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Examiners' report

DESIGN AND TECHNOLOGY: DESIGN ENGINEERING

H404

For first teaching in 2017

H404/01 Summer 2024 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 answers 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 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 materials, product functionality, manufacturing processes and techniques
- demonstrate their understanding of wider social, moral and environmental issues that impact on the design and manufacturing industries.

To do well in this particular series, candidates needed a sound grasp of basic electronic circuit principles, a good working knowledge of a range of sensors, their suitability for motor control applications, as well as compound gear systems and associated gear ratios to calculate output speeds of rotation.

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 explaining suitable properties of glass-reinforced thermos softening polymers, and how focus groups can be used when developing a cat feeder.

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 brand loyalty and promotion, as well as planned obsolescence, and were able to provide examples. However, most candidates struggled to demonstrate knowledge and/or understanding of Total Quality Management (TQM).

Candidates that did well on this paper, recalled scientific formulae accurately and were able to apply mathematical skills to rearrange 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 'distribution to markets' question, with a large number of appropriate points made and explained, targeted against the identified aspects of the questions, of 'environment' and 'supply and demand'.

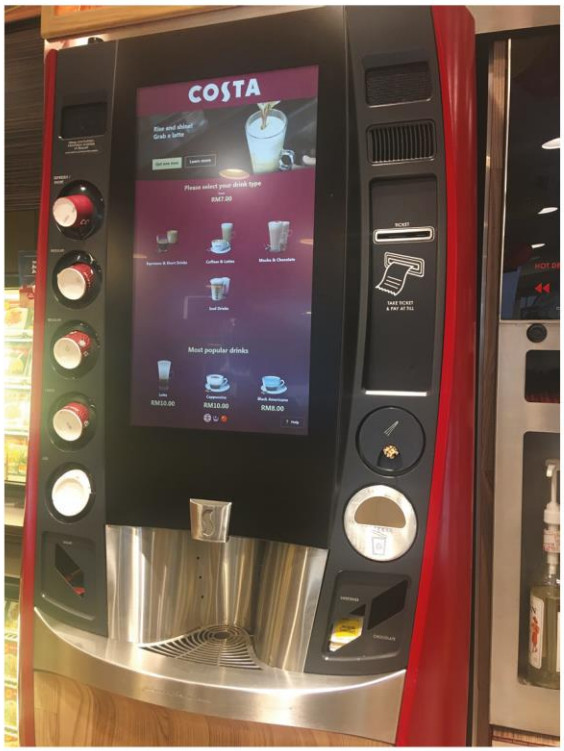
Candidates that did not do well on this paper had a weak grasp of the fundamentals of electronics, including Ohm's Law and the power formula (P=VI). Maths skills tended to be weak, and responses were disorganised or missing working out and units that could have earned valuable marks. A tendency to respond with vague, generic or non-specific responses to the question context was a feature of poorer responses when considering safety features of a coffee machine, and properties of glass-reinforced thermo softening polymers. Responses to extended writing questions lacked evidence of analysis and points were often made with little justification. Weaker candidates provided answers to these questions that did not respond to the overarching context of 'distribution to markets'.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• demonstrated a good knowledge of the mechanical properties of polymers and composites • confidently recalled the format of a two-stage compound gear system and effectively applied their own calculations to identify an overall gear ratio • a good working knowledge of electronic sensors for use for control of rotation in a mechanical system • provided good quality sketches • 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 rearrange these correctly • confidently provided details of the units used and their conversion in maths questions • effectively analysed extended writing questions and mind mapped responses before presenting good quality descriptive writing.	• 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 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 • demonstrated little awareness of units in calculations • struggled with conversion of litres to cm3 • struggled to recall formulae for power calculations and Ohm's Law • struggled to rearrange formulae.

Question 1 (a) (i)

1 **Fig. 1.1** shows a self-service coffee vending machine. This type of machine is often found at petrol stations.

Fig. 1.1



(a) The machine can make several types of fresh hot coffee. It has a touch screen user interface.

The machine uses fresh milk which must be refrigerated. It needs to be plugged in to mains electricity and connected to a freshwater supply.

(i) Identify **two** safety features that could be included in the design of a coffee vending machine.

Justify how **each** of the safety features you have identified helps to keep users safe.

1 .....

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2 .....

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[4]

Candidates responded well to this question on the whole. Most candidates identified clear safety features with specific hazards to the user related to these, e.g. provide a drainage grille and tray to prevent hot spills overflowing on to the user and burning them.

Where candidates did not achieve full marks, they either repeated aspects given in the question, or gave generic responses relating to aspects such as electrical safety that were not specific to the coffee machine.

Question 1 (a) (ii)

(ii) Explain **one** benefit and **one** drawback of using a touch screen interface in products such as coffee vending machines.

Benefit .....

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Drawback .....

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[4]

This was a well answered question by most candidates. The most common benefits related to ease of use, accessibility and inclusivity, and for drawbacks many responses related to high initial cost, high cost of replacement, the fragile nature of a glass screen, and the need to clean regularly to ensure correct operation.

Where candidates did not achieve full marks, they gave points that were not specifically relevant to a machine with a touchscreen but could also apply to an alternative with push button input, e.g. require regular cleaning. In some cases, the benefit and/or drawback were identified, but they were not explained.

Assessment for learning

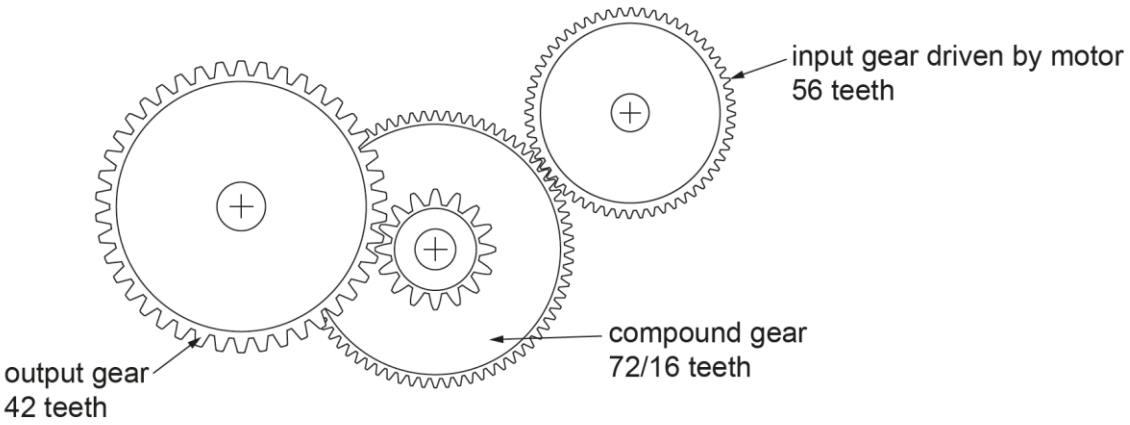
Candidates should be trained to relate their responses to the context in the question wherever possible.

Question 1 (b) (i)

(b) The coffee vending machine uses a grinder mechanism to grind coffee beans into powder.

Fig. 1.2 shows how the coffee grinder mechanism is driven by an electric motor through a compound gear train.

Fig. 1.2



(i) The electric motor runs at a speed of 3000 rpm.

Use the information in **Fig. 1.2** to calculate the rotational speed of the output gear. Give your answer in rpm to the nearest whole number. Show your working. **[3]**

Rotational speed ..... rpm

Candidates that could recall the gear ratio formula for a compound gear train did well on this question. A surprisingly high number of candidates could not recall the gear ratio formula correctly or did not know how to apply this to a compound gear train.

Question 1 (b) (ii)

(ii) The gears in **Fig. 1.2** have teeth of different sizes.

Explain **one** reason why the designer chose to use a gear with larger teeth for the output gear.

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

This answer received a high number of incorrect answers. Many candidates either missed the reference to larger teeth and instead answered the question in relation to a larger gear or thought that the output gear did the crushing of the coffee beans. Candidates that responded well related the increased size of the teeth to increased shear strength required to cope with a larger torque when crushing the beans.

Question 1 (b) (iii)

(iii) The gears in **Fig. 1.2** are manufactured from glass-filled nylon which is a type of glass-reinforced thermo softening polymer.

Identify **two** properties of a glass-reinforced thermo softening polymer that makes it suitable for manufacturing gears.

Justify **each** of your answers.

1 .....

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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 GRP in relation to gears, such as high tensile strength, good strength to weight ratio and suitability for injection moulding. The best responses justified these properties and related them to improvements in resistance to turning forces, reduced load on the motor, and ability to mould into intricate shapes respectively. However, there were many candidates who did not give clear rationale in their answers for example making comments such as durable or strong but did not make it clear how this is better than other materials.

The weaker responses often had vaguely identified properties which could fit any context or were not specific to gears.

Question 1 (c) (i)

(c)

(i) Describe ways in which product designers and manufacturers promote **brand awareness** in customers.

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

This question was answered well by most candidates. The most common responses related to advertising, logos, colour schemes, the use of social media and celebrity endorsement. The best examples considered these branding methods across a range of products to reflect the identity of the manufacturer and provided examples.

Where candidates did not achieve full marks, it was because the points made did not describe how the brand would gain increased awareness. For example, some candidates gave high quality product as a method, but did not describe how this would raise brand awareness, missing the necessary link to product/brand promotion.

Question 1 (c) (ii)

(ii) Describe ways in which product designers and manufacturers encourage **brand loyalty** from customers.

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

This was a well answered question. The most common responses related to reward schemes, discounts and free goods for existing customers. The best responses include specific examples, with many candidates making the links to coffee drinker reward schemes, and the use of the Costa App. Another popular good response referred to Apple's integration of a product family including iPhones, MacBooks, Apple Watches and Air Pods.

Where candidates did not achieve full marks, it was because the response was vague or they did not make the connection to existing customers. Some candidates confused planned obsolescence with brand loyalty.

Question 2 (a) (i)

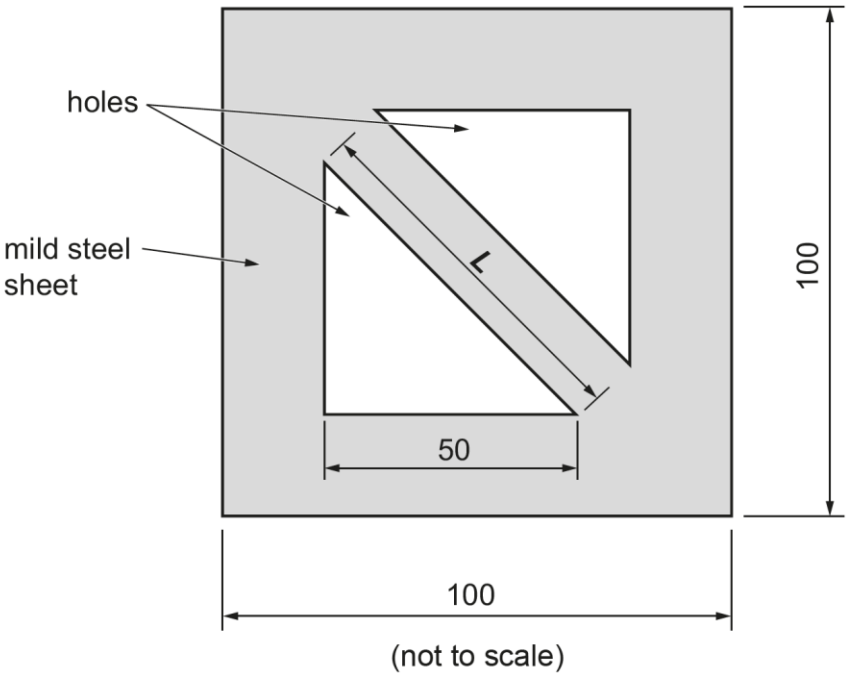
2

(a) **Fig. 2.1** shows a part made from a square sheet of mild steel. The part has two triangular holes cut out.

The two holes are identical. Each hole is in the shape of a right-angled isosceles triangle.

All measurements are shown in mm.

Fig. 2.1



(i) Calculate the length marked ***L*** on **Fig. 2.1**. Give your answer in mm to **1** decimal place. Show your working. **[3]**

L ..... mm

Most candidates did well on this question as they could identify the need to use Pythagoras' Theorem, and recall and apply it correctly.

Question 2 (a) (ii)

(ii) The surface area of the face of the steel sheet **without** the two triangular holes cut out is 10 000 mm^2.

Calculate the surface area of the face of the steel sheet shown in **Fig. 2.1** once the two triangular holes have been cut out. Give your answer in mm^2 and show your working. **[2]**

Surface area ..... mm^2

Most candidates earned all the marks on this question, correctly identifying that the area of the two triangles is that of a square.

Weaker responses tended to show that the candidate had overlooked the surface area of the face of the steel sheet which is given in the question stem. This also led to an excessive amount of work undertaken.

Question 2 (a) (iii)

(iii) A paint finish needs to be applied to the part in **Fig. 2.1**.

Every 1 mm^2 of surface area requires 2×10^{-4} cm^3 of paint.

The sheet thickness is 5 mm.

The four outside edges of the part have a total surface area of 2000 mm^2.

Use your answers to **part (a)(i)** and **part (a)(ii)** to calculate the total volume of paint required to cover **both** sides of the part and **all** the exposed edges. Give your answer in cm^3 to **2** decimal places. Show your working. **[5]**

Total volume ..... cm^3

The responses to this question were varied, although around 60% of candidates did do very well. This tended to be where all the stages of the working had been shown clearly, with many benefitting from clearly identifiable errors carried forward from the previous questions or within the question that could be rewarded. The best responses tended to feature sketches or a logical layout indicating the steps taken.

Exemplar 1

2000 + 7500 + triangle edges

(50 × 5) × 4 + (70.7 × 5) × 2

= 1000 + 707 = 1707

2000 + 7500 + 1707 = 9500 mm² + 1207

= 11207 mm²

1 mm² = 2 × 10⁻⁴ cm²

9500 mm² = 1.9 cm² × 5500

7 mm² = 2 × 10⁻⁴ cm²

11207 = 2.24

Total volume 2.24 cm³

Exemplar 1 is an excellent example where the candidate has worked methodically to the correct answer.

Question 2 (b) (i)

(b) A heater is being used to prevent water pipes freezing in winter. The heater has a resistance of 32 Ω.

(i) The heater is connected directly to a 24 V dc power supply.

Calculate the power dissipated in the heater. Give your answer in watts (W) and show your working. **[3]**

Power ..... W

The majority of candidates performed well on this question, as they were able to recall the formula $P = V^2R$. However, a surprisingly high number of candidates struggled to recall the formula and therefore performed poorly on this question.

Assessment for learning

Section 6.4e of the course specification details that candidates should be able to demonstrate an understanding of the basic principles of electricity including: voltage, current, Ohm's Law and power.

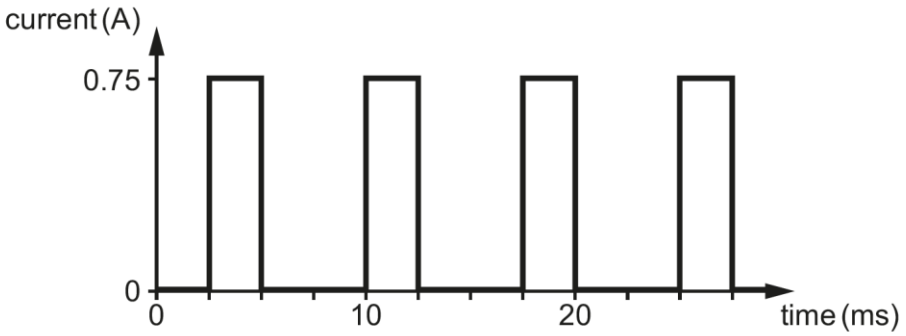
Candidates should be given the opportunities to undertake calculations that require them to recall the associated formulae, rearrange them and substitute values. This can be done alongside breadboard activities/experiments or electronic circuit simulators to prove the values that are measured.

Question 2 (b) (ii)

(ii) To reduce the heater power, the current through the heater is repeatedly pulsed on and off.

Fig. 2.2 shows a graph of how the current varies over time.

Fig. 2.2



Use the graph to calculate the average current flowing through the heater. Give your answer in amps (A) and show your working. **[2]**

Average current ..... A

Most candidates struggled to earn marks in response to this question. Candidates that did do well, correctly identified the mark/space for one full cycle from the graph and used the two values to correctly calculate the average current.

Where candidates did not earn any marks, it was because they incorrectly calculated the average current, misinterpreting the graph, or overlooking the repeat nature of the cycle.

Question 2 (b) (iii)

(iii) The heater uses a 24 V dc power supply.

Use your answer from **part (b)(ii)** to calculate the average power dissipated in the heater when the current is pulsed as shown in **Fig. 2.2**.

Give your answer in watts (W) and show your working. **[3]**

Average power ..... W

Over 50% candidates performed well on this question, this is because they correctly recalled the formula P = IV, showed clearly all the stages of their working and benefitted from error carried forward marks in some cases as a result. Many of these candidates were able to gain full marks (ECF) despite the error in 2bii.

Where candidates did not achieve full marks, in most cases they did not recall the formula P = IV.

Question 3 (a)

3

(a) Explain, using a specific example, how a manufacturer can use a planned obsolescence business strategy to promote future product sales.

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

The responses to this question were varied. Candidates that responded well used examples of companies and products to support their explanation of planned obsolescence and could use specific aspects of the example to identify planned obsolescence.

Where candidates did not achieve full marks, it was because their response did not convey their clear understanding that planned obsolescence is the process of designing products to go out of fashion or no longer function after a specific period.

Many candidates used the example of Apple iPhones. Good responses included where candidates explained that software updates that slowed operation, or lack of software support after time, led to the phones being replaced for new models. However, many focused on decaying battery life, a feature of all batteries in products.

Question 3 (b)

(b) Discuss how a Total Quality Management (TQM) strategy can help a manufacturing company achieve sustained levels of quality.

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

Most candidates struggled to earn many marks in response to this question as it was clear that they did not know what Total Quality Management (TQM) is.

Level 3 responses were where candidates recognised the holistic nature of TQM as a start to finish process involving and empowering the workforce and in some instances included examples of manufacturers, such as Toyota.

Level 2 responses tended to be limited exclusively to quality control and/or quality assurance of manufacturing and assembly processes, and/or product testing. The better Level 2 responses included examples such as batch sampling, x-ray testing and the use of go no-go gauges.

Level 1 responses tended to be quite vague and repeat elements of the question. Many mentioned testing of materials, machines or products to achieve high quality, with little or no analysis or exemplification of how this can be done.

Assessment for learning

It is important that all aspects of the specification are included in the delivery of this course in order for candidates to perform to their best ability.

Exemplar 2

This style of management ensures there is a positive philosophy inside the company for each employee to continue to strive for quality. ~~This initially can be covered in quality assurance~~ An example of this is Nissan where engineers are encouraged to write reports around issues they've had with cars to ensure those mistakes are avoided in the future.

Quality assurance could be encouraged under this strategy to frequently check tooling, and design processes to ensure products are set up to have a high quality production.

Quality control can be used to check samples in each batch to ensure no recurring problems are occuring during manufacturing.

Visual checks can also be used to ensure parts are visually correct. This is used by Audi to ensure the cars are visually good and also check panel tolerances with go-no-go gauges. [8]

A good example of quality assurance is Boeing Airplanes where they are only allowed to buy parts from certified sellers to ensure quality and materials meet the required quality for the use.

Exemplar 2 includes examples of Nissan, Audi and Boeing to support the points made.

Question 4 (a)

4 **Fig. 4.1** shows an automatic cat feeder.

Fig. 4.1

The cat feeder is designed to automatically dispense dry pelleted food to a pet cat for up to three days. The user can program how often the cat is fed and the quantity of food that is dispensed at each meal.

(a) Describe how focus groups can be used when developing a new automatic cat feeder.

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

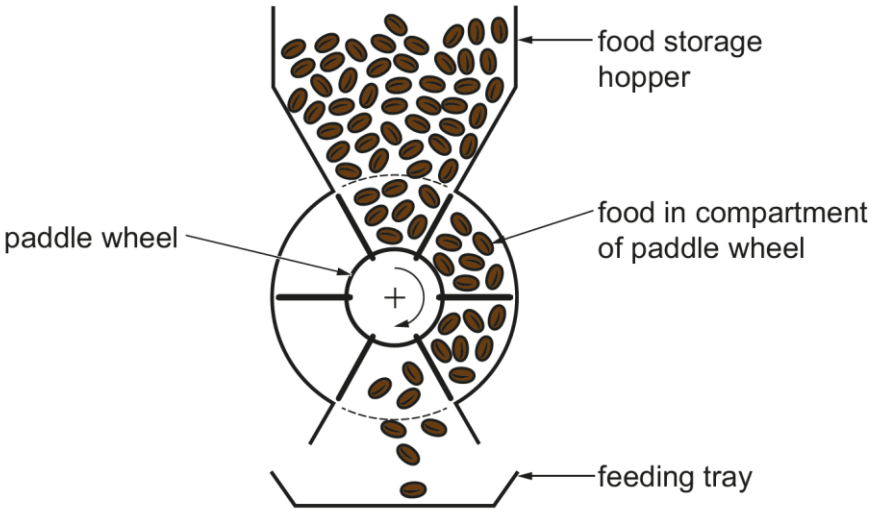
This question received a varied set of responses. Candidates that answered the question well were able to relate focus group work to the cat feeder and considered testing with cats to obtain quantitative data relating to food types, quantity and frequency. Many described how users could comment on aesthetics and ergonomics in testing.

Where candidates achieved low marks, it was typically because their answers were vague, generic, or not explicitly related to the context of the cat feeder.

Question 4 (b) (i)

(b) The food dispensing mechanism for the automatic cat feeder is shown in **Fig. 4.2**.

Fig. 4.2

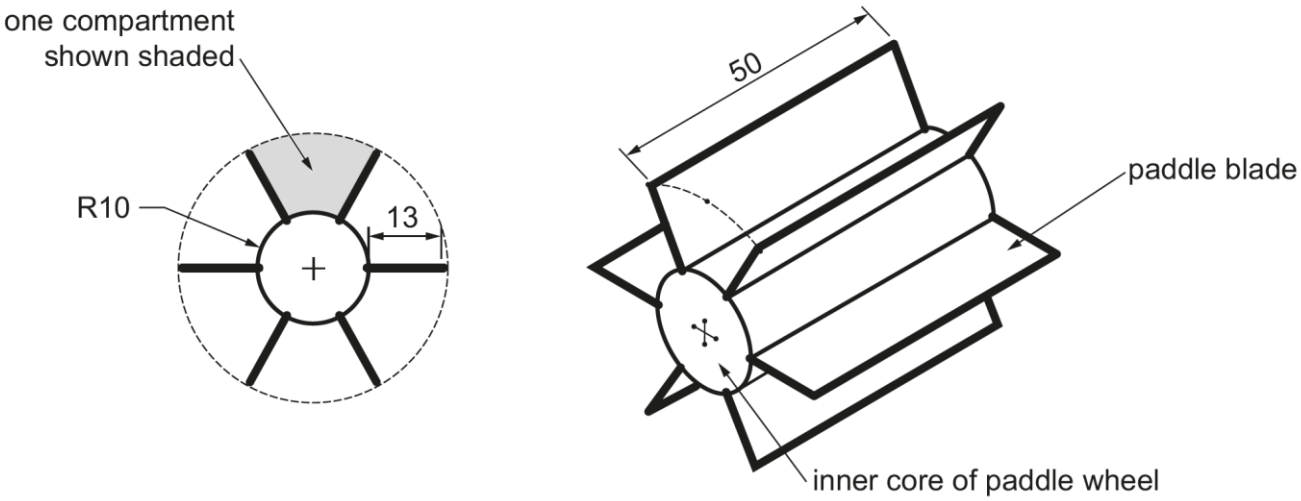


As the paddle wheel rotates, food is transferred from the hopper and dropped into the feeding tray.

Every $\frac{1}{6}$ of a revolution, food that is held in one compartment of the paddle wheel is dropped into the feeding tray.

Fig. 4.3 shows the dimensions of the paddle wheel in mm.

Fig. 4.3



(i) The volume of the inner core of the paddle wheel is 15.7 cm^3.

Calculate the volume of one compartment of the paddle wheel. Give your answer in cm^3 and show your working.

The formula for calculating the volume of a cylinder is $\pi r^2 h$.

You must ignore the thickness of the paddle blades. **[4]**

Volume ..... cm^3

Around 50% of candidates performed very well on this question. In most of these cases the mathematical operations were set out in a logical manner, often with sketches to aid the process.

However, over 35% of candidates struggled with this question. Many of these candidates did not calculate the correct total radius of the paddle wheel of 23mm. This was because they either overlooked the two relevant dimensions given on the diagram or they misinterpreted what the values were referring to. Some candidates spent time calculating the radius of the inner core of the wheel from the volume of 15.7cm^3 that was given, having overlooked that the radius, R10, was given on the diagram.

Assessment for learning

Understanding drawings

Candidates should be taught to read technical drawings and be able to interpret dimensioning conventions. Attention to aspects of BS8888 such as identifying centres of rotation, movement and direction, and dimensioning arcs/circles and cylindrical components will be of benefit.

Question 4 (b) (ii)

(ii) 1 litre of cat food has a mass of 400 g.

Use your answer from **part (b)(i)** to calculate the mass of cat food carried in each compartment of the paddle wheel. Give your answer in grams (g) and show your working. **[4]**

Mass ..... g

Many candidates struggled with this question. In most cases this was because they had struggled on the previous question, and they were unsure of how to convert units. Either they did not know how to convert litres to cm^3, or did not do it correctly, with many candidates converting 1 litre to 10cm3 or 100cm3, instead of the correct value of 1000cm3.

Where candidates performed well, they were confident with unit conversion, and showed clearly all the stages of their working and benefitted from error carried forward marks in some cases as a result. Many of these candidates were able to gain full marks (ECF) despite the error in 4 (b) (i).

Assessment for learning

Unit conversion

The conversion of units is a common requirement on this examination paper. Candidates should be given the opportunity to work through practice problems that require the conversion of units.

Question 4 (c) (i)

(c)
(i) The paddle wheel is rotated by an electric motor in a closed loop control system.

Describe how a closed loop control system achieves improved performance over an open-loop system.

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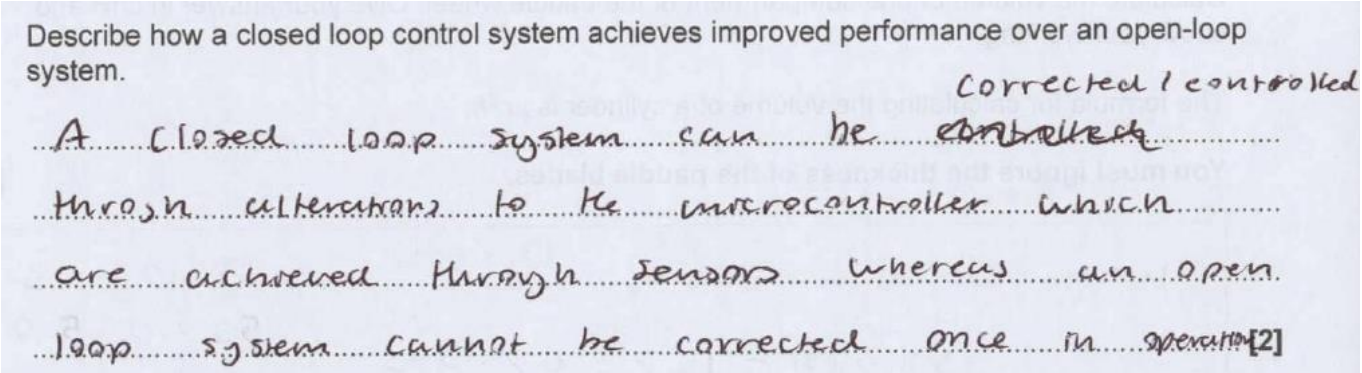
..... **[2]**

A surprisingly high number of candidates did not know what a closed loop system is. In these cases, they struggled to earn any marks.

Candidates that did perform well gave answers that described how precise control is achieved, with data from a sensor that is monitoring the output of the system being fed back to a microcontroller, which in turn adjusts the output device performance.

Exemplar 3


Describe how a closed loop control system achieves improved performance over an open-loop system.

A closed loop system can be controlled corrected / controlled through alterations to the microcontroller which are achieved through sensors whereas an open loop system cannot be corrected once in operation [2]

The response in Exemplar 3 provides sufficient evidence to convince that the candidate knows what a closed loop system is.

Assessment for learning

Candidates should be exposed to closed loop programmable electronic control systems. Construction kits such as Lego EV3 and VEX include motors that have built in rotary encoders that can be monitored to then adjust output performance. These devices can also be carefully dismantled so that candidates can see how they function and what they look like inside.

Question 4 (c) (ii)

(ii) Use annotated sketches and/or notes to show how a suitable sensor can be used to detect when the paddle wheel has rotated $\frac{1}{6}$ of a revolution.

You **must** name the sensor used. **[3]**

Named sensor .....

The best performing candidates named a specific sensor and clearly illustrated the interaction of it with the paddle wheel in an annotated sketch. Supporting notes were effective in most of these cases in explaining how a signal or pulse would be generated every sixth of a rotation of the paddle wheel and monitored by a microcontroller which would then control the motor to stop.

Many of the lowest scoring candidates did not correctly identify a sensor, often using generic terms such as 'motion sensor'. In a number of cases the sensor identified was different from the one shown in the sketch. Many of the sketches were not of an adequate quality to show how the sensor interacted with the paddle wheel or if the method used was feasible.

Overall, the quality of sketching was weak, and candidates would have benefitted from using a compass or circle template to improve the quality of their sketched communication.

Assessment for learning

Quality of sketches

The quality of sketched communication can have a significant impact on performances on some of the questions that feature on this examination. It is likely that Design Engineering candidates will need to sketch aspects of mechanical systems, often involving rotation. They should be taught to use appropriate drawing equipment to raise the standard of their sketches.

Question 4 (d)*

(d)* Discuss the factors that need to be considered when distributing products to markets.

In your answer you **must** consider:

- environmental considerations
- supply and demand.

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

0ver 50% of candidates struggled to earn many marks in response to this question. An overarching issue was that many did not relate their discussions to distribution to markets.

Level 3 responses were where candidates were able to give valid points for both environment and supply and demand and expand on their points with options and/or examples. The most popular responses included consideration of the use of electrical vehicles to reduce carbon emissions, reducing packaging size to optimise capacity on cargo ships, and recyclable packaging when considering the environmental impact. These candidates tended to make the link to supply and demand and discussed the need for local distribution centres in order to reduce delivery time and satisfy demand. The best responses featured specific examples such as Amazon.

Level 2 responses tended to feature candidates that were able to discuss environmental points in relation to distribution to markets but were less sure of supply and demand in relation to distributing to market and points tended to be confused. Many of these responses had textbook definitions of supply and demand with no link to the overall context of distribution to markets. The strongest responses included examples such as the use of electric vehicles.

Level 1 responses tended to focus on the aspect of 'environmental' or 'supply and demand' and did not relate discussions to distribution. In some cases, the answers were either vague or not relevant to the question. Some candidates did not correctly interpret the term 'distribution to markets' and described the issues experienced by market sellers.

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Question 1 (a) (i): Photo – Costa Coffee vending machine, © rohaizadabu / Shutterstock

Question 4 (a): Photo – Automatic pet food dispenser, © Oleksandr Kharchenko / Alamy Stock Photo

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- be able to track your progress and achievements through the courses.

How can you access our online courses?

Access courses from Teach Cambridge. Teach Cambridge is our secure teacher website, where you'll find all teacher support for your subject.

If you already have a Teach Cambridge account, you'll find available courses for your subject under Assessment - NEA/Coursework - Online courses. Click on the blue arrow to start the course.

If you don't have a Teach Cambridge account yet, ask your exams officer to set you up – just send them this link and ask them to add you as a Teacher.

Access the courses **anytime, anywhere and at your own pace**. You can also revisit the courses as many times as you need.

Which courses are available?

There are **two types** of online course: an **introductory module** and **subject-specific** courses.

The introductory module, Building your Confidence in Internal Assessment, is designed for all teachers who are involved in internal assessment for our qualifications. It covers the following topics:

- the purpose and benefits of internal assessment
- the roles and responsibilities of teachers, assessors, internal verifiers and moderators
- the principles and methods of standardisation
- the best practices for collecting, storing and submitting evidence
- the common issues and challenges in internal assessment and how to avoid them.

The subject-specific courses are tailored for each qualification that has non-exam assessment (NEA) units, except for AS Level and Entry Level. They cover the following topics:

- the structure and content of the NEA units
- the assessment objectives and marking criteria for the NEA units
- examples of student work with commentary and feedback for the NEA units
- interactive marking practice and feedback for the NEA units.

We are also developing courses for some of the examined units, which will be available soon.

How can you get support and feedback?

If you have any queries, please contact our Customer Support Centre on 01223 553998 or email support@ocr.org.uk.

We welcome your feedback and suggestions on how to improve the online courses and make them more useful and relevant for you. You can share your views by completing the evaluation form at the end of each course.

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
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We really value your feedback

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