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Cambridge National

Engineering

Unit **R105:** Design briefs, design specifications and user requirements

Level 1/2 Cambridge National Award/Certificate in Engineering Design

Mark Scheme for January 2016

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Question			Answer/Indicative content	Mark	Guidance
1	(a)		One mark for each correctly joined client requirement with suggested product feature **Client requirement** — **Suggested product feature** Must connect with mobile devices → 3m extendable cable Must allow the user a good range of movement when wearing the headphones → Made from high impact plastic Must block out external noise → Standard 3.5mm headphone jack Must be easy to store and carry → Seal well around the ears Must be durable and withstand being dropped → Foldable hinge	4	No marks for more than one line to one product feature

Question			Answer/Indicative content	Mark	Guidance
	(b)		One mark awarded for **each** valid point • Corporate branding/logo (1) could be printed/added to the head band or side of headphone (1) • Logo/Trademark/symbol could be embossed into the plastic moulding (1) • Position of the corporate brand (1) • Headphones could be produced in the corporate colours/pattern of the company (1) • Headphones could be designed in the style of the companies well known products (1) • Headphones could be packaged in corporate branded boxes/packaging (1) • Obvious company style (1)	2	
	(c)		One mark awarded for **each** valid point o Customer surveys (1) o Questionnaires (1) o Focus groups (1) o Interviews with possible customers (1) o Analyse existing products (1) o Market research (1) o Investigate current fashion trends (1) o Investigate current buying trends (1) o Online research (1)	2	Do not award “Primary / Secondary”.

Question			Answer/Indicative content	Mark	Guidance
	(d)		Up to two marks for a clear description or two marks for two valid examples • The choice of material (1) might vary due to the supply cost (1) • The choice of material might change (1) due to the cost of manufacture (1) • The complexity of the designs shape (1) may change due to how expensive it is to make • The tooling cost (1) might make certain designs too expensive to make (1) • The quality of electrical components (1) might change due to the cost of the components (1) • The use of new technologies (1) • The surface finish (1) of the material might change if the processing production costs are too high (1)	2	Accept other feasible and valid response Award two marks for two examples included in the explanation e.g. change of material (1) cost of components(1)

Question			Answer/Indicative content	Mark	Guidance
2	(a)	(i)	Award **one** mark for valid responses that may include; • must be easy to charge up • must be easy to keep clean • must be lightweight • must be easy to switch on and off • must stand up when not in use • must be waterproof • must be energy efficient/long battery life/rechargeable • must have changeable/replaceable head • must have texture to make easy to grip • could come in different head sizes i.e. 1 for children, and 1 for adults • must be available in a range of colours	2	Only accept answers related to the topics listed Generic points such as 'looks good', 'not too heavy', 'appealing to the target market', should be quantified with reference to specific features, usability or design specification topics listed in indicative content. Marks can also be awarded for points related to the areas below: User needs Product requirements Manufacturing considerations Production costs Regulations and safeguards Do not award marks for being able to clean teeth or fit in the mouth.

Question			Answer/Indicative content	Mark	Guidance
		(ii)	Up to four marks awarded for a clear explanation that exemplifies any of the points listed above. For example: • The electric toothbrush has a charging station and clip on charging port (1) therefore it can be easily located in the dock when charging. (1) • The casing of the toothbrush is made from smooth plastic that can be wiped with ease (1) and the head is removable to allow the user to wash it (1). • The toothbrush features an easy to operate push button (1) that is easy to reach and allow the user to change modes/settings. • The electric toothbrush is easy to switch on and off **because** the press button is easily reached by the thumb, (1) textured for feel and different sizes for on and for off for easy recognition without looking. (1) • Easy to stand up when not in use **because** it has a smooth flat, relatively wide base, (1) and a low centre of gravity (heavy battery is at the bottom). (1)	4	Up to three marks for a clear explanation of 1 design specification point. Do not award marks for being able to clean teeth or fit in the mouth. Allow "ECF" from 2(a)(i) where the specification point was not valid.

Question			Answer/Indicative content	Mark	Guidance
	(b)		Up to two marks for a clear description of the process		Accept other valid responses Only accept 'prototype' 'model' in the optimise phase.
		(i)	Design • The designer will produce a design specification (1) from the clients brief and then produce a range of initial designs (1) • The designer will produce a range of initial designs (1) and then develop these designs into a final design for the client (1) • The designer will generate sketches (1) of what the product will look like and then use CAD to produce the final design (1) • The designer will produce a design for the product (1) and then use this design to produce manufacturing plans (1) for the production of the product	2	Accept references to 'final' design'.
		(ii)	Optimise • The designer will produce a prototype of the final design (1) to check the fit/function/aesthetics of the design (1) • The designer will produce virtual models of the design (CAD) (1) • The designer will produce a range of prototypes (1) to ensure there are no errors (1) in the design • The design will be checked for errors in design (1) or possible production issues (1) • The designer will ensure that the design is error proof (1) • Make improvements to the design (1) based on client feedback (1) • Error proofing (1) will be carried out to ensure the design can be manufactured/assembled (1)	2	Do not accept "See if it works". Do not accept references to "testing".

Question			Answer/Indicative content	Mark	Guidance
3	(a)		Up to two marks for a clear description or two marks for two valid examples in each part of the question Product safety • The design has been made strong enough (1) to withstand prolonged use (1) • The design is made from durable materials (1) that will not break under continual use (1) • The chair has rounded corners (1) to ensure no sharp edges (1) • The chair will be used by children (1) and therefore must conform with safety standards (1) • The chair has a wide base/four legs (1) to ensure it is stable (1) Cost of production • The chair needs to produced in high volumes (1) therefore moulded plastic has been used (1) • The chair needs to be mass produced so a single piece injection moulding (1) reduces cost at high volumes (1) • A single piece design (1) reduces the cost of additional components (1) • The minimum number of components have been used in its production (1) reducing the product cost (1) Ergonomics • The chair seat is a specific height from the ground (1) so it is comfortable to sit on (1) • The height of the back rest (1) is a suitable height for the user (1) • The shape of the seat and back rest (1) are sculpted to support the user (1) • The chair has four legs (1) to ensure it is stable when being sat on (1).	6	Accept other valid or similar responses Answers should relate to the features of the chair that influences the cost of production.

Question			Answer/Indicative content	Mark	Guidance
	(b)		Up to two marks for a clear description. • The product is to be used daily for long periods of time and must therefore be designed to be durable (1) and last for a long length of time (1) • The plastic utilised in its production is sourced from recycled material (1) and is subsequently recyclable again at the end of its life (1) • The product can be produced in high volumes (1) with small levels of energy consumption per product (1) • The product can be easily recycled at the end of its life (1) • The product can be stacked for reducing transportation and impact on the environment.	2	Accept other feasible and valid response
	(c)		One mark awarded for **each** valid point • Must withstand prolonged use • Must be able to be stacked for storage • Must withstand the weight of an adult • Must not topple over/stable • Must be recyclable • Must be comfortable • Must be made from a material that is resistant to spillages • Must be durable • Must be lightweight/portable.	2	Accept other feasible and valid response

Question			Answer/Indicative content	Mark	Guidance
4	(a)		One mark awarded for **each** valid point • High volume production (1) • Low cost manufacturing (1) • Flexibility of the material (1) • Allows the clip to bend when it clips together (1) • Will last a long time (1) • Will withstand repeated use (1) • Clip together lots of times (1) • Easy to mould complex geometry (1) in single process (1) • In use, the clip will be lightweight (1) easy to close and to open, yet long lasting. (1) • Withstand corrosion (1) • Lightweight (1) • Recyclable (1) • Durable (1)	2	Accept other feasible and valid response Only accept 'cheap' if validated by 'to manufacture' or 'high production volume' or similar Do not accept "strong" unless qualified … and won't break easy (1)
	(b)		One mark awarded for **each** valid point • Cost of production (1) • Design/geometry must be able to be produced (1) • Single piece moulding for each part of the clip (1) • All the edges are rounded highlighting the moulding process (1) • Injection moulding allows large numbers to be produced (1) • Clips need to be cheap to produce so must be manufactured in a cost effective way (1) • Cost per component is important so single piece moulding used (1) • Each part is complex but made in one piece reducing component production cost when produced in high volumes (1)	4	Accept other feasible and valid response

Question			Answer/Indicative content	Mark	Guidance
			• The webbed design of the two parts of the clip create very strong structures (1) using the minimum amount of material so this is very cost effective. (1) • The moulding process for the plastic can be very precise and reliable (1) so reducing waste from any reject mouldings and so saving materials and production costs. (1) • Can be molded in a variety of colours (1).		
	(c)		Up to two marks for a clear explanation. • High cost of tooling (1) is offset by large quantity of components produced at low cost (1) • Initial investment is high (1) but cost per product is cheap (1) • Machinery is expensive (1) so high volume production offsets the capital investment (1) • The cost of material becomes cheaper when parts are produced in large quantities (1) because the material can be ordered in larger amounts. (1) • High volume production is used in the production of plastic products in order to reduce unit costs (1) by creating mould tools that allow for the replication of large quantities of components (1) • High volume production allows for bulk buying of materials (1) this reduces manufacturing costs. (1)	2	Accept other feasible and valid response

Question			Answer/Indicative content	Mark	Guidance
	(d)		Up to two marks for a clear explanation. • Limited availability of material would stop production (1) • If suppliers did not deliver material on time (1) then production could be affected (1) • A regular supply of material is important because large quantities of parts are being made (1) this ensures that production is not interrupted due to shortage of material. (1) • If material is not available in large quantities the cost of the product can increase (1) • Many high volume production environments use Just-In-Time (JIT) (1) production methods which are not effective if material is not easy to source (1) • The manufacturer may not be able to store large amounts of raw materials or completed components (1) so they need to be able to rely on regular deliveries of materials in order to maintain production levels.	2	Accept other feasible and valid response

Question			Answer/Indicative content	Mark	Guidance
5	**(a)**	**(i)**	One mark awarded for **each** valid point • Nuts • Bolts • Screws • Bearings • Washers • Gears • Bushes • Motors • Fuses • Pins • Cable/wire • Electronic components.	2	Accept other feasible and valid response Any fastener, connectors, terminals. Do not accept “plug”.

Question			Answer/Indicative content	Mark	Guidance
		(ii)	Up to two marks for a clear explanation • Standard tools like drills or taps can be used in production (1) this means that tooling is easy to source/replace at reasonable cost. (1) • Reduction of the numbers of parts that need to be produced (1) meaning inventory and tooling/machining costs are optimised. (1) • Components can be produced or purchased in high volume (1) which reduces the cost per component (1) • Components are available at a reduced price (1) due to the large quantities they are produced in. (1) • Components are reliable (1) and result in little waste or scrap after assembly (1) • Parts are reliably available which means less time is lost in production (1) due to inability to source components (1) • Standard components are made in large quantities by one manufacturer (1) so they are extremely accurate and reliable (1) and available to bulk buy at low unit cost. • It is not cost effective for a manufacturer to produce their own little components (1). This would require work space, storage, skilled labour, machinery and quality checking. (1) This could lead to higher manufacturing costs, possible wastage and rejects (1)	4	Accept other valid responses

Question			Answer/Indicative content	Mark	Guidance
	(b)		Up to three marks for a clear explanation. • By ensuring that the design of components/products allows them to be easily taken apart and disassembled. (1) This might be achieved through the use of standard parts (1) or allowing disassembly to be achieved using common tools. (1) • Design products that have easily accessible components (1) this will allow them to be easily removed or changed (1) in turn, improving the maintainability of the product. (1) • Use standard parts (1) so that tools for removing key fastenings can be easily sourced (1) and parts replaced if necessary (1) • Use temporary fasteners (1) not clip together components (1) or permanent fixings such as adhesive or welding. (1) • Use non-permanent fixing methods (1) such as nuts/bolts/screws not welding or adhesive/glues (1) allowing the components to be repeatability disassembled. (1) • Use readily available components (1) that can be purchased easily should they need replacing (1) reducing the complexity and cost of maintenance (1) • Designers may include instructions provided with the product (1).	3	Accept other valid responses

Question			Answer/Indicative content	Mark	Guidance
	(c)		Up to three marks for a clear explanation. Examples and relevant points could include: • Creating components to absolute dimensions would cost too much • Manufacturing processes mean that there is always variation in dimensions and designers have to consider this • There is always an acceptable variation that can optimise a components production cost • It gives the customer confidence that the component will for no matter what • The application of the component will define its tolerance • Manufacturers can still have confidence that standard components will work/fit (1) as they know acceptable tolerances worked to (1)	3	Accept other valid responses

Question			Answer/Indicative content	Mark	Guidance
6	(a)	(i)	One mark awarded for a valid modern material and one mark for an example product • Composites e.g. Carbon fibre - Automotive/Motorsport applications – e.g. race car components, formula 1 / rally cars, drive shafts, - Aerospace e.g. aeroplane parts, Drones/UAVs (Unmanned Aerial Vehicles) - Electronic casings e.g. phone cases, laptop covers - Model aeroplanes or cars e.g. body shells, chassis - Marine e.g. yacht, catamarans, kayaks - Sport e.g. cycle design, bobsleigh, skis - Medical e.g. prosthetics • Smart materials e.g. - memory metals e.g. glasses design - thermochromic materials/paints e.g. heat safety in children/baby products, motorsport applications to check heat dissipation • Advanced metal alloys e.g. - Titanium alloys e.g. aerospace, high performance automotive applications • Environmentally safe/sustainable materials e.g. - Starch based polymers e.g. automotive components, sustainable housing - Sustainable forest material e.g. building materials - Recycled material e.g. playground rubber flooring from recycled tyres, insulation from recycled plastic/paper	2	Accept other valid examples and products Do not accept ‘composite’ or ‘smart material’ unless exemplified with an example e.g. composite – carbon fibre

Question			Answer/Indicative content	Mark	Guidance
		(ii)	Up to two marks for a clear description Composite materials – • Carbon fibre is light weight (1) and has higher strength. (1) • Due to its lighter weight (1) carbon fibre can improve performance in given applications such as improved speed, acceleration or reductions in fuel consumption. (1) • Carbon fibre can help reduce energy usage (1) this is due to its lighter weight (1) therefore less energy is required to move or transport objects. (1) Accept reference to benefits e.g. • Properties e.g. strength (1), weight (1), ability to be formed/processed (1) • Improved performance of products e.g. energy efficiency (1), faster due to lighter weight (1), safety due to strength/rigidity (1) Smart materials e.g. • Memory metals can be used to help the durability of products (1) such as the design of glasses that resist being bent. (1) • Thermochromic materials or coatings can improve safety (1) and help to alert users to changes in temperature. (1) Accept reference to benefits e.g. • Safety features, reduction of additional components due to smart applications (1), reliability of materials due to the ability for self-repair or non-permanent damage to product (1). Advanced metal alloys e.g. • The use of advanced metal alloys has allowed high-end production applications to achieve better strength/conductivity properties (1) with lower weight (1)	2	Allow ECF from part 6 (a) (i) i.e. inappropriate material given in part (a) (i).

Question			Answer/Indicative content	Mark	Guidance
			Accept reference to benefits e.g. • Properties e.g. strength (1), weight (1), rigidity (1), tensile strength (1). • Improved performance e.g. lighter weight (1), conductivity (1), heat resistance (1). Sustainable materials e.g. • The use of starch based polymers means that components that were usually made in traditional plastic are now biodegradable (1). • The use of sustainable forest material ensures that tress are continually replanted (1) minimising the impact on depleted forests (1).		

Question			Answer/Indicative content	Mark	Guidance
	(b)		Award up to six marks for a discussion of the impact of sustainable design on the development of a new product. **Level 3 (5–6 Marks)** Learners provide a thorough discussion of the impact of sustainable design on the development of products. They show a clear understanding of the required question material. Specialist language and terms would be used in the appropriate areas being discussed and the required information will be well structured in its presentation. Good examples used to justify the impact of sustainable design on products. Learners will demonstrate an accurate level of spelling, punctuation and grammar. **Level 2 (3–4 Marks)** Learners provide an adequate discussion which shows a reasonable level of understanding of the impact of sustainable design on the development of products. Some examples used to justify the impact of sustainable design on products. Some evidence of the use of specialist language although not always in the appropriate areas being discussed. Information, for the most part, will be reasonably structured but may contain occasional errors in spelling, punctuation and grammar. **Level 1 (1–2 Marks)** Learners provide a basic discussion which shows some understanding of the question material but uses little or no specialist language. Few or no examples used to justify the impact of sustainable design on products. Answers may be ambiguous or disjointed. Contains obvious errors in spelling, punctuation and grammar 0 marks = no response or no response worthy of credit. Annotate as 'Seen' at end of the response.	6	Examples and relevant points could include. Resource depletion: • Energy efficient power in the product minimises the use of fossil fuels for power sources • Materials used do not add to the depletion of resources Renewable resources: • Renewable energy sources can be used to power the product • Materials are used from renewable sources • Renewable energy is used to generate power during production • Renewable energy is used to power the vehicles used for distribution or transportation of the product Energy efficiency: • Product is designed to use as little energy as possible during its life • Production is optimised to use as little energy as possible Disposal: • Product can be disassembled and disposed of at the end of its life • Materials and components can be recycled/reused Life cycle: • Where materials are sourced from • The energy used in their production • The energy used by the product throughout its use • Maintenance throughout the products life – ease of disassembly • The end of the products life – disassembly, recycling, reuse • The carbon footprint of the component is considered throughout design, production, use and end of life

Question			Answer/Indicative content	Mark	Guidance
					Materials: • Source of materials • Use of recycled materials such as plastic • Lightweight materials to improve energy efficiency • Renewable resources • Materials used minimise resource depletion • Materials used that reduce waste Energy usage: • Product uses energy efficient components • The carbon footprint produced throughout production • Production: • Production processes are selected that minimise energy use • Energy efficient production processes may affect the geometry of components • Products are designed to be packaged in an optimised way reducing transportation and logistics requirements PR/Consumers: • The consumer may value sustainable design and pay more for the product • The sustainable nature of the design may lead to different product choice by the customer • The company can present a responsible image

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