GCE

Design and Technology

H404/01: Principles of Design Engineering

Advanced GCE

Mark Scheme for June 2019

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

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

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

Annotations

Annotation Meaning

Annotation	Meaning
	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Tick (not used on level Qs)
	Benefit of doubt
	Noted but no credit given
L1	Level 1 response
L2	Level 2 response
L3	Level 3 response
L4	Level 4 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 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 ways may include: ● Provide safety warning labels (e.g. maximum load 2 people) (1). ● Door interlock to prevent lift moving if door is open (1). ● Overweight load sensor (1). ● Key lock to prevent children playing in lift (1). ● Battery backup in case of power failure (1). ● Alarm button to summon help in an emergency (1). ● Also accept design related responses (1) ● Any other valid suggestion.	3 No marks for simple one word responses.	One mark for identifying each of three ways in which the manufacturer of the home lift can ensure the safe operation of the lift by its users.
1	(b)	(i)	Speed = distance/time Time = distance/speed (1). Conversion of 2800 mm to 2.8 m (1). Time = 2.8/0.08 Time = 35 s (1).	3	Award three marks as follows: One mark for rearranging the speed formula in terms of time. One mark for conversion of units. One mark for calculating the time taken in seconds for the lift to rise between floors. 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.

1		**(ii)**	In 1 second, number of nut revolutions = linear distance / thread pitch = 80/8 = 10 revolutions (1). Sprocket gear ratio = driven / driver = 30/20 Motor revolutions in 1 second = 10* x 30/20 = 15 revolutions (1). OR Calculate that the nut rotation at 10 revolutions is 600rpm therefore at 15 revolutions multiply by 1.5 = 900rpm (1) Conversion to rpm: Motor rotational speed = 15*x60 = 900 rpm (1).	**3**	Award three marks as follows: One mark for calculating the number of not revolutions in one second. One mark for calculating the number of motor revolutions in one second. One mark for calculating the motor rotational speed in rpm. 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		**(iii)**	Possible reasons may include: ● Safety – if one chain fails there is a backup (1). ● The two chains share the load (1). ● Each chain can be thinner which could save cost, reduce weight, and allow a more compact drive system (1).	**2** No marks for simple one word responses	One mark for identifying each of two reasons why a double chain drive is used in this application.

			● If one chain fails, the lift will continue to work (1). ● They are more secure in instances where a belt drive might be used due to them being non slip drives (1). ● Any other valid suggestion.		
1		**(iv)**	Showing understanding that the lift rises 0.08m in 1s (1). i.e. 0.08 = h (1) GPE = mgh = 350x9.81x0.08 = 274.68 J (1). Showing understanding that the power required is equal to the increase in GPE in 1s (or for 'calculating' the power): Power = E/t = 274.68*/1 = 274.68 W (1). I.e. time = 1s	**3**	Award three marks as follows: One mark for showing understanding that the lift rises 0.08m in 1s. One mark for calculating the GPE. One mark for calculating the power required in W to raise the lift at stated velocity – i.e. understanding that the power required is equal to the increase in GPS in 1s. 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. Allow 275W Correct answer scores full marks

					Allow any valid method, e.g. Weight of lift car = mg = 350 x 9.81 = 3433.5N (1) P = FV = 3433.5 x 0.08 = 274.68 W (1)
1		**(v)**	Possible advantages may include: ● Mechanism is self-locking (1) so the lift will not fall when the drive stops (1). ● Mechanism is behind the lift (1), so no headroom needed above the lift (1). ● No cables to stretch (1), which would could cause problems with lift position (1). ● Simple mechanism (1) so easy to install and maintain (1). ● Lower power output required (1) ● Any other valid suggestion. Possible disadvantages may include: ● Slow output (1) so the lift takes a long time to travel between floors (1). ● Long screw thread needed (1), which is difficult to install (1). ● High friction between nut and thread (1), so good lubrication (or ball screw) needed (1). ● Any other valid suggestion.	**4**	Up to two marks for explaining an advantage of using a screw thread and nut mechanism in a lift. Up to two marks for explaining a disadvantage of using a screw thread and nut mechanism in a lift. In each case: 1st mark for a valid point about a screw thread and nut mechanism. 2nd mark for relating the point to the function of the lift.

1		(c)	**Indicative content:** ● Explanation of what a UI is. ● Examples of physical UI, possibly relating to anthropometrics. ● Reference to ergonomics. ● Examples of software UI. ● Menu driven UI, help screens. ● Back buttons, cancel buttons. ● Commonly used functions easily accessible. ● Touch screens, soft keys, display devices. ● Voice activated, speech. ● Intuitive use, no need for instruction manual. ● User feels part of product. ● Good product reviews, good brand image. ● Any other valid suggestion.	**8**	**Level 3 [6-8 marks]** The candidate has a clear understanding of the significance of good user interface design in engineered products i.e. that good UI is able to simplify a complex product or system interaction. They produce a thorough discussion in relation to the question by explaining the influence of good user interface design. The explanation is clear and well-developed and a number of examples are used to exemplify the points being made. **Level 2 [3-5 marks]** The candidate has a reasonable understanding of the significance of good user interface design in engineered products, i.e. that they recognise specifically what good UI does for example products. They produce a thorough discussion in relation to the question by explaining the influence of good user interface design. The explanation 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 user

					interface design. Any reference to this issue is descriptive in nature and has little appreciation of how user interface design influences engineered products. The response contains no analysis or evaluation. **0 marks** No answer or answer not worthy of credit.

2	**(a)**		$D1^2 = 305^2 + 215^2 = 139249.999$ (1). $D2^2 = D1^2 + 100^2 = 149249.999$ (1). Max part length = $\sqrt{}149249.999 = 386.3$ mm (1).	**3**	Award three marks as follows: One mark for calculating first base diagonal. One mark for calculating second base diagonal. One mark for calculating maximum straight part length in mm to 1 decimal place that can be shipped in the cardboard box. 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. Correct answer scores full marks
2	**(b)**	**(i)**	Possible instruments may include: ● Vernier caliper (1). ● Digital caliper (1). ● Micrometer (1). ● Accept term Electronic Caliper (1) ● Any other valid suggestion.	**1**	One mark for identifying a suitable instrument that can be used in given context.

2		**(ii)**	Cone volume = 1/3 x ($\pi(26)^2/4$) x 20 = 3539.527723 mm^3 (1). Cylinder volume = ($\pi(26)^2/4$) x 15 = 7963.937376 mm^3 (1). Total volume of part = 7963.937376* + 3539.527723 = 11503.46509 mm^3 (1). Volume conversion 11503.46509/10^3 = 11.50346509 cm^3 (1). Mass = volume x density = 11.50346509* x 8.73 = 100.4252503 g = 100.4 g (1).	**5**	Award five marks as follows: One mark for calculating the cone volume. One mark for calculating the cylinder volume. One mark for calculating the total volume of the part. One mark for volume conversion. One mark for calculating the mass in g to one decimal place of the part. 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. Candidates may have combined the separate stages into few steps – award full marks accordingly.

2		**(iii)**	Original volume of the bar = $(\pi(30)^2/4) \times (15+20)$ = 24740.04214 mm^3 (1). Waste volume = original volume – volume of part from 2c(iii) Waste volume = 24740.04214 - 11503.4651 (see below) = 13236.5 mm^3 (1). Accept 11503.4 Accept 11503 Accept any ECF from previous question 2cii	**2**	Award two marks as follows: One mark for calculating the original volume of the bar. One mark for calculating the volume in mm^3 to one decimal place of the waste brass generated. 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.

2		**(iv)**	(26/100) x 2 = 0.52 mm (1). 26 – 0.52* = 25.48mm (1).	**2**	Award two marks as follows: One mark for calculating the value of the tolerance of 2%. One mark for calculating the minimum allowable diameter in mm of the part. 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.
2		**(c)**	v = 0 at maximum height s (1). $u^2 = -(2 \times -9.81 \times 2.5)$ $u = 7.0\ ms^{-1}$ (1).	**2**	Award two marks as follows: One mark for showing that at the maximum height the vertical velocity is zero. One mark for calculating the initial velocity in ms^{-1}.

					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. Award marks for any other valid method

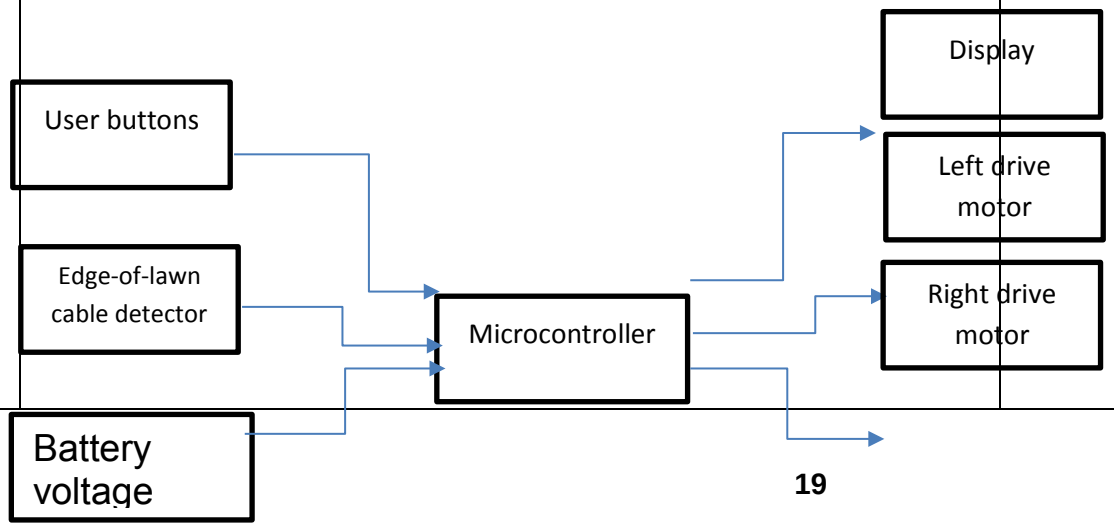
3	**(a)***		**Indicative content:** For existing designs: ● BSI standards will set some requirements that may mean changing the product's design. ● It may be necessary to change the manufacturing method. ● Both the above have cost implications. ● Employer re-training may be necessary if manufacturing methods change. ● Implications of investment in new machinery. ● Any other valid suggestion. For new designs: ● BSI documents are quite expensive to purchase. ● Standards might impose constraints on a design which are restrictive and limiting. ● A clear set of standards can be helpful in guiding designers. ● Any other valid suggestion. General points: ● Quality control procedures and testing. ● Customer trust in the product may improve the market hold. ● Increased sales. ● Customer loyalty. ● Brand image. ● Increased product reliability resulting in less recalls. ● Less chance of customer litigation. Any other valid suggestion.	**8** Only give credit to arguments which relate to the implications for the **manufacturer**. Responses which focus on facts about kitemarked products (without giving **implications** to the manufacturer) should be limited to L1.	**Level 3 [6-8 marks]** The candidate has a clear understanding of the implications to manufacturers of producing Kitemark approved products. They produce a thorough discussion in relation to the question by explaining the impact on manufactures of complying with the standards set. The explanation of implications is clear and well-developed and a number of different perspectives 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. There will be a number of implications to the manufacturer discussed, giving both positive and negative arguments.* **Level 2 [3-5 marks]** The candidate has a reasonable understanding of the implications to manufacturers of producing Kitemark approved products. They produce a thorough discussion in relation to the question by explaining the impact on manufacturers of complying with the standards set. The explanation is sufficient although one or two opportunities are missed in providing different perspectives. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence. There will be one or two implications to the manufacturer, and the*

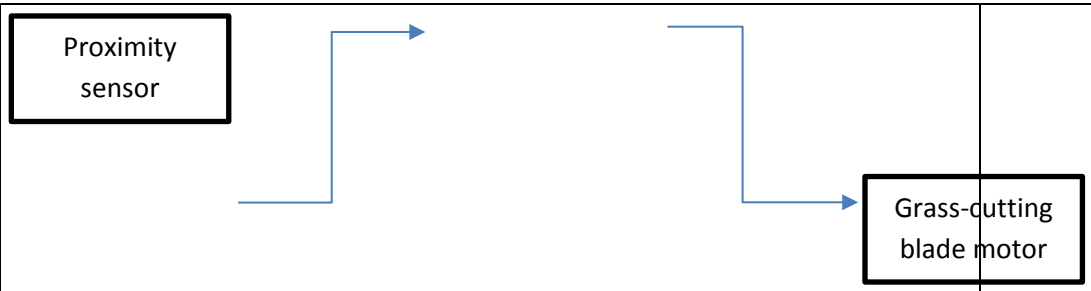
					arguments may be one-sided, probably negative. **Level 1 [1-2 marks]** The candidate has a basic knowledge of standard setting processes. Any reference to ways standard setting impact on manufacturers is largely descriptive in nature. The response contains no analysis or evaluation. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear. There will be little appreciation of the implications to the manufacturer.* **0 marks** No answer or answer not worthy of credit.
3	**(b)**	**(i)**	Possible responses may include: ● A bold venture capturing innovation/courageous or bold decision making/initiative and resourcefulness (1). Plus one of the following... ● Making the most of an opportunity to earn money (1). ● Creating a new business (1). ● New and energetic undertakings (1). ● Breaking new ground (1). ● Any other valid suggestion.	**2**	One mark for demonstrating an understanding of Enterprise. One further mark for explaining Enterprise through the context of designing. This is a definition style question and therefore mark on the basis of any valid points being made. Answers must be in the context of designing.

3		**(ii)**	Possible ways may include: ● Entrepreneurship (1) – the process of launching a new business, taking a financial risk in the hope of a good return (1). ● Ability to recover from setbacks (1), learning lessons along the way (1). ● Commercial partnerships (1), recognising the benefits of forging partnerships with others (1). ● Sharing ideas amongst other experts (1) to gain access to global technology (1). ● Venture capitalists – stakeholders who invest money into entrepreneurial companies (1) who then have a strong interest in the company's success (1). ● Crowd funding – asking a large amount of people for a small amount of money (1), who may or may not then own a share in the company (1). ● Any other valid suggestion.	**4**	In each case: Award one mark for a suitable example form the list, and one further mark for justification. Specific reference to the context in the question is needed for marks to be awarded.

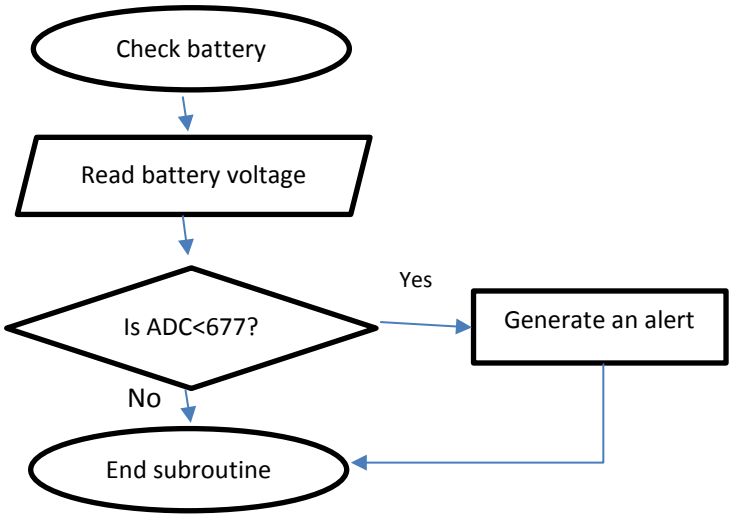
4	(a)		Possible issues may include: ● The system will need to be rainproof (1). ● The charging station may be a long distance from a power socket (1). ● A low voltage (e.g. 12V) could be used (1). ● There are regulations and legislation for outdoor mains voltages (1). ● The lawnmower may cut through the power cable (1). ● An RCD socket could be used (1). ● Potential hazards if a user came into contact with mains electricity (1). ● Any other valid suggestion.	**2**	One mark for identifying each of two issues associated with providing power to the charging station. Do not award marks for very simple statements such as “electricity is dangerous outdoors”, or “you could get a shock”.
4	(b)	(i)	Possible responses may include: 1 mark for identifying the ribs in the part. 1 mark for explaining how these increase rigidity: o Effectively achieve triangulation o Prevent plastic moving up/down o They increase the effective thickness of the part. Any other valid suggestion.	**2**	Up to two marks for describing how the rigidity of the thermos softening polymer part is achieved through effective desigining. 1st mark for identifying the ribs in the part. 2nd mark for describing how these ribs increase rigidity.
		(ii)	1st mark = injection moulding (1). 2nd mark for evidence: ● Ejector pin marks (1). ● Complex part shape (1). ● Thin walled structure (1). ● Embossing text/graphic on surface (1) ● Single coloured component (1) ● Any other valid suggestion.	**2**	One mark for identifying the industrial method used. One mark for identifying a piece of evidence. Evidence must come from the images Fig 4.2a and Fig 4.2b.

4		**(iii)**	Possible reasons may include: PP< marking identifies the type of thermo softening polymer used, as it may be indistinguishable from other polymers of similar properties/characteristics (1). This is significant to: ● comply with 'end of life directive legislation' (1). ● prevent the material ending up in landfill (1). ● proper reprocessing/recycling of the material (1). ● Any other valid suggestion.	**2**	Up to two marks for explaining a reason as to why a plastic manufacturer marks the type of plastic used on their product in this way. 2nd mark should be given for explaining significance. No requirement to identify PP as polypropylene.
4		**(c)**	Possible responses in relation to DC motors may include: ● They have high torque (1), which will be necessary why driving the lawnmower up an incline (1). ● They can be reversed (1), so the robot can manoeuvre away from obstacles (1). ● They have high speed (1), so will need a gearbox to reduce speed (1). ● Any other valid suggestion. Possible responses in relation to stepper motors may include: ● They can rotate through a precise angle (1), which means the robot can calculate how far it has travelled (1). ● They are low torque (1), so there may be insufficient drive for a heavy lawnmower (1). ● They require a more complex drive circuit (1), which adds to costs and development time (1).	**4**	In each case: Award one mark for a valid point about the motor. Award one mark for relating the point to the function of the robotic lawnmower.

			● Any other valid suggestion.		
4		**(d)**	Input subsystems: ● Edge-of-lawn cable detector (1). ● Proximity sensor (1). ● Battery voltage monitor (1). ● (Clock time-keeper) (1). ● Any other valid suggestion. Output subsystems: ● Left drive motor (1). ● Right drive motor (1). ● Grass-cutting blade motor (1). ● Any other valid suggestion. 	**4**	Award two marks for identifying **two** input subsystems. Award two marks for identifying **two** output subsystems: Maximum of 3 marks if the candidate has not used correct diagram conventions for a system diagram. Signal lines must be drawn and arrows used to indicate signal flow. Do not award a mark if inputs/outputs are transposed.

					
4	**(e)**	**(i)**	I = V/R (1). I = 10.5/(3900+1800) = 1.842105 mA (1). $V_A = I \times R_2 = 1.842105 \times 1.8 = 3.315789473$ V = 3.32 V (to 2d.p.) (1).	**3**	Award three marks as follows: One mark for recalling the correct formula. One mark for calculating the current. One mark for calculating V_A to two decimal places. 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. Award marks for any other valid method, e.g. potential divider formula.

4		**(ii)**	3.32/5.0 = 0.664 (1). ADC = 0.664 x 1023 = 679.272 (1). ADC output = 679 (1).	**3**	Award three marks as follows: One mark for calculating ratio of V_A to full scale value. One mark for calculating the ADC calculated value. One mark for giving the final answer as a rounded-down integer. 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. Award marks for any other valid method.

4		**(iii)**		**3**	Award one mark for correctly drawn input box (parallelogram) to read battery voltage (ADC). Award one mark for decision box (diamond) to ask 'is ADC<677'?. Award one mark for an indication of 'generate an alert' if above answer is 'yes'. Maximum of two marks if the candidate has not used correct diagram conventions for a flowchart. Only penalise an incorrect flowchart shape once. Allow ECF from e (ii). No marks for programming 'code'.

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