



Oxford Cambridge and RSA

# Monday 13 May 2019 – Afternoon

## AS Level in Design and Technology: Design Engineering

### H004/01 Principles of Design Engineering

Time allowed: 1 hour 45 minutes



**You may use:**

- a scientific calculator
- a ruler
- pencils/pens
- geometrical instruments



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

Centre number

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Candidate number

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First name(s)

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Last name

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### INSTRUCTIONS

- Use black ink. HB pencil may be used for graphs and diagrams only.
- 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.

### 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.

2

Answer **all** the questions.

1 **Fig. 1.1** shows a domestic washing machine that is used to clean clothes.



**Fig. 1.1**

(a) Identify **two** design requirements that would have been taken into account when designing the washing machine.

- 1 .....
- .....
- 2 .....
- .....

[2]

(b) (i) State **two** inputs that would be included in a system diagram for the washing machine.

- 1 .....
- 2 .....

[2]

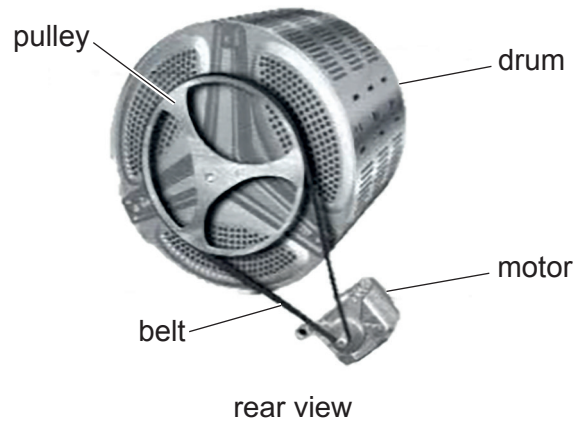
(ii) State **two** outputs that would be included in a system diagram for the washing machine.

- 1 .....
- 2 .....

[2]

3

(c) A major part of a washing machine is the drum. Clothes are placed into the drum when they need to be washed. To spin the drum a belt driven system is often used such as the one shown in **Fig. 1.2** below.



**Fig. 1.2**

(i) Identify and explain **one** reason why washing machines use this belt driven system.

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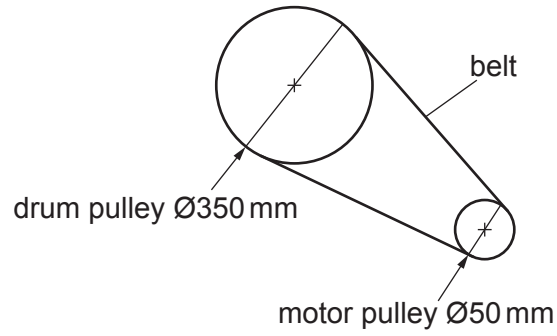
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.....

..... [3]

4

(ii) Fig. 1.3 shows the diameters of the drum and motor pulleys.



**Fig. 1.3**  
(not to scale)

Calculate the drum speed if the motor is rotating at 45 rev/s. Give your answer in rev/min to 1 decimal place. Show your working.

Drum speed ..... rev/min

[4]

5

(d) Fig. 1.4 shows the drum of the washing machine.



Fig. 1.4

(i) Name a suitable metal which the drum could be manufactured from and explain **two** reasons why this metal is suitable.

Metal: .....

1 .....

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2 .....

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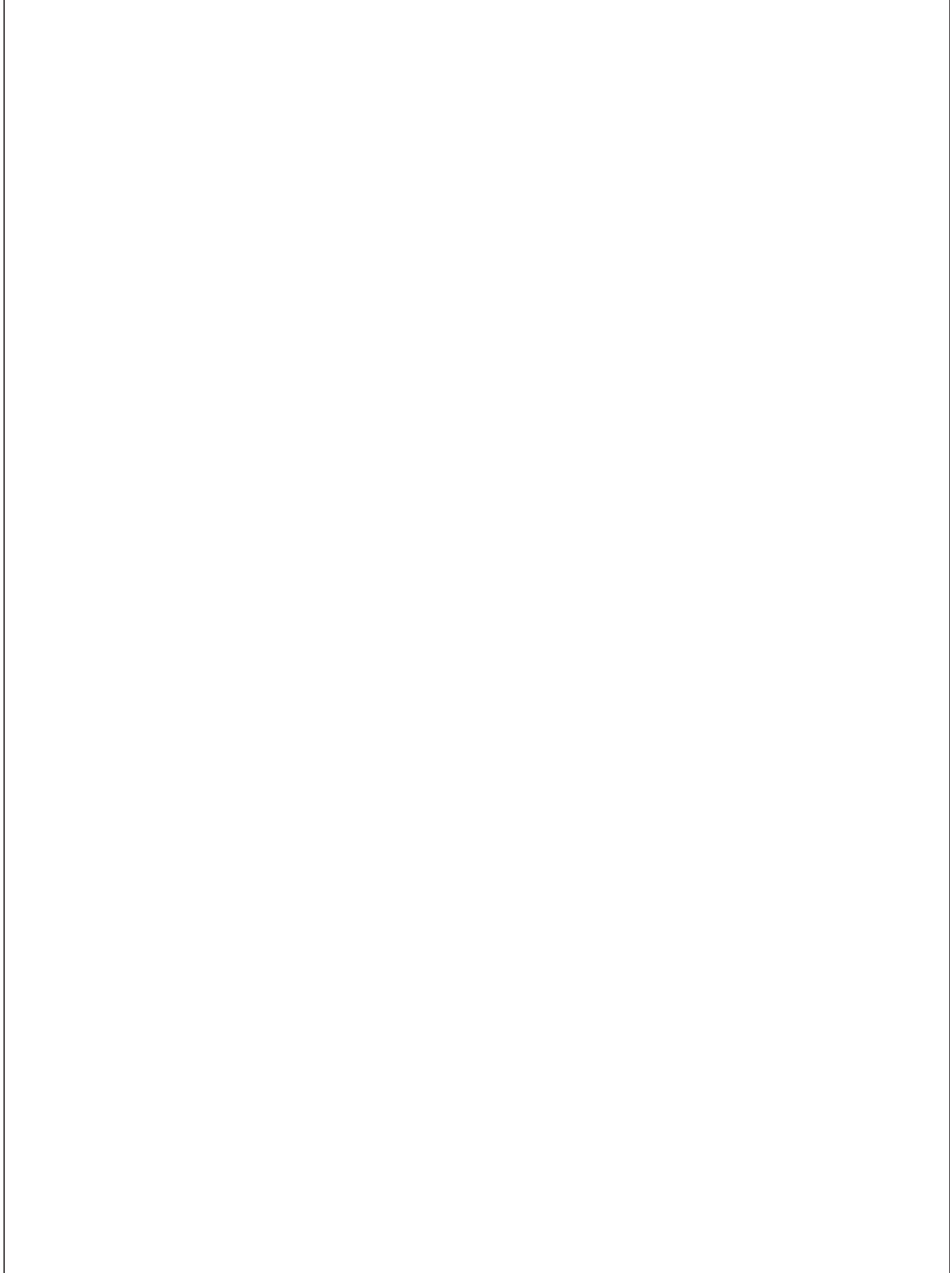
[5]

6

(ii) Use annotated sketches and/or notes to show how the drum in **Fig. 1.4** would be manufactured in a batch of 5000.

Your response must make reference to the:

- sequence of stages involved in manufacturing the drum;
- joining methods needed;
- tools and equipment required.



[6]

7

2 Fig. 2.1 shows an example of a bicycle for hire.



Fig. 2.1

The bicycle shown in Fig. 2.1 is designed to support a maximum weight of 150 kg.

Fig. 2.2 shows a cross-section of the hollow cylindrical tube that forms the seat post. The tube has a wall thickness of 2 mm and an outside diameter of 50 mm.

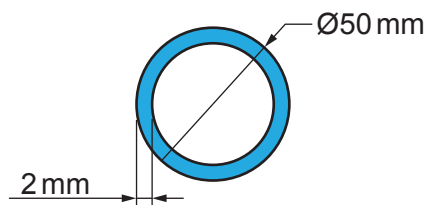


Fig. 2.2  
(not to scale)

(a) (i) Convert 150 kg to Newtons (N) stating the formula used.

..... N

[2]

8

- (ii) Calculate the shaded cross-sectional area of the hollow cylindrical tube in  $\text{m}^2$  to 3 significant figures. Show your working.

The formula used to calculate the area of a circle is  $A = \pi r^2$

Shaded cross-sectional area of hollow cylindrical tube .....  $\text{m}^2$

[2]

- (iii) Calculate the stress in the seat post in MPa when loaded to the maximum weight of 150 kg. Show your working.

Stress in seat post ..... MPa

[3]



9

- (b) The length of the seat post is 60 cm. When a person weighing 150 kg sits on the bicycle the length of the seat post compresses by 0.04 mm. Calculate the Young's Modulus of the material of the seat post in GPa. Show your working.

Young's Modulus of material of seat post ..... GPa

[5]

- (c) Bicycles can be hired multiple times in one day. The cost to the individual is £2 for every 30 minutes a bicycle is hired. Each bicycle costs the bicycle hire company £1400 per year.

Calculate how many days it takes to cover the £1400 cost of a bicycle if the bicycle is, on average, hired by 16 different people a day and  $\frac{3}{4}$  of their journeys are completed within 30 minutes and the rest within one hour. Show your working.

..... days

[3]

- 3 Fig. 3.1 shows a street light with a light sensor on the top which is used to illuminate pavements and roads at night.

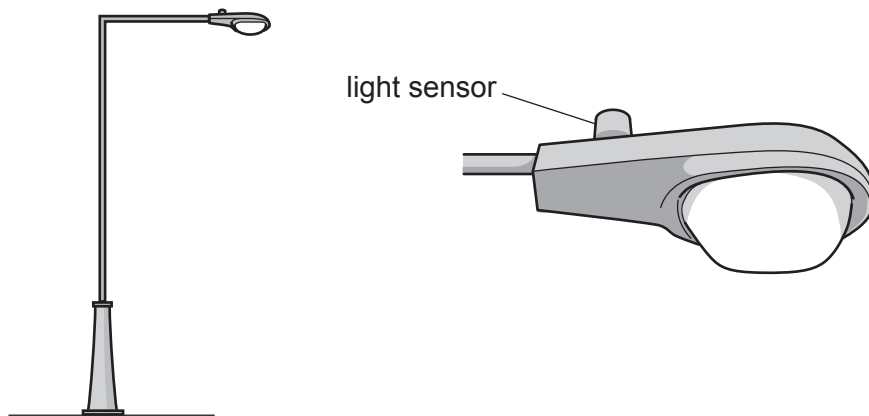


Fig. 3.1

Additional support ( $x$ ) is added to the street light structure as shown in Fig. 3.2 below.

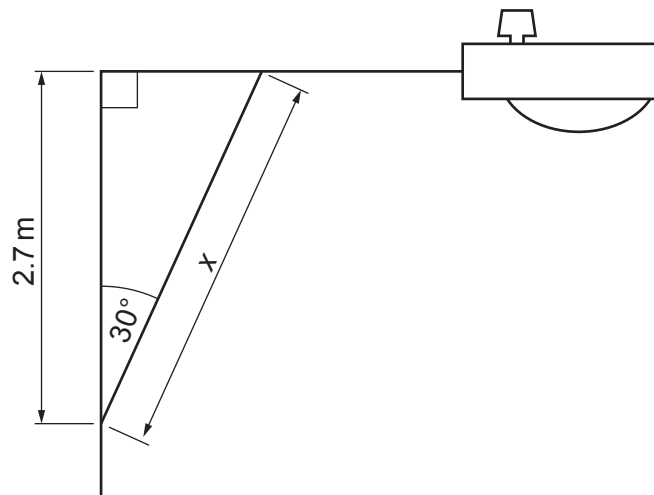


Fig. 3.2  
(not to scale)

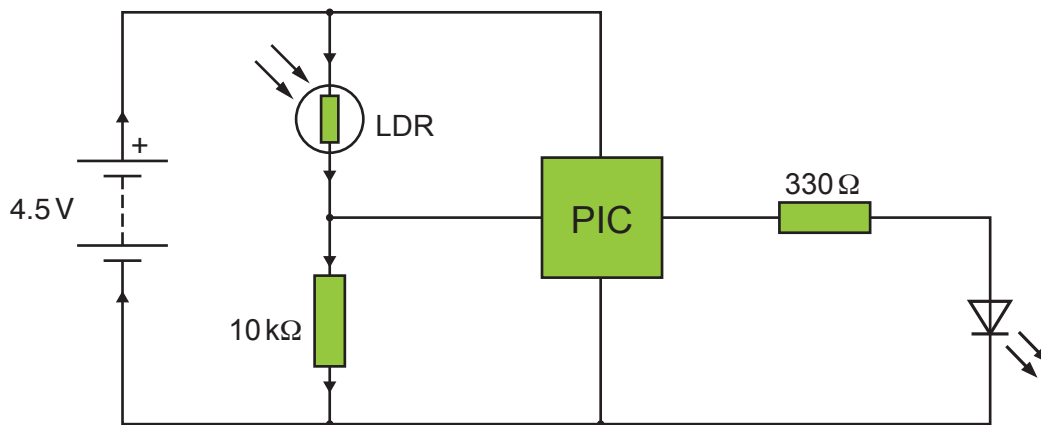
- (a) Using the information in Fig. 3.2, calculate the length  $x$  in metres (m) to 2 decimal places. Show your working.

$x$  ..... m



12

The student wanted to redesign the circuit in **Fig. 3.3** using a microcontroller. The student chose to use only one 3vdc LED as the output in the circuit which is shown in **Fig. 3.4** below.



**Fig. 3.4**

- (c) (i) Draw a flowchart to show how the microcontroller could turn on the LED when it is dark and then off when it is light. Your solution needs to be a closed loop system so that the student can test it multiple times without resetting the system.

[4]

- (ii) Using the potential divider formula and the student workings shown in Fig. 3.5, calculate the resistance of the LDR labelled in Fig. 3.4 in ohms ( $\Omega$ ) when the output voltage is 3.75 volts. Show your working.

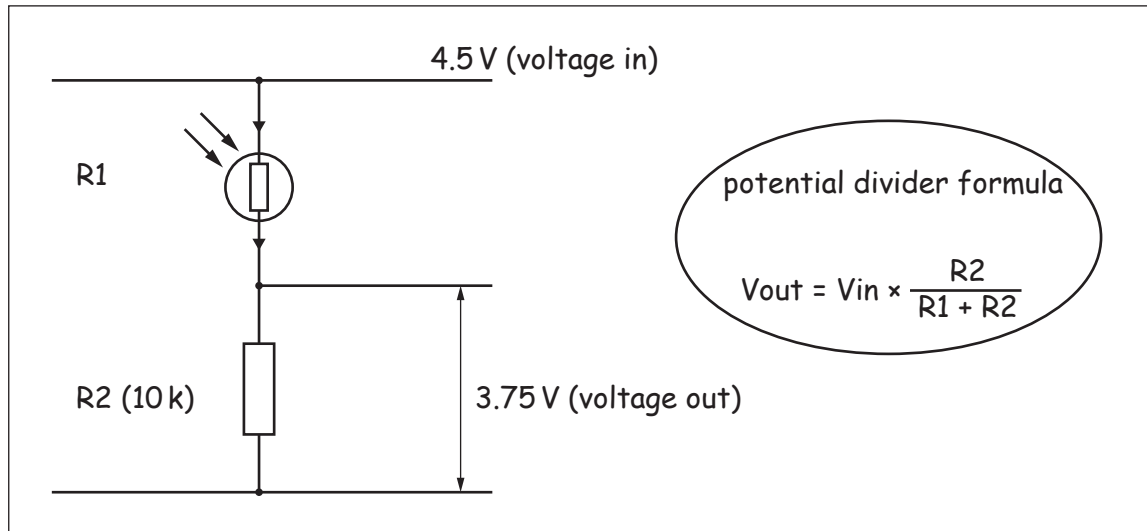


Fig. 3.5

Resistance of the LDR .....  $\Omega$

[2]

- 4 Fig. 4.1 shows an example of a model aircraft and a remote control which an operator can use to fly and move the aircraft in the air.

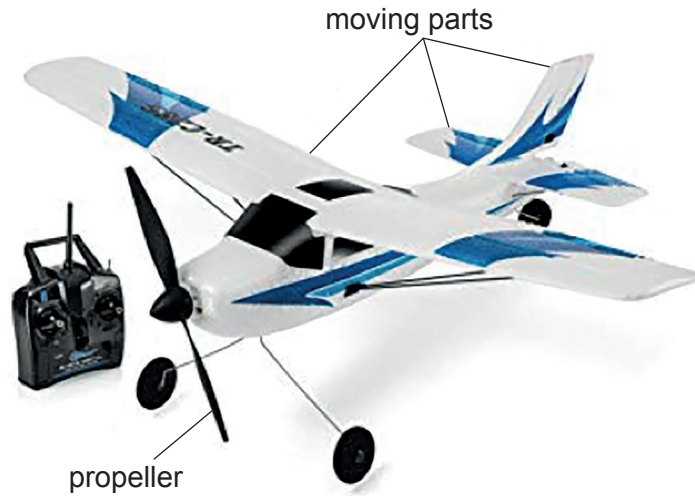


Fig. 4.1

- (a) When the model aircraft is in the air the operator can control the moving parts allowing the model aircraft to move left/right and up/down. The moving parts are often controlled by servo motors.
- (i) Identify and explain **one** reason why a servo motor is better than a DC motor for controlling the moving parts of the model aircraft.

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..... [2]

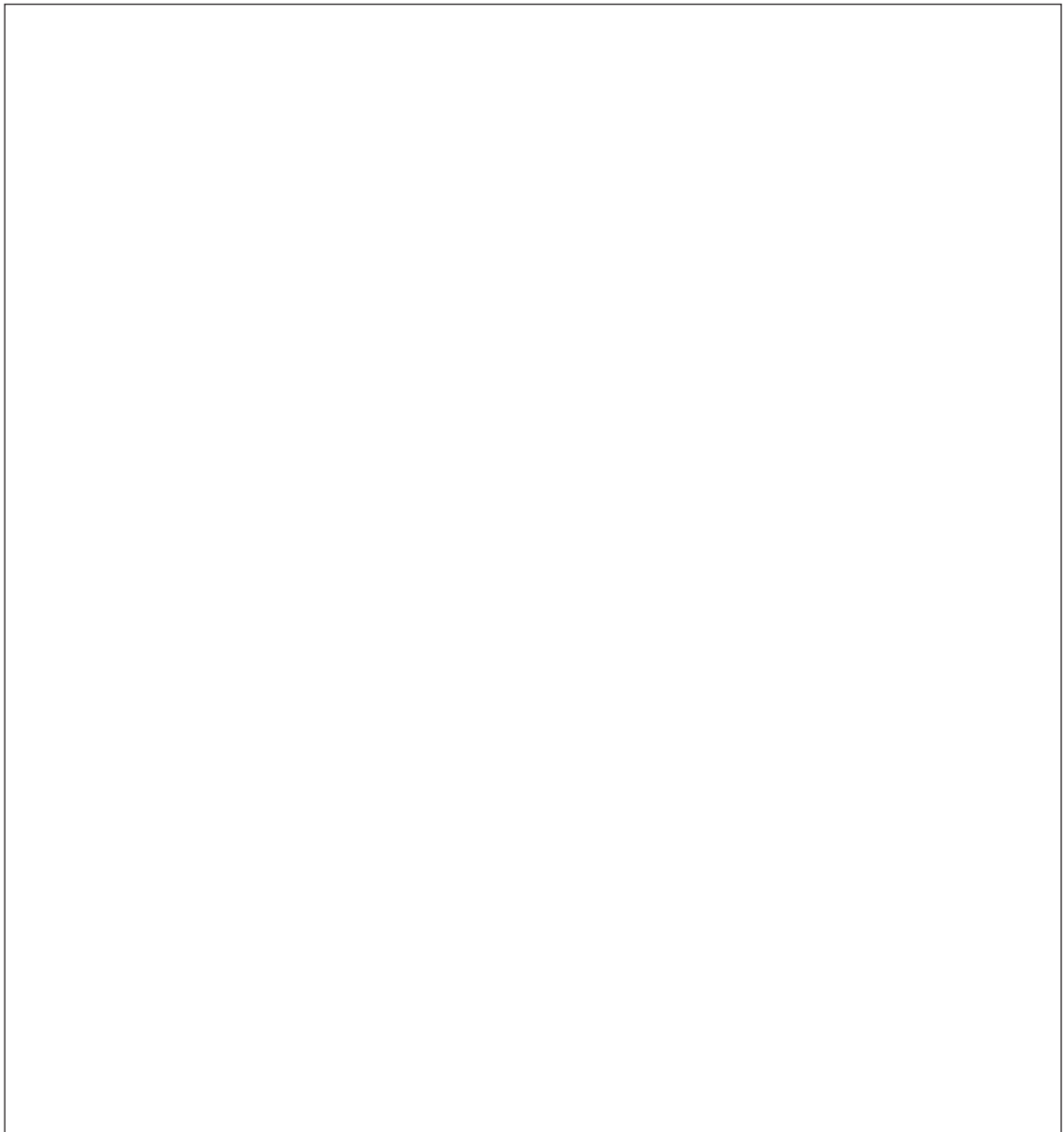
15

**Fig. 4.2** shows a servo motor and a potentiometer (variable resistor) which could be used as part of the control system for the moving parts of the model aircraft.



**Fig. 4.2**

- (ii) Draw a circuit diagram to show how the potentiometer could control the servo motor using a programmable controller.







(c) The propeller on the model aircraft in **Fig. 4.1** is connected to a DC motor.

(i) Describe how the speed of a DC motor can be controlled so the operator can easily change the speed of the model aircraft.

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..... [3]

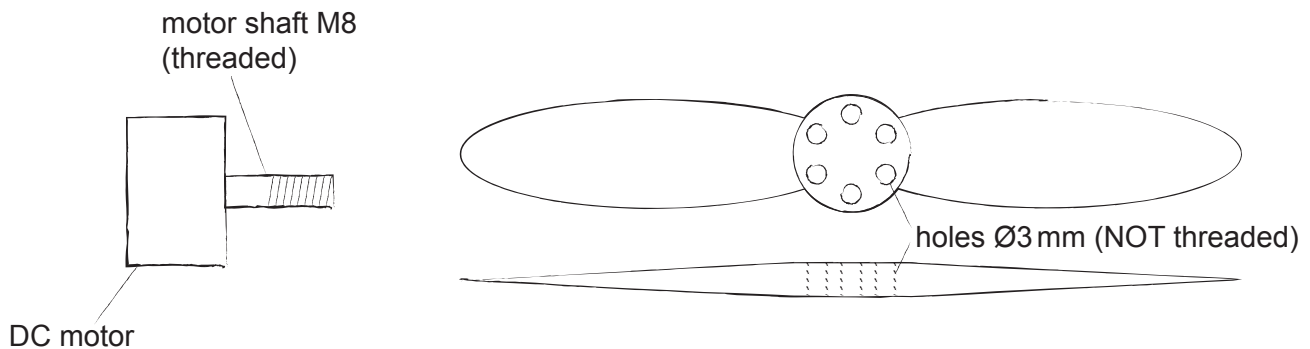
18

**Fig. 4.3** shows a DC motor and a propeller which can be used together to provide thrust for any model aircraft.

**Fig. 4.4** shows a sketch of these components drawn in 2D.



**Fig. 4.3**

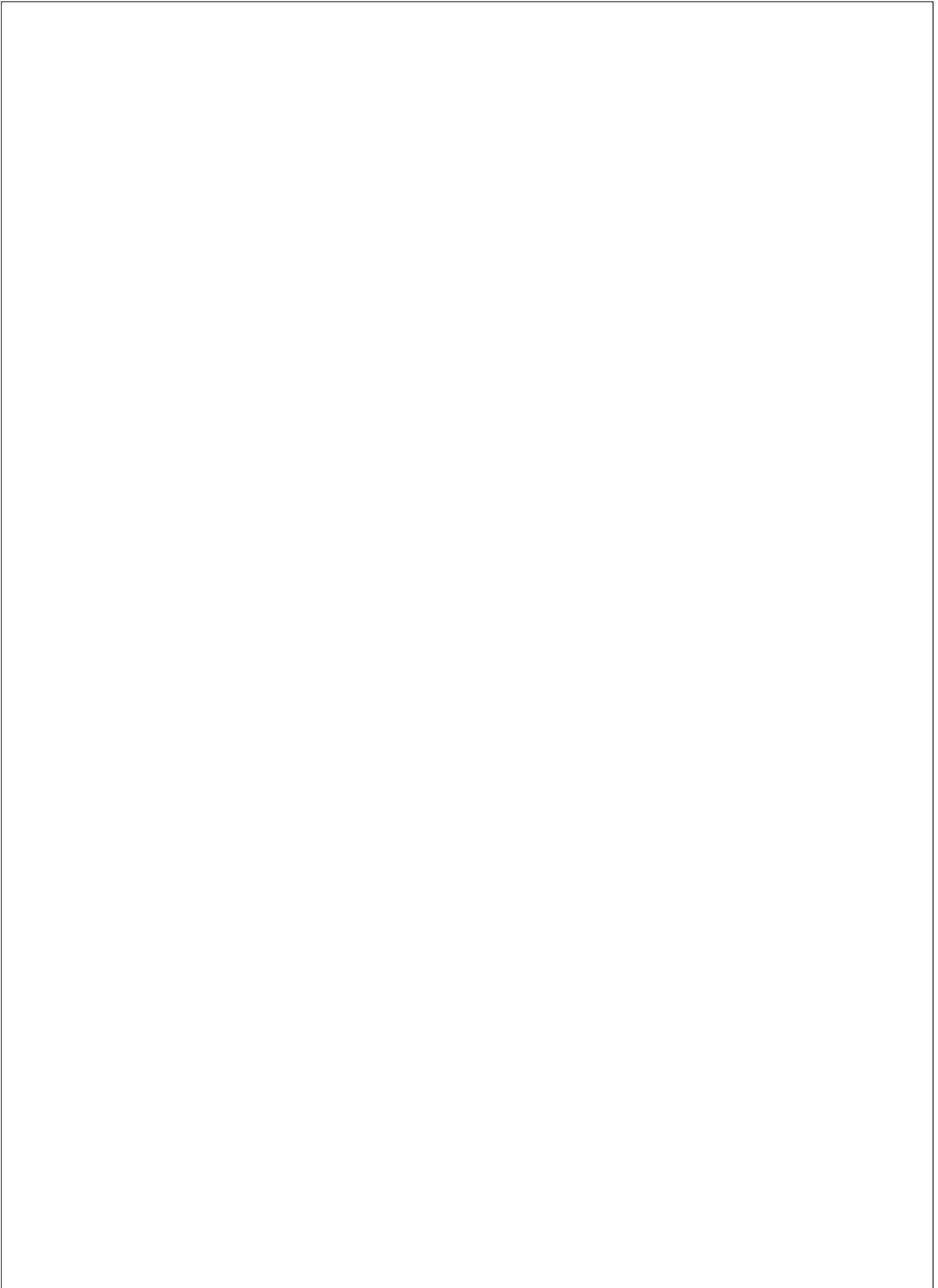


**Fig. 4.4**  
(not to scale)

- (ii) In the box opposite, use annotated sketches and/or notes to show how the propeller can be attached to the DC motor. **The motor and the propeller cannot be modified in anyway, i.e. drilling, cutting or bending.**

Your response must show:

- how the movement from the DC motor will be transmitted to the propeller;
- how the attachment(s) will allow the propeller to move securely. The attachment(s) should also be able to be removed easily;
- the material(s)/component(s) to be used.



[6]



(b) Waste plastic materials and products are a serious issue. State **two** measures that the Government of a small island could put in place to tackle this problem. Justify **each** of your responses.

1 .....

.....

.....

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2 .....

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[4]

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).

A large area of lined paper for writing answers. It features a vertical margin line on the left side and horizontal dotted lines for writing. The lines are evenly spaced and extend across the width of the page.

A blank sheet of lined paper with a vertical margin line on the left and horizontal ruling lines across the page. The page is otherwise empty of text or markings.

A large rectangular area with a solid vertical line on the left side and horizontal dotted lines extending across the page, providing a space for writing answers.



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