GCE

Design and Technology

H406/01: Principles of Product Design

Advanced GCE

Mark Scheme for June 2019

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Annotations

Annotation	Meaning
BP	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 (not used on level Qs)
BOD	Benefit of doubt
SEEN	Noted but no credit given
L1	Level 1 response
L2	Level 2 response
L3	Level 3 response
ECF	Error carried forward
RE	Rounding error
highlighter	A line is highlighted next to relevant part if only part is answering Q

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.

Question			Answer	Mark	Guidance
1	(a)		Possible design features may include: • Compact size (1): as it will need to be carried around in a pocket or handbag for spontaneous use (1). • Adjustable length of the stick (1): so the user can chose different angles or distances for the photographs/ videos (1). • Adjustable phone mount (1): so that different cameras of different sizes can be used (1). • There are no loose components, (1) all components of the selfie stick are joined and ready to be opened and adjusted so it can be put up quickly to capture a spontaneous moment (1). • Easy to reach button (1): enables the user to comfortably capture the image while holding the stick with one hand (1). • Any other valid suggestion for given context. .	**4** No marks for simple one word responses. Must be in relation to functionality. No marks for stating a part given on diagram e.g. handle	In each case: One mark for analysing **Fig. 1** to identify a design feature that ensures the selfie stick functions as intended. One mark for justifying why this design feature supports functionality. The responses **must** be taken from **Fig. 1**. Specific reference to the context in the question is needed for marks to be awarded.
1	(b)		Possible metals may include: • Aluminium/aluminium alloy (1) lightweight material that would make the selfie stick more comfortable to hold in one hand (1)/ Good strength to weight ratio (1) • Stainless steel (1) corrosion resistant so wouldn't rust if the selfie stick was used outside in damp conditions (1) • Any other valid suggestion that makes material suitable for the given context.	**2** No marks for strong/ cheap unless **justified.** Credit can be awarded for aesthetics if justified.	One mark for identifying a suitable metal. Cast iron and mild steel are unsuitable. One mark for explaining why this metal would be used for the telescopic pole of the selfie stick.

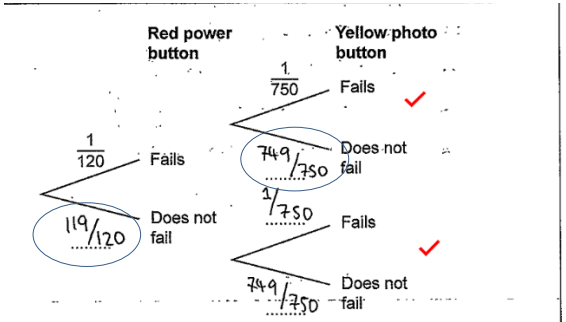
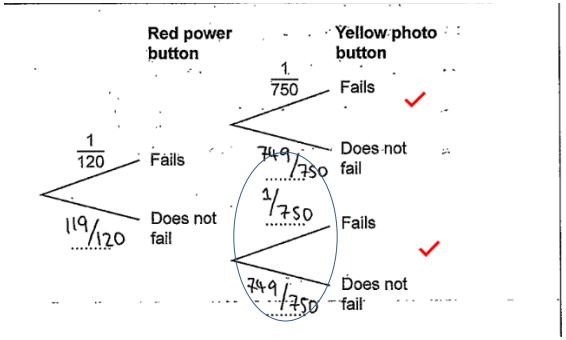
1	**(c)**		Total pole length: 585 – 116 = **469 mm** (1). Length of one section: 469*/7 + 3 = **70 mm** (1). Alternative method: (469* + (7x3)) / 7 = **70 mm** (1)	**2**	Award two marks as follows: One mark for calculating the total pole length. One mark for calculating the length of one section of the telescopic pole. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. *Allow error carried forward (ECF) where correct working out is shown.
1	**(d)**		Possible advantages to the designer may include: • The initial design can be modelled very quickly and initial feedback from stakeholders given (1) to give the designer confidence in the direction of the design and saving time and money (1). • Increases reliability of the selfie stick as the design or parts of the design can be repeatedly tested and improved (1) to make sure that they function correctly and safely e.g. the optimum length of the telescopic pole (1). • The designer can set up focus groups/user testing and allow hands on testing in context (1) to get feedback about aesthetics/ergonomics/ usability/how to improve the design (1). • The designer can experiment in CAD models on screen to explore different finishes and materials for the handle (1) with minimal cost	**6**	In each case: Up to two marks for explaining an advantage of using iterative models when developing the design for the selfie stick. Specific reference to the context in the question is needed for marks to be awarded. **Referring to three**

			and material waste (1). • Using inexpensive modelling materials saves money/time (1) rather than making final fully working prototypes (1) • The designer can test the comfort and ergonomics of handle design with different users with a range of block models (1) to ensure that they can comfortably reach the capture button and help to decide on the most successful design (1). • Any other valid suggestion for given context.		**advantages of modelling.**
1	**(e)**		**Indicative content:** How the design and manufacture of the selfie stick could be optimised to keep costs as low as possible may include: • Using standardised parts. Off the shelf parts for the telescopic pole, fixtures and button could be used to save parts being manufactured. This would save on tooling costs and reduce the cost of the product as they could be bought in in bulk and low cost. • Explore alternative materials that could reduce cost/quantity of materials without compromising quality, for example the telescopic pole could be stainless steel rather than anodised aluminium to reduce the costs. • Product size. The overall product size/ wall thickness of the materials could be reduced to keep costs low. This could include more thoughtful design that incorporates reinforced mouldings with webbing etc. • Replaceable/changeable parts for phone updates and to be suitable for use with different models/ brands of phones. • Integral fixtures. The parts of the handle could be designed to snap together when assembled, reducing the need for additional screws which could cost money to purchase and labour to fit. • Reduction in different materials. The design could be simplified to remove the metal band in image C, and replace it with the same material as the rest of the handle. This would reduce the number or stages in production reducing cost and time of manufacture. • Using CAD software 'finite' element analysis to see where it is	**6** For MB3 to be awarded there will be two or three ways in which optimisation could be introduced are discussed. If candidate does not provide an analytical/evaluative response then only L1 can be awarded.	**Level 3 [5-6 marks]** The candidate has a clear understanding of optimisation. They produce a thorough discussion in relation to the question by explaining a number of ways in which the design and manufacture of the selfie stick could be optimised to keep costs as low as possible. The explanation of ways in which optimisation could be introduced is clear and well-developed and different perspectives are used to exemplify the points being made. **Level 2 [3-4 marks]** The candidate has a reasonable understanding of optimisation. They produce a sound discussion in relation to the question by explaining a number of ways in which the design and manufacture of the selfie stick could be optimised

			possible to remove material without compromising strength when different parameters are set. • Any other valid suggestion for given context.		to keep costs as low as possible. The explanation of ways in which optimisation could be introduced is sufficient although one or two opportunities are missed in providing different perspectives. **Level 1 [1-2 marks]** The candidate has a basic knowledge of optimisation. Any reference to ways in which optimisation could be introduced is largely descriptive in nature. The response contains no analysis or evaluation. **0 marks** No response or no response worthy of credit.
1	**(f)**		Possible ways may include: • Bluetooth technology on phones enabled the user to capture a photograph out of reach of the phone itself (1). This meant that people could increase the number of people in the photograph or the angle that the photograph was taken, changing the way that people recorded events in their lives (1). • Camera and video technology becoming smaller and lower cost (1) meaning that they could be integrated into products and has fed into the culture of user generated content such as you tube and social media (1). • GPS technology in products such as activity trackers (1) that encouraged healthier lifestyles as they can track exercise and set	**6**	In each case: Up to two marks for describing one way in which past and present technologies have influenced the products Answer could be in the context of a selfie stick or an alternative product, as long as the context is clarified.

			fitness goals (1). • Telescopic poles are used in a variety of different products e.g. umbrellas, fishing rods (1) the designer is utilising a mechanism that they already know to be successful. (1) • Any other valid suggestion for given context. • Current design thinking may include sustainable design, inclusive design, reference to historical or present design thinking e.g. form follows function.		

Question			Answer	Mark	Guidance
2	(a)		Upper bounds calculated: = 30.5 = 60.5 (1) Area calculated: 30.5x 60.5 = **1845.25 mm^2** (1)	2	Award two marks as follows: One mark for **recognising both upper bounds**. One mark for calculating the area of the rectangle **using the upper bound**. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. Upper bounds will have to be accepted within the following ranges: 30.49 - 39.50 60.49 – 60.50
2	(b)		75 x 60 = 4500 minutes 4500*/3 = 1500 days (1). 1500*/365 = 4.1 = approximately 4 years (1).	2	Award two marks as follows: One mark for calculating the number of minutes in 75 hours and for dividing this number by 3 to get the number of days. One mark for dividing the number of days by 365/364. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. Accept 4 years, 4.1 years but not 5 years.

					*Allow error carried forward (ECF) where correct working out is shown.
2	**(c)**	**(i)**	Probability that red power button does not fail is $\frac{119}{120}$ Probability that yellow photo button does not fail is $\frac{749}{750}$ (1).  On the lower branch where the red button does not fail: Probability that yellow photo button does fails is $\frac{1}{750}$  Probability that yellow photo button does not fail is $\frac{749}{750}$ (1).	**2**	Award two marks as follows: One mark for correctly calculating the probability if the button does not fail for both the red and yellow button. One mark for having the lower branch of the yellow photo button matching the upper branch, yellow responses do not depend on red button probabilities. The whole tree should be completed for the 2 marks
		(ii)	$\frac{1}{120}$ x $\frac{1}{750}$ (1) = 0.00001.. or $\frac{1}{90000}$ (1)	**2**	Award two marks as follows: One mark for recognising that the two fractions need to be multiplied together. One mark for calculating the correct answer (accept answers that round to 0.00001.

2	**(d)**		Possible ways may include: • Position of frequently used buttons (1) for easy reach while still holding the control (1). • Colour of the buttons to indicate function and improve usability (1) e.g. red for off on the power button (1). • Raised areas on the buttons/ button shape (1) to help identify function without having to look (1). • Size of the buttons related to buttons (1) used more frequently being bigger e.g. Vol. (1). • Spacing in between the buttons (1) so that the average finger can press each one individually without pressing the one next to it (1). • 'Standard' colours used that are used on other controls to aid recognition (1) and to follow colours used on the TV menus and control screens (1). • Direction of movement of volume rocker button – up is increase, down is decrease (1) Following natural movement and usual orientation in products to avoid confusion (1). • Any other valid suggestion for given context.	**4**	In each case: Up to two marks for describing one way in which ergonomic factors would be considered when designing the buttons on the remote control. Specific reference to the context in the question is needed for marks to be awarded. If context of a remote and ergonomics is covered without direct reference to the buttons – max 1 mark Do not except simple statements for example, Easier to use unless, unless qualified.
2	**(e)**		Angle = 90° (1). Radius= 30-16 = 14 mm (1). Length of quarter circle = 2π14* x 90*/360 = 21.99 (1). Length of arc = (21.99 – 2) = 19.99 mm (1).	**4**	Award four marks as follows: One mark for identifying the angle that needs to be used in the equation. One mark for calculating the radius of the outer circle. One mark for applying the formula correctly to calculate the length of the arc for a quarter of the circumference of the circle. One mark for taking into account the gaps in between the arcs and removing 2mm, to two d.p.

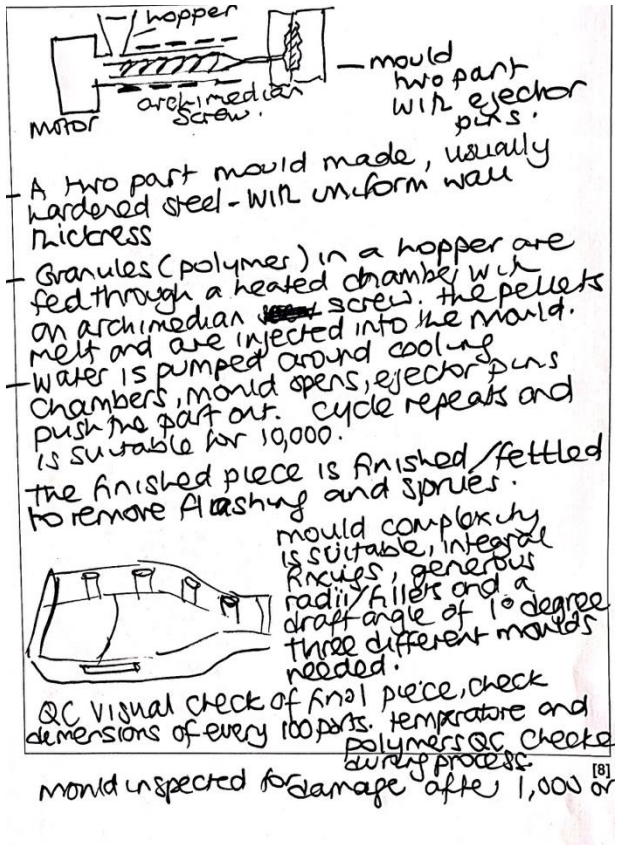
					If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. If 20mm (rounded up) is given award max 3 marks working out must be shown to support this. Alternative methods of calculation are acceptable. *Allow error carried forward (ECF) where correct working out is shown.
3	**(a)**		Possible responses may include: Life Cycle Assessment (LCA) is used as a tool to assess the environmental impacts of a product at each stage, from the extraction of raw material and disposal (cradle to grave) (1) the impact of the product while it is being manufactured (1) transported/distributed (1) and disposal at the end of life (1). • Any other valid suggestion for given context.	**4**	Up to four marks for describing what is meant by the term LCA. This is a definition style question and therefore mark on the basis of any valid points being made. Any stages identified or described in detail are worthy of credit. Maximum of 3 marks for identifying basic stages. No credit awarded for product lifecycle.
3	**(b)**		**Indicative content:** The importance of the LCA and its **influence** on design practice may include: Increases designer's awareness of environmental impact of their product as they have to consider every stage of its life. As concerns about global warming are rising it gives them	**8**	**Level 3 [6-8 marks]** The candidate has a clear understanding of the importance of the LCA. They produce a thorough discussion in relation to the question by explaining how the LCA influences design practice. The explanation of influences is clear and well-developed and a number of examples are used to exemplify the points being made.

			the responsibility of reducing the carbon footprint of their product. • Finite resources will eventually run out so designers are encouraged to select materials that can be sustainable or recycled. *Example:* FSC wood. • Raw Materials need to be processed and that uses energy which contributes to global warming, so designers are encouraged to use recycled materials, or select ones that need less processing *Example:* Car tyres being used for artificial turf. • Waste from products are polluting the planet. The pollution from the use of the product is highlighted in the LCA and designers can build in features to reduce the impact of that pollution. *Example:* Electric car. • Manufacturing processes create pollution and waste, which contributes to climate change. Alternative manufacturing processes would be considered and selected to reduce waste or reduce stages in manufacture. • Transporting materials uses finite resources and increases the carbon emissions. To reduce this designers/manufacturers could produce the product with local materials or relocate the factory to near the material source. Similarly, move assembly plant / factory near to where most sales take place, and where many components are manufactured. *Example:* JLR building an assembly plant for their cars in China. • Energy used during the products life, some products use electricity and energy during their use. • When a product is obsolete it is thrown away and can end up in landfill or in the oceans. It is then harmful to wildlife and takes a long time to degrade.		**Level 2 [3-5 marks]** The candidate has a reasonable understanding of the importance of the LCA. They produce a reasonable discussion in relation to the question by explaining how the LCA influences design practice. The explanation of influences is sufficient although one or two opportunities are missed in referring to different examples. **Level 1 [1-2 marks]** The candidate has a basic knowledge of the importance of the LCA. Any reference to this issue is descriptive in nature and has little appreciation of how the LCA influences design practice. The response contains no analysis or evaluation. **0 marks** No answer or answer not worthy of credit.

			The number of parts and different materials of the design could be reduced and clearly labelled to aid recycling. The materials that are used could be ones that naturally breakdown in the environment. *Example:* creating bamboo toothbrushes rather than plastic ones. • Reference might be made to the circular economy and design for disassembly. • Any other valid suggestion for given context.		

Question			Answer	Mark	Guidance
4	(a)	(i)	Possible thermopolymers may include: • ABS (1). • Polypropylene (1). • Any other valid suggestion for given context. If the answer provided by the candidate is ABS: • High impact resistance so it will withstand being knocked into walls or obstacles (1). • Stiff so unlikely to bend or misshape when the hover board is in use (1). • Excess material (flashing/ sprues) can be melted down and is easily recycled (1) • Any other valid suggestion for given context.	**2** No marks for strong/ cheap/ recycling unless justified	One mark for identifying a suitable thermopolymer. One mark for explaining why this thermopolymer would be used in the manufacture of the components of the outer shell of the hover board. Acrylic is not acceptable as too brittle
		(ii)	The only manufacturing processes that is suitable for this product is: • Injection moulding (1).	**1**	One mark for identifying a suitable manufacturing process for the components of the outer shell of the hover board.

		(iii)	**Indicative content:** The candidate is expected to demonstrate their understanding of the process related to the given product through a series of annotated sketches and/or notes. Max Level 1 marks if it the process is incorrect from part (ii). a max of 2 marks can be awarded for mention of relevant stages – i.e heating of polymer granules, any detail of a two part mould, removal of flash and relevant QC checks etc For Level 3 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, refer to the mould (made of harden steel for batch of 10,000, uniform wall thickness to keep cycle time to a minimum, the mould has radii/ fillets as sharp corners are avoided and draft angles of at least one degree, holes produced using core pins. Process: • **Polymer granules** added to **hopper.** • The granules are heated by heaters as they are rotated. An **archimedean screw** revolves granules and become **molten.** • A **hydraulic ram** injects the molten polymer into a mould via a **sprue**. • The **mould/die** is the shape of the component/s for hover board shell, it is likely to be multiple moulding per cycle with one sprue feeding several components. • **Cooling ducts** through the mould/die for water cool the mould. • The mould is opened. • The moulding is ejected via **ejector pins**. • The **sprue** and any **flash** is removed. • The mould/die is cleaned using compressed air. • The process is repeated. QC checks might refer to monitoring of temperature throughout cycle, checks of moulds after 1,000 uses, inspection of final moulding, removal of	**8** All processes demonstrated must relate to the hover board.	**Level 3 [6-8 marks]** The candidate demonstrates a good level of detail of the process needed to manufacture the components of the outer shell of the hover board using technical terms and considering any relevant specialist tooling (mould detail is relevant to the product) and quality control checks. Sketches, if used will be clear and supported with relevant notes. The 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 components of the outer shell of the hover board using some technical terms and there will be some consideration of any relevant specialist tooling/ moulds and/ or reference to 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 components of the outer shell of the hover board with a limited use of technical terms and there will be a basic consideration of any relevant

			sprues, flashing etc • Quality of the plastic could be checked at both the hopper and when it has been formed. • The colour of the final moulding is checked against a sample. • The thickness of the end product is checked. • Any imperfections could be checked to ensure the plastic has flowed correctly. • Moulded components placed on a 'template' or 'jig' to check positions of critical openings and fixing holes.  	exemplar of a typical high level response	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.
		(iv)	Possible ways may include:	**4**	In each case:

			• The design includes integral fixings to join the two parts together (1) this minimises assembly and gives greater accuracy (1). • The shell is screwed together which means the product can be dismantled (1) and then can be repaired, or parts re-used (1). • The design is symmetrical (1) so it minimises any re-orientation of each section when the product is being assembled (1). • Any other valid suggestion for given context.		Up to two marks for describing one way that the responsibilities and principles associated with designing for manufacture (DFM) have been incorporated in the design of the outer shell of the hover board. Specific reference to the context in the question is needed for marks to be awarded. Do not accept simple statements such as, makes it faster/quicker, unless qualified.
4	**(b)**		Speed = distance/time (1). 2.4 / (20/60) = 7.2km/h (1). 7.2* x 1000 / (60 x60) = 2 m/s (1).	**3**	Award three marks as follows: One mark for recalling how to calculate speed One mark for correctly calculating the speed. One mark for converting to m/s. If correct answer is given without working out shown award full marks. Where an incorrect answer is given working out should be used to credit appropriate marks. *Allow error carried forward (ECF) where correct working out is shown.

4	(c) *		**Indicative content:** Implications to the designer and manufacturer of applying legislation and standards to a product may include: Consumer protection act (CPA): • Legally health and safety information should be on products. *Manufacturer Implications:* This could increase costs and manufacturing stages, however helps to prevent harmful products/ use and in turn compensation. *Possible example:* Allergy advice on cereal boxes if the contents contains nuts or is made in a factory with nuts. • If a defective product causes injury, death or damage compensation can be claimed. *Designer & Manufacturer Implications:* Testing throughout the design of a product and quality control checks during manufacture will minimise the risk of defective products. This increases the time and cost spent on each stage, however helps to prevent harmful products and decreases risk of compensation claims. *Possible example:* Hover boards setting on fire because they were overheating. British standards: • There are a set of standards that should be followed to ensure safety and inclusivity. *Designer & Manufacturer Implications:* increased responsibility to the designer to apply these standards. Products may have to have components that are a specific sizes or have specific features and materials to prevent injury or harm. This could restrict the designer. Manufacturers have their own standardized tests to ensure products comply and are safe. *Possible examples:* the bars of a babies cot have to be a certain distance apart to minimise risk of injury, the flammability and toxicity of materials e.g. paint used should be checked against the standards meet high safety standards needed for children. Manufacturers tests for insulation (electricity or heat). Intellectual Property laws: • These laws protect ideas and inventions. *Designer Implications:* The designs/ part of the design that they create could infringe on designers	8	**Level 3 [6-8 marks]** The candidate has a clear understanding of legislation and standards. They produce a thorough discussion in relation to the question by explaining the implications of applying legislation and standards to the designer and manufacturer of a product. The explanation of influences is clear and well-developed and a number of products are used to exemplify the points being made. *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]** The candidate has a reasonable understanding of legislation and standards. They produce a reasonable discussion in relation to the question by explaining the implications of applying legislation and standards to the designer and/or manufacturer of a product. The explanation of influences is sufficient although one or two opportunities are missed in referring to different products. *There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.*

			that other people own the rights to. This would mean that their design might not be able to be used or they would have to pay compensation to another company. It would also take time to settle. *Possible examples:* Apple made claims that Samsung had copied the Apple iPhone technology. It led to a lengthy court battle where Samsung filed counter claims and both were found guilty of some infringements. WEEE directive: • Manufacturers are responsible for the electronic products end of life *Designer & Manufacturer Implications:* The product needs to be designed for disassembly, clearly labelled parts and a system for users to return products at the end of life. *Possible examples:* When you get a washing machine delivered they now take away the old one so the user is not responsible for its disposal. • Any other valid suggestion such as electrical testing, recycling information.		**Level 1 [1-2 marks]** The candidate has a basic knowledge of legislation and standards. Any reference to this issue is descriptive in nature and has little appreciation of how these two areas affect the designer and/or manufacturer of a product. The response contains no analysis or evaluation. *The information has some relevance and is presented with limited structure or detail. The information is supported by limited evidence.* **0 marks** No answer or answer not worthy of credit.

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored

Oxford Cambridge and RSA Examinations
is a Company Limited by Guarantee
Registered in England
Registered Office; The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA
Registered Company Number: 3484466
OCR is an exempt Charity

OCR (Oxford Cambridge and RSA Examinations)
Head office
Telephone: 01223 552552
Facsimile: 01223 552553