OCR
Oxford Cambridge and RSA

Tuesday 10 June 2025 – Morning

A Level in Design and Technology: Design Engineering

H404/02 Problem Solving in Design Engineering

Time allowed: 1 hour 45 minutes

You must have:
- the Resource Booklet

You can use:
- a ruler (cm/mm)
- a scientific calculator
- geometrical instruments

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- Answer **all** the questions.
- Use the Resource Booklet to answer all the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Each question tells you which part of the Resource Booklet to use.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **16** pages.

ADVICE
- Read each question carefully before you start your answer.

Read the **Resource Booklet** before you answer the questions.

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]**

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]**

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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

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

(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 .....

(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]**

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:

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]**

END OF QUESTION PAPER