



General Certificate of Secondary Education
2024

Centre Number

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Candidate Number

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Technology and Design

Unit 2

Option B:

Mechanical and Pneumatic
Control Systems

MV18

[GTY22]

WEDNESDAY 12 JUNE, MORNING

Time

1 hour 30 minutes, plus your additional time allowance.

Instructions to Candidates

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write on blank pages.

Questions which require drawing or sketching should be completed using an H.B. pencil.

All other questions must be completed using black ink only.

Answer **both** questions.

Information for Candidates

The total mark for this paper is 100.

Quality of written communication will be assessed in Question **2(f)**.

Figures in brackets printed at the end of each question indicate the marks awarded to each question or part question.

The Formula sheet is on page 3.

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Formulae for GCSE Technology and Design

You should use, where appropriate, the formulae given below when answering questions which include calculations.

1 Gear ratio of a simple gear train = $\frac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}}$

For a compound gear train:

Total Gear ratio = the product of the gear ratios of all the subsystems

i.e. $\mathbf{GR_T = GR_1 \times GR_2 \times GR_3 \dots}$

2 Velocity Ratio = $\frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$ or $\frac{\text{Diameter of driven}}{\text{Diameter of driver}}$

3 Mechanical Advantage = $\frac{\text{Load}}{\text{Effort}}$

4 Efficiency (%) = $\left(\frac{\text{mechanical advantage}}{\text{velocity ratio}} \right) \times 100$

5 Force = Pressure \times Area ($F = P \times A$)

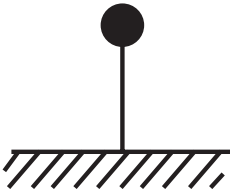
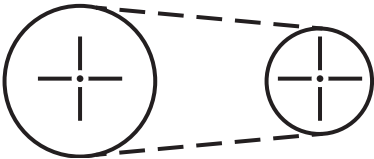
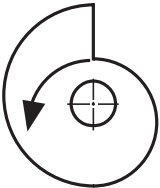
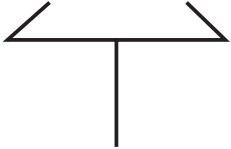
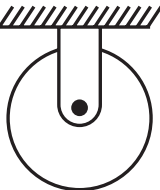
6 Circumference of a circle = $\pi \times \text{diameter}$

7 Area of a circle = πr^2

Answer All Questions

- 1 (a) Complete **Table 1** by naming each of the mechanical symbols and inserting the appropriate letter from the list opposite to describe its function. Each letter may be used only once. [10 marks]

Table 1

Symbol	Name of symbol	Function
		
		
		
		
		

Function

- A** Allows movement around a point.
- B** To enable the output to rise slowly and fall suddenly.
- C** To change the direction of rotation through 90 degrees.
- D** Transmits motion from one parallel shaft to another.
- E** Changes the direction of the effort to lift a load.

(b) Fig. 1 shows an image of a child's pencil case.

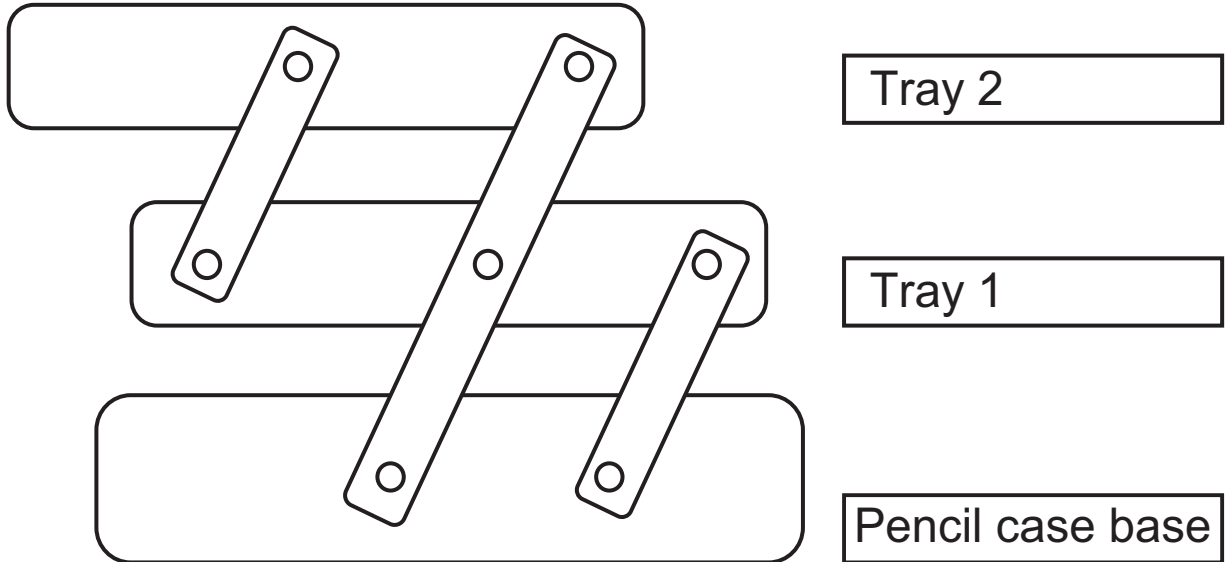
Fig. 1



(i) State the name of the linkage shown in **Fig. 1**.
[1 mark]

(ii) **Fig. 2** shows a drawing of the linkage in **Fig. 1**.
Mark with an **X** the fixed pivot points. [2 marks]

Fig. 2



(iii) Outline **two** reasons why this type of design is suitable for the pencil case shown in **Fig. 1**.
[1 mark for each]

1. _____

2. _____

- (c) (i) Pulleys and belts are used in many transmission systems. **Table 2** gives three examples of applications for belt drives. Complete **Table 2** by identifying the most appropriate belt from the list given, each belt should be used only once.
[3 marks]

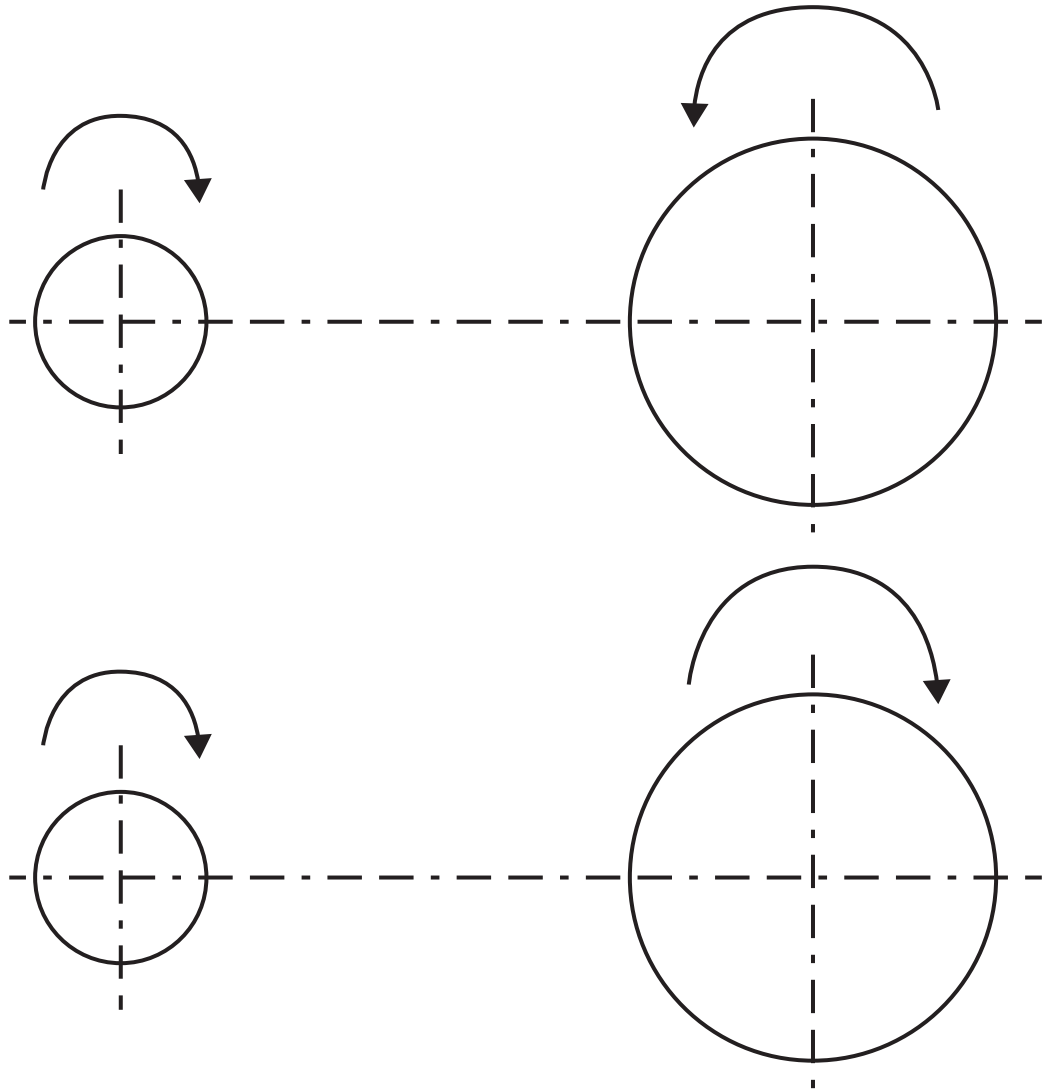
Flat belt
Toothed belt
Round belt

Table 2

Application	Type of belt
Vacuum cleaner brush head	
Running belt of a treadmill	
Timing belt for a car	

- (ii) Complete the sketches in **Fig. 3** to show the belt arrangements needed to transmit the motion shown by the arrows. [2 marks]

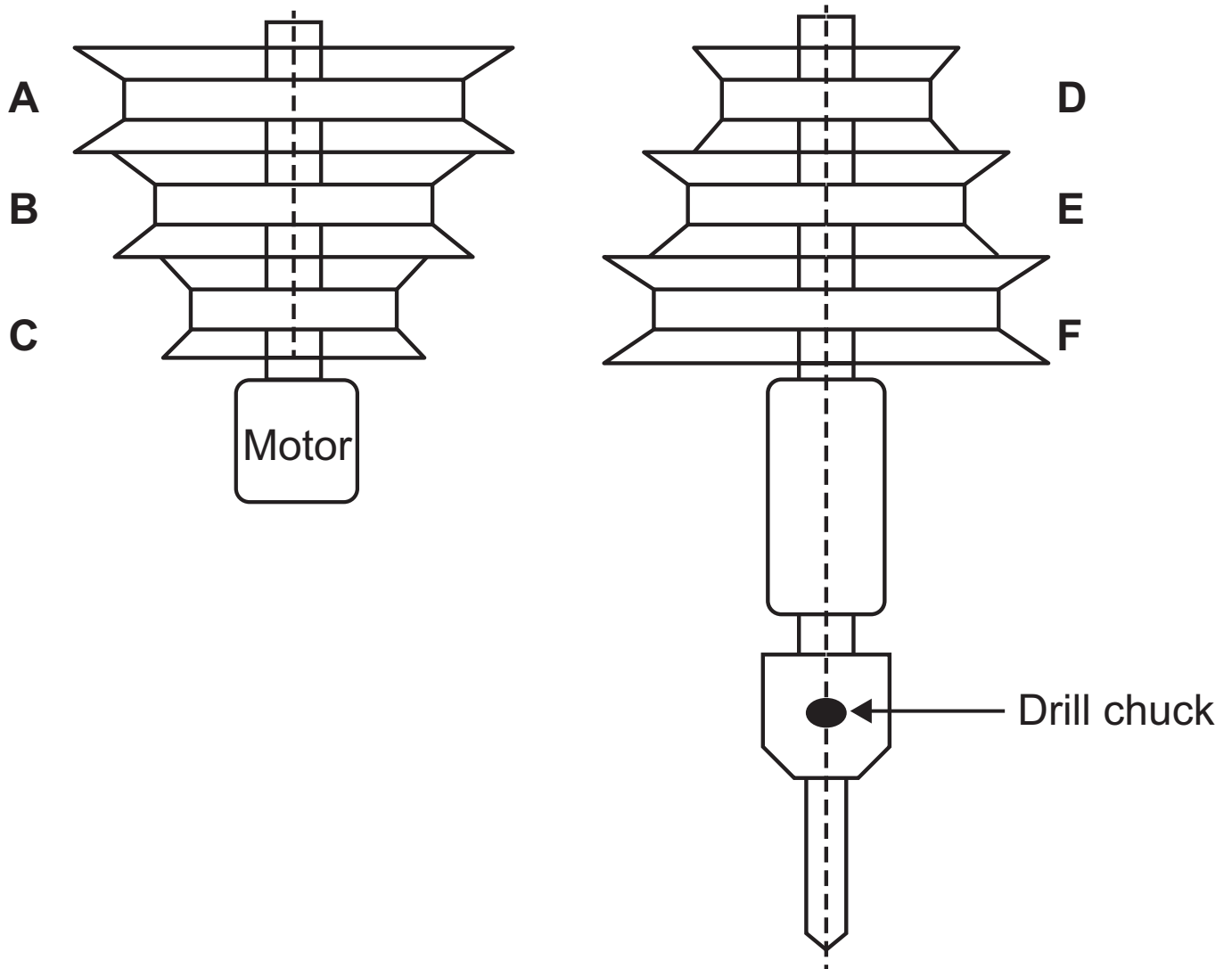
Fig. 3



(d) Pillar drills can be pulley driven or gear driven.

Fig. 4 shows a pulley drive arrangement for a pillar drill.

Fig. 4



(i) Name a suitable belt that could be used with this pulley drive system. [1 mark]

(ii) Sketch the cross section of the belt that would be used with this pulley drive system. [1 mark]

(iii) **Table 3** gives information about this pulley drive arrangement. Assuming a constant motor speed, complete **Table 3**. [3 marks]

Table 3

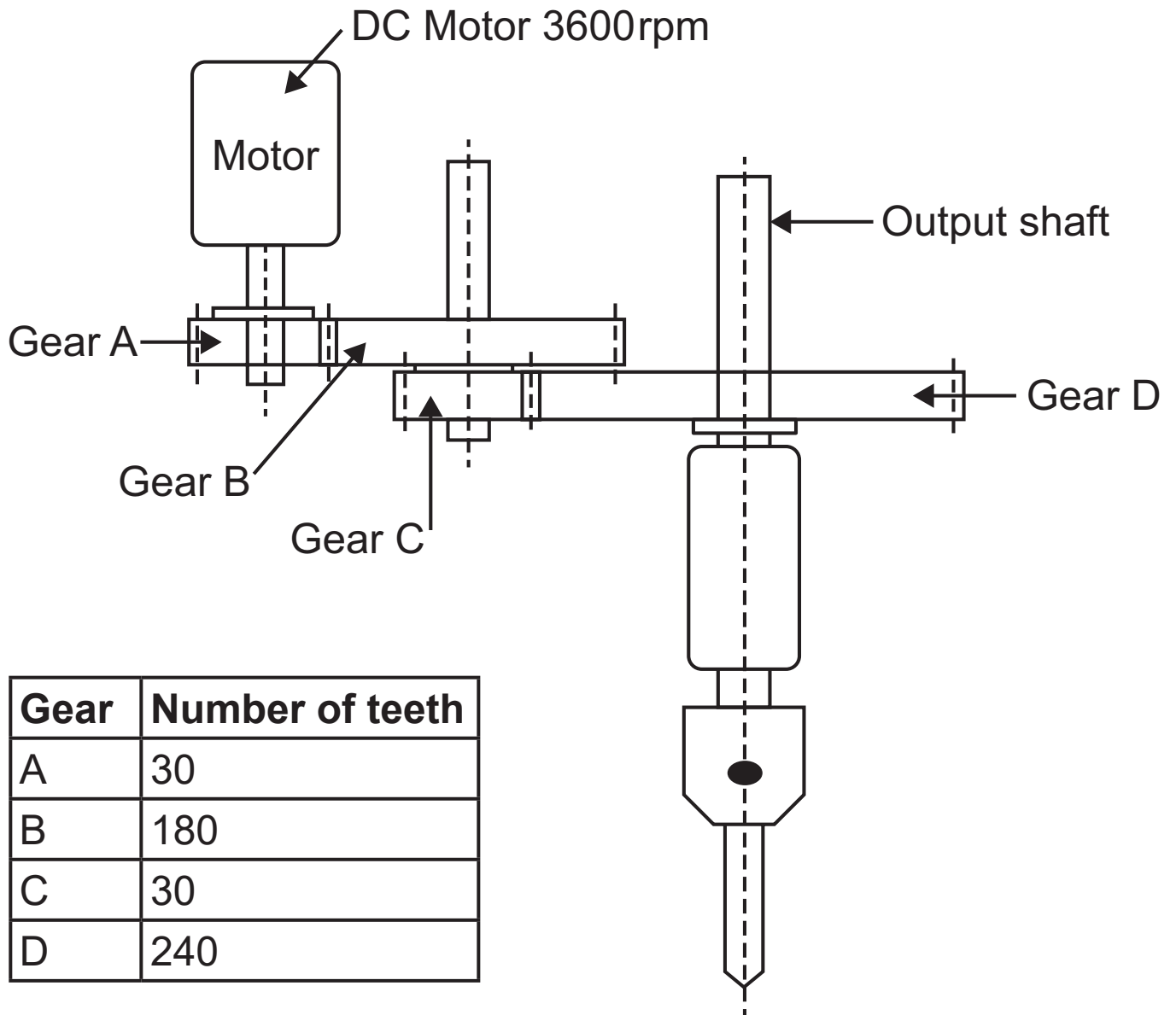
Name of the Driver pulley	Diameter in mm	Name of the Driven pulley	Diameter in mm	Velocity Ratio	Output speed
A	270	D	45	1:6	
B		E	120	1:1	360
C	45	F	270		60

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

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(Questions continue overleaf)

The manufacturer has decided to produce a pillar drill with a gear driven system as shown in **Fig. 5**.

Fig. 5



(iv) Calculate the gear ratio for the system in **Fig. 5**.

Candidates need to show their working out in the space below. [3 marks]

Answer _____

(v) Calculate the speed of the output gear **D** as shown on **Fig. 5**. [2 marks]

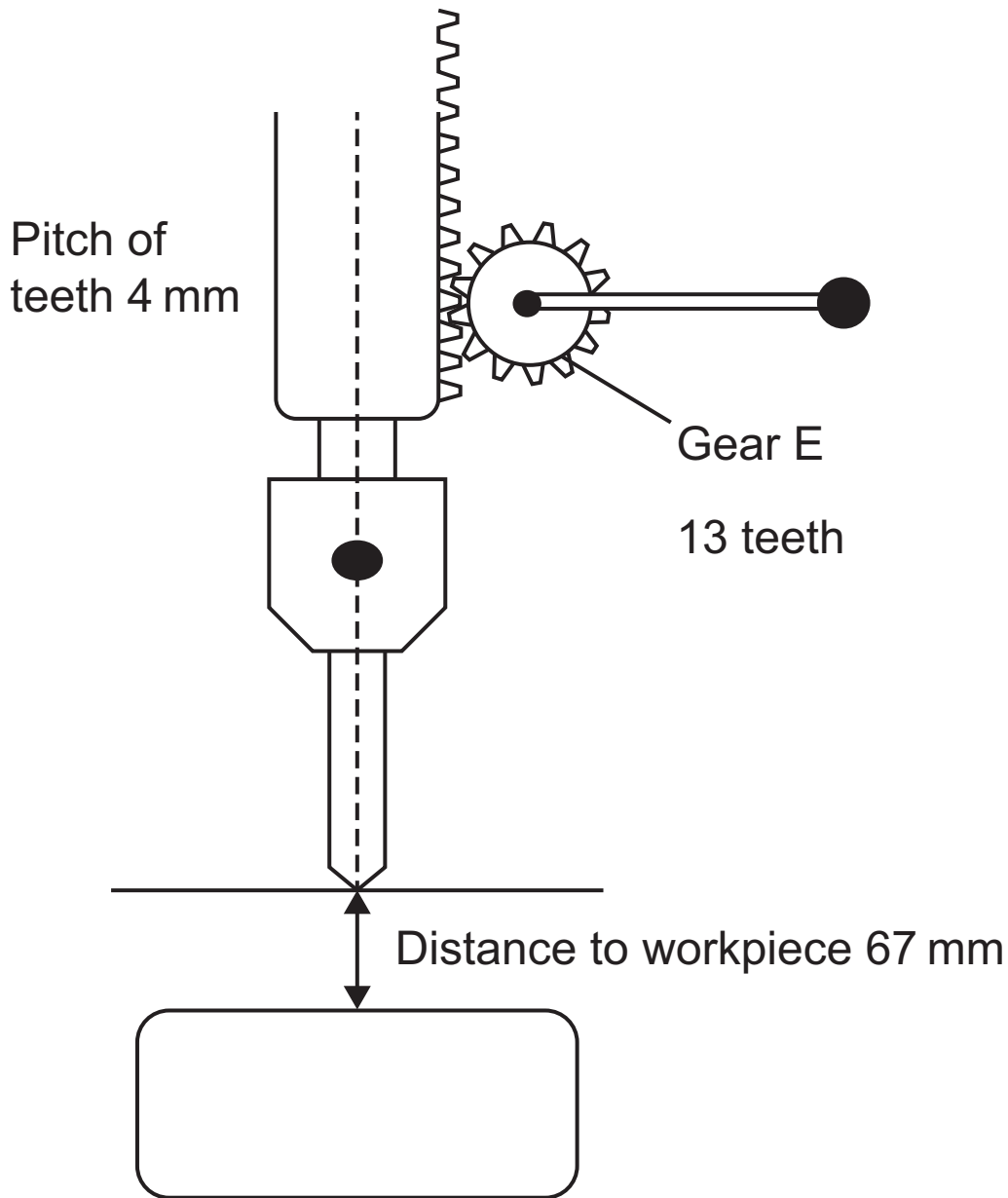
Candidates need to show their working out in the space below.

Answer _____

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The pillar drill has a mechanism for lowering the drill bit into the workpiece as shown in the schematic diagram **Fig. 6**.

Fig. 6



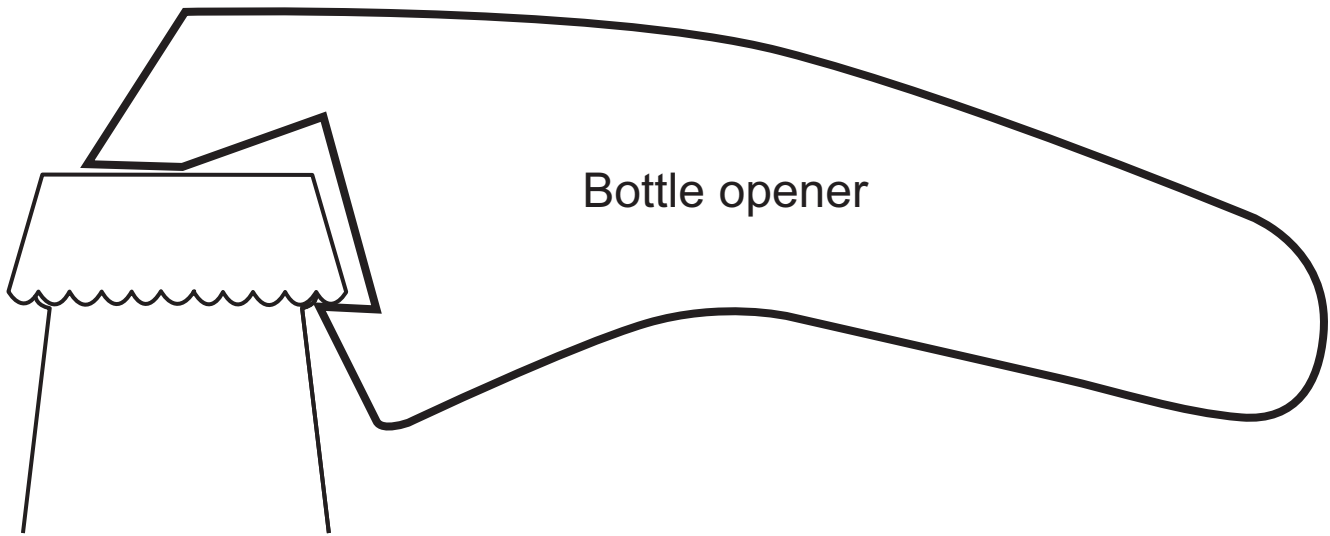
(vi) What is the name of the mechanism for lowering the drill as shown in **Fig. 6**? [1 mark]

(vii) Calculate how many times the handle must be rotated to allow a hole of 50 mm deep to be drilled in the workpiece. Candidates need to show their working out in the space below. [3 marks]

Answer _____

(e) Fig. 7 shows a diagram of a bottle opener in use.

Fig. 7



(i) Give **two** reasons why stainless steel would be a suitable material for this bottle opener. [2 marks]

1. _____

2. _____

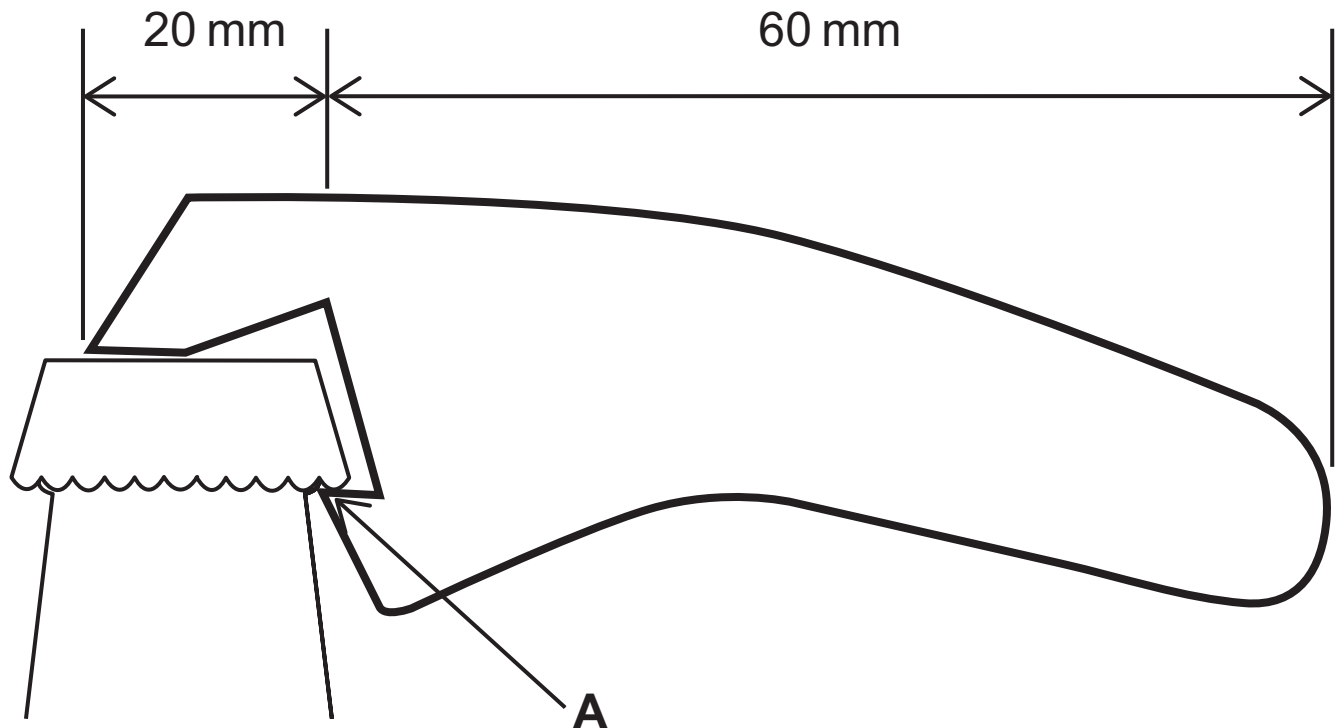
(ii) On **Fig. 7**, use arrows and labels to identify the fulcrum, load and effort. [3 marks]

(iii) State the class of lever shown in **Fig. 7**. [1 mark]

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(Questions continue overleaf)

(iv) If a 15 N effort is required by the user to remove the cap, how much force is produced at point **A** as shown in **Fig. 8** below?

Fig. 8



Candidates need to show their working out in the space below. [2 marks]

Answer _____

- (v) Calculate the mechanical advantage of the bottle opener shown in **Fig. 8**. Candidates need to show their working out in the space below. [2 marks]

Answer _____

- (vi) The effort is required to move 44.8 mm to allow the lid to be removed from the bottle. This will lift the lid by 2.8 mm. Calculate the efficiency of this bottle opener. Candidates need to show their working out in the space below. [3 marks]



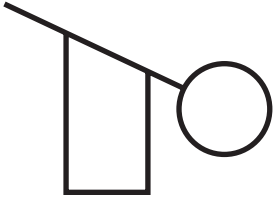

Answer _____

(vii) The bottle opener in **Fig. 8** is to be manufactured to allow easier use for elderly people. Show with the aid of a detailed and annotated sketch, or sketches, how this bottle opener could be re-designed to be more user friendly for this market. [3 marks]

2 **Table 4** shows the pneumatic symbols for methods of valve actuation.

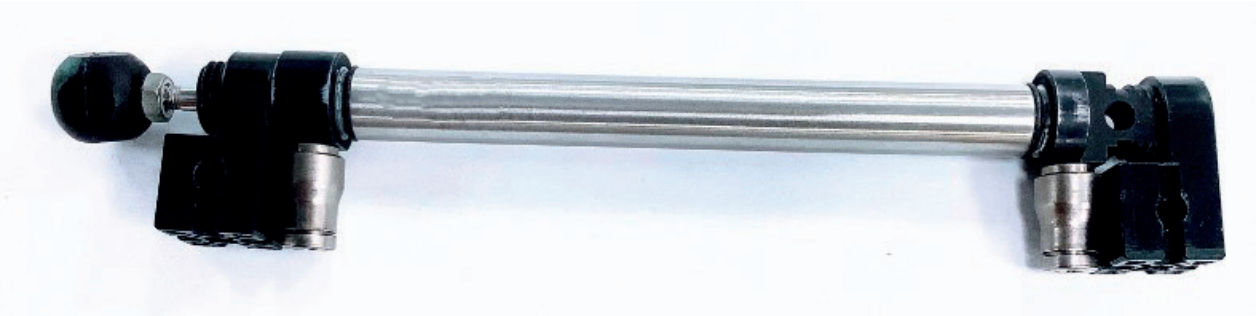
(a) Complete **Table 4** by inserting the correct name for each method of actuation. [4 marks]

Table 4

Symbol	Name of Symbol
	
	
	
	

(b) Fig. 9 shows a pneumatic component.

Fig. 9



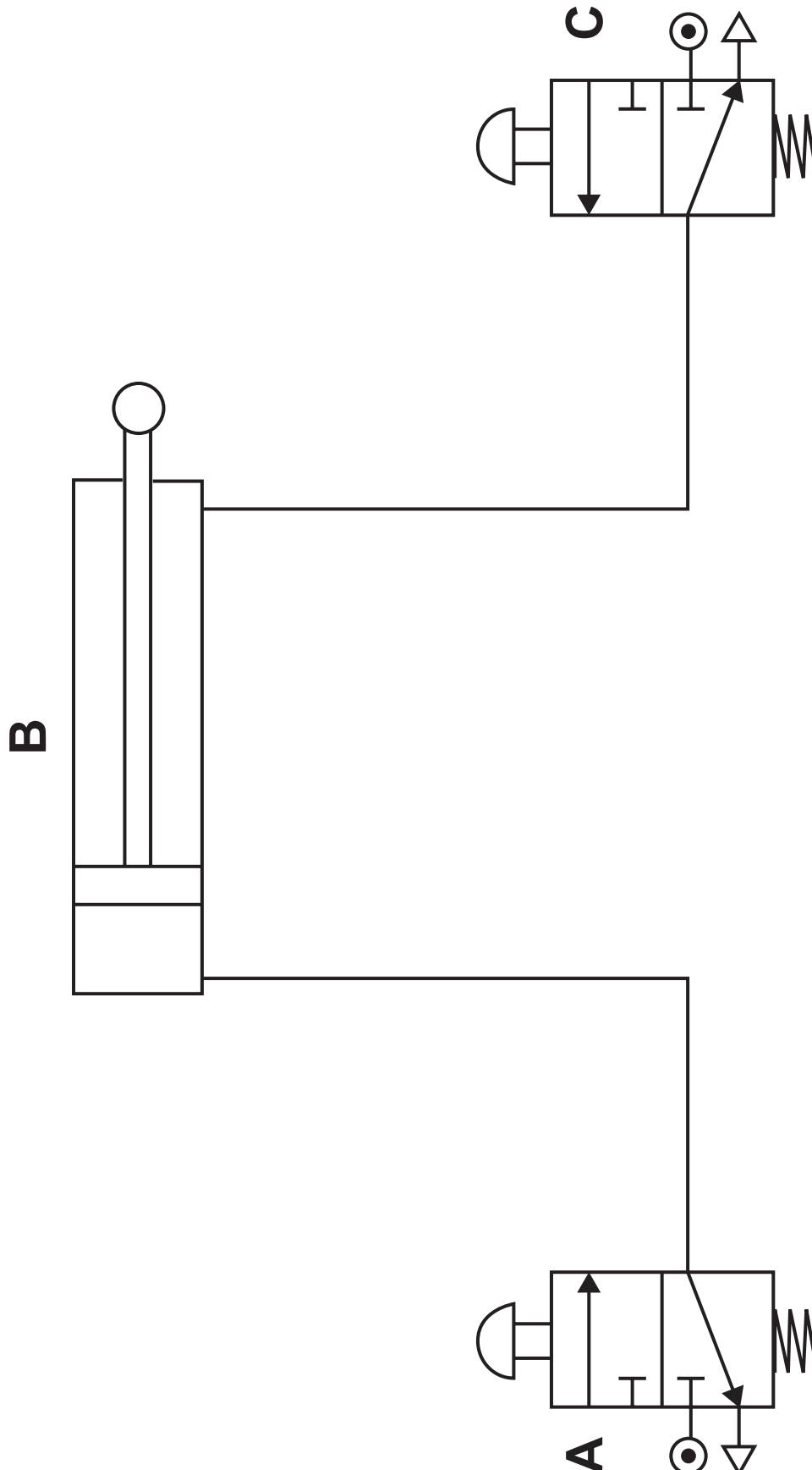
(i) Identify the pneumatic component shown in **Fig. 9**.
[1 mark]

(ii) What unique feature helps to identify it? [1 mark]

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(Questions continue overleaf)

(c) Fig. 10 shows a pneumatic circuit used to outstroke and instroke component **B**.

Fig. 10



(i) Name the component labelled **A**. [1 mark]

(ii) For the component **A** state the: [2 marks]

method of operation:

method of return:

(iii) It was found that the speed of operation of component **B** was too fast. Modify **Fig. 10** to enable the outstroke and instroke of component **B** to be controlled. [3 marks]

(iv) Which component controls the outstroke?
[1 mark]

Which component controls the instroke?
[1 mark]

(v) A total force of 500 N is needed to outstroke component **B**. The diameter of component **B** is 50 mm. Calculate, in N/mm^2 , the air pressure required to outstroke component **B**. [3 marks]
Candidates need to show their working out in the space below.

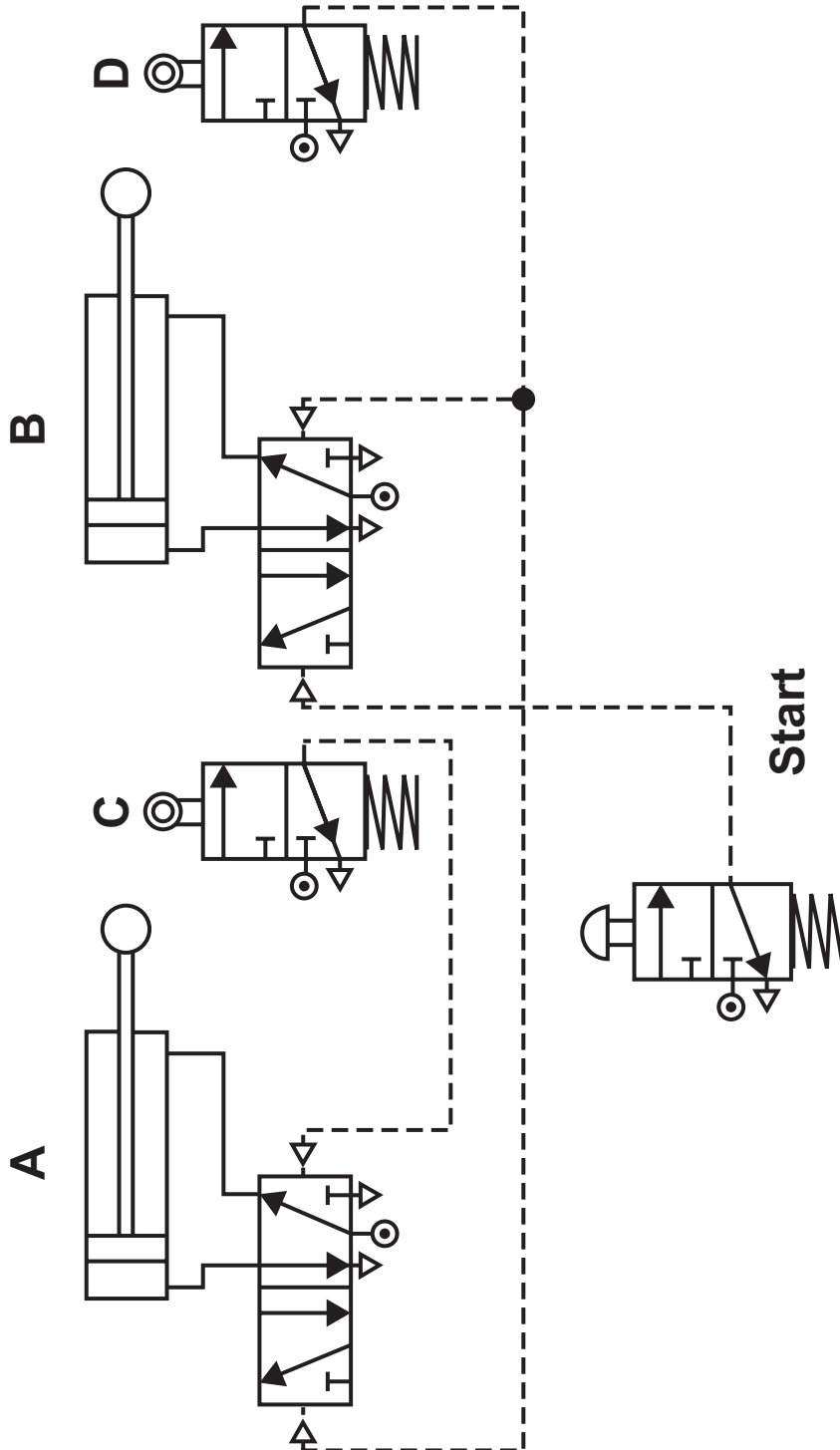
Answer _____

(vi) If the air pressure does not change, what force will be exerted on the instroke of component **B**, if the diameter of the piston rod is 10 mm?
Candidates need to show their working out in the space below. [4 marks]

Answer _____

(d) Fig. 11 shows a pneumatic circuit used in an airport luggage carousel.

Fig. 11



- (i) The statements in boxes **1** to **6** describe how the circuit in **Fig. 11** operates. Place the number from the correct statement, in the correct order in the flow diagram below. The first has been done for you.
[5 marks]

1 Roller trip 3PV **D** is activated.

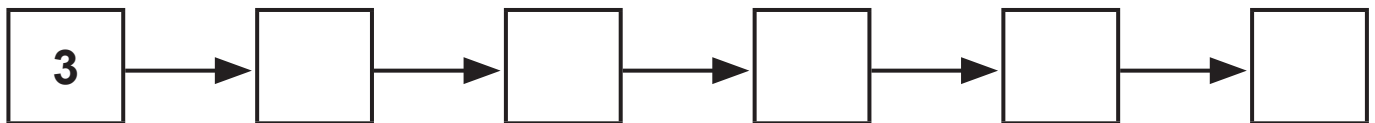
2 Roller trip 3PV **C** is activated.

3 Start component is activated.

4 Cylinder **B** outstrokes.

5 Cylinder **A** instrokes.

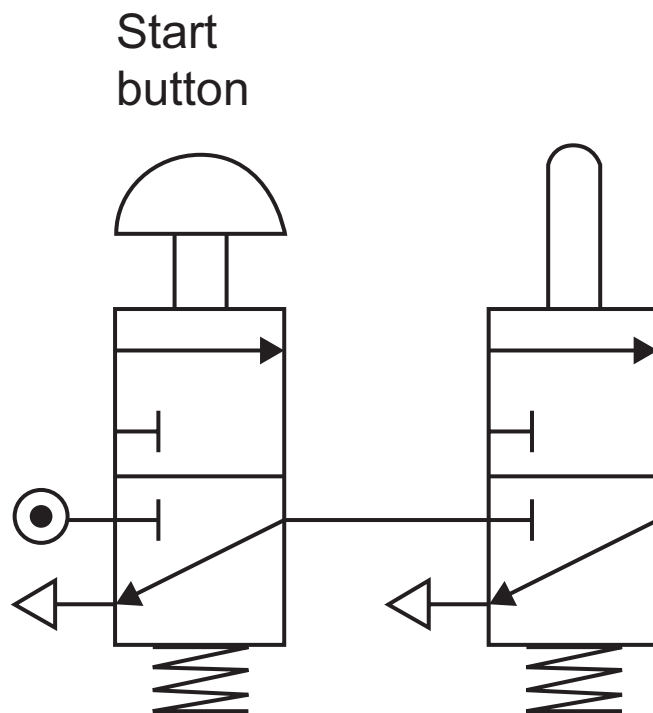
6 Cylinder **B** instrokes and **A** outstrokes.



- (ii) Cylinder **B** instrokes and Cylinder **A** outstrokes simultaneously. What component in **Fig. 11** enables this to happen? [1 mark]
-

The method of actuation for **Fig. 12** is shown in **Fig. 13**.

Fig. 13



(i) State the logic shown in **Fig. 13**. [1 mark]

(ii) Give a reason for this type of logic connection. [1 mark]

(iii) Fig. 14 opposite shows part of an incomplete pneumatic circuit used to cut the potatoes as shown in **Fig. 12**.

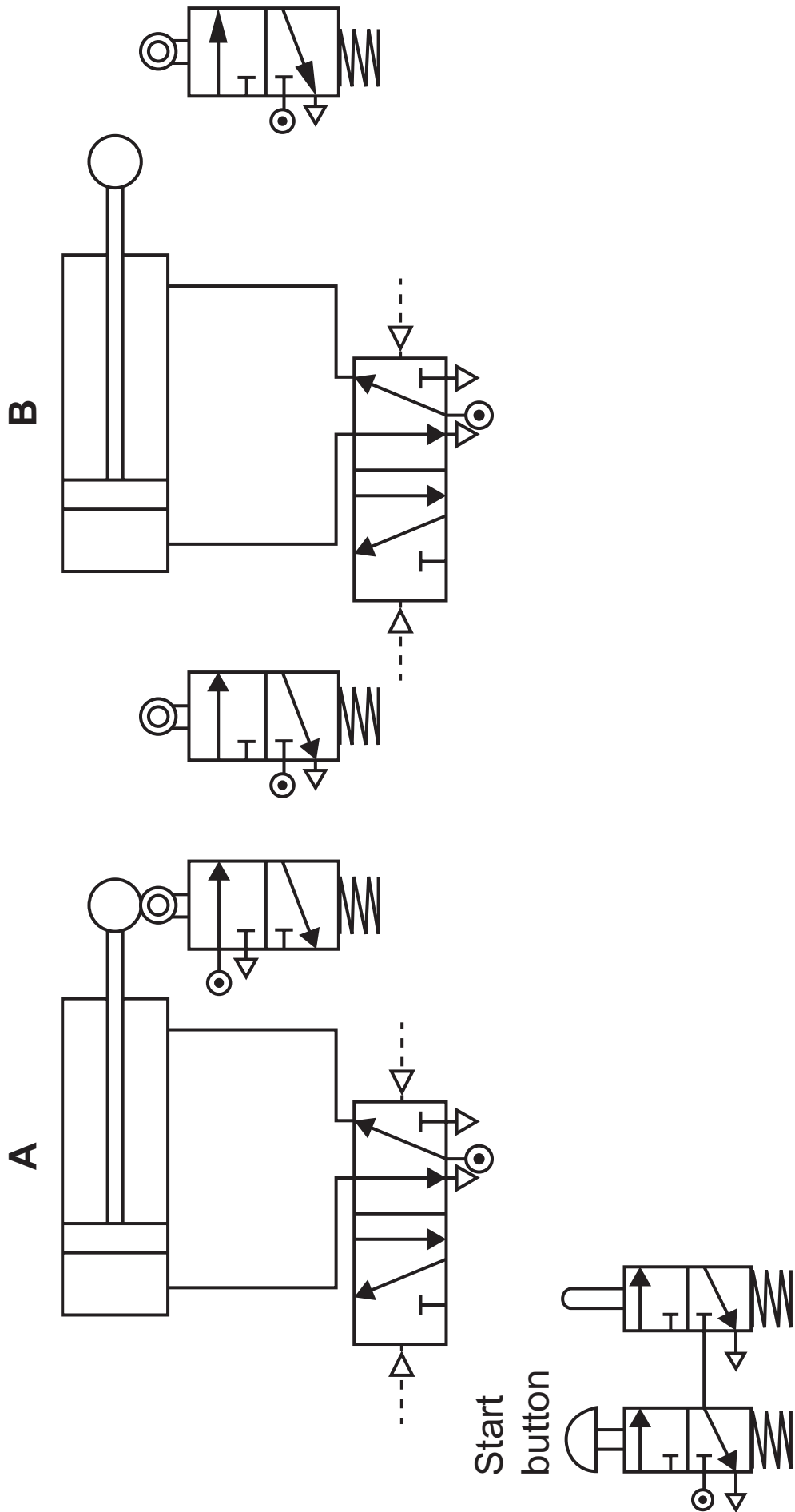
When complete, the sequence of operation should be:

- 1: Starting actuators are pressed.
- 2: Cylinder **A** outstrokes.
- 3: Cylinder **B** outstrokes.
- 4: Cylinder **A** instrokes.
- 5: When cylinder **A** is fully retracted cylinder **B** instrokes.

State the logic sequence for the circuit opposite.
[1 mark]

(iv) Complete the circuit on **Fig. 14** to give the required sequence described for the potato chipper.
[9 marks]

Fig. 14



(v) During operation it was found that there was not enough time between the potato being pushed forward by cylinder **A** and cylinder **B** pressing it into chips. Describe how the circuit in **Fig. 14** could be modified to overcome this problem. [3 marks]

(f) Over the last decade there has been a rapid increase in the demand for industrial robots in manufacture. Discuss **two** reasons why a manufacturer would be reluctant to introduce robotic manufacturing to the factory production line. Discuss **two** reasons why it may be beneficial to a manufacturing business. [8 marks]

Quality of written communication will be assessed in this question.

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