Qualification Accredited

Oxford Cambridge and RSA

A LEVEL

Examiners' report

DESIGN AND TECHNOLOGY: DESIGN ENGINEERING

H404

For first teaching in 2017

H404/01 Summer 2023 series

Version 1

ocr.org.uk/designandtechnology

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. A selection of candidate responses is also provided. 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 and the mark scheme can be downloaded from OCR.

Paper 1 series overview

This paper contained four sets of questions that predominantly cover technical principles. Throughout the paper candidates are required to:

- analyse existing products with specific regards to their material and component properties
- recall scientific formulae and demonstrate applied mathematical skills
- demonstrate their understanding of manufacturing processes and significant technological advancements in design engineering
- demonstrate their understanding of programmable components and associated programming principles.

To do well in this component, candidates needed a fundamental understanding of electronic components and their applications within circuits, in particular motor control and input selection. Candidates also needed to be able to accurately recall and apply scientific and mathematical formulae to calculate energy absorbed, missing angles and side lengths of triangles for instance.

To do well in extended writing responses, candidates needed to make sure that the points made were exemplified with specific examples, for example, when stating points relating to recyclability, the consideration of material selection and inclusion of polymer identification codes. Many excellent responses contained reference to a specific key figure and an associated technical advancement. Others needed to develop more detailed, specific responses to gain high marks.

In mathematical questions candidates should show their workings. If an incorrect final response is given but their method is correct, candidates can gain marks. Candidates who did less well did not show their working and were therefore unable to gain credit for it.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• demonstrated good knowledge of electronic components and their purpose within a circuit • were able to recall and rearrange formulae correctly • demonstrated a clear understanding of and distinction between the needs of a user and manufacturer • worked through mathematical questions in a logical, structured way • confidently identified manufacturing processes and the order in which they would take place • were able to confidently recall a key historical technical advancement and the figures associated with it • showed a good understanding of digital input components and how they function.	• gave generic responses that did not relate to the context of the question • overlooked the differences between benefits to the user and manufacturer • approached mathematical questions in a disorganised way with minimal workings shown • demonstrated little awareness of the required answer format and rounded answers unnecessarily • focused on one aspect in extended writing responses rather than appreciating the depth and complexity of the topic • struggled to rearrange formulae • struggled to follow the path of the flowchart relating to signals being monitored by a microcontroller.

Question 1 (a)

1 This shows a USB-powered personal mini fan.

Item removed due to third party copyright restrictions

(a) The flexible stem of the personal mini fan is covered with PVC. PVC is a thermo softening polymer.

Identify **two** reasons why a thermo softening polymer is a suitable material for the flexible stem.

1 ....

....

2 ....

....

[2]

Candidates responded well to this question. Most candidates were able to identify two different reasons such as flexibility to allow the stem to bend and the polymer acting as an electrical insulator.

Candidates did not achieve full marks when points were not justified within the context such as single word responses; ‘light’ or ‘cheap’.

Question 1 (b)

(b) Explain why bearings are needed in mechanical systems such as those used in the personal mini fan.

....

....

....

.... **[2]**

On the whole candidates responded well to this question. The most successful responses were able to identify that bearings would reduce friction resulting in greater mechanical efficiency.

Some candidates were able to identify why a bearing is needed but did not continue to explain why. For instance, some candidates correctly identified an increased speed of rotation but did not stipulate why.

Question 1 (c)

(c) The personal mini fan is powered by plugging it in to a USB socket.

Explain **one** benefit to the user and **one** benefit to the manufacturer of designing the personal mini fan to be powered from a USB socket.

Benefit to user ....

....

....

Benefit to manufacturer ....

....

....

[4]

Candidates typically responded well here and were able to access all the marks available. The best responses made a clear differentiation between the benefits to the user and manufacturer, presenting different benefits for each. Candidates often identified the commonality of USB sockets increasing the usability of the personal mini fan, and the standardised component being readily available therefore reducing manufacturing time/cost.

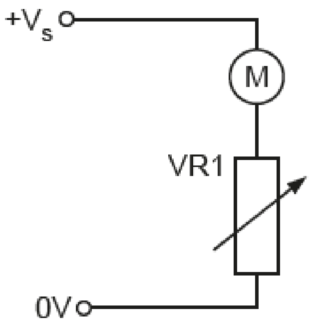
Some candidates were able to identify benefits but made points that were not explained in relation to the user or manufacturer.

Question 1 (d) (i)

(d) The personal mini fan contains a DC motor.

A designer wishes to develop a personal mini fan product by adding a control to adjust the speed of the motor. Different circuits are being considered to achieve this.

This circuit shows how a variable resistor VR1 is used to control the speed of the motor.



(i) When variable resistor VR1 is set at 20 Ω, the fan runs at $\frac{1}{2}$ its maximum speed. At this speed, the current flowing through the circuit is 250 mA.

Calculate the power dissipated in variable resistor VR1 when it is set at 20 Ω. Give your answer in W and show your working. **[4]**

Power dissipated in variable resistor VR1 .... W

This question was answered well, and candidates were able to access a range of marks. Although several candidates did not achieve the correct answer, marks were still given for recalling and manipulating the Ohm's Law then Watt's Law formulae correctly and converting mA to amps.

The less successful responses demonstrated that candidates did not have a good understanding of unit conversion and the principles of Ohm's Law and Watt's Law.

Assessment for learning

The technical concepts behind this question are of a fundamental level in GCSE Combined Science and Physics. There is an expectation that all A Level Design and Technology: Design Engineering candidates would be able to access a question of this nature and limited complexity. It would benefit candidates to revisit principles such as unit conversion, Ohm's Law and Watt's Law periodically throughout the course.

Question 1 (d) (ii)

(ii) Use your result from **part d(i)** to explain why using a variable resistor is not an efficient way of controlling the speed of a DC motor.

....

....

....

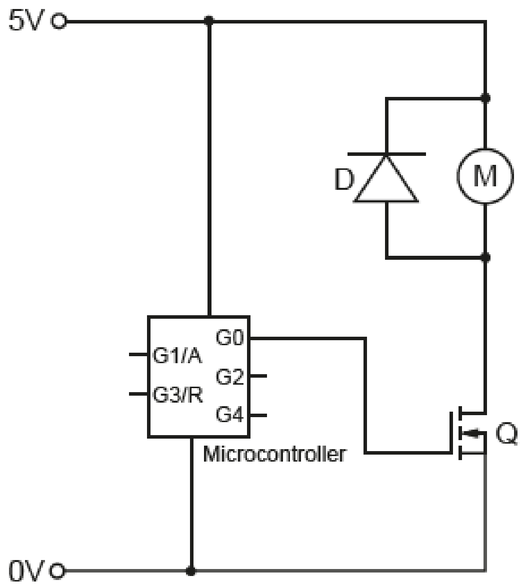
.... **[2]**

This was a well answered question and candidates were often able to link their response to the previous question by identifying that the power is dissipated as heat and not put to any useful purpose within the circuit to power the fan.

Less successful responses often repeated the question by stating that the variable resistor is not efficient but did not refer to power being wasted or lost as heat energy.

Question 1 (d) (iii)

(iii) This circuit shows the motor being controlled by a microcontroller and other components.



Identify component Q and explain its function in this circuit.

....

....

.... **[2]**

The responses to this question were varied. When candidates correctly identified the MOSFET transistor they often gained both marks by also stating it is an amplifying device to increase the current flowing through the fan. Candidates were able to gain marks for identifying the purpose of the component even if it was not correctly identified.

Incorrect responses often identified the component as a switch or variable resistor.

Question 1 (d) (iv)

(iv) Identify **one** reason for including diode D in the circuit.

....

.... **[1]**

Responses were varied to this question. To gain marks candidates needed to identify the reason for including the diode in the circuit rather than stating the generic purpose of a diode. Candidates who performed well identified the removal of back EMF from the motor or to protect the MOSFET.

Misconception

Candidates often correctly identified the purpose of a diode but did not consider or give reason for including a diode in the circuit shown. Understanding the role of the diode to protect the MOSFET was a key factor for this question.

Question 1 (d) (v)

(v) Despite the increased complexity, explain **one** reason why a designer might choose to use a microcontroller to achieve motor speed control in products such as a personal mini fan.

....

....

....

.... **[2]**

Candidates responded well to this question. The best responses identified reasons such as increased functionality to allow for more precise and efficient speed control.

Where candidates did not achieve full marks it was because they did not explain their point clearly with relevant justification.

Question 1 (e)

(e) The personal mini fan sells online for less than £4.00. It is classed as a novelty electrical item. It contains no user serviceable parts and product reviews suggest that it has a lifespan of less than one year.

Discuss the role of a designer in ensuring the responsible disposal of products such as the personal mini fan at the end of their product life.

....

....

....

....

....

.... **[8]**

Level 3 responses made clear points and were well constructed. Candidates often identified the use of material identification or recycling symbols on the product itself or the packaging, design for disassembly and take-back incentives. The best responses also mentioned legislative requirements/directives such as WEEE or RoHS.

Level 2 responses tended to identify several methods to make sure responsible disposal however opportunities to develop and explain their points were missed. Recyclability was often identified but not exemplified or linked to the mini fan or other products for instance.

Level 1 responses missed the focus of the question relating to disposal. Level 1 responses often focused on energy consumption while in use or focusing on the user rather than the role of the designer.

Exemplar 1

The designer should ensure that all materials used are marked with a symbol to show the consumer what materials they are made of. Such as the stem being marked as PVC as some polymers are indistingshable. This is so that components can be recycled responsibly. The designer could offer an incentive to return the product once it reaches end of life in exchange for a reward such as a voucher or product upgrad. This means that fan components

Exemplar 1 is an extract of a Level 3 response where the candidate has clearly identified and exemplified recycling symbols as a method to identify materials used. The candidate continues to explain a further point regarding incentives to return the product at the end of life.

Question 2 (a)

2 (a) **Fig. 2.1** shows a conical drill bit.

Fig. 2.2 shows the cross section of the conical drill bit.

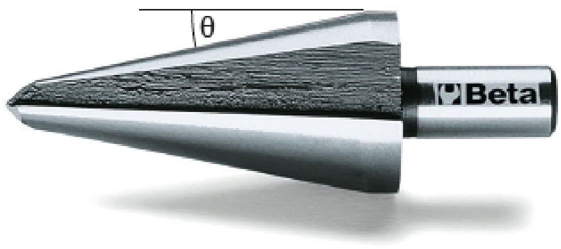


Fig. 2.1

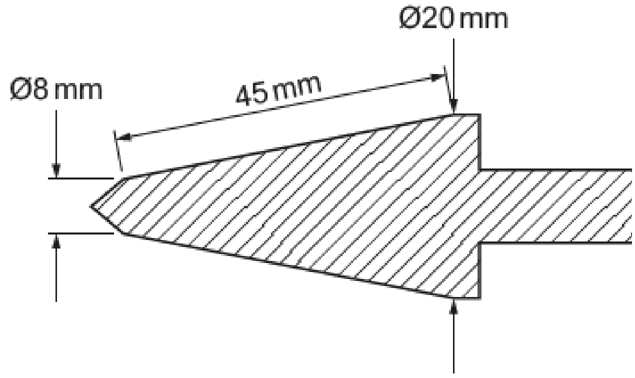


Fig. 2.2
(not to scale)

A student needs to calculate taper angle θ.

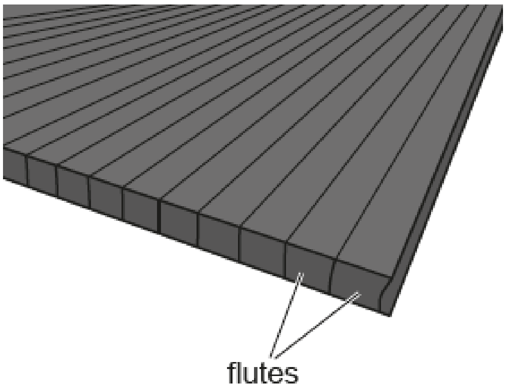
Calculate the taper angle θ in degrees. Give your answer to **1** decimal place and show your working. **[4]**

θ .... °

Candidates responded well to this question, although several candidates did not give their final answer to one decimal place. Candidates often identified the need to calculate the length of the opposite side followed by the arcsine. When candidates did not achieve full marks, their workings would often gain credit if the steps were followed.

Question 2 (b) (i)

(b) This shows part of a corrugated polymer sheet.



The corrugated polymer sheet has hollow flutes which run through the entire length of the sheet. These sheets are sometimes used in solar water heating systems in which the flutes are filled with water and heated by radiant energy from the sun.

The table shows data for the corrugated polymer sheet.

Sheet dimensions	500 mm × 500 mm
Sheet thickness	8.0 mm
Internal cross section of flutes	7.0 mm × 7.0 mm
Number of flutes per metre length	134
Sheet material	Polypropylene

(i) Identify the industrial manufacturing process for corrugated polymer sheets of the type shown above.

.... **[1]**

Responses were varied for this question and candidates often struggled to correctly identify 'extrusion moulding'.

Assessment for learning

A significant number of candidates demonstrated that they did not have a confident grasp of industrial manufacturing methods. It would benefit candidates to be exposed to learning opportunities in a range of contexts that help them to consider appropriate suitable industrial manufacturing processes for a range of products.

Question 2 (b) (ii)

(ii) Use the data in the table to calculate the volume of **one flute** in the corrugated polymer sheet. Give your answer in cm^3 and show your working. **[3]**

Volume .... cm^3

Responses to this question were mostly good with candidates able to correctly recall the formula to calculate volume. Most candidates were able to calculate the cross-sectional area of the flute but some multiplied this value by the sheet thickness rather than the length. Less successful responses typically included errors in unit conversion between mm^2 and cm^3.

Question 2 (b) (iii)

(iii) Use the data in the table and your answer to **part (b)(ii)** to calculate the total volume of **all** flutes in the corrugated polymer sheet. Give your answer in cm^3 and show your working. **[2]**

Total volume .... cm^3

This question required candidates to use their response from the previous question and multiply it by the length of the sheet. Candidates were required to identify that the 134 needs to be halved and then multiplied by their answer to the previous question. Candidates were able to achieve full marks for this question even if their answer for part 2bii was incorrect due to Error Carried Forward.

Question 2 (b) (iv)

(iv) On a sunny day, the corrugated polymer sheet absorbs the sun's energy at a rate of 2.0 kW per m^2.

You will need to use the data in the table on **page 8**.

Determine by calculation that the energy absorbed by the corrugated polymer sheet over a period of 15 minutes is 450 000 J. Show your working. **[5]**

Candidates responded well to this question however care must be taken when a question requires a candidate to determine by calculation to make sure that each step is detailed. Candidates who did not perform well in this question did not consider the surface area or unit conversion within their calculations.

Determine by calculation questions

Where a question requires candidates to determine a response by calculation it is important that every step in the calculation is detailed and presented. If a candidate omits a step from their workings, they may limit the marks they are able to be given for.

Question 2 (b) (v)

(v) It is assumed that all heat absorbed is transferred to the water.

Calculate the temperature rise of the water to the nearest °C in the corrugated polymer sheet over a period of 15 minutes.

Use information in **part (iv)** and the formula $Q = mc\Delta T$ where:

Q = heat energy in J
m = mass of water held in corrugated polymer sheet (1.642 kg)
c = specific heat capacity of water (4200 J / kg °C)
ΔT = temperature change in °C

Show your working. **[3]**

Temperature rise of water .... °C

Responses to this question were mostly good with candidates correctly rearranging the formula and substituting the correct values.

A typical error for this question was candidates not rounding their answer to the nearest °C.

Question 3 (a) (i)

3 (a) (i) Describe, with an example, a way in which textiles can be used for reinforcement in engineered designs.

....

....

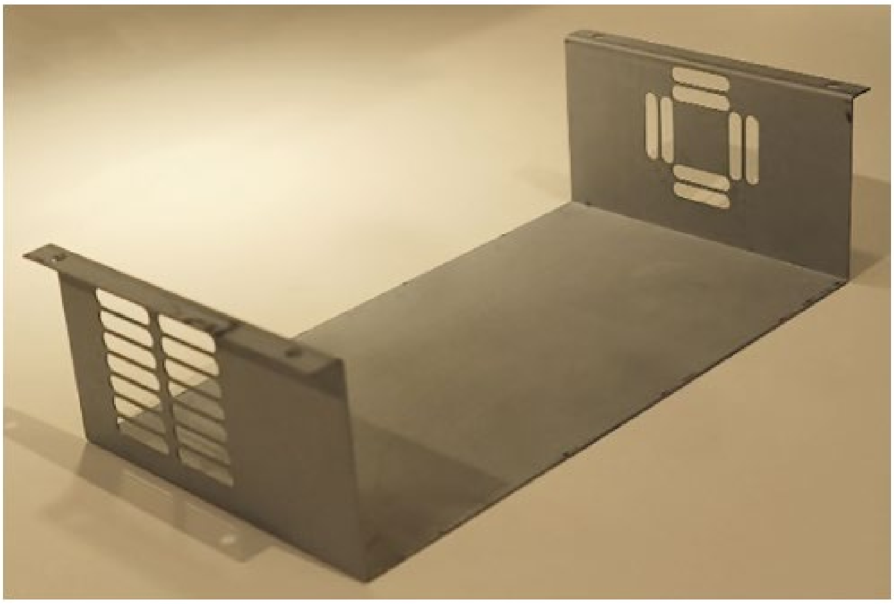
....

.... **[2]**

Responses to this question were varied with candidates often not specifying a particular textile or the method in which reinforcement has been achieved. The best responses included candidates identiying textiles such as nylon/Kevlar/carbon fibre that can be woven or bonded to reinforce products such as tyres/bullet-proof garments/CFRP parts.

Question 3 (a) (ii)

(ii) This shows a sheet metal part which is manufactured in a batch of 5000.



Describe the industrial manufacturing processes which would have been used to manufacture the sheet metal part.

....

....

....

....

....

.... **[4]**

There were a wide range of responses to this question. The best responses identified the sheet metal part first being cut or stamped then bent/formed to shape. These responses correctly identified appropriate processes and associated machinery.

Those candidates who did not perform so well in this question either did not explain the processes identified or did not consider the order in which these processes took place.

Question 3 (b)*

(b)* Historically, significant advances in design engineering have often been brought about by a key technical advancement or discovery.

Identify a key historical technical advancement or discovery and the figures associated with it. Discuss how this work has had an influence on future developments in design engineering.

....

....

....

....

....

.... **[8]**

Level 3 responses were able to clearly identify a key historical technical advancement and the figures associated with it. Typically, these responses detailed the initial impact of the technical discovery followed by the impact this has had on future iterations and developments within the context. Specific products were identified, and explanation was clear and concise.

Level 2 responses tended to identify and explain a key historical technical advancement but did not refer to the figures associated with it. There were often opportunities missed with regards to exemplification to further support the points they were making.

Level 1 responses missed the focus of the question relating to technical advancements. Level 1 responses often focused on generic statements that were not always relevant to the question such as the use of triangulation for reinforcement or mechanical advantage.

The best responses referred to technical advancements such as transistors (with relation to Moore's Law), touch screens in mobile devices (Apple, Steve Jobs), and the lightbulb (Thomas Edison).

Assessment for learning

When learning about key historical advancements or discoveries it would be beneficial for candidates to study the key figures associated with them.

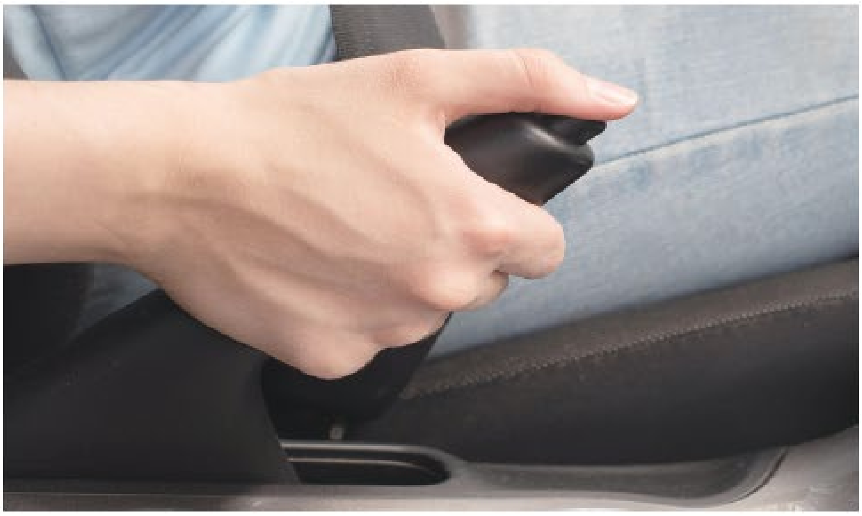
A number of examples can be found in Section 2 of the Hodder Education endorsed textbook.

Question 4 (a)

4 Cars contain a wide range of control systems.

In many cars, the conventional lever-operated parking brake has been replaced with an electric parking brake which is operated by a switch.

This shows a car driver operating a conventional lever-operated parking brake.



This shows a driver operating an electric parking brake switch.

(a) Explain **one** reason why a manufacturer might choose to install an electric parking brake rather than a lever-operated parking brake in a car.

....

....

....

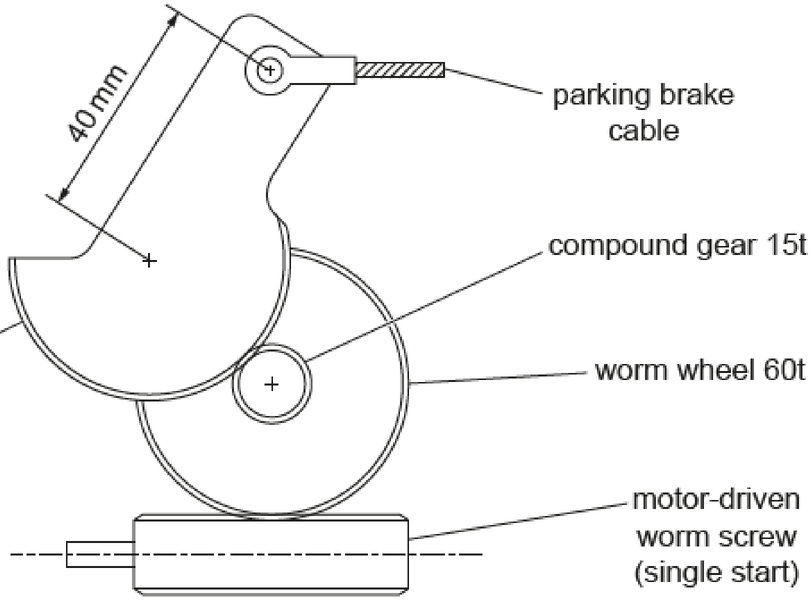
.... **[2]**

This question was generally answered very well. Most candidates referred to inclusivity factors with relation to the strength and dexterity required to operate, or enhanced safety features or functionality.

The less successful responses focused on the user rather than on the reasons why a manufacturer might choose to install an electric parking brake.

Question 4 (b) (i)

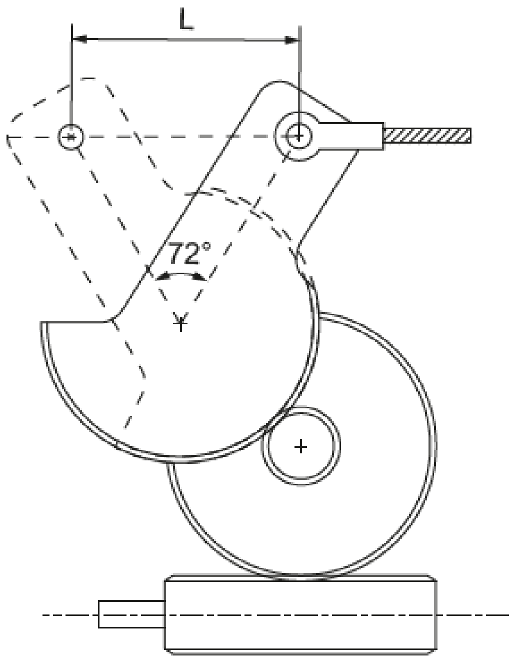
(b) This shows the mechanical actuator system for an electric parking brake.



(not to scale)

The actuator uses a motor and gears to pull a cable which applies the parking brake.

During operation, the output gear rotates through 72° into the position shown.



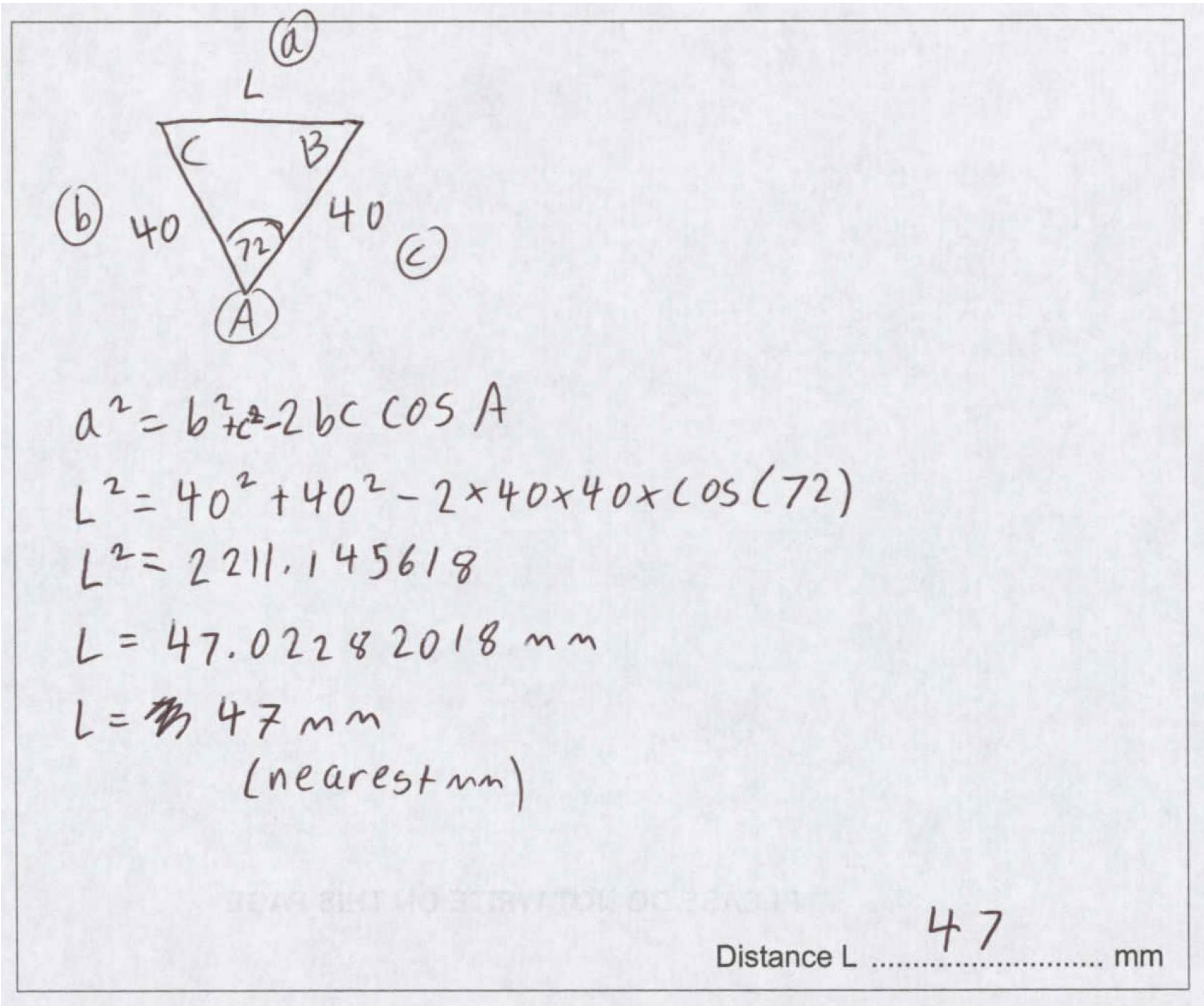
The parking brake cable is pulled through a distance marked L.

(i) Use the information on **page 14** to calculate distance L. Give your answer to the nearest mm and show your working. **[4]**

Distance L .... mm

This question resulted in a range of responses. Candidates who answered the question split the triangle into two right angled triangles before applying/manipulating appropriate trigonometry formula. Care must be taken by candidates not to round their answers throughout their working and pay specific attention to the format of the final answer. Several candidates missed out on full marks by not rounding their answer to the nearest mm.

Exemplar 2



$a^2 = b^2 + c^2 - 2bc \cos A$

$L^2 = 40^2 + 40^2 - 2 \times 40 \times 40 \times \cos(72)$

$L^2 = 2211.145618$

$L = 47.02282018$ mm

$L = 47$ mm (nearest mm)

Distance L ......47...... mm

Exemplar 2 is an example of a response where a candidate has clearly presented their working in a logical manner to achieve the correct response.

Question 4 (b) (ii)

(ii) Use the information on **page 14** to calculate the number of revolutions of the worm wheel that are required to rotate the output gear through an angle of 72°. Show your working. **[3]**

Number of revolutions of worm wheel ....

Candidates who responded well to this question identified the need to multiply 0.8 by 60 to achieve the final answer of 48 revolutions. Several candidates correctly identified the compound gear would rotate through 0.8 revolutions but missed the last crucial step to calculate the number of revolutions the worm wheel rotates through.

The less successful responses often identified the correct formula for gear ratio but did not apply it correctly to the context of the question.

Question 4 (c) (i)

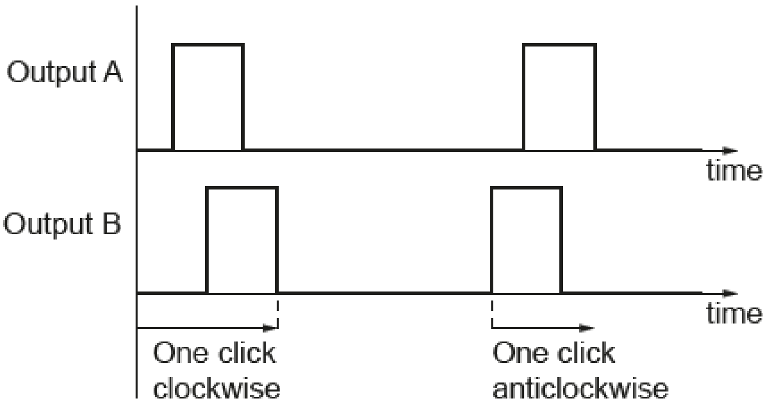
(c) This shows the central console control knob in a car.

The control knob clicks as it is rotated and it can be assigned to many different functions.

The control knob is connected to an incremental rotary encoder which produces two output signals, A and B.

Outputs A and B each produce one pulse in sequence when the control knob is turned through one click.

The graph shows the pulses produced by outputs A and B when the control knob is rotated through a single click clockwise and a single click anticlockwise.



(i) Describe how incremental rotary encoders can benefit design engineers.

....

....

....

....

....

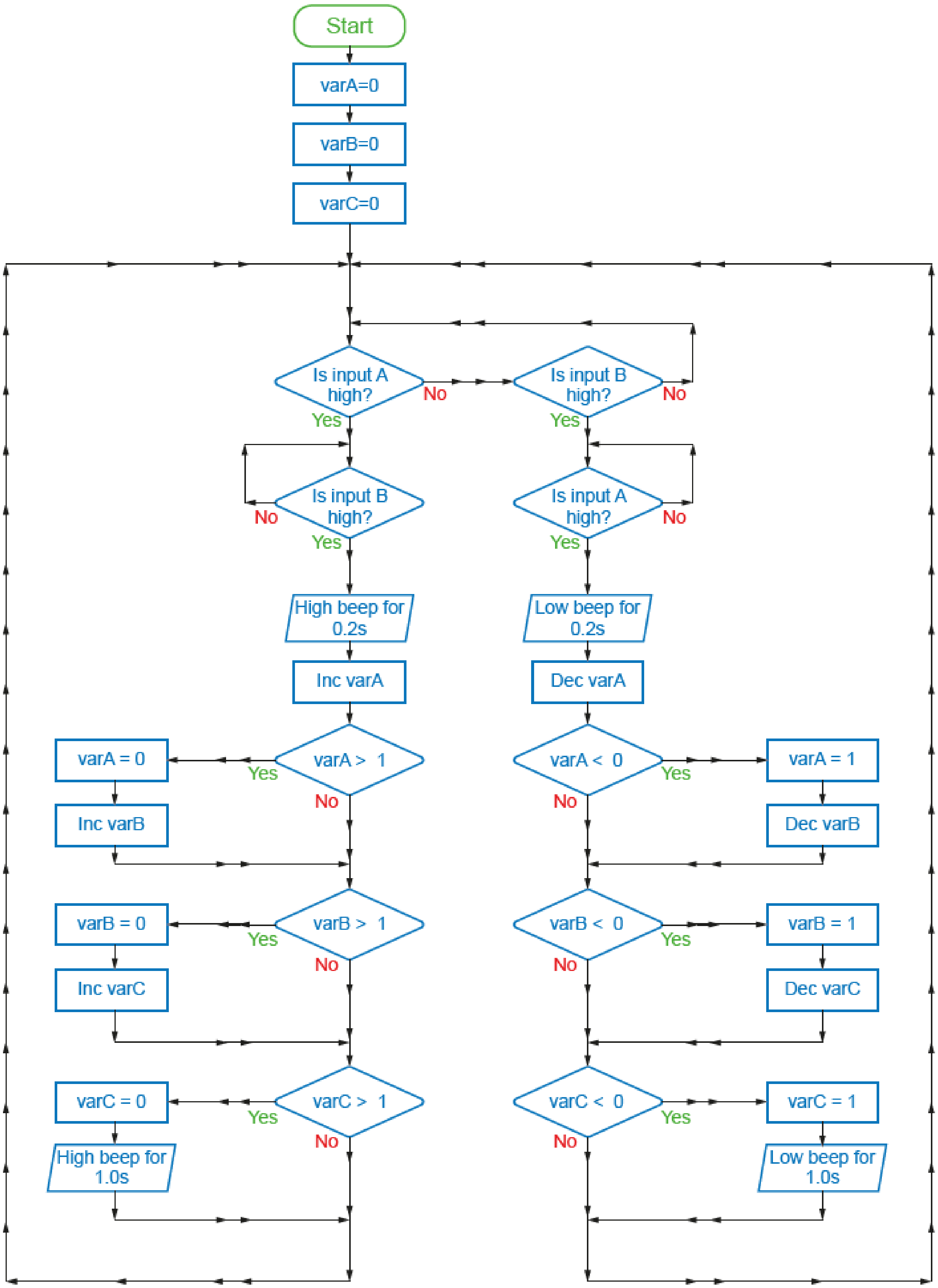
.... **[3]**

Candidates responded well to this question and were able to identify benefits such as the ability to measure direction and speed of a rotating shaft. Candidates often also correctly identified that incremental rotary encoders have no end stops and are versatile input components.

Candidates who did not perform well did not give a detailed explanation of the benefit or demonstrate an understanding of the component.

Question 4 (c) (ii)

The signals from A and B are monitored by a microcontroller running the following flowchart program.



(ii) Use the information on **pages 17 and 18** to describe how the system provides audible feedback to the user when the control knob is rotated **clockwise**.

....

....

....

....

....

.... **[4]**

Candidates who performed well in this question were able to identify that the order of the inputs influenced whether the flowchart followed the left-hand or right-hand route. A followed by B would then result in a high beep for 0.2s. Some candidates demonstrated a deeper understanding of the flowchart by identifying that a longer high beep of 1.0s would sound after the 8th click.

Candidates who did not perform so well were able to identify that a high beep would sound but often did not support this by demonstrating an understanding of the order of the inputs.

Exemplar 3

When the knob is rotated clockwise output A produces a signal and output B produces a delayed signal after A. Input A is high first and then B, therefore we follow the left side of the flow chart. This then produces a high beep of 0.2 s, which is an audible feedback to the user that the knob has been rotated clockwise.

Exemplar 3 is an example of a response where a candidate has demonstrated a clear understanding of the flowchart and is able to explain each step.

Question 4 (c) (iii)

(iii) The flowchart program is restarted from the START command and the control knob is rotated **five clicks clockwise**.

Write down the values of variables A, B and C after the fifth click. **[3]**

Variable A ....

Variable B ....

Variable C ....

Question 4 (c) (iv)

(iv) The control knob is then rotated **two clicks anticlockwise**.

Write down the **new** values of variables A, B and C. **[2]**

Variable A ....

Variable B ....

Variable C ....

These final two questions generated a range of responses. Candidates who identified that a binary sequence would be produced often generated correct or partially correct responses. On several occasions candidates did not identify that the variables would not count higher than 1 and several responses included values such as 5.

Misconception

A significant number of candidates did not recognise or understand the greater than (>) or less than (<) symbols in the flowchart and gave variable values greater than 1 or lower than 0. The flowchart would check each variable value after each click and if greater than 1 would reset to 0 (clockwise) and if less than 0 would reset to 1 (anti-clockwise).

Copyright information

Q4: Image of handbrake, Alamy ID 2D8FMPR, © Alena Ivochkina / Alamy Stock Photo

Q4: Image of Breach Switch, Alamy ID KPR7XP, © Panther Media GmbH / Alamy Stock Photo

Q4c: Image of control, Alamy ID 2GG92AX, © Hanna Kuprevich / Alamy Stock Photo

Supporting you

Teach Cambridge

Make sure you visit our secure website **Teach Cambridge** to find the full range of resources and support for the subjects you teach. This includes secure materials such as set assignments and exemplars, online and on-demand training.

Don't have access? If your school or college teaches any OCR qualifications, please contact your exams officer. You can forward them this link to help get you started.

Reviews of marking

If any of your students' results are not as expected, you may wish to consider one of our post-results services. For full information about the options available visit the OCR website.

Access to Scripts

For the June 2023 series, Exams Officers will be able to download copies of your candidates' completed papers or 'scripts' for all of our General Qualifications including Entry Level, GCSE and AS/A Level. Your centre can use these scripts to decide whether to request a review of marking and to support teaching and learning.

Our free, on-demand service, Access to Scripts is available via our single sign-on service, My Cambridge. Step-by-step instructions are on our website.

Keep up-to-date

We send a monthly bulletin to tell you about important updates. You can also sign up for your subject specific updates. If you haven't already, sign up here.

OCR Professional Development

Attend one of our popular CPD courses to hear directly from a senior assessor or drop in to a Q&A session. Most of our courses are delivered live via an online platform, so you can attend from any location.

Please find details for all our courses for your subject on **Teach Cambridge**. You'll also find links to our online courses on NEA marking and support.

Signed up for ExamBuilder?

ExamBuilder is the question builder platform for a range of our GCSE, A Level, Cambridge Nationals and Cambridge Technicals qualifications. Find out more.

ExamBuilder is **free for all OCR centres** with an Interchange account and gives you unlimited users per centre. We need an Interchange username to validate the identity of your centre's first user account for ExamBuilder.

If you do not have an Interchange account please contact your centre administrator (usually the Exams Officer) to request a username, or nominate an existing Interchange user in your department.

Active Results

Review students' exam performance with our free online results analysis tool. It is available for all GCSEs, AS and A Levels and Cambridge Nationals.

Find out more.

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on
01223 553998

Alternatively, you can email us on
support@ocr.org.uk

For more information visit
- **ocr.org.uk/qualifications/resource-finder**
- **ocr.org.uk**
- **facebook.com/ocrexams**
- **twitter.com/ocrexams**
- **instagram.com/ocrexaminations**
- **linkedin.com/company/ocr**
- **youtube.com/ocrexams**

We really value your feedback

Click to send us an autogenerated email about this resource. Add comments if you want to. Let us know how we can improve this resource or what else you need. Your email address will not be used or shared for any marketing purposes.

I like this **I dislike this**

Please note – web links are correct at date of publication but other websites may change over time. If you have any problems with a link you may want to navigate to that organisation's website for a direct search.

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT