



Oxford Cambridge and RSA

GCE

Design and Technology

H406/01: Principles of Product Design

Advanced GCE

Mark Scheme for November 2020

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Tick
	Cross
	Confused (replaces the question mark)
	Benefit of doubt
	AO1 – Knowledge and understanding
	AO2 – Apply knowledge and understanding
	AO3 - Analyse
	AO4 - Evaluation
	Omission
	Not answered question
	Noted but no credit given
	Too vague
	Own figure rule

REP	Repetition
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Question	Answer	Mark	Guidance
1 (a)	<p>Possible examples may include:</p> <ul style="list-style-type: none"> • Grip circumference/span/hand-width for the overall width of the walkie-talkie (1). • Hand length for the length of the walkie-talkie (1). • Thumb length for the reach of the thumb to the button while in use (1). • Finger width to determine the size of the button (1). • Any other valid suggestion. 	2	<p>In each case:</p> <p>One mark for an example of how anthropometric data could have been used in the design development of the walk-talkie.</p> <p>Specific reference to the context in the question is needed for marks to be awarded.</p> <p>Do not award marks for ergonomic examples. Must be a human measurement/ size that relates to the walkie-talkie design. No marks for simple one word responses, e.g. 'hand'.</p>
(b) i	<p>Possible factors may include:</p> <ul style="list-style-type: none"> • The comfort of the user's hand (1) through grips shown as ridges on the edge/material used is softer to the touch round the edge (1). • The screen display should be simple/clear to understand (1) to allow the users to interact with the walkie-talkie (1). • The position of the buttons should be placed where the fingers and thumb naturally fall (1) so they can be pressed while being held (1). • Any other valid suggestion. 	4	<p>In each case:</p> <p>One mark for identifying an ergonomic factor that would need to be considered during the design development of the walkie-talkie.</p>

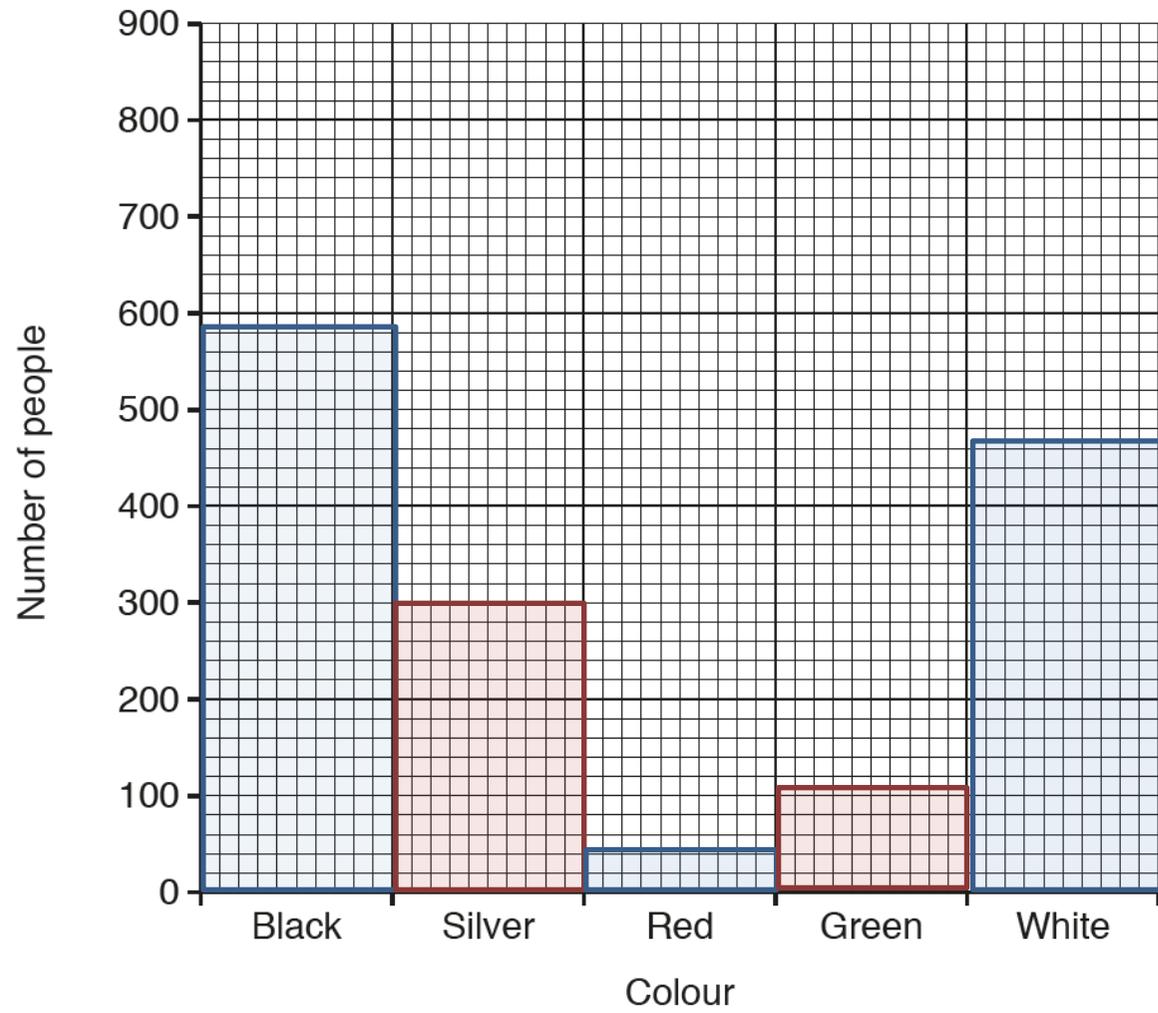
				<p>One mark for justifying why this ergonomic factor would be considered.</p> <p>Specific reference to the context in the question is needed for marks to be awarded.</p> <p>Colour can be awarded marks if related to ease of use, e.g controls easy to find because of colour use.</p> <p>Do not award marks for anthropometric examples.</p> <p>No marks for simple one word responses e.g. 'comfort'. Ergonomic factor must be identified and justified in relation to the walkie-talkie.</p>
	<p>ii</p>	<p>Possible descriptions of how ergonomic factors could be tested may include:</p> <ul style="list-style-type: none"> • Comfort/size of the grip could be tested using models (1) and tested with users/stakeholders (1) • The programming of the display could be tested to see if the design was intuitive (1) and/or users could navigate easily through the menus (1). • Position of the buttons - users could be given various models with different layouts for the buttons (1) with the easier to use/ access design being selected to inform the next iteration of the model (1). • Any other valid suggestion. 	<p>2</p>	<p>Up to two marks for describing how the effectiveness of the chosen ergonomic factor could be tested during the iterative design process.</p> <p>Answers should relate back to part (i) in order to achieve the full two marks.</p> <p>Specific reference to the context in the question is needed for marks to be awarded.</p>

	(c)	<p>Possible smart or modern materials may include:</p> <ul style="list-style-type: none"> • Phosphorescent pigment (1) could be used to make the walkie-talkie glow in the dark (1). • Bio-polymers (1) could be used in the casing of the walkie-talkie so that at the end of life it can degrade/will create less environmental impact (1). • LED/OLED screen (1) could be used as it is then backlit and easy to read the numbers on the screen in the dark (1). • Pro-cap or resistive touch screens (1) would improve the user interface/ease of use (1). • Any other valid suggestion. 	2	<p>One mark for identifying a suitable smart or modern material.</p> <p>One mark for justifying how this smart or modern material would improve the design. Polymers are not modern materials.</p> <p>Specific reference to the context in the question is needed for marks to be awarded.</p>
	(d) i	<p>Possible responses may include:</p> <ul style="list-style-type: none"> • From January to May the product was in a 'growth stage'/ the product had just been launched and sales were increasing (1) as a result of the walkie-talkie becoming more popular (1). • From May through to August the product was in a 'maturity stage'/ sales levelled out/reduced (1) as a result of a factors such as market saturation/another walkie-talkie being introduced to the market (1). • Any other valid suggestion. 	4	<p>In each case:</p> <p>One mark for identifying the correct stage of the product's lifecycle in the timeline specified.</p> <p>One mark for explaining this stage in the context of walkie-talkie sales.</p> <p>For full marks reference should be made to growth, maturity and decline, of terms not used max 3 marks</p>
	ii	<p>Possible reasons may include:</p> <ul style="list-style-type: none"> • An increase in marketing through social media or use of an influencer may have seen a large number of sales (1). • The price point of the product may have decreased (1). • A new colour of walkie-talkie may have been introduced to attract a wider audience (1). • A heightened need may have been created by a specific security incident/change I legislation (1). • 	2	<p>In each case:</p> <p>One mark for stating a possible reason for the change in the number of units sold from August to October -seasonal demand, production issues are acceptable answers.</p>

		<ul style="list-style-type: none"> Any other valid suggestion. 		Specific reference to the context in the question is needed for marks to be awarded.
	iii	<p>7% of units sold in December 2019: $7/100 \times 900 = 63$ units Total number of units sold in January 2020: $900 - 63 = 837$ units (1) Alternatively you just calculate: $0.93 \times 900 = 837$ units.</p>	1	One mark for calculating 7% of 900 and then determining the total number of units sold.
	(e)	<p>Indicative content:</p> <ul style="list-style-type: none"> Qualitative observations could be through interviews to gain an understanding of potential user. This primary research gives the designer the ability to work through or identify any misunderstandings, once a prototype of a product has been made. Quantitative observations from anthropometrics need to be interpreted throughout the development of the design to ensure that the product fits the intended user. Designers should be able to understand the percentiles of measurements for a specific group of people to ensure the design is inclusive. Market research, informing design decisions by identifying trends demographics & buying habits at the beginning of the design process. This information could be through companies providing secondary research such as MINTEL who provides in-depth market analysis and consumer opinions that the designer can access for a fee. The advantage of this is that a wider audience has been reached, so the information is likely to be more accurate for commercial production. However, this may not be specific to the product being designed. Focus groups are an important way of gathering market research as part of a feasibility study. The designer will need to be able to objectively listen and gather opinions from others about their idea or product. This could include usability studies. This information could then be used to improve the design and test viability. Any other valid suggestion. 	8	<p>Level 3 [6-8 marks] The candidate has a clear understanding of the importance of designers interpreting their own market research data and information from specialist websites and publications. They produce a thorough discussion in relation to the question by explaining how designers interpret their own market research data and information from specialist websites and publications to inform design decisions. The explanation is clear and well-developed and a number of examples of research methods are used to exemplify the points being made.</p> <p>Level 2 [3-5 marks] The candidate has a reasonable understanding of the importance of primary and/or secondary research. They produce a sound discussion in relation to</p>

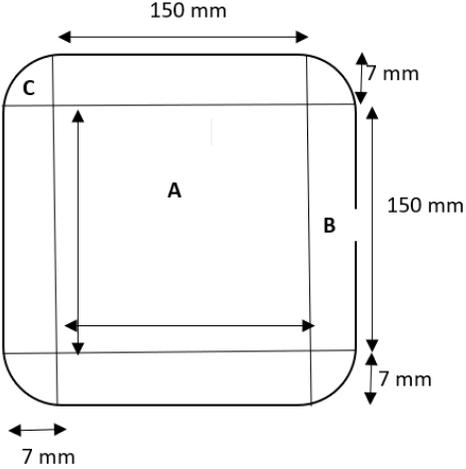
				<p>the question by explaining the use of primary and/or secondary research methods to inform design decisions. The explanation is sufficient although one or two opportunities are missed in referring to different examples of research methods.</p> <p>Level 1 [1-2 marks] The candidate has a basic knowledge of the importance of primary and/or secondary research. Any reference to this issue is descriptive in nature and has little appreciation of how research informs design decisions. The response contains no analysis or evaluation.</p> <p>0 marks No answer or answer not worthy of credit.</p>
2	(a)	<p>Possible advantages may include:</p> <ul style="list-style-type: none"> • Reduces cost as less material is needed in manufacture (1). • Reduces weight as less material is needed in manufacture (1). • Reduces impact on the environment as less material is needed (1). • Allows the user to see into the waste paper bin so they know it is full (1). • Any other valid suggestion. 	2	<p>In each case:</p> <p>One mark for identifying an advantage of using expanded metal mesh rather than solid sheet for the waste paper basket, reference to the context in the question is needed for marks to be awarded.</p> <p>Cheap must be qualified</p>

(b)	<p>Possible explanations if how structural integrity is secured may include:</p> <ul style="list-style-type: none"> • The top rim and the bottom of the waste paper bin are solid metal (1) to help stiffen the structure and maintain the shape (1) ensuring it can take impact from objects that are thrown in (1). • The use of the diamond pattern allows for less material to be used (1) without losing too much strength (1) because of the triangulation. (1) • There could be ribs or webs (1) underneath the base of the bin which stiffen the material (1) without increasing the material quantity (1). • Any other valid suggestion. 	3	<p>Up to three marks for explaining how the design of the waste paper basket ensures structural integrity.</p> <p>Use a mix and match approach.</p> <p>Specific reference to the context in the question is needed for marks to be awarded.</p>																		
(c)	<p>Calculation of number of people.</p> <table border="1" data-bbox="367 612 878 858"> <thead> <tr> <th>Colour</th> <th>% people</th> <th>Number of people</th> </tr> </thead> <tbody> <tr> <td>Black</td> <td>39</td> <td>585</td> </tr> <tr> <td>Silver</td> <td>20</td> <td>300</td> </tr> <tr> <td>Red</td> <td>3</td> <td>45</td> </tr> <tr> <td>Green</td> <td>7</td> <td>105</td> </tr> <tr> <td>White</td> <td>31</td> <td>465</td> </tr> </tbody> </table> <p>Correct chart:</p>	Colour	% people	Number of people	Black	39	585	Silver	20	300	Red	3	45	Green	7	105	White	31	465	3	<p>Award three marks as follows:</p> <p>One mark for calculating the correct number of people from the percentages given.</p> <p>One mark for plotting this information onto a bar chart. This will include using an appropriate scale.</p> <p>One mark for labelling the axes correctly.</p> <p>Max one mark if the % are plotted rather than the calculation</p>
Colour	% people	Number of people																			
Black	39	585																			
Silver	20	300																			
Red	3	45																			
Green	7	105																			
White	31	465																			



	(d) (i)	<p>To calculate the length of the 4 radius corners: $d=20$ $\pi d = 62.8318530718 \text{ mm}$ (1) allow 63</p> <p>Length of the sides: $150 \times 4 = 600 \text{ mm}$</p> <p>Total length: $600 + 62.8318530718 = 662.831853072 = 66.28 \text{ cm}$ (1)</p> <p>External Surface area: $66.28 \times 30 = 1988 \text{ cm}^2$ (1) accept 1989 (rounded up)</p>	3	<p>Award three marks as follows:</p> <p>One mark for calculating the radius of the 4 corners. One mark for calculating the total length of the material.</p> <p>One mark for calculating the surface area correctly even if just one face (30x15)</p> <p>If correct answer is given without working out shown award full marks.</p> <p>Where an incorrect answer is given working out should be used to credit appropriate marks.</p> <p>*Allow error carried forward (ECF) where correct working out is shown.</p> <p>Where an incorrect answer is shown but candidate shows understanding the process of calculating the surface area of a cylinder or face – award 1 mark</p>
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		<p>(ii) $360/3 = 120$ (1)</p> <p>$120 \times 66.28^* = 7953.6$ cm (1)</p> <p>$= 79.5$ m (1)</p>	<p>3</p>	<p>Award three marks as follows:</p> <p>One mark for identifying how many baskets can fit across a roll of mesh. If 0.9/0.3 is seen max 1 mark</p> <p>One mark for demonstrating continuation of the above principles to establish the length of material required.</p> <p>One mark for converting units from cm to m and providing answer to 1 decimal place.</p> <p>If correct answer is given without working out shown award full marks.</p> <p>Where an incorrect answer is given working out should be used to credit appropriate marks.</p> <p>*Allow error carried forward (ECF) where correct working out is shown.</p>

	<p>(iii)</p> <p>One way –</p>  <p>Method 1</p> <p>Work out area of cross section</p> <p>$[A=15^2] + [B = 15 \times 0.7 \times 4 \text{ (4 of shape B)}] \text{ (1)}$ $C \pi \times 0.7^2 \text{ (4 pieces make a full circle) (1)}$ Total area = 268.539.... (1)</p> <p>Volume = area of cross section x length = 268.539*.. x 30 = 8056.179... (1)</p> <p>Vol in litres = 8.056*....= 8 litres (1)</p> <p>Method 2</p> <p>Area of rectangle minus 4 corners</p> <p>$(15 + 0.7 + 0.7)^2 = 268.96 \text{ (1)}$</p>	<p>5</p>	<p>Award five marks as follows:</p> <p>Method 1</p> <p>One mark for calculating A+B One mark for calculating C One mark for calculating total area of cross section. One mark for calculating volume. One mark for calculating volume to nearest half litre.</p> <p>Method 2</p> <p>One mark for calculating area of whole rectangle. One mark for calculating extra at four corners. One mark for calculating total area of cross section. One mark for calculating volume. One mark for calculating volume to nearest half litre.</p> <p>If correct answer is given without working out shown award full marks.</p> <p>Where an incorrect answer is given working out should be used to credit appropriate marks.</p>
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		<p>Extra at each corner = $0.7^2 - \frac{\pi \times 0.7^2}{4} = 0.10515\dots$ Four corners = 0.4206 (1)</p> <p>Area of cross section = $268.96^* - 0.4206^* = 268.5393\dots$ (1) Volume = $268.5293^* \dots \times 30 = 8056.179$ (1)</p> <p>Vol in litres = $8.056^* \dots = 8$ litres (1)</p>		<p>*Allow error carried forward (ECF) where correct working out is shown.</p>
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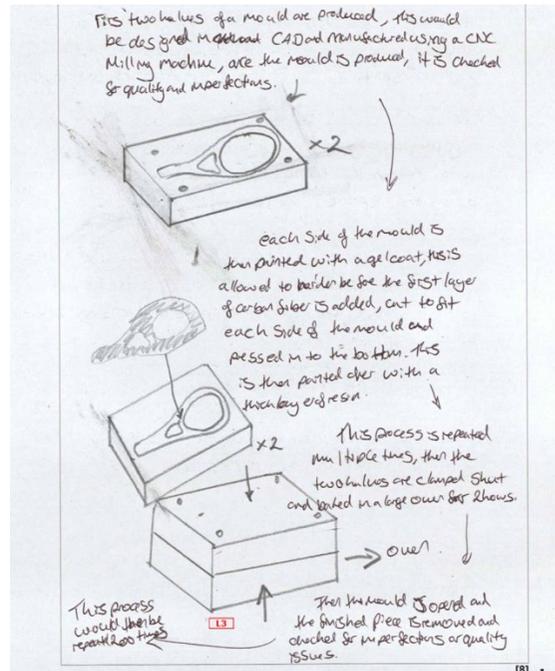
3	(a)	<p>Possible problems may include:</p> <ul style="list-style-type: none"> • Fossil fuels are finite resources (1) which means that are running out (1). • They cannot be replaced (1) therefore the more we use them the quicker they will run out (1). • Fossil fuels are burned to create energy and this creates pollution (1). The pollution then builds up in the atmosphere and affects the ozone layer/ leads to global warming/ greenhouse gases (1). • Fossil fuels are extracted from the ground (1) which can cause damage to the environment/wildlife around the site of extraction (1). • Fossil fuels are more readily available in some countries than others (1), therefore increasing the power of that country where it is abundant (1). • Where other countries are reliant on that supply (1) the abundant country can control the cost/supply of the fossil fuel (1). • Any other valid suggestion. 	6	<p>In each case:</p> <p>Up to two marks for explaining a problem with the widespread use of fossil fuels.</p> <p>Reference to transportation and price increase is accepted</p> <p>Use a mix and match approach.</p>
	(b) *	<p>Indicative content:</p> <ul style="list-style-type: none"> • By increasing the use of alternative energy sources the UK will slowly reduce their carbon footprint and work towards directives from the EU- Renewable Energy Directive (RED) which requires 15% of all the UK energy will be generated from renewable sources by 2020 and emission reduction targets which mean that the UK will have to cut emissions by 80% by 2050. This will take time to put in place and be costly to implement. • Renewable energy sources that are powered by the weather, for example solar power and wind turbines produce an unpredictable quantity of energy as they are affected by conditions outside of human control. • Wind farms can create noise and “eye-sore” which makes them less popular in areas that are densely populated. They can also have a negative impact on animals and wildlife in more rural areas. • Crops grown to fuel biomass in Countries where they should be using their land to grow food for the communities has caused ethical issues and had an impact on nature and wildlife. • Hydro power produces a very steady flow of power and it very reliable. It can also have a positive impact on the environment creating large reservoirs of water that wildlife can thrive by. 	8	<p>Level 3 [6-8 marks]</p> <p>The candidate has a clear understanding of alternative renewable energy sources. They produce a thorough discussion in relation to the question by explaining some of the implications of using alternative energy sources. The explanation is clear and well-developed and specific examples are used to exemplify the points being made.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated with the use of examples.</i></p> <p>If candidate does not provide an analytical/ evaluative response, then only L1 can be awarded.</p>

	<p>Reference to more than one source of renewable energy is needed to access marks in level 3</p> <ul style="list-style-type: none"> Any other valid suggestion. 	<p>Level 2 [3-5 marks] The candidate has a reasonable understanding of the implications of alternative energy sources. They produce a sound discussion in relation to the question by explaining some of the implication of using alternative energy sources. The explanation of implications is sufficient although one or two opportunities are missed in referring to different examples.</p> <p><i>There is a line of reasoning presented with some structure. The information presented for the most part relevant and supported by some evidence.</i></p> <p>Level 1 [1-2 marks] The candidate has a basic knowledge of alternative renewable energy sources. Any reference to this issue is descriptive in nature and has little appreciation of the implications of increasing the use of alternative renewable energy sources. The response contains no analysis or evaluation.</p> <p><i>The information has some relevance and is presented with limited structure or detail. The</i></p>
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				<p><i>information is supported by limited evidence.</i></p> <p>0 marks No answer or answer not worthy of credit.</p>
4	(a)	<p>Possible performance comparisons may include:</p> <ul style="list-style-type: none"> • The composite racket is likely to be lighter than the aluminium racket (1) making it easier to hold and swing (1). • The aluminium racket is likely to be less stiff than the composite racket (1) creating less shock/vibration to the user when in use (1). • The composite racket is less likely to get dented or marked when in use (1) as the racket made from an aluminium alloy is a softer material (1). • The composite racket can have reinforced sections added during manufacture to improve strength/performance (1) when compared with an aluminium racket without adding weight (1). • Any other valid suggestion. 	2	<p>Up to two marks for comparing the performance of a tennis racket frame made from an aluminium alloy with the performance of a tennis racket made from a composite material.</p> <p>If candidate makes assumption that aluminium alloy is the superior material i.e. that is lighter, more durable etc accept the answer and justification</p> <p>Do not accept any reference to cost.</p>
	(b)	<p>Indicative content:</p> <p>The candidate is expected to demonstrate their understanding of the process involved through a series of annotated sketches and/or notes. There may be variations to the process as indicated but to get into L3 candidates must demonstrate a clear understanding of the end to end process.</p> <ul style="list-style-type: none"> • Layers of graphite and fiberglass are assembled as a flat sandwich. (accept other appropriate materials such as boron, Kevlar etc.) 	8	<p>Level 3 [6-8 marks]</p> <p>The candidate demonstrates a good level of detail of the process needed to manufacture the frame using technical terms and considering any relevant specialist tooling and quality control checks. Sketches, if used will be clear and supported with relevant notes. The</p> <p>All processors demonstrated must relate to the tennis racket.</p>

- The sandwich is cut into strips
- The strips are rolled around a flexible tube, which is inserted into a **racket shaped mould**.
- **The mould is heated**, and air pumped through the tube to **increase pressure and bond** the layers.
- The rackets are removed and visually inspected.
- The rackets are then **drilled**.
- A jig is used to ensure the holes are drilled in the correct places.
- The holes are inspected, and rough edges are removed.
- **A polymer coating is applied.**
- The racket is tested for stiffness and balance.
- Any brand name is applied.

Any other valid suggestion.



[13] This response achieves the bottom of level 3

Candidates can draw on practical experience from product analysis and the workshop to support their answer to this question.

process includes all relevant stages.

Level 2 [3-5 marks]

The candidate will demonstrate a sound level of detail of the process needed to manufacture the frame using some technical terms and there will be some consideration of any relevant specialist tooling and quality control checks. Sketches, if used, will for the most part be clear and supported with notes most of which are relevant. The process includes some relevant stages.

Level 1 [1-2 marks]

The candidate will demonstrate a limited level of detail of the process needed to manufacture the frame with a limited use of technical terms and there will be a basic consideration of any relevant specialist tooling and quality control checks. Sketches, if used, will be unclear with only basic notes to accompany them. Few relevant stages are included.

0 marks

No response or no response worthy of credit.

	(c)	<p>Possible finishes may include:</p> <ul style="list-style-type: none"> Anodising (1) This will give the racket a different colour that will not chip or peel when being continuously hit (1). Any other valid suggestion. 	2	<p>One mark for identifying a suitable finish for a tennis racket frame made from an aluminium alloy. e.g. electroplating, powder coating, or paint to apply colour</p> <p>One mark for justifying why this is an appropriate finish to use.</p> <p>Specific reference to the context in the question is needed for marks to be awarded.</p>
	(d)	<p>Possible physical testing methods may include:</p> <ul style="list-style-type: none"> The materials could be tested to determine the rate of corrosion when exposed to sun and rain (1). Materials could be exposed to different weather conditions/tested for a change in toughness (1). Durability analysis of the racket (1) to test the wear rate of the strings/handle. Function testing through destructive testing (1) to assess how the tennis racket will perform in normal use. (1) User trials (1) could be used to evaluate the performance/feel of the racket, when in use (1) Any other valid suggestion. 	4	<p>In each case:</p> <p>Up to two marks for explaining a way in which physical testing could be used to test the functional feasibility of a tennis racket before full-scale commercial manufacture.</p> <p>Do not award marks for QC checks throughout production. Specific reference to the context in the question is needed for marks to be awarded.</p>

	(e)	<p>Indicative content:</p> <ul style="list-style-type: none"> • The use of automation in the production line through Computer Integrated Manufacture has a huge impact on the manufacturing industry. <ul style="list-style-type: none"> ○ Initial cost of these systems is large and it requires a complete plan of how the material will flow through production. ○ It increases safety as robots can perform dangerous/ toxic activities. For example, when applying paint, the fumes can be hazardous if inhaled. ○ Improves the quality as there is less chance for human error. ○ 24 hour production as the machines do not need to take breaks or have a rest, which increases productivity and saves the manufacturer money. • Digital technologies/ programs can be used to calculate the optimum method of manufacture, reducing waste and saving money. • The need for traditional skills has demised and this results in less workers being needed, resulting in job losses. • Lights out manufacturing facilities can be operated with few human workers using the IOT. • Customised products can be manufactured to high standards – e.g. Nike trainers. • Stock levels can be monitored and techniques automated to order and flag up stock levels. • JIT can be used for companies to adapt to changes in level of demand, reducing waste and unsold products. • Digital files can be shared globally in real time, sent to manufacturing units anywhere in the world. • The use of digital system using visual measurement or weighing sensors at key points of the manufacture process. • Any other valid suggestion that relates to manufacturing. 	<p>6</p> <p>For MB3 to be awarded there or will be two or three impacts listed.</p> <p>If candidate does not provide an analytical/ evaluative response, then only L1 can be awarded.</p>	<p>Level 3 [5-6 marks] The candidate has a clear understanding of ICT and digital technologies. They produce a thorough discussion in relation to the question by explaining a number of ways in which ICT and digital technologies have impacted on the manufacturing industry. The explanation is clear and well-developed and specific examples are used to exemplify the points being made.</p> <p>Level 2 [3-4 marks] The candidate has a reasonable understanding impact of ICT and digital technologies. They produce a sound discussion in relation to the question by explaining a number of ways in which ICT and digital technologies impact on the manufacturing industry. The explanation is sufficient although one or two opportunities are missed in referring to different examples.</p> <p>Level 1 [1-2 marks]</p>

					<p>The candidate has a basic knowledge of ICT and digital technologies. Any reference to ways in which ICT and digital technologies impact on the manufacturing industry could be introduced is largely descriptive in nature. The response contains no analysis or evaluation.</p> <p>0 marks No response or no response worthy of credit.</p>
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