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*Examiners' report*

# DESIGN AND TECHNOLOGY: DESIGN ENGINEERING

**H404**
For first teaching in 2017

## H404/01 Summer 2019 series

Version 1

# Contents

# Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

# Paper 1 series overview

The first A2 Level Principles of Design Engineering examination followed the success of the AS examination in 2018, where it was clear that candidates had been suitably prepared for assessment on the new course content. The strength of the candidate’s application of science and mathematical principles complemented a consistently strong application of the breadth of design engineering content in this series, and reflected the knowledge required of modern engineers in industry today. The paper was completed with confidence and demonstrated an ability to understand a range of contextual challenges.

From their core knowledge, candidates were able to consider contexts that included home mobility, accurate part manufacture, robotic lawn mowers, and discuss good user interface and the BSI Kitemark.

Candidates had an excellent understanding of user needs which helped them to empathise with users of a lift system, and were able to discuss user interface for engineered products. Candidates also responded well to how manufacturers of parts are able to reach specific recognised standards.

Candidates had a number of opportunities to draw program related diagrams, focusing on the mapping of inputs and outputs of a micro-controlled product, and the subroutine that gave the product specific performance functionality, which was the ability to return to a recharging station autonomously.

The topic of enterprise was challenging for candidates across the board, and despite requiring the knowledge of a definition of enterprise and what it looks like at the development stage of a project, candidates showed ingenuity in coming up with suitable responses that linked to innovation and funding streams.

Candidates were confident in their process knowledge through a series of questions on injection moulding and the design of parts for this process. All candidates were able to identify traits and features of parts for either reinforcement, and/or end of life recycling.

For the mathematical questions, there was an opportunity for candidates to interpret numerous scenarios, and show an application of maths to identify anticipated performance of motors, the maximum size of parts in defined packaging, calculate tolerance and wastage from machining, and work out values of engineering outcomes at specific points in use, such as the velocity of a moving object and the value within a circuit which would trigger a subroutine. Candidates were excellent at tackling these questions, in different ways, and presenting working out consistently.

For the level-based questions, it was good to see the quality of structured approaches from many candidates, who were able to formulate an argument either from the position of someone specific, like the manufacturer, or from a range of stakeholders, in the context of user interface.

Overall the exam for this series drew a very strong set of responses and shows that candidates had been suitably prepared for the range of contextual and mathematical questions that the paper can include.

## Question 1 (a)

**1** A home lift can be installed in a house where one or more occupants may have mobility problems and may not be able to use stairs easily.

**Fig. 1.1** shows an electrically-powered home lift. The first image shows the lift on the ground floor. The second image shows the lift on the upper floor.

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**Fig. 1.1**

**(a)** Identify **three** ways in which the manufacturer of the home lift can ensure the safe operation of the lift by its users.

1 ..............................................................................................................................

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2 ..............................................................................................................................

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3 ..............................................................................................................................

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**[3]**

For each method stated, be they physical design features or a test conducted, a mark was given. Relevant additions to the lift where users would interact with the product were credited along with sufficiently described tests, assuming neither was considered duplicate responses to one another.

## Question 1 (b) (i)

**(b)** The home lift in **Fig. 1.1** uses a screw thread and nut mechanism in which the nut is attached to the lift and rotated through a double chain drive by an electric motor. The screw thread is held in position and does not move. **Fig. 1.2** shows the mechanism.

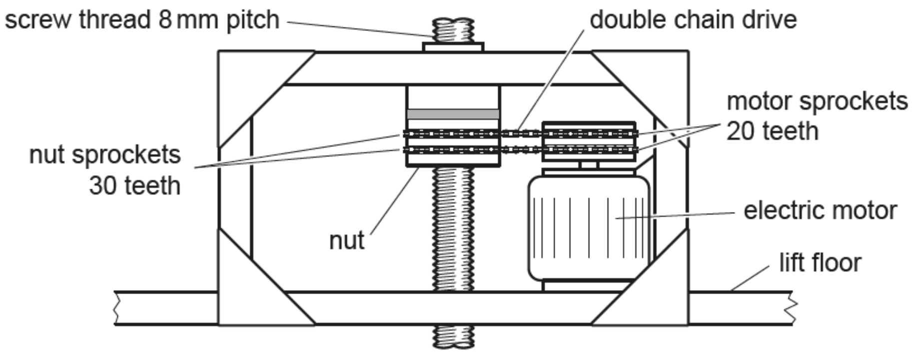


**Fig. 1.2**
(not to scale)

**(i)** The lift moves at a speed of $0.08\,\text{m}\,\text{s}^{-1}$.

Calculate the time taken in seconds (s) for the lift to rise between floors which are 2800 mm apart. Show your working.

Time .................................... s

**[3]**

For this question, candidates were asked to rearrange the simple formulae for speed = distance/time into a format where time was unknown, then convert the measurement of 2800 millimetres to 2.8 metres, in order to establish a time of 35 seconds for the time required for a lift to travel a specific distance.

A mark was given for rearranging the formula accordingly, a second mark for the correct conversion of units from millimetres to metres, and a final mark for the time calculation.

 

## Question 1 (b) (ii)

**(ii)** Analysing the data in **Fig. 1.2**, calculate the motor rotational speed required in revolutions per minute (rpm) to cause the nut to climb up the thread at a speed of $0.08\,m\,s^{-1}$. Show your working.

Motor rotational speed ............................... rpm

**[3]**

For this question, candidates were required to calculate the motor rotational speed in rpm to achieve a climb of the lift of 0.08 metres per second.

To do this, candidates would need to first recognise that the nut revolutions per second were 10 using the speed of 0.08 metres per second and the thread of 8mm, which would result in its rpm being 600 revolutions per minute. They would then need to recognise that the motor was geared to the thread, and the ratio of this was 1.5 (or 15 revolutions per second), which would mean that the motor rotational speed was the multiplication of these two values to give an answer of 900rpm.

Many candidates achieved a mark for the initial calculation of the gear ratio, but subsequently did not move onto calculating the motor rotational speed.

## Question 1 (b) (iii)

**(iii)** Give **two** reasons why a double chain drive is used in this application.

1 ..........................................................................................................................

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2 ..........................................................................................................................

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**[2]**

For this short response question, candidates were required to name two reasons for a double chain drive system being used for a lift.

Candidates commonly responded with answers describing an improved level of safety where one chain would be in place if the other failed.

The second very common response from candidates related to dividing the load between each chain equally.

Only a small number of candidates considered the alternative belt drive system being able to slip, or the opportunity for each chain to be thinner to make the design more compact.

## Question 1 (b) (iv)

**(iv)** The maximum total mass of the lift and occupants is 350 kg.

Calculate the power required in watts (W) to raise the 350 kg lift at a velocity of 0.08 m $s^{-1}$. Show your working.

*gravitational potential energy = mgh* *power =* $\frac{E}{t}$

*gravitational field strength, g = 9.81 N* $kg^{-1}$

Power ................................. W

**[3]**

In this mathematical question, a formula is given for gravitational potential energy. Candidates simply had to input the mass of 350, the gravitational field strength of 9.81, and both recognise and then include the lift travel distance (h) of 0.08 metres per second, to result in the correct answer.

Where candidates very commonly made a mistake in this question was in providing the correct answer but rounded up. As there was no request to provide an answer to a specific number of decimal places, those that rounded to 275 lost a mark, while those who gave an unrounded answer achieved all three marks.

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|---|---|---|
| | **AfL** | **Rounding Errors**<br>This is the first instance where candidates fell afoul of rounding their answers either during calculations, or at the end when giving their final answer, when not required to. Candidates should only round answers at the end of their calculations, and only when instructed to (e.g. Give your answer to 2.s.f).<br>In line with other course specifications, a rounding error -1 mark was applied only once throughout the entire paper, irrespective of how many times candidates made this mistake. This was also applied in line with the error carried forward rule, which ensures that a connected sequence of questions, of which there were two in this paper, would not result in the punishment of a candidate for making an error and using this in a subsequent question. |

| | | |
|---|---|---|
| ? | **Misconception** | Candidates made the assumption that calculations should be rounded to a significant number. |

## Exemplar 1

$350 \times 9.81 \times 2.8 = 9613.8\ J$

$\frac{9613.8}{35} = \underline{274.7\ W}$

Power ..........275.......... W

**[3]**

This candidate makes the common mistake of rounding a correct response when not asked to in the question, resulting in a mark lost.

## Question 1 (b) (v)

**(v)** Conventional lifts usually use a cable mechanism with an electric motor located at the top of the lift shaft.

Explain **one** advantage and **one** disadvantage of using a screw thread and nut mechanism in a lift.

Advantage .............................................................................................................

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Disadvantage .............................................................................................................

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............................................................................................................. **[4]**

For this question candidates were asked to explain an advantage and disadvantage of using a screw thread mechanism instead of a cable mechanism for the lift.

Many candidates felt that a key advantage was that a screw thread mechanism would self-lock if the system failed and would not see the lift fall down due to the nut sitting on the thread.

Another common response related to the system being smaller and neater for a home lift and removed the need for excessive space above the lift for the cable system to be housed.

For the disadvantage, candidates felt there would be more significant maintenance and wear to a screw thread and nut mechanism over the cable system, but more commonly felt that the screw thread was much slower than the cable system in the context of moving between the distance of two floors.

## Question 1 (c)

**(c)** Discuss, using examples, the significance of good user interface design in engineered products.

.......................................................................................................................................... **[8]**

For the first levelled response question, candidates were asked to discuss the significance of user interface design in engineered products.

In order to achieve the highest mark band of 6-8 marks, candidates had to establish in their response the fact that good user interface primarily is aimed at simplifying the often complex operation of engineered products or systems. While a spectrum of responses was seen, there were common responses given across the cohort as outlined below in Afl.

Candidates were welcome to discuss either the physical hardware or software of engineered products, referring specifically to buttons or dials with equal value to touch screens and voice-controlled functionality. Candidates could also make reference to anthropometrics as part of physical interaction, and ergonomics in relation to ongoing or repeated use, but stronger responses would produce a clear and well developed response with a range of examples referring to the simplified methods for users to achieve a complex range of outcomes.

| | | |
|---|---|---|
| | **AfL** | It was common for candidates to discuss the home lift from Question 1 for their answer, an Apple iPhone, or a Washing Machine user interface in this response. While these were accepted responses, it is a better approach for candidates to identify the most appropriate example products and systems in response to the question, where they can describe numerous points relating to interface design.<br><br>Products which included a complex range of functional outputs that require programming would be ideal for this question. |

## Question 2 (a)

2 **(a)** A manufacturer wishes to ship items in the cardboard box shown in **Fig. 2.1**. The cardboard box is a cuboid shape.

**Fig. 2.1**

The box has internal dimensions of 305 × 215 × 100 mm.

Calculate the maximum straight part length which can be shipped in this cardboard box. Give your answer in mm to 1 decimal place and show your working.

Maximum straight part length ...................................... mm

**[3]**

Using the height, width and depth measurements of a shipping box, candidates were asked in this question to work out the longest maximum length a part could be that would fit inside this box. This required candidates to first use the width and length measurements to calculate the diagonal distance across the base of the box. The candidate then had to use this new measurement and the depth of the box to calculate the diagonal measurement from opposite corners of the box.

Candidates were required to provide their response to 1 decimal place, with some candidates making the mistake of rounding the numbers they calculated during the working out process. This rounding was identified thanks to the 'Error carried forward' (ECF) provision in this question.

A significant number of candidates who scored less than full marks calculated the diagonal across the base of the box only.

| | | |
|---|---|---|
| | **AfL** | **Rounding Errors**<br>Candidates rounded their answers during calculation, but were only instructed to round to one decimal place in their final answer. |

| | | |
|---|---|---|
| | **Misconception** | Candidates made the assumption that calculations should be rounded to a significant number. |

## Question 2 (b) (i)

**(b)** **Fig. 2.2** shows an orthographic (two-dimensional) diagram of a part manufactured from brass. Dimensions are given in mm.

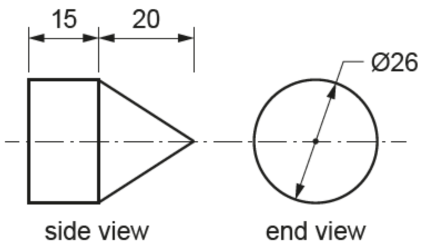


**Fig. 2.2**
(not to scale)

**(i)** Name an instrument which could be used to measure the diameter of the part shown in **Fig. 2.2** to a precision of 0.02 mm.

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|---|
| For this short response question, candidates were challenged to name a specific tool suitable to measure small measurements, less than 0.1mm.<br><br>For candidates who named tools suitable for fine measurements such as callipers and micrometers, a mark was given.<br><br>Those who identified digital or electronic versions of these were more accurate responses.<br><br>Those who named a ruler or steel rule were not given a mark as these would not provide the level of accuracy required. |

## Question 2 (b) (ii)

**(ii)** Calculate the mass in grams (g) of the part shown in **Fig. 2.2**. Give your answer to 1 decimal place and show your working.

*Area of a circle* = $\pi d^2/4$

*Volume of a cone* = $\frac{1}{3}$ × *base area* × *height*

*Density of brass* = $8.73\,g\,cm^{-3}$

Mass ....................................g

**[5]**

For this longer mathematical question, candidates were tasked with working out the mass of a machined part, by calculating the volume of the part from two separate volumes, and adding these values together, before multiplying this by the density.

Where candidates made a common error, this was in rounding up the answer to 100g, rather than leaving the answer as requested.

It was also common for candidates to make mistakes in calculating the volumes with numerous answers having the decimal place four or more places out.

Those who achieved the right answer took a methodical approach and documented their working out clearly.

 

## Exemplar 2

7764
35160

$D = 26\,mm \div 10 \quad D = \cancel{0.026}\ 2.6\,cm$

$\dfrac{\pi \times 2.6^2}{4} = 5.3\,cm^2$

Volume of ~~con~~ cone $= \dfrac{1}{3} \times 5.3 \times \dfrac{20}{10} = \dfrac{53}{15}\,cm^2$

(h) $1.5 \times 5.3 = 7.95\,cm^2$

$7.95 + \dfrac{53}{15} = 11.5\,cm^2$

$11.5 \times 8.73\,g = 100.4\,g$

Mass 100.4 g

**[5]**

This candidate shows all of the workings out and presents the answer in an appropriate format.

| | | |
|---|---|---|
| | **AfL** | **Rounding Errors**<br>Candidates rounded their answers during calculation, but were only instructed to round to one decimal place in their final answer. |

| | | |
|---|---|---|
| | **Misconception** | Candidates made the assumption that calculations should be rounded to a significant number. |

## Question 2 (b) (iii)

**(iii)** The part in **Fig. 2.2** is to be turned on a centre lathe from a cylindrical brass bar with diameter 30 mm and length 35 mm.

Calculate the volume in $mm^3$ of the waste brass generated. Give your answer to 1 decimal place and show your working.

Volume ............................. $mm^3$

**[2]**

As a follow up to the previous, this question asked candidates to calculate the waste material produced in the machining process from the solid bar to the final part.

In order to arrive at the correct answer, candidates had to take their answer from the previous question, without rounding it to fewer decimal places, and subtract this from the total volume of the bar.

Where candidates commonly made a mistake was in using a rounded version of the volume from the previous question.

## Question 2 (b) (iv)

**(iv)** The diameter of the part must be 26.00 mm with a tolerance of ±2%.

Calculate the **minimum** allowable diameter in mm of the part. Show your working.

Minimum diameter ...............................mm

**[2]**

For this question the candidates had to work out the minimum allowable diameter of a part if it were machined to a tolerance of 2%.

This was a very accessible question for many, who identified that they could calculate the 2% value of the measurement and subtract this from the total diameter.

## Question 2 (c)

**(c)** A machine is being developed to help tennis players practise their serve. The machine projects a tennis ball vertically to a height, s, of 2.5 m.

Use the formula, $v^2 = u^2 + 2as$, to calculate the initial velocity, u, at which the ball needs to leave the machine so that it just reaches the required height of 2.5 m. Give your answer in $m\,s^{-1}$ and show your working.

*Acceleration, a, due to gravity in this situation is –9.81 $m\,s^{-2}$*

Initial velocity .................................... $m\,s^{-1}$

**[2]**

This question asked candidates to input values into a formula that was provided, in order to calculate the initial velocity at which a ball needs to leave a machine to achieve a target height of 2.5 metres.

For candidates who recognised that at the maximum height of 2.5 metres the velocity is zero, were then able to rearrange the formula with one unknown and establish an answer of 7 metres per second.

## Question 3 (a)

3 **(a)*** To certify that products conform to a standard set by the British Standards Institute (BSI), many products carry the BSI Kitemark® shown in **Fig. 3**.

TM

**Fig. 3**

Discuss the implications to manufacturers of producing Kitemark® approved products.

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...................................................................................................................................... **[8]**

For this second levelled question, which is also the only extended response question in the paper, candidates had to discuss the implications of producing products to meet the requirements of the British Standards Kitemark, but from the perspective of the manufacturer.

Numerous candidates did not achieve marks in sections of their answer that related to the benefits to the customer. Those who addressed the impact on time for production, additional incurred costs, restrictions on the products manufacture, and the potential redesign of the product in question were very much on the right track if they could create a clear and structured discussion.

Candidates who focused more on general points relating to customer loyalty or increased sales of products had less opportunity to access marks, as their discussion points often required a benefit of doubt to credit to their responses.

| | | |
|---|---|---|
| | **AfL** | For a levelled question, it is important that the candidates identify who they are writing about, the user or the manufacturer. Their empathy with that specific person, group or organisation will help them to better structure a response to the question, and forms part of candidates understanding of broader stakeholders for a product.<br><br>The BSI Kitemark has obvious benefits for the customer, but for a manufacturer, a common perception might be that it would be easier, cheaper and faster to produce product not to this standard, and therefore producing to the BSI standards would impact on people, costs, timing, and require the introduction of numerous checks both internal and external, and be something that over time might require continued investment and effort to maintain. |

| | | |
|---|---|---|
| ? | **Misconception** | Candidates took the approach of responding from the position of the user/customer, rather than the perspective of the manufacturer. This resulted in broad statements about products being better, safer or an improved design, but these did not relate to implications for the manufacturer. |

## Question 3 (b) (i)

**(b) (i)** Explain what is meant by **'enterprise'** in the context of designing.

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Responses to this question were considerably below expectation, as a large majority of candidates did not know the term and did not mention linked terms such as innovation, new or bold initiatives, or were not able to give an example in relation to the process of design.

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|---|---|---|
| | **AfL** | It is important that the full content of the specification is covered in anticipation of this examination.<br>This question is a clear example where the content is present in the specification, and also clear and explicit in the supporting textbook for this course, but was not well covered, resulting in a below expected performance. |

## Question 3 (b) (ii)

**(ii)** Describe **two** ways in which enterprise can help drive the development of new product ideas.

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2 ..........................................................................................................................

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**[4]**

Following on from the definition of enterprise, this question asked candidates to describe two examples of how enterprise can help drive the development of a new product.

Again this question was poorly tackled, with a large number of candidates suggesting types of research or stakeholder engagement.

For those who achieved some of the marks, they mentioned ideas such as crowdfunding, venture capitalism, commercial partnerships, or some form of financial risk. Higher mark candidates were able to describe these with some examples or context.

## Question 4 (a)

**4** **Fig. 4.1** shows a robotic lawnmower.

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**Fig. 4.1**

**(a)** A 12 V battery is used to power the robotic lawnmower. The robotic lawnmower returns to a charging station placed at the edge of the lawn to recharge its battery. The charging station requires a source of power.

Identify **two** issues associated with providing power to the charging station.

1 ..........................................................................................................................

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2 ..........................................................................................................................

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**[2]**

For this question, candidates were tasked with identifying issues that related to installing a charging station outside for a robotic lawnmower.

While the question was highly accessible to the majority of candidates, those who discussed issues relating to the system needing to be rainproof, socket location and providing a specific level of power to an outdoor installation, or the potential for wires to be cut accidentally, were able to access the marks available.

## Question 4 (b) (i)

**(b)** The case of the robotic lawnmower is made from a thermo softening polymer.

**Fig. 4.2a** and **Fig. 4.2b** show two views of a typical thermo softening polymer part from a similar garden product.

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**Fig. 4.2a**

Item removed due to third party copyright restrictions

**Fig. 4.2b**

**(i)** Describe how the rigidity of the thermo softening polymer part in **Fig. 4.2a** and **Fig. 4.2b** is achieved through effective designing.

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Candidates had to discuss visual observations that identified ribs between inner and outer walls of the part, and these being designed to create triangulation between the walls, therefore improving rigidity.

The candidates could also mention wall thickness in places, relating to the fact that some areas were thicker where the part had to be more rigid.

## Question 4 (b) (ii)

**(ii)** State the industrial method used to manufacture the thermo softening polymer part and identify **one** piece of evidence from either **Fig. 4.2a** or **Fig. 4.2b** that leads you to this conclusion.

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This question was made up of two parts in one response. The first asked candidates to name the process used to make the part from the previous question, and the second was to identify a feature that evidenced that it was made by that process.

The process in question was injection moulding. Candidates were able to identify circular marks on the surface of the part, which could be identified as ejector pins, an injection point, or where a sprue had been removed, among other common features of injection moulded parts such as specific wall thicknesses, embossed information on the surface of the part, or a single colour/material part of complex design.

### Exemplar 3

This part would have been injection moulded as the circles on the plastic indicate it has been pushed out of and injection moulding mould. **[2]**

This candidate's response is clear, identifying the process, and justifying it through the ejector pin markings seen in the figure.

## Question 4 (b) (iii)

**(iii)** The >PP< marking that is visible on the surface of the product in **Fig. 4.2b** identifies the type of thermo softening polymer that has been used.

Explain **one** reason why a plastic manufacturer marks the type of plastic used on their product in this way.

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For this very accessible question, the task was to explain why the part had a visible material marking (in this case PP) on the surface of the part.

Candidates consistently identified the need to identify different polymer parts specifically, given the unreliable nature of relying on the appearance of the material, in order to be able to recycle or reprocess the part at its end of life.

Top candidate responses acknowledged that many polymers have similar or comparable working properties, which would require time consuming investigation to establish what polymer it was.

## Question 4 (c)

**(c)** Compare the use of DC motors and stepper motors for driving the wheels of a robotic lawnmower.

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For this question, candidates were tasked with comparing and contrasting the application of both DC and stepper motors for a robotics lawn mower. The candidates had to consider both of the motor types in relation to the context of the product and the functions it would be carrying out.

Candidates who achieved half marks or less were only able to explain the differences between DC and stepper motors, in relation to performance, the need for control, and the type of output and accuracy each could achieve.

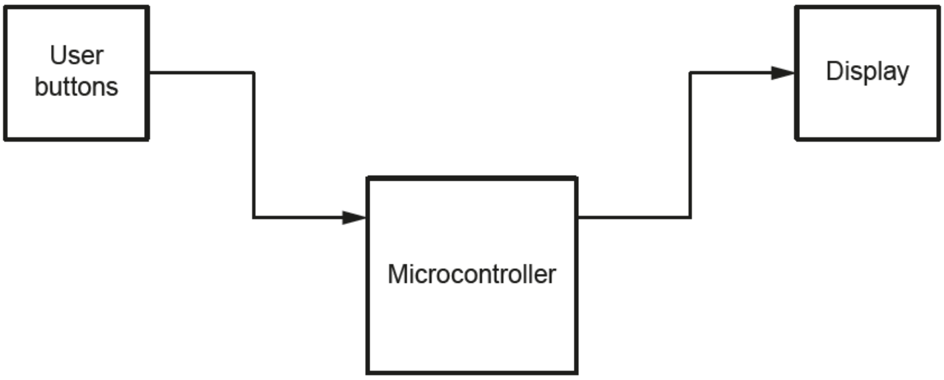
Candidates achieving top marks were able to explain why a DC motor might work for one part of the lawn mower, while stepper motors might be more applicable to another part of the lawn mower. Candidates who recognised the control aspect of stepper motors were able to speculate the need for control in the movement of the lawn mower around a specific lawn space, while the spinning blades would be more suited to DC motors.

## Question 4 (d)

**(d)** The robotic lawnmower is controlled by an electronic system with a number of sensors, user-operated controls and outputs. The robotic lawnmower function is described below:

- The user sets the lawnmower to operate at a set time every day using buttons and a display.
- At the set time, the lawnmower automatically undocks from its charging station, starts its grass-cutting blade and begins to move across the lawn.
- A cable, buried around the edge of the lawn, carries an electronic signal which the lawnmower detects and uses to avoid running off the edge of the lawn.
- Proximity sensors on the lawnmower detect the presence of obstacles in the lawnmower's path so that they can be avoided.
- The lawnmower monitors its battery voltage and if the voltage falls below a set level the lawnmower returns to its charging station.

Use this function description to complete the system diagram below for the robotic lawnmower.




**[4]**

For this diagram-based question, candidates had to read the bullet pointed information, and translate these points into function boxes that were either inputs into, or outputs from the microcontroller. A total of four correct inputs and/or outputs would be sufficient for full marks.

Some candidates became confused by the diagram and attempted to plan a flowchart of the robot's operation, while others mapped clear inputs but did not include obvious outputs in relation to the robot and the previous question about motors.

Candidates who named differing inputs from sensors to buttons were able to access the input marks, and those who named individual outputs from the microcontroller such as the blade motor and the drive motors (left and/or right) were able to access the output marks.

## Question 4 (e) (i)

**(e)** **Fig. 4.3** shows a circuit diagram for the part of the robotic lawnmower which monitors the battery voltage.

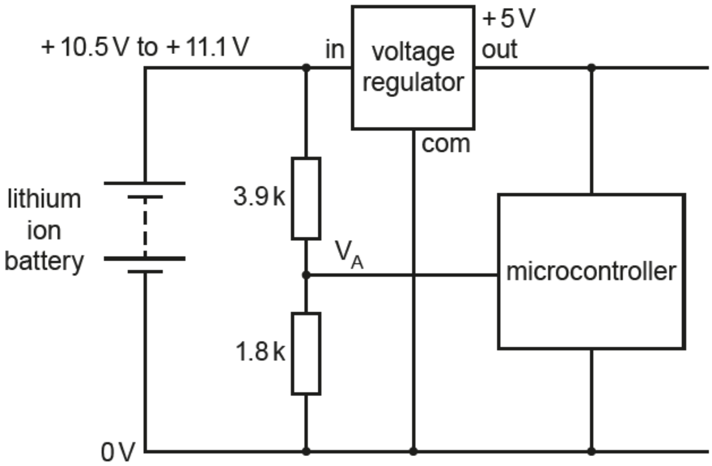



**Fig. 4.3**

The lithium ion battery produces a nominal voltage of 11.1 V. When the battery voltage drops to 10.5 V an alert is generated within the microcontroller code and the robotic lawnmower returns to its charging station.

**(i)** Calculate the voltage (V) at point $V_A$ in **Fig. 4.3** when the battery voltage is 10.5 V. Give your answer to 2 decimal places and show your working.

Voltage .................................. V

**[3]**

For this question, candidates are required to rearrange a simple formula to calculate the current at a specific voltage, and then use this answer to calculate the voltage at a specific point in the circuit that triggers the robotic lawn mower to return to a charging station.

For many candidates, the calculation of the current of the overall circuit was easy to achieve. Where they then kept the current value at its full value, and not to a decimal place, they then went on to calculate the voltage point Va.

Candidates who rearranged the formula correctly but went on to calculate the wrong value achieved a single mark.

## Question 4 (e) (ii)

**(ii)** Voltage $V_A$ in **Fig. 4.3** is fed into an analogue to digital converter (ADC) pin on the microcontroller. The ADC produces a full-scale value of 1023 when the analogue input is 5.0 V.

Calculate the ADC value produced when the input voltage $V_A$ is at the value you calculated in **part (e)(i)**. Give your answer as a rounded-down integer and show your working.

**[3]**

This question required the use of the answer to the previous question, and as such was applicable to the error carried forward rule. The question asked candidates to calculate the value of Va if the full-scale ratio of this value is 1023.

This was an accessible question for candidates who were able to use ratios to calculate their value, which irrespective of the answer to the previous question, resulted in an ADC output value rounded down to the nearest whole number.

## Question 4 (e) (iii)

**(iii)** Draw a flowchart of the robotic lawnmower subroutine to check the battery voltage and generate an alert if the battery voltage falls below 10.5 V.

**[3]**

For the final question in the paper, candidates were tasked with drawing an accurate flow diagram using correct symbols, for the subroutine used by the robot to check the battery voltage, which would importantly trigger a set of instructions to return to the charging station when required to.

Candidates largely used the appropriate symbols for the diagram, and almost all were able to create a decision box relating to the drop in ADC value or voltage, which subsequently triggered an alert. The inclusion of a step to read the battery voltage along with the decision and alert would result in all three marks, and candidates in the majority were consistently accessing two of these.

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