OCR
Oxford Cambridge and RSA

Monday 15 May 2023 – Afternoon

AS Level in Design and Technology: Design Engineering

H004/01 Principles of Design Engineering

Time allowed: 1 hour 45 minutes

8931537532

You can use:
- a ruler (cm/mm)
- a scientific calculator
- geometrical instruments

H004014

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

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

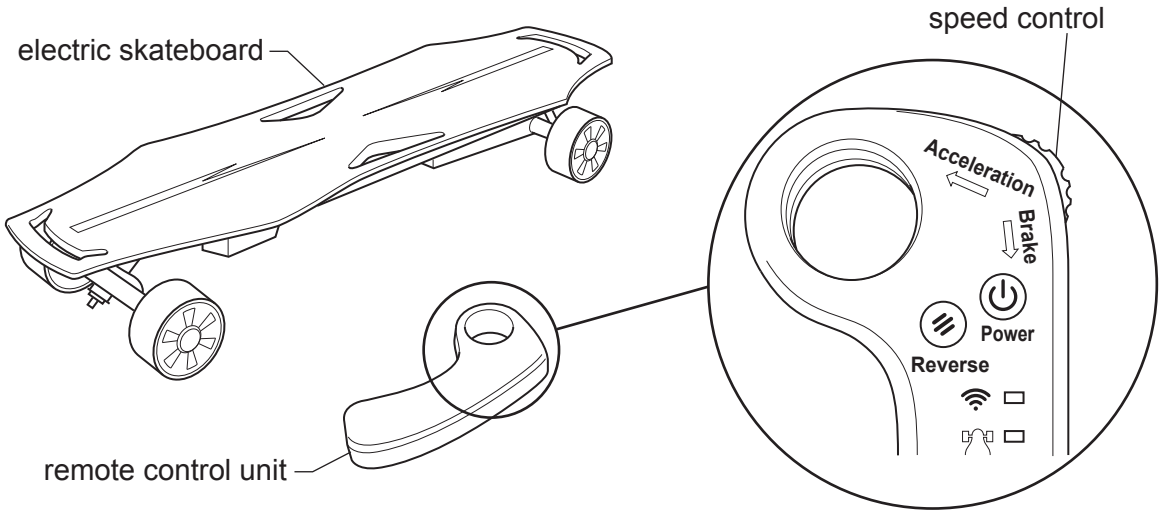
Last name _____

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 **90**.
- 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.

1 This is an electric skateboard and a remote control unit.



(a) Identify **one** type of wireless technology that could be used to connect the remote control unit to the electric skateboard.

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

(b) Identify **two** design considerations that would need to be taken into account when designing the remote control unit.

Justify **each** of your answers.

1 .....

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2 .....

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[4]

(c) Inside the remote control unit is a printed circuit board (PCB) on which the electronic components are mounted.

Use annotated sketches and/or notes to show how:

- a PCB is manufactured on a commercial scale
- electronic components are soldered to a PCB. **[6]**

(d) The remote control unit connects to the motor of the electric skateboard. The speed of the motor on the electric skateboard changes when the user adjusts the speed control on the remote control unit.

Describe how this system works.

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

Electric skateboards can be driven by either a motor directly within the wheel, as shown in **Fig. 1.1** or by a motor which is external and connected via a belt as shown in **Fig. 1.2**.

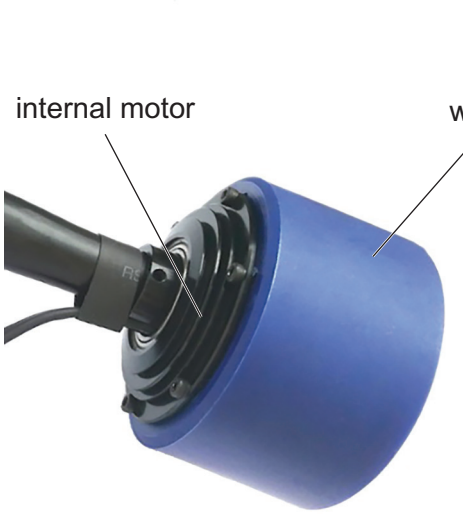

Fig. 1.1

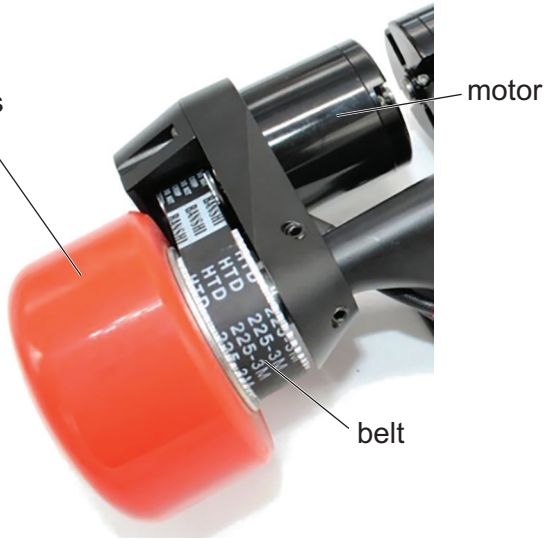

Fig. 1.2

(e)* Discuss the advantages and disadvantages of each method in driving the wheels of an electric skateboard. **[8]**

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2 **Fig. 2.1** shows a circular stencil containing an arrow. The diameter of the stencil is 80 cm.

Fig. 2.2 shows the measurements of the arrow within the stencil. All measurements are shown in cm.

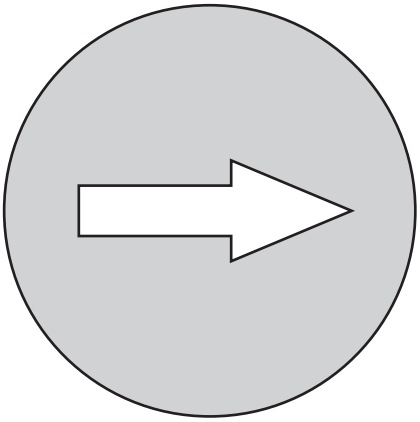


Fig. 2.1

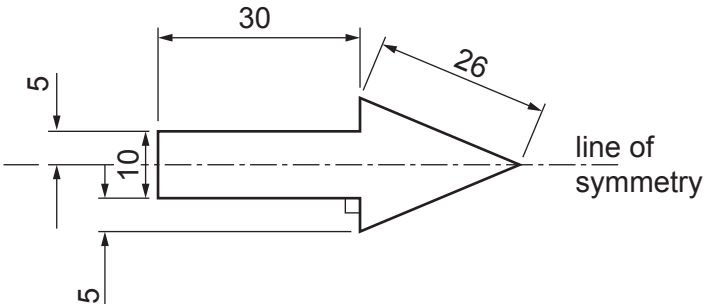


Fig. 2.2
(not to scale)

(a) A laser cutter will be used to cut the stencil. The laser cutter travels at 80 mm per second.

Calculate the time it will take to cut the shape of the circle and the shape of the arrow to form the stencil. Give your answer in seconds to **2** decimal places. Show your working. **[6]**

Time ..... seconds

(b) The stencil is used to produce the arrow on a surface by spraying through the arrow shape in the stencil with yellow aerosol paint.

(i) Calculate the area of the arrow that will be sprayed. Give your answer in cm^2 and show your working. **[6]**

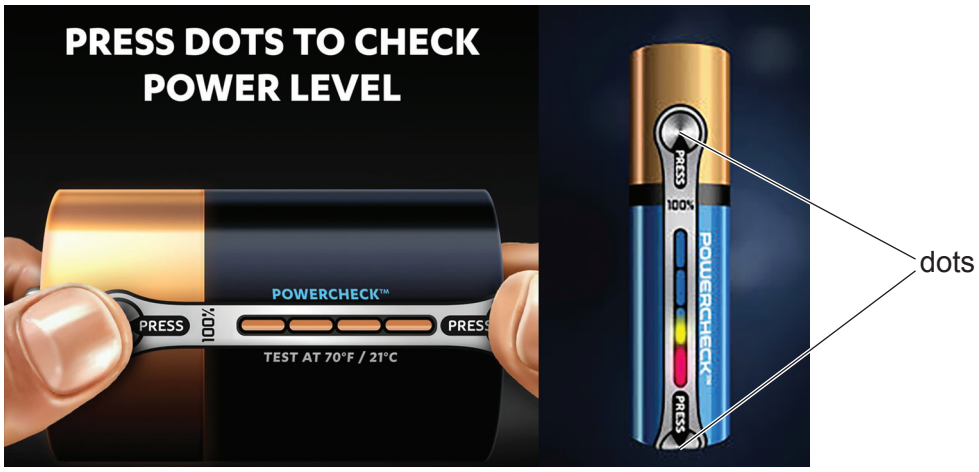
Area of the arrow that will be sprayed ..... cm^2

(ii) One can of yellow aerosol paint covers $2\,m^2$.

Use your answer from **part (b)(i)** to calculate the number of complete arrows that can be sprayed from one can of yellow aerosol paint. Show your working. **[3]**

Number of complete arrows .....

3 This is a battery which is having its power checked. When the user presses the dots as shown, the level of power in the battery is indicated by the colour display on the side of the battery.



(a) Identify **one** smart material that could be used to produce the display to show the power in a battery.

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

(b) A drawer contains 15 fully charged batteries and 6 discharged batteries.

Calculate the probability of someone taking two fully charged batteries from the drawer. Show your working. **[3]**

Probability .....

This is the battery packaging which is made from cardboard and a thermo softening polymer.

cardboard

thermo softening polymer battery casing

(c) Identify a suitable thermo softening polymer for the battery casing.

Explain **two** reasons why this thermo softening polymer is suitable.

Thermo softening polymer .....

1 .....

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2 .....

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[5]

(d) The use and storage of batteries in a workshop environment may cause hazards. This means risk assessments need to be carried out.

(i) Identify and explain **one** reason why a workshop environment needs to have risk assessments.

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

(ii) Complete the table to identify **two** hazards and **two** control measures for a workshop environment when using and storing batteries. **[4]**

Hazard	Control Measure
1	1 ....
2	2 ....

4 This is a belay device. The belay device is used with a rope to lower a climber down a wall or rock face safely.

(a) A belay device is usually made from an aluminium alloy.

Identify and explain **two** reasons why an aluminium alloy would be used.

1 .....

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2 .....

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[4]

(b) Identify **one** way the belay device could become damaged and unsafe to use.

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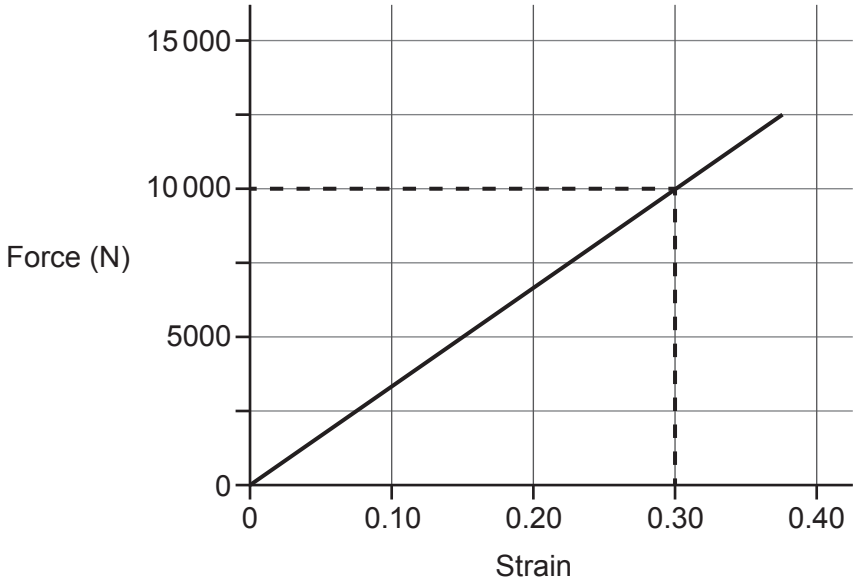
..... **[1]**

(c) Use annotated sketches and/or notes to show how the belay device would be manufactured using a die casting process.

Identify any relevant equipment, machinery and materials. **[6]**

(d) This graph shows the force versus strain for a climbing rope with a radius of 5 mm.



Calculate Young's Modulus of the climbing rope. Give your answer in GPa to **2** decimal places. Show your working. **[5]**

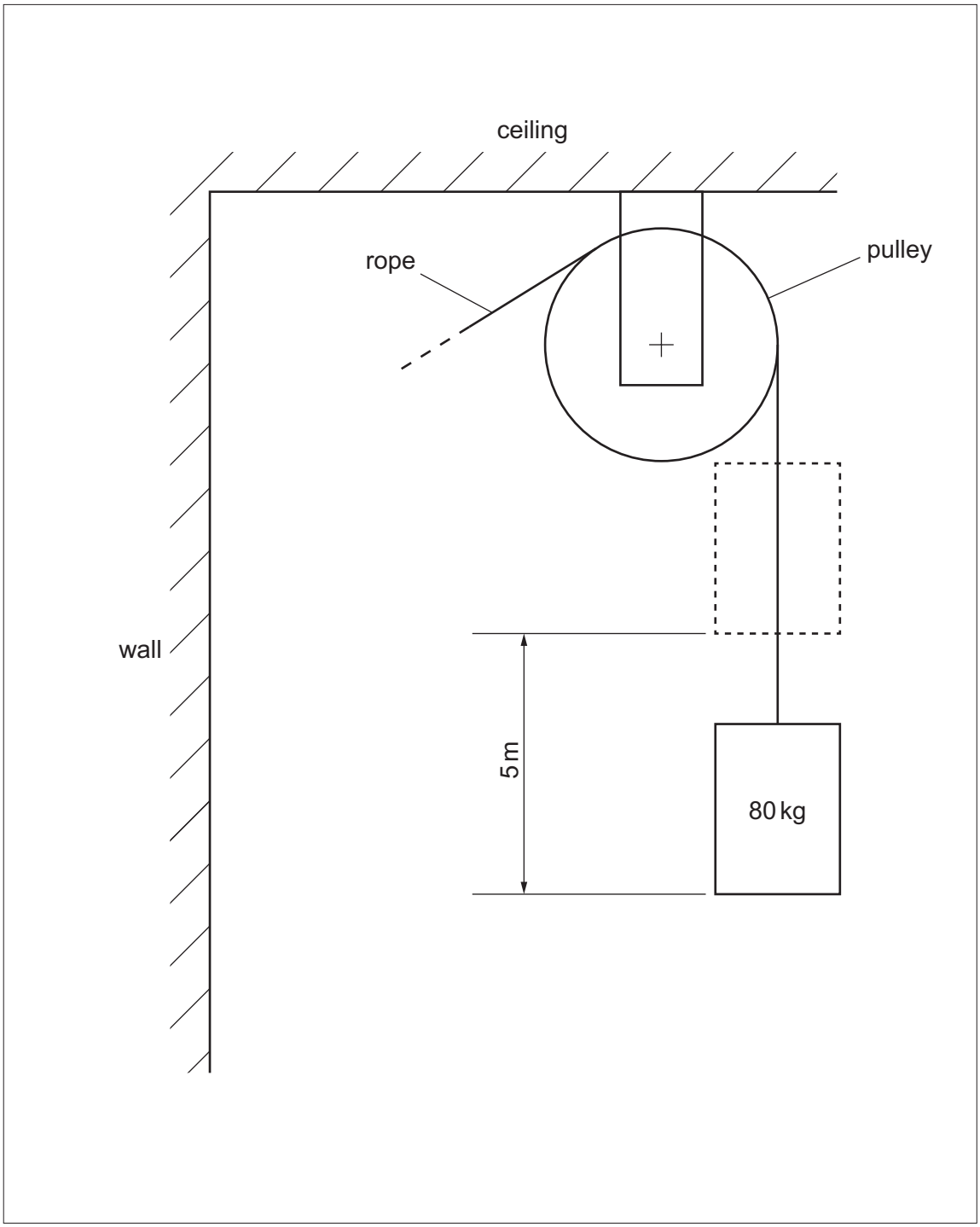
Young's Modulus ..... GPa

(e) (i) One method of testing a climbing rope is to use a test rig.

The system that is used should:

- activate by momentarily actuating a push button switch
- lift a weight of 80 kg to 5 m
- drop the weight automatically when it reaches 5 m.

Use annotated sketches and/or notes in the box below to complete the system. **[6]**



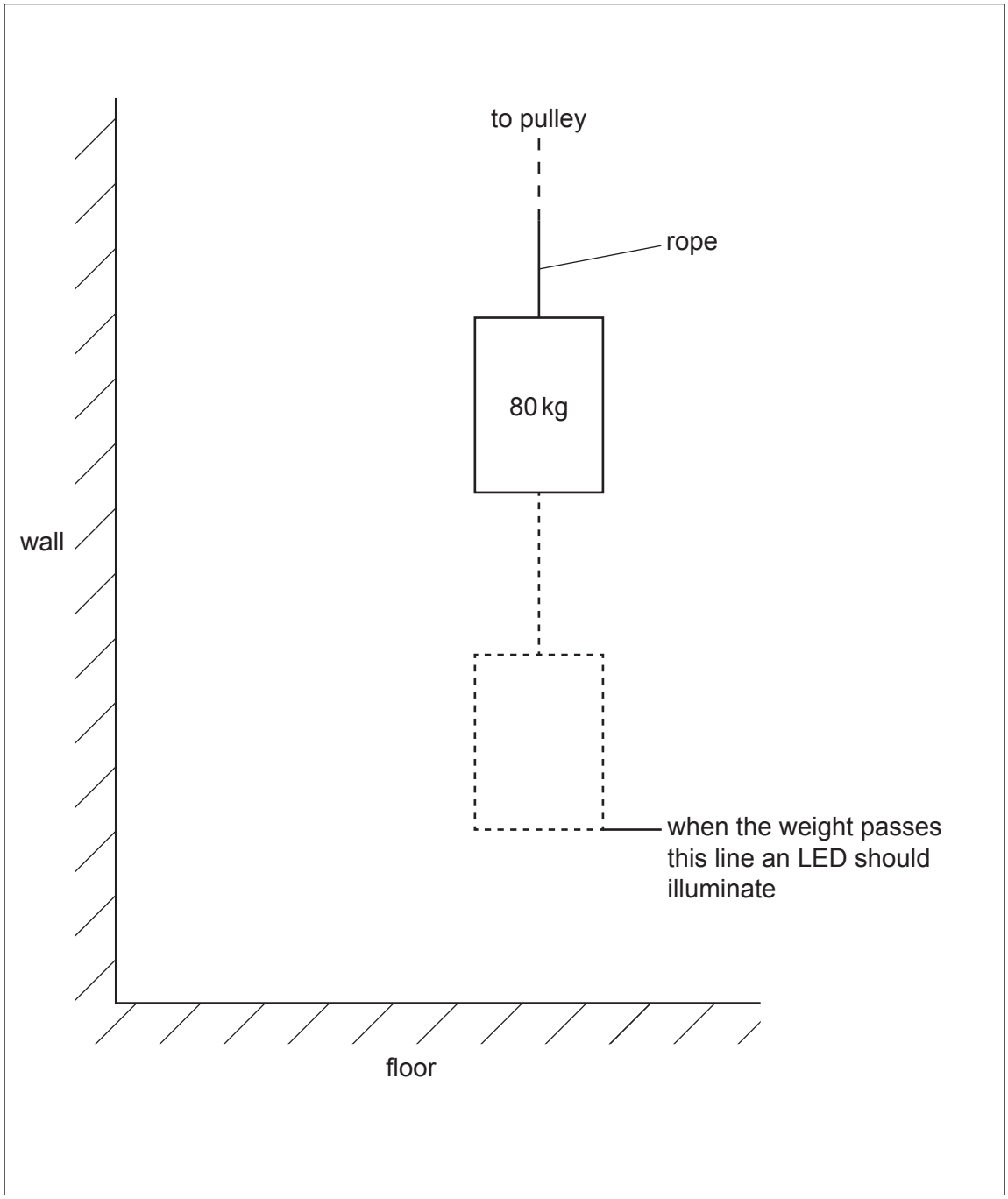
(ii) You have now been tasked to add an extra feature to the test rig.

The system should:

- illuminate an LED if the rope stretches causing the weight to pass the line indicated on the diagram
- use a sensor to detect the weight's distance below this line
- include a display to indicate this distance.

You should avoid attaching sensors to the weight and the rope.

Use annotated sketches and/or notes in the box below to complete the system. **[5]**



5 Companies have to take decisions when designing and manufacturing products.

(a) Identify and explain **two** factors companies should take into account when bringing new products to market.

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2 .....

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[4]

(b)* Discuss what manufacturers in the mobile phone industry could do to help reduce their impact on the environment. **[8]**

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