Rewarding Learning

Centre Number

Candidate Number

General Certificate of Secondary Education
2025

Technology and Design

Unit 2
Option B:
Mechanical and Pneumatic
Control Systems

[GTY22]

GTY22

WEDNESDAY 11 JUNE, MORNING

TIME

1 hour 30 minutes.

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 outside the boxed area on each page or 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.
Do not write in pencil or with a gel pen.
Answer **both** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Quality of written communication will be assessed in Question **2(e)**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
The Formula sheet is on page 3.

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(Questions start on page 4)

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 $= \dfrac{\text{number of teeth on driven gear}}{\text{number of teeth on driver gear}}$

For a compound gear train:
Total Gear ratio = the product of the gear ratios of all the subsystems
i.e. $GR_T = GR_1 \times GR_2 \times GR_3 \ldots$

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

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

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

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

6 Circumference of a circle = π × diameter

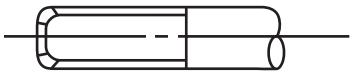
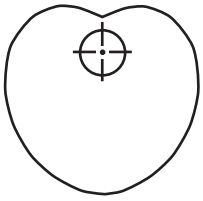
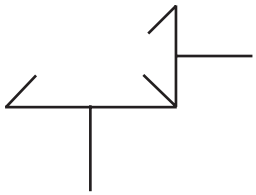
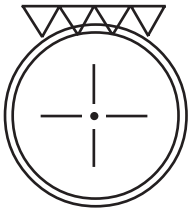
7 Area of a circle = πr^2

Answer **all** questions

1 **Table 1** refers to mechanical control symbols.

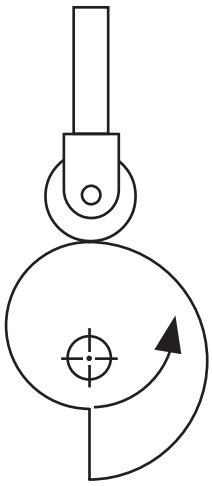
(a) Using the first row as a guide, complete **Table 1**.

Table 1

Sketch of Symbol	Name of symbol	Function
	Threaded bar	Converts a rotary motion into a linear motion.
		Allows a follower to rise and fall with uniform velocity.
		To change direction of rotation through 90 degrees.
	Rack & pinion	
	Knife follower	

[4]

(b) **Fig. 1** shows a cam and follower.



Source: CCEA

Fig. 1

(i) Name the type of cam and follower shown in **Fig. 1** above.

Cam: _____ [1]

Follower: _____ [1]

(ii) **Fig. 2** shows cam motion profile graphs. Which graph matches the movement you would expect to see from the type of cam in **Fig. 1**? Place a tick (✓) in the correct box.

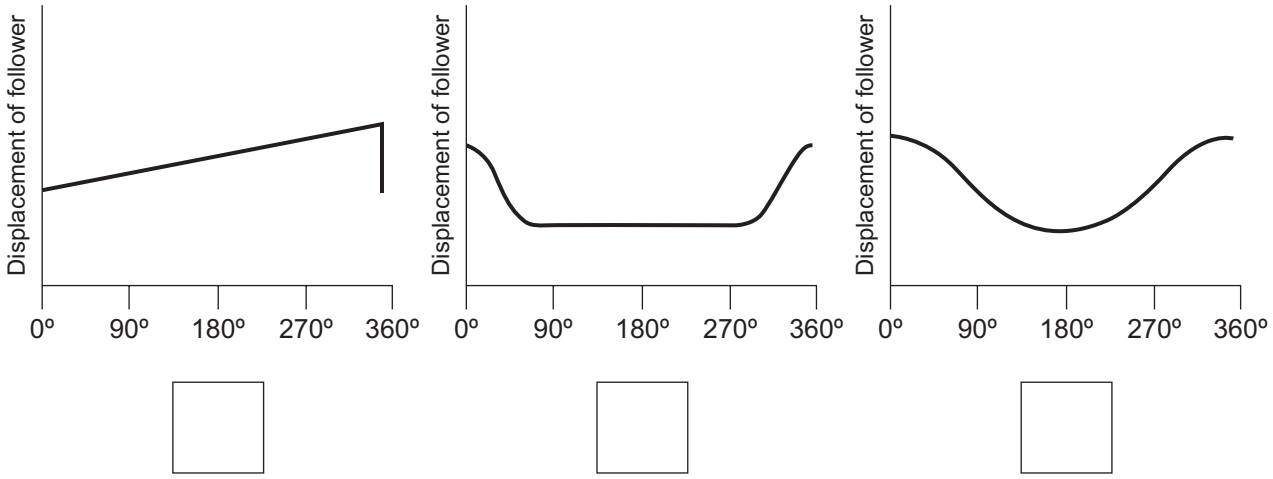


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Fig. 2

[1]

[Turn over

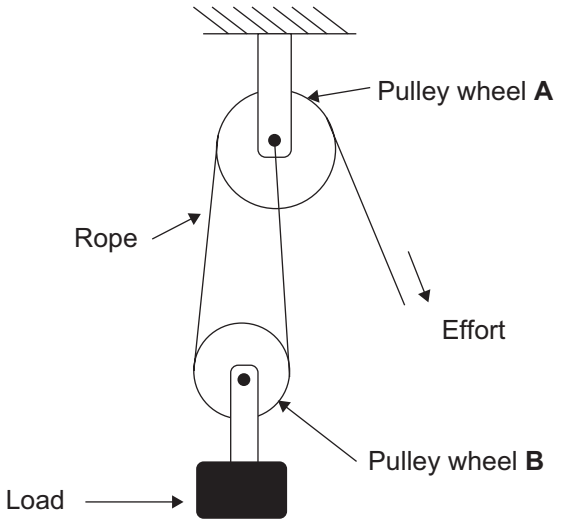
(iii) The direction of rotation is marked on **Fig. 1**. Explain why this cam does not turn in a clockwise direction.

_____

_____

_____ [2]

(c) **Fig. 3** shows a pulley system used to lift a heavy load.



Source: CCEA

Fig. 3

(i) Place a tick (✓) in the correct box to respond to the following question.

Pulley wheel **B** is:

a fixed pulley wheel ☐

a movable pulley wheel ☐

[1]

(ii) Calculate the distance moved by the load in **Fig. 3** when the effort is pulled through a distance of 1.8 metres.

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

Answer _____ [3]

(iii) If the pulley system in **Fig. 3** is 100% efficient, what is the maximum load that can be lifted when an effort of 40 N is applied?

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

Answer _____ [3]

(iv) A larger load than that in **Fig. 3** is to be lifted using the same force of 40 N. Sketch a new pulley system below that would give a velocity ratio of 3, to allow this load to be lifted.

[3]

(v) If the efficiency of the new pulley system in **(c)(iv)** is 80%, calculate the mechanical advantage of the system.

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

Answer _____ [4]

(d) **Fig. 4** shows an electric hand mixer, while **Fig. 5** shows the symbol of the mechanism inside.

Source: © Getty Images

Fig. 4

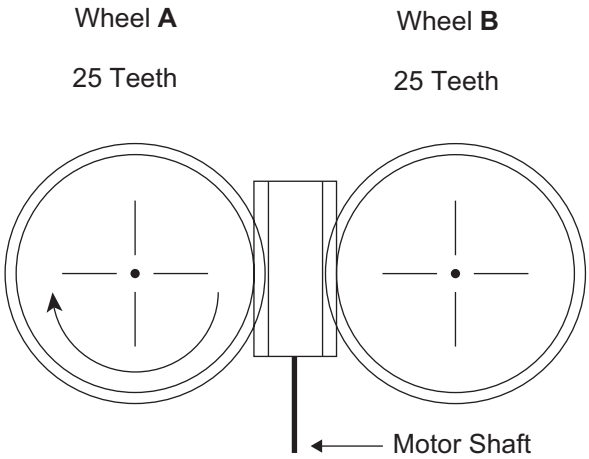


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Fig. 5

(i) Name the gear system shown in **Fig. 5**.

_____ [2]

(ii) Use an arrow to mark on **Fig. 5** the direction of rotation of gear wheel **B**. [1]

(iii) Name a suitable material to manufacture the gear system in **Fig. 5** and justify your material selection.

Material: _____ [1]

Reason for use: _____

_____ [1]

[Turn over

(iv) Give **one** application for the gear system shown in **Fig. 6** below.

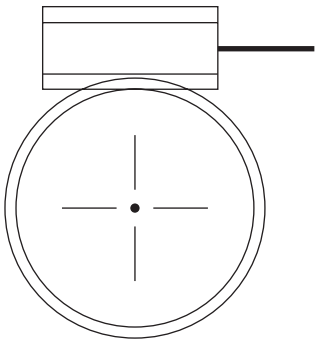

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Fig. 6

Application: _____ [1]

(v) Calculate the gear ratio for the system shown in **Fig. 5**. Express your answer as a ratio in its simplest form.

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

Answer _____ [2]

(vi) If the motor shaft in **Fig. 5** is rotating at 1250 rev/min, calculate the speed of the wheels.

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

Answer _____ [2]

(e) **Fig. 7** shows the mechanism on a child's bike.

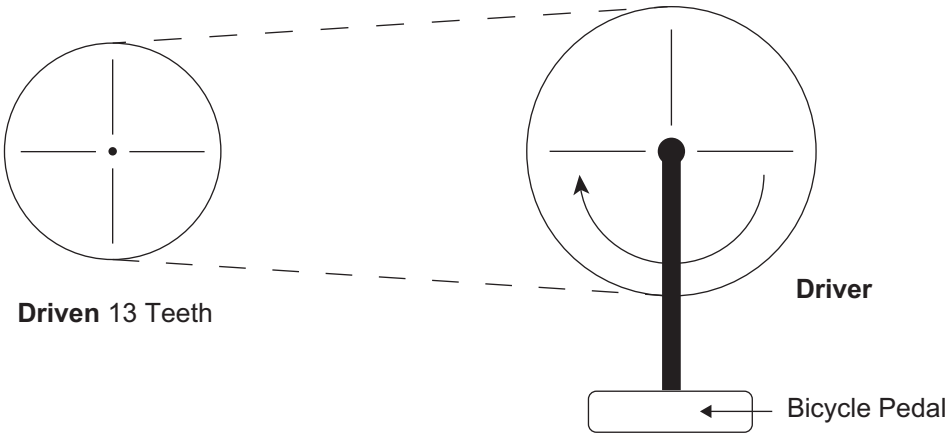

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Fig. 7

(i) State the name of the mechanism shown in **Fig. 7**.

Answer _____ [1]

(ii) If the child pedals in a clockwise direction as shown in **Fig. 7**, mark on **Fig. 7** the direction of rotation of the driven wheel. [1]

(iii) If the gear ratio is 1:3, calculate the number of teeth on the driver.

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

Answer _____ [3]

The child progresses to a new bike that has the mechanism shown in **Fig. 8**.

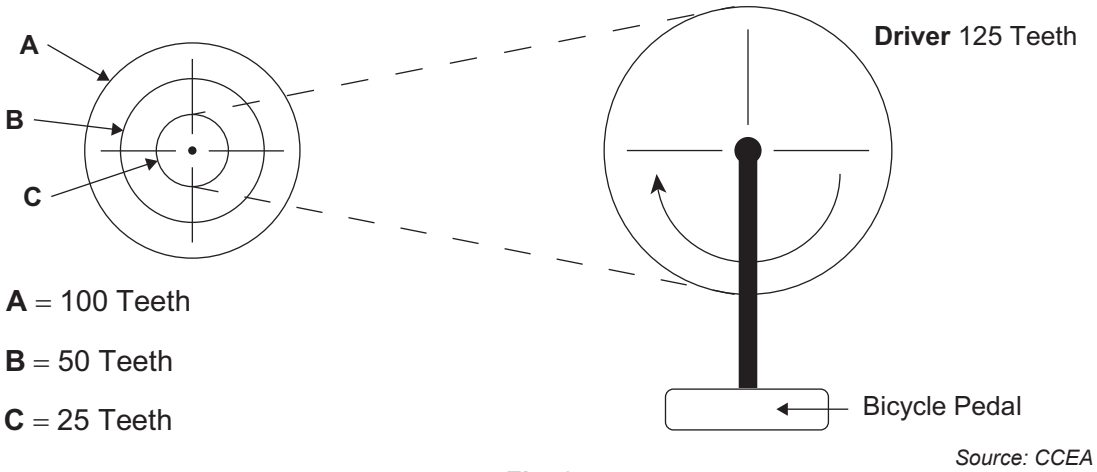

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Fig. 8

(iv) Give **two** benefits of the mechanism shown in **Fig. 8** compared to that in **Fig. 7**.

1. _____

_____ [1]

2. _____

_____ [1]

(v) The bike mechanism has 3 possible positions, **A**, **B** and **C**. Calculate the gear ratios of the system when in positions **B** and **C**. Express your answer as a gear ratio in its simplest form.

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

Answer **B**: _____ [2]

Answer **C**: _____ [2]

[Turn over

(vi) When the mechanism in **Fig. 8** is in position **A**, the child pedals at a speed of 100 rev/min and covers a distance of 220 metres/min. Calculate the diameter of the bicycle wheel that would be needed to make this possible.

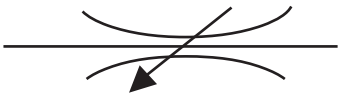
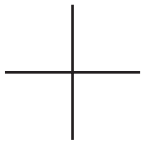
Candidates need to show their working out in the space below.

Answer _____ [6]

2 **Table 2** shows some pneumatic symbols.

(a) Complete **Table 2** by inserting the correct name for each symbol.

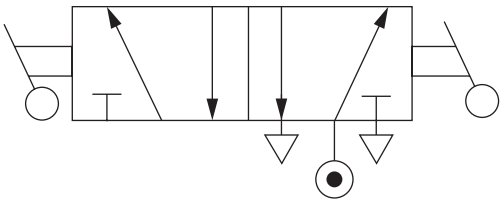
Table 2

Symbol	Name of symbol
	
	

[4]

[Turn over

(b) The symbol for a pneumatic valve is shown in **Fig. 9** below.



Source: CCEA

Fig. 9

(i) Complete **Table 3** below for the valve shown in **Fig. 9**.

Table 3

Number of switching positions	
Number of ports	
Method of actuating	
Method of resetting	

[4]

(ii) The valve in **Fig. 9** is to be connected to a cylinder to open and close a heavy fridge door. State **one** factor that should be considered when choosing a suitable cylinder for the task.

_____

_____

_____ [1]

(c) A homeowner wishes to install a pneumatic bollard that can be raised to prevent unlawful parking in their driveway. **Fig. 10** shows the bollard lowered and raised and **Fig. 11** shows a model of the circuit used to operate the bollard.

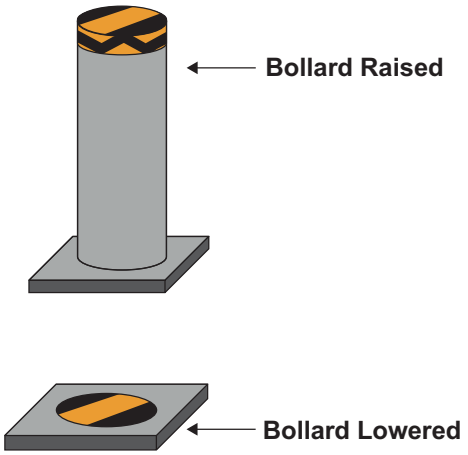


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Fig. 10

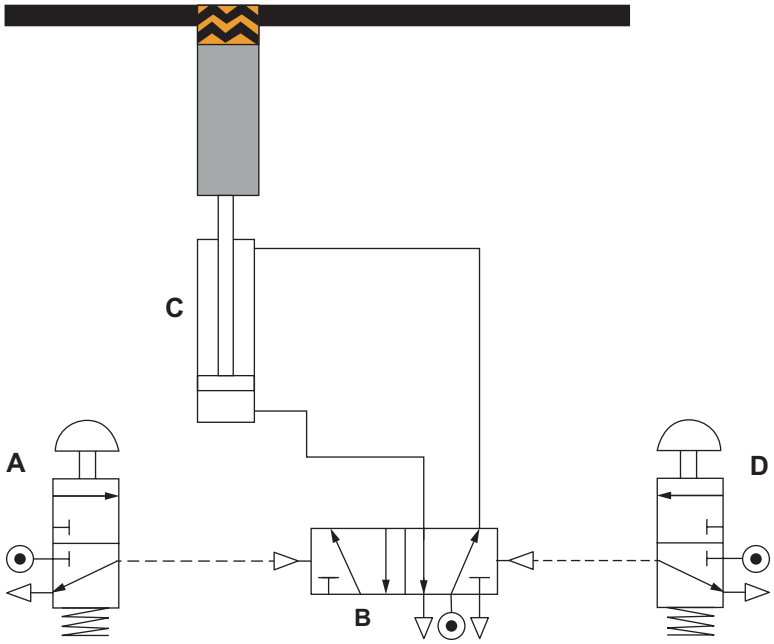

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Fig. 11

(i) State the type of motion produced by the bollard.

_____ [1]

(ii) Name the components labelled **A** and **C** in the circuit shown in **Fig. 11**.

A _____ [1]

C _____ [1]

(iii) State the method of actuation used for valve **B**.

_____ [1]

[Turn over

(iv) Explain why this method of actuation is suitable to operate valve **B**.

_____

_____

_____ [2]

(v) The speed of raising the bollard needs to be controlled. Insert on **Fig. 11** the valve needed to control the speed of the bollard when it is rising. [3]

(vi) Calculate the force used to raise the bollard if the supply pressure is 0.6 N/mm^2 and the diameter of the piston is 50 mm.

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

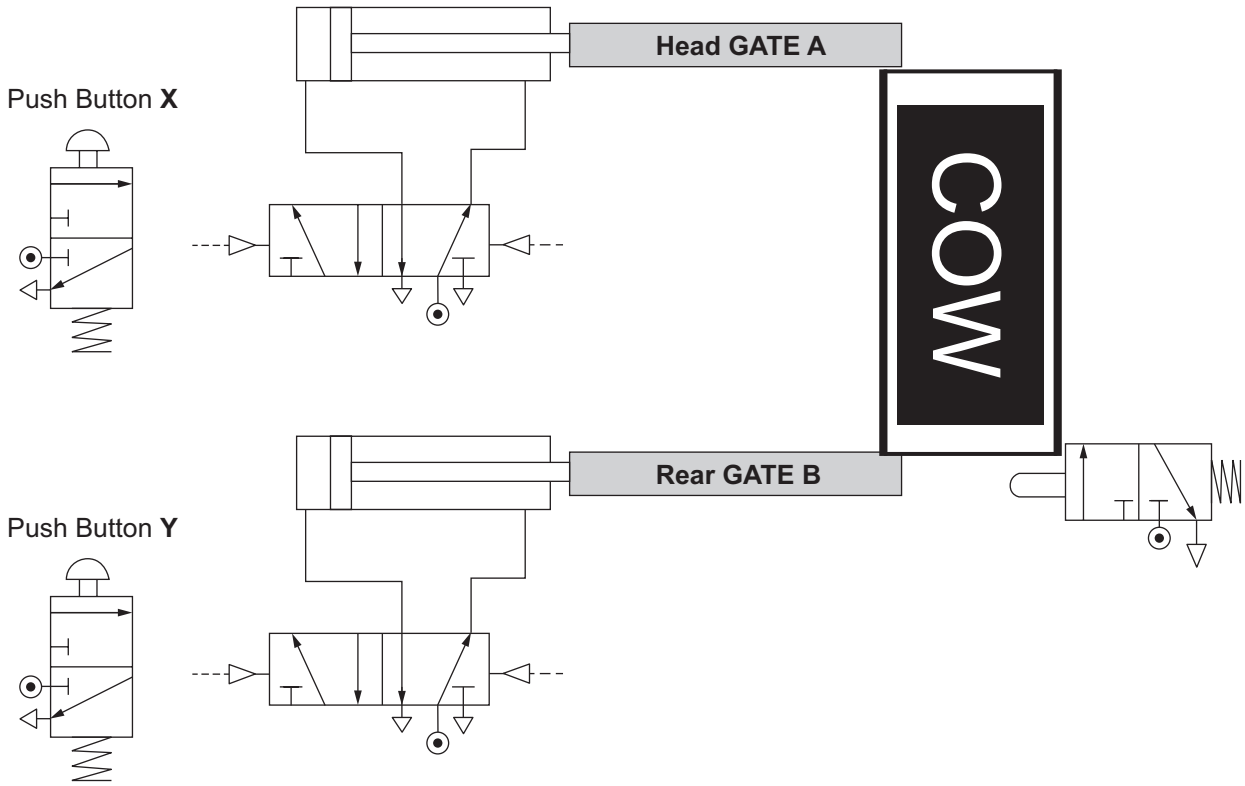
Answer _____ [3]

(vii) The piston rod has a diameter of 10 mm, calculate the force used to lower the bollard.

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

Answer _____ [4]

(d) Cattle must be constrained during routine ear tagging. A cattle crush holds the cow to minimise the risk of injury to the cow and to the farmer. **Fig. 12** shows the incomplete pneumatic circuit used to control the head and rear gates in a model cattle crush. Button **X** is pressed to close the head gate **A**. When the cow is safely in the crush, button **Y** is pressed to close the rear gate **B**. Once the rear gate **B** closes, it pushes a plunger operated 3/2 valve to open gates **A** and **B**.



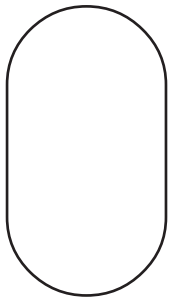
Source: CCEA

Fig. 12

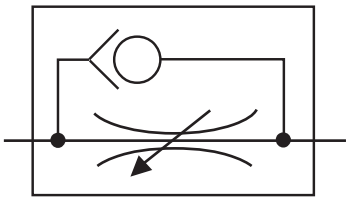
(i) Complete the circuit in **Fig. 12** by adding the pipework to give the required sequence of operation as detailed above. [4]

[Turn over

(ii) The components marked **D** and **E** in **Fig. 13** below should be added into the circuit in **Fig. 12** after the plunger operated 3/2 valve is pressed. Name both components. State the function of each component and explain why they should be added to the circuit.



D



E

Source: CCEA

Fig. 13

D: _____ [1]

E: _____ [1]

Reason:

_____

_____

_____

_____

_____ [3]

(iii) It has been decided to upgrade the pneumatic system. Complete **Fig. 14** below to enable the following sequence:

- When button **X** is pressed, Gate **A** will close
- Gate **B** should automatically close shortly after gate **A** closes
- Shortly after that, gates **A** and **B** should open together
- The sequence can then be repeated by the operator pressing button **X**. [6]

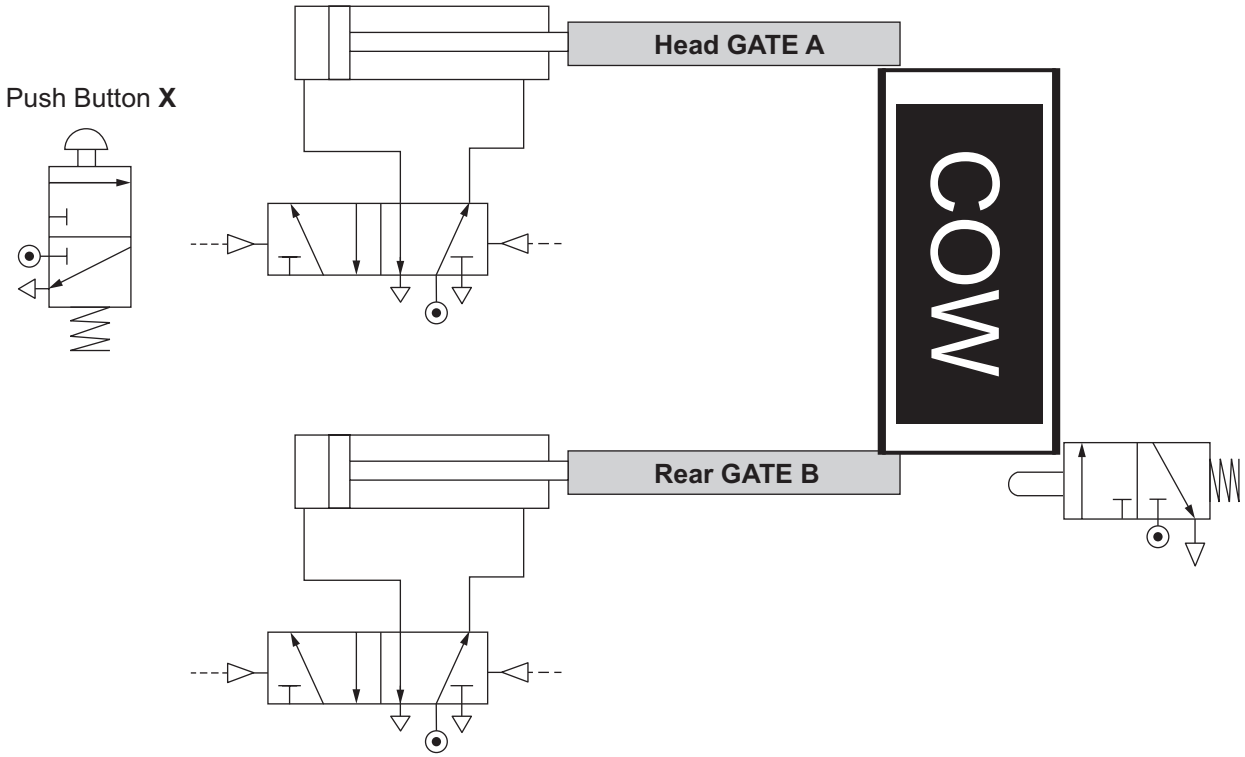


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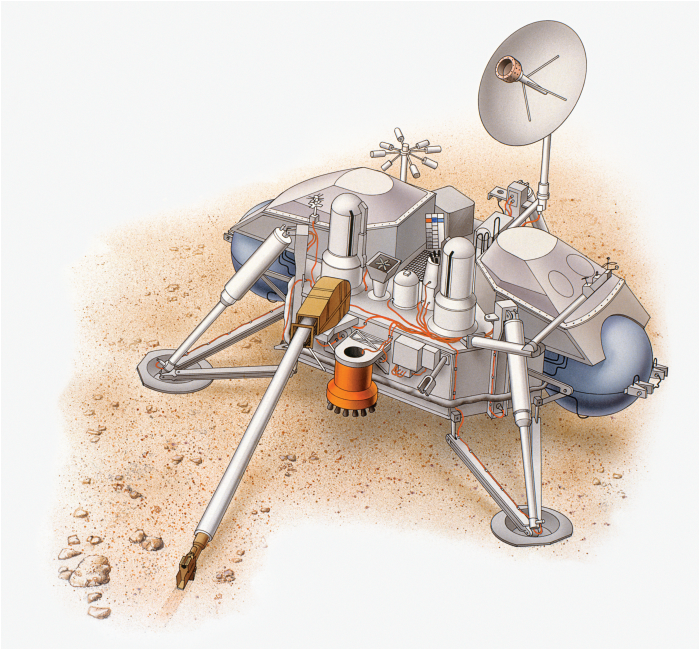
Fig. 14

[Turn over

(e) Shown in **Fig. 15** is the NASA Viking 2 Lander which landed on Mars and used a robotic pneumatic system to process surface samples. Describe and discuss **three** reasons why pneumatics is suitable for working environments such as space exploration or other hostile environments.

Quality of written communication will be assessed in this question.



Source: © Getty Images

Fig. 15

1. _____

_____

_____

_____

_____

_____

_____

_____

_____

2. _____

3. _____

_____ [10]

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Question Number	Marks
1	
2	
Total Marks	

Examiner Number

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