream container application.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• PP has an excellent resistance to fatigue meaning that it will not break or tear with the constant removal and refitting of the lid
• PP is a food safe polymer making it suitable to contain the ice cream
• an ice cream container will potentially have a short lifespan so PP is suitable as it can be recycled
• PP can be injection moulded or vacuum formed which is necessary to achieve the close tolerances needed for the ice cream lid to securely click in place
• PP remains relatively flexible at low temperatures allowing the lid of the container to ‘snap’ over the rim of the ice cream container
• PP is a thermoplastic that is readily recycled, an essential property for a product with a short lifespan
• PP is a tough material that will withstand the likely impact that occurs in transit from supplier to store, store to consumer
• PP has a naturally milky appearance but can be easily pigmented allowing it to represent a variety of brands
• PP is available in a variety of grades; some are clear and would be appropriate for ice cream containers that wish to display the colour of the ice cream.

This list is not exhaustive.

Accept any other valid responses.</td><td>6 marks</td><td>AO4 1b</td></tr>
</table>

Qu	Part	Marking Guidance	Total marks	AO
19		**Figure 10** shows the internal view of an injection moulded component. State the function of each of the labelled features. **1 mark** for the function of each feature. **Indicative content**: **Moulded boss** • To help locate two halves of an injection moulded casing. • To allow a 'self-tapping' screw to be used to secure two halves of an injection moulding casing together. **Rib** • To provide strength and rigidity to an injection moulded casing. • To reduce the volume of plastic needed by allowing for a thinner wall thickness. **Snap fitting** • Hold together two halves of an injection moulded casing together without the need for any additional mechanical fixings. • Hold and locate a component such as a PCB without the need for additional mechanical fixings. • Allow for quick and simple assembly without the need for tools. **This list is not exhaustive.** **Accept any other valid responses.**	**3 marks**	AO4 1a

Qu	Part	Marking Guidance		Total marks	AO
20		**Figure 11** shows a chocolate bar packaging. **Figure 12** shows a larger mathematically similar promotional version. Use the information on the diagrams to calculate the percentage (%) increase in volume of the new promotional packaging in **Figure 12**, from the original packaging in **Figure 11**.		**6 marks**	AO4 1c
		Volume of original packaging	Area of triangle × length $120 \times \frac{80}{2} = 4\,800$ $4\,800 \times 300$ $= 1\,440\,000$	1 mark (M1) 1 mark (A1)	
		Establish scale factor between length of original packaging and length of new packaging. **(They could pick any known dimension)**	$\frac{\text{length of new shape}}{\text{length of old shape}}$ Font size: $\frac{88}{80} = 1.1$ Or Gap: $\frac{11}{10} = 1.1$ $= 1.1$	1 mark (A1)	
		Finding missing lengths in new packaging. **(original size x scale factor)**	$300 \times 1.1 = 330$ $80 \times 1.1 = 88$ $120 \times 1.1 = 132$	1 mark (A1)	
		Finding volume of new packaging.	Area of triangle × length $132 \times \frac{88}{2} = 5\,808$ $5\,808 \times 330$ $= 1\,916\,640$	1 mark (A1)	

		Calculating percentage increase of new packaging.	$\frac{\text{new volume}}{\text{old volume}}$	1 mark (A1)		
			$\frac{1\ 916\ 640}{1\ 440\ 000} = 1.331$			
			1.331 − 1 = 0.331			
			0.331 × 100 = 33.1%			
			Or			
			$\frac{\text{change in volume}}{\text{old volume}}$			
			$\frac{(1\ 916\ 640 - 1\ 440\ 000)}{1\ 440\ 000}$ = 0.331			
			0.331 × 100 = 33.1%			
		Or				
		Calculate the volume scale factor from the length scale factor.	88/80 or 11/11	1 mark (M1)		
			= 1.1	1 mark (A1)		
			= their 1.1 × their 1.1 × their 1.1	1 mark (M1)		
			= 1.331	1 mark (A1)		
		Finding percentage increase of new packaging.	Their 1.331 – 1 = 0.331	1 mark (M1)		
			Their 0.331 × 100 = 33.1%	1 mark (A1)		
		Calculating the % increase from the original packaging to the new packaging. Where no working has been shown but final answer is accurate	= 33.1%	6 marks		

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>21</td><td></td><td>
Compare and contrast the suitability of producing vehicle signage using either a digital printed image or plotter cut vinyl.
<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>5–6 marks</td><td>Response shows detailed analysis and compares the two processes in detail with reference to factors such as costs, ease of use and durability. The response provides detailed evaluation of the suitability of each as a method of producing vehicle signage.</td></tr>
<tr><td>3–4 marks</td><td>Response shows good analysis and evaluation of both methods for producing the signage. Responses provide some evaluation with reference to factors such as costs, ease of use and durability.</td></tr>
<tr><td>1–2 marks</td><td>The response focuses on one technique with basic evaluation. Response tends to be descriptive rather than evaluative.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>
Indicative content:

Digital printed image

• Full colour digital images or photographs can be printed on to a substrate before application allowing for corporate logos and pictures to be featured.
• Large format prints can be created and scaled for a variety of sized vehicles.
• One large self-adhesive feature is easier to apply and ensure that it is square and in line with the vehicle panel.
• Digital printing requires costly machinery which can make the process prohibitive for smaller companies.
• Digital printing has limited UV resistance so may fade quickly and lose its visual impact.

Plotter cut vinyl

• A limited range of colours are available so it may not be possible to match a company’s branding.
• Only simple text, numbers and simple graphics are really viable to produce.
• Individual cut letters and numbers are more prone to coming unstuck than a large digital print.
• The coloured vinyl has good resistance to UV maintaining a vivid colour for longer.
• Plotter cutters are fairly affordable and can be run off simple often free software.
</td><td>6 marks

3 marks
3 marks</td><td>AO3 2a
AO3 2b</td></tr>
</table>

		• Cut vinyl letters are cheaper than a digitally printed equivalent and are therefore more flexible for advertising special events or price changes etc. • Plotter cut images are vector based and therefore can be scaled without loss of resolution/quality. **This list is not exhaustive.** **Accept any other valid responses.**		

<table>
<tr><th>Qu</th><th>Part</th><th>Marking Guidance</th><th>Total marks</th><th>AO</th></tr>
<tr><td>22</td><td></td><td>Explain why foam board is a suitable material for the manufacture of an architectural model.

<table>
<tr><th>Marks</th><th>Description</th></tr>
<tr><td>3–4 marks</td><td>A good explanation of why foam board is an appropriate material for the manufacture of an architectural model. At the top end of the mark band the examples will include justification.</td></tr>
<tr><td>1–2 marks</td><td>The response offers a basic explanation of why foam board is used but tends to be generic and may not relate directly to the context.</td></tr>
<tr><td>0 marks</td><td>No response worthy of credit.</td></tr>
</table>

Indicative content:

• foam board is a lightweight rigid material that make it suitable for representing walls, roofs and other flat architectural features
• foam board can be easily cut and joined allowing for models to be manufactured without the need for expensive machinery
• foam board is usually supplied in white, making it suitable for architectural models where often decisions regarding colour and external materials are made at a subsequent time
• accurate shapes and voids can be cut out from foam board, allowing various scales of models to be accurately represented.

This list is not exhaustive.

Accept any other valid responses.</td><td>4 marks</td><td>AO4 1b</td></tr>
</table>