OCR
Oxford Cambridge and RSA

Accredited

A Level in Design and Technology: Product Design (H406/01)

Principles of Product Design

Sample Question Paper Version 3.1

Date – Morning/Afternoon

Time allowed: 1 hour 30 minutes

You may use:
- a scientific calculator
- a ruler
- geometrical instruments

First name	
Last name	
Centre number	
Candidate number	

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. Additional paper may be used if necessary, but you must clearly show your candidate number, centre number and question number(s).
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **80**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*****).
- This document consists of **20** pages.

1 **Fig.1** shows a bike helmet.
Fig.2 shows a cross-section of the bicycle helmet.

Fig.1

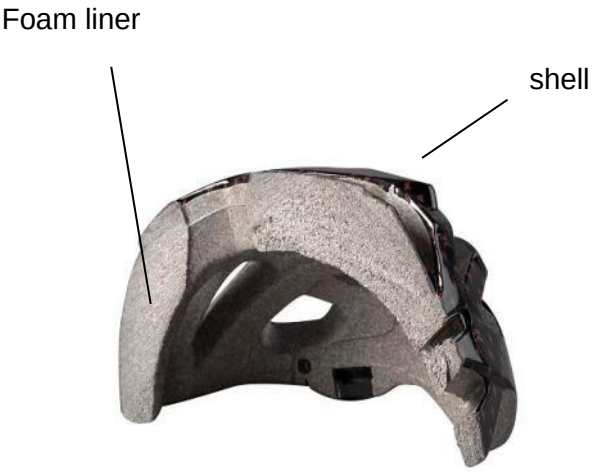

Fig.2

(a) **(i)** Name **one** thermopolymer that is suitable for the foam liner of the bicycle helmet and explain why this could be used.

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…… **[2]**

(ii) A typical adult's medium size cycle bicycle helmet weighs 400 g. The shell, straps and clips make up $\frac{5}{8}$ of the total weight.

The volume of the thermopolymer foam is 0.003 m^3.

Calculate the density of thermopolymer foam used in g/cm^3.

Density of thermopolymer = ……g/cm^3 **[2]**

(b) Bicycle helmets are often ventilated by holes through the shell and the foam liner.

The use of Polycarbonate for the shell material enables larger ventilation holes than when PET is used as the shell material.

Explain **two** reasons why Polycarbonate is a more suitable material than PET where large ventilation holes are required.

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…… **[4]**

(c) Explain why a woven fabric is more suitable for the chin strap than a knitted or non-woven fabric.

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…… **[2]**

(d) A designer wants to obtain stakeholder and user opinions on several new designs for a bicycle helmet.

Explain **two** different methods of obtaining opinions from stakeholders and users, and how they benefit the designer in the design of the bicycle helmet.

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(e) Product labels provide important information for consumers.

Explain how the information found on product labels on bicycle helmets can reassure consumers. Refer to **two** different types of information in your answer.

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…….... **[4]**

(f) Manufacturers need to carry out destructive and non-destructive tests on their products before they are sold to the public.

Discuss how destructive testing of a bicycle helmet might be used to yield information about its performance in use.

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…… **[6]**

2 A manufacturer of home accessories is looking to repurpose gardening products to bring a feel of the outside into small flats that have no outdoor space.

Fig. 3 shows the design the manufacturer is considering for a product, which would be made from polypropylene.

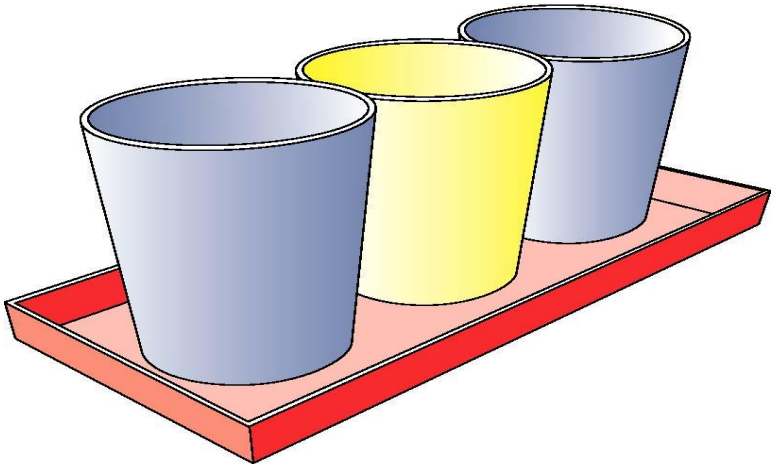
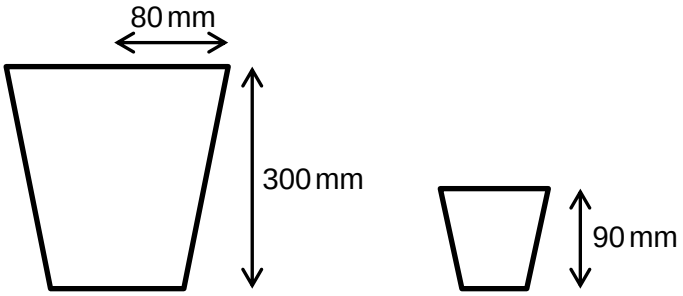


Fig. 3

(a) The manufacturer considers using a similar shape to existing pots for the new indoor pots. A scaling ratio would need to be considered.



Calculate the radius of the top of the smaller pot.

Radius = …… mm **[2]**

(b) The table below gives the production costs for the individual pieces shown in **Fig. 3**.

Description	**Cost**
Yellow pot	£0.10
Blue pot	£0.11
Red tray	£0.58

Analyse the information above to calculate the percentage profit for one set of pots. There is a suggested retail price of £9.99 per set.

Percentage profit = …… % **[3]**

(c) (i) After user testing, it has been decided that the dimensions of the pot need to be adjusted.

The radius at the top of the pot is 38 mm, the height is 90 mm and there are 5° draft angles on the sides.

Calculate the radius of the base of each pot.

Radius = …… mm **[3]**

(ii) The tray needs to hold 3 pots. To ensure a comfortable fit, the dimensions from the top of the pots are to be used to calculate the dimensions of the tray. There needs to be a 10 mm gap in between the top of each pot. There should also be a 10 mm clearance between the pots and the nearest inside edge of the tray.

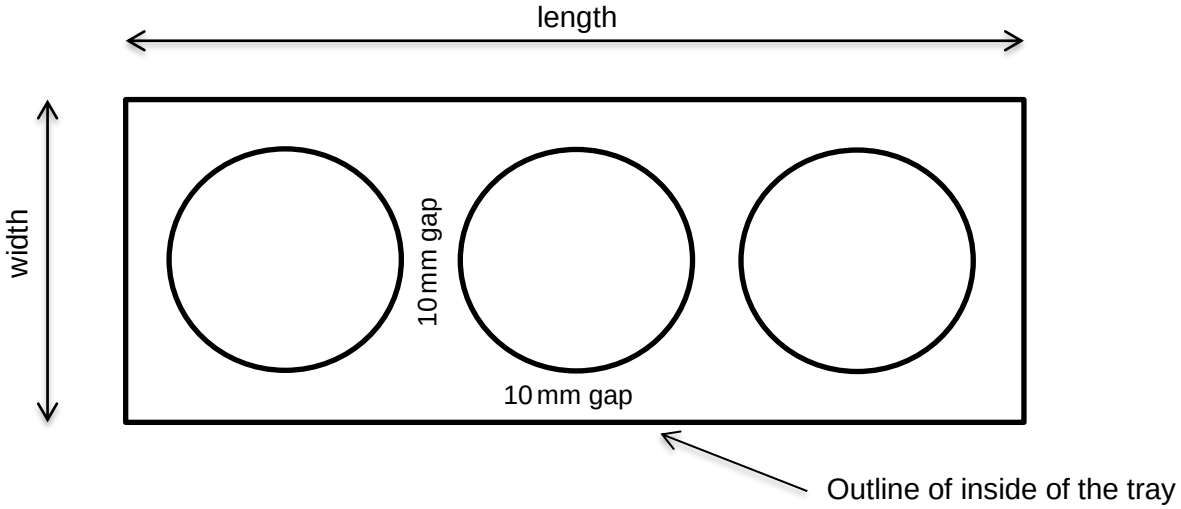


Fig. 4

Analyse the information given to calculate the width and length of the inside of the tray base.

Width = …… mm, Length = …… mm **[3]**

(iii) **Fig. 5** shows recesses in the tray to locate each pot for stability.

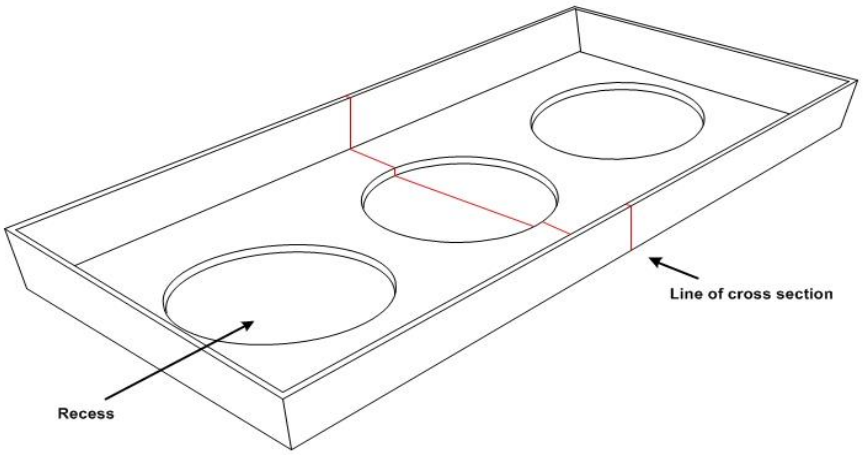


Fig. 6 shows detail of the cross section of the tray. The side walls are 2 mm thick. The base is 4 mm thick, except the recesses for the plant pots, which are each 2 mm deep and have a radius 1 mm larger than the radius of the bases of the pots.

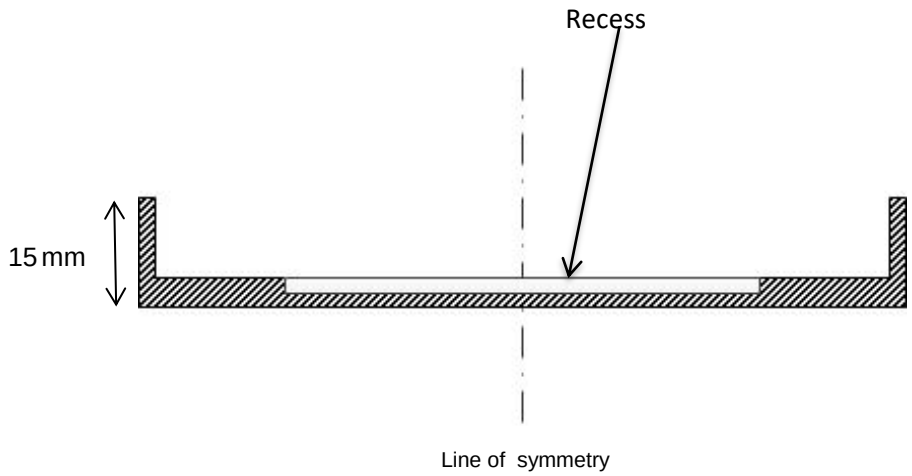


Fig. 6

Calculate the volume of polypropylene that would be required for each tray.
Give your answer in cm^3.

Please note:

- For the purpose of calculation, the sides of the tray are perpendicular to the base.
- You will need to use the radius of the base of the pots that you calculated in question **c (i)**.

Volume = …… cm^3 **[5]**

(iv) It is expected that the polypropylene tray will be manufactured in batches of 10 000.

Give three reasons why injection moulding would be the preferred method of manufacture for the tray as shown in **Fig.3** and **Fig.5**.

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3 Many products are designed with planned obsolescence in mind.

(a) Give **two** reasons why products become obsolete.

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2 ……..……..

……...…… **[2]**

(b) Using **one** product as an example, explain how planned obsolescence has been considered in its design and how this benefits the consumer.

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(c)* Discuss the effect planned obsolescence has on the environment and what designers can do to limit this. You should use examples to support your answer.

.... **[8]**

4. **Fig. 7** shows a pair of high definition headphones.

Fig. 7

(a) Part A shown on **Fig. 7** has been manufactured by high pressure die casting.

(i) Give **one** example of a suitable material for Part A and explain your reason for this choice.

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(ii) Explain why high pressure die casting is more suitable than sand casting for the manufacture of Part **A**.

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[6]

(iii) Explain, using sketches and notes, the process of die casting Part A as a batch of 1 000.

Give details of any special tooling and quality control checks that would be used.

[8]

(b) Anthropometric data will be used in the design of the headphones.

Explain **one** way in which the designer will use anthropometric data to ensure the product will be suitable for the widest possible range of people.

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(c) Discuss the importance and influence of ergonomics in product design.
Use examples in your response.

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Summary of updates

Date	Version	Details
April 2022	3.1	Updated copyright acknowledgements.

OCR
Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level in Design and Technology: Product Design

H406/01 Principles of Product Design

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 80

This document consists of 36 pages

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:
   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. **Annotations**

Annotation	Meaning
BP	Blank page
✔	Point where mark is awarded
✘	Incorrect response
L1	Level one response
L2	Level two response
L3	Level three response
ECF	Error carried forward
BOD	Benefit of doubt accepted
REP	Repetition
SEEN	Noted, but no credit given
PD	Poor diagram offering unclear response

11. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

The breakdown of Assessment Objectives for A Level in Design & Technology

	Assessment Objective
AO3	**Analyse and evaluate –** • **design decisions and outcomes, including for prototypes made by themselves and others** • **wider issues in design and technology**
AO3.1a	Analyse design decisions and outcomes, including for prototypes made by themselves and others
AO3.1b	Evaluate design decisions and outcomes, including for prototypes made by themselves and others
AO3.2a	Analyse wider issues in design and technology
AO3.2b	Evaluate wider issues in design and technology
AO4	**Demonstrate and apply knowledge and understanding of –** • **technical principles** • **design and making principles**
AO4.1a	Demonstrate knowledge of technical principles
AO4.1b	Demonstrate understanding of technical principles
AO4.1c	Apply knowledge and understanding of technical principles
AO4.2a	Demonstrate knowledge of design and making principles
AO4.2b	Demonstrate understanding of design and making principles
AO4.2c	Apply knowledge and understanding of design and making principles

Question			Answer	Marks	Guidance
1	(a)	(i)	Thermopolymer that is suitable for the bicycle helmet and why, e.g.: EPS Expanded Polystyrene foam would be suitable (✓) as it is a crushable foam and will absorb energy if the head were to impact a surface (✓) Other possible thermopolymers could include: • EPP Expanded Polypropylene foam • EPU Expanded Polyurethane foam Other possible reasons for suitability could include: • Can be moulded to the internal profile/shape of the helmet • Moulds itself to the head shape of different wearers • EPS – single use – absorbs impact but does not recover, it permanently deforms. Needs replacing after impact • EPP – multi-impact foam - a bit more 'give' but recovers its shape after impact. Increasing in use in helmets. (Plastazote is a common tradename/brand of EPP foam) • EPU – crushable foam similar to EPS. Forms a skin when moulded which gives a better surface more resistant to damage **Award credit for any other appropriate response**	**2** **AO4 1c**	1 mark for identifying a suitable thermopolymer for the bicycle helmet. 1 mark for explaining why the polymer is suitable. Specific reference to thermopolymers in relation to the bicycle helmet is needed for the marks. **Do not accept** EVA (Ethylene Vinyl Acetate), neoprene (polychloroprene), latex foam or gel. Must be a crushable foam.

Question			Answer	Marks	Guidance
1	(a)	(ii)	$(1 - \frac{5}{8}) \times 400 = 150$ (✓) *density* = mass ÷ volume = 150* ÷ 3000 = 0.05 g/cm^3 (✓)	**2** **AO4 1c**	1 mark for calculating the weight of the thermopolymer foam. 1 mark for calculating the density of the foam polymer having converted from m^3 to cm^3. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks.**
1	(b)		Reasons why polycarbonate is a more suitable material than PET for the shell of the helmet, e.g.: Polycarbonate is tougher (✓) This is important for thinner sections of material to have greater potential to withstand cracking from impact (✓) Polycarbonate has significantly greater 'Notched Impact Strength' (✓) which means that scratches and dents need much greater impact force to convert them to cracks (✓) Other responses could include: • PET is more susceptible to damage from impact and is likely to crack or break • Polycarbonate is less ductile than PET. The shell of the helmet is more likely to retain its shape after repeated impacts from day to day normal use. • Polycarbonate has a high melting point and can be included in the mould when the foam liner is formed 'in-situ' in the shell of the helmet • Polycarbonate has a lower density than PET Products with larger vent holes are desirable for users looking for lightweight designs	**4** **AO4 1c**	1 mark for identifying each of two reasons why polycarbonate is more suitable than PET for the shell of the bicycle helmet. 1 mark for explaining the suitability in relation to the larger ventilation holes in the shell of the bicycle helmet. Specific reference to the suitability of polycarbonate in relation to the ventilation holes of the bicycle helmet is needed for the marks. **Do not accept** increased stiffness.

Question			Answer	Marks	Guidance
			Award credit for any other appropriate response		
1	**(c)**		Comparative reason for the suitability of a woven fabric rather than a knitted or non-woven fabric for the chin strap, e.g.: Woven fabrics are stronger than non-woven fabrics because of their structure, therefore it is more suitable for the chin strap webbing. (✓) The fibres are mechanically interlocked, whereas in non-woven fabrics the fibres are 'entangled' and joined by adhesives, solvents, or heat (✓) Other reasons could include: • A non-woven fabric would have a more limited life than a woven fabric in this situation where they it is repeatedly, flexed, stretched, and threaded through the helmet clip. This is due to its structure where fibres are not woven together mechanically. The strap would be more susceptible to being 'pulled apart' when used on the chin strap and would be likely to fray. • Knitted fabrics 'stretch and give' more than woven fabrics. 'Stretch and give' in the chin straps would mean the helmet would not be guaranteed to stay close to the head it is protecting. • Woven fabric for the chin strap is the best option for safety. Knitted or non-woven alternatives would stretch, fray, wear, or break under loading, compromising the safety performance of the helmet when protecting the head in a collision. A polymer woven webbing would perform as required and last almost indefinitely. **Award credit for any other appropriate response**	**2** **AO4 1c**	1 mark for identifying a reason why woven fabric is more suitable than knitted or non-woven fabric for the chin strap of the bicycle helmet. 1 mark for explaining the suitability of a woven fabric in comparison to a knitted or non-woven fabric in relation to the chin strap of the bicycle helmet. Specific reference to the comparison between woven fabrics and knitted or non-woven fabric in relation to the chin strap of the bicycle helmet is needed for the marks.

Question			Answer	Marks	Guidance
1	(d)		Different methods of obtaining opinions from stakeholders and users, and how they benefit the design process, e.g.: Using a focus group, the designer can obtain a wide range of opinions from users of different ages and backgrounds (✓), through first-hand contact with samples/models of the helmets, obtaining comments on issues, such as ease of operation of moving parts, in-depth qualitative data is obtained. (✓) An internet based survey with images of the new cycle helmets with questions (e.g. survey monkey) can be sent to large numbers of participants to gain opinions on the visual and aesthetic aspects. (✓) The data can be analysed from the digital survey and graphs and charts produced automatically. (✓) Other methods could include: • questionnaire asking specific questions to a selected audience of users • interviews with a single user or stakeholder enables a focused discussion of all issues of interest and concern • 'street survey' (field research) with market researchers • market research 'clinic' enables users to examine models or prototypes • social media. The designer can specifically target groups of cyclists and cycle clubs, for their opinions on the new helmets. Other benefits to the design process could include: • quantitative feedback and data • common viewpoints • agreement on technical or legal perspectives	**4** **AO4** **2 x 2b** **2 x 2c**	1 mark for explaining a method of obtaining opinions from stakeholders and users. 1 mark for explaining how the method would benefit the designer in the design of the bicycle helmet. Specific reference to the benefit of methods in relation to the design of the bicycle helmet is needed for the full marks. Candidates can draw on experience from iterative designing to support their response to this question.

Question			Answer	Marks	Guidance
			• validate opinion • obtain opinions on competitors' approaches. **Award credit for any other appropriate response**		
1	**(e)**		How specific information found on product labels on bicycle helmets can reassure consumers, e.g.: In the UK, the British Standards Institution (BSI) Kitemark will be found on helmets to show it meets the British Standard. (✓) This reassures the consumer that all of the parts of the helmet have been tested against a detailed specification of requirements. (✓) The date of manufacture indicates the age of the helmet. (✓) Manufacturers recommend helmets are replaced every 3 to 5 years. This gives clear assurance to consumers that the helmet is fully safe up until that date (✓). Other points that may be included: • CPSC (US Consumer Product Safety Commission, similar to BSI in the UK) safety endorsement is reassurance that the helmet meets a specific safety standard for bicycle helmets. • CE –"Conformité Européene" which means "European Conformity" is a mandatory conformity marking meaning that the helmet conforms to certain standards required for sale in the European Economic Area. • ASTM is an international standards organisation with over 12000 ASTM voluntary standards. These standards are used around the world to improve product quality and enhance health and safety • Assurances mean that concern can be taken to a	**4** **AO4** **2 x 1c** **AO4** **2 x 2a**	1 mark for identifying each of two types of information that is appropriate for the labelling on bicycle helmet labels. 1 mark for explaining how each type of information can reassure consumers. Specific reference to information labelling that would be found in bicycle helmets is needed for the marks.

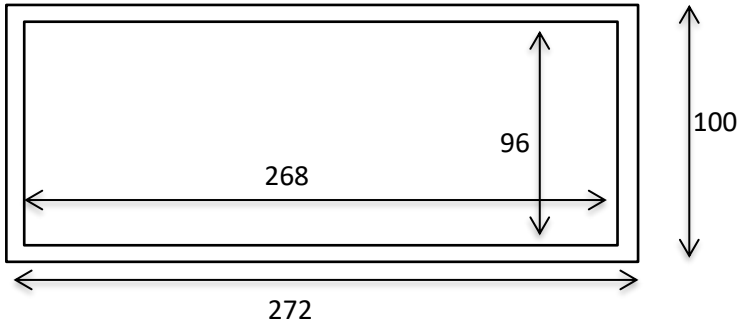
Question			Answer	Marks	Guidance
			Trades Description Officer (The Trade Descriptions Act 1968). • Labels on helmets may include instructions not to paint or modify them or apply any kind of solvent that would impair the impact resistance of the helmet shell. • Instructions may inform consumers that the helmet should be replaced if scratched or damaged in any way, as the damage is likely to compromise the safety of the helmet. **Award credit for any other appropriate response**		

					Content	Levels of response
1	(f)		Indicative content: • A variety of standard and non-standard 'destructive' tests could be carried out on bicycle helmets. • Helmet testing should as far as possible simulate the situations that would be encountered by the helmet in case of impact. Tests should be repeatable, measurable and include a range of situations a helmet might reasonably encounter. • Helmet testing provides a measurement of how a helmet reacts during an event to protect the wearer's head and brain. Data obtained should be reliable, consistent, and comparable to a benchmark standard. • A variety of tests are needed to determine the helmet's performance and ability to stay on the head in different environmental conditions such as wet, heat, cold. • A range of headform sizes are used in standardised tests, with a circumference of 500mm increasing in increments of 10mm. A typical standard specification for a headform has a mass of 5Kg, regardless of size. The proportions and shape are determined by standard anthropometric data. Differently proportioned headforms address the needs of children and ethnic groups. Methods of destructive testing could include: • Impact test • Hardness Test • Tensile test • Dynamic Retention Test • Abrasion test • Positional Stability (Roll-Off) Test.	**6** **AO3** **1 x 1a** **AO3** **1 x 1b** **AO4** **4 x 1c**	If a candidate demonstrates generic knowledge about destructive testing that do not relate to a bicycle helmet, they should not be awarded 0 marks. Candidates can draw on experience from iterative designing and product analysis to support their response to this question. --- A candidate operating at Level 3 would be expected to access the majority of the AO4 (1c) marks and at least one of the AO3 (1a/1b) marks. A candidate operating at Level 2 would be expected to access at least half of the AO4 (1c) marks and at least one of the AO3 (1a/1b) marks. A candidate operating at Level 1 would only be expected to access the AO4 (1c) marks.	**Level 3 (5–6 marks)** Candidate produces a thorough discussion of how destructive testing of a bicycle helmet might be used to yield information about its performance in use. Candidate shows a mature understanding and analysis of the impact testing has on the viability of products. This creates a discussion that is both cohesive and well-considered. **Level 2 (3–4 marks)** Candidate produces a sound discussion of how destructive testing of a bicycle helmet might be used to yield information about its performance in use. Candidate shows a reasonable understanding and analysis of the impact testing has on the viability of products. This creates a discussion that is for the most part cohesive and well-considered. **Level 1 (1–2 marks)** Candidate demonstrates a basic knowledge of how destructive testing of a bicycle

			Award credit for any other appropriate response			helmet might be used to yield information about its performance in use. Any understanding is limited with little consideration of the impact testing has on the viability of products. There is no analysis or evaluation. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance
2	(a)		300 : 90 = 10 :3 = 1: $\frac{3}{10}$ (✓) 80 × $\frac{3}{10}$ * = 24 mm (✓) **Award credit for any other appropriate method of calculation**	**2** **AO4 1c**	1 mark for calculating the ratio required to rescale the indoor pots. 1 mark for calculating the radius from the ratio. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks.**
2	(b)		Production costs 10 + (2 x 11) + 58 = 90 pence (✓) Profit 9.99 – 0.90* = £9.09 (✓) Percentage profit (909* ÷ 90*) x 100 = 1010% (✓) **Award credit for any other appropriate method of calculation**	**3** **AO3 1 x 2a** **AO4 2 x 1c**	1 mark for analysing the information from the table and **Fig. 3** in order to formulate the required calculation. 1 mark for calculating the profit in pounds sterling. 1 mark for calculating the percentage profit. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks.**
2	(c)	(i)	Tan5 = $\frac{x}{90}$ (✓) x = 7.87 (✓) radius = 38 – 7.87 = 30.1 mm (✓) **Award credit for any other appropriate method of calculation**	**3** **AO4 1c**	1 mark for the appropriate use of the tan rule. 1 mark for calculating the required measurement (x). 1 mark for calculating the radius at the base. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks**

Question			Answer	Marks	Guidance
2	(c)	(ii)	Width = (2r) + (2 x 10) = (2 x 38) +20 = 96 mm (✓) Length = (2r x 3) + (2 x 10) + (2 x10) = (76 x 3) + 20 + 20 = 268 mm (✓) **Award credit for any other appropriate method of calculation**	**2** **AO3 2a**	1 mark for analysing the information given in order to calculate the width of the tray. 1 mark for analysing the information given in order to calculate the length of the tray. **Correct answer scores full marks**

2	**(c)**	**(iii)**	 Volume of outer cuboid with inner cuboid cut out = (272* x 100* x 15) – (268* x 96* x 11) (✓) = 408000 – 283008 = 124992 mm^3 (✓) Volume of three recesses = 3 x (π x (30.1***** + 1)^2 x 2) = 18262.0 mm^3 (✓) Total volume of polypropylene: 124992* - 18262.0* = 106730.0 mm^3(✓) 106730.0* mm^3 = 106.73 cm^3(✓) **Award credit for any other appropriate method and response.** (alternative: base = 96* x 268* x 4 -3(π x 31.1^2* x 2) = 84650.0(✓)(✓) Length = 2(272* x 15 x 2) = 16320 Width = 2(96* x 15 x 2) = 5760(✓) Total = 84650.0* + 16320* + 5760* = 106730.0 mm^3 (✓) 106730.0* mm^3 = 106.73 cm^3(✓)	**5** **AO3** **2 x 2a** **AO4** **3 x 1c**	***ECF for the radius of the base given in c(i).** 1 mark for analysing the information and data from Fig.5 and Fig.6 in order to formulate the required calculation for the mass of the sides of the tray. 1 mark for calculating mass of the sides of the tray. 1 mark for analysing the information and data from Fig.5 and Fig.6 in order to formulate the required calculation for the mass of the base of the tray. 1 mark for calculating the volume of polypropylene required for the tray. 1 mark for converting the volume of polypropylene required from mm^3 to cm^3. *Allow error carried forward (ECF) where correct working out is shown. **Correct answer scores full marks**

2	**(c)**	**(iv)**	Why injection moulding would be the preferred method of manufacture for the tray, e.g.: Will offer good product consistency and good dimensional control in the definition of all corners, edges and detail, due to the high pressures involved. (✓) Very quick cycle times (5-10 seconds per unit for simple components) mean cost and time efficiencies through the manufacture. (✓) It will reduce the requirements for finishing. Plant pots would be delivered from the injection moulding machine with no post-processing required. (✓) Other responses could include: • It is possible to add fillers and stabilisers to the pellets fed into the machine, to improve strength and durability properties in the plant pot tray. • Can be automated easier than other thermos forming and moulding processes • Very close tolerances can be achieved • Colour can be changed easily • Only as much plastic as is necessary is used to create the part. Excess plastic can be ground up and recycled after use. **Award credit for any other appropriate response**	**3** **AO4 1c**	1 mark for each of three identified reasons why injection moulding is the preferred method of manufacture for the polypropylene tray. Specific reference to injection moulding in relation to the manufacture of batch produced plant pots is needed for the marks.

3	**(a)**		Reasons why products become obsolete, e.g.: Products become obsolete because their value and competitiveness reduce as more desirable alternative products become available, or user styles, preferences and requirements change. (✓) Manufacturers need to ensure continuity of sales to be sustainable as a business. Products are updated as a commercial decision to make older products out of date and not desirable to ensure profit and employment (✓) Other reasons could include: • new fashions are introduced each season, with new patterns, styles, trends, colours becoming popular. • PC's and laptops become unable to handle the updated operating systems and software that are introduced frequently, and producers cease to support older operating systems. • aggressive marketing and advertising campaigns (e.g. "You NEED 4D TV – change your TV, change your life") persuade people to discard old TV's as 'out of date and not wanted anymore;' • new designs for thinner, smaller items (like smart phones, tablets) are making it really hard for people to fix and prolong the use of these devices. • The availability of parts and accessories becomes limited over time, so items cannot be repaired. **Award credit for any other appropriate response**	**2** **AO4 2a**	1 mark for each of two identified reasons why products become obsolete.

3	**(b)**		how planned obsolescence has been considered in its design and how this benefits the consumer, e.g.: Medical items such as sterile surgical gloves or needles designed to be disposable and cannot be reused. (✓) They have a planned life and therefore planned obsolescence. This is for reasons of health and hygiene in a context where transfer of infection is an ever-present danger. (✓) Other responses could include: • Planned obsolescence increases the availability of products to those that can't afford the best. e.g. a toaster may not last long but most people (who couldn't afford a top model costing £200 don't mind purchasing a £10 toaster every couple of years when it wears out. • A useful life for components of machines and equipment can be established, so whether it still works or it is completely worn out, the component is replaced. For example, a car tyre, which is deemed to be ''unsafe' after a certain depth of tread is reached, indicating that the rubber compounds and structure of the tyre, as well as its effectiveness in grip, are inadequate on safety grounds. • Disposable razors can be thrown away after use before they become blunt when they are more likely to be used in an incorrect way to try and make them perform the task intended and cause an injury or compromise safety, health or hygiene. Other examples could include: • nappies • disposable cutlery. **Award credit for any other appropriate response**	**2** **AO4 2b**	1 mark for giving an example of a product where planned obsolescence is clearly considered in its design. 1 mark for explaining how the planned obsolescence of this product benefits the consumer. Specific reference to planned obsolescence benefiting the user in relation to the exemplified product is needed for the marks.

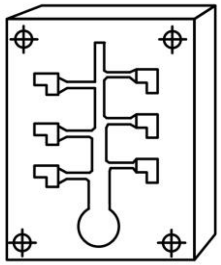
Question			Answer	Marks	Guidance	
					Content	Levels of response
3	(c)*		Indicative content: **The effect planned obsolescence has on the environment, with examples:** • Products that are obsolete end up as landfill even though they aren't broken. Chemicals from the products can escape and damage or pollute the ground or atmosphere. For example, mobile phones contain lead, cadmium, and mercury which are harmful for the environment as they leak from landfill sites. • New products are being manufactured in high volumes to replace products that still work but are no longer desirable. This high volume manufacturing uses energy, which uses the world's finite resources and causes pollution in the waste substances from industry. • Electrical products are 'recycled' by people in low wage economies where they burn and melt the plastic off to obtain the components and/or precious metals. This creates gases and pollution that harm the environment. The leftovers are then put on rubbish dumps. • Electronic waste (e-waste) has contributed greatly to many dangerous and toxic landfills in countries like China, India and Ghana. • The processes to recycle the products generated by planned obsolescence are often more harmful to the environment than landfill.	**8** **AO3 2 x 2a** **AO3 2 x 2b** **AO4 2 x 2a** **AO4 2 x 2b**	Responses may use examples of planned obsolescence having a positive or negative effect on the environment. As a guide for full marks there will be two or three different examples or products discussed. A candidate operating at Level 3 should be accessing all AO4 marks, at least one of the AO3 (2a) marks and at least one of the AO3 (2b) marks. A candidate operating at Level 2 will be accessing both of the AO4 (1a/2a) marks, at least one of the AO4 (1b/2b) marks, at least one for the AO3 (2a) marks and at least one of the AO3 (2b) marks. A candidate operating at Level 1 will access either marks from AO4 (1a/2a/1b/2b).	**Level 3 (6–8 marks)** Candidate produces a thorough discussion of the effect planned obsolescence has on the environment and what designers can do to limit this. Candidate shows a mature understanding and analysis of the wider issues in the question using appropriate and well-considered examples to inform their response. This creates a discussion that is both cohesive and well-considered. 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. **Level 2 (3–5 marks)** Candidate produces a sound discussion of the effect planned obsolescence has on the environment and what designers can do to limit this. Candidate shows a reasonable understanding and analysis of the wider issues in the question using adequate and for the most part well-considered examples to inform their response. This creates a discussion that is for the most part well-considered.

Question			Answer	Marks	Guidance	
					Content	Levels of response
			What designers can do to limit the effects of planned obsolescence, with examples: • Designers can design with 'circular economy' in mind, cradle to cradle, design products to have a longer life span, e.g. the 'Tripp Trapp' high chair grows with child to last longer. Use of standard components and non-permanent fastenings enable their re-use. • Designers can limit damage to the environment through their choice of materials, choosing easily recyclable materials or using recycled materials in products, e.g. carpets that are returned and recycled into new carpets after use. • Designers can specify materials which can be thrown away but are safe for the environment. Some products are manufactured from Polylactide (PLA) which is a biodegradable polymer. • Designers can use appropriate labelling to encourage purchases of environmentally friendly products, e.g. "Greener" or "Eco-friendly." • Designers can create environmentally friendly products that not only save resources and reduce pollution but create a culture of awareness. The dishwasher created by Yanko Designs actually cleans dirty dishes by steaming them in the pre-wash cycle and keeping the water to reuse it in later phases. **Award credit for other appropriate responses**			There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence. **Level 1 (1–2 marks)** Candidate demonstrates a basic knowledge of the effect planned obsolescence has on the environment and what designers can do to limit this. Any understanding is limited with little consideration of wider issues. There is no analysis or evaluation. The information has some relevance and is presented with limited structure or detail The information is supported by limited evidence. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance
4	(a)	(i)	A suitable material for Part A, with reasons for its suitability, e.g.: Aluminium alloys (✓) have very good strength and hardness properties which will be important for the adjustment elements of Part A(✓) Other responses could include: • Magnesium alloys would be suitable for part A because of its low density. Low weight is a key requirement in the design of the headphones. • Zinc alloys has outstanding corrosion resistance and is therefore suitable for the headphones that will be used in a variety of indoor and outdoor environments. • Magnesium alloys has good stiffness and strength-to-weight ratio making it ideal for the engineered Part A with adjustments against adjacent components of the headphones. • Zinc alloys has excellent EMI and RFI shielding properties, and therefore will not interfere with the sound qualities of the headphones. • Aluminium alloys has good finishing characteristics, and can be anodised in a range of colours and finishes to provide for a range of styles of headphones • Aluminium alloys has full recyclability and therefore presents the component and the headphones as an environmentally friendly product. **Award credit for any other appropriate response.**	**2** **AO4 1c**	1 mark for identification of a suitable material for Part A of the headphones. 1 mark for explaining the suitability of this material choice. Specific reference to a suitable material in relation to Part A of the headphones is needed for the marks.

Question			Answer	Marks	Guidance	
					Content	Levels of response
4	(a)	(ii)	Indicative content: • Die casting produces higher dimensional accuracy than sand casting. This is important as Part A forms part of the adjustment of the headphones and must operate smoothly. Uniformity of die-produced parts is exceptional; sand casting is less precise, requiring post-processing and machining. • Thinner walls and sections can be cast with die casting as compared to sand casting. This is important for Part A as the walls and sections are thin where the swivel pins of the earphones are connected. • Die casting achieves a cast component with low porosity and therefore higher density and hardness, important properties for Part A where there are moving parts and to deliver a long service life. • Inserts can be cast-in during the die casting process, such as threaded inserts and bearing surfaces required in Part A. This will enable the swivel adjustment mechanism for the earphones and the sliding mechanism for the headband. • Due to the accuracy of the process and the hardened steel tooling used, die casting reduces or eliminates secondary machining operations beyond removal of the small sprues. Sand casting would require removal of the runners/risers and machining of the surfaces and holes in Part A following casting. • Die casting is ideal for large production runs of components such as Part A, due to the rapid cycle times. Die cast tooling requires minimal maintenance and the process can be automated. Sand casting is labour intensive with slow cycle times, and requires high maintenance.	**6** **AO4 1c**	If a candidate demonstrates generic knowledge about die casting and/or sand casting and does not apply this knowledge to the manufacture of Part A of the headphones, they should not be awarded 0 marks. Candidates can draw on practical experience to support their response to this question.	**Level 3 (5–6 marks)** The candidate will demonstrate a thorough understanding of why high pressure die casting is more suitable than sand casting for the manufacture of Part A. There is a well-developed explanation in context which is clear and logically structured. The information presented is relevant and substantiated with the use of examples. **Level 2 (3–4 marks)** The candidate will demonstrate a sound understanding why high pressure die casting is more suitable than sand casting for the manufacture of Part A. There is a reasonable explanation in context with some structure. The information presented is in the most-part relevant and supported by some evidence. **Level 1 (1–2 marks)** The candidate will demonstrate limited knowledge of high pressure die casting and/or sand casting for the manufacture of Part **A**. Limited examples are used. The information has some relevance and is presented with limited structure or detail The

Question			Answer	Marks	Guidance	
					Content	Levels of response
			Responses may include reference to, or make comparisons to, other parts of the processes: In **die casting**, molten metal is forced into a permanent mould/die cavity under high pressure. It is similar to injection moulding. The die is produced from hardened steel. The die is re-used many thousands of times. Despite the high costs of the mould and the equipment it is cost effective for high volume production runs. The process can be automated and rapid. In **sand casting**, a pattern is used to create an empty cavity of the shape of the part required in sand, which is enclosed in a moulding box. Molten metal is poured into the mould cavity in the sand and when cooled the sand is broken away to reveal the part required. The sand can be re-used to produce further moulds from the pattern. Equipment costs are low and the process is labour intensive and slow, therefore is ideal for small quantities and prototyping. **Award credit for any other appropriate response**			information is supported by limited evidence. Level 0 (0 marks) No response or no response worthy of credit.

Question			Answer	Marks	Guidance	
					Content	Levels of response
4	(a)	(iii)	Indicative content: Responses may refer more specifically to either hot-chamber or cold-chamber die casting. **Whichever die casting process is chosen, the following stages apply:** A hardened steel mould / die capable of producing tens of thousands of castings in rapid succession is made in two sections to permit removal of castings. • For Part A is it likely to be a multiple cavity die (see diagram)  **Multiple-Cavity Die** • 'Cores' (rods) would be included as part of the dies to produce the pivot holes in Part A. • Inserts – the bearing sleeves (e.g. brass) in the pivot holes of Part A, are inserted. • The two sections of the mould / die are mounted securely in a machine and are arranged so that one is stationary (fixed die half) while the other is moveable (injector die half). • To begin the casting cycle, the two die halves are clamped tightly together by the die casting machine. • Hydraulics are used to achieve the high pressures	**8** **AO4** **2 x 1a** **AO4** **6 x 1c**	All processes demonstrated in the candidate's response must be in relation to the die casting as associated with the batch manufacture of Part A of the headphones. Candidate operating at Level 3 will access all of the AO4 (1a) marks, the majority of the AO4 (1c) marks. Candidate operating at Level 2 will access all of the AO4 (1a) marks, at least one of the AO4 (1c) marks. Candidate operating at Level 1 will access at least one of the AO4 (1a) marks.	**Level 3 (6–8 marks)** The candidate will demonstrate a thorough understanding of die casting as associated with the batch manufacture of Part A of the headphones. There is a sophisticated level of application that fully considers any special tooling and quality control checks that would be used. The explanation is supported by clear sketches and notes. **Level 2 (3–5 marks)** The candidate will demonstrate a sound understanding of die casting as associated with the batch manufacture of Part A of the headphones. There is a reasonable level of application that mostly considers any special tooling and quality control checks that would be used. The explanation is supported by sketches and/or notes.

Question	Answer	Marks	Guidance	
			Content	Levels of response
	involved. • Molten metal of a sufficient quantity for Part A (or multiple of plus sprue) is injected into the die cavity where it solidifies quickly. • Dies are cooled by water circulating through channels / holes in the dies. The components will solidify quicker and the casting can be removed while solid but still hot, enabling the process to be repeated again giving a much faster cycle time / turnaround of components. • The die halves are drawn apart and the casting is ejected. • Sprues are removed. • Machines are equipped with automatic cycling controls. • Safety interlock systems are used to prevent the die from opening during the casting cycles. **Quality Control** • Quality in die casting is maintained through the use of process controls and feedback between the process control computer and the die casting machine. • Process controllers utilize microprocessors to access transducers mounted on the die casting machine, to obtain velocity, position, hydraulic pressure, metal temperature, and tie-bar strain data, etc. • The microprocessor then adjusts the die casting machine operation through special valves, thus optimising the process and assuring consistent castings. • The process controller also collects machine performance data for statistical analysis in quality			**Level 1 (1–2 marks)** The candidate demonstrates a limited understanding of die casting as associated with the batch manufacture of Part A of the headphones. There is limited application with little consideration of any special tooling and quality control checks that would be used. Sketches and/or notes are used, but are not coherent. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance	
					Content	Levels of response
			control. **Award credit for any other appropriate response**			

Question			Answer	Marks	Guidance
4	**(b)**		How anthropometric data may have been used to ensure the product will be suitable for the widest possible range of people, e.g.: Anthropometric data will provide the length of the side-to-side arc over the head from the centre of one ear to the centre of the other. This will be used to determine the range of adjustment of the headband (✓). The range of arc lengths to be accommodated will be the 5th – 95th percentile (✓) probably for ages 10 to adult inclusive. Other possible responses could include:	**2** **AO4 1 x 2b** **AO4 1 x 2c**	1 mark for explaining how the designer will use anthropometric data when designing the headphones. 1 mark for explaining how the given use of anthropometric data will ensure the headphones will be suitable for the widest possible range of people. Specific reference to anthropometric data being used in relation to headphones is needed for the marks.

Question			Answer		Marks	Guidance	
						Content	Levels of response
			• Anthropometric data will provide the head breadth (upper cheek to upper cheek) dimension. This will be used to determine the working distance between the two earphones, accommodating the flexing of the headband. • The swivel joints on the top of the earphones need to allow the earphones to move to the vertical position. • Anthropometric data will provide ear height and width to determine the size of the earphones. **Award credit for any other appropriate response**				

Question			Answer	Marks	Guidance	
					Content	Levels of response
4	(c)		Indicative content: • Ergonomics (& human factors) is the practice of designing products, systems, and processes to take proper account of the interaction between them and the people who use them. 'Usability' is achieved through a thorough understanding and application of ergonomics, describing how easy the product is to use, how clear and obvious the functions are. • Reference to ergonomics being about the 'fit' between people and the things they do, the objects they use, and the environments they work, travel or play in. If a good fit is achieved, the stresses on people are reduced. They are more comfortable, they can do things more quickly and easily, and they make fewer mistakes. 'Fit' doesn't just mean the physical fit of a person, it concerns psychological and psychological aspects. • Reference to hand tools (such as garden shears or secateurs) as an example. Bad design may cause result in slower work and more error, and possibly injury or accidents. The grip and the level of muscle exertion needed must be considered. The wrist angle is also important. Slight contouring of the grip or flared handles can increase comfort and reduce slippage in sweaty hands. Handles should be at least 100–125 mm long for power grip. Longer handles give mechanical advantage. Smooth handles for tools requiring wrist rotation should be avoided because of the increased risk of slippage and	**8** **AO3** **2 x 1a** **AO3** **2 x 1b** **AO4** **1 x 1a** **AO4** **1 x 1b** **AO4** **1 x 2a** **AO4** **1 x 2b**	If a candidate only discusses anthropometrics, they can only access marks up to Level 1. Examples may include examples of ergonomics having a beneficial or constraining effect on the design of products. Candidates can draw on practical experience of iterative designing and product analysis to support their response to this question. Candidate operating at Level 3 will access all of the AO4 (1a/1b/2a/2b) marks and at least one of the AO3 (1a/1b) marks. Candidate operating at Level 2 will access at least half of the AO4 (1a/1b/2a/2b) marks and at least one of the AO3 (1a/1b) marks. Candidate operating at Level 1 will access the AO4 (1a/1b/2a/2b) marks.	**Level 3 (6–8 marks)** Candidate produces a thorough discussion of the importance and influence of ergonomics in product design. Candidate shows a mature understanding and analysis of the issues in the question using appropriate and well-considered examples to inform their response. This creates a discussion that is both cohesive and well-considered. **Level 2 (3–5 marks)** Candidate produces a sound discussion of the importance and influence of ergonomics in product design. Candidate shows a reasonable understanding and analysis of the issues in the question using adequate and for the most part well-considered examples to inform their response. This creates a discussion that is for the most part well-considered. **Level 1 (1–2 marks)** Candidate demonstrates a basic knowledge of the importance and influence of ergonomics in product design. Any understanding is limited with little consideration of issues raised in the question.

Question			Answer	Marks	Guidance	
					Content	Levels of response
			rotational wrist damage. Padding handles reduces the force needed to grip the tool. The effect of tool weight is also a factor. Use of rests, supports, two hand grips, etc. can all help to decrease the effort required to use heavy tools. When only right-handed users are considered, left-handers may be at an increased risk of injury. • Reference to a mobile phone as an example. The layout of the buttons is important – they should be the right size and distance apart, and the right size text, colour and level of illumination to be read in different locations, and accessible by able-bodied and those with impairments (such as eyesight, hearing, dexterity, mobility and memory). Smartphones have different 'accessibility' settings for these so that users can find the touchscreen layout that suits them best. The volume of ringtones and the way the phone vibrates also affect is usability, and a variety of settings are now a common feature to accommodate a wide range of users. • Reference to the design of work-based products (e.g. seating, computers, machinery and equipment) so that tasks consider ergonomics. Some of the main biomechanical principles to consider in product design are: • Joints must be in a neutral position. • Keep the work close to the body. • A twisted trunk strains the back and upper body. • Sudden movements produce peak stresses.			There is no analysis or evaluation. **Level 0 (0 marks)** No response or no response worthy of credit.

Question			Answer	Marks	Guidance	
					Content	Levels of response
			• Alternate postures as well as movements and positions. • Limit the duration of continuous movement. • Prevent muscular fatigue. • Frequent short breaks are preferred to one long break. • Limit energy expenditure in individual tasks. • After heavy tasks, rest is essential. **Reference to constraints such as the following in the discussion:** • A wide plethora of adjustments and alternative settings in products can create confusion. The elderly and those with impairment will invariably need assistance to understand and make such adjustments. • The design of products for the workplace that are 'healthy' do not necessarily result in tasks being completed in the shortest times. For example the wearing of safety equipment and the following of safety procedures will all add time to the actual task. This adds costs, but the importance of applying ergonomics is crucial over the long term. • 'Adjustment' is a major feature in designs, but even applying 5th to 95th percentiles does not cover every person and situation. 'Mr Average' is often a long way from the person carrying out the task. **Award credit for any other appropriate response**			

Assessment Objectives (AO) grid

Question	AO3	AO4
1ai		2
1aii		2
1b		4
1c		2
1d		4
1e		4
1f	2	4
2a		2
2b	1	2
2ci		3
2cii	2	
2ciii	2	3
2civ		3
3a		2
3b		2
3c*	4	4
4ai		2
4aii		6
4aiii		8
4b		2
4c	4	4
Total	15	65
Overall	80	

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