



Rewarding Learning

ADVANCED
General Certificate of Education
2019

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]

FRIDAY 7 JUNE, AFTERNOON



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 **3(d)(i)**, **3(d)(ii)**, **4(c)**, **4(d)(i)** and **4(d)(ii)**, **5(h)** and **6(i)(i)** and **6(i)(ii)** should be made on the A3 pro forma answer pages provided.

At the conclusion 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 Question **1(e)**, **3(c)** and **5(e)**.

Figures in brackets printed down the right hand side of the 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	
Total Marks	

- (iii) Calculate the range for V_o in **Fig. 1** if the component R_v is set to its mid position and the resistance of the LDR ranges from $70\text{ k}\Omega$ to $1\text{ M}\Omega$.

Answer _____ [3]

- (b) The voltage divider circuit shown in **Fig. 1** is to be used to make one of three input sensors for an environmental control system. The input sensor must produce an output V_o (logic 'high' and logic 'low') when the light levels vary. It has been proposed that a Schmitt trigger could be utilised as indicated in **Fig. 2**.

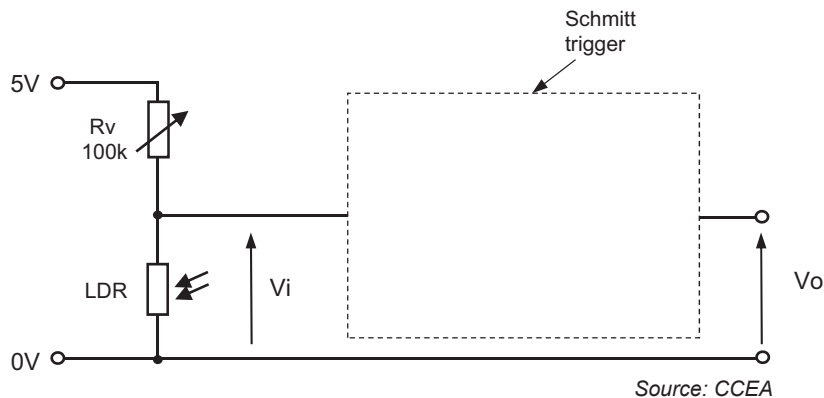


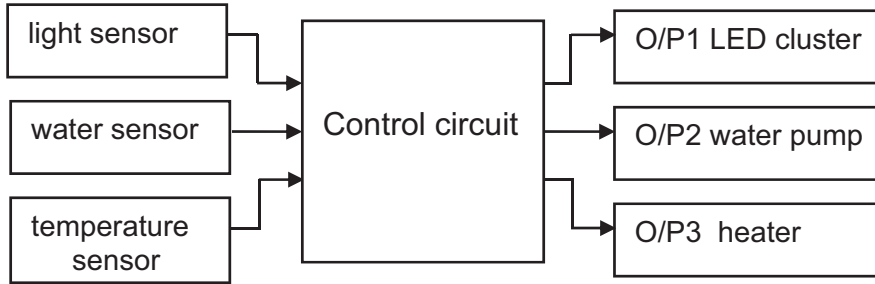
Fig. 2

- (i) Complete the circuit in **Fig. 2** by inserting a Schmitt trigger symbol showing the connections to the voltage divider and output voltage V_o . [1]
- (ii) With reference to V_i and V_o in **Fig. 2** explain the purpose of a Schmitt trigger.

 _____ [2]

Examiner Only	
Marks	Re-mark

- (c) An incomplete systems diagram for an environmental control system for a commercial greenhouse is shown in **Fig. 3**. It consists of three digital input sensors, a control circuit and three outputs to maintain the optimum environment in the greenhouse.



Source: CCEA

Fig. 3

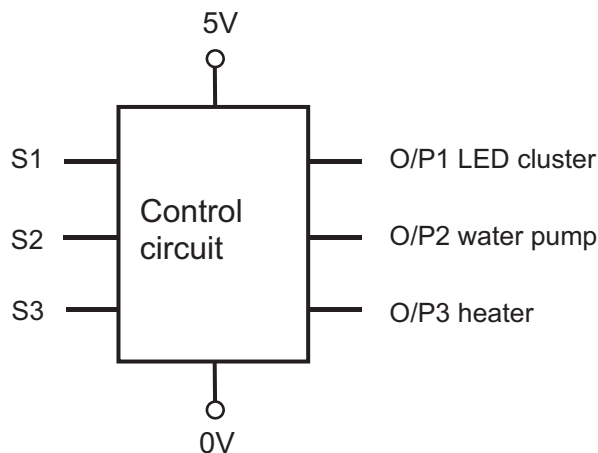
- (i) The water and temperature sensors in **Fig. 3** are both positioned inside the greenhouse and form part of the closed loop control for the pump and heater respectively. Complete the systems diagram in **Fig. 3** by adding lines and arrows so that it accurately represents closed loop control of the pump and heater. [2]
- (ii) The light sensor in **Fig. 3** is positioned outside the greenhouse and is considered to be part of the open loop control for the LED cluster. Explain what is meant by the term open loop control in the context of electronic control.

[2]

Examiner Only	
Marks	Re-mark

Examiner Only	
Marks	Re-mark

- (d) The control circuit in **Fig. 3** is shown in more detail in **Fig. 4**. It consists of hard-wired logic circuits that switch the outputs on in response to digital inputs from the sensors, e.g. a logic '1' on O/P2 will switch on the water pump only under the following conditions: S2 only high, S2 **and** S3 only high, S1 **and** S2 only high.



Source: CCEA

Fig. 4

- (i) Complete the truth table below, which shows the different combinations of logic inputs S1, S2 and S3 from the sensors which produce a logic 'high' on O/P2.

S3	S2	S1	O/P2
			1
			1
			1

[3]

- (ii) Draw a Karnaugh map in the space below to determine a minimised logic expression for O/P2.

Minimised expression O/P2 _____ [2]

(iii) Draw a logic circuit that will produce the required output for O/P2.

Examiner Only	
Marks	Re-mark

[3]

- (f) A temperature sensor and two heaters are shown in **Fig. 5**. The output voltage of the sensor varies from 0 to 5 volts as the temperature ranges from 0°C to 40°C. The sensor provides an output voltage which is directly proportional to the temperature. The 48 volt heaters are to be used to heat a greenhouse as required.

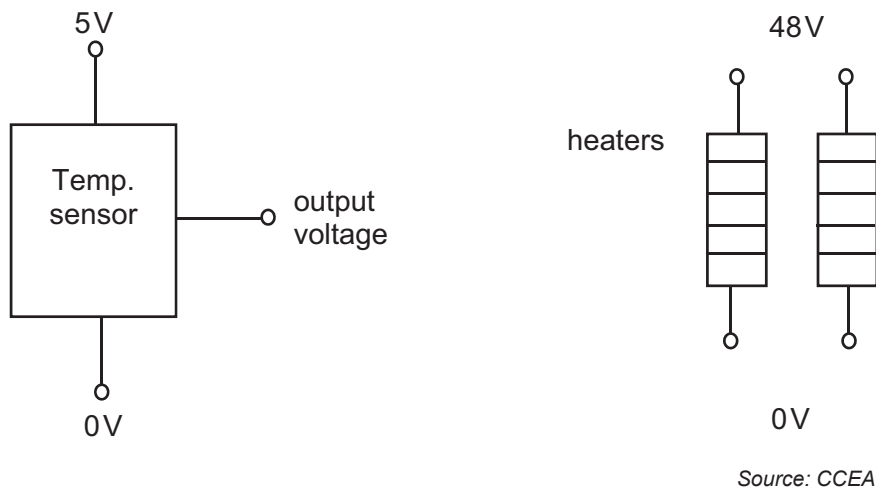


Fig. 5

A PIC based circuit with an analogue input is to be used to check the sensor and in turn control the heater elements. The voltage range of the analogue input is 0 to 5 volts and the corresponding digital range is 0 to 255.

Using annotated electronic circuit diagrams on the blank pages following, design a PIC based circuit and associated flow chart program that will fulfil the following:

- Check the temperature every 30 seconds.
- If the temperature is equal to or below 16°C, switch both heating elements on until the temperature is above 16°C at which point one heating element should be kept on.
- If the temperature is equal to or above 24°C both elements should switch off until one or both are required again.
- A single status LED will indicate the operation of the system by flashing at a rate of 2 hertz when any element is operational.

The flow chart should include the calculated digital equivalents for corresponding temperatures in any decision boxes that are used.

[10]

Examiner Only	
Marks	Re-mark

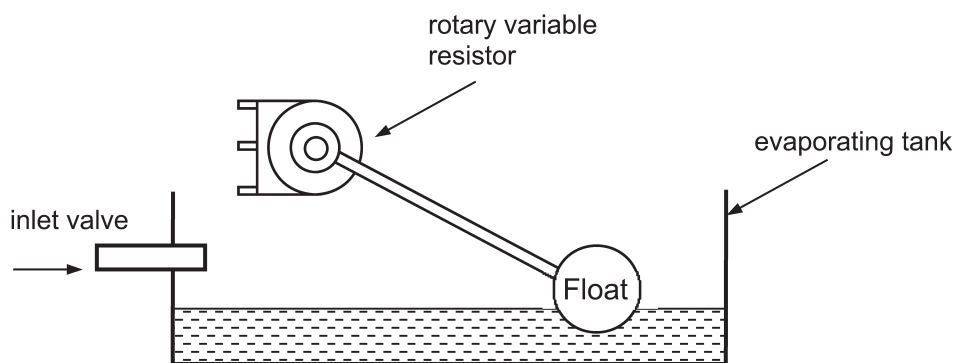
Answer page question 1(f)

Examiner Only	
Marks	Re-mark

Answer page question 1(f) (continued)

Examiner Only	
Marks	Re-mark

- 2 (a) An industrial process utilises a float attached to a rotary variable resistor to measure the level of liquid in an evaporating tank as shown in Fig. 6.



Source: CCEA

Fig. 6

Draw a labelled circuit diagram showing how a variable resistor can be connected to a 5 volt power supply in order to obtain a voltage that varies as the float in Fig. 6 rises and falls.

Examiner Only	
Marks	Re-mark

[2]

- (b) A diagram representing a circuit used to display the quantity of liquid in the evaporating tank is shown in **Fig. 7**. The LCD meter will display a number between 0 and 5000 to represent the quantity in litres ranging from empty to full.

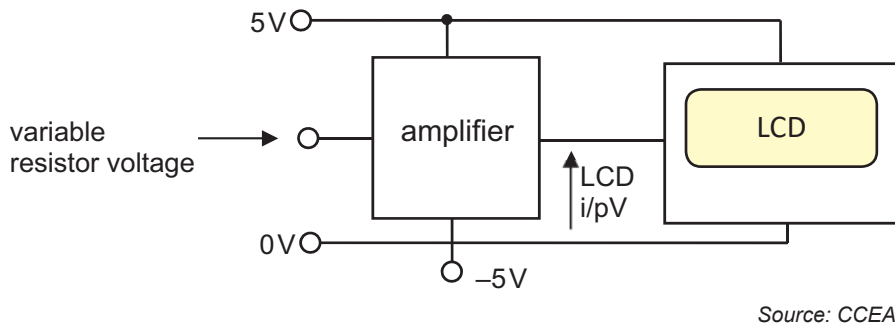


Fig. 7

- (i) State **one** main advantage of using an LCD type compared to an LED type display.

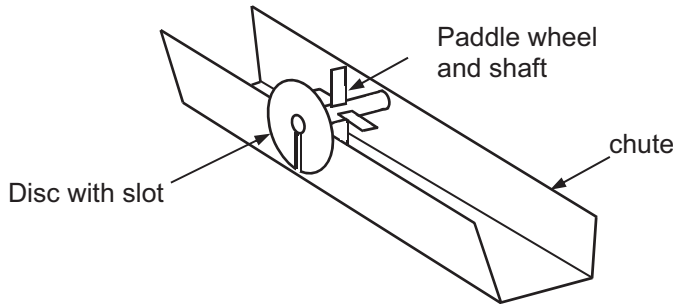
_____ [1]

- (ii) The variable resistor voltage in **Fig. 7** varies between 0 volts and 1.25 volts for an empty and full tank. The LCD input voltage range is 0–5 volts for the meter to display 0–5000. Draw and label a design for an amplifier, based on a dual supply op amp to match the variable resistor voltage and the LCD input voltage. State the calculated gain and any suitable resistor values to achieve this gain.

[5]

Examiner Only	
Marks	Re-mark

- (c) An industrial process requires a system to measure the rate of liquid flowing down a chute as shown in **Fig. 8**. The proposed system makes use of a slot cut into a disc which is attached to a shaft and paddle wheel that is turned by the flowing liquid.



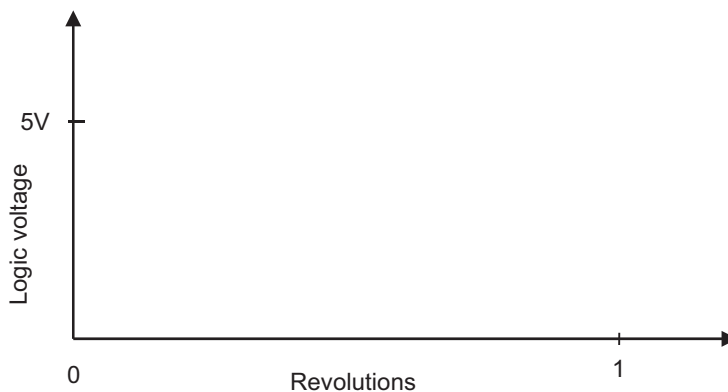
Source: CCEA

Fig. 8

- (i) The rotation of the disc is to be detected by a slotted optical switch. Show with the aid of a sketch how a slotted optical switch could be arranged to detect the slot in the disc shown in **Fig. 8**.

[2]

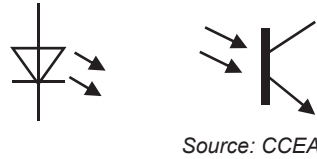
- (ii) A slotted optical switch based circuit is required to produce a 5 volt logic 'pulse' when the slot is detected and a 0 volt logic 'low' when the solid disc is detected. Sketch a graph on the axes below to show what the logic voltage for one revolution of the disc might look like.



[2]

Examiner Only	
Marks	Re-mark

- (iii) Using the circuit symbols below complete the circuit diagram so that a 5 volt logic 'high' is output when the slot is detected and a 0 volt logic 'low' when the solid disc is detected.



[3]

- (iv) State **one** advantage of using an optical method for detecting the revolving paddle wheel and shaft shown in **Fig. 8**.

_____ [1]

- (d) **Fig. 9** shows a Zener diode which is to be used to provide a regulated 5 volt supply for a slotted optical switch circuit.

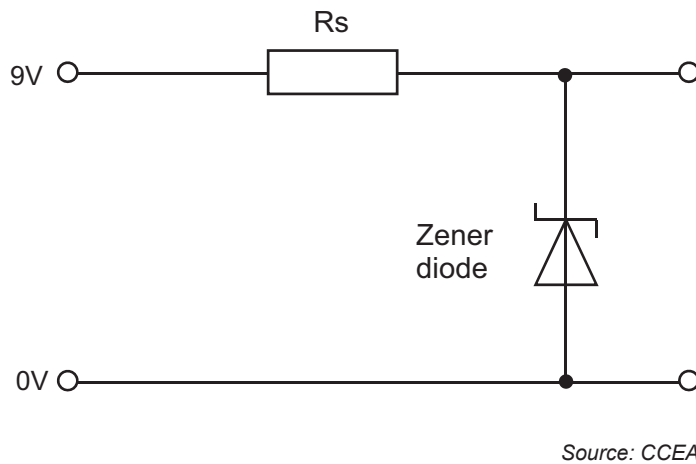


Fig. 9

- (i) Explain the principle of operation of a Zener diode as a voltage regulator.

 _____ [2]

Examiner Only	
Marks	Re-mark

- (ii) Calculate the value required for the series resistor for the Zener diode based power supply shown in **Fig. 9** if the maximum Zener diode current is 10mA.

Examiner Only	
Marks	Re-mark

Answer _____ ohms [2]

- (e) The logic voltage from the optical switch circuit described in (c)(ii) is to be used to display the flow rate from 0–9 on a 7 segment display using a 4 bit binary counter as shown in the systems diagram in **Fig. 10**.

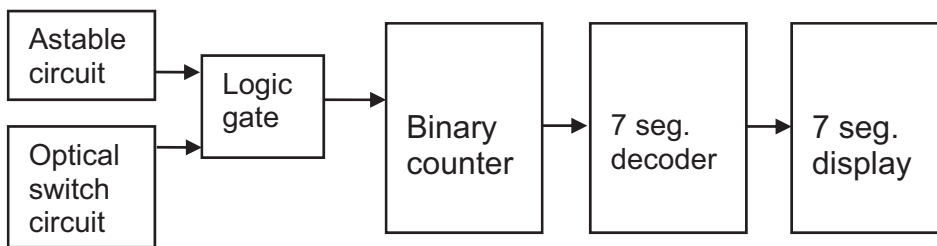
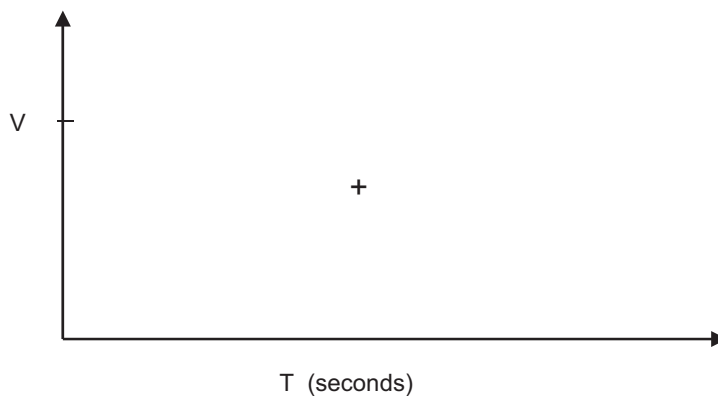


Fig. 10

- (i) The binary counter shown in **Fig. 10** has a negative edge triggered clock input. Using the axes below, draw a series of clock pulses and explain with the aid of annotation what is meant by the term 'negative edge triggered'.



[3]

- (ii) An incomplete circuit diagram is shown in **Fig. 11**. Complete the circuit diagram, adding any missing components and power supply connections, to enable the flow rate of the liquid in **Fig. 8** to be displayed on a single 7 segment display (common cathode). The flow rate should be continuously counted for 1 second and then displayed for 5 seconds before being reset. Assume that a series of logic pulses is generated from the rotating disc in **Fig. 8** and that an appropriate astable waveform as shown is available.

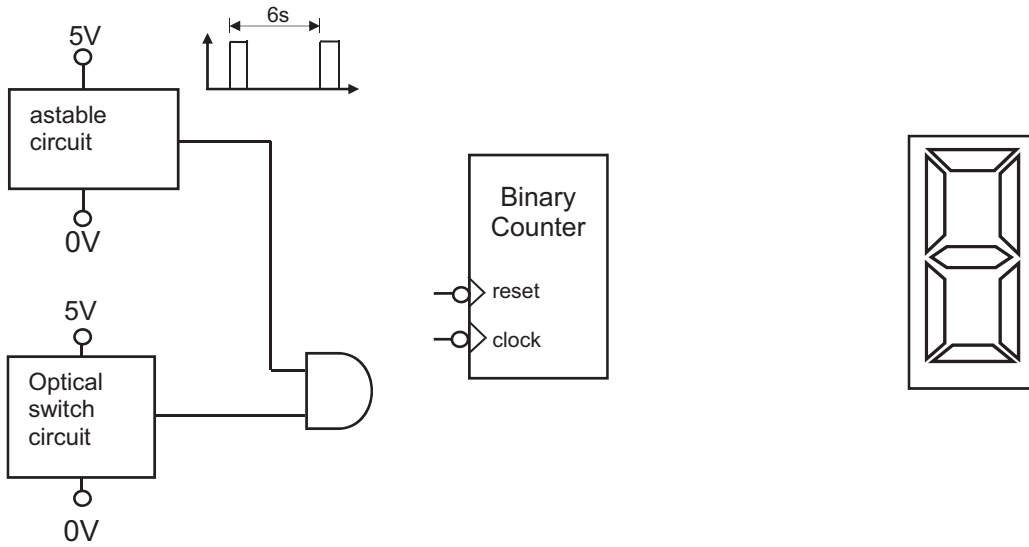


Fig. 11

[7]

Examiner Only	
Marks	Re-mark

- (f) A stepper motor with a mechanical arm that is used to agitate a fluid mixture in an industrial process is shown in **Fig. 12** along with the stepper motor driver. The arm is either stationary at 0° or oscillates backwards and forwards through $\pm 30^\circ$ or $\pm 60^\circ$ depending on which angle is selected by an operator. The stepper motor has a step angle of 1.5° .

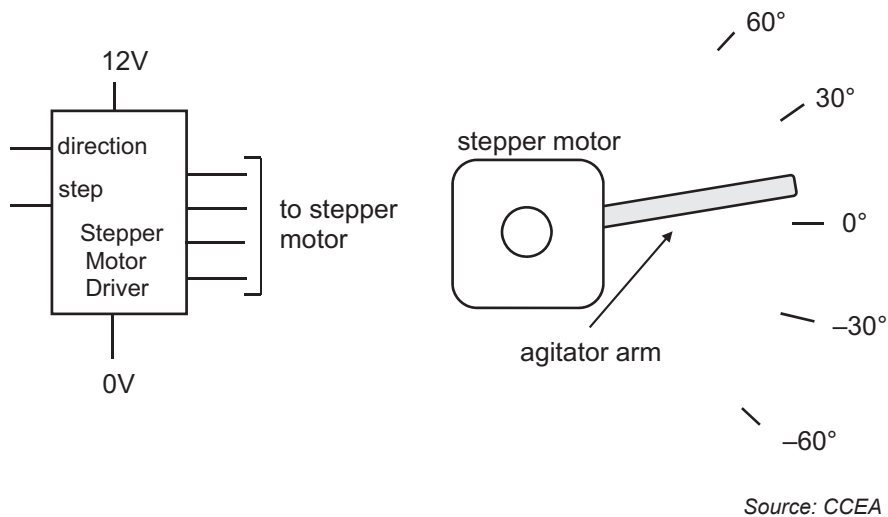


Fig. 12

On the blank pages following, design a suitable PIC based circuit and associated flow chart that will achieve the following:

- The operator can choose between no movement (0°) or either one of the two agitation angles.
- The stepper motor will move the agitator arm backwards and forwards at a speed of 10 steps per second.
- The arm will continue to operate at the selected speed and angle until another angle (or no movement) is selected.
- If no movement is selected the agitator arm must return to the 0° position. [10]

Examiner Only	
Marks	Re-mark

Answer page question 2(f)

Examiner Only	
Marks	Re-mark

Answer page question 2(f) (continued)

Examiner Only	
Marks	Re-mark

Section B

Mechanical and Pneumatic Control Systems

Answer **both** questions in this section

- 3 (a) (i) Outline **two** main safety risks associated with the use of mechanical systems and **two** main procedures used to minimise them.

Risk

_____ [1]

Procedure

_____ [1]

Risk

_____ [1]

Procedure

_____ [1]

Examiner Only

Marks Re-mark

(ii) A student has used a 3D printer to produce a cam with the following requirements:

- 0° – 90° Uniform Acceleration and Retardation with a rise of 60mm
- 90° – 120° Dwell
- 120° – 270° Simple Harmonic Motion with a fall of 40mm
- 270° – 360° Uniform Velocity with a fall of 20mm

Complete the blank performance/displacement diagram in **Fig. 13** to meet these requirements. [4]

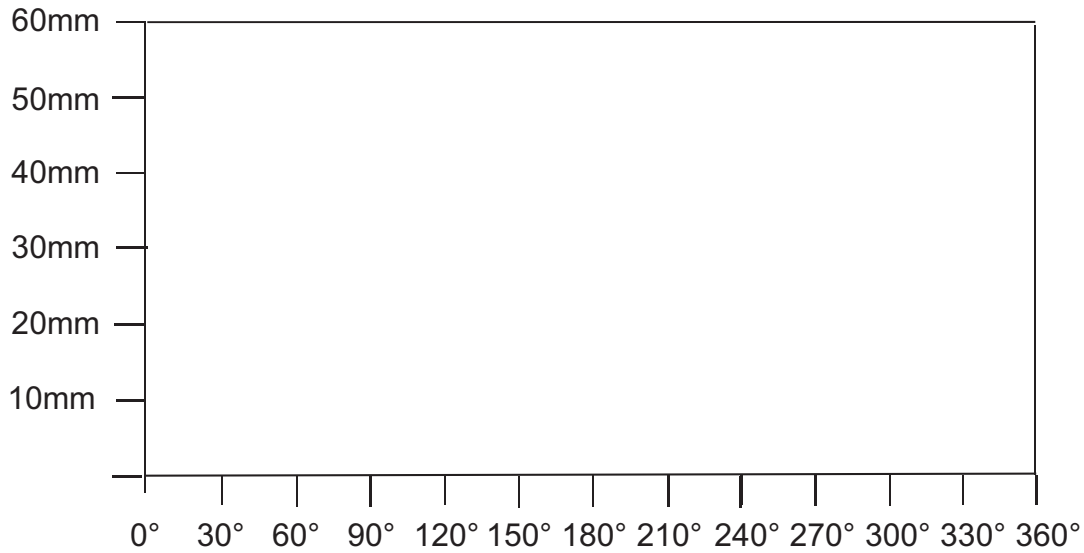


Fig. 13

Examiner Only	
Marks	Re-mark

- (b) (i) Constant velocity joints are used on the garden rotavator shown in Fig. 14. Using an annotated sketch, outline the main features of a constant velocity joint and explain why it would be selected in preference to a universal joint for a given application of your choice.



© Enfys / Getty Images

Fig. 14

[3]

Explanation

[2]

Examiner Only	
Marks	Re-mark

(ii) Gaskets are used in the engine housing for the rotavator shown in Fig. 14. Describe the main function of a gasket.

[2]

(iii) Fig. 15 shows a prototype mechanical system for the garden rotavator. Explain the difference between a simple and compound pulley system.

[2]

(iv) Calculate the velocity ratio from pulley A to gear K.

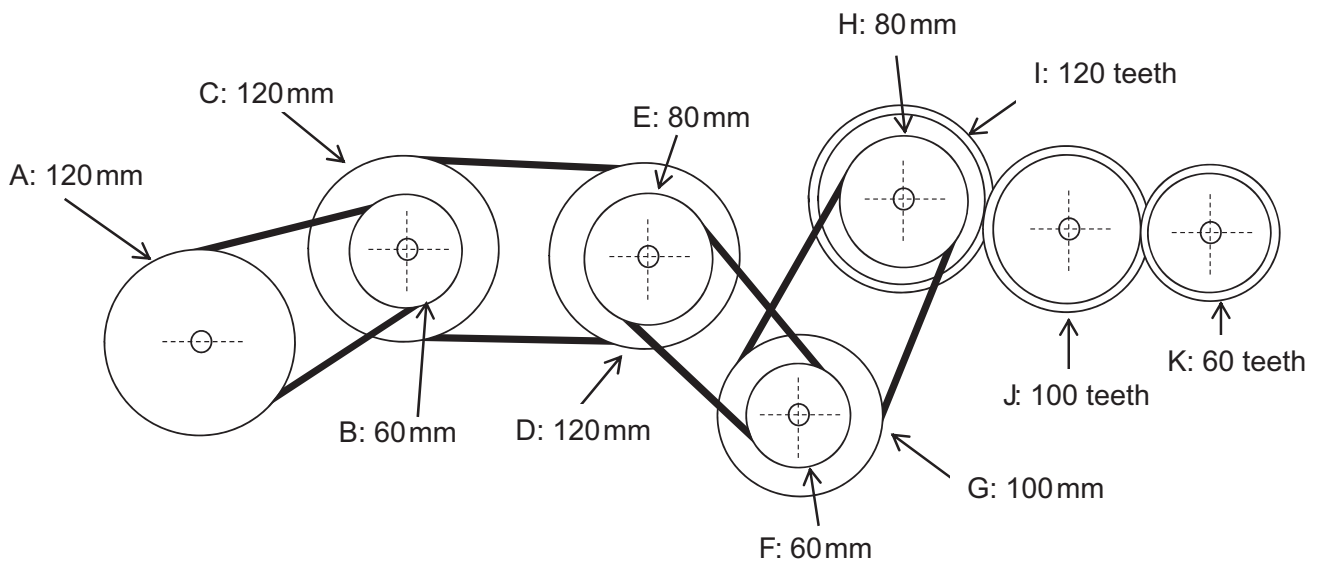


Fig. 15

Answer _____ [2]

Examiner Only	
Marks	Re-mark

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- 4 (a) (i) Outline the main difference between an open loop and a closed loop system and outline **one** specific application of a closed loop system.

Difference

[2]

Application

[1]

- (ii) Pulleys and bearings are often used in mechanical systems for lifting food in the catering industry. Using an annotated sketch outline the main features of a pulley block system with a mechanical advantage of 3.

[2]

Examiner Only	
Marks	Re-mark

- (iii) Using an annotated sketch, outline the main features of a taper bearing and state a specific application.

Examiner Only

Marks Re-mark

[3]

Application _____ [1]

- (iv) With reference to **Fig. 16** and the data below, calculate the volume of air consumed by the double acting cylinder during one complete cycle. Assume $\pi = 3.14$.

$D = 8 \text{ mm}$

$S = 40 \text{ mm}$

$d = 2 \text{ mm}$

Gauge Pressure = 4

Atmospheric Pressure = 1.5

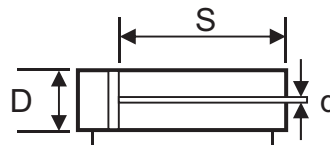


Fig. 16

Answer _____ cm^3 [4]

- (v) The identical double acting cylinders B1, B2 and B3 in **Fig. 17** each operate with an air pressure of 0.5 N/mm^2 and have a piston rod radius of 5 mm and a combined total area (not including the area of the piston rods) of 5652 mm^2 during the instroke. It is intended to replace B1, B2 and B3 with one large double acting cylinder. Calculate the outstroke force that the replacement cylinder would need to provide in order to equate to the combined force produced by B1, B2 and B3. Assume $\pi = 3.14$.

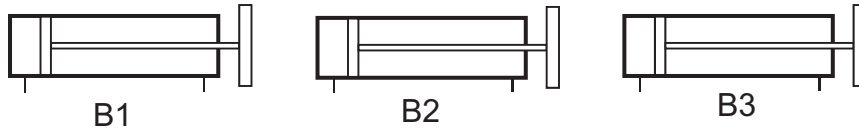


Fig. 17

Answer _____ [3]

Examiner Only	
Marks	Re-mark

(c) Inside a food production plant, a range of pneumatic systems is used. Complete the following sequence on A3 pro forma (answer number **4(c)**). Some of the piping has been completed on the pro forma to assist you. The sequence begins:

- By closing either guard A or B and activating the START 3/2 Valve C, Cylinder A goes positive.
- When Cylinder A is in the positive position it is detected by the roller trip 3/2 valve.
- Cylinder B then goes positive. When Cylinder B is in the positive position it is detected by the 3/2 valve and sends Cylinder C negative.
- Following detection by the 3/2 valve there is a delay in time before Cylinder C goes positive. Following detection by the 3/2 valve Cylinder B then goes negative. When Cylinder B is in the negative position it is detected by the roller trip 3/2 valve and enables Cylinders D1 and D2 to go positive.
- Following detection by the air bleed Cylinders D1 and D2 go negative.
- Following detection of Cylinder D1 in the negative position Cylinder A goes negative.
- Following detection of Cylinder A in the negative position the sequence resets.

[10]

(d) On the pro formas provided (answer number **4(d)(i)** and **4(d)(ii)**), design, draw and annotate an appropriate system which would achieve the following requirements:

(i) Repeatedly test pieces of packaging material using the double acting cylinder while counting the number of strokes. The counter is incremented each time it receives a pulse of air. The cylinder must be speed controlled in both directions. The circuit must automatically detect when the cylinder is positive or negative using a non-contact method.

A suitable mechanism must be attached to the cylinder to enable it to be moved to a set angle by the operator (indicated on pro forma) to test different pieces of material. The mechanism will rotate the cylinder anti-clockwise and can be locked in position. [6]

(ii) A means of enabling the double acting cylinder to clamp the material in place while it undergoes further testing. The circuit will be started when the proximity sensor has been momentarily activated and must use an appropriate mechanism to clamp the material in the shown position. The circuit must automatically retract the cylinder after a time delay (components indicated on pro forma). [4]

Examiner Only	
Marks	Re-mark

Section C

Product Design

Answer **both** questions in this section



Source: Principal Examiner

Fig. 19

- 5 Electronic products such as the tablet shown in **Fig. 19** are constantly changing as technology develops. Some consumers may view this product as fulfilling a need in the market while others may view this product as satisfying a demand in the market.

- (a) Distinguish between needs and demands when describing the role of markets in product design.

[2]

- (b) (i) The company designing and manufacturing the tablets has completed an environmental audit.
Explain what is meant by an environmental audit.

[2]

Examiner Only	
Marks	Re-mark

(h) The tablet shown in **Fig. 20** below measures 230 mm wide, 180 mm in height and 8 mm in depth. On the blank A3 pro forma (answer number **5(h)**) use detailed annotated sketches to produce **one** possible solution for the following:

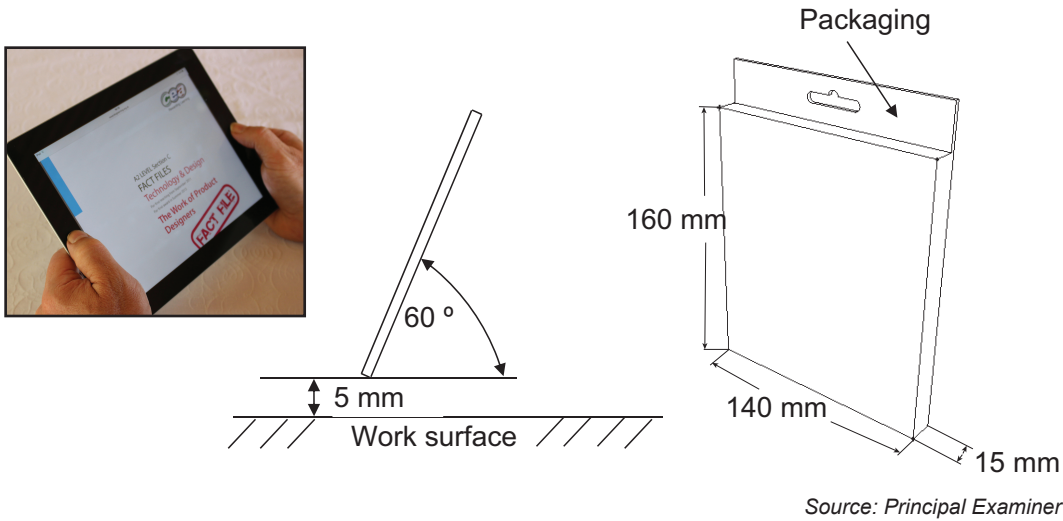
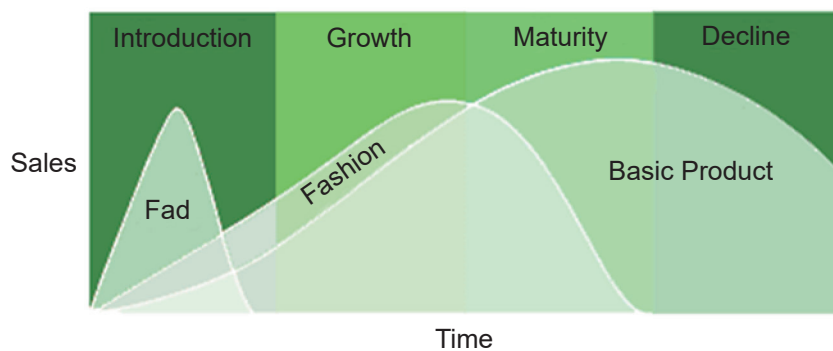


Fig. 20

An appropriate design of a stand which can be dismantled to fit inside the packaging shown in **Fig. 20**. Your design should require minimal assembly whilst ensuring that the stand is rigid and that the tablet can be positioned as shown. Show how your design has minimised the use of materials and processes. Explain how your design may be suitable for batch production. [10]

Examiner Only	
Marks	Re-mark

(c) The product life cycle for fad, fashion and basic products is represented on the graph shown in **Fig. 22** below.



Source: Fact files

Fig. 22

(i) With reference to **Fig. 22**, explain why basic products offer the longest product life cycle of the three.

[2]

(ii) With reference to **Fig. 22**, explain the characteristics which give rise to the shape of the graph for a fad product.

[2]

Examiner Only

Marks Re-mark

(d) The disposal of products and the control of pollution are key challenges for product design companies.

(i) Briefly outline **two** different ways in which product designers and manufacturers can influence the disposal of products and therefore help address environmental concerns.

1. _____

2. _____

_____ [2]

(ii) Briefly outline **two** different ways in which product designers and manufacturers can influence pollution control and therefore help address environmental concerns.

1. _____

2. _____

_____ [2]

(e) The company producing the car vacuum cleaners has considered adopting a flexible manufacturing system (FMS) as a means of organising its production.

Briefly outline **three** main benefits associated with adopting a flexible manufacturing system (FMS).

1. _____

2. _____

3. _____

_____ [3]

Examiner Only	
Marks	Re-mark

- (f) When placing a product geographically, designers need to be aware of the international and regional differences which exist.

With reference to **two** different products of your choice, explain how international and/or regional differences have influenced the design of your chosen examples.

1. _____

_____ [2]

2. _____

_____ [2]

Examiner Only	
Marks	Re-mark

(g) When promoting new models of the car vacuum cleaner it is important to have a clear understanding of the limitations that the use of sales promotion and personal selling may offer in trying to increase product sales.

(i) Briefly outline **two** main advantages and **two** main disadvantages associated with the use of sales promotion as a way of increasing product sales.

Advantage 1

Advantage 2

[2]

Disadvantage 1

Disadvantage 2

[2]

Examiner Only	
Marks	Re-mark

- (i) **Fig. 23** below shows a photograph of a hand-held car vacuum cleaner with its accessories together with outline drawings of a whiteboard box to be used to package the product. The vacuum cleaner is used for upholstery and interiors and operates via a 12V socket. A 3 m cable and 3 accessories are provided. These accessories are packaged and inserted into the box which has four photographs, text and graphics printed on the exterior.

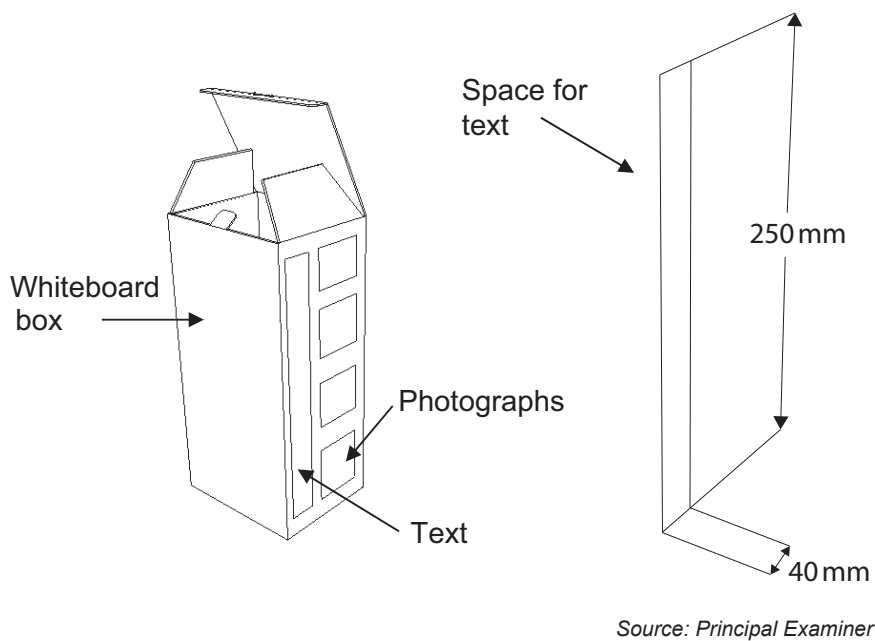


Fig. 23

Examiner Only	
Marks	Re-mark

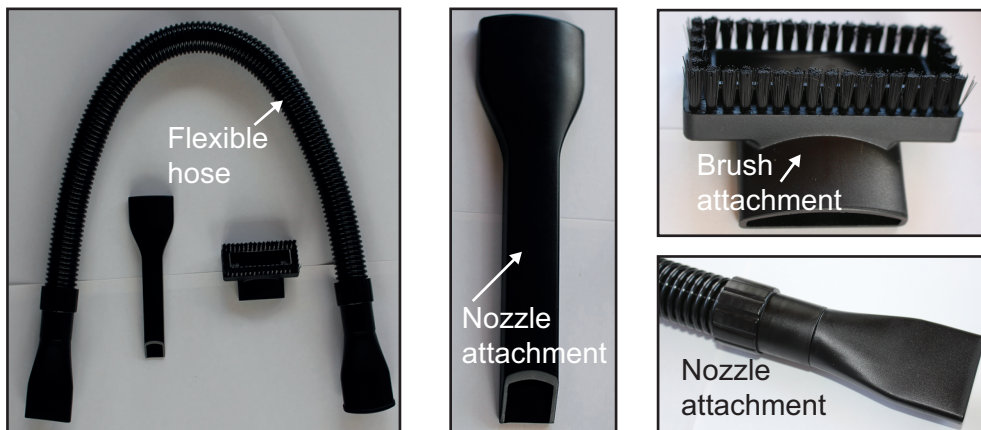
Examiner Only	
Marks	Re-mark

(i) With reference to the information in **Fig. 23** opposite and on the blank A3 pro forma (answer number **6(i)(i) & 6(i)(ii)**), produce one possible solution for the following:

- A layout of a design (scale 1:1) with specified text size and style to communicate product information to a variety of audiences. The text box has been drawn for you on the pro forma. Justify your selection of text and style. [5]

(ii) With reference to the flexible hose, nozzles and brush attachment shown in **Fig. 24** below and on the blank A3 pro forma (answer number **6(i)(i) & 6(i)(ii)**), use detailed annotated sketches to produce one possible solution for the following:

- A low cost innovative design of a wall mounted holder that would enable the flexible hose, nozzles and brush attachment to be quickly removed for use and quickly replaced after use in order to reduce the possibility of these attachments getting lost or misplaced. [5]

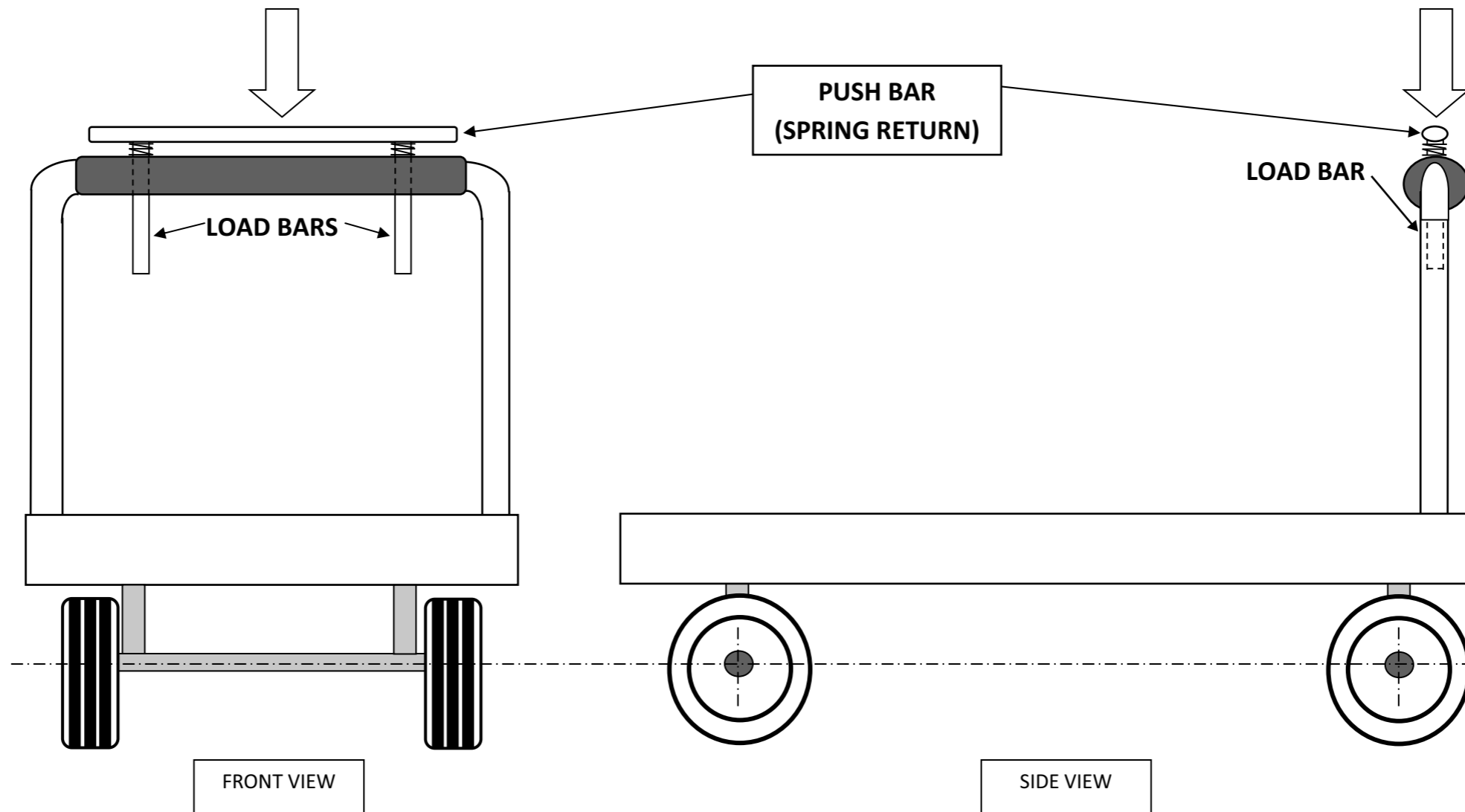


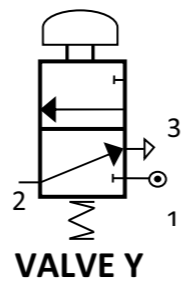
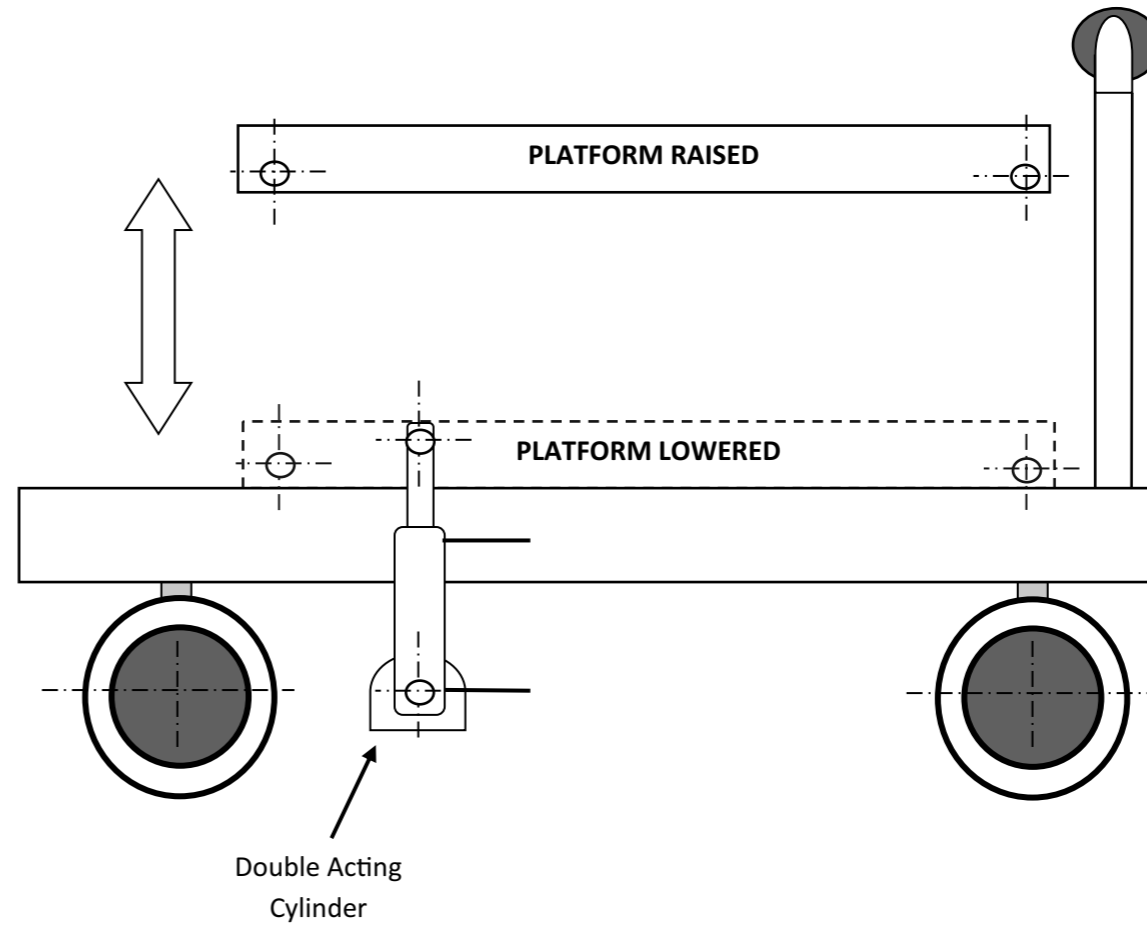
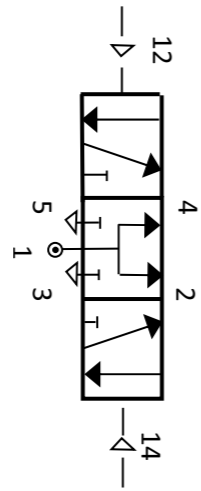
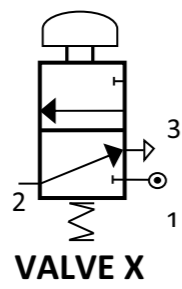
Source: Principal Examiner

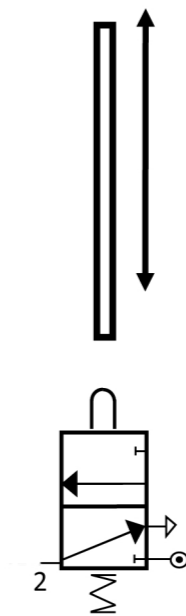
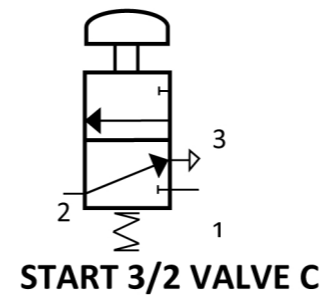
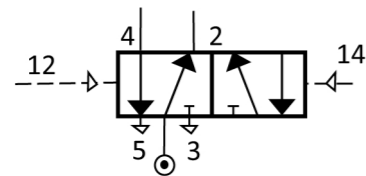
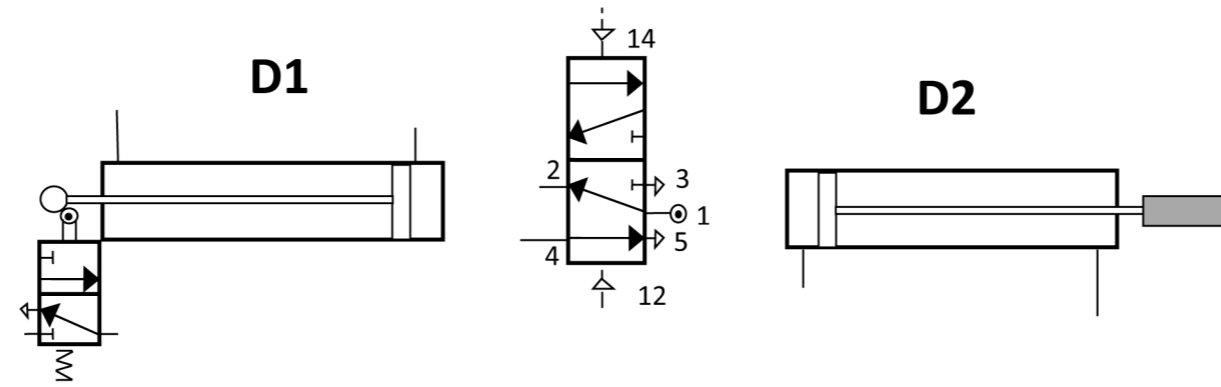
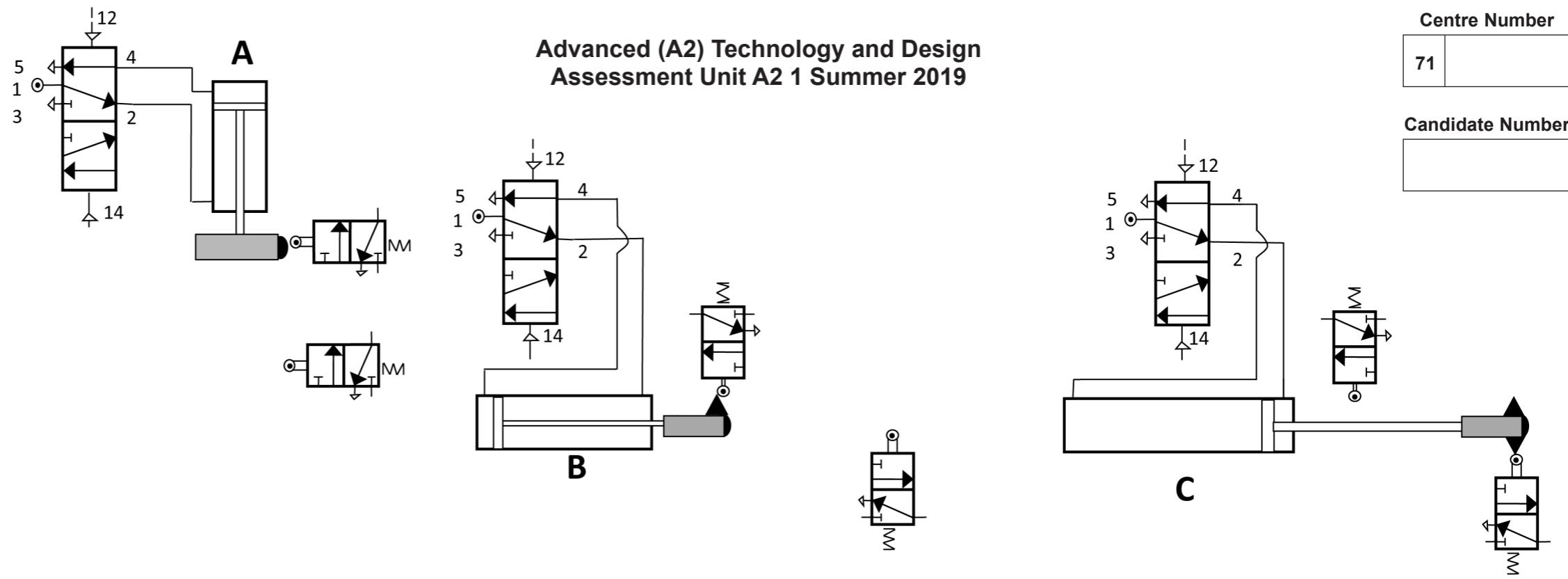
Fig. 24

THIS IS THE END OF THE QUESTION PAPER

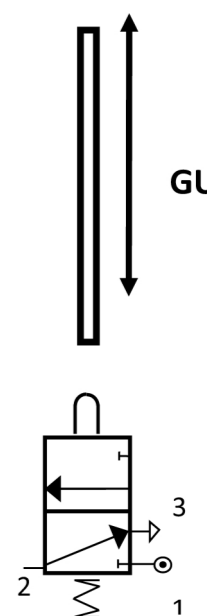
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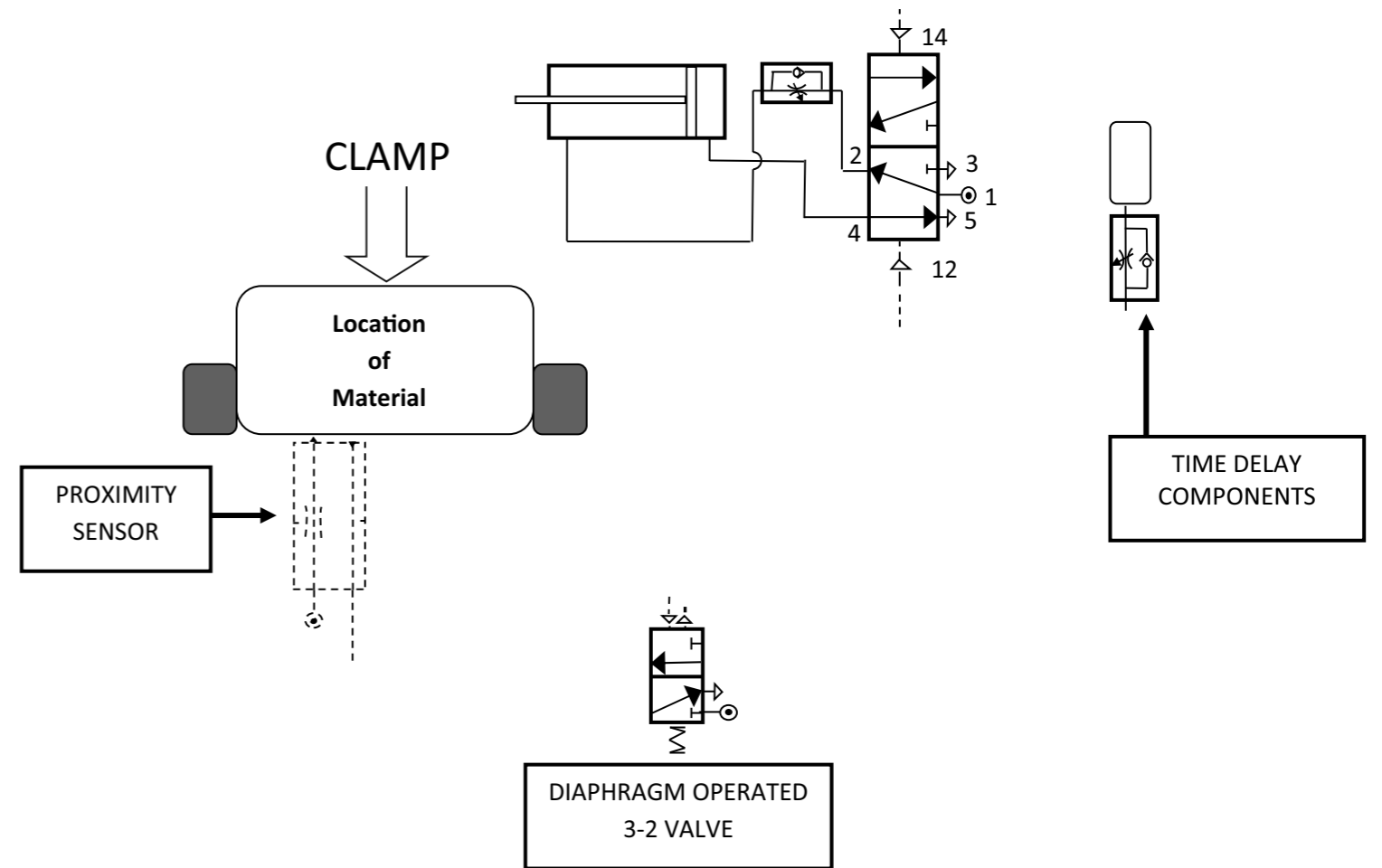
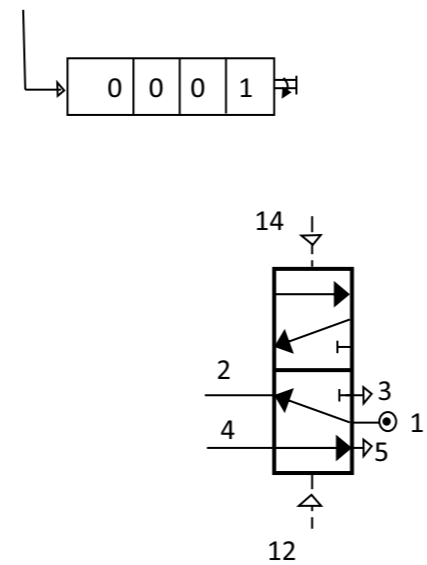
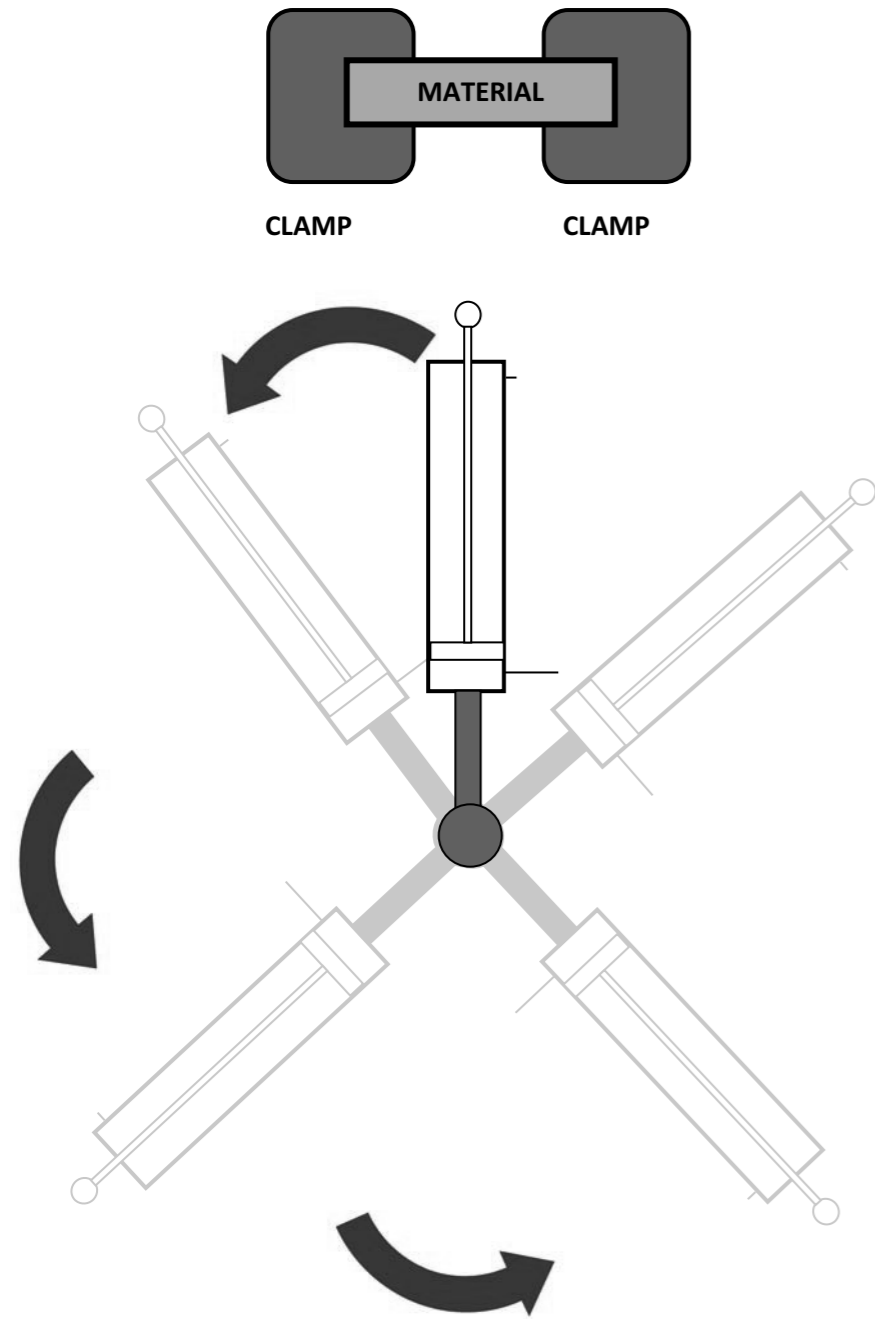




GUARD A



GUARD B



Centre Number

71	
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Candidate Number

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