New Specification

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ADVANCED
General Certificate of Education
2010

Technology and Design

Assessment Unit A2 1

assessing

Systems and Control

[AV211]

AV211

FRIDAY 28 MAY, MORNING

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number on the Answer Booklet provided and on the A3 pro forma answer pages provided.
Answer **either** the **two** questions in Section A **or** the **two** questions in Section B.
Answers to questions **1(e)**, **2(c)(ii)**, **3(a)(iii)**, **3(b)**, **3(e)**, **4(b)**, **4(c)** and **4(d)** 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 the Answer Booklet with the treasury tag supplied.

INFORMATION FOR CANDIDATES

The total mark for this paper is 80, including a maximum of 4 marks for quality of written communication.
Marks for quality of written communication will be awarded for questions **2(c)(iii)** and **3(c)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

Answer **either** the **two** questions in Section A **or** the **two** questions in Section B.

Section A

Electronic/Microelectronic Systems

1 A block diagram for a soil heating system for a greenhouse is shown in **Fig. 1(a)**. The heating elements are controlled by a switch unit which in turn can be programmed using the time clock module.

Fig. 1(a)

(a) (i) Explain why the system shown in **Fig. 1(a)** is an open loop control system. [2]

(ii) Redraw the block diagram shown in **Fig. 1(a)** modifying it to become a closed loop system and describe the function of any additional blocks. [3]

(iii) The time clock module and electrical switch unit which operate at 5 volts are electrically isolated from the high voltage heating elements using an optical switch. Explain with the aid of a diagram how this is achieved. [4]

(b) Views of a concept design for an electronic planting aid to set the distance between plant seeds is shown in **Fig. 1(b)**. As the device is pushed over the soil, a sound is to be emitted to indicate to the user that a seed is to be planted.
The input to the electronic system is based on a disc with notches which will activate a microswitch. The disc is fixed to the rubber wheel.

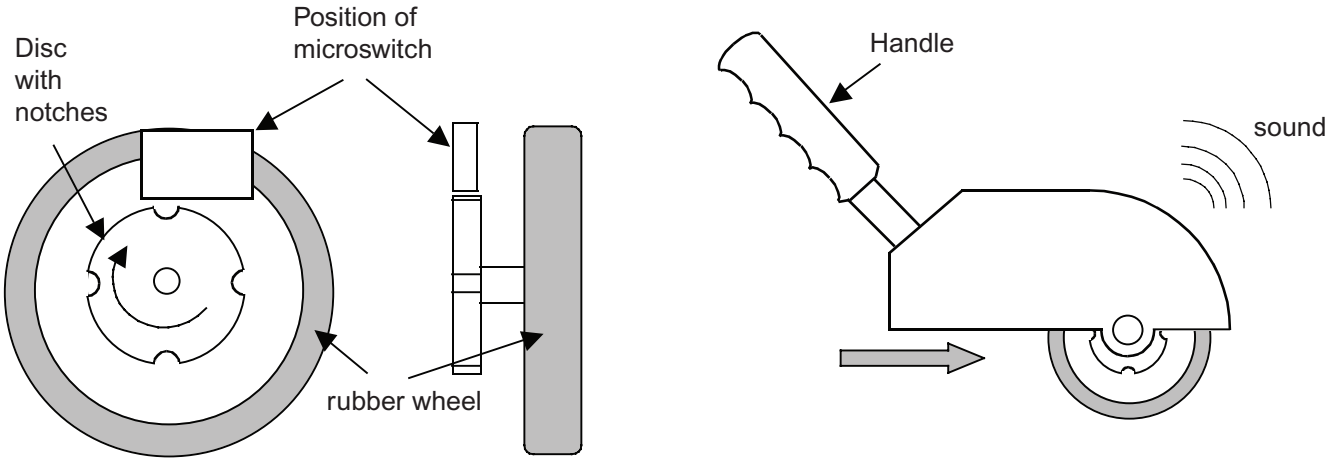


Fig. 1(b)

Name and draw a method other than a mechanical switch to detect the rotation of the disc. [3]

(c) The initial circuit to be used in the planting aid is a PIC-based circuit as shown in **Fig. 1(c)**.

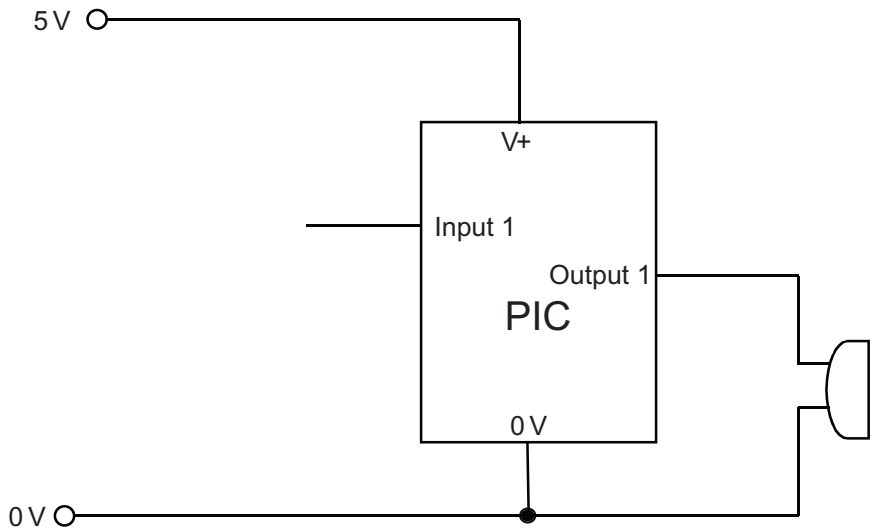


Fig. 1(c)

(i) With the aid of a circuit diagram explain how a microswitch could be used in conjunction with a resistor to provide a digital input to the PIC shown in **Fig. 1(c)**. [4]

(ii) Every time a notch on the disc passes under the microswitch, the PIC circuit shown in **Fig. 1(c)** must produce an output pulse with a duration of 0.2 seconds to drive the buzzer and indicate that a seed should be planted. Write a flowchart program which will achieve this. [4]

(iii) If the rubber wheel on the system shown in **Fig. 1(b)** is rotated too quickly, some of the notches may not be detected. Calculate the maximum allowable revolutions per minute (RPM) of the wheel if the PIC circuit in **Fig. 1(c)** produces an output pulse with a duration of 0.2 seconds. [3]

(d) An addition to the circuit for the planting aid is shown in **Fig. 1(d)** where the output from the PIC circuit in **Fig. 1(c)** is connected to the input (clk) pin of a BCD counter.
A 7-segment display will provide a visual indication of the number of seeds that should have been planted in a row.

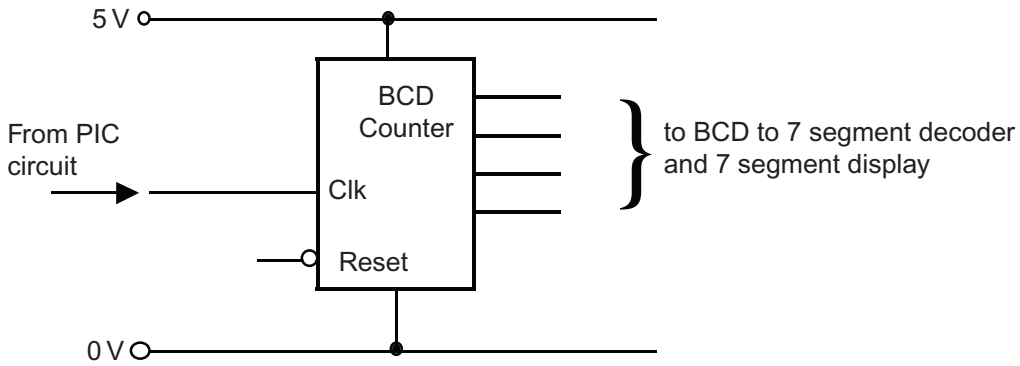


Fig. 1(d)

(i) State the function of the BCD to 7-segment decoder in the circuit shown in **Fig. 1(d)**. [2]

(ii) Explain why a BCD counter is more appropriate for this application than a binary counter. [3]

(iii) Show with the aid of a circuit diagram how the BCD counter shown in **Fig. 1(d)** can be reset. [2]

(e) Using electronic circuit diagrams on the blank pro forma provided (answer number **1(e)**), show how the following could be achieved.

- Count and display up to a maximum of 99, the number of seeds planted.
- A means to enable the user to alter the distance between the planting of seeds.

[10]

2 The voltage divider circuit shown in **Fig. 2(a)** is to be used as part of a circuit for measuring the temperature of water in a storage tank. The resistance/temperature characteristic for the thermistor Rth is also shown.

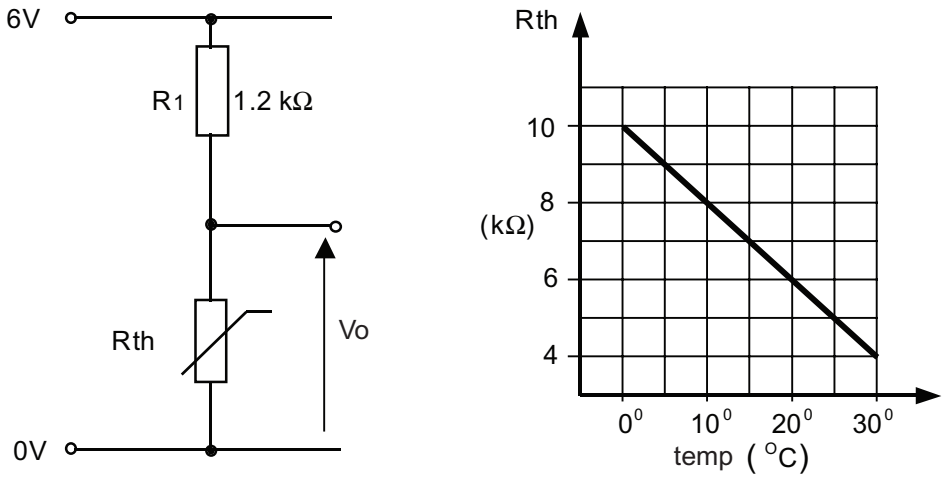


Fig. 2(a)

(a) (i) State the main physical property of a thermistor for this application. [1]

(ii) State the purpose of the voltage divider arrangement shown in **Fig. 2(a)**. [1]

(iii) If the water temperature varies between 5 °C and 15 °C, calculate the voltage Vo for both these temperatures. [4]

(iv) Calculate the total power dissipated by R1 and Rth at 20 °C. [2]

(v) Suggest **one** practical advantage of replacing the fixed resistor in **Fig. 2(a)** with a variable type resistor. [2]

(b) The output voltage Vo from the voltage divider in **Fig. 2(a)** is to be connected to a 10-segment LED bar array and driver as shown **Fig. 2(b)**, where each segment is to represent 1 °C. In order for this to happen, the output voltage Vo from the voltage divider must be amplified by a factor of 40.

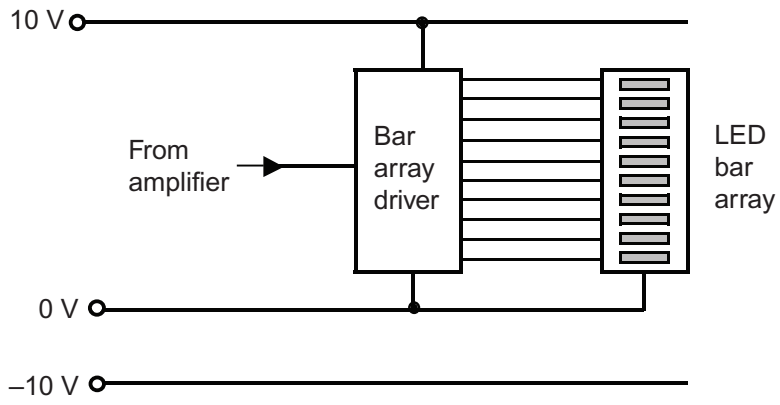


Fig. 2(b)

(i) Describe the function of a bar array driver. [2]

(ii) Design an amplifier, based on an op amp to match the voltage divider output from **Fig. 2(a)** to the input of the display driver and show how it would be connected to the circuit shown in **Fig. 2(b)**. [2]

(iii) Suggest suitable resistor values for the amplifier in part **(b)(ii)** given that the gains of inverting and non-inverting amplifiers are –Rf/R1 and 1 + Rf/R1 respectively where resistor Rf is the feedback resistor. [3]

(c) A PIC based circuit could be used to measure and display the level of water in the storage tank. A float attached to a rotary potentiometer could be used to detect the water level. The PIC shown in **Fig. 2(c)** has five input ports (i/p 0–i/p 4) and eight output ports (o/p 0–o/p 7).

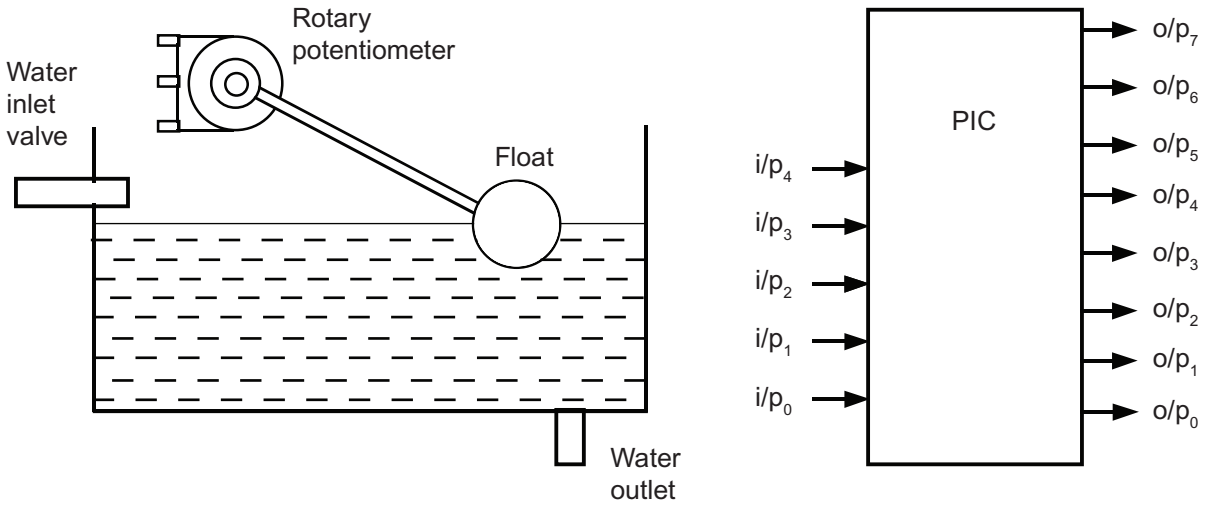


Fig. 2(c)

(i) The input ports on the PIC shown in **Fig. 2(c)** can function as either digital or analogue inputs. Briefly explain the difference between these two types of input. [2]

(ii) The voltage range of the analogue port on the PIC shown in **Fig. 2(c)** is from 0 V to 6 V with a corresponding digital range from 0 to 255.
Using electronic circuit diagrams on the blank pro forma provided (answer number **2(c)(ii)**), design a circuit based on the float system and PIC shown in **Fig. 2(c)** and write a flow chart program to fulfil the following:

- determine the water level using the potentiometer on i/p 1.
- display the level on seven LEDs o/p 0–o/p 6 where o/p 0 indicates that the tank is empty and o/p 6 indicates that the tank is full. Outputs indicate equidistant input levels in the tank.
- open a high voltage water valve connected to o/p 7 to allow the tank to refill when the tank is empty.
- switch off the water valve when the tank is full. [12]

(iii) PIC microcontrollers are a common choice for pupils who want to design and make control circuits for project work. Describe **two** main features of PICs that have made them so popular for project work, illustrating your answer with examples. Justify choosing a hard wired solution in preference to a PIC for certain applications. [5]

Quality of written communication [4]

Answer **either** the **two** questions in Section A **or** the **two** questions in Section B.

Section B

Mechanical and Pneumatic Control systems

3 **Fig. 3(a)** shows a cam and follower to be used as part of a prototype mechanical system. The cam rotates in a clockwise direction and the roller follower is offset to the right of the cam centre line by 10 mm.

(a) **(i)** Name and sketch **one** other follower, apart from a knife edge or roller, which can be used with cams. [2]

(ii) The cam rotates at 120 rev/min with a torque of 1.75 Nm. Calculate the power expended. [3]

(iii) On the pro forma provided (answer number **3(a)(iii)**), construct a performance/ displacement diagram which would accurately produce the following motion:
- 0–120 rise 60 mm with uniform acceleration and retardation
- 120–180 rise 20 mm with uniform velocity
- 180–360 fall 80 mm with simple harmonic motion. [5]

A scale of 1 mm = 1 mm should be used

(b) On the pro forma provided (answer number **3(b)**), using appropriate formal drawing techniques, construct a cam profile which would accurately follow the performance/ displacement diagram as shown in **Fig. 3(b)**. The diameter of the offset roller follower is 10 mm and the minimum cam diameter is 25 mm. Your answer may be drawn to a suitable scale. [10]

(c) A gearbox which provides the drive/motion for the cam uses a lubricant with a specific classification. Explain how lubricants are classified, discuss the mechanics of lubrication and viscosity and the factors to be considered when justifying the choice of a lubricant for a particular application. [5]

Quality of written communication [4]

(d) A universal joint has been used to transmit motion from the gearbox to the cam. Describe **one** main problem which is likely to be encountered during operation and suggest a solution. [1]

(e) In addition, **Fig. 3(a)** shows a pair of wheels which are to be used in conjunction with the cam and follower. On the blank pro forma provided (answer number **3(e)**) design and draw a mechanical system which would achieve each of the following requirements:
- A gearing system which will allow a change in the direction of the wheels' rotation when required as the motor only turns in the one direction.
- A manually activated system which will engage and disengage the transmission of motion from the motor to the rest of the system. [10]

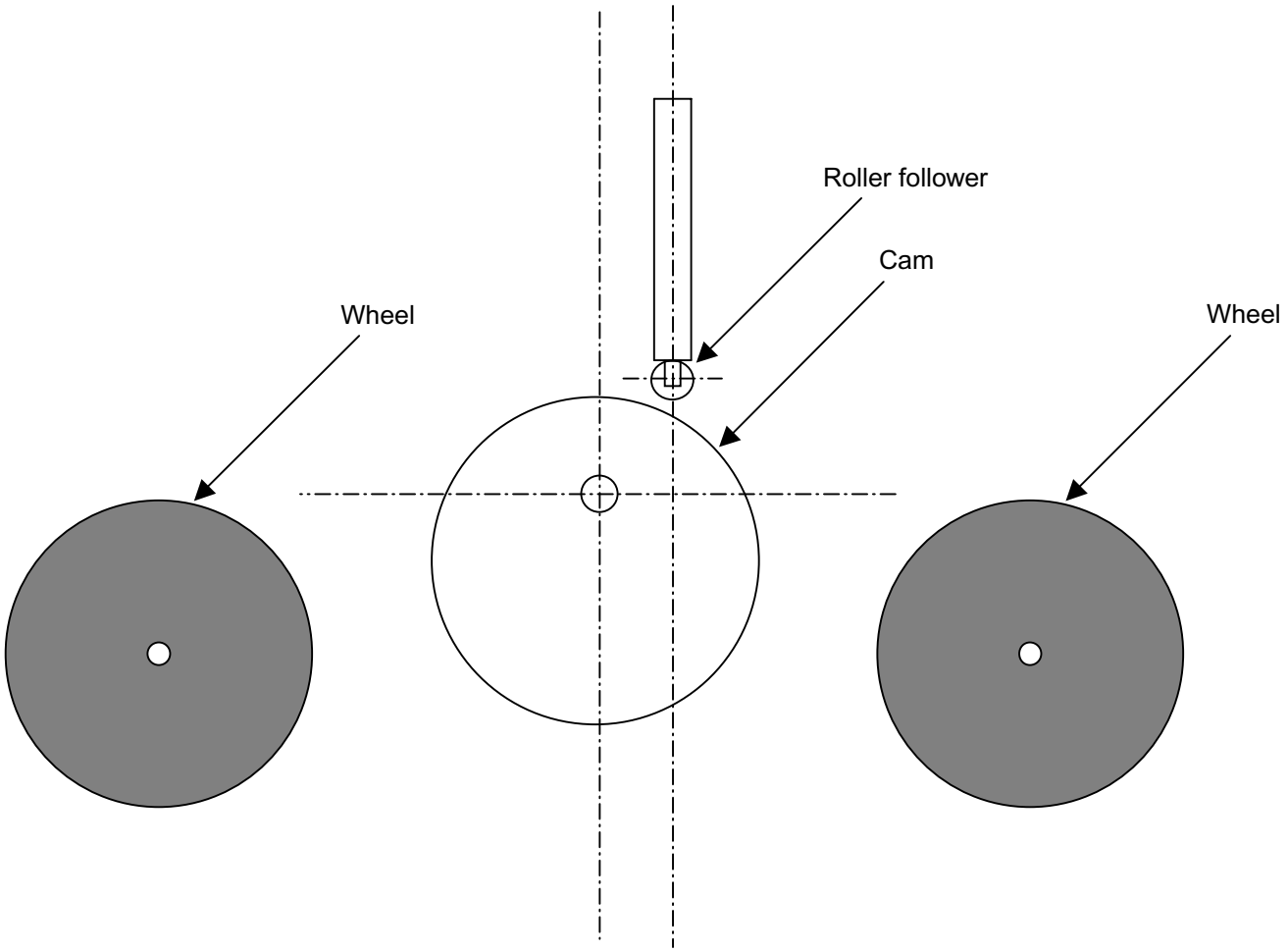


Fig. 3(a)

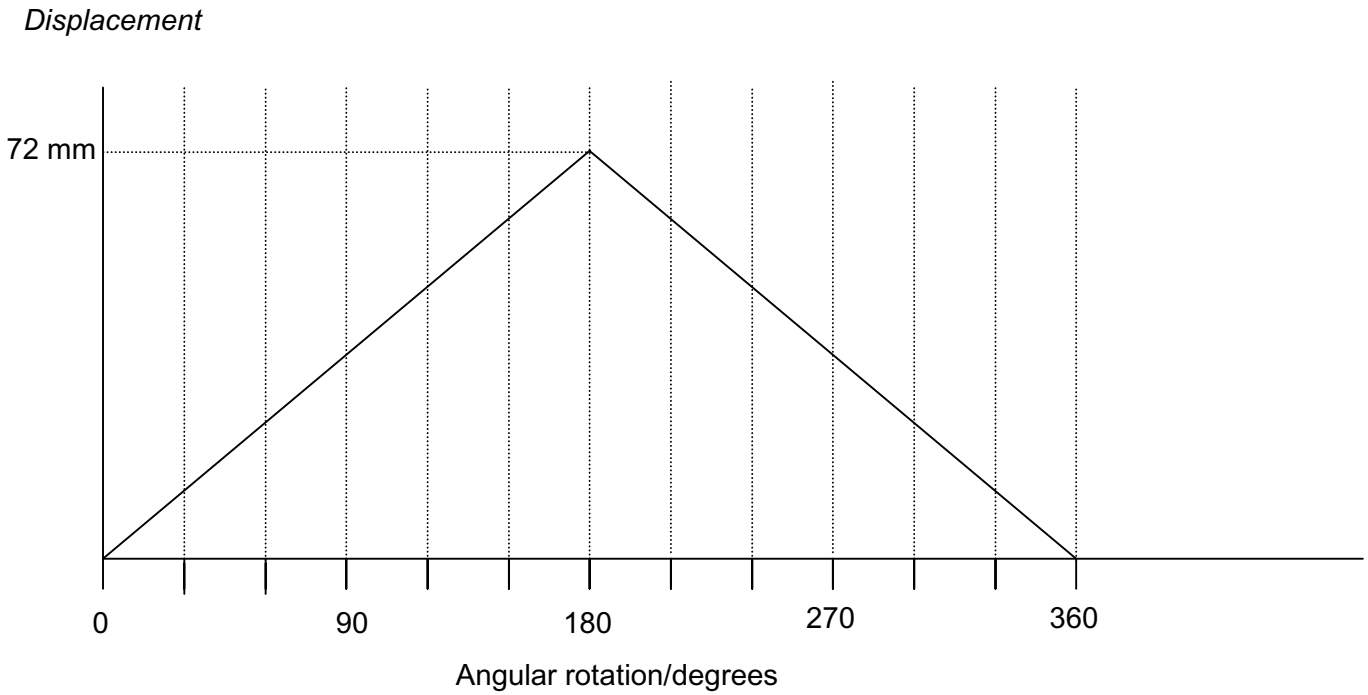


Fig. 3(b)

4 **(a)** **(i)** Briefly describe **three** safety issues associated with using pneumatic components. [3]

(ii) The work done by a single acting cylinder during the outstroke is 785 J. The cylinder has a stroke length of 100 mm and is supplied with an air pressure of 1 N/mm^2. Calculate the diameter of the piston. Assume π = 3.14. [3]

(b) **Fig. 4(a)** shows part of a pneumatic-based production line used to stamp and sort boxes according to their size.

The following sequence begins when a solenoid Start valve receives an electrical signal which not only activates the sequence, but switches on the conveyor belts:

- Cylinder A outstrokes to close the gate.
- Cylinder B outstrokes and stamps the underside of the box.
- Cylinder B instrokes.
- Cylinder C outstrokes slowly to push the box on to the lower conveyor belt.
- Cylinder C instrokes.
- Cylinder D instrokes once the box activates the **Air Bleed** to open the trap door.
- Cylinder A instrokes.
- Cylinder D outstrokes.

On the pro forma provided (answer number **4(b)**), draw a suitable interlocking/cascade sequential pneumatic circuit to achieve the desired sequence. [16]

(c) **Fig. 4(b)** shows a single acting cylinder **Q** which is to be used to stamp rejected boxes at a further stage in the production line.

On the pro forma provided (answer number **4(c)**), add any necessary components and piping to enable the cylinder to be operated with valve **Y** having the option of using valve **X** when a larger air pressure is required. When valve **X** is activated, air from an already activated valve **Y** may need to be blocked. [6]

(d) On the blank pro forma provided (answer number **4(d)**), design and draw a pneumatic system which will stamp and remove oversized boxes (box 3) from the upper conveyor belt.

The system should

- Detect the box, generate a signal to stop the motorised conveyor, then wait a few seconds before stamping the box.
- After completing the stamping, the box should be pushed to the side of the upper conveyor belt slowly. [12]

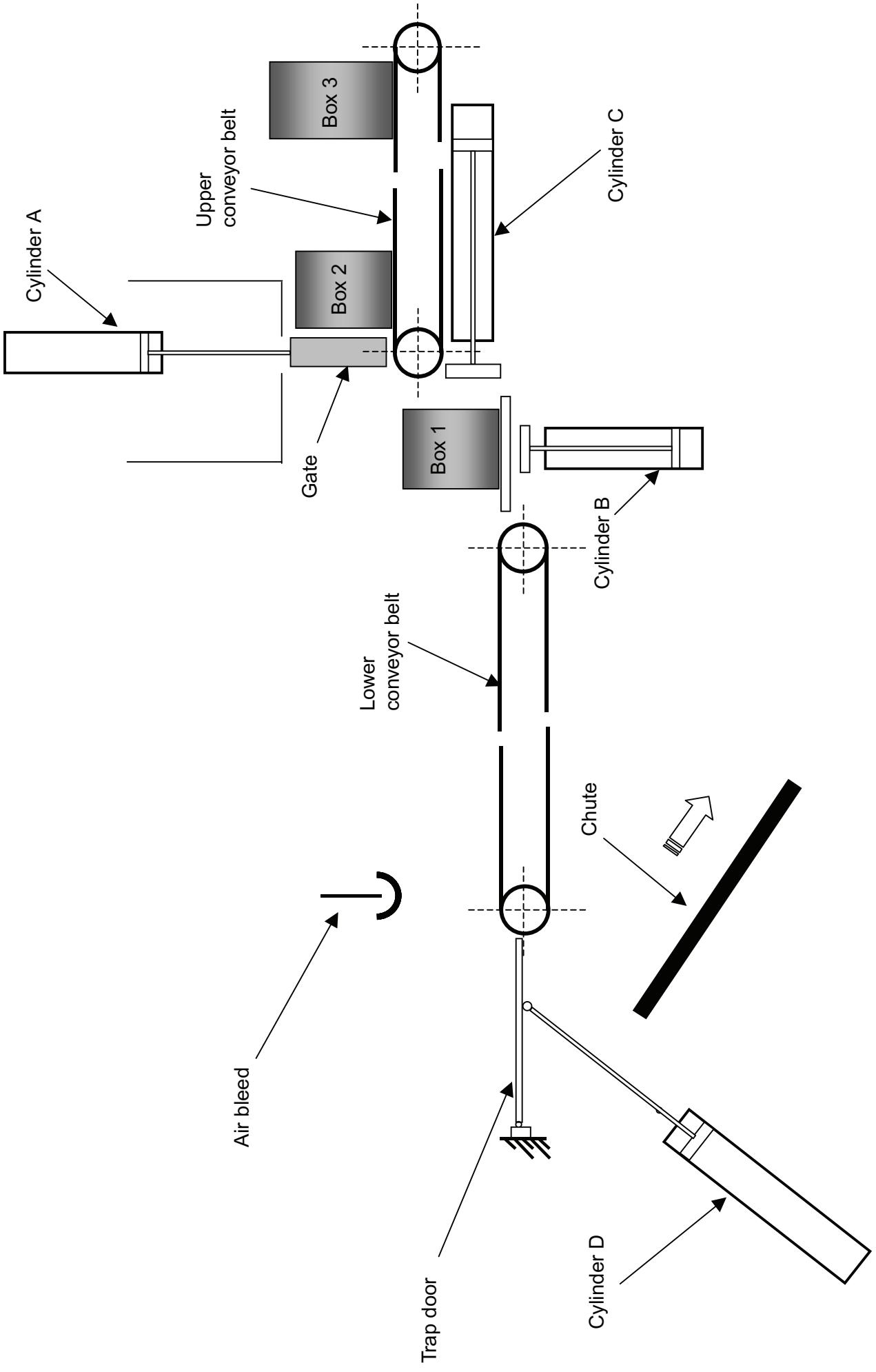
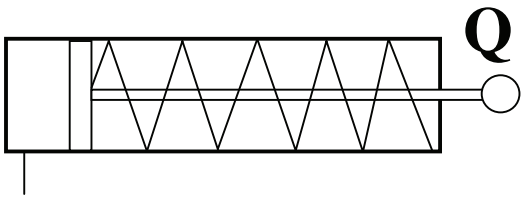
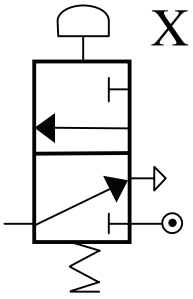


Fig. 4(a)





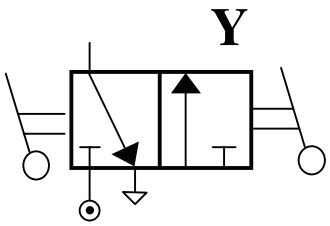


Fig. 4(b)

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