



Rewarding Learning

ADVANCED
General Certificate of Education
January 2014

Technology and Design

Assessment Unit A2 1

assessing

Systems and Control and
Product Design

[AV211]



TUESDAY 14 JANUARY, 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 **both** questions in **either** Section A, Section B **or** Section C.

Answers to Questions **1(d)**, **2(e)**, **3(e)(i)**, **4(c)**, **4(d)(i) and (ii)**, **5(g)(i)** and **6(f)(i) and (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 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 **1(e)**, **3(c)** and **6(d)**.

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



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

Section A

Electronic/Microelectronic Systems

- 1 A voltage divider circuit consisting of a power supply, LDR and fixed resistor is shown in **Fig. 1(a)**.

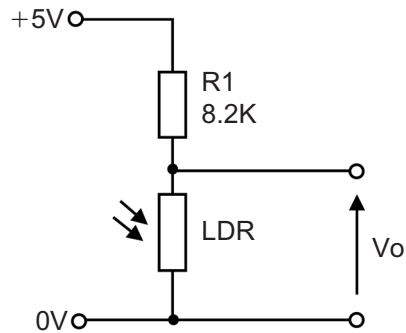


Fig. 1(a)

- (a) (i) State the principal property of an LDR. [1]

- (ii) Depending on light conditions the resistance of the LDR shown in **Fig. 1(a)** will vary between 180Ω and $180\text{k}\Omega$. Calculate the corresponding values for V_o . [2]

- (b) A student has designed a system for checking the clarity of water samples taken from a river. It consists of a housed light source (bulb) directed at one side of the water sample and the LDR based voltage divider from **Fig. 1(a)** housed on the other side of the sample. **Fig. 1(b)** shows how the system is arranged. A digital voltmeter is to be used to display the results of the water clarity tests.

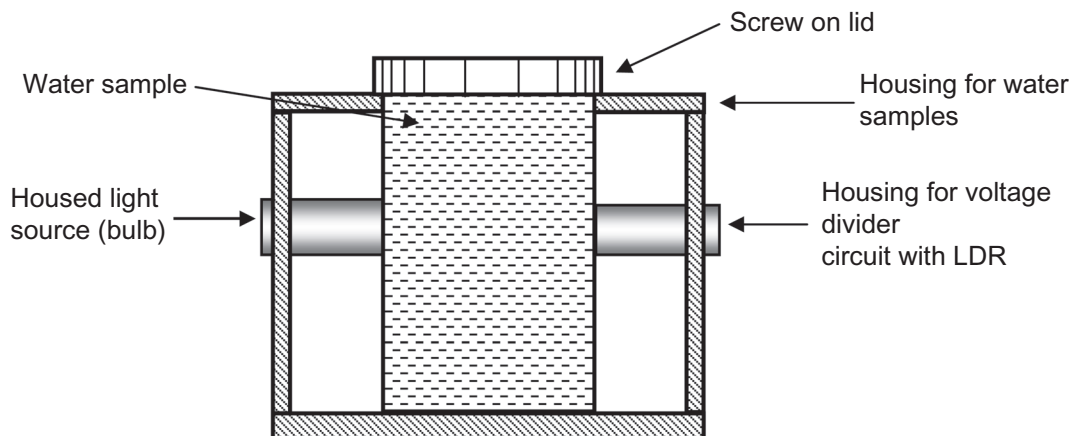


Fig. 1(b)

- (i) When testing a full range of water samples, it was found that the output from the voltage divider varied between 2.5 volts and 3.3 volts.

The voltage to be displayed on the digital voltmeter in millivolts should represent the full range of water samples with a number displayed between 0 and 1000 millivolts. A Wheatstone bridge and an amplifier are therefore needed to meet this requirement. Determine the gain of the amplifier. [2]

- (ii) Draw a Wheatstone bridge, which incorporates **Fig. 1(a)**, and a differential amplifier circuit based on an op amp. Calculate suitable resistor values to achieve the gain required in **(b)(i)** if the output of a differential amplifier is given by $R_f/R_1(V_2-V_1)$ where resistor R_f is the feedback resistor. [4]

- (iii) Draw a block diagram for the testing system in **Fig. 1(b)** including the associated bridge, amplifier and meter from **(b)(i)** and **(b)(ii)** labelling the input, control and output sub systems. [3]

- (iv) With reference to the characteristics of a typical LDR, state **two** important practical considerations when designing a system such as the one shown in **Fig. 1(b)** where an LDR is to be used as the basis for a sensor. [2]

- (v) Draw and describe a sensor that can be used to detect changes in light level as an alternative to the bulb and LDR in **Fig. 1(b)**. [3]

- (c) The output voltage from a voltage divider can be connected to the analogue input of a PIC shown in **Fig. 1(c)** which has mixed analogue and digital I/O.

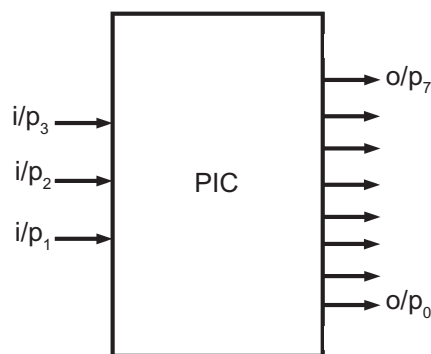


Fig. 1(c)

- (i) Briefly explain the meaning of the term analogue and digital I/O when referring to a PIC. [2]

- (ii) The voltage of the analogue input on the PIC shown in **Fig. 1(c)** ranges from 0V to 2.5V and the corresponding digital range is 0 to 255. Calculate the digital equivalent values that correspond to analogue input voltage values of 1.6V and 1.8V respectively. [2]

- (d) Water samples are to be tested in batches of four. The system in question 1(b) is to be developed using the PIC shown in Fig. 1(c) to produce a system where the amplifier and digital voltmeter are replaced with a display/control panel as shown in Fig. 1(d). The SAMPLE LEDs indicate a red fail or green pass status for each of the four different water samples in the batch.

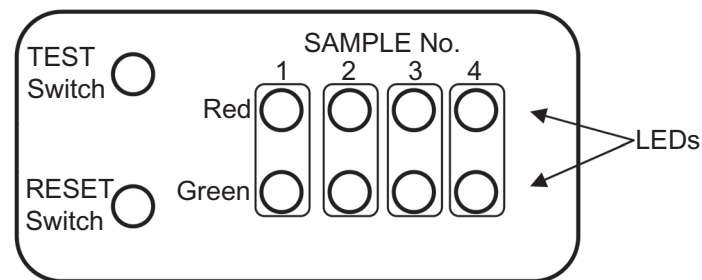


Fig. 1(d)

Using annotated electronic circuit diagrams on the blank pro forma provided (answer number 1(d)) design a PIC based circuit and associated program that will achieve the following:

- Each time a water sample is inserted a test button is momentarily pressed which will initiate the water clarity test.
 - If the voltage divider output V_o is less than or equal to 1.6 volts the first green SAMPLE LED will illuminate, indicating the sample has passed. If V_o is greater than 1.6 volts the first red SAMPLE LED will illuminate indicating a fail.
 - This sequence is repeated a further three times until all four samples have been tested and either a green or red LED is illuminated for each sample.
 - Any further samples will not be tested unless the reset switch is momentarily pushed which will cause all SAMPLE LEDs to switch off and allow the process to begin again.
- [10]

- (e) PICs are a popular choice for school project circuit designs. A variety of interface methods are employed in order to connect them to various input components and output devices.

Discuss **three** main factors to be considered when connecting input components or output devices to PICs. Supplement your discussion with **two** specific examples. [5]

Quality of written communication [4]

- 2 (a) A manufacturing clean room is accessed through three sliding doors A, B and C as shown in **Fig. 2(a)**. The sequence for opening the doors must be observed in order to minimise contamination when entering and exiting the room. Correct operation requires the opening of any single door or any two adjacent doors. All three doors must not be opened at the same time and both outer doors (A and C) must not be opened at the same time. A wall mounted green light indicates that the doors are being used correctly while a red light warns of incorrect usage. Each door generates a logic 1 signal when open and a logic 0 when closed. The green light is illuminated when all doors are closed.

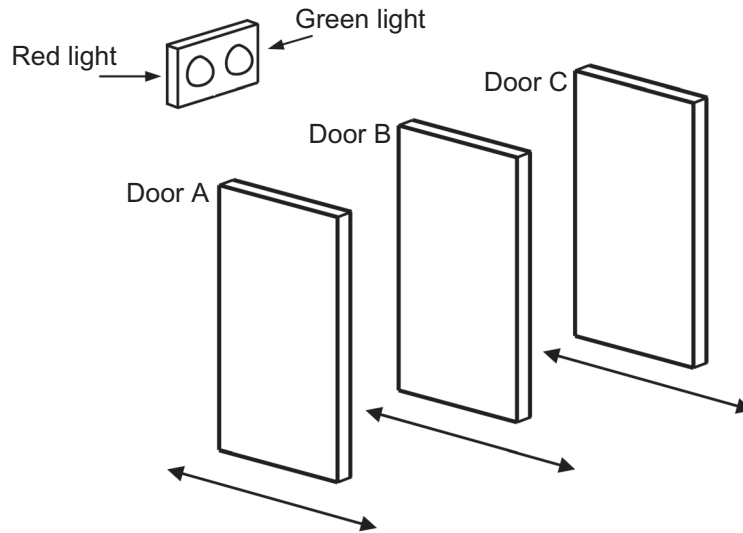


Fig. 2(a)

- (i) Draw a truth table to represent all possible logic states for the doors and the corresponding red and green indicator lights shown in **Fig. 2(a)**. [3]
- (ii) Deduce minimised expressions using Karnaugh maps for the red and green indicator lights. [4]
- (iii) Draw logic circuits to control the red and green indicator lights assuming a logic 1 output will switch the lights on. [2]
- (b) When a person is passing through the door system shown in **Fig. 2(a)** a high speed fan which is turned by a high voltage DC motor produces an air shower to remove contamination. The DC motor is switched on and off using a 5 volt logic signal as shown in **Fig. 2(b)**.

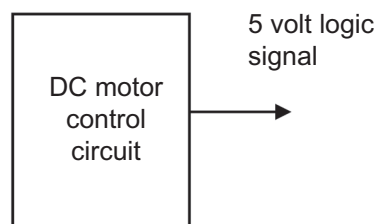


Fig. 2(b)

- (i) Give **two** main functional reasons why a DC motor makes a suitable choice for this application. [2]
- (ii) With the aid of an annotated circuit diagram show how suitable driving circuitry can be used to interface a high voltage DC motor to a 5 volt logic circuit so that a logic 1 will switch the DC motor on. [3]

(c) An additional feature to the door entry system in **Fig. 2(a)** is the provision of a wall mounted LED seven segment display. The display is to show the time in seconds left until the air between the doors is cleaned by the air shower.

Fig. 2(c) shows the seven segment display and a circuit diagram showing the arrangement of LEDs within each segment. The forward voltage of each LED is 2.2 volts and when a segment is illuminated the current in each LED is 10 mA.

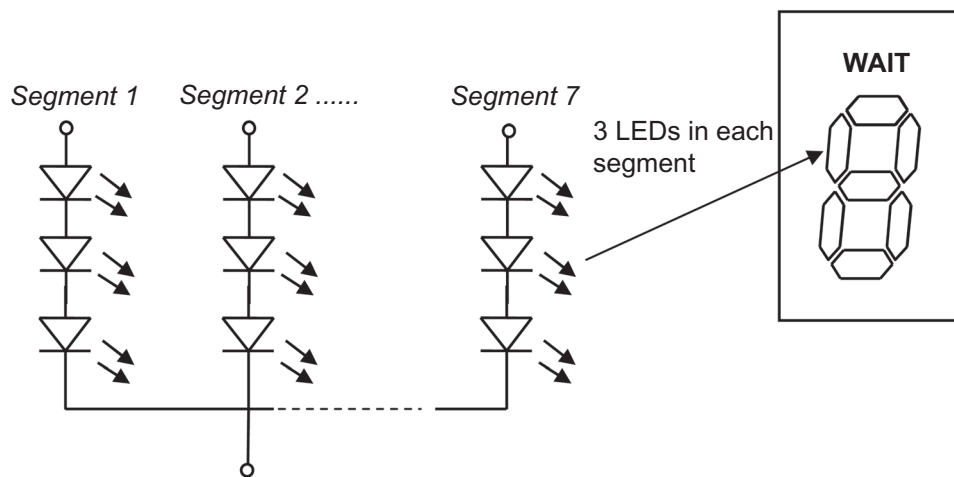


Fig. 2(c)

- (i) State if the LED display shown in **Fig. 2(c)** is connected in common anode or common cathode mode and briefly justify your answer. [2]
- (ii) Calculate the value for a protective resistor for one segment of the display shown in **Fig. 2(c)** if the power supply is 12 volts. Then determine by calculation if a 0.125 watt rated resistor would be suitable. [4]
- (iii) Calculate the total power dissipated by the seven segment display shown in **Fig. 2(c)** when all segments are illuminated (assume a current of 10 mA in each LED). [2]

(d) **Fig. 2(d)** shows a BCD up/down counter that is to be used as part of a circuit to control the seven segment display in **Fig. 2(c)**. Explain the meaning of the following terms with reference to the up/down counter:

(i) Binary outputs. [2]

(ii) LSB. [2]

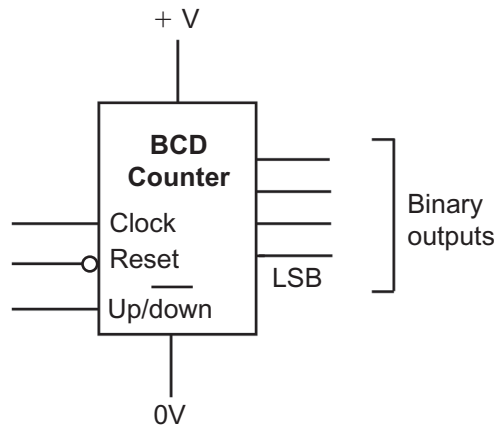


Fig. 2(d)

(iii) With the aid of a diagram explain how the binary counter shown in **Fig. 2(d)** could be used as a frequency divider. [4]

(e) A circuit is required to control the seven segment display shown in **Fig. 2(c)**. On the blank pro forma provided (answer number **2(e)**) design and annotate a circuit that will utilise the counter in **Fig. 2(d)** and additional circuitry to achieve the following:

- Provide a signal to start a 10 second time delay when a door is closed.
- Display the time remaining from nine to zero at one second intervals.
- Reset the counter in preparation for the next time the door is closed. [10]

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

Section B

Mechanical and Pneumatic Control Systems.

- 3 **Fig. 3(a)** shows an image of a prototype elevator that is used in buildings to transport people and goods between floors.

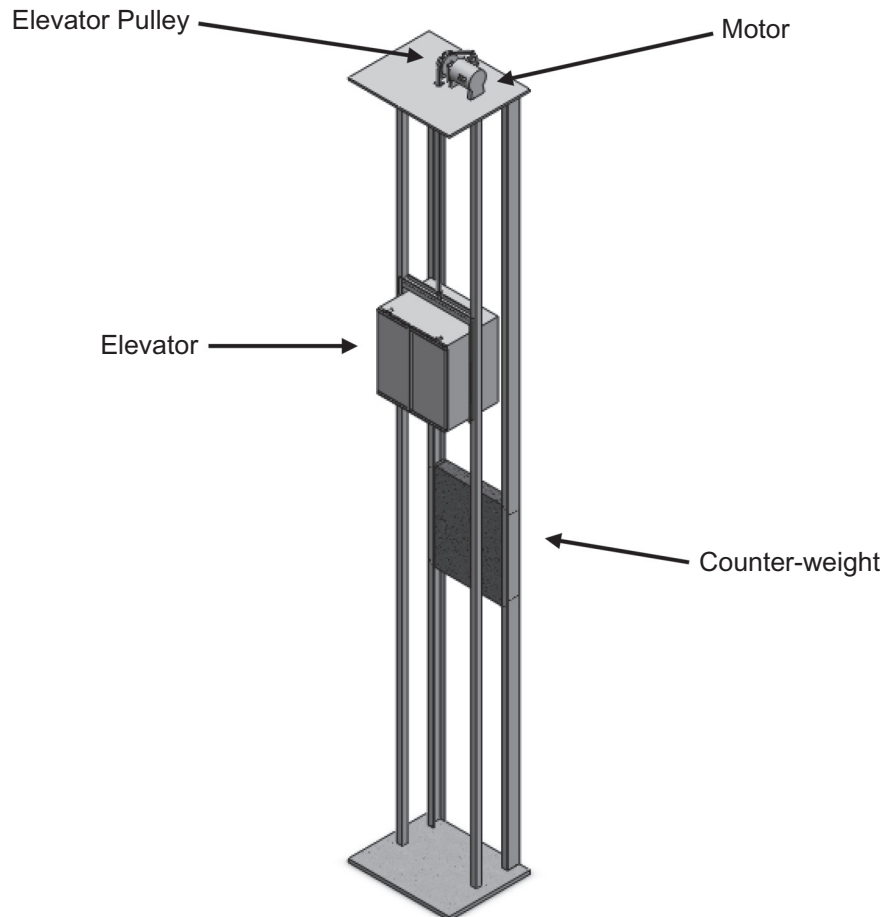


Fig. 3(a)

- (a) (i) Outline **two** main safety procedures associated with the use of mechanical control systems. [2]
- (ii) The elevator pulley lifts a load with a mass of 85 kg up a vertical height and gains 1981.5 kJ in potential energy before coming to rest. Calculate the vertical height the load is lifted (assume $g = 9.82 \text{ m/s}^2$). [3]
- (iii) Calculate the overall power required from the motor to lift the elevator 6.2 metres in 30 seconds if the gravitational force on the elevator is 6000 N. Assume a 20% loss of power due to friction. [4]

(b) Fig. 3 (b)(i) shows an image of a pulley and motor system commonly used in elevators.

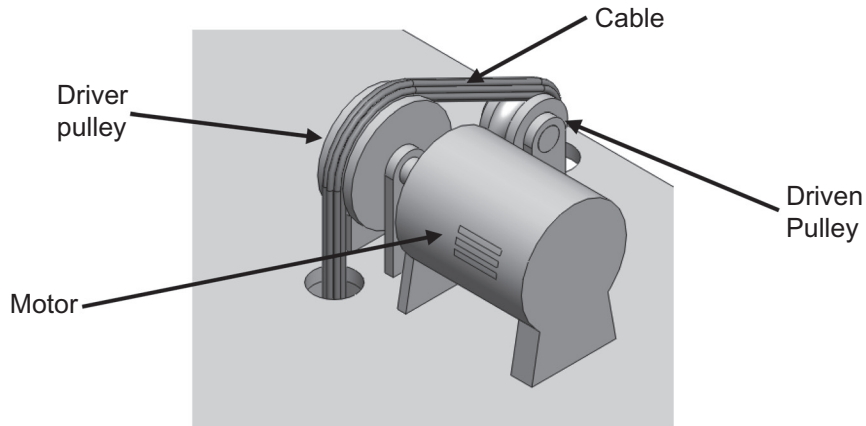


Fig. 3(b)(i)

- (i) Explain the difference between simple and compound pulley systems. [2]
- (ii) With reference to Fig. 3(b)(i) and Fig. 3(b)(ii) draw and explain how a ratchet and pawl mechanism could be incorporated with the pulley so that the cable can be locked in place during routine maintenance. [5]

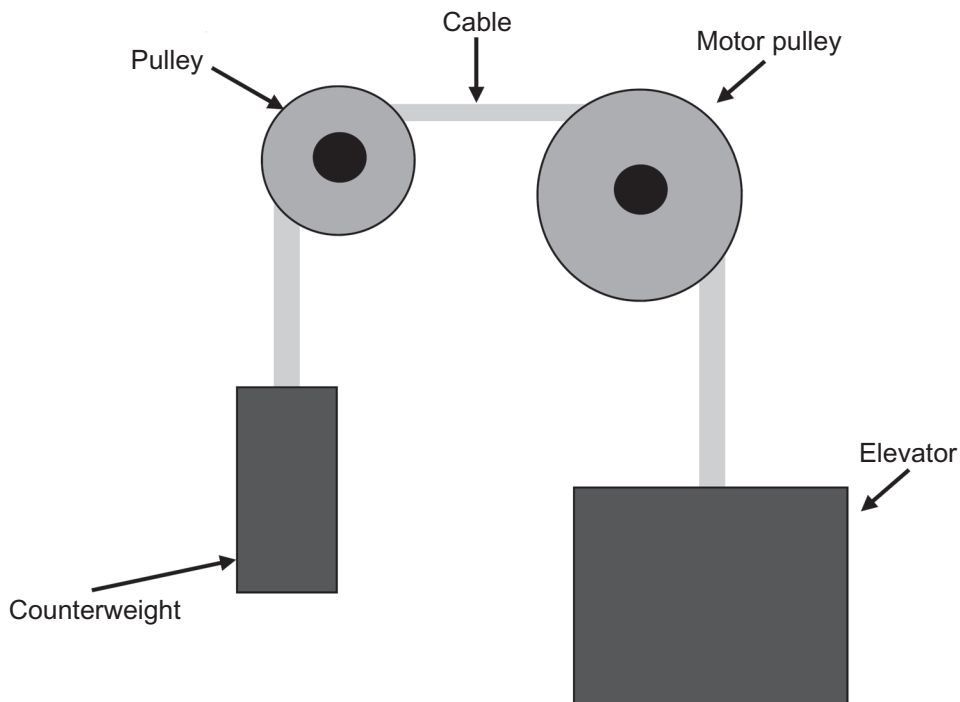


Fig. 3(b)(ii)

(c) The pulleys on the elevator system use brakes to slow down when the elevator reaches its selected floor. Outline **one** main advantage and **one** main disadvantage of each of the following brakes, disc and band. Justify why a disc brake may be used for the elevator. [5]

Quality of written communication [4]

(d) Fig. 3(d) shows a part sectional view of a pulley shaft and housing used in the elevator system. Using an annotated sketch show a suitable bearing to support the pulley shaft and outline an appropriate method to secure it in the housing while making provision for lubrication. [5]

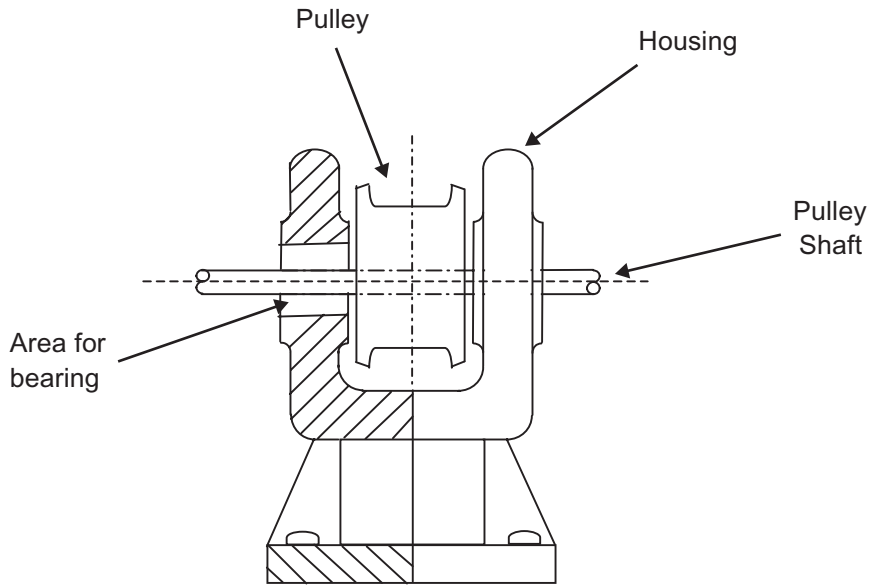


Fig. 3(d)

(e) On the pro forma provided (answer number 3(e)(i)) design, draw and annotate an appropriate mechanical system which would achieve the following requirement:

(i) A method of opening and closing the elevator doors A and B at the same time using the motor shaft. Your design must be held in the top compartment in Fig. 3(e)(i). Attachments must be clearly shown from the motor to the door connectors. [5]

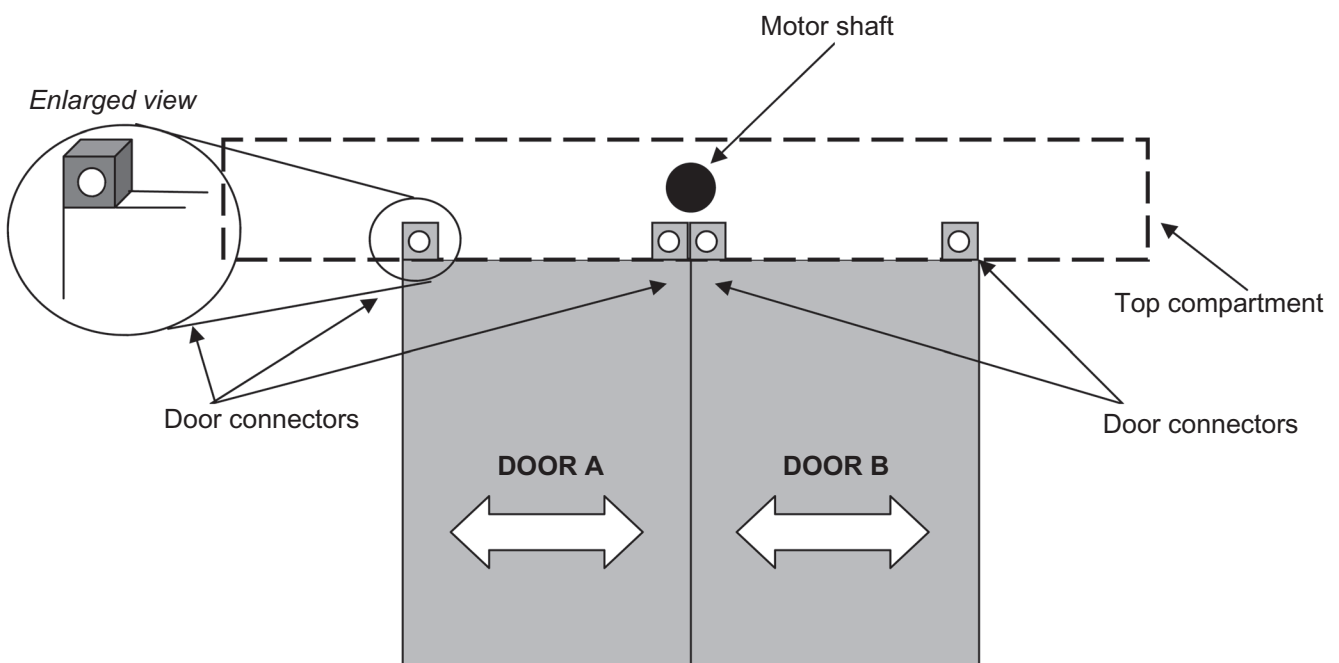


Fig. 3(e)(i)

(ii) In your answer booklet produce a suitable pulley design for the elevator (making reference to **Fig. 3(e)(ii)** below) using only pulleys with a diameter between 20 mm and 100 mm that will provide a suitable output speed to move the elevator 2.25 metres in 30 seconds. One rotation of the output shaft moves the elevator 25 mm. The input speed from the motor is 5760 rpm with both the input and output shafts required to rotate in an anticlockwise direction (**state clearly the diameter for each of the pulleys on shafts A, B, C and D**). **Fig. 3(e)(ii)** is not drawn to scale.

[5]

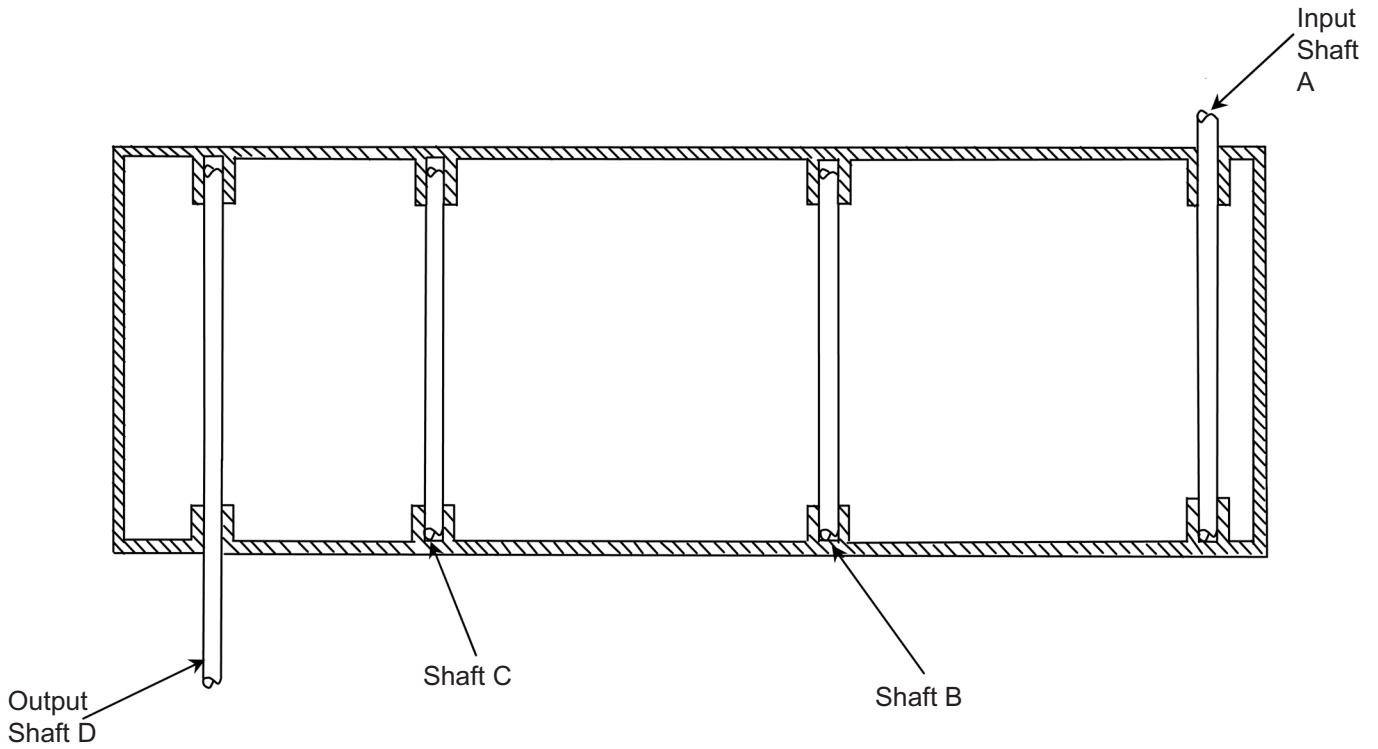


Fig. 3(e)(ii)

- 4 (a) (i) Explain what is meant by the term interlocking when applied to pneumatic systems. [2]
- (ii) Vacuum lifting cups are used on a range of pneumatic systems. Outline the main purpose of a lifting cup and name a specific application. [2]
- (b) (i) Calculate the work done by the cylinder in Fig. 4(b)(i) below if the force required to push the cylinder positive is 1800 N and the distance moved by the force is 400 mm. [2]

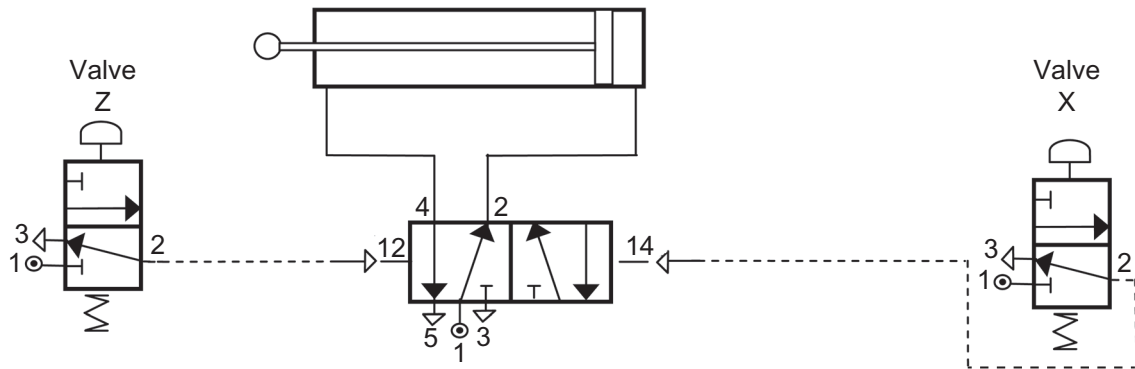


Fig. 4(b)(i)

- (ii) With reference to Table 1 and Fig. 4(b)(ii) select an appropriate piston rod size, cylinder size and air pressure in order to produce the maximum force during the instroke of the cylinder. Then select an appropriate piston rod size, cylinder size and air pressure in order to produce the minimum force during the instroke of the cylinder. In each case calculate the maximum and minimum forces for the values you have chosen from Table 1. [4]

Table 1

Available (d) piston rod sizes	Available (D) cylinder sizes	Available air pressure settings
14 mm	36 mm	2 bar
18 mm	48 mm	5 bar
22 mm	60 mm	8 bar

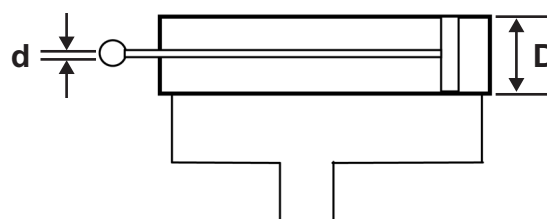


Fig. 4(b)(ii)

(c) The pro forma (answer number **4(c)**) shows a pneumatic conveyor system used in a box packaging company. The sequence is as follows:

- The packaged box enters the conveyor rollers from the factory chute. The sequence begins by activating the START 3PV.
- Cylinder A pushes the box down the rollers. The packaged box is detected by the air bleed and this sends Cylinder B positive.
- When Cylinder B is in the positive position it is detected by a micro-switch/solenoid operated 3/2 Valve which is used to send Cylinder B negative.
- When Cylinder B is in the negative position it is detected by the roller 3/2 Valve which is used to send Cylinder A negative.
- When Cylinder A is in the negative position it is detected by the roller 3/2 Valve which is used to send Cylinder C positive pushing the packaged box down the rollers.
- When Cylinder C is in the positive position it is detected by an air bleed which is used to send Cylinder C negative.
- When Cylinder C is in the negative position it is detected by the 3/2 Valve which is used to send Cylinder D positive pushing the packaged box down the rollers.
- When Cylinder D is in the positive position it is detected by the 3/2 Valve which is used to send Cylinder D negative.
- Detection of Cylinder D in the negative position will repeat the sequence.

On the pro forma provided (answer number **4(c)**) draw a suitable pneumatic circuit with any additional components to achieve the desired sequence outlined above. [20]

(d) On the pro forma provided (answer number **4(d)(i) and (ii)**) design and draw a system which will:

- (i) Use a mechanical linkage attached to Cylinder F to enable the packaged box to be flipped 90 degrees on the cylinder instroke before it reaches the shrink wrap area. Mechanical attachments to the cylinder must be clearly demonstrated. [4]

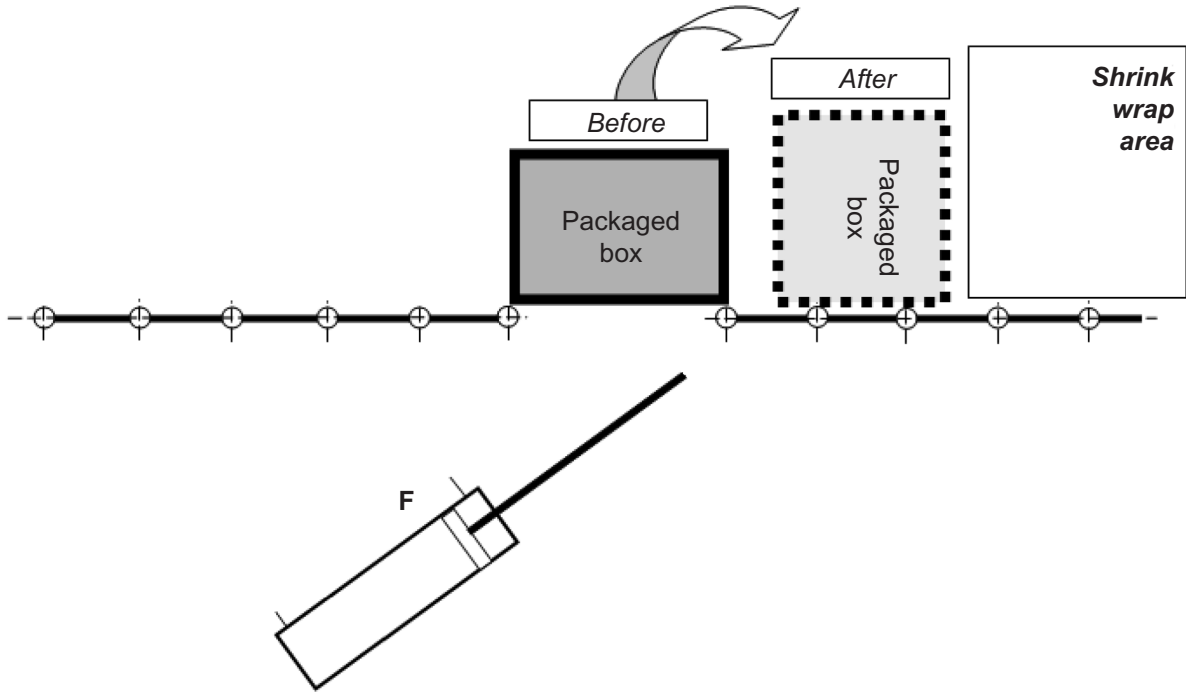


Fig. 4(d)(i)

- (ii) Independently use a proximity sensor to activate Cylinder E enabling it to stamp the packaged boxes when they enter the chute and then after a short time delay automatically retract. [6]

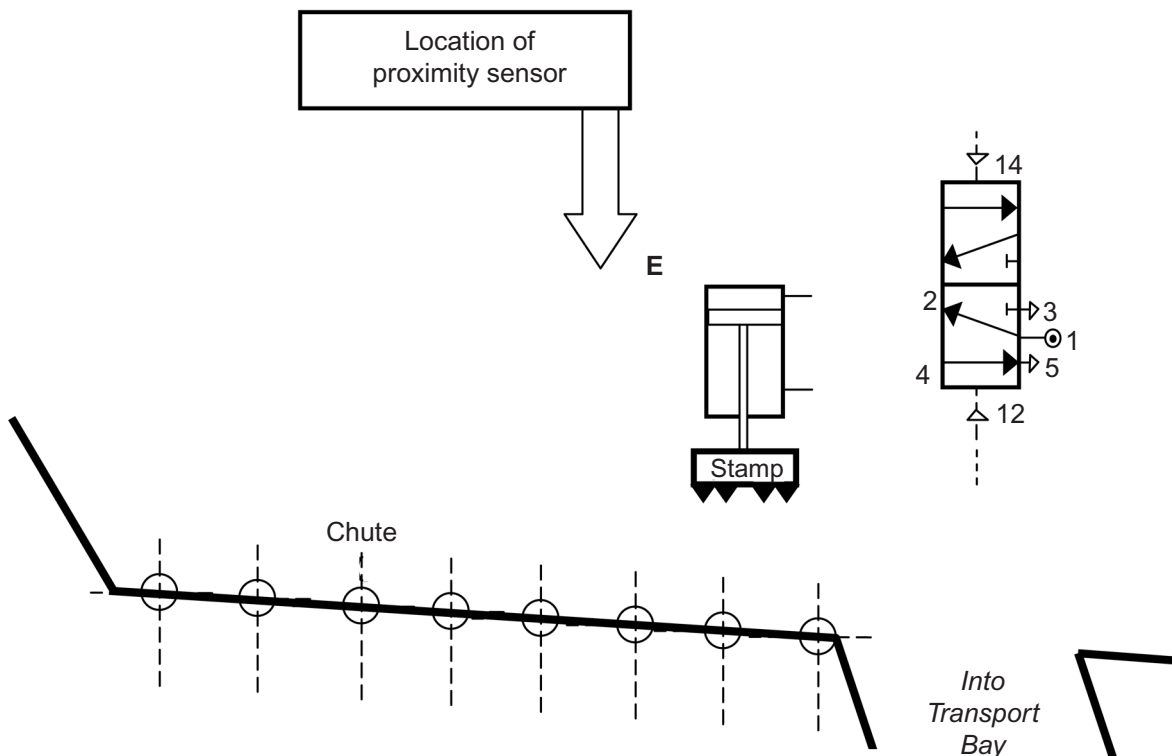


Fig. 4(d)(ii)

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

Section C

Product Design

5 Electronic consumer products such as mobile phones and games consoles are constantly developing as technology changes. Some of these products may be described as fulfilling a need while others may be described as satisfying a demand.

(a) Briefly distinguish between needs and demands with regards to the creation of products. [2]

(b) The introduction of new electronic products to the market may be as a result of technology push or market pull.

(i) With reference to electronic products outline **two** main factors associated with technology push. [4]

(ii) With reference to electronic products outline **two** main factors associated with market pull. [4]

(c) For many mobile phone companies the results obtained from detailed market research form the direction a company will take with its product range.

This detailed market research may include exploratory, explanatory and predictive projects. With reference to mobile phones explain **two** main characteristics associated with each of the following:

- Exploratory projects.
- Explanatory projects.
- Predictive projects. [6]

(d) Information and Communication Technology (ICT) is used to implement these market research projects and to analyse the outcome from the research.

(i) Briefly outline **two** different ways in which ICT is used to implement market research projects. [2]

(ii) Briefly outline **two** different ways in which ICT is used to analyse the outcome from the research. [2]

(e) For mobile phone companies understanding the types of consumers who emerge at each stage of the life cycle of their product is important.

With reference to mobile phones briefly explain **two** main characteristics associated with each of the following types of consumer:

- Opinion leaders.
- Late adopters. [4]

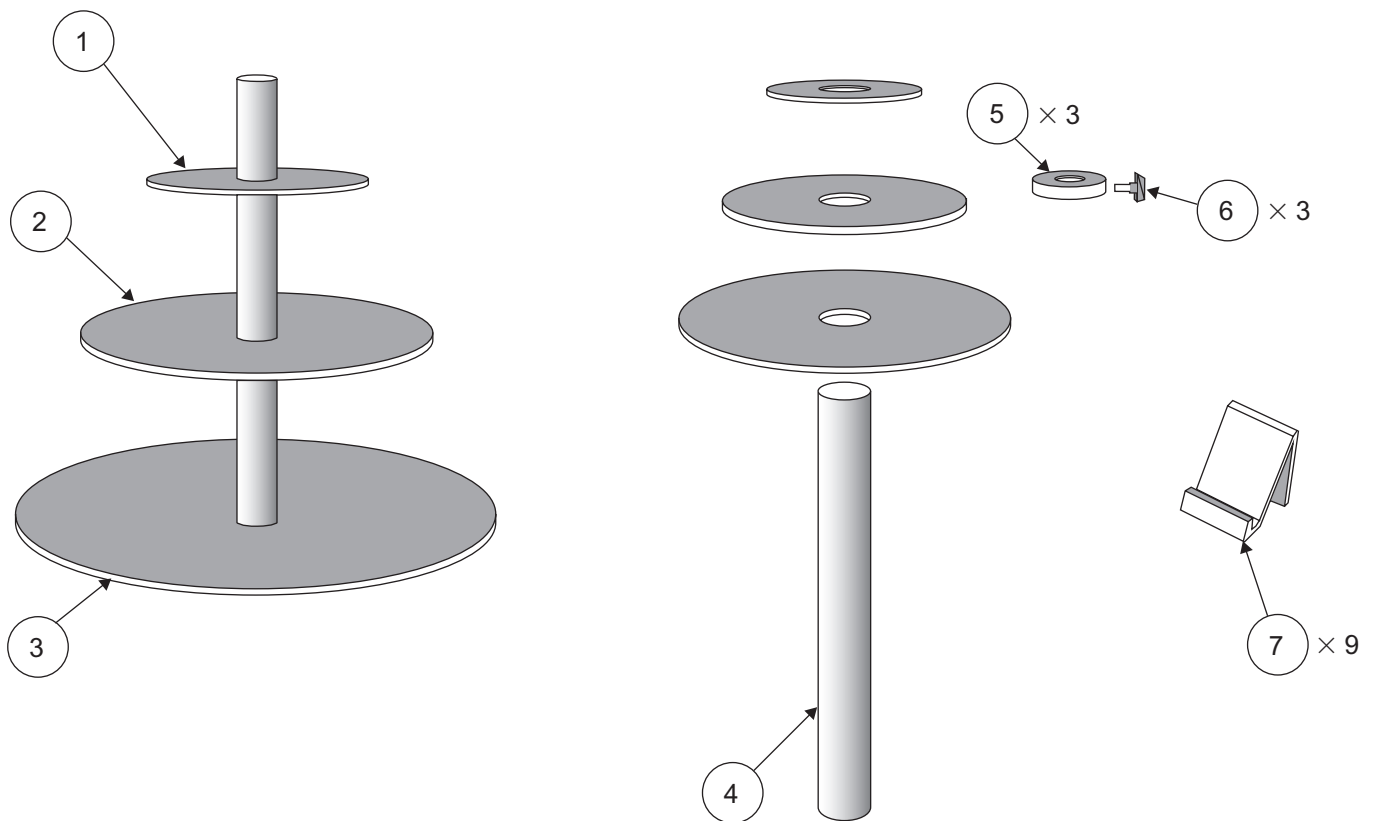
(f) The management of waste, the disposal of products and the control of pollution present real environmental challenges to electronic companies.

(i) Give **two** main environmental reasons why it is so important for electronic companies to consider the management of waste. [2]

(ii) Briefly outline **two** different ways in which electronic companies can start to address environmental issues through the disposal of products. [2]

(iii) Briefly outline **two** different ways in which electronic companies can start to address environmental issues through pollution control. [2]

(g) Eye catching shop window displays for mobile phones are used to attract the attention of customers. **Fig. 5(g)** shows drawings and information on a student's design for a stand in order to display nine mobile phones in a shop window. These nine phones will sit in the phone display with two on the top tier, three on the middle and the remaining four on the bottom tier. The base of this stand will eventually be connected to a motor to enable the display to rotate.



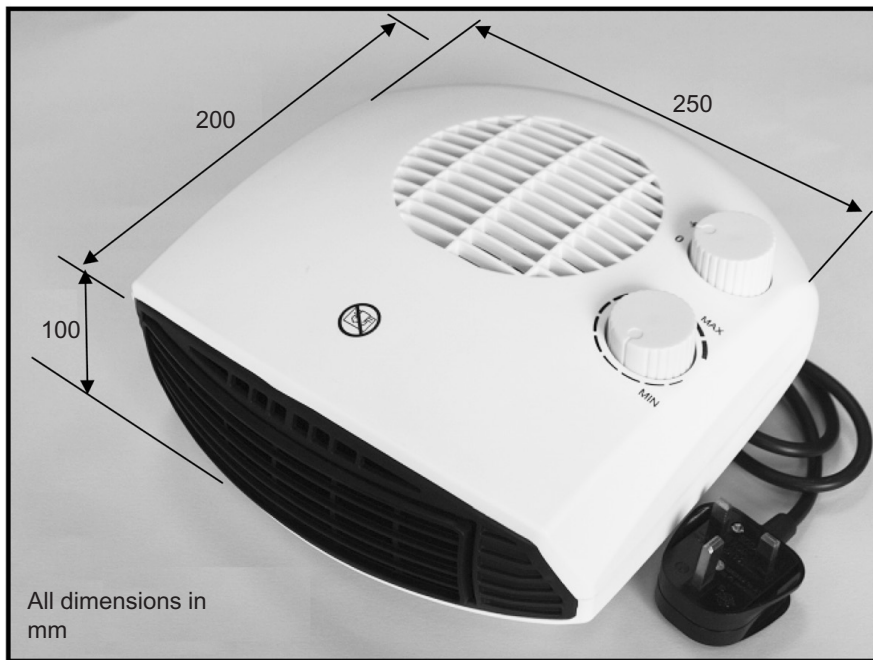
Reference/ Description	Material	Measurements	Processes
1. Top tier	Medium Density Fibreboard (MDF)	12 mm thick and 200 mm diameter	Cut, drilled, sanded, sealed and paint sprayed
2. Middle tier	Medium Density Fibreboard (MDF)	12 mm thick and 300 mm diameter	Cut, drilled, sanded, sealed and paint sprayed
3. Bottom tier	Medium Density Fibreboard (MDF)	12 mm thick and 400 mm diameter	Cut, drilled, sanded, sealed and paint sprayed
4. Centre column	Mild steel	50 mm diameter tubing with 3 mm wall thickness	Chrome plated
5 Support plate	Plastic (nylon)	120 mm diameter and 20 mm thick (glued to bottom of tiers)	Lathe work
6. Thumb screw	Plastic (nylon)	60 mm long	Lathe work
7. Phone display	Acrylic	80 mm wide 340 mm long	Cut, edges prepared and folded

Fig. 5(g)

- (i) With reference to **Fig. 5(g)** above and using the blank A3 pro forma provided (answer number **5(g)(i)**) produce detailed annotated sketches of modifications you would make to the design in order to make it a viable product by fulfilling the following requirements:
- Modifications to any **three** components in order to minimise the use of materials whilst maintaining its display function. [3]
 - Modifications to any **three** components in order to minimise the use of manufacturing processes. [3]
- (ii) In your answer booklet explain:
- **Two** different methods which the manufacturer could adopt in order to reduce the product's environmental impact. [2]
 - With reference to **two** different original components of the product why they would be suitable for batch production. [2]

- 6 The companies which design and manufacture domestic products such as the electric heater shown in **Fig. 6(f)(i)** place great value on the use of market research.
- (a) (i) Briefly outline the main purpose associated with market research. [1]
- (ii) When researching the market the company consulted a marketing information system.
- Briefly explain **two** main characteristics associated with each of the following tasks of a marketing information system:
- Price research.
 - Promotional research.
 - Market testing. [6]
- (b) In the company's environmental policy, reference is made to the need to consider alternative renewable energy sources to power the plant.
- (i) Explain the basic principles of wind as a renewable energy source. [3]
- (ii) Explain the basic principles of biomass as a renewable energy source. [3]
- (c) Many products on the market including the heater shown in **Fig. 6(f)(i)** have different life cycles.
- (i) Outline the life cycle for a fashion product of your choice. [2]
- (ii) Outline the life cycle for a basic product of your choice. [2]
- (d) Designers such as Trevor Baylis have had a great influence on revitalising many electronic products.
- Describe and fully justify with reference to **five** main discussion points the impact that Trevor Baylis has had on product design. [5]
- Quality of written communication [4]
- (e) The domestic electric heater shown in **Fig. 6(f)(i)** has a two part injection moulded plastic housing.
- Explain **two** main quality control processes that may be used for the plastic housing. [4]

(f) (i) Fig. 6(f)(i) shows a photograph of the heater with some key overall dimensions of the product.



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Fig. 6(f)(i)

On the blank A3 pro forma provided (answer number **6(f)(i) and (ii)**) design and draw suitable packaging for the heater which will give adequate protection to the product, have a suitable surface for printing on and will use the minimum amount of material (specify the types, sizes and thicknesses of materials to be used). [5]

(ii) Fig. 6(f)(ii) below shows a photograph of the base and part drawings of the heater.



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Base of heater

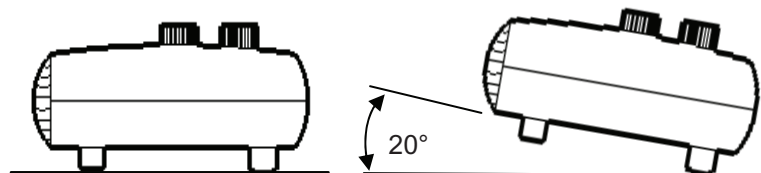


Fig. 6(f)(ii)

On the blank A3 pro forma provided (answer number **6(f)(i) and (ii)**) design an appropriate means which will allow the user to quickly and securely change the elevation of the front of the heater to a single preset angle of approximately 20°. Your design should be low cost, permanently fixed to the base of the heater and be suitable for batch production. [5]

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Question No. 1(d)

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Candidate Number

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

Question No. 2(e)

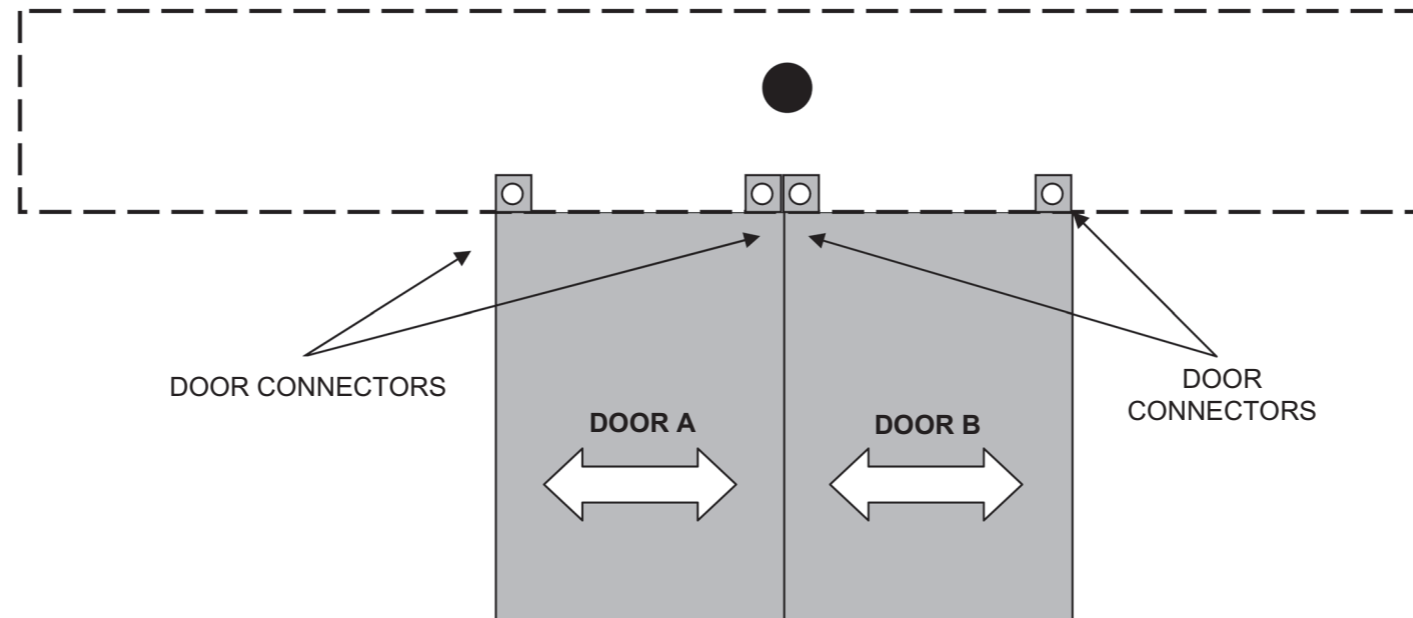
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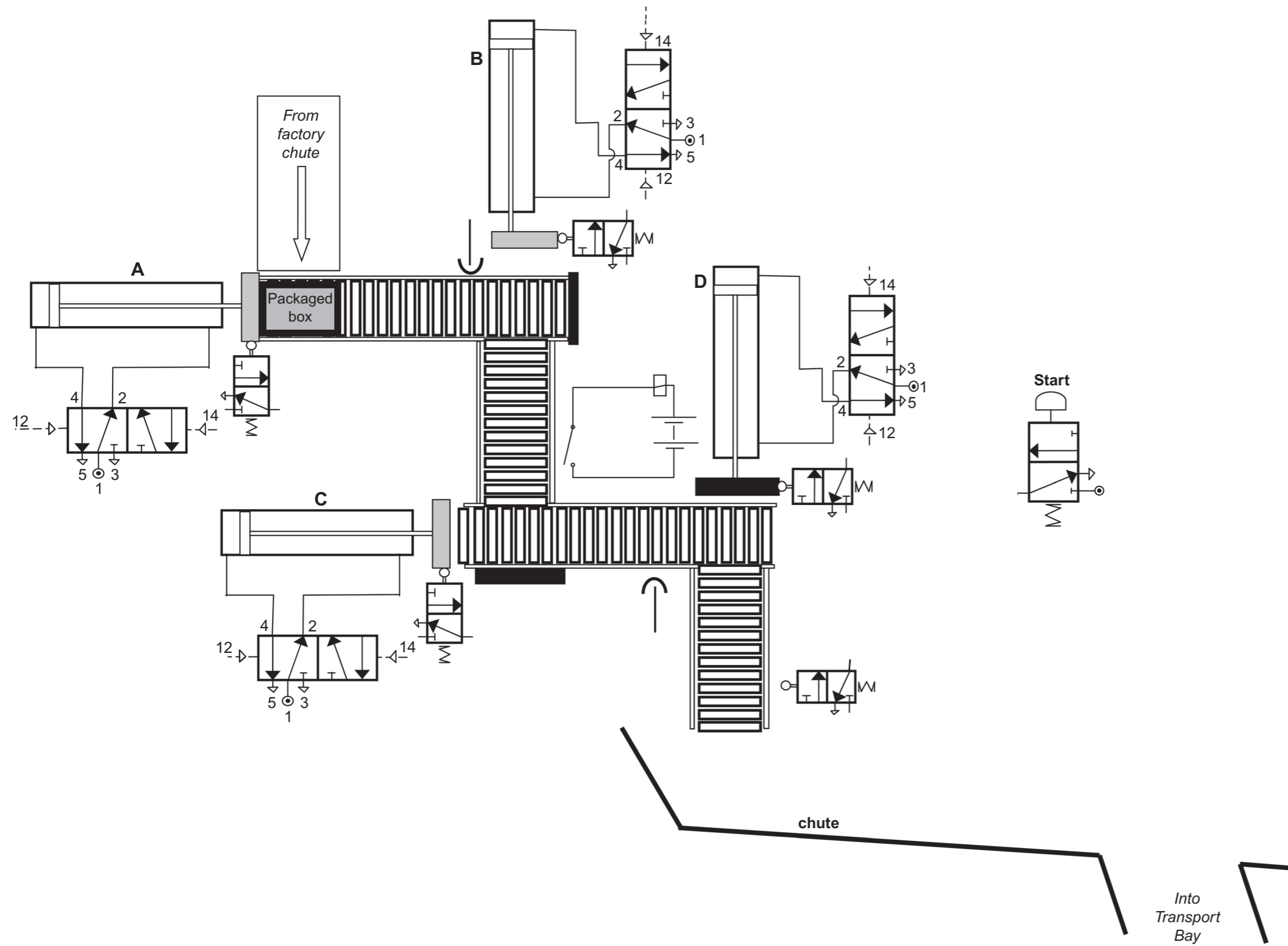
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Candidate Number

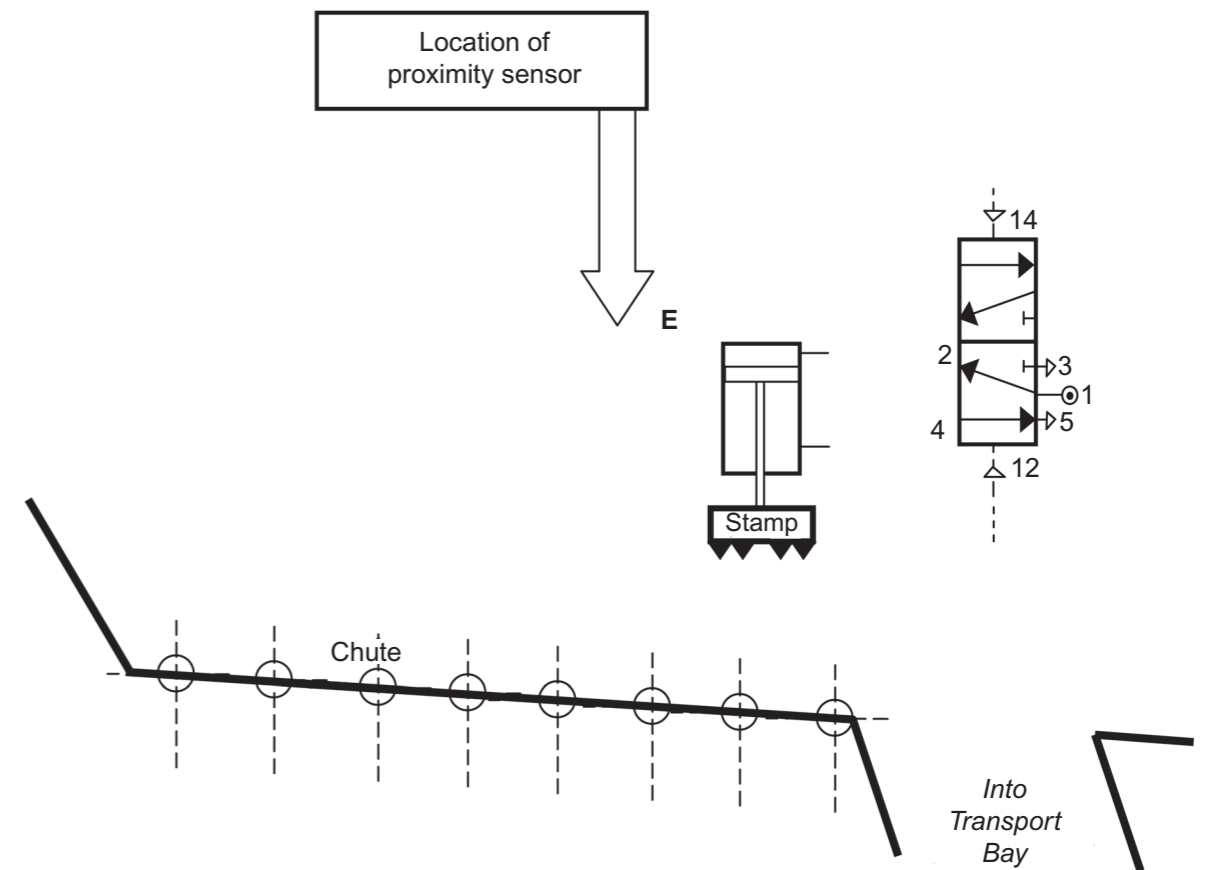
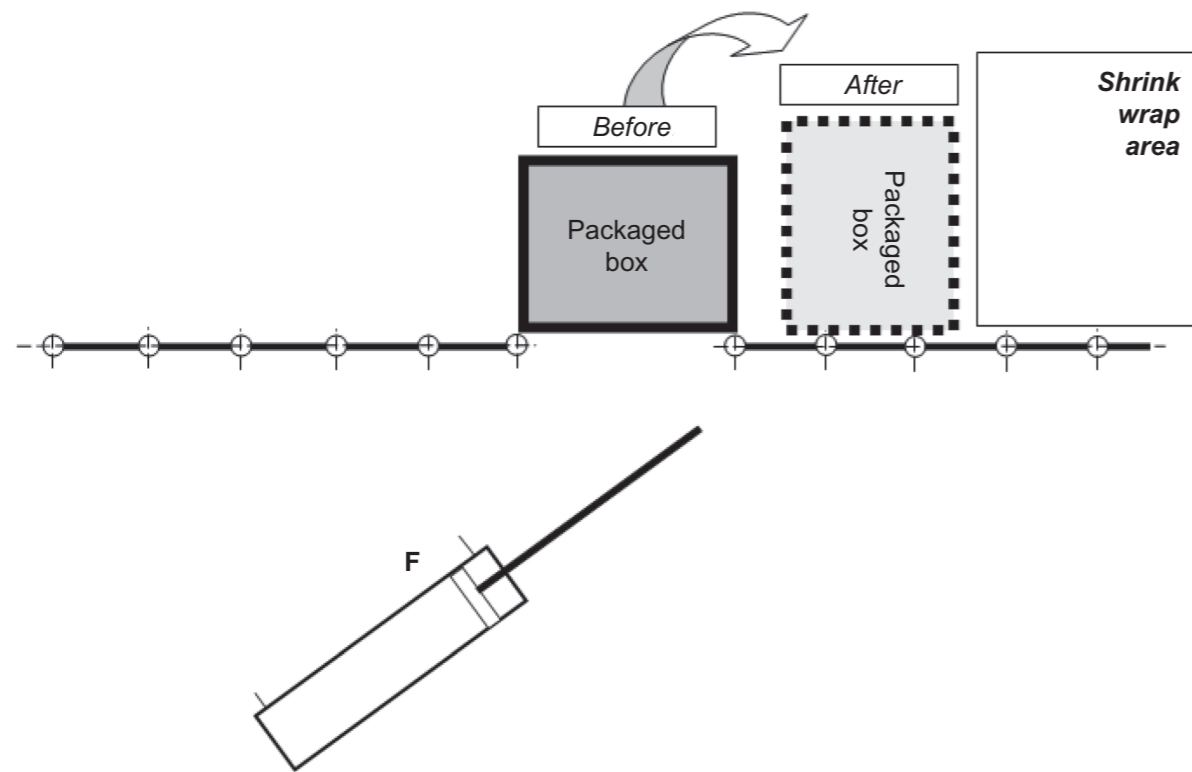
Pro forma answer page
(answer number 2(e))



**Pro forma answer page
(answer number 3(e)(i))**



Pro forma answer page
(answer number 4(c))



Pro forma answer page
(answer number 4(d)(i) and (ii))

Question No. 5(g)(i)

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

Question No. 6(f)(i) and (ii)

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Pro forma answer page
(answer number 6(f)(i) and (ii))