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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

H404/02 Summer 2025 series

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.

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Paper 2 series overview

The structure of the paper has remained the same over several years and it is encouraging to see that candidates are practising these types of questions. The quality of response this year has an improvement on previous years with candidates demonstrating a good understanding of the subject and an ability to apply their theory to a problem-solving based question.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• student had greatly improved on recent years when drawing flow charts. They were able to use the correct symbols and understand the need for feedback in the system when appropriate • used the examples in the RB to support their response, not just copy it out • where able to identify the wider issues that might affect the different questions, using examples from their learning and research • construct a response to the extended response questions, many were too the point and efficient in their writing • where able to apply their theoretical knowledge of systems into practical applications.	• struggling to problem solve the issues that are presented to them, through either lack of basic understanding of the subject area or did not know how to apply it to the question • candidates were not able to communicate their thoughts through graphical means in the problem-solving question • did not use the RB enough in their responses, or just copied out bits of text and did not relate it to their response or the question • deviated away from the question in their response, or did not answer the question. It is recommended that they read the question a few times while write their response • struggles to apply the given equations to the question. This was either through retrieving the wrong information from the RB or applying it incorrectly.

Question 1*

1* The development of autonomous vehicles to help during disasters has introduced many issues for design engineers.

Discuss the key technical challenges **and** ethical considerations a design engineer would face when developing an autonomous vehicle for use during disasters.

In your answer you **must** consider:

- technical challenges
- ethical considerations.

Refer to **pages 2 – 4** of the Resource Booklet. **[14]**

When answering this question there was a generally a good range of responses from the candidates. Most were able to recognise the difference between the technical and ethical considerations that would arise. Many were able to give a least a couple of valid points for each, showing a good understanding of how they could be applied to this context.

Many candidates used the resource booklet for this question with good affect, however some quoted what was written in the resource booklet and did not relate these comments to the question or substantiated it in their response.

Candidates who achieved a Level 4 response were able to identify both the technical and ethical considerations that a Design Engineer would face, giving direct links to the example in the question and used the resource booklet to support their considerations rather than be lead them. They were also able to give a balanced response with well-constructed responses for both the technical and ethical considerations both in equal measure.

Candidates in the lower mark ranges tended to focus on one of the considerations more than the other. They also used direct quotes from the resource booklet without substantiating it.

Exemplar 1

There are numerous technical challenges which stem from the environment and situation these vehicles would be used in. Firstly, the vehicle needs to be able to traverse various ~~teria~~ ~~terrain~~ terrain as it has to navigate through rubble, wild fires, or forrest terrain. Additionaly the vehicle must be able to withstand the environment meaning it must be ~~tempare~~ temperature resistant, water proof and able to withstand large impacts as after a disaster there could be loose debris or fires which the vehicle must be able to traverse through. The vehicle needs to be able to adapt to different situations just as humans can, when it is clearing debris or trying to save some one from rubble it needs to identify how to do it without causing and more damage. This introduces the challenge of training the vehicle using machine learing & AI technology so that it is able to make decisions as humans are able to and identify the right way to operate. Finally it is also important to maximise the operation time of the vehicle as it may be hard to refill or recharge the vehicle while in a disaster area.

There are also ethical considerations some of which encourage the use of autonomous vehicles. The use of these vehicles would help to protect relief workers as they could be sent in first to ensure an area is safe ~~pe~~ before relief workers arrive. These vehicles would also be able to identify area of high interest where there could be people to save faster than humans can, saving this time can be crucial when saving lives. However, a large portion of the population do not trust the use of autonomous vehicles meaning a human would have to be there with the vehicle mitigating a lot of their benefits. Additionaly to gain peoples trusts fail safes would have to be created for the vehicles creating another design ~~tek~~ technical challenge. The vehicles decission making protocols allow it to be completely fair and unbiased it situations allowing for a completely fair victim rescue approach. However some may argue that certain groups like children must be prioritised.

Exemplar 1 shows a high Level 4 mark. The candidate clearly understands the different considerations and can relate them to both the technical and ethical aspects of design. They have used the resource booklet to good effect and used it to support their answer.

Question 2*

2* **Page 3** of the Resource Booklet describes a Magirus Aircore TAF35 fire-fighting robot.

Such complex systems are developed through the collaboration of many different design and engineering specialists.

Critically examine the significance of collaboration amongst engineers in the design and development of complex systems such as the fire-fighting robot.

In your answer you **must** consider:

- the design phase of the product
- prototype and testing
- manufacture and production.

Refer to **page 3** of the Resource Booklet and also draw on examples from your own studies. **[12]**

In this question it was clear that candidates felt more confident about discussing collaboration between engineers during the design phase rather than the prototyping and testing or manufacture stages.

Where candidates have achieved Level 4 marks, they have clearly identified not only the need for collaboration between a range of engineers but also have outlined the benefits this would have on the design process and the overall product. These candidates were able to identify the advantages of multiple engineers working on a project through the different areas that were to be considered. These candidates were also able to acknowledge the positive and negative aspects of collaboration.

Those candidates that achieved the lower mark bands struggled to relate the collaboration to the prototype and testing phase of the process, sometimes just describing the processes that would be taken place without mentioning the significance that different engineers would have on the process. They also may have produced a one-sided examination, without looking at the weaknesses that this collaboration can bring to the products development.

A few candidates did not respond to the question in relation to collaboration and instead produced a product analysis.

Assessment for learning

When learning about collaboration within a products development, try to incorporate the full life of the product from cradle to grave and how engineers have been able to affect each area.

Question 3 (a) (i)

3 **Page 5** of the Resource Booklet shows a concept for a miniature search robot named 'Scout'.

The Scout robot uses rubber tracks to allow it to travel over uneven ground.

(a) The rubber tracks are to be purchased from a specialist supplier. The designers need to calculate how much track will be required for the Scout robot.

(i) Use **Fig. 4** to calculate the length of rubber track that will be needed for **one** side of the Scout robot. Give your answer in mm and show your working. You should ignore track thickness. **[3]**

Length of rubber track .... mm

In general, this was answered well. Most candidates were able to recall the required equation and understood about how to calculate the length of the track needed.

Where errors were made it was with calculating the circumference of the drive pulleys.

Question 3 (a) (ii)

The design engineers need to calculate the mass of the rubber tracks.

(ii) Use your answer from **part (a)(i)** and **Fig. 4** to calculate the total mass of **both** rubber tracks. Give your answer in kgs and show your working.

The following equations may prove useful:

(V) Volume = (A) Area × (L) Length (m) mass = (ρ) density × (V) volume **[3]**

Total mass of both rubber tracks .... kgs

This question was answered well, with ECF being allowed from the previous response. Most candidates where able to use the given equations to calculate the volume and mass of the track.

The most common error was giving the answer for the mass of one track instead of for both.

Question 3 (b) (i)

(b) It is proposed that each rubber track is driven by an SS-55 electric motor. The drive from the motor will pass through a ZS-50 gear box to the drive sprocket.

Details of the electric motor and gear box are given on **page 6** of the Resource Booklet.

(i) Use **Fig. 6** to calculate the velocity ratio of the ZS-50 gear box. Show your working. **[2]**

Velocity ratio ....

Many candidates found this question challenging, with several candidates unable to calculate the velocity ration of a compound gear system.

Some candidates that did attempt the question got the Driver and Driven gears the wrong way round leading them to the incorrect answer.

Assessment for learning

Care should be taken when teaching how to calculate the Velocity ration of a gear system. Candidates need to make sure they know which gears are driver and which are driven.

Question 3 (b) (ii)

(ii) Determine by calculation that the proposed motor gear box combination will produce an output speed of 3.53 km/h for the Scout robot.

Show your working and use the following information:

- your answer to **part (b)(i)**
- pages **5 and 6** of the Resource Booklet
- output rotational speed = $\frac{\text{input rotational speed}}{\text{velocity ratio}}$
- $v = \frac{3}{25}\pi r N$

Where:

v is the speed of the Scout robot (in km/h)
r is the effective radius of the drive pulley (in m)
N is the rotational speed of the drive pulley (in rpm) **[4]**

In this question we were looking for the candidates to use their response to the previous question to determine the given speed of the Scout robot. ECF was used in this question based on their previous response. Most candidates were able to demonstrate their mathematical knowledge by applying the given equation and the relevant information from the resource booklet to find the correct workings.

It was interesting to see some candidates working backwards from the answer. This is more evident if they were not confident about their previous answer.

Question 4

4 The Scout robot is equipped with a tilting fork mechanism which will help to clear small pieces of debris from its path.

Details of the fork system are shown on **page 7** of the Resource Booklet.

The forks are actuated using a pneumatic cylinder which is controlled by a programmable control system. The forks are automatically tilted when the system detects an object closer than 150 mm to the robot.

The Scout robot developers have asked you to design the fork actuation system.

There are **two** issues that need to be solved.

Use sketches and/or notes to determine suitable technical solutions that overcome the **two** issues identified.

Issue 1:

A pneumatic cylinder must be attached to the forks so that the necessary movement can be achieved.

The forks must lift a 120 N load at their tip as shown in **Fig. 7** of the Resource Booklet.

The type of cylinder used is shown in **Fig. 8** of the Resource Booklet.

1a) Determine the force output of the cylinder and distance of the pivot from the load and effort.

1b) Show a method of attaching the fork to the end of the pneumatic piston to allow for rotary motion at the point of attachment.

Issue 2:

The programmable control system uses an ultrasonic sensor to detect objects closer than 150 mm.

- When an object is detected, the forks should tilt up.
- The forks should return to horizontal when the operator presses a button on the controller.
- The system should record the number of times the forks have operated.

Produce a program flow chart for the control system which will achieve the required function. **[16]**

1a:

1b:

2:

This question was assessing the candidate's problem-solving abilities and whether they can use the knowledge they have acquired over the course and apply it to a practical application.

The question was separated into two issues with the first issue being broken down again into two parts.

Issue 1a

In the first part the candidates had to determine the output force of the piston using the given information in the resource booklet. Most candidates were able to do this, but where candidates made errors, it tended to be in the unit conversion.

Once the force was found candidates had to design a lever system that would be able to amplify the output force to the required force for the forks. Where candidates got this part correct, they were able to identify the type of lever used and determine the distance from the effort to the fulcrum and the load to the fulcrum. They clearly showed the difference and demonstrated their understanding of lever design. Those students who found it challenging either got the load and effort distances the wrong way round or did not calculate the correct ratio.

It was encouraging to see candidates using different methods to solve to problem, some opting to use moments to calculate the lengths.

Issue 1b

The second part of this was to show how the piston could be connected to the folk mechanism. In this question we were looking for the students understanding of standardised components and fittings that could be used. It was clear that many candidates over complicated this response developing mechanisms which were not required.

Where students gained a Level 4 response for this section, they were able to show a simple method of connection where they had considered the required motion. They had acknowledged this motion and how the efficiency of the system could be improved with bearings or lubrication.

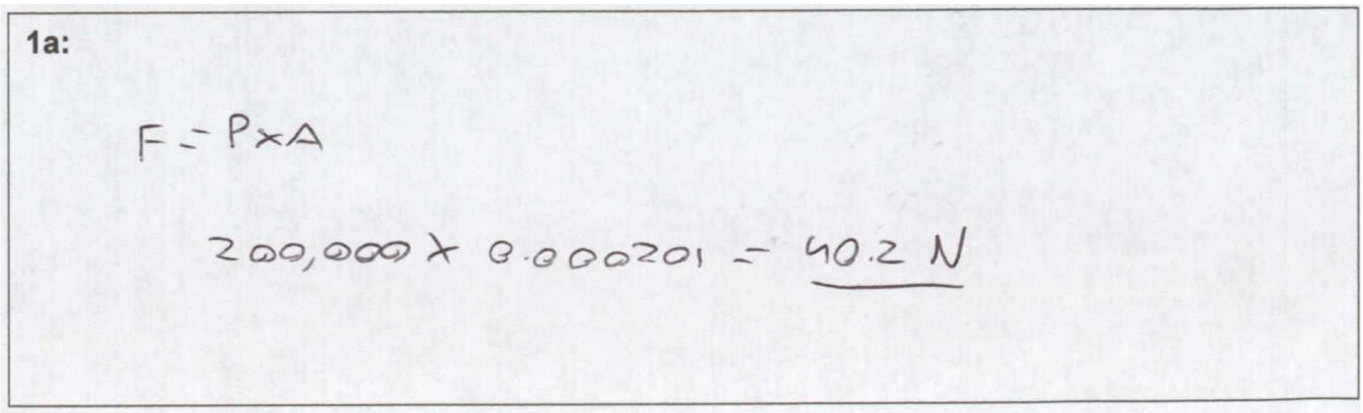
Issue 2

The flowcharts that were produced this year in the responses were an improvement on previous years. Candidates are starting to understand the way to structure a flowchart and use the correct symbols throughout.

Where candidates scored in a Level 4 response, they were able to identify all the key areas with this system and demonstrated a clear understanding of how the micro-controller would receive and store the required information. They also recognised the need to a correct feedback loop.

Where candidates did not gain marks, they did not have the correct symbols or layout of the system. Some candidates struggled to take the operation of the system and produce a flowchart from it.

Exemplar 2

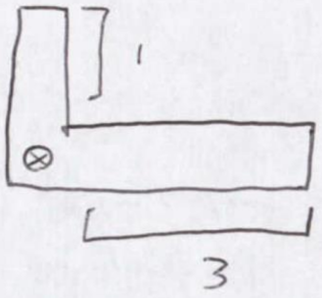


1a:

F = P×A

200,000 × 0.000201 = 40.2 N

$MA = 120 = \frac{40.2}{x}$ $x = 3$ $MA = 3$

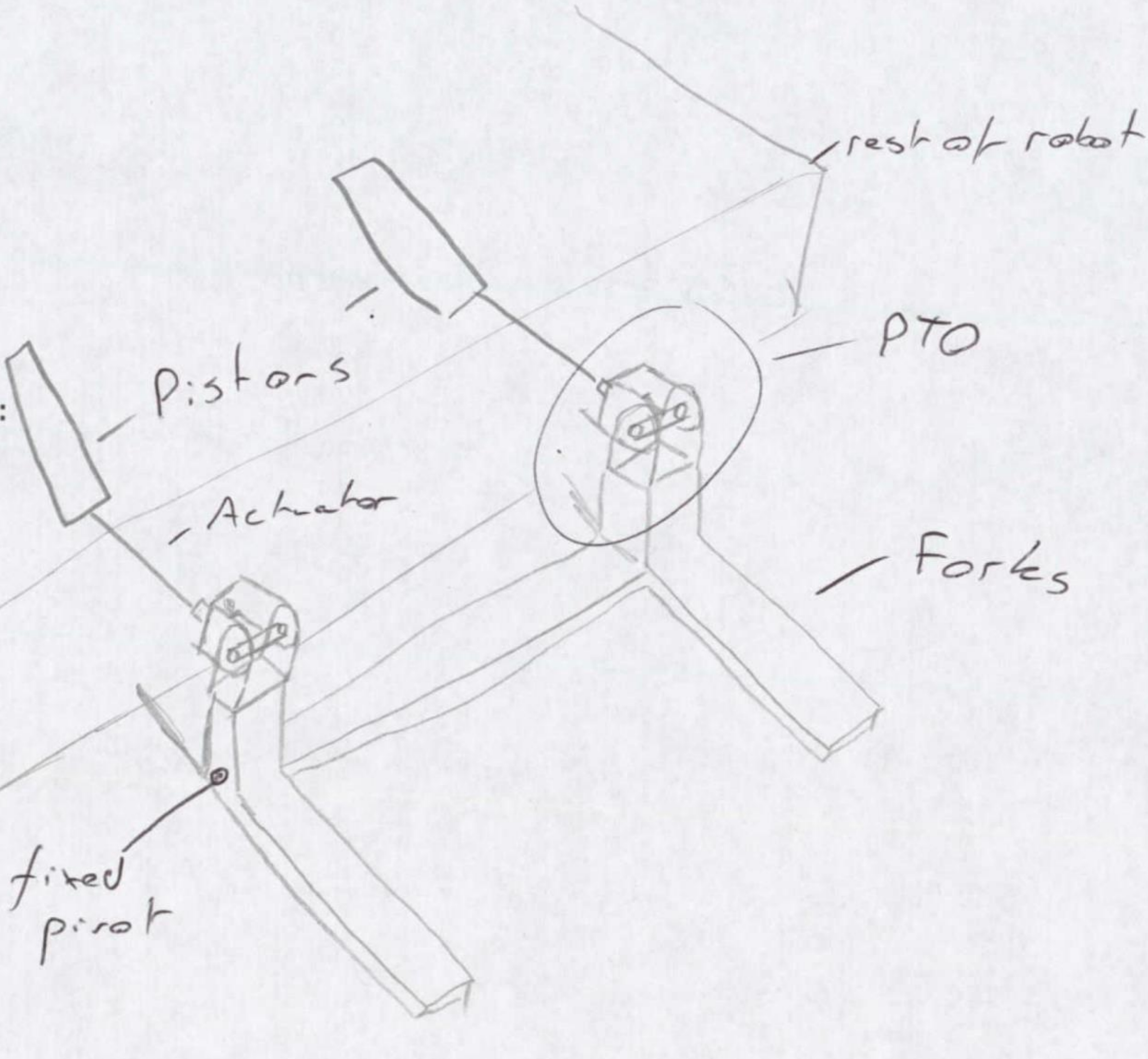


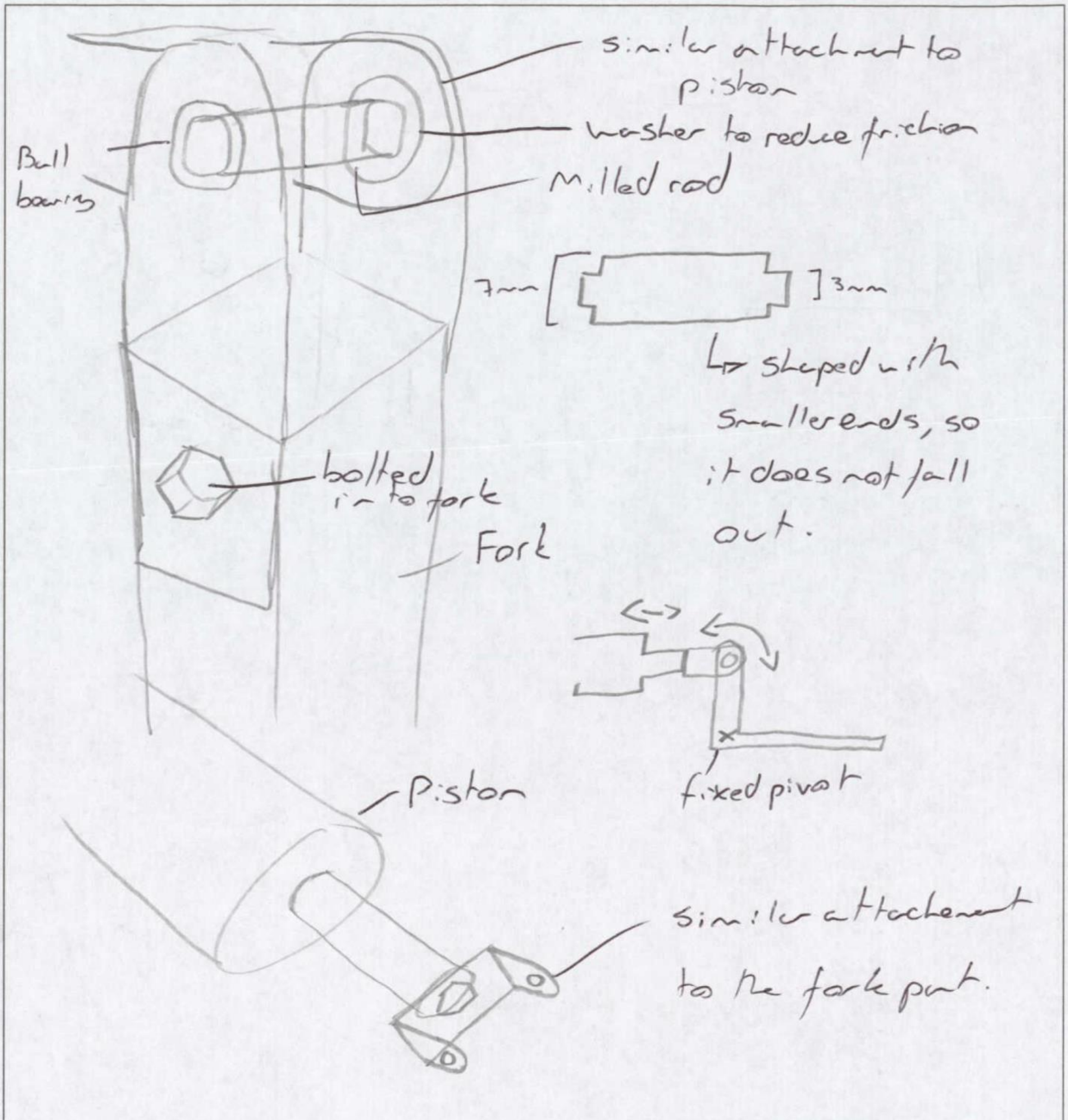
pivot to load: 150mm

pivot to effort: 50mm

The fork must be 3x as long as the arm.

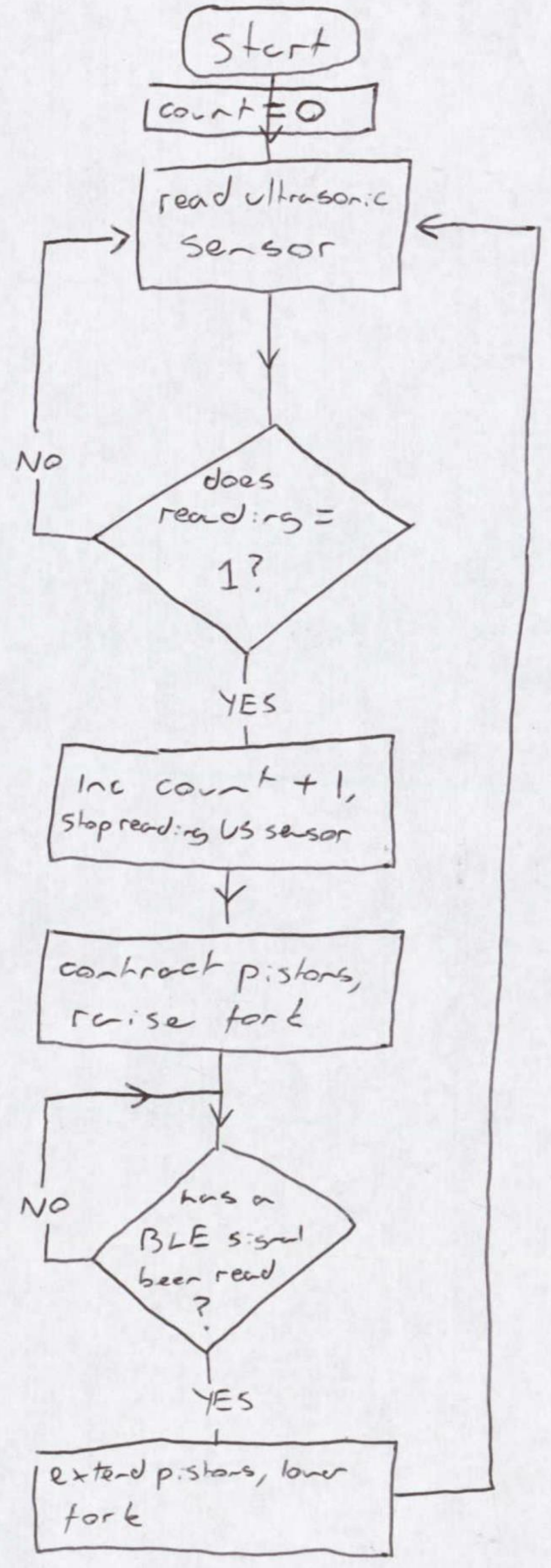
1b:





Attaching the fork and piston to one rod allows for rotary motion from a linear input. The piston attachment slides into the fork attachment allowing for compact, smooth motion.

2:



ADC:

if distance ≥ 150, read 1

if distance ≤ 150, read 0

Button

when the button is pressed assume signal sent by BLE.

Exemplar 2 shows a Level 4 response. In this response the candidate has clearly demonstrated their understanding of issue 1 creating a lever system that would produce the required force from the put. They have also produced a good quality flowchart in issue 2 which covers all the areas required in the mark scheme.

Question 5

5 The Scout search robot is being designed for batch production.

The manufacturers will make the robot chassis in two parts from 3 mm thick aluminium sheet. They are unsure of the most effective process for manufacture.

Details of the two chassis parts are shown on **page 8** of the Resource Booklet.

Use sketches and/or notes to show an appropriate method of batch manufacture for the robot chassis.

In your answer you **must** consider:

- a detailed description of the cutting and shaping processes used
- details of any dies, formers or jigs
- methods of joining the parts to ensure the structural integrity of the completed chassis.

Refer to **page 8** of the Resource Booklet. **[16]**

This question was assessing the candidates understanding of manufacturing techniques.

Most candidates recognised the need for batch production techniques with many opting for some form of CNC system to cut the net out (Laser, Plasma etc). these candidates were able to explain not only the process but the suitability of the process for this application.

Candidates who achieved a Level 4 response were able to recognise the need for bending the net into shape and where able to identify appropriate methods of both bending and rolling the material. Some higher end responses mentioned about heating the material to reduce stress or over bending to allow for the materials elasticity.

Some candidates who identified a batch production method went on and described a one-off production process, using hammers and saws to produce the required shape. Others described inappropriate processes such as high pressure die casting or vacuum forming.

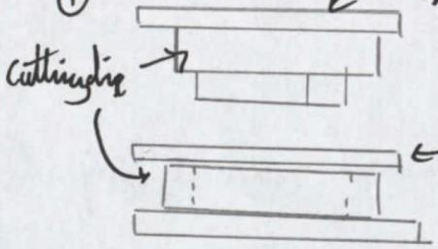
In general, the candidates showed a good understanding of the required processes.

Exemplar 3

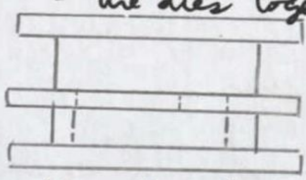
Top Casing: top casing will first be stamped out of a stock sheet and then bent into form with a bending jig

Stamping → hydraulic press

① stock sheet placed between the dies



② hydraulic press forces the dies together

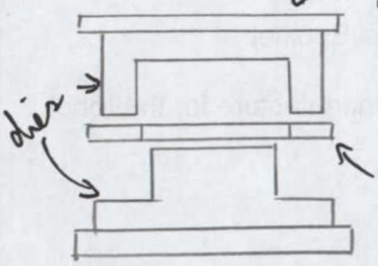


cutting the design out of the sheet which then falls through the bottom die into a collecting area

③ the hydraulic press is then turned off, set up is reset and the excess material is removed

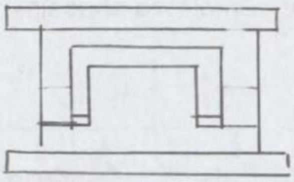
The stamped sheet is then placed into a bending jig:

① ← hydraulic press



stamped sheet is ~~pla~~ positioned between the dies

② hydraulic press then clamps the dies together, bending the stamped sheet

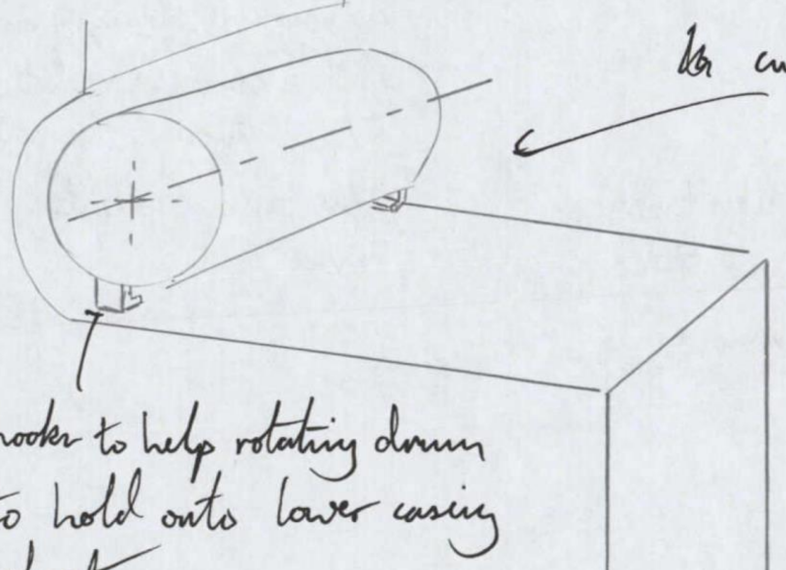


③ hydraulic press is turned off, dies are separated and the bent top casing is removed

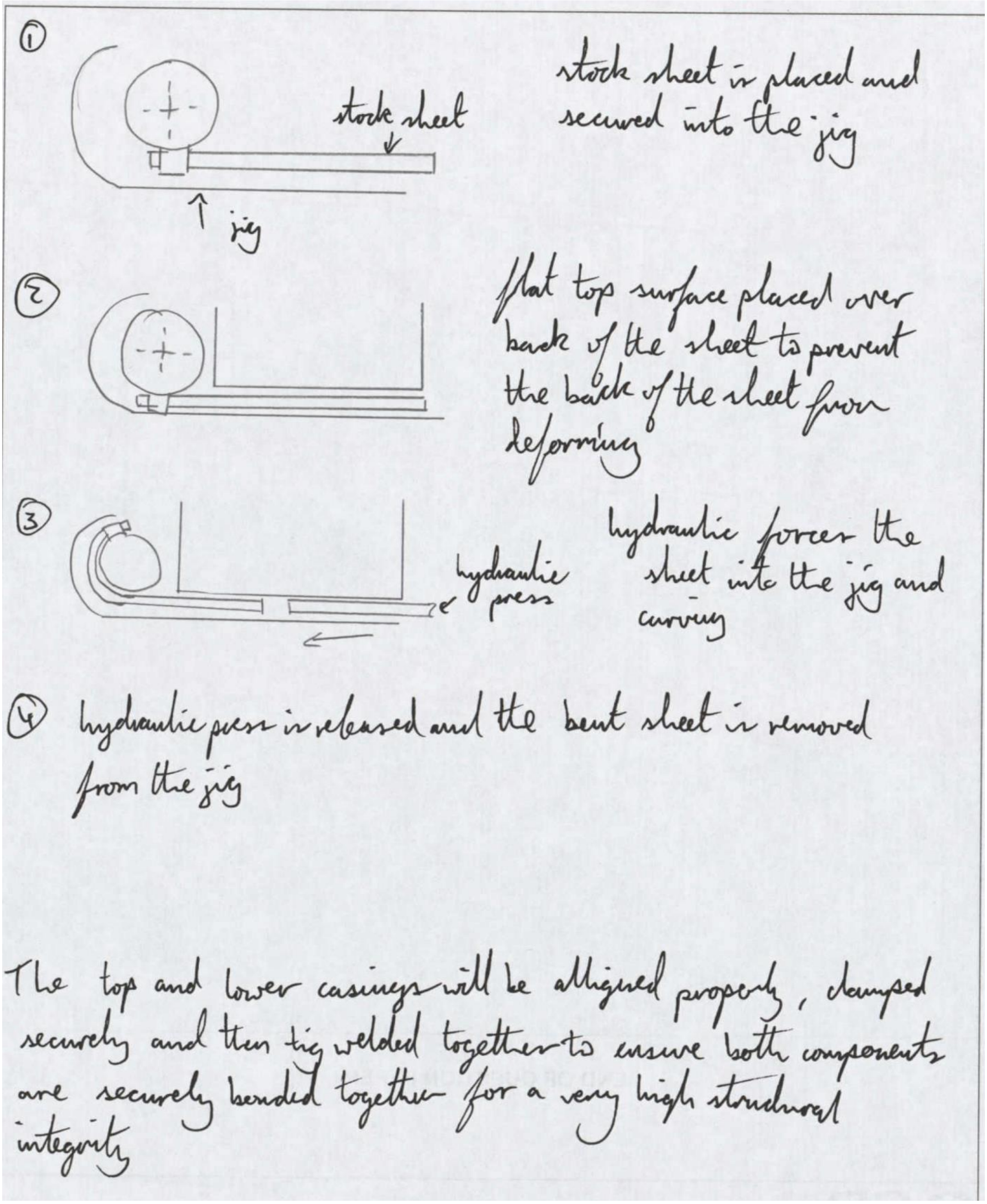
lower casing:

Curved end will be created with a ~~shed~~ simple curving jig

~~kr~~ curving jig



hooks to help rotating drum to hold onto lower casing sheet



Exemplar 3 shows a Level 4 response. In this response the candidate has identified the production processes and clearly shown a good understanding through annotated sketches. All aspects of the component have been covered.

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