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Examiners' report

A LEVEL

DESIGN AND TECHNOLOGY: DESIGN ENGINEERING

OCR Level 3 Advanced GCE in Design and Technology: Design Engineering

H404

For first teaching in 2017

H404/01 Summer 2025 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. 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 Teach Cambridge.

Paper 1 series overview

This paper is set out through four sets of questions that predominantly cover technical principles. Candidates are required to:

- analyse existing products or systems
- recall scientific formulae and demonstrate applied mathematical skills
- demonstrate their technical knowledge of mechanisms
- demonstrate their technical knowledge of materials, product functionality, manufacturing processes and techniques
- demonstrate their understanding of wider social, ethical and environmental issues that impact on the design and manufacturing industries
- analyse and demonstrate understanding of microcontroller pseudocode in flow chart form

To do well in this series, candidates needed a sound grasp of electronics and polymer manufacturing processes, a good understanding of ergonomics, and knowledge of how materials are sourced in relation to social, ethical and environmental considerations.

To do well in written responses, candidates needed to work to the marks available and justify the points made with specifics for the context given, for example, when identifying and justifying suitable properties of thermo softening polymers and describing the principle of designing a product for repair and maintenance.

Overall, the exam for this series drew a strong set of responses and shows that many candidates had been suitably prepared for the range of contextual and mathematical questions that the paper can include. Most candidates had a good awareness of ergonomics, as well as ethical and environmental issues relating to the sourcing of materials and were able to provide examples. However, many candidates struggled to demonstrate knowledge and/or understanding of commercial electronics manufacture including surface mount technology (SMT), pick-and-place machines, reflow soldering ovens. Many candidates had limited knowledge of microcontrollers, often limited to one off-the-shelf product such as Arduino and Microbit and struggled to demonstrate an awareness of how microcontroller integrated circuits are embedded into electronic circuits. Many candidates struggled to interpret pseudocode in flow chart form.

Candidates that did well on this paper, recalled scientific formulae accurately and were able to apply mathematical skills to re-arrange them. They were confident in their ability to convert units and presented the working to their maths responses neatly and in an organised, structured manner that could be followed, while paying attention to units of measurement.

A feature of strong performances was evidence of analysis in the responses to the extended writing questions. For example, for the 'ergonomics' question they identified four or more ergonomic features of the electric toothbrush and explained the reason for them. For the 'materials sourcing' question, they targeted the identified aspects of the questions, of 'social', 'ethical' and 'environmental'.

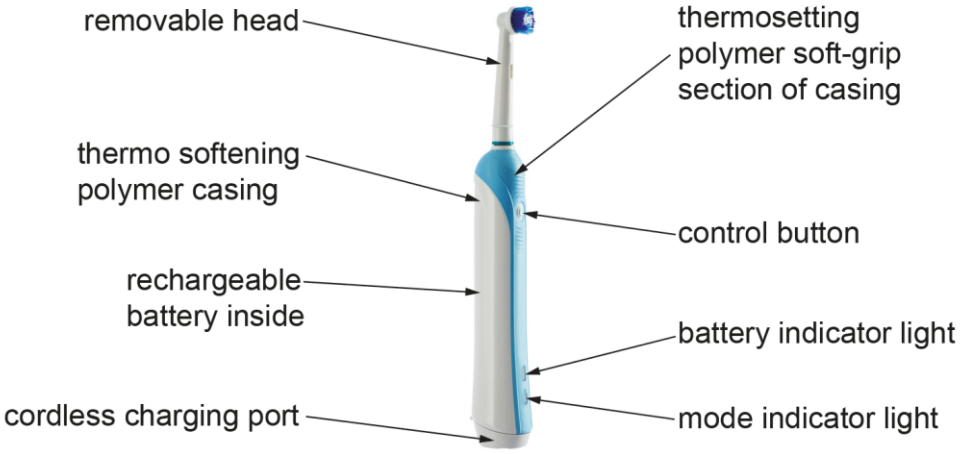
Less successful candidates on this paper tended to lack Maths skills, and responses were disorganised or missing working-out that could have earned valuable marks. A tendency to respond with vague, generic or non-specific responses to the question context was a feature of poorer responses, such as when describing the principle of designing a product for repair and maintenance. Responses to extended writing questions lacked evidence of analysis and points were often made with little justification. Less successful did not respond to the over-arching context of 'how the use of SMT and the inclusion of an embedded microcontroller make it straight forward' for the manufacturer to release three head torch models.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• demonstrated a good knowledge of polymer manufacturing, the differences between thermo softening and thermo setting polymers, and properties of thermo softening polymers • provided good quality sketches, using drawing aids for accuracy • answered in relation to the context of the question with detailed and/or points specific to the context made • worked through maths questions in an organised and structured way • recalled formulae and could re-arrange these correctly • effectively analysed extended writing questions and mind mapped responses before presenting good quality descriptive writing • gave examples in extended writing questions • had good knowledge of commercial electronic manufacturing processes.	• struggled to identify material properties or destructive tests by name • provided vague or generic responses that did not respond to the context of the question • overlooked numerous opportunities in extended writing responses, with answers that lacked evidence of analytical thinking skills • provided free-hand sketches that were difficult to interpret • approached maths questions in a disorganised and/or erratic way with little evidence of working out or structure that may have helped earn marks for errors carried forward, or for appropriate working • struggled to re-arrange formulae • made errors in mathematical calculations, indicating weak calculator skills or the lack of a calculator • could not interpret pseudocode in flow chart form • had little knowledge of commercial electronics manufacturing processes.

Question 1 (a) (i)

1 **Fig. 1.1** shows an electric toothbrush.

Fig. 1.1



(a)

(i) Identify **three** functional reasons why the electric toothbrush has a removable head.

1 .....

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2 .....

.....

3 .....

.....

[3]

Most candidates responded well to this question. Reasons were identified clearly, e.g. to allow the head to be easily cleaned.

Where candidates did not achieve full marks, they tended to think that removal of the brush head provided access to the inside of the toothbrush for maintenance and/or to replace the battery.

Question 1(a) (ii)

(ii) Identify **two** properties of a thermo softening polymer that make it suitable for the casing of the electric toothbrush.

Justify **each** of your answers.

1 .....

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.....

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2 .....

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[4]

This was a reasonably well answered question. Many candidates were able to give specific properties of thermo softening polymers that were appropriate for the context of the question. Properties such as good impact resistance, toughness, poor electrical and thermal conductivity were popular in strong responses.

Less successful responses tended to show little understanding of what a property is, or candidates struggled to identify a property. Some included the suggestion that a thermo softening polymer was suited to being used to the case because it would mould from the heat of the user's hand to suit their grip. Answers of this type demonstrated that candidates had limited knowledge of the use of polymers in everyday products.

Assessment for learning

The specification section 5.1 (a) (iv) indicates that candidates should understand that selection of materials and components is influenced by a range of factors, including properties and characteristics.

5.3 (a) identifies a range of characteristics and properties that candidates should be familiar with.

These include:

Density, tensile strength, strength to weight ratio, hardness, durability, thermal and electrical conductivity, corrosion resistance, stiffness, elasticity, plasticity, impact resistance, malleability and ductility, machinability.

It would benefit candidates to undertake learning activities that provide the opportunity to analyse and examine the components of existing products and systems to identify the required characteristics and properties that have led to the choice of material used. This could be combined with product disassembly activities and undertaken theoretically using digital material property chooser charts.

Question 1(a) (iii)

(iii) The manufacturer chose to include a soft-grip section on the casing of the electric toothbrush.

The soft-grip material is a thermoplastic elastomer (TPE) which is a type of thermosetting polymer.

Describe **two** challenges to the manufacturer of including a soft-grip section on the casing of the electric toothbrush.

1 .....

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2 .....

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[4]

This was a reasonably well answered question by most candidates. Where candidates did well, they identified the challenge posed by combining two different types of polymers with different thermal properties. The strongest responses also included reference to injection moulding and the additional cost and time implications of an additional manufacturing process.

Few candidates were aware of the two-shot injection moulding process. Less successful responses tended to look at design issues including concerns about dimensional accuracy.

Question 1 (b) (i)

Fig. 1.2 shows an electric toothbrush on a charging base. The base is used to charge the battery inside the electric toothbrush.

Fig. 1.2

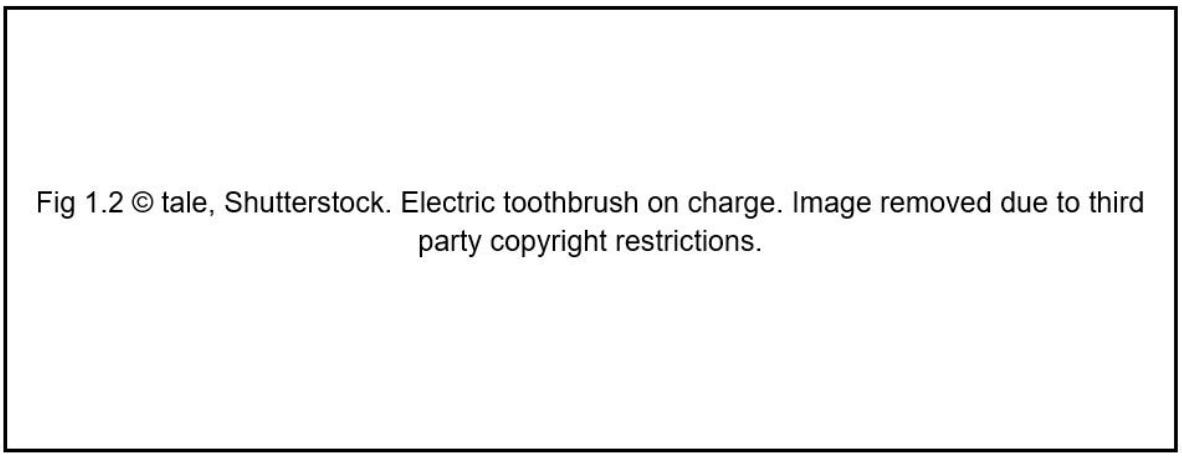


Fig 1.2 © tale, Shutterstock. Electric toothbrush on charge. Image removed due to third party copyright restrictions.

(b)

(i) The electric toothbrush contains a 3.7 V rechargeable battery.

A current of 0.1A is passed through the battery when it is charging.

Calculate the power in watts (W) put into the battery during charging. Show your working. **[2]**

Power ..... W

Most candidates correctly recalled the formula P = IV and calculated the correct answer.

Question 1 (b) (ii)

(ii) The efficiency of the charging system for the electric toothbrush is 74%.

Use your answer from **part (b)(i)** to calculate the power drawn from the mains power supply during the charging process. Give your answer in W and show your working. **[2]**

Power ..... W

Around 50% of candidates were able to correctly express the efficiency of the system and calculate the power drawn from the mains power supply. Power from mains = 0.37 / 0.74 = 0.5W.

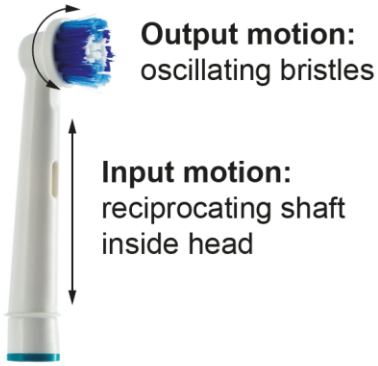
Where candidates did not earn all the marks, they tended to do 0.37 x 0.74 = 0.2738W.

Question 1 (c)

(c) An electric toothbrush head contains a mechanism that converts reciprocating motion of a shaft into oscillating motion of the bristles.

Fig. 1.3 shows the input and output motions.

Fig. 1.3



Draw an annotated sketch to show a mechanism capable of producing the required conversion of motion in the electric toothbrush head. **[2]**

Many candidates successfully communicated a mechanism that would convert reciprocating motion to oscillating motion. The most popular mechanisms were rack and pinion, and crank and slider.

However, the quality of sketching was generally poor from most candidates, particularly where drawing aids such as rules, circle templates or compasses had not been used. In many cases candidates did not accurately identify pivot points, or they were missing, and it was difficult to understand how the mechanism drawn would work.

Less successful responses included mechanisms that did not convert reciprocating to oscillating motion, for example, a worm and worm wheel.

Assessment for learning

It would benefit candidates to be familiar with aspects of BS8888 drawing standard to communicate mechanisms. In most cases drawing convention simplifies how complex components are communicated. For example, using BS8888 a spur gear can be represented by concentric circles and centre lines. Candidates should be encouraged to use drawing aids to improve the quality of communication of mechanical systems. These skills are also appropriate for communicating design ideas in the NEA.

Question 1 (d)

(d) Discuss the ergonomic design features of the electric toothbrush shown in **Fig. 1.1**.

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

This was a well answered question by most candidates. Many candidates earned marks in high Level 2 or Level 3. In Level 3 responses, candidates identified four or more features and evidenced good analysis and well-developed points relating to the context, such as the need for a soft grip and/or ridges to improve grip/friction when using a vibrating toothbrush that may be wet and prevent slipping/dropping.

Level 2 responses included two to three features, but some of the less successful responses lacked the levels of analysis of Level 3, and didn't make the links to the context. For example, overlooking the presence of water/toothpaste and/or the vibration of the toothbrush.

There were few Level 1 responses, but these tended to be quite vague and/or be focused on the soft grip from Question 1 (a) (iii) almost exclusively, demonstrating a lack of confidence in how to respond to the question and/or independent analytical thinking skills. In some cases, candidates had not read the question correctly and instead of identifying ergonomic features of the electric toothbrush shown in the picture, they identified anthropometric data that could have been used for aspects of the electric toothbrush.

Question 2 (a) (i)

2

(a) A student wants to 3D print a hollow sphere.

(i) The sphere must have an **internal** volume of 45 cm^3.

The student requires the sphere to have a wall thickness of 3 mm.

Calculate the **external diameter** of the hollow sphere. Give your answer in mm to **3** significant figures and show your working.

Use the rearranged formula: $r^3 = 45 / \frac{4}{3}\pi$
where:
r = radius **[5]**

External diameter of hollow sphere ..... mm

Approximately 40% of candidates earned all five marks. In most of these cases, responses featured supporting sketches and/or a logical layout indicating the steps taken.

Most candidates were able to re-arrange the formula, however where candidates did not earn all the marks, they tended to struggle with the calculation, with many of the less successful responses demonstrating a struggle with the cube root calculation and overlooking the necessary unit conversion from cms to mms.

Exemplar 1

$r^3 = 45 / 4/3\,\pi$

$\therefore r^3 = 10.74$

$r = 2.21$ cm

$r + 3 \Rightarrow$ [illegible]

$0.0221 + (3 \times 10^{-3})$

$= 0.0251$ m

$\therefore$ external diametre $= 0.0251 \times 2$

$= 0.0502$ m

$\therefore$ 50.2 mm

External diameter of hollow sphere ..... 50.2 ..... mm

The Exemplar 1 response above is a good example that shows working out that is logically presented. This enables the examiner to see what values have been used throughout the calculation. For example, this example uses values to three significant figures resulting in a response that is slightly different from the mark scheme worked example.

Assessment for learning

Candidates should be encouraged to do a quick sketch at the start of complex Maths questions of this nature.

Question 2 (a) (ii)

(ii) 3D printing is an additive manufacturing method. The printer builds the 3D part by depositing PLA thermo polymer on to the printer bed.

The PLA is supplied as a filament wire with a diameter of 1.75 mm.

The 3D printer software predicts that 2.2×10^4 mm^3 of PLA will be used to produce the sphere and the associated support structure.

Calculate the length in mm of PLA filament wire that will be used. Show your working.

Use the formula: $V = \pi r^2 l$
where:
V = volume of a cylinder
r = radius
l = length **[4]**

Length of PLA filament wire ..... mm

Candidates that correctly rearranged the formula tended to do well. Most candidates calculated the radius of the filament correctly.

Where candidates struggled, there was often evidence of the correct method being used, but incorrect calculations demonstrating that they lacked the necessary calculator skills.

Question 2 (b) (i)

(b) 35 000 parts are made in a batch as part of an industrial manufacturing process.

There is a probability during the process that each part could suffer from two independent manufacturing faults.

Probability of fault A occurring = 0.02
Probability of fault B occurring = 0.01

(i) Calculate the number of parts in the batch that are likely to suffer **fault A**. Show your working. **[2]**

Number of parts .....

Most candidates did well on this question.

Where candidates dropped marks, it was usually due to not using a calculator and providing an answer that was a factor of ten out.

Question 2 (b) (ii)

(ii) A part is rejected if it suffers from both faults.

Calculate the number of parts in the batch that are likely to suffer from **both faults**. **[2]**

Number of parts .....

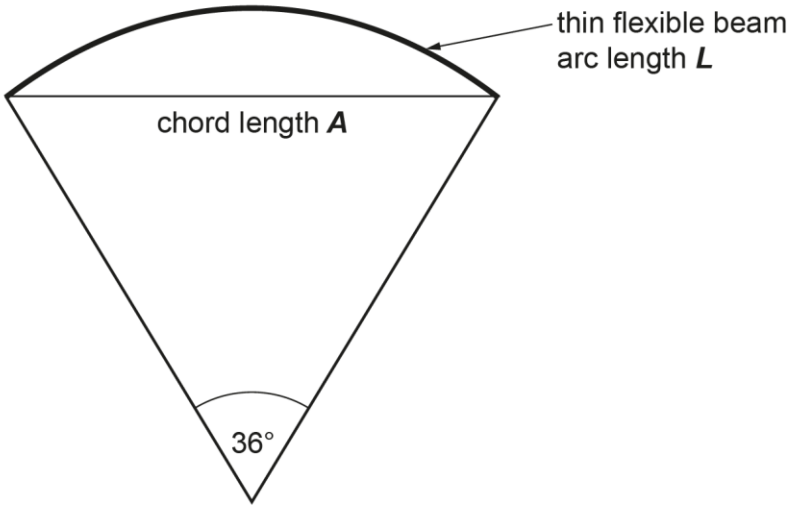
Approximately 50% of candidates performed well on this question, knowing that the correct calculation required the probabilities of both faults to be multiplied.

Candidates that did not do well on this question clearly did not know how to do the calculation.

Question 2 (c) (i)

(c) **Fig. 2.1** shows a thin, flexible curved beam made from plywood.

Fig. 2.1



(not to scale)

The beam is an arc taken from a circle of radius 1000 mm.

The arc subtends an angle of 36° at the centre of the circle.

(i) Use **Fig. 2.1** and the given formula to calculate the arc length ***L*** of the plywood beam. Give your answer to the nearest mm and show your working.

$L = 2\pi r \times$ (subtended angle / 360) **[2]**

Arc length ***L*** ..... mm

Most candidates performed well on this question.

A small number of candidates did not score all the marks available, and this was usually down to poor analysis of the question and the data provided and then substituting the wrong values. Some candidates did not provide the final answer to the nearest mm.

Question 2 (c) (ii)

(ii) Use **Fig. 2.1** to calculate the chord length ***A***. Give your answer to the nearest mm and show your working.

Use the formula: $\boldsymbol{A} = \sqrt{a^2 + b^2 - 2ab\cos 36}$ **[2]**

Chord length ***A*** ..... mm

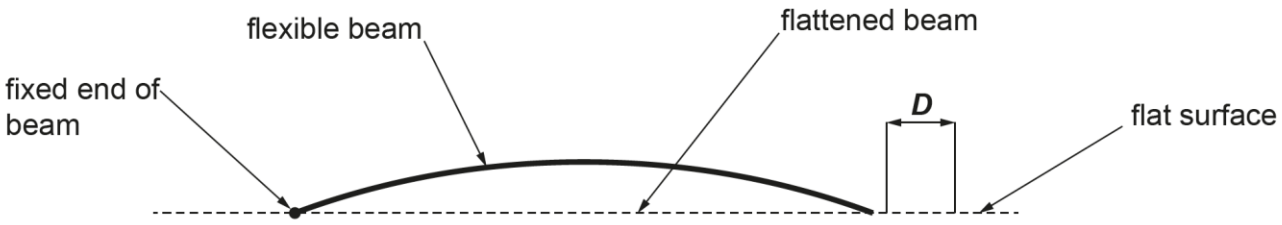
Over 50% of candidates performed well on this question.

Where candidates did not score all the marks, they did not identify that the formula given is the cosine rule and/or know how to apply it to the triangle in **Fig. 2.1**. This resulted in the incorrect values being substituted for a and b. However, in some cases a value was calculated that could be used in the next question. Some candidates did not provide the final answer to the nearest mm.

Question 2 (c) (iii)

(iii) The flexible plywood beam is placed on a flat surface as shown in **Fig. 2.2**.

Fig. 2.2



(not to scale)

The left end of the flexible beam is fixed in position and a load is placed on top of the beam. This causes the beam to flatten as indicated by the dashed line in **Fig. 2.2**.

Use your answers from **part (c)(i) and part (c)(ii)** to calculate the distance ***D*** moved by the right end of the flexible beam as it is flattened. Give your answer in mm and show your working. **[2]**

Distance ***D*** moved ..... mm

Over 50% of candidates correctly calculated the distance D, realising that distance D = arc length – chord length.

Where errors were carried forward from the previous two questions, many candidates were able to earn the marks. However, where negative values were likely, candidates tended to swap the values around and were unable to earn any marks.

Question 3 (a)

3

(a) Design Engineers design products with repair and maintenance in mind.

Describe the principle of designing a product for repair and maintenance.

Use an example of a product in your answer.

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

Most candidates answered this question well and provided appropriate examples including products or systems, access panels, standard components, standard tools and maintenance instruction manuals.

Where candidates achieved low marks, it was typically because their answers were vague and lacked examples.

Question 3 (b)*

(b)* Cobalt is a key component of the batteries used in electric cars and many other electronic devices.

Cobalt is extracted by mining. There is concern that miners are exploited and exposed to dangerous conditions.

Discuss the responsibilities of manufacturers to ensure that the materials they use are sourced responsibly.

Use examples of **social**, **ethical** and **environmental** issues in your answer.

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

This was a generally well answered question with most candidates able to address the ethical and environmental aspects placing them in Level 2 or above. Many were able to give examples and were familiar with cobalt mining in the Democratic Republic of Congo, as well as the issues relating to fair pay, working conditions, lack of H&S governance and PPE provision. Other good responses included references to Fair Trade and FSC, for crops and wood respectively.

Level 3 responses addressed all three aspects of the question and provided good examples for the 'social' aspect. These tended to relate to company profile, loss of brand loyalty and sales, and protest demonstrations.

Some of the less successful Level 2 responses had examples but then struggled to relate these back to the responsibilities of the manufacturer.

Less successful responses tended to be limited to ethical or environmental considerations only and many of these were confused that employers in LEDCs, where many mineral resources are sourced, are not governed by the same H&S and working regulations as they are in this country.

Exemplar 2

Use examples of **social**, **ethical** and **environmental** issues in your answer.

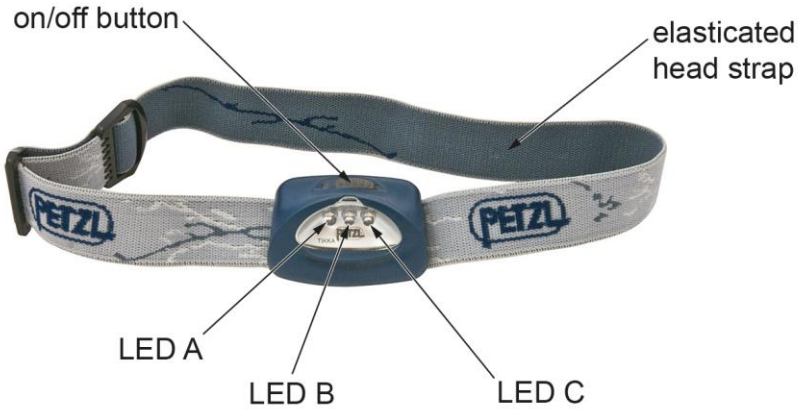
One environmental issue that is important to consider is how the materials are being extracted. If all of the borings and machines used are running off of fossil fuels this will have not only a tremendous impact on the environment but will also expose all of the miners continually to harmful gases which could create health concerns down the line. The emissions produced should be kept as low as possible and offset in some way if possible. A major ethical concern of the sourcing of cobalt is the destruction of animals' habitats when mining the materials from the ground. Many animals will live on the surface before it is excavated. The manufacturer should ensure that the habitats were cleared ethically before mining had started. Another ethical issue that the manufacturer will run into is the treatment of all of the miners. They are generally exposed to many hazardous materials when mining and while they are also often overworked and underpaid. The manufacturer should ensure the miners working conditions are as safe as possible. Finally a social responsibility the manufacturer has is ensuring that the mines are as far away from urban areas as possible as the large amounts of noise and the disruption to the area will have a negative impact on the societies around it. [8]

Exemplar 2 above shows a Level 3 response including all three aspects of the question.

Question 4 (a) (i)

4 **Fig. 4.1** shows the basic version of a head torch.

Fig. 4.1



(a)

(i) Identify **one** reason why physical testing would be carried out on a pre-production prototype of the head torch.

Justify your answer.

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..... **[2]**

This question was answered well by most candidates. Most candidates identified the need to physically test the head torch for ergonomic (comfort) reasons, or to test that the elasticated head strap was suitable for a large range of users. Many candidates made the links to the likely intended use of the head torch being for outdoor activities such as camping, caving and climbing and identified the need to identify that it was suitably durable or robust for these activities.

Where candidates did not earn all the marks, responses were generic or vague and not specific ally linked to the context, e.g. 'to see if it works'.

Question 4 (a) (ii)

(ii) Identify and describe **one** destructive test that could be carried out on a manufactured head torch.

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..... **[2]**

Most candidates earned all the marks available. The most popular answer related to accelerated stretch testing of the elasticated strap. Although many candidates did not know the specific names of tests, e.g. impact test, drop test, they were able to earn the marks by describing the test.

In many cases candidates did not describe the test identified but explained the reason for the test instead, e.g. 'drop test, to make sure suitable durability as the head torch is likely to fall off the user's head at different heights.'

Where candidates did not perform well, they identified tests that were not destructive, for example, 'test elasticity to see if it fits a range of heads', or not appropriate.

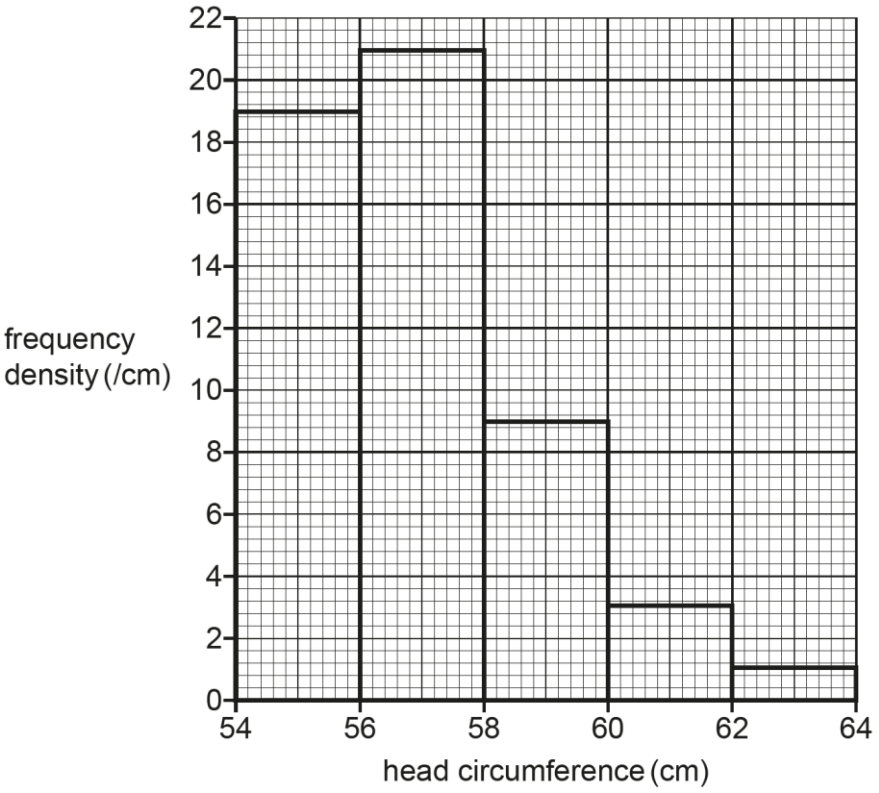
Question 4 (b) (i)

(b) The manufacturer collected head circumference data from a sample of people to determine the length of the strap for the head torch.

The data was grouped and presented in a histogram.

The histogram and supporting data is shown in **Fig. 4.2**.

Fig. 4.2



Head circumference range (cm)	Frequency
54–56	38
56–58	42
58–60	18
60–62	6
62–64	2

(i) Use the information in **Fig. 4.2** to calculate the number of people used in the sample. Show your working. **[1]**

Number of people .....

Nearly all candidates earned the mark for this question.

Question 4 (b) (ii)

(ii) Use the information in **Fig. 4.2** and your answer to **part (b)(i)** to estimate by calculation the mean head circumference of the sample. Give your answer in cm and show your working. **[3]**

Mean head circumference of the sample ..... cm

Approximately 20% of candidates performed well on this question.

Candidates either knew the correct method to estimate by calculation the mean head circumference, or they did not.

Assessment for learning

Candidates should learn how to analyse data from histograms, where values are grouped into ranges, or classes.

To estimate by calculation the mean value of a sample the following calculation should be undertaken:

Mean value of sample =

((Mean value of each class) x (frequency)) / (number of people in sample)

Question 4 (c) (i)

(c) The head torch contains an embedded microcontroller.

The microcontroller and other electronic components are mounted on a printed circuit board (PCB) using surface mount technology (SMT).

A PCB from a similar product is shown in **Fig. 4.3**.

Fig. 4.3

Fig 4.3. A PCB from a similar product. © Quality Stock Arts, Shutterstock. Image removed due to third party copyright restrictions.

The PCB is batch manufactured using a pick-and-place machine and a reflow soldering oven.

(i) Describe the meaning of the term **pick-and-place machine**.

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..... **[2]**

Where candidates described the picking of components and placing them on PCBs, there were able to access all the marks. Many were able to take an educated guess and earn the marks, but it was obvious they were not familiar with the over-arching themes of Question 4 (c) and Question 4 (e) being commercial electronics manufacture.

Candidates that did not perform well, provided generic and/or vague responses, such as, 'a robot that will pick up a part and place it elsewhere'. Where response did not specifically relate to electronics manufacture, they could not be given marks.

Question 4 (c) (ii)

(ii) Describe the meaning of the term **reflow soldering oven**.

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..... **[2]**

A surprisingly high number of candidates did not know what a reflow soldering oven is.

Candidates that did perform well were able to provide a detailed description that included reference to the solder paste on the PCB melting and SMT components being soldered in place on cooling.

Assessment for learning

Specification point 7.3 (b) states that candidates should:

Demonstrate an understanding of the industrial methods used for assembling electronic products, including:
i. surface mount technology (SMT)

ii. PCB assembly using solder stencils, pick-and-place machines and reflow soldering ovens.

Questions 4 (c) (i), 4 (c) (ii) and 4 (e) highlighted that many candidates had not learnt about commercial electronics manufacture.

It is important that this content is covered in schemes of work. Online videos are available to show candidates these manufacturing processes and systems in factories.

Question 4 (d)

(d) The manufacturer intends to develop the basic head torch. It wants the user to be able to change the brightness by repeatedly pressing the button.

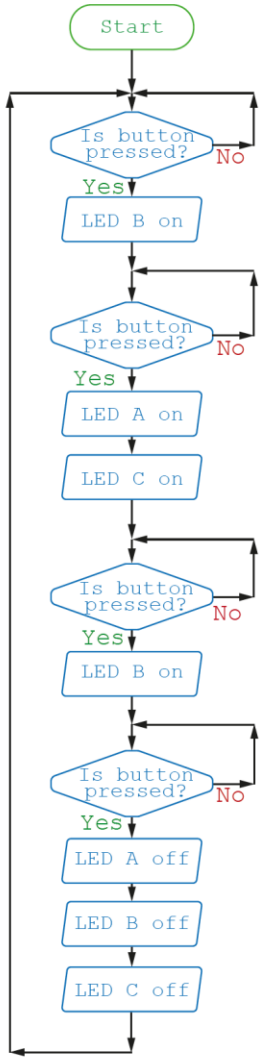
Fig. 4.4 shows how the LEDs will switch on or off in a cycle.

Fig. 4.4

Button press number	Mode	LED A	LED B	LED C
1	Dim	OFF	ON	OFF
2	Normal	ON	OFF	ON
3	Bright	ON	ON	ON
4	Off	OFF	OFF	OFF

During the development, the head torch microcontroller is programmed with the flowchart shown in **Fig. 4.5**.

Fig. 4.5

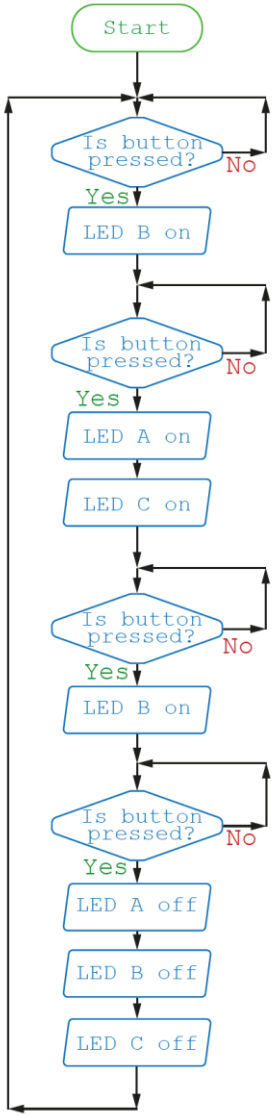


The flowchart program does not perform as expected.

Analyse the information in **Fig. 4.4**. On the flowchart below identify the following using annotations and drawings:

- the errors
- the changes that are needed to make it function correctly.

The flowchart below is a repeat of **Fig. 4.5**. **[4]**



Most candidates correctly identified that LED B needed to be off after the second button press and gave the change to the flow chart either with a drawn cell and an arrow, or a redrawn section of flow chart.

Few candidates identified the second error in the flow chart. This is the lack of delays after button presses, to both compensate for the length of time the button would be pressed and switch bouncing.

Candidates that struggled with this question demonstrated that they did not understand how to interpret pseudocode in flowchart form.

Assessment for learning

It will benefit candidates to have a working knowledge of a range microcontrollers, such as Arduino, Microbit and Genie / PICAXE.

H404.01 and H404.02 examinations use flow chart to represent pseudocode which is a programming medium used by Genie and PICAXE systems. For candidates to have the opportunity to learn to use flow charts for programming, programming activities, including simulations, can be undertaken in Circuit Wizard (Genie) or PICAXE Editor 6 (PICAXE). The latter application is free of charge to download and run on centre networks.

Question 4 (e)

(e) As part of its business strategy, the manufacturer plans to release three models of the head torch.

Fig. 4.6 summarises the three models.

Fig. 4.6

Models	LED function	LED colour
Basic version	Simple on/off function, no brightness control	White
Intermediate version	Three brightness levels	White
Advanced version	Several brightness levels, plus flashing function	Selectable white or red

The manufacturer wants to release the three different models with minimal changes to its manufacturing system.

Discuss how the use of surface mount technology (SMT) and the inclusion of an embedded microcontroller make it straightforward for the manufacturer to do this.

Refer to **hardware** and **software** in your answer. **[8]**

Most candidates struggled to perform well on this question. Although many were able to explain how a microcontroller could be programmed for the different models by adapting the flow chart given in Question 4 (d), many demonstrated little knowledge of commercial electronics manufacture and surface mount technology (SMT). Many overlooked that the embedded microcontroller would be used in all models and did not make the necessary links to perform well in the question.

In Level 3 responses candidates provided evidence that they clearly understood the advantage of using SMT with an embedded microcontroller and reference to the use of minimal components and the overall size of SMT PCB's, linking well to manufacturing and production lines. In many cases they identified that only one PCB layout was required with a pick-and-place machine programmed to add additional LEDs to provide the functionality required for the intermediate and advanced versions of the head torch. They detailed the differences in the programming required for the different models.

Candidates that performed at Level 2 successfully generally made the links that one PCB could be used for all three models. Most responses also included reference to this, however, less successful responses tended to state that the basic head torch did not need a microcontroller and talked about the components needed. Many candidates had limited knowledge of microcontrollers, often limited to one off-the-shelf product such as Arduino and Microbit and struggled to demonstrate an awareness of how microcontroller integrated circuits are embedded into electronic circuits.

Level 1 performances demonstrated little knowledge and/or understanding of surface mount technology (SMT). Less successful responses did not respond to the over-arching context of 'how the use of SMT and the inclusion of an embedded microcontroller make it straight forward' for the manufacturer to release three head torch models.

Assessment for learning

Programmable interface controller (PIC) integrated circuits are cheap microcontrollers that candidates can embed in their own electronic circuits. Circuit Wizard will help candidates to design, program and simulate their own printed circuit board with an embedded Genie PIC. PICAXE Editor 6 will help candidates to program an embedded PICAXE microcontroller.

Arduino and Microbit devices are examples of programmable electronic systems that have embedded microcontrollers. However, candidates can develop their own Arduino circuits on breadboards using an ATMEGA 328 microcontroller integrated circuit. A good place to learn about this can be found here.

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