OCR
Oxford Cambridge and RSA

Wednesday 5 June 2024 – Afternoon

A Level in Design and Technology: Design Engineering

H404/01 Principles of Design Engineering

Time allowed: 1 hour 30 minutes

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.

INFORMATION
- The total mark for this paper is **80**.
- 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 **20** pages.

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

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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.

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[4]

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(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]

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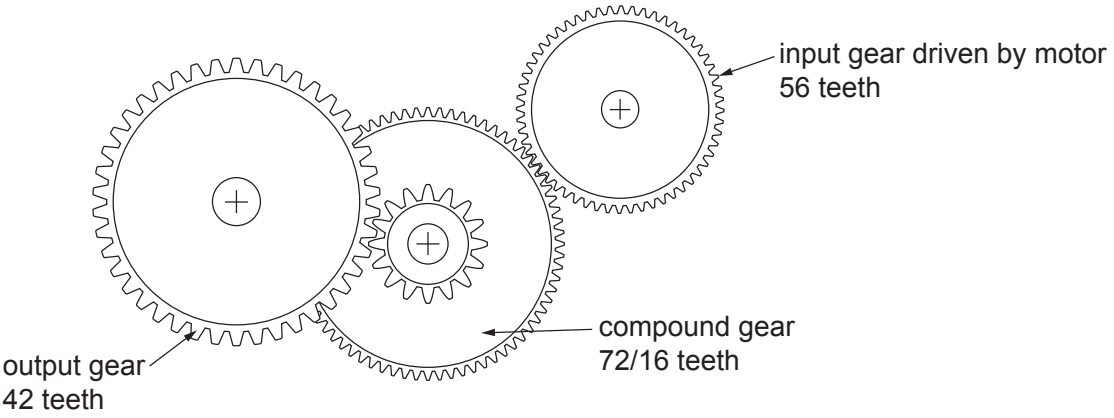
(b) The coffee vending machine uses a grinder mechanism to grind coffee beans into powder.

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

(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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(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.

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

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

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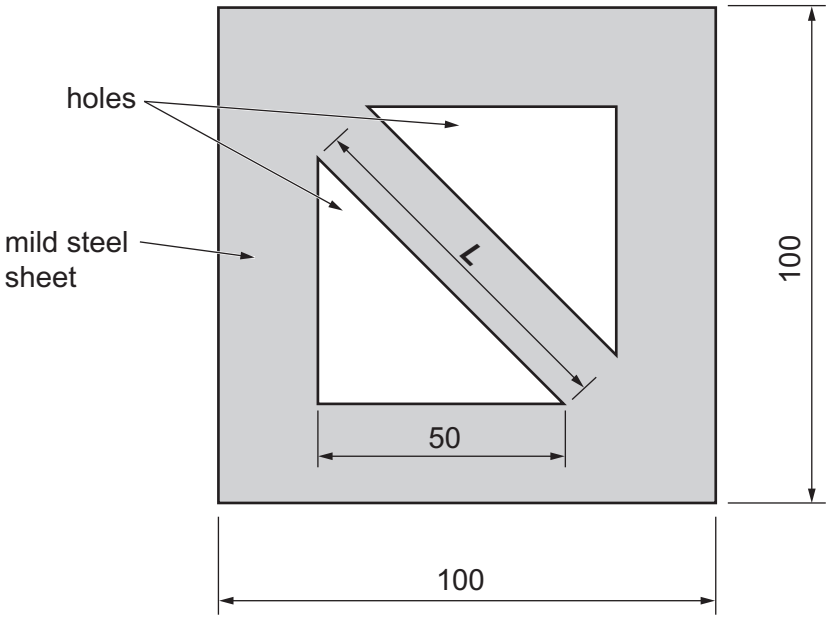
(a) **Fig. 2.1** shows a part made from a square sheet of mild steel. The part has two triangular holes cut out.

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



(not to scale)

(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

(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

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(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

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(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.

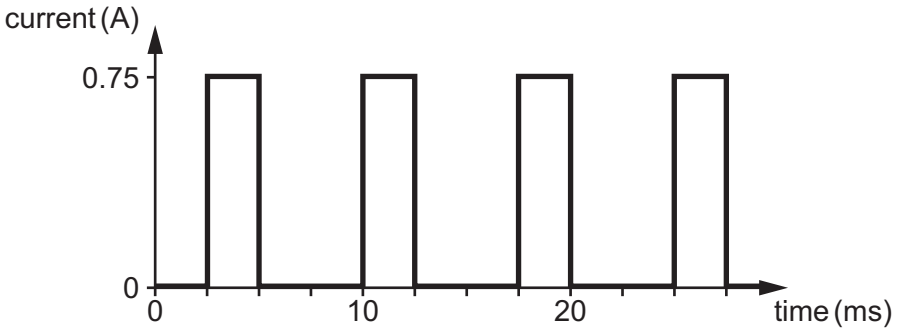
Calculate the power dissipated in the heater. Give your answer in watts (W) and show your working. **[3]**

Power ..... W

(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

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(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

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

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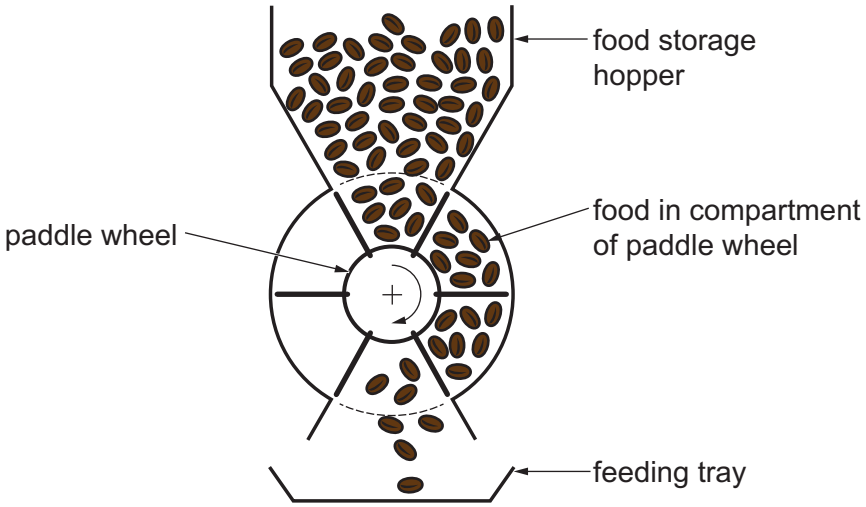
(b) The food dispensing mechanism for the automatic cat feeder is shown in **Fig. 4.2**.

Fig. 4.2

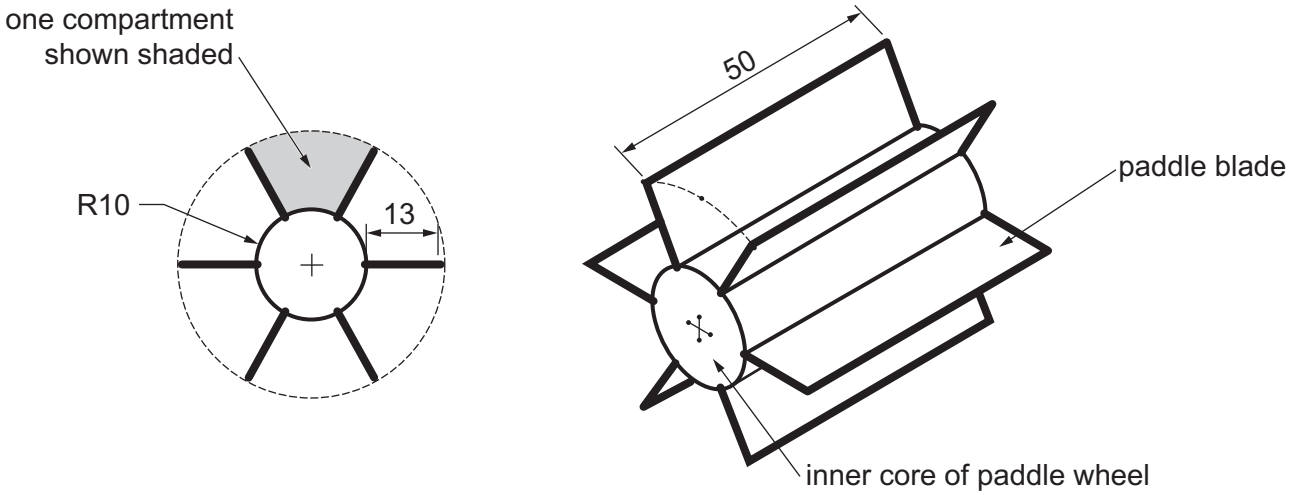


As the paddle wheel rotates, food is transferred from the hopper and dropped into the feeding tray.

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



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(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

(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

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(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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(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 .....

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(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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END OF QUESTION PAPER

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