



Rewarding Learning

ADVANCED (A2)

General Certificate of Education

2025

Centre Number

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Candidate Number

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# Technology and Design

Assessment Unit A2 1

*assessing*

Systems and Control or  
Product Design

[ATE11]

MONDAY 2 JUNE, MORNING



ATE11

## TIME

2 hours.

## INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page and on the A3 pro forma answer pages provided.

Answer **both** questions in **either** Section A, B or C.

Answer to Questions **1(e)**, **2(f)**, **3(g)**, **4(b)**, **4(c)**, **4(e)**, **5(i)** and **6(h)(i)** and **(ii)** should be made on the A3 pro forma answer pages provided.

At the end of the examination, attach the A3 pro forma answer pages securely to this paper with the treasury tag supplied.

## INFORMATION FOR CANDIDATES

The total mark for this paper is 80.

Quality of written communication will be assessed in Questions **1(c)**, **3(e)** and **6(d)**.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	

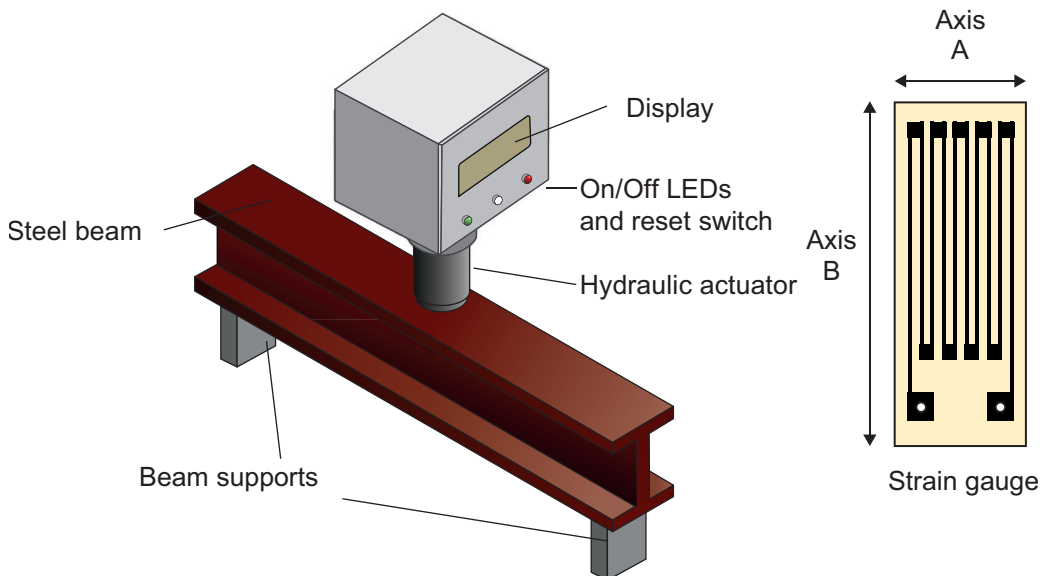
<b>Total Marks</b>	
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## Section A

### Electronic and Microelectronic Control Systems

Answer **both** questions in this section.

- 1 (a) A system to test and measure the deflection of a loaded steel beam is shown in **Fig. 1** along with a strain gauge that is to be used to detect the deflection of the beam. A fixed motor-driven hydraulic actuator is used to apply a load to the beam.



Source: CCEA

**Fig. 1**

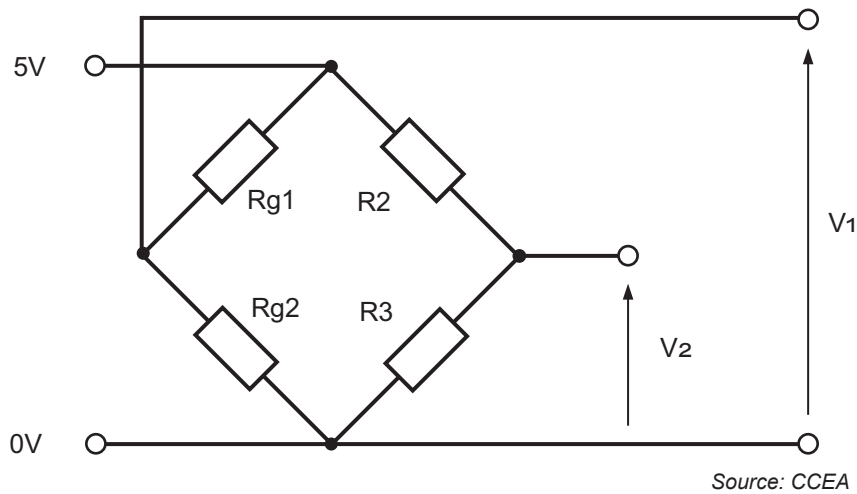
- (i) State the main physical property of a strain gauge that changes when the gauge is deformed.

\_\_\_\_\_ [1]

Examiner Only	
Marks	Remark



- (b) Two strain gauges are to be connected as part of a bridge circuit as shown in **Fig. 2**, where  $R_{g1}$  and  $R_{g2}$  will represent the resistances of the strain gauges. The resistance values of  $R_{g1}$ ,  $R_{g2}$ ,  $R_2$  and  $R_3$  are each  $150.0\Omega$  when the sensors are unstrained.



**Fig. 2**

- (i) Explain the principle of operation of the bridge circuit shown in **Fig. 2**.

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[2]

- (ii) During testing it was found that the resistance values of  $R_{g1}$  and  $R_{g2}$  in **Fig. 2** were  $150.2\Omega$  and  $150.8\Omega$  respectively when the beam in **Fig. 1** was subjected to the maximum load. Calculate  $V_1$  when the beam was subjected to the maximum load.

**Candidates need to show their working out in the space below.**

Answer \_\_\_\_\_ volts [2]

Examiner Only	
Marks	Remark



(c) The motor-driven hydraulic actuator shown in **Fig. 1** uses an LED type display to show the hydraulic pressure as the beam is being tested. Give **two** reasons for using an LED type display for this application rather than an LCD type display. Describe **one** method of multiplexing that can be employed to drive an LED type display and explain **one** advantage of using this method of multiplexing.

**Quality of written communication will be assessed in this question.**

Reason 1 \_\_\_\_\_

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Reason 2 \_\_\_\_\_

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Examiner Only	
Marks	Remark

Method of multiplexing \_\_\_\_\_

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Advantage of multiplexing \_\_\_\_\_

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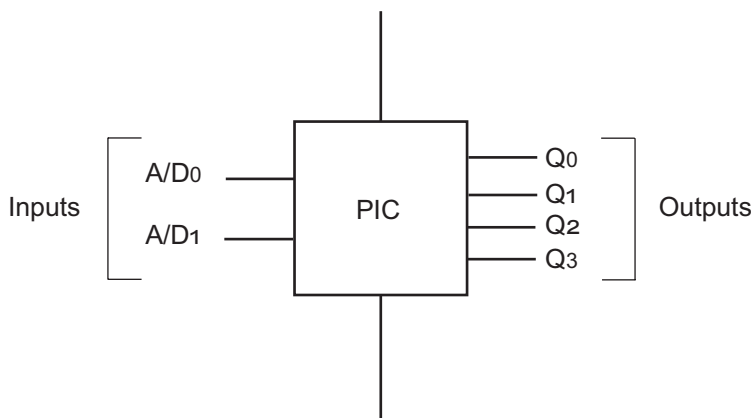
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\_\_\_\_\_ [9]

Examiner Only	
Marks	Remark

(d) **Fig. 3** shows a PIC that is to be used as part of a system to control the beam tester shown in **Fig. 1**. The PIC has mixed analogue / digital inputs and digital outputs.



Source: CCEA

**Fig. 3**

- (i) The PIC shown in **Fig. 3** has on board analogue to digital convertors with an input range from 0 to 5 volts and a corresponding digital range from 0 to 255. Calculate the digital equivalent value for an analogue input of 2.1 volts.

**Candidates need to show their working out in the space below.**

Answer \_\_\_\_\_ [2]

Examiner Only	
Marks	Remark

- (ii) The PIC shown in **Fig. 3** is to be used to control the hydraulic actuator in **Fig. 1** which in turn is driven by a reversible 24 volt DC motor. In addition, there is a reset switch and two LEDs to indicate when the hydraulic actuator is either operational or off. Draw a block diagram to represent the complete PIC based system for the beam tester. Include blocks to represent the inputs, outputs and any drivers required.

Examiner Only	
Marks	Remark

[4]

(e) On the A3 pro forma (**answer number 1(e)**), draw an annotated circuit diagram with an associated flow chart program for a complete system based on **Fig. 1** and **Fig. 3**. Your answer should meet the following specification points:

- When the system is turned on, the 24 volt DC motor-driven actuator should operate and the On LED should illuminate to indicate loading is taking place.
- As the beam is being loaded by the actuator, the output from the op-amp should be checked once every second.
- If the output of the op-amp exceeds 2.1 volts, the DC motor should automatically stop and the Off LED should then illuminate to indicate loading has stopped.
- If the reset switch is momentarily pressed at any time during operation, the 24 volt DC motor should immediately reverse, to release the hydraulic pressure. At the same time, the Off LED should flash to indicate that loading is being reversed.
- When the op-amp output has lowered back to 0 volts, the DC motor-driven actuator should stop and both LEDs should switch off.

Note. You are not required to redraw the bridge or op-amp circuits and you may assume that the appropriate voltage is presented at the PIC input.

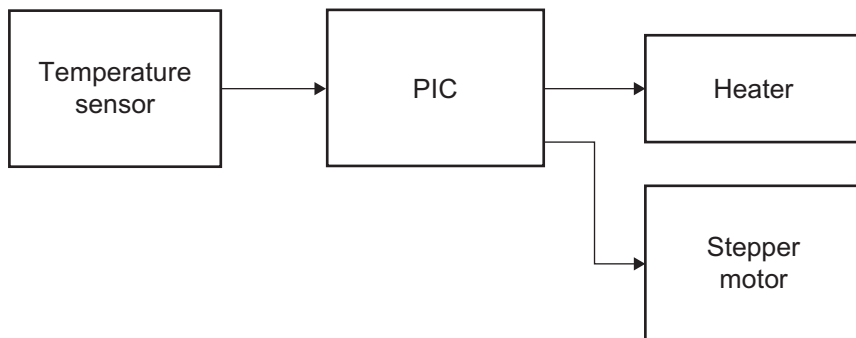
[10]

Examiner Only	
Marks	Remark

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**(Questions continue overleaf)**

- 2 (a) A systems diagram for a basic PIC based open loop system to control an industrial process is shown in **Fig. 4**. A sensor is used to detect changes in temperature and open a vent by means of a stepper motor if it is too hot. If the temperature is too cold, a heater is operated.



Source: CCEA

**Fig. 4**

- (i) Complete the diagram in **Fig. 4** so that it accurately represents a closed loop system. [2]
- (ii) The power supply for the circuit represented in **Fig. 4** uses a voltage regulator. Explain the function of a voltage regulator and state **one** main drawback to its operation.

Explanation

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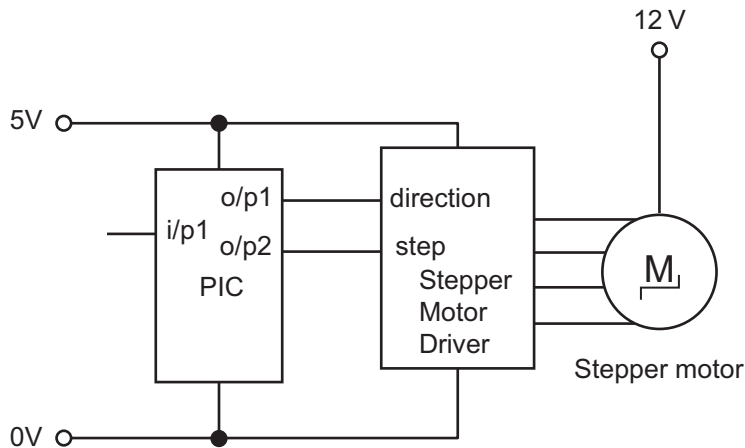
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[2]

Drawback \_\_\_\_\_ [1]

Examiner Only	
Marks	Remark

- (b) A PIC based stepper motor and driver circuit is shown in **Fig. 5**. The 12 volt stepper motor has a step angle of  $1.8^\circ$ . When the direction pin on the stepper motor driver is 'pulled high', the stepper motor rotates clockwise.



Source: CCEA

**Fig. 5**

- (i) Calculate the frequency, in hertz, for the step input to the stepper motor driver in **Fig. 5** if the motor is required to rotate at 15 rpm (revolutions per minute).

**Candidates need to show their working out in the space below.**

Answer \_\_\_\_\_ Hz [3]

- (ii) Calculate the number of steps required to rotate the stepper motor in **Fig. 5** by 1.5 turns.

**Candidates need to show their working out in the space below.**

Answer \_\_\_\_\_ steps [1]

Examiner Only	
Marks	Remark

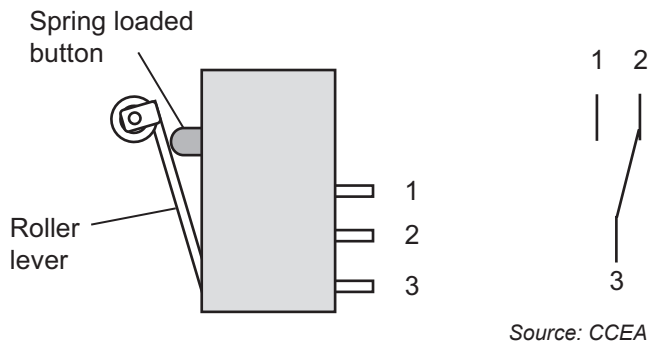
- (iii) Using the minimum number of commands, draw a flow chart for a subroutine named STEP to cause the stepper motor in **Fig. 5** to rotate clockwise by 1.5 turns at a rate of 15rpm then pause for 0.3 seconds.



Examiner Only	
Marks	Remark

[6]

- (c) A roller lever activated microswitch along with its corresponding circuit symbol and terminal labels is shown in **Fig. 6**. Both switch and symbol are shown in the unoperated state.



**Fig. 6**

- (i) Explain why the button on a microswitch is spring loaded.

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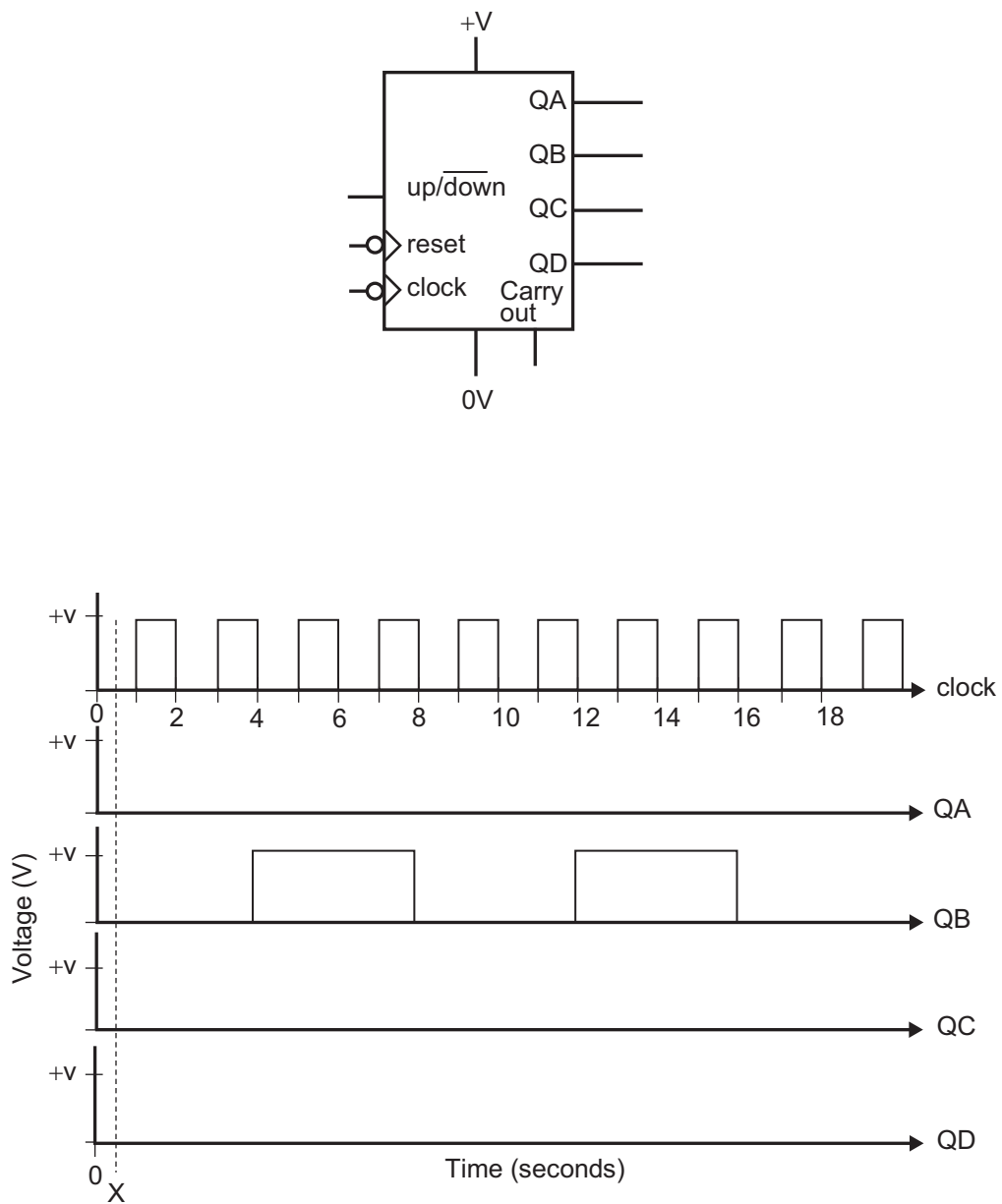
[2]

- (ii) Show with the aid of a circuit diagram how the microswitch shown in **Fig. 6** could be used to produce a logic 'high' when the roller lever is unoperated and a logic 'low' when operated.

[2]

Examiner Only	
Marks	Remark

(d) A 4-bit binary counter is shown in **Fig. 7** with outputs labelled as QA to QD where output QA is the least significant bit. Incomplete graphs representing the clock input and the four outputs expected from the binary counter are also shown.



Source: CCEA

**Fig. 7**



(e) A 7 segment decoder is often used in conjunction with a binary counter in order to drive a 7 segment display. An incomplete part of a logic truth table for a decoder is shown in **Fig. 8** below. The inputs to the decoder are A, B, C and D where A is the least significant bit. The corresponding outputs are a, b, c, d, e, f and g. Complete the missing logic values on **Fig. 8** for the two decimal values given.

number	A	B	C	D	a	b	c	d	e	f	g
1	1	0	0	0							
3					1	1	1	1	0	0	1

Fig. 8

[2]

Examiner Only	
Marks	Remark

- (f) Resistors are often supplied to schools in packs of one thousand where the resistor leads are held in a paper tape carrier as shown in Fig. 9. A prototype system for counting the number of resistors on the tape carrier is to be designed where a roller lever microswitch will detect each individual resistor lead. The roller on the microswitch will run along the leads in the direction shown.

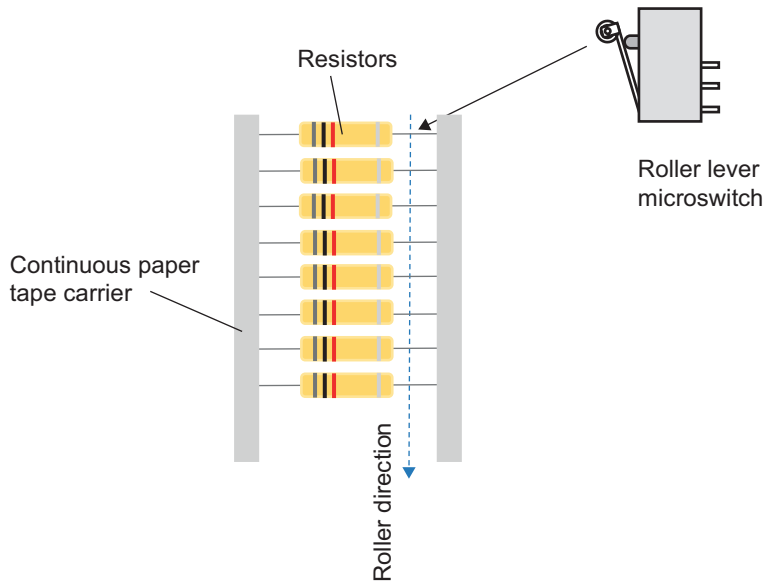


Fig. 9

Using an annotated circuit diagram on the A3 pro forma (**answer number 2(f)**), design a hard wired system that will fulfil the following:

- Count up to 999 resistors and display the number on common cathode 7 segment displays.
- Include a means of preventing false counts due to contact 'bounce' within the microswitch when operating.
- Allow the user to reset the display by means of a push to make switch.

[10]

Examiner Only	
Marks	Remark

## Section B

### Mechanical and Pneumatic Control Systems

Answer **both** questions in this section.

- 3 (a) Chains and sprockets are commonly used in mechanical systems. Explain **one** advantage and **one** disadvantage of a chain and sprocket.

Advantage

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[2]

Disadvantage

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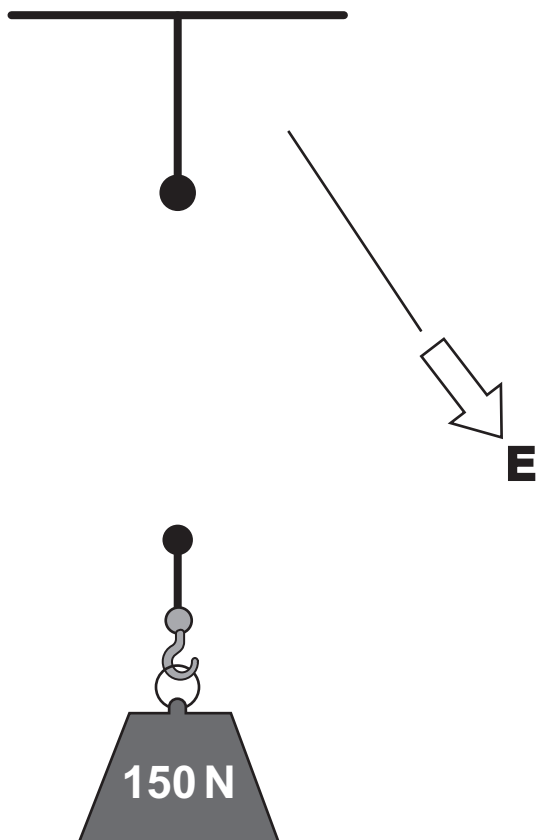
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[2]

Examiner Only	
Marks	Remark

- (b) (i) Pulley block systems are often used in lifting equipment. Complete **Fig. 10** below to show a pulley block system with a mechanical advantage of 3.



Source: CCEA

Fig. 10

[3]

- (ii) Calculate the force required at **E** to lift the 150 N load shown in **Fig. 10**.

Candidates need to show their working out in the space below.

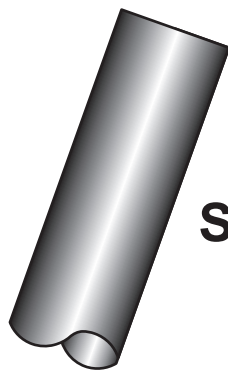
Answer = \_\_\_\_\_ N [1]

Examiner Only	
Marks	Remark

- (c) (i) **Fig. 11** shows a diagram of two rotating shafts which are out of alignment. Complete **Fig. 11** by adding an annotated sketch of a universal joint connecting shafts **A** and **B**.



**Shaft A**



**Shaft B**

Source: CCEA

**Fig. 11**

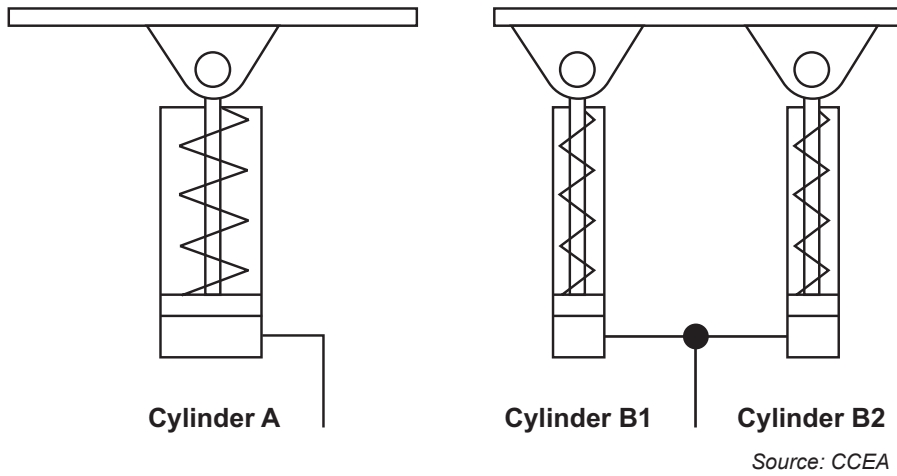
[3]

- (ii) State **one** specific application for a universal joint.

[1]

Examiner Only	
Marks	Remark

- (d) A lifting device uses pneumatic cylinder **A** shown below in **Fig. 12**. This cylinder is supplied with an air pressure of  $0.5 \text{ N/mm}^2$  and has a cylinder diameter of  $160 \text{ mm}$ . In order to increase stability of the lifting device, it is intended to replace cylinder **A** with two identical cylinders (cylinders **B1** and **B2**). These two cylinders produce the same overall outstroke force as cylinder **A** when operated at the same air pressure.



**Fig. 12**

Calculate the cylinder outstroke force and the diameter of cylinder **B1**.

Assume  $\pi = 3.14$  and ignore friction.

**Candidates need to show their working out in the space below.**

Outstroke force \_\_\_\_\_ N [2]

Diameter of cylinder **B1** \_\_\_\_\_ mm [1]

Examiner Only	
Marks	Remark

(e) With reference to **three** specific points, discuss the limitations associated with the use of each of the following:

- Mechanical components and systems.
- Pneumatic components and systems.
- Hydraulic components and systems.

**Quality of written communication will be assessed in this question.**

Mechanical components and systems

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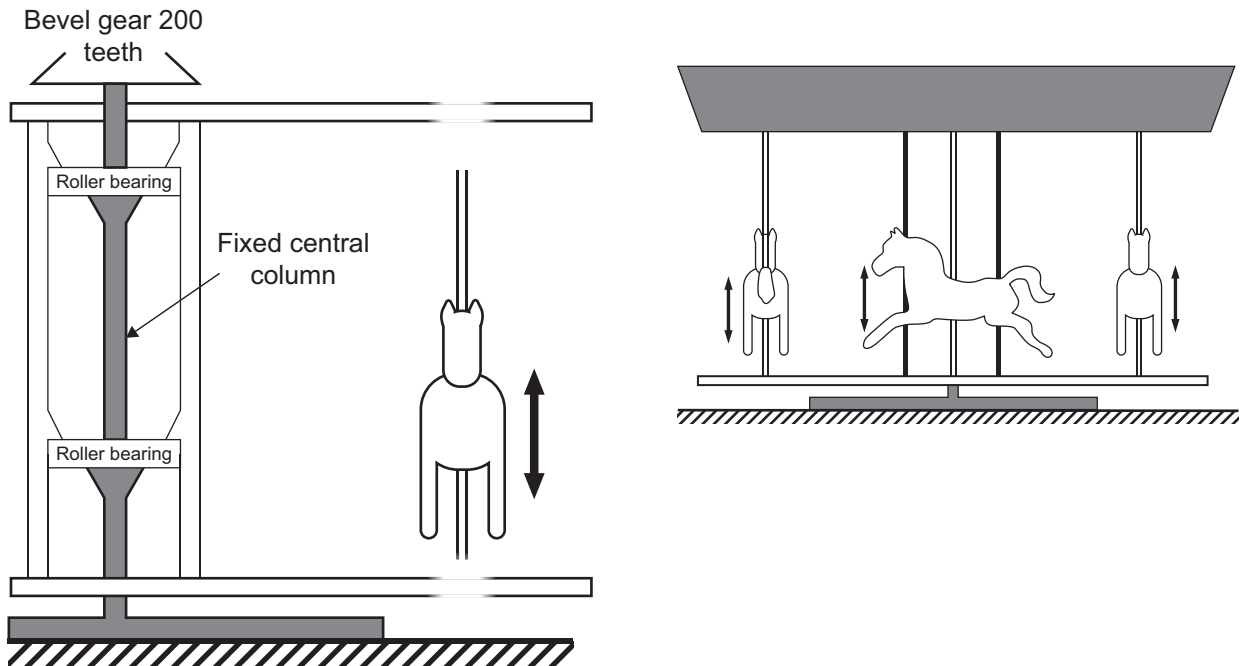
Examiner Only	
Marks	Remark





(g) A company manufacturing equipment and rides for amusement parks is in the process of designing a horse carousel as shown in Fig. 13.

The horse carousel rotates about a fixed central column. Each horse should rise and fall a distance of 300 mm, eight times during each rotation of the carousel.



Source: CCEA

Fig. 13

Using the A3 pro forma provided (**answer number 3(g)**), design, draw and annotate a solution that will use the bevel gear to enable horses on the carousel to rise and fall by a distance of 300 mm, eight times per revolution of the carousel. Indicate in your solution all appropriate mechanisms, bearings and guides for your design.

Show your working out on the A3 pro forma.

[10]

Examiner Only	
Marks	Remark

- 4 A dodgem ride for children has been designed with a drive system shown in Fig. 14. The drive is powered by an electric motor coupled to Gear A with an input speed of 4000 revs per minute (rpm).

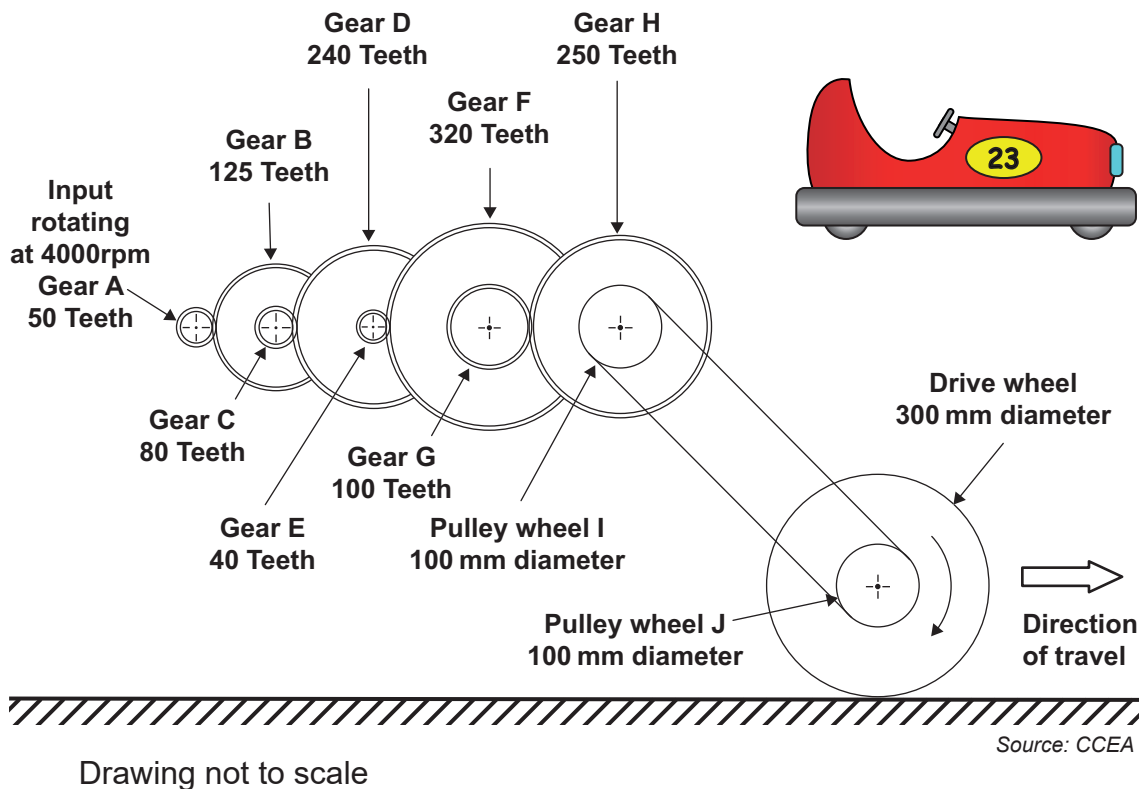


Fig. 14

- (a) (i) Calculate the velocity ratio of the drive system from gear A to pulley J shown in Fig. 14.

Candidates need to show their working out in the space below.

Answer = \_\_\_\_\_ [2]

Examiner Only	
Marks	Remark

- (ii) If the velocity ratio of the dodgem in **Fig. 14** is changed to 94, calculate the linear speed produced by the drive wheel using an input speed of 4000 rpm.

Give your answer in metres per minute.

**Candidates need to show their working out in the space below.**

Answer = \_\_\_\_\_ m/min [2]

Examiner Only	
Marks	Remark

- (b) A safety system in a prototype roller coaster ride uses a range of pneumatic and mechanical systems during the loading and unloading of the users.

Complete the following sequence on the A3 pro forma (**answer number 4(b)**) using the minimum number of groups. Some of the piping has been completed on the pro forma to assist you. The sequence begins:

- By closing the 3/2 valves on the entrance and exit gates **A** and **B** and when the rollercoaster car position activates the 3/2 valve **C**, this will activate the circuit sending cylinder **A** positive.
- When cylinder **A** is positive it will send cylinder **B** positive.
- When cylinder **B** goes positive it will send cylinder **C** negative.
- When cylinder **C** goes negative, it is detected by a 3/2 valve which sends cylinder **D** negative after a short time delay.
- When valve **D** is pressed by the operator, cylinder **D** goes positive and is detected by a 3/2 valve which sends cylinder **C** positive.
- When cylinder **C** goes positive it sends cylinder **B** negative.
- When cylinder **B** goes negative, it is detected by a 3/2 valve which sends cylinder **A** negative.
- The speed of cylinder **C** must be adjustable in both directions. [9]

- (c) A children's ride uses a cam to create motion. On the pro forma (**answer number 4(c)**) and using an appropriate drawing technique, construct a cam profile which would accurately follow the performance / displacement diagram shown on the pro forma. The minimum cam diameter is shown. The follower is a knife follower, and the cam rotates in a clockwise direction. The follower is in line with the centre line of the cam. [9]

Examiner Only	
Marks	Remark

(d) The fairground equipment manufacturer is developing a drop tower ride which raises the passengers vertically and drops them under the force of gravity.

(i) Garter seals are used in the construction of some parts of the drop tower ride. Describe the purpose of the spring in a garter seal.

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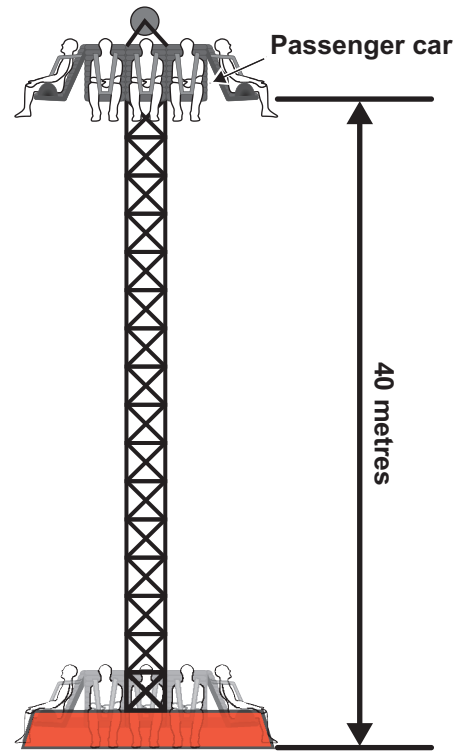
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[2]

Examiner Only	
Marks	Remark

- (ii) The design for the drop tower ride shown in **Fig. 15** specifies that it should raise the passenger car which has a weight of 15000 N to a height of 40 metres in 30 seconds.

The ride uses a drum hoist which has an efficiency of 75%.



Source: CCEA

**Fig. 15**

Calculate the power input in kW required to raise the passenger car.

**Candidates need to show their working out in the space below.**

Examiner Only	
Marks	Remark

Answer = \_\_\_\_\_ kW [3]



## Section C

### Product Design

Answer **both** questions in this section.

- 5 A local design and manufacturing company responsible for producing laptop accessories similar to those shown in **Fig. 16** is considering expanding its product range.



Source: CCEA

**Fig. 16**

- (a) When considering the market for new products, the design and manufacturing company needs to be aware of the difference between needs and demands.

Distinguish between needs and demands.

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 [2]

- (b) The product life cycle of any new accessory will need to be fully investigated.

- (i) Briefly outline **two** characteristics associated with the growth stage of the product life cycle.

1. \_\_\_\_\_

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 [1]

2. \_\_\_\_\_

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 [1]

- (ii) Briefly outline **two** characteristics associated with the maturity stage of the product life cycle.

1. \_\_\_\_\_

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 [1]

2. \_\_\_\_\_

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 [1]

Examiner Only

Marks Remark



(ii) With reference to **one** specific example, explain how the European Union has influenced environmental issues through product design.

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 [2]

(e) Some of the new accessories are to be made from biodegradable plastics.

Briefly outline **two** advantages and **one** disadvantage in the use of biodegradable plastics.

Advantage 1

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 [1]

Advantage 2

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 [1]

Disadvantage

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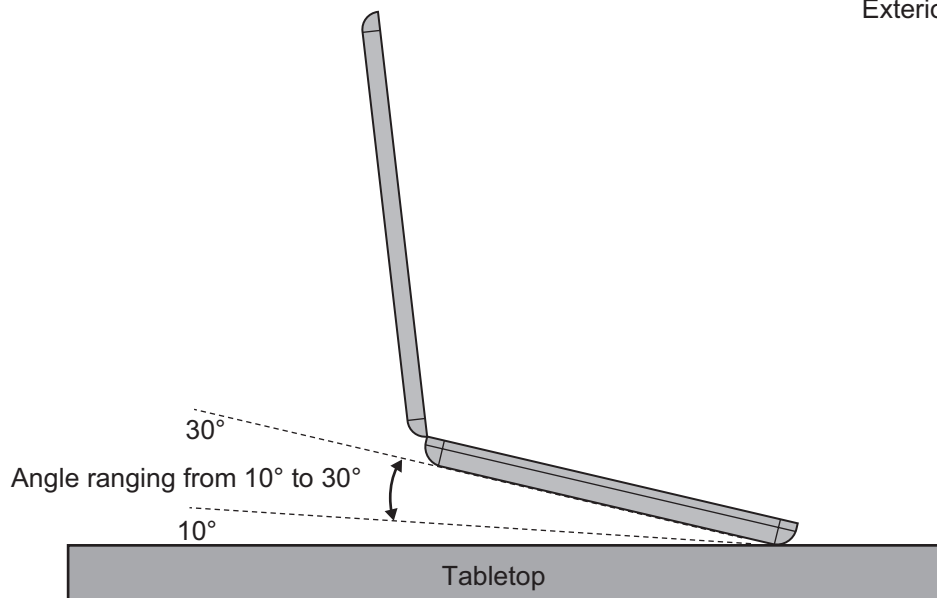
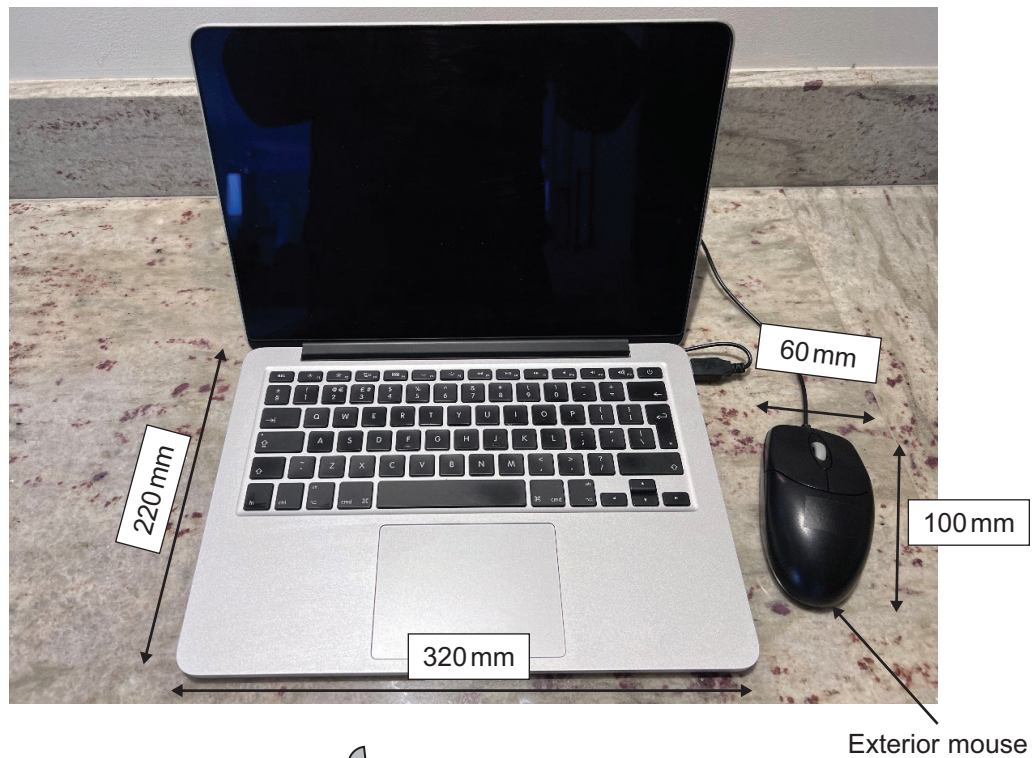
 [1]

Examiner Only	
Marks	Remark





- (i) **Fig. 17** below shows images of a laptop. Feedback from market research has highlighted the need for a lightweight, easily assembled, compact stand that will allow airflow around the base when in use. It was also highlighted that it must be able to accommodate an exterior mouse to be used with the device for easier control.



Source: CCEA

**Fig. 17**

With reference to **Fig. 17** and on the blank A3 pro forma (**answer number 5(i)**), use detailed annotated sketches to produce **one** possible solution for the following:

Design a lightweight, compact, easily assembled stand which will allow the user to quickly adjust the laptop to angles between  $10^\circ$  and  $30^\circ$  as shown in **Fig. 17**. In addition, it should provide a retractable surface for use with an exterior mouse for either a left or right-handed user. Give suitable dimensions for the design and state a suitable material and an appropriate manufacturing process for small scale production. [10]

Examiner Only	
Marks	Remark

- 6 The barbeque (BBQ) shown below in **Fig. 18** may be considered to have been designed to be inclusive for all society.



Source: CCEA

**Fig. 18**

- (a) (i) Outline what is meant by the statement “designed to be inclusive for all society”.

\_\_\_\_\_ [1]

- (ii) Outline **two** different ways a new product arises.

1. \_\_\_\_\_ [1]

2. \_\_\_\_\_ [1]

Examiner Only	
Marks	Remark







(e) The Memphis movement has had a considerable influence on product design. Outline **two** characteristics which describe the influence of Memphis in terms of product design.

1. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

2. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

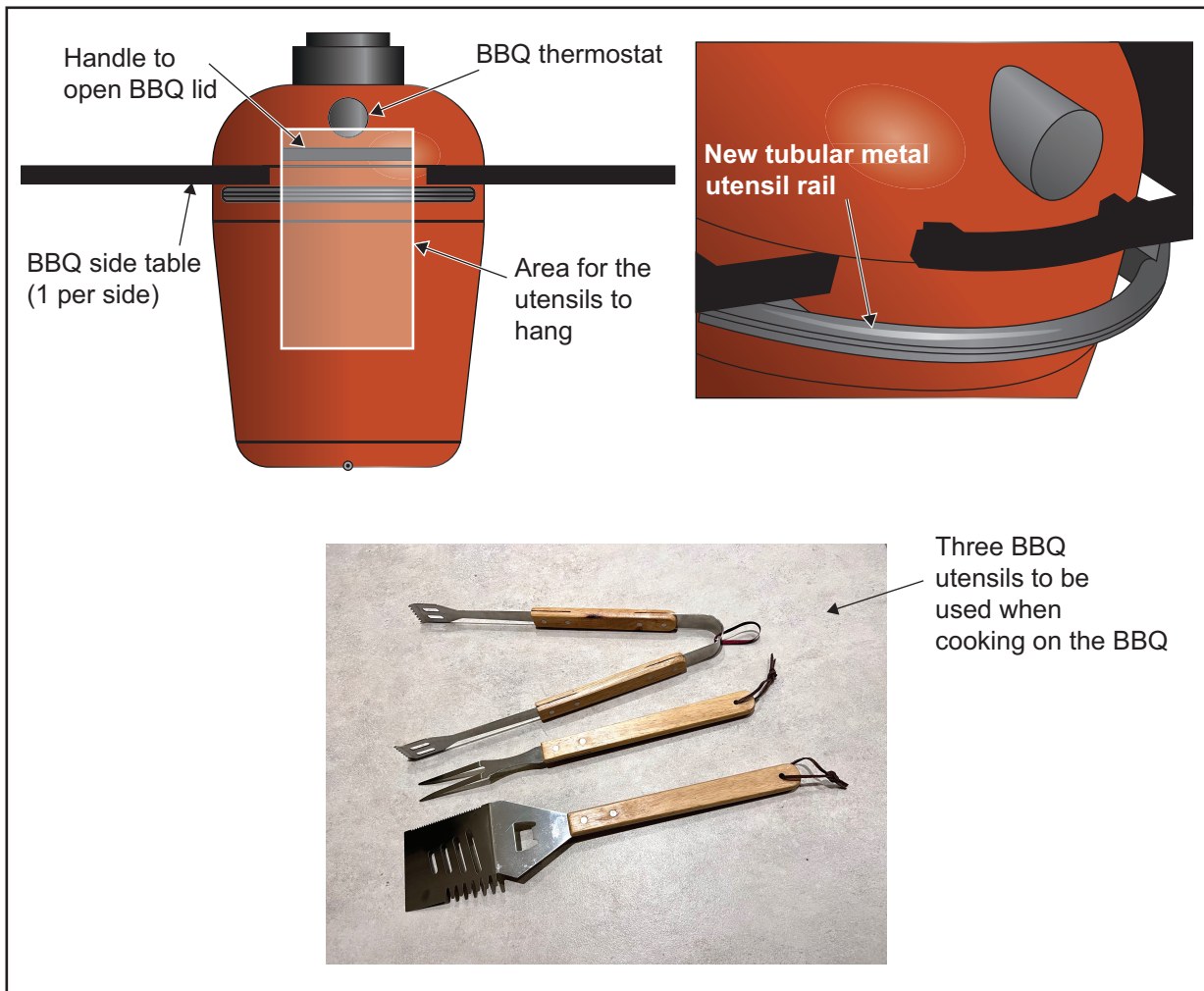
(f) The company responsible for the design and manufacture of the BBQ range are aware of the demand for new products. New products can either be classified as technology push or market pull.

(i) With reference to an example of your choice, explain what is meant by technology push.  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

Examiner Only	
Marks	Remark



(h) The BBQ has been improved to include a new tubular metal utensils rail. During testing it was found that the utensils could not be held securely on this rail.



Source: CCEA

Fig. 19

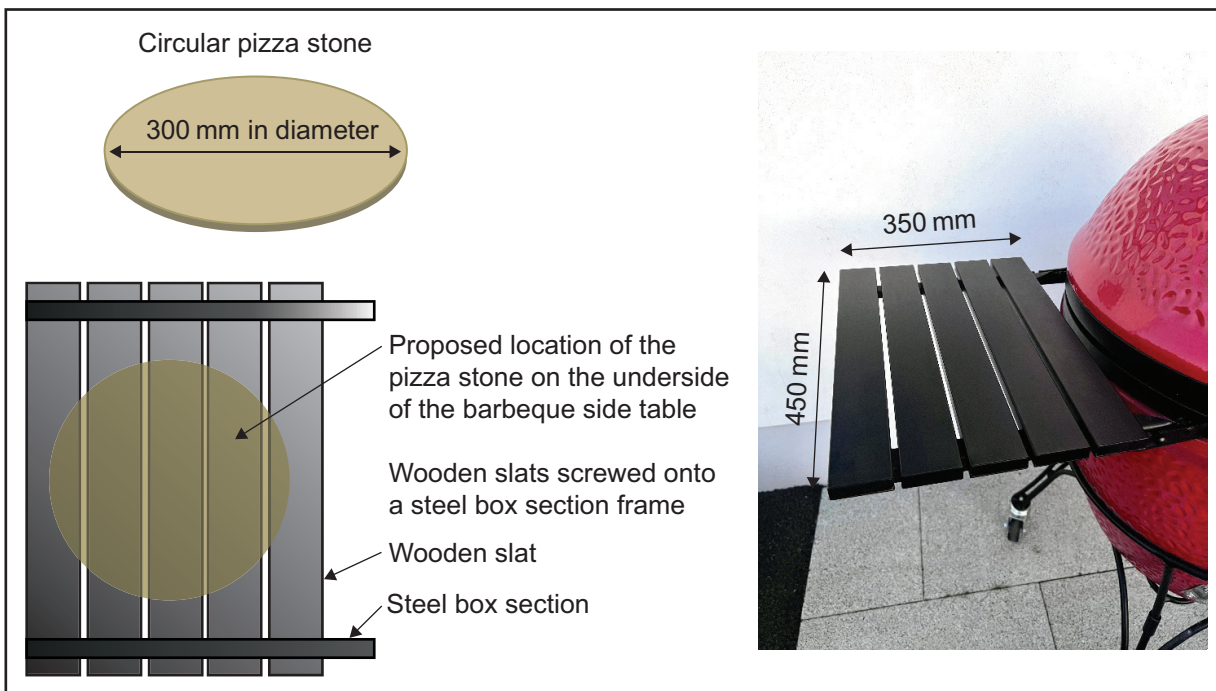
With reference to **Fig. 19** and on the blank A3 pro forma (**answer number 6(h)(i)**), use detailed annotated sketches to produce one possible solution for the following:

- (i) An appropriate bracket that could be securely fixed to the new tubular metal utensil rail on the front of the BBQ, that will hold the three utensils shown. The design must allow the utensils to hang vertically to prevent food contamination. The bracket must be easily attached and removed from the utensil rail. [5]

The company want to supply a pizza stone which is to be stored on the underside of the side table as seen below in **Fig. 20**. The side table is in the horizontal position when in use and can be folded down to sit vertically for storage.

With reference to **Fig. 20** and on the blank A3 pro forma (**answer number 6(h)(ii)**) use detailed annotated sketches to produce one possible solution for the following:

- (ii) An appropriate method of storing the pizza stone to the underside of the side table. The pizza stone must be securely held, easily attached and removed as required. [5]



Source: CCEA

**Fig. 20**

Examiner Only	
Marks	Remark

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**THIS IS THE END OF THE QUESTION PAPER**

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Pro forma answer page  
(answer number 1(e))

Advanced (A2) Technology and Design  
Assessment Unit A2 1 Summer 2025

Centre Number

71

Candidate Number



**Pro forma answer page  
(answer number 2(f))**

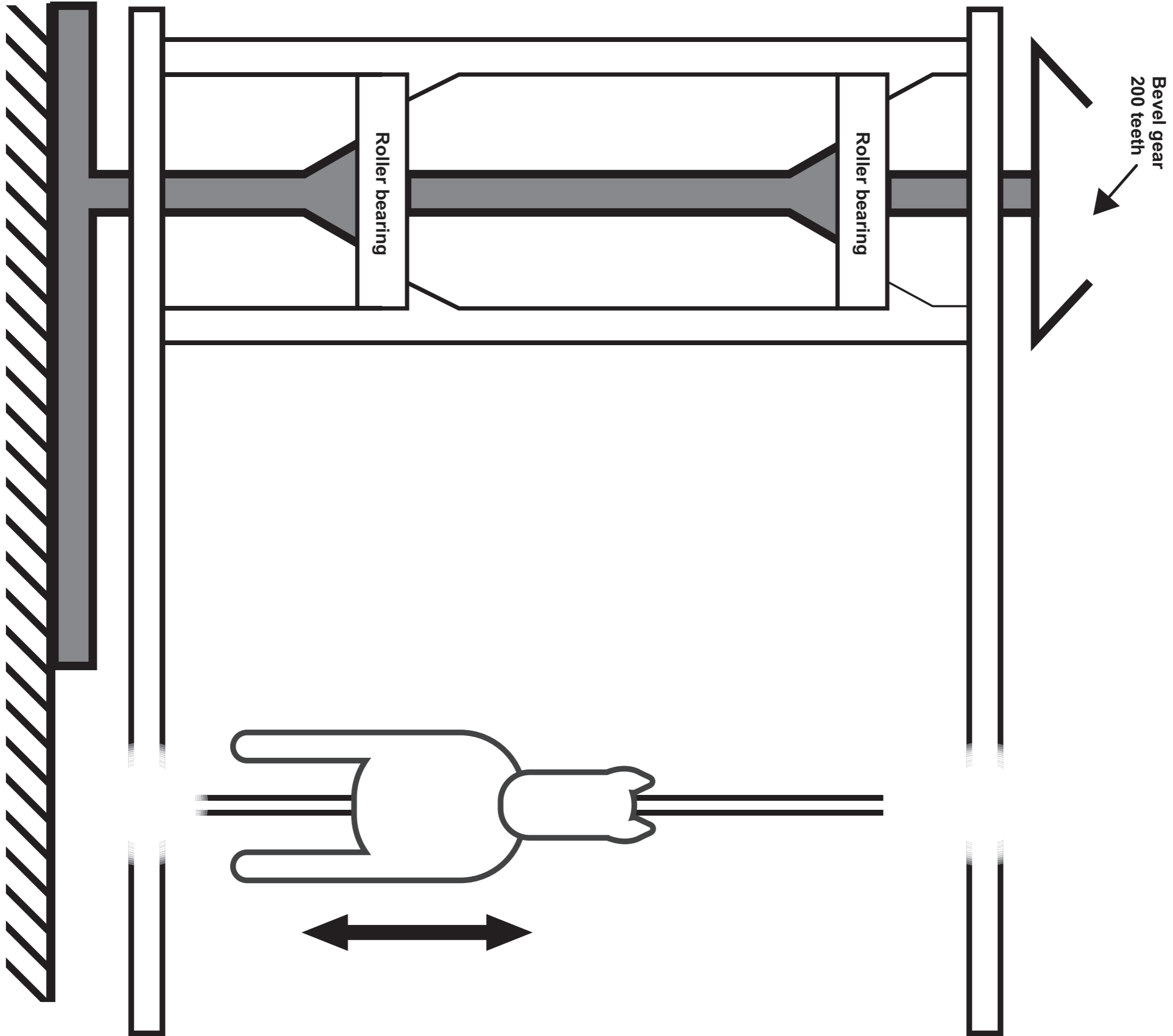
**Advanced (A2) Technology and Design  
Assessment Unit A2 1 Summer 2025**

**Centre Number**

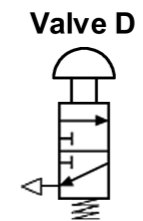
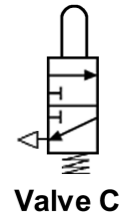
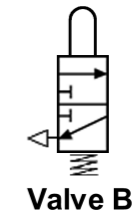
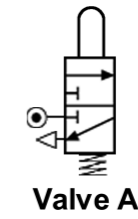
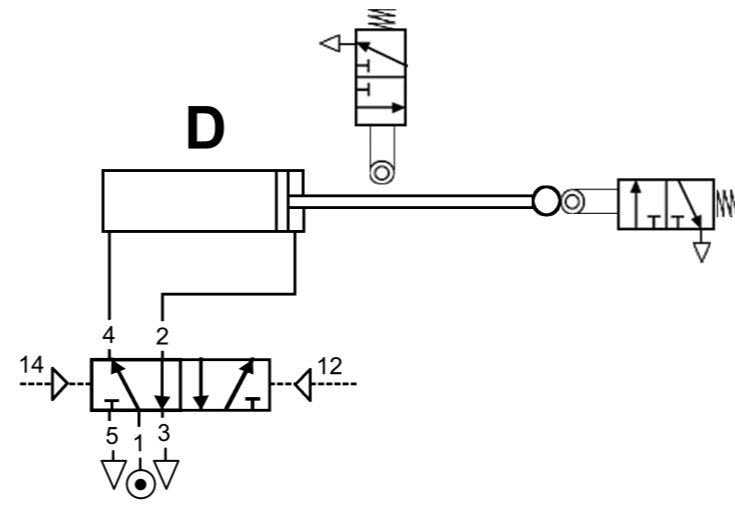
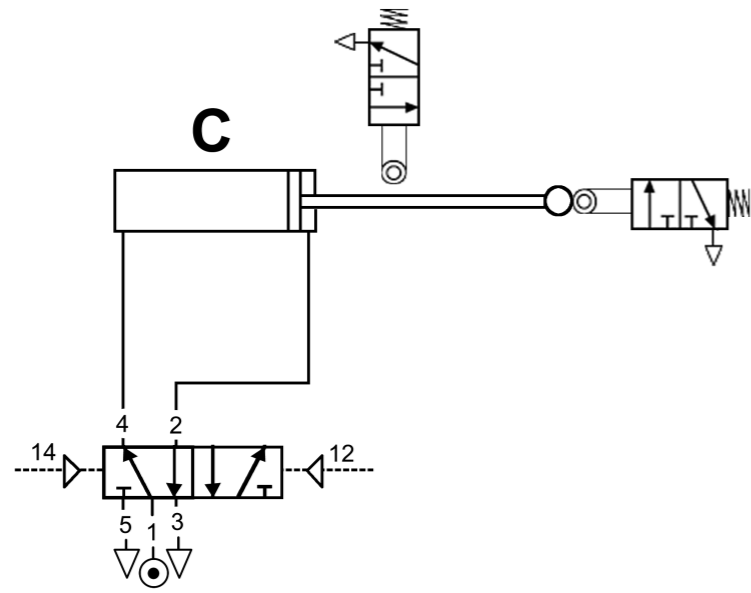
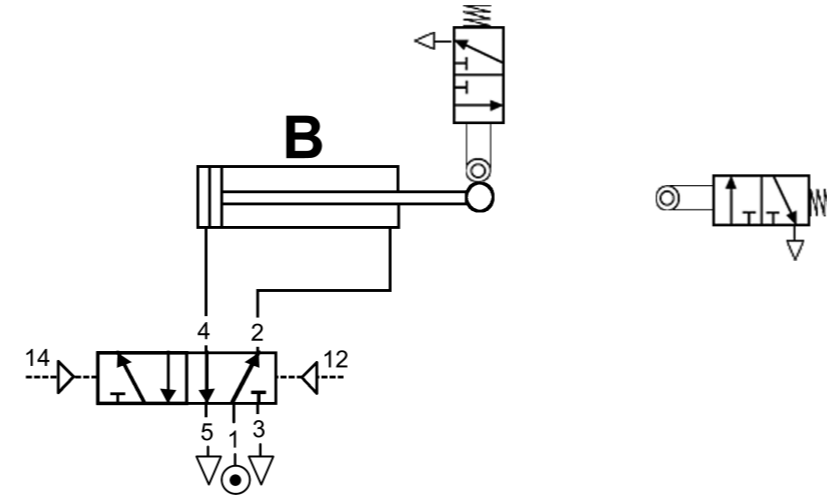
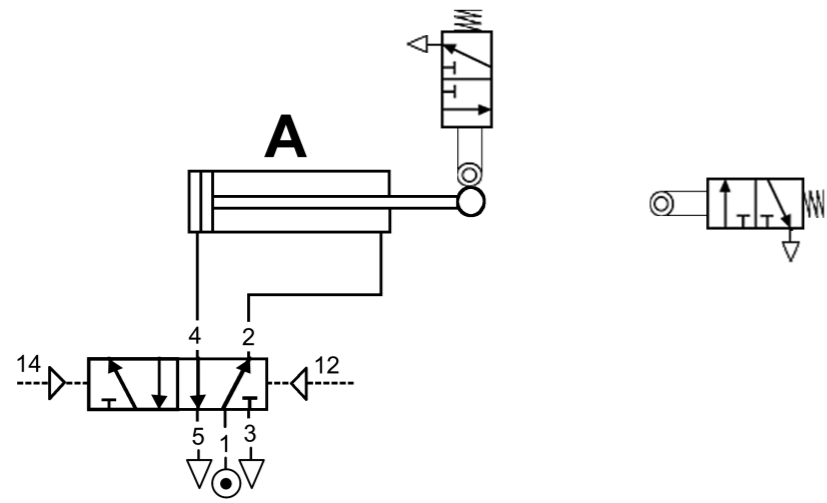
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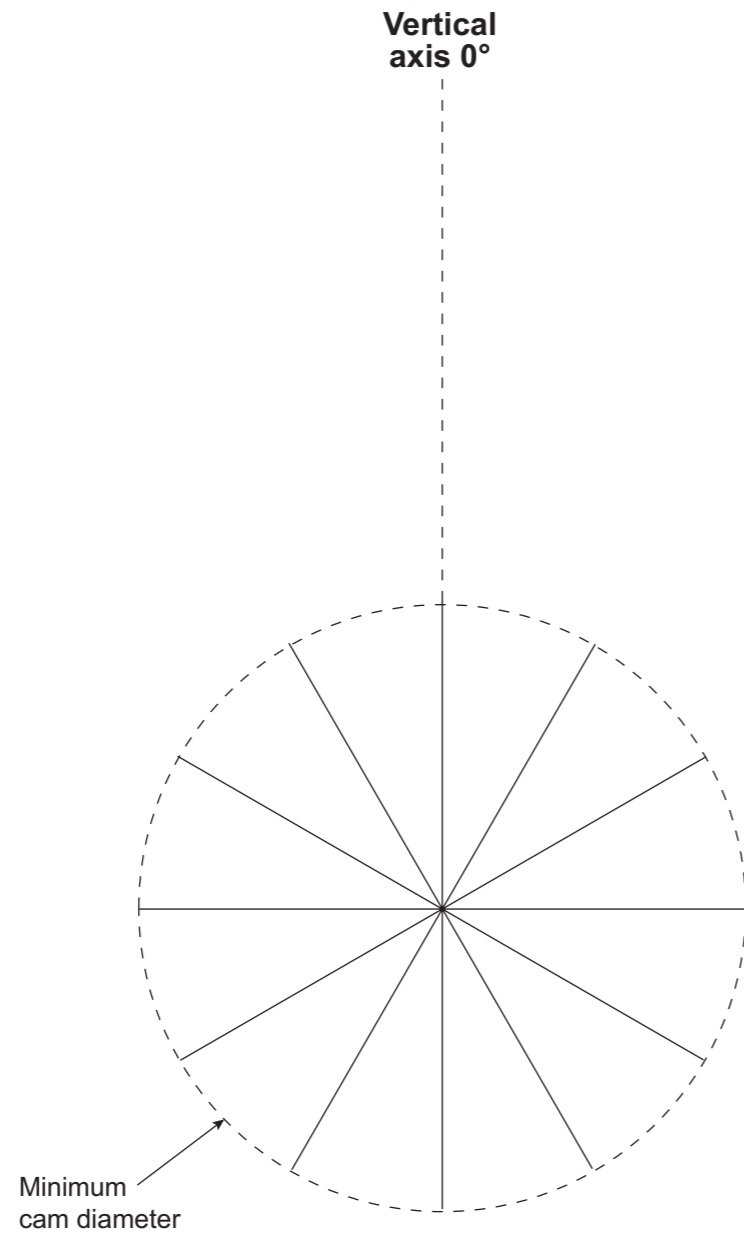




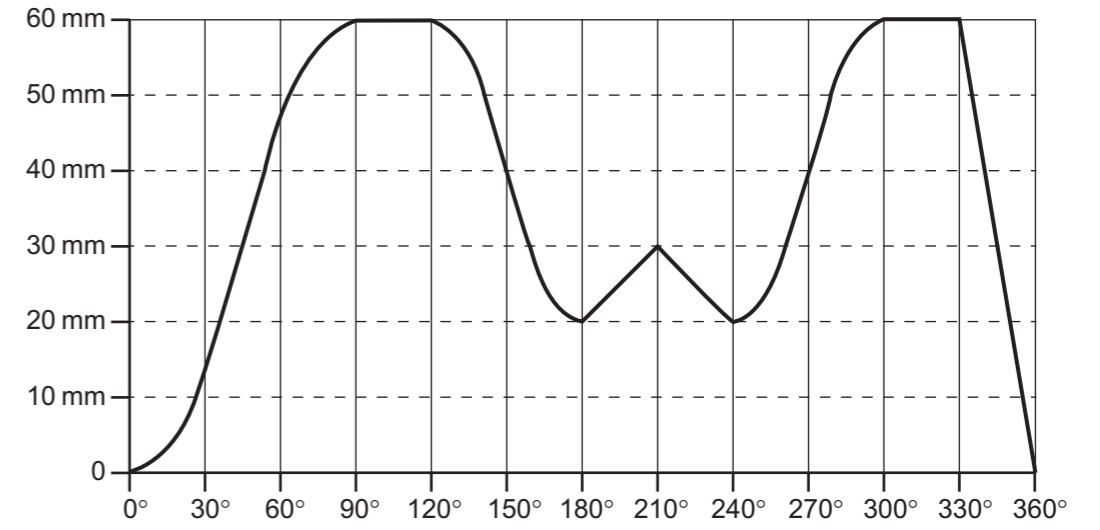




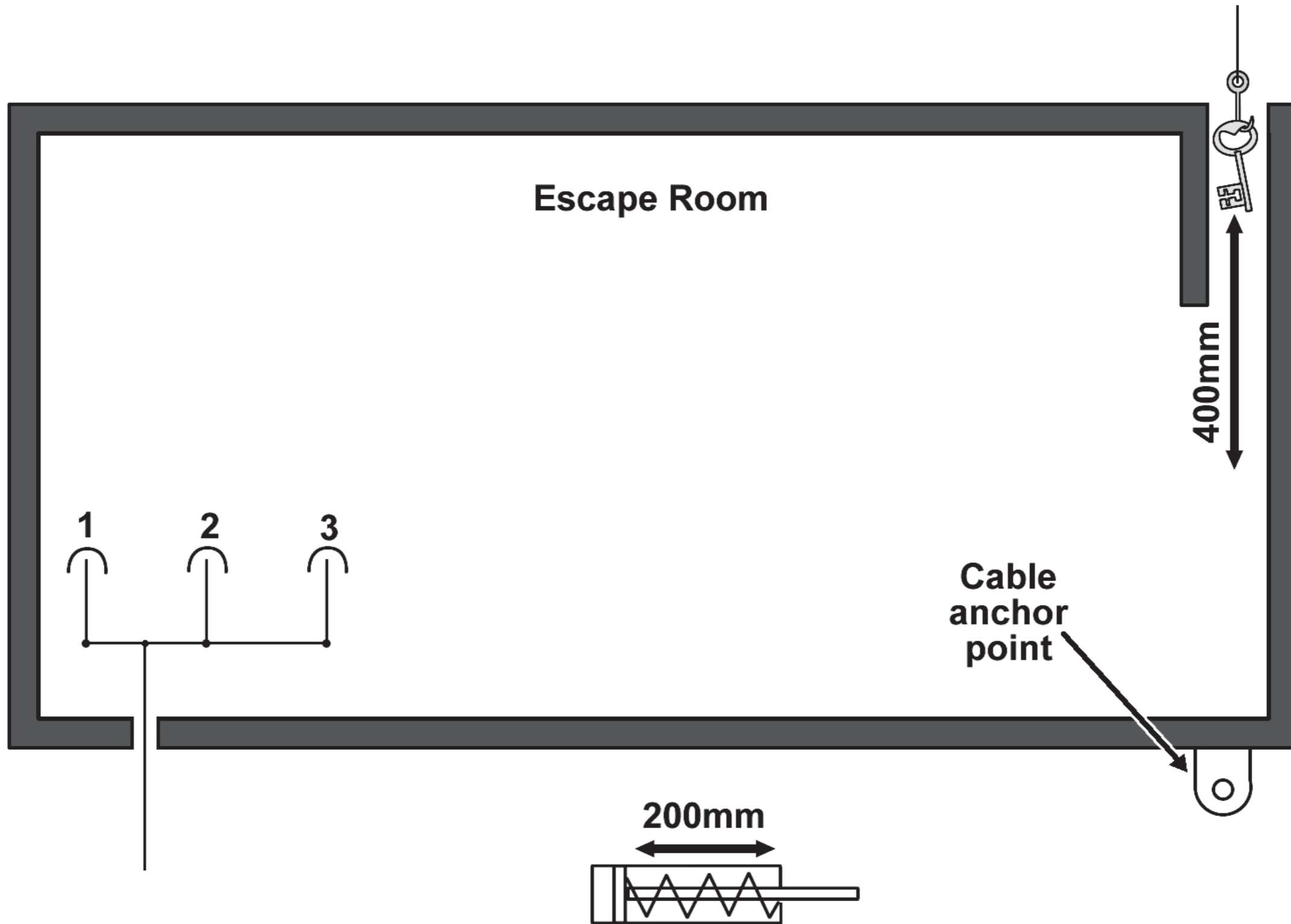




Performance / displacement diagram









**Pro forma answer page  
(answer number 5(i))**

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**Pro forma answer page  
(answer number 6(h)(i)&(ii))**

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Assessment Unit A2 1 Summer 2025**

**Centre Number**

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**Candidate Number**

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