OCR
Oxford Cambridge and RSA

A Level in Design and Technology: Design Engineering

H404/01 Principles of Design Engineering

Practice Paper – Set 1

Time allowed: 1 hour 30 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 **80**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in the question marked with an asterisk (*).
- This document consists of **20** pages.

Answer **all** the questions.

1 **Fig. 1.1** shows a mobile phone in a handheld gimbal, a device that uses a set of motors and sensors to keep the phone steady, so that smooth video shots can be recorded.

Fig. 1.1

(a) Identify **two** reasons why using a handheld gimbal with mobile phones has recently increased in popularity.

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[2]

(b) A design engineering company is considering whether to invest in developing a new handheld gimbal for use with mobile phones.

Identify **three** issues the company would need to investigate before deciding whether to proceed.

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[3]

(c) (i) **Fig. 1.2a** shows an annotated diagram of the handheld gimbal control system.

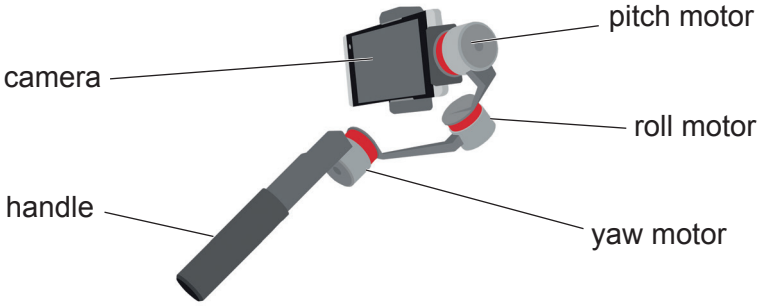

Fig. 1.2a

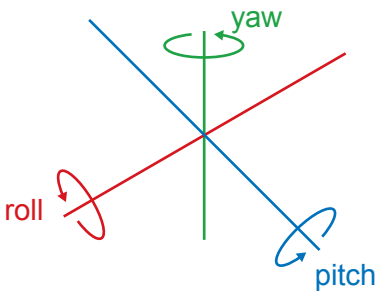

Fig. 1.2b

Three motors are used to stabilise the camera in the three axes of pitch, roll and yaw as shown in **Fig. 1.2b**.

Sensors are located at specific points around the handheld gimbal. When the sensors detect movement of the camera in each of the three axes, the motors counteract that motion almost instantly. The system is controlled by a microcontroller.

The handheld gimbal can remove most, but not all, of the unwanted motion caused by the movements of the user's hand.

Discuss possible limitations when using the handheld gimbal control system.

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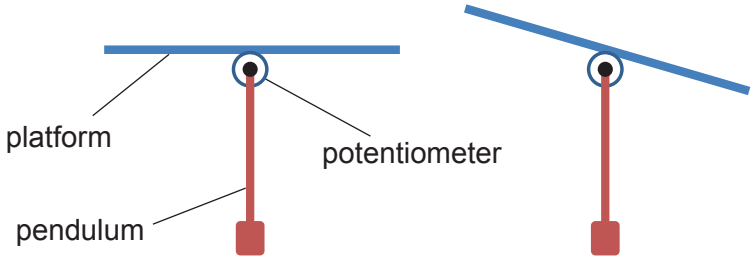
..... **[6]**

(ii) **Fig. 1.3** shows a prototype system for sensing the angle of tilt of an object. It consists of a pendulum, freely pivoted on a potentiometer (a variable resistor). Data for the potentiometer is given below.



Potentiometer data	
Full rotation angle	300°
Track resistance	10 kΩ

Fig. 1.3

The potentiometer is connected in the circuit shown in **Fig. 1.4**.

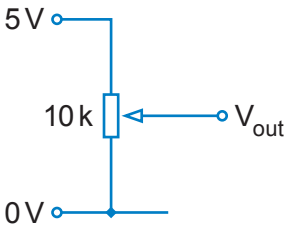


Fig. 1.4

When the gimbal is held horizontal to the ground, the potentiometer output voltage (V_{out}) is 2.50 V.

When the gimbal is tilted the V_{out} rises to 2.70 V.

Calculate the angle through which the gimbal has tilted. Show your working.

Angle ..... °

[3]

(iii) Data for the actual sensor used on the handheld gimbal is given below.

Power supply	1.8 to 3.6 V
Power consumption	<1 mW
Sensitivity	0.005 g

Explain **one** reason why this sensor is suitable for use on the handheld gimbal.

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(d) (i) Electric motors as used in the handheld gimbal often make use of modern materials such as rare earth magnets.

Explain **one** reason why modern materials are used in electric motors.

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..... **[2]**

(ii) State **one** type of motor that would be suitable for use in the handheld gimbal and explain why it would be used.

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..... **[2]**

(iii) Explain, using sketches and/or notes, how the motor you identified in **part (ii)** could be controlled.

You should:

- identify the signals required for the motor to operate correctly;
- explain how these signals affect the direction, speed and position of the motor.

[4]

2 (a) **Fig. 2.1** shows a 3-dimensional isometric projection of a part.

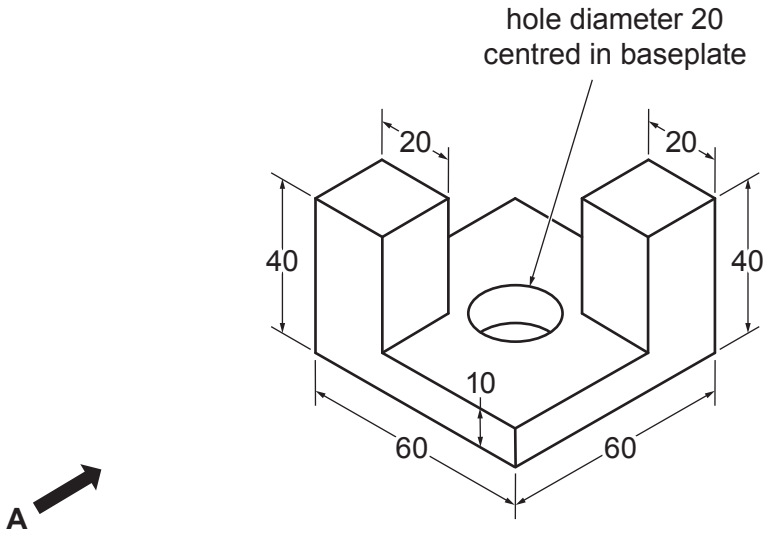

Fig. 2.1

Draw, on the 10 mm grid below, an accurate 2-dimensional elevation of the part from direction **A**. Indicate any hidden lines.

[3]

(b) **Fig. 2.2a** shows one leg of a camera tripod. **Fig. 2.2b** shows the right-angled triangle formed by one leg of the tripod.

Fig. 2.2a
(not to scale)

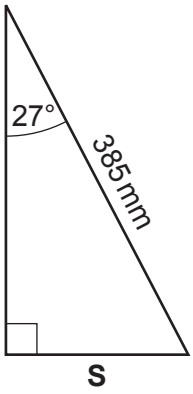

Fig. 2.2b
(not to scale)

Using the information from **Fig. 2.2b**, calculate the length of **S** correct to the nearest mm. Show your working.

Length **S** ..... mm

[3]

(c) **Fig. 2.3** shows a bicycle brake lever.

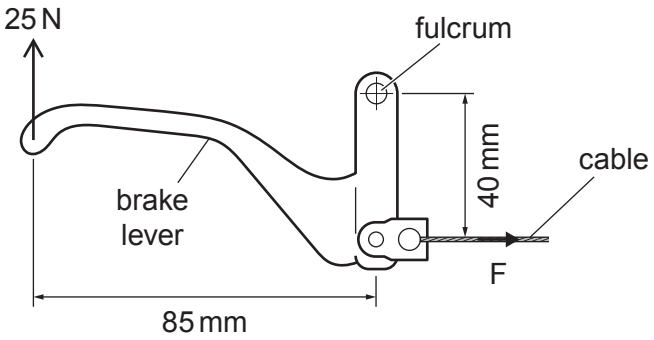

Fig. 2.3
(not to scale)

(i) Using the information from **Fig. 2.3**, calculate the tensile force F exerted on the cable when the rider exerts a 25 N force at the end of the brake lever. Show your working.

Tensile force F ..... N

[2]

The cable is made from stainless steel. It has an unstretched length of 1500 mm and a diameter of 1.6 mm.

(ii) Calculate the cross sectional area of the wire in m^2 to 3 significant figures. Show your working.

Area of a circle = πr^2

Cross sectional area of wire ..... m^2

[3]

(iii) Calculate the stress in the wire in $Pa(Nm^{-2})$ when a tensile force of 300 N is applied to the end of the cable. Show your working.

Stress in wire ..... $Pa(Nm^{-2})$

[3]

(iv) Calculate the extension of the cable in mm to 3 significant figures. Show your working.

Young's modulus of stainless steel = 180 GPa

Extension of cable ..... mm

[3]

(d) A ladder manufacturer carried out a survey on the body masses of 30 users. A histogram of the results is shown in **Fig. 2.4**.

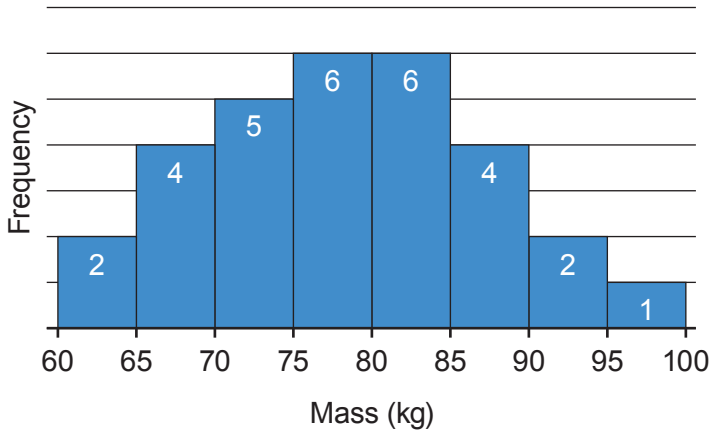

Fig. 2.4

(i) Calculate the percentage of users in the survey who had a body mass above 90 kg. Show your working.

Percentage of users ..... %

[2]

(ii) Anthropometric data for the UK population states that the 50th percentile body mass is 84 kg.

Show that the 50th percentile mass of the sample in **Fig. 2.4** is less than 84 kg.

[2]

3 **(a)** Designers and manufacturers should consider the social footprint and the ecological footprint of any materials they use.

(i) Describe how a social footprint is created by the manufacture of a product.

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(ii) Describe the ecological footprint that results when using timber in products.

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(b)* Discuss how a lifecycle assessment (LCA) would be carried out on a domestic refrigerator.

Make reference to the following stages of the product's life in your answer:

- manufacture;
- use;
- end of life.

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4 **Fig. 4.1** shows a domestic washing machine.

Fig. 4.1

(a) The side panels of the washing machine shown in **Fig. 4.1** are manufactured from a sheet metal with indentations.

State **one** reason why the side panels have been manufactured in this way.

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

(b) **Fig. 4.2** shows the belt and pulley drive system between the motor and the washing machine drum.

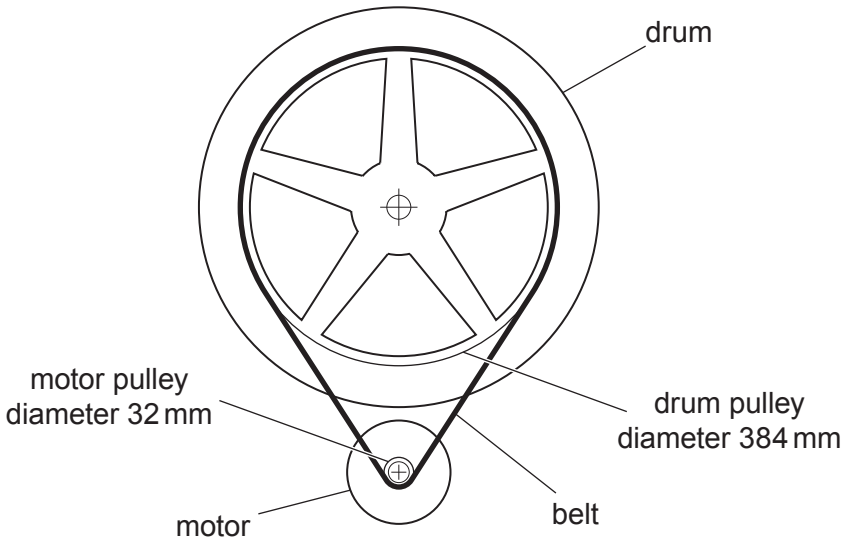

Fig. 4.2
(not to scale)

(i) Identify **three** reasons why a belt and pulley drive system would be used in the washing machine.

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[3]

(ii) The maximum rotational drum speed is 1600 rpm.

Calculate the rotational speed of the motor when the drum is spinning at maximum speed.

Rotational speed ..... rpm

[2]

(iii) Describe how a closed loop control system is used to regulate the rotational speed of the washing machine drum.

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(c) User interfaces on early washing machines used simple LED indicators, but many modern washing machines feature graphical displays.

Explain **two** ways in which a graphical display enhances the user interface on the washing machine.

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[4]

(d) Discuss how the washing machine manufacturer would use destructive **and** non-destructive testing methods to assess the machine's suitability for purpose.

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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).