OCR
Oxford Cambridge and RSA

Friday 16 June 2023 – 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.
- 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 refer to.

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.

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

1* Climate change is affecting all parts of the world. Failing to control it could have devastating impacts on our lives. People need to make big changes to their lifestyles to limit the impact of climate change.

Critically examine the ways in which climate change and the methods to control it, affects people and communities around the world.

Refer to information on **pages 2–3** of the Resource Booklet and also information from your own studies or experience. **[12]**

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2* Weather Watch (WW) is using the funding it has received to manufacture its Pro Weather Station (PWS).

100 000 of the sensor and remote display units will be required.

Critically examine the factors that a design engineer would need to consider when manufacturing the PWS sensor and remote display units.

In your answer you **must** consider:

- materials
- manufacturing methods
- power source
- data transfer
- aesthetic factors.

Refer to information on **page 4** of the Resource Booklet. **[14]**

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3 The funnel on the top of the PWS sensor unit catches rainwater for measurement. **Fig. 5** in the Resource Booklet shows 3D and 2D projections of the funnel.

(a) (i) Use the information in **Fig. 5** of the Resource Booklet to calculate the **total volume** of the funnel (**both sections**). Give your answer in cm^3 to **2** decimal places. Show your working.

Volume of a cone = $\frac{1}{3} \pi r^2 h$ **[6]**

Total volume ..... cm^3

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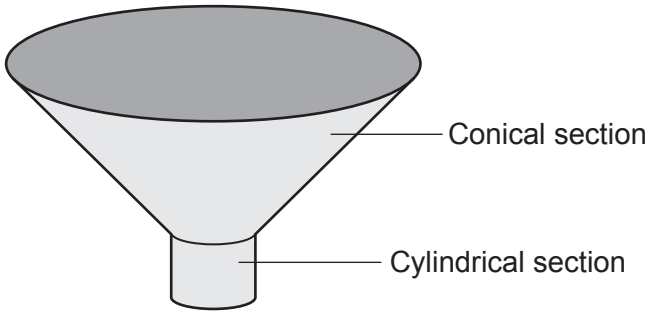
(ii) The 3D projection of the funnel is shown below in grayscale:



- During a period of rain, the rain falls steadily at a rate of $0.2\,cm^3$ per cm^2 per hour.
- The area of the top of the funnel is $95.0\,cm^2$.
- The volume of **just** the cylindrical section of the funnel is $4.7\,cm^3$.

Calculate the time it takes for the rain to fill just the cylindrical section of the funnel. Give your answer in minutes to **1** decimal place. Show your working.

You do not need to refer to the Resource Booklet for this question. **[3]**

Time ..... minutes

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(b) The PWS sensor unit uses the BP135 pressure sensor to measure the air pressure. Data for the BP135 sensor is given in **Fig. 6** of the Resource Booklet.

(i) Use data from **Fig. 6** of the Resource Booklet to determine the value of the output voltage from the BP135 sensor when the air pressure is 100 kPa.

..... **[1]**

(ii) The output from the BP135 sensor is fed into the analogue input of a microcontroller. The smallest change of input voltage that the microcontroller can detect is 5 mV.

Use the information in **Fig. 6** of the Resource Booklet to calculate the smallest change in air pressure that can be detected by the microcontroller. Give your answer in kPa and show your working. **[2]**

Smallest change in air pressure ..... kPa

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4 WW requires 100 000 PWS sensor unit mounting solutions that will be flatpacked for transportation.

Use sketches and/or notes to outline a suitable monopole design for the mounting solution.

For the monopole you must only select mild steel tubes from **Fig. 8** of the Resource Booklet but you may cut or modify the tubes if you wish.

In your answer you **must** consider the **design requirements** as listed on **page 6** of the Resource Booklet and include details of:

- mild steel tube sizes chosen for the monopole
- specialist parts and assembly methods to enable flatpacking
- standard components to be used
- manufacturing processes
- finishes.

Refer to **all** of the information on **page 6** of the Resource Booklet. **[16]**

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5 WW wants to explore the feasibility of adding a wind speed sensor to the PWS.

The design engineers have to solve the following **two** issues to help with the development of the wind speed sensor.

Issue 1:

The sensor must produce output electrical signals which could be processed by a PICAXE 14M2 microcontroller.

Use sketches and/or notes to further develop the wind speed sensor shown in **Fig. 9** of the Resource Booklet.

In your answer you **must**:

- explain how the sensor works
- identify specific electronic components
- identify any mechanisms used
- describe the output signals produced.

Issue 2:

The signal from the wind speed sensor will be processed by a PICAXE 14M2 microcontroller and transmitted to the remote display unit by radio frequency.

Details of the PICAXE 14M2 microcontroller and the radio frequency transmitter are shown in **Fig. 10** and **Fig. 11** of the Resource Booklet.

To enable the wind speed sensor to function as described:

- Draw a circuit diagram to show how the wind sensor electronic components identified in your response to Issue 1 and the radio transmitter components should be connected to the PICAXE 14M2 microcontroller.

- Draw a program flowchart that indicates how rotation speed of the rod is monitored and data transmitted to the remote display unit.

In your answer use the simplified block circuit symbol to draw the radio transmission circuit.

Refer to **pages 7–9** of the Resource Booklet. **[16]**

Issue 1:

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Issue 2:

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END OF QUESTION PAPER

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