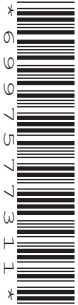# OCR
Oxford Cambridge and RSA

AS Level in Design and Technology: Design Engineering
H004/01 Principles of Design Engineering

Monday 14 May 2018 – Afternoon
Time allowed: 1 hour 45 minutes

You may use:
- a scientific calculator
- a ruler
- pencils/pens
- geometrical instruments

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Do **not** write in the barcodes.

INFORMATION
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in the questions marked with an asterisk (*****).
- This document consists of **24** pages.

Turn over

Answer **all** the questions.

1 **Fig. 1.1** shows a standard microwave oven used to heat or cook food/liquid.

Fig. 1.1

(a) When a company is developing a new product like a microwave oven it needs to consider different stakeholder requirements.

Describe **two** methods which could be used to investigate stakeholder requirements for the design of a new microwave oven.

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[4]

(b) The new microwave oven has an electronic system. A design engineer would make extensive use of computer-aided engineering (CAE) software when developing this electronic system.

Explain **two** reasons why CAE software would be used in the development of an electronic system, such as in a microwave oven.

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(c) **Fig. 1.2** shows the system diagram for the microwave oven with two labels missing.
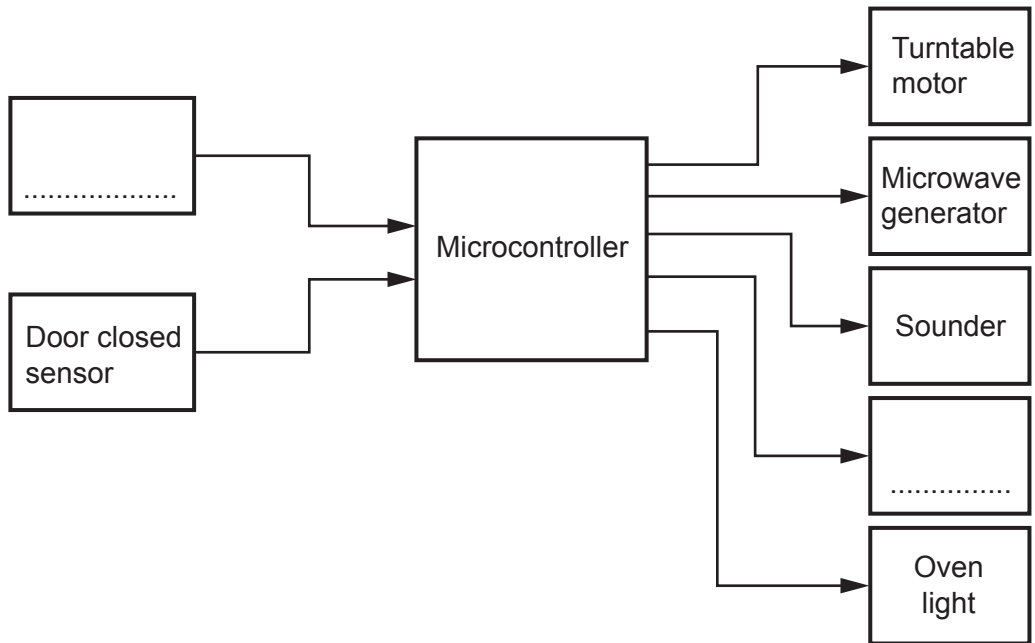

Fig. 1.2

(i) Complete the **two** missing labels on the system diagram in **Fig. 1.2**. **[2]**

 (ii) The system diagram in **Fig. 1.2** is an example of an open loop control system.

 Explain how an open loop control system works in a product such as a microwave oven.

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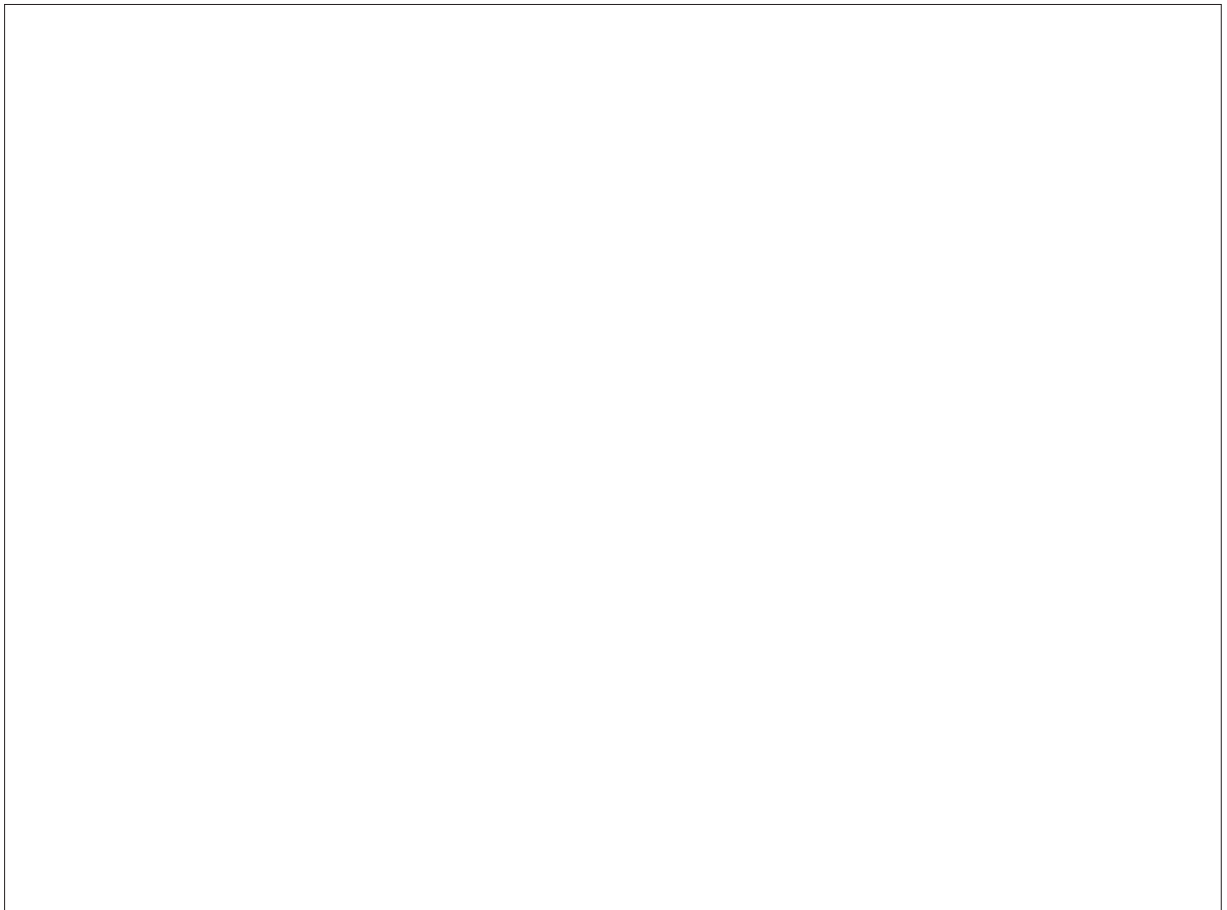
 .... **[2]**

 (iii) The door closed sensor in the system diagram in **Fig. 1.2** is constructed using a switch.

 Draw a circuit diagram to show how a switch and a pull-down resistor are connected to the digital input of a microcontroller to produce a signal when the switch is closed.

 [2]

(iv) The oven light, located inside the microwave oven, consists of three white LEDs wired as shown in **Fig. 1.3**.
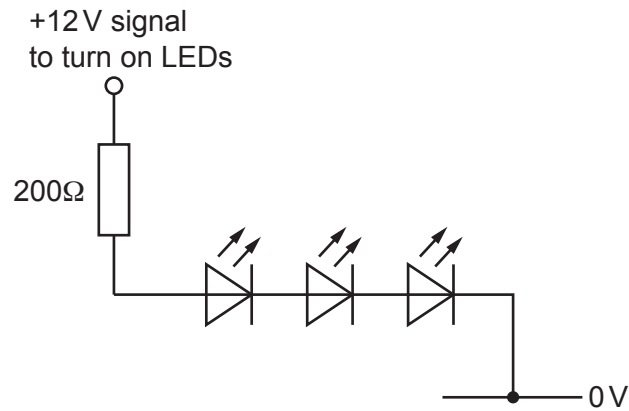
Fig. 1.3

To connect the oven light to the microcontroller, it is necessary to know the current through the LEDs.

Each LED in **Fig. 1.3** has a voltage drop of 2.5 V.

Calculate the current in mA through the LEDs. You **must** state the formula used in your calculation. Show your working.

Current ....mA

[3]

Turn over

(d) The microwave oven shown in **Fig. 1.1** uses a rotating turntable inside for the food/liquid to sit on. This turntable is driven by a motor and a compound gear train as shown in **Fig. 1.4**.
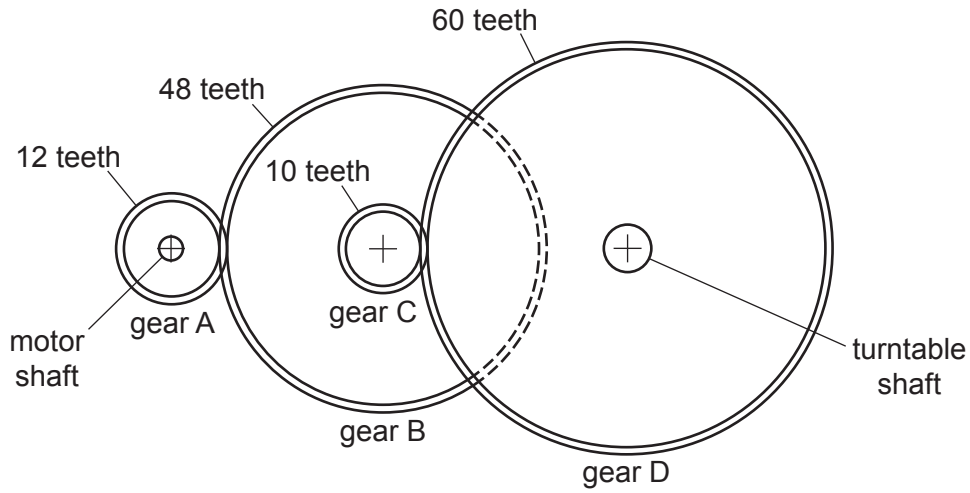
Fig. 1.4

(i) The motor speed is 100 rpm.

Calculate the rotational speed of the turntable shaft. Show your working.

Rotational speed .... rpm

[3]

(ii) Gear D and the turntable shaft are manufactured from a metal alloy.

Use annotated sketches and/or notes to show how gear D could be securely attached to the shaft. Include technical terms.

[3]

2 (a) A new type of battery is advertised as 'lasting 20% longer' than the old type.

In a test, the new type of battery has a lifetime of 4.5 hours.

Calculate the lifetime of the old type of battery. Show your working.

Lifetime .... hours

[2]

Turn over

(b) A design engineer wants to support a pipe at an angle of 12° to the horizontal to allow fluid to drain properly. The pipe is held between two vertical supports, 800 mm apart, as shown in **Fig. 2.1**.
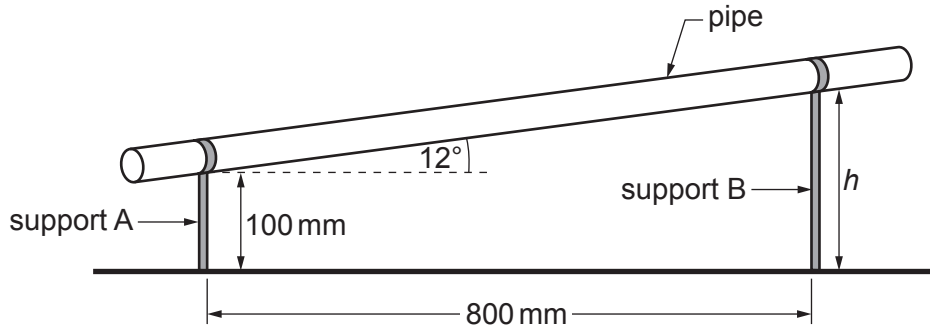
Fig. 2.1
(not to scale)

The height of support A is 100 mm.

Calculate the height (*h*) of support B. Show your working.

Height .... mm

[3]

(c) After manufacturing a batch of switches the probability of finding a faulty switch is $\frac{1}{5000}$

Two switches are selected at random.

Find the probability that **both** switches are **not** faulty. Show your working.

Probability ....

[3]

(d) During the setting of a sensor to measure force, the data shown in **Fig. 2.2** was collected.

Force (Newtons)	V_{out} (Volts)
0	1.15
1	1.22
2	1.24
3	1.30
4	1.36
5	1.43
6	1.46
7	1.50

Fig. 2.2

(i) Plot this data on the graph below and draw a best fit line.

[2]
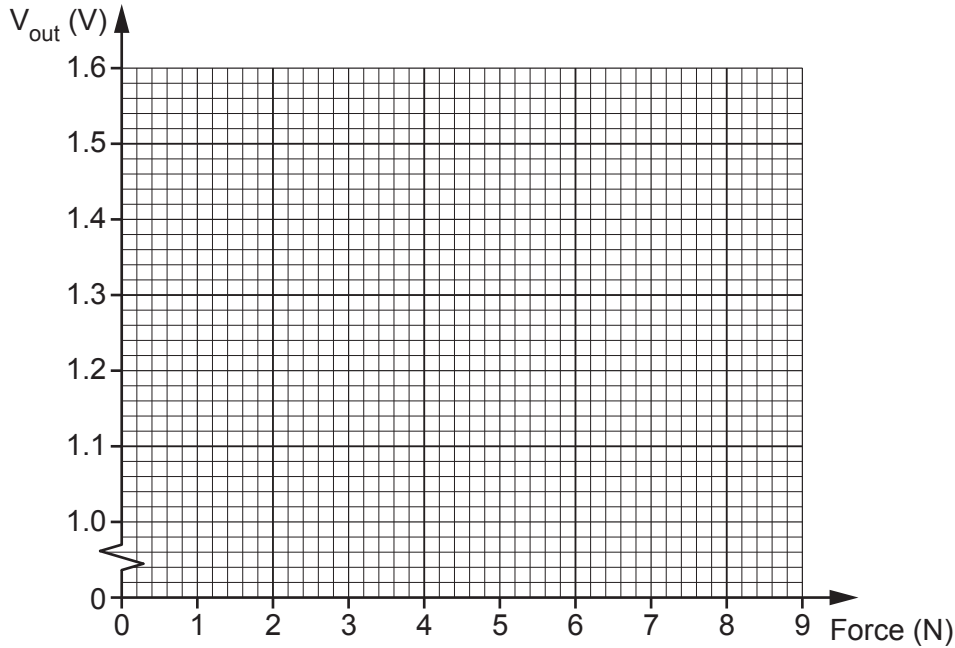
(ii) Explain how the graph shows that this sensor produces a linear output in response to the applied force.

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(iii) Extend the best fit line on the graph above, to predict the V_{out} (V) when the force is 8.5 N.

V_{out} .... volts **[2]**

Turn over

3 **Fig. 3.1** shows an automatic sensor sink tap, which produces a flow of water when a person places their hands under the spout. Such taps are increasingly being installed in public toilets.

Fig. 3.1

(a) Discuss possible reasons for the growing demand of automatic sensor sink taps in public toilets.

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(b) The tap body is batch produced from a non-ferrous metal.

Explain **two** reasons why a non-ferrous metal is a suitable material for manufacturing an automatic sensor sink tap.

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(c) The automatic sensor sink tap is controlled by an electronic system, based around a microcontroller. A reflective infra-red sensor is used to detect the presence of a user's hands. The water continues to flow for two seconds after the hands are removed.

(i) Describe how a reflective infra-red sensor works.

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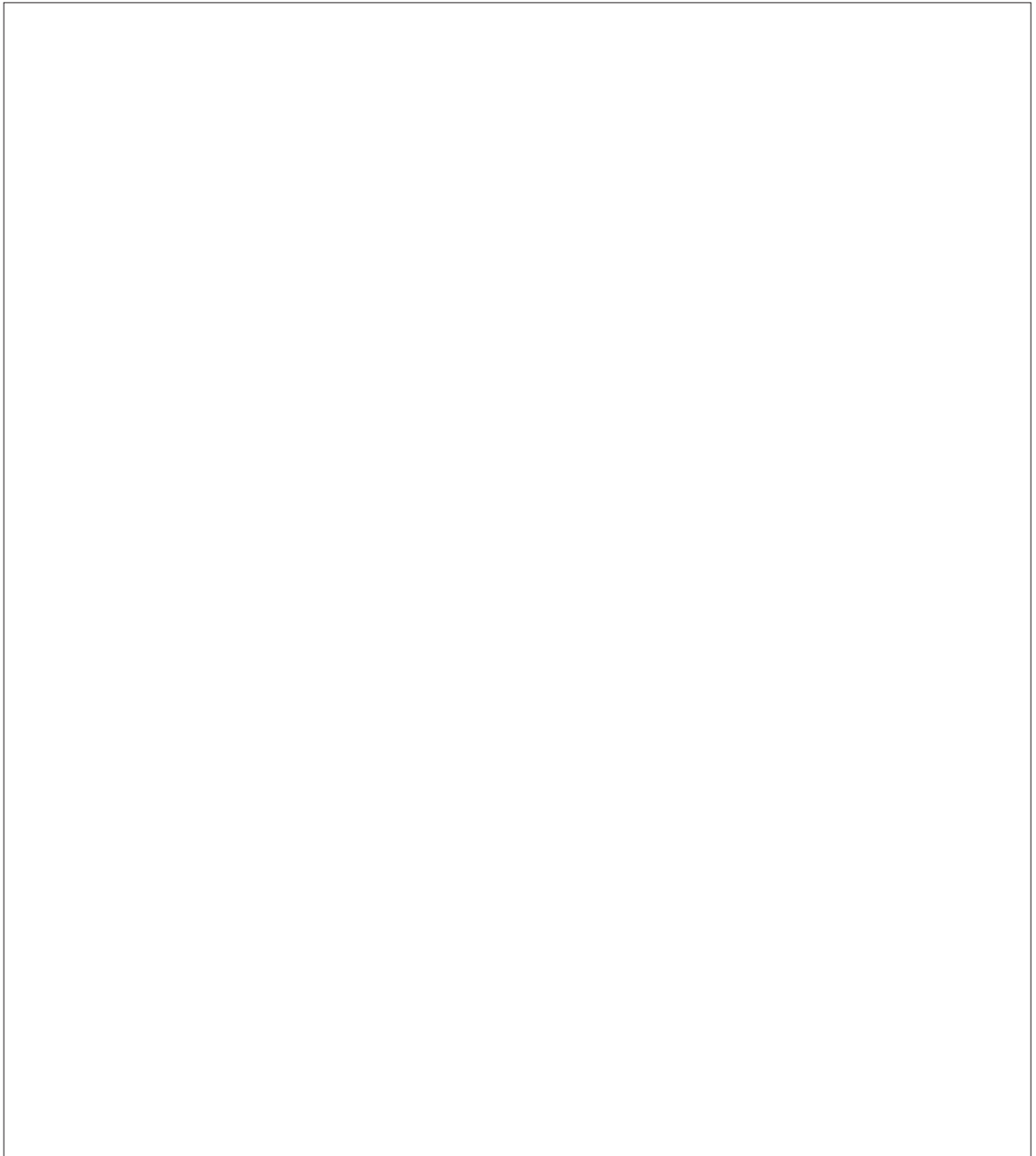
.... **[3]**

(ii) Draw a flow chart to show how the microcontroller could be programmed to achieve the correct function for the automatic sensor sink tap.

[4]

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4 A weather station has an automated air monitoring system which monitors the air quality in an urban environment. **Fig. 4.1** shows an automated air monitoring system.
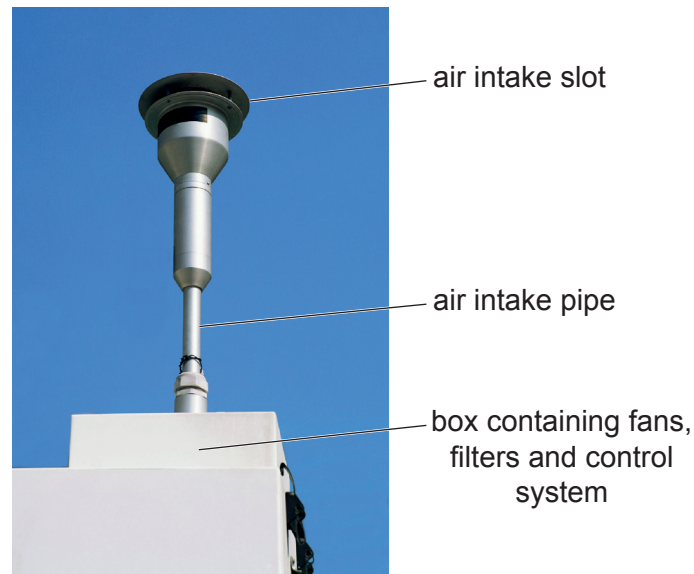
Fig. 4.1

(a) The automated air monitoring system uses fans to draw air from the environment and pass it through filters which trap particles, such as dust, for later analysis.

Fig. 4.2 shows an example of the type of fan that could be used in the automated air monitoring system. Three fans were identified for this purpose. The table in **Fig. 4.3** below shows the data collected. The filter manufacturer recommends that an air flow rate of at least $10\,m^3\,hour^{-1}$ is required.
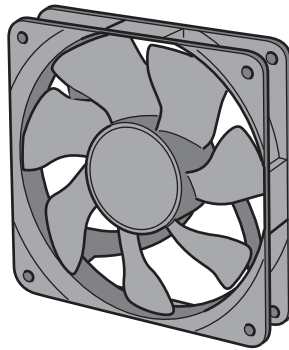
Fig. 4.2

	Items of data				
Fan	Voltage	Dimensions	Air flow rate	Speed	Temperature range
A	5 V dc	40 × 40 × 20 mm	$0.18\,m^3\,min^{-1}$	6200 rpm	−10 to +70 °C
B	12 V dc	40 × 40 × 10 mm	$0.20\,m^3\,min^{-1}$	6000 rpm	−10 to +70 °C
C	24 V dc	80 × 80 × 25 mm	$1.16\,m^3\,min^{-1}$	3000 rpm	−10 to +70 °C

Fig. 4.3

(i) Carry out a calculation to show that the air flow rate of fan A is suitable for the automated air monitoring system.

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(ii) Other than the air flow rate, justify **one** other item of data from the table in **Fig. 4.3** that a design engineer should consider when selecting a suitable fan for the automated air monitoring system.

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.... **[2]**

(iii) The automated air monitoring system box, as shown in **Fig. 4.1**, is manufactured from aluminium alloy and has a density of $56\,kg\,m^{-3}$.

Calculate the mass (in kg) of the aluminium alloy box measuring $1.0\,m \times 0.3\,m \times 0.3\,m$.

Mass ....kg

[3]

(b)* Discuss the possible constraints when using renewable energy sources to supply power for engineered products such as the automated air monitoring system.

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(c) Included in the weather station is a water monitoring system that uses a filter to collect data on water quality. A water filter will trap microorganisms that may be living in the water.

Fig. 4.4

Fig. 4.4 shows a water filter that could be used in the water monitoring system.

(i) Analysing **Fig. 4.4**, give **two** design features of the water filter that would make it suitable for use in the water monitoring system. Justify your response.

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(ii) Analysis and evaluation of products are important parts of the design and manufacturing process. Explain **two** reasons why it is important to undertake product analysis/ evaluation.

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5 (a) Explain **two** reasons why a design engineer would consider planned obsolescence when designing a new engineered product.

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Turn over

(b)* Discuss how environmental incentives or directives have impacted on the way in which engineered products and systems are produced.

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

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