



General Certificate of Secondary Education
2025

Technology and Design

Unit 2
Option B: Mechanical and Pneumatic
Control Systems

[GTU22]

WEDNESDAY 11 JUNE, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are intended to ensure that the GCSE examinations are marked consistently and fairly. The mark schemes provide markers with an indication of the nature and range of candidates' responses. The mark schemes should be read in conjunction with these general marking instructions..

Assessment objectives

Below are the assessment objectives for GCSE Technology and Design.

Candidates must:

- AO1** Recall, select and communicate their knowledge and understanding of Technology and Design in a range of contexts;
- AO2** Apply skills knowledge and understanding, including quality standards in a variety of design contexts. Plan and carry out investigations and making tasks involving an appropriate range of tools, equipment, materials and processes; and
- AO3** Analyse and evaluate evidence, design proposals and outcomes, make reasoned judgements and present conclusions and recommendations.

Quality of candidates' responses

In marking the examination papers, examiners should be looking for a quality of response reflecting the level of maturity which may reasonably be expected of a 16-year-old which is the age at which the majority of candidates sit their GCSE examinations.

Flexibility in marking

Mark schemes are not intended to be totally prescriptive. No mark scheme can cover all the responses which candidates may produce. In the event of an unanticipated answer, examiners are expected to use their professional judgement to assess the validity of answers. If an answer is particularly problematic, then examiners should seek the guidance of the Supervising Examiner.

Positive Marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for what candidates know, understand and can do rather than penalising candidates for errors or omissions. Examiners should make use of the whole of the available mark range for any particular question and be prepared to award full marks for a response which is as good as might reasonably be expected of a 16-year-old GCSE candidate..

Awarding zero marks

Marks should only be awarded for valid responses and no marks should be awarded for an answer which is completely incorrect or inappropriate.

Types of mark schemes

Mark schemes for tasks or questions which require candidates to respond in extended written form are marked on the basis of levels of response which take account of the quality of written communication.

Other questions which require only short answers are marked on a point for point basis with marks awarded for each valid piece of information provided.

Levels of response

Tasks and questions requiring candidates to respond in extended writing are marked in terms of levels of response. In deciding which level of response to award, examiners should look for the 'best fit' bearing in mind that weakness in one area may be compensated for by strength in another. In deciding which mark within a particular level to award to any response, examiners are expected to use their professional judgement. The following guidance is provided to assist examiners.

Level 1: Response which merits inclusion in the band and should be awarded the lower mark.
Level 2: Response which merits inclusion in the band and should be awarded the higher mark.

Marking calculations

In marking answers involving calculations, examiners should apply the “own figure rule” so that candidates are not penalised more than once for a computational error.

Quality of written communication

Quality of written communication is taken into account in assessing candidates’ responses to all tasks and questions that require them to respond in written form. These tasks and questions are marked on the basis of levels of response. The description for each level of response includes reference to the quality of written communication.

For conciseness, quality of written communication is distinguished within levels of response as follows:


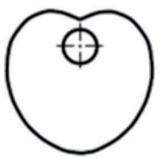
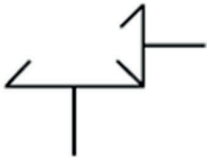


- Band 1: Quality of written communication is basic.
- Band 2: Quality of written communication is limited.
- Band 3: Quality of written communication is satisfactory.
- Band 4: Quality of written communication is good.
- Band 5: Quality of written communication is excellent.

In interpreting these level descriptions, examiners should refer to the more detailed guidance provided in the relevant question in the mark scheme.

1 (a)

Table 1

AVAILABLE MARKS

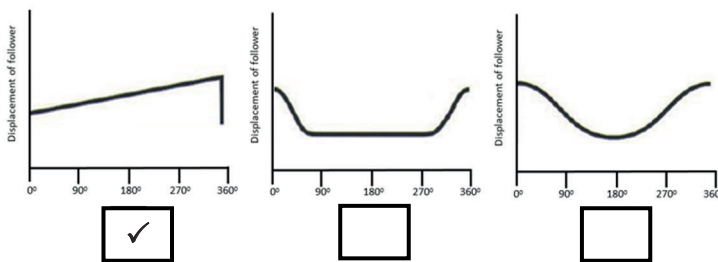
Sketch of Symbol	Name of Symbol	Function
	Threaded bar	Converts a rotary motion into a linear motion
	Heart-shaped cam	Allows a follower to rise and fall with uniform velocity
	Meshed bevel gear	To change direction of rotation through 90 degrees
	Rack & pinion	To convert rotary motion to linear or vice versa
	Knife follower	Accurately follows a cam profile

[4]

(b) (i) Snail cam [1]
Roller follower [1]

[2]

(ii)



[1]

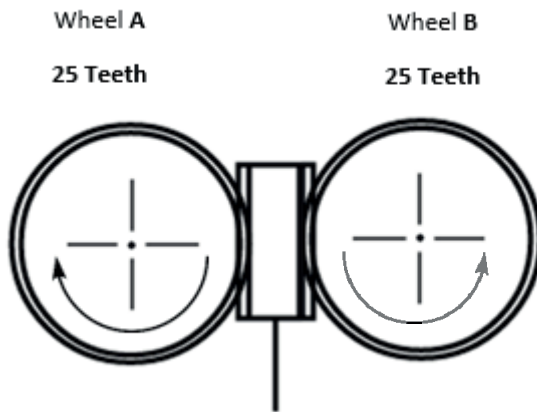
(iii) The follower will 'jam' against the cam [1]
preventing the cam from rotating/or causing it to break [1]
(2 × [1])

[2]

All relevant, valid responses will be given credit

(d) (i) Worm [1] and worm wheel [1] [2]

(ii) Arrow marked as below:



[1]

(iii) Material: Nylon [1]

Reason: Any **one** from:

Self-lubricating/no lubrication required [1]

Quiet in operation [1]

(2 × [1])

[2]

All relevant, valid responses will be given credit

(iv) Any **one** from:

Conveyor belt/lifts/fishing reel/power steering/guitar tuning

(1 × [1])

[1]

All relevant, valid responses will be given credit

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

$$= 25/1 \text{ [1]}$$

$$= 25:1 \text{ [1]}$$

[2]

(vi) Output speed = input speed ÷ gear ratio

$$\text{Output speed} = 1250 \div 25 \text{ [1]}$$

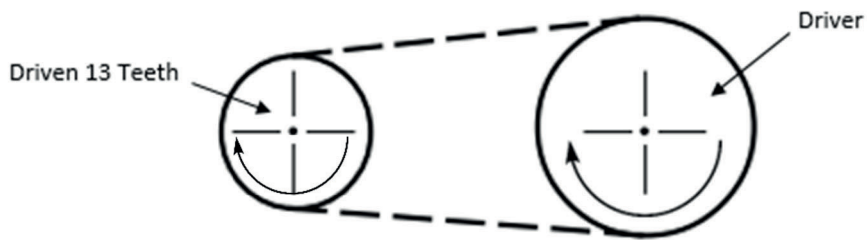
$$\text{Output speed} = 50 \text{ rev/min [1]}$$

[2]

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(e) (i) Sprocket and chain [1]

(ii) Arrow marked as below:



[1]

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

$$\begin{aligned} \text{Number of teeth on driver} &= \text{Number of teeth on driven} / \text{Gear ratio} [1] \\ &= 13 / 1:3 [1] \\ &= 39 \text{ teeth} [1] \end{aligned}$$

[3]

(iv) Any **two** from:

- Make cycling at various speeds more comfortable [1]
 - Higher gear ratio allows increased top speeds [1]
 - Lower gear ratio makes it easier for climbing hills [1]
 - Lower gear ratio allows rough terrain to be easier covered [1]
- (2 × [1])

[2]

All relevant, valid responses will be given credit

(v) Gear ratio = $\frac{\text{Number of teeth on driven}}{\text{Number of teeth on driver}}$

$$\begin{aligned} B &= 50/125 [1] & C &= 25/125 [1] \\ &= 2.5 [1] & &= 1:5 [1] \end{aligned}$$

[4]

(vi) Gear ratio = $\frac{\text{Number of teeth on driven}}{\text{Number of teeth on driver}}$

$$\begin{aligned} A &= 100/125 \\ &= 1:1.25 [1] \end{aligned}$$

$$\begin{aligned} \text{Output speed of A} &= \text{input speed} \div \text{gear ratio} \\ &= 100 \div (1/1.25) \\ &= 125 \text{ rev/min} [1] \end{aligned}$$

$$\pi D = 220\text{m} \div 125 [1]$$

$$\pi D = 1.76 [1]$$

$$D = 1.76 \div \pi [1]$$

$$D = 0.56 \text{ m}$$





$$D = 56 \text{ cm} [1]$$

[6]

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2 (a)

Symbol	Name of symbol
	Bidirectional flow restrictor
	Pipeline junction
	Roller trip
	Pipeline not connected

(1 × [4])

[4]

(b) (i)

Number of switching positions	2
Number of ports	5
Method of actuating	lever
Method of resetting	lever

(1 × [4])

[4]

(ii) Any **one** from:

Force required to move load [1]

Stroke length [1]

Bore size [1]

(1 × [1])

[1]

All relevant, valid responses will be given credit

(c) (i) Linear/reciprocating

[1]

(ii) 3/2 valve [1]

Double acting cylinder (DAC) [1]

[2]

(iii) Pilot pressure

[1]

(iv) User does not need to position the on/off button near the system [1]

A pilot air operated valve will change state when a **brief** air signal acts or the user will not need to hold down 3/2 valve [1]

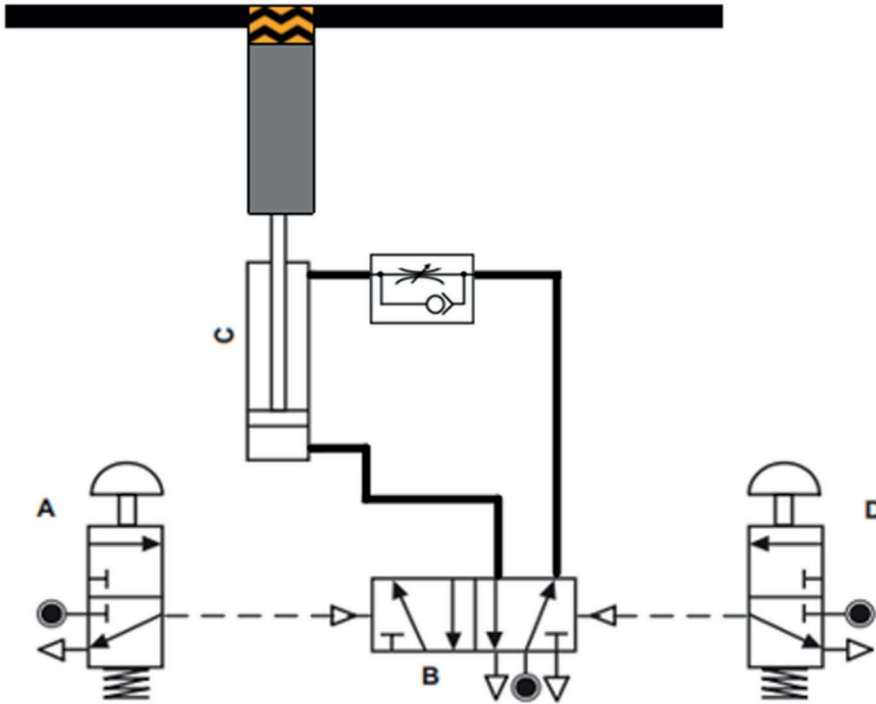
(2 × [1])

[2]

All relevant, valid responses will be given credit

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(v)



Addition of a unidirectional flow restrictor/regulator symbol [1]
Located on exhaust pipeline [1]
Correct orientation [1]

[3]

(vi)

$$F = P \times A$$
$$A = \pi \times 25^2 \text{ or } \pi = 625 \text{ [1]}$$
$$F = 0.6 \times 1963.495$$
$$F = 1178 \text{ [1] N [1]}$$

[3]

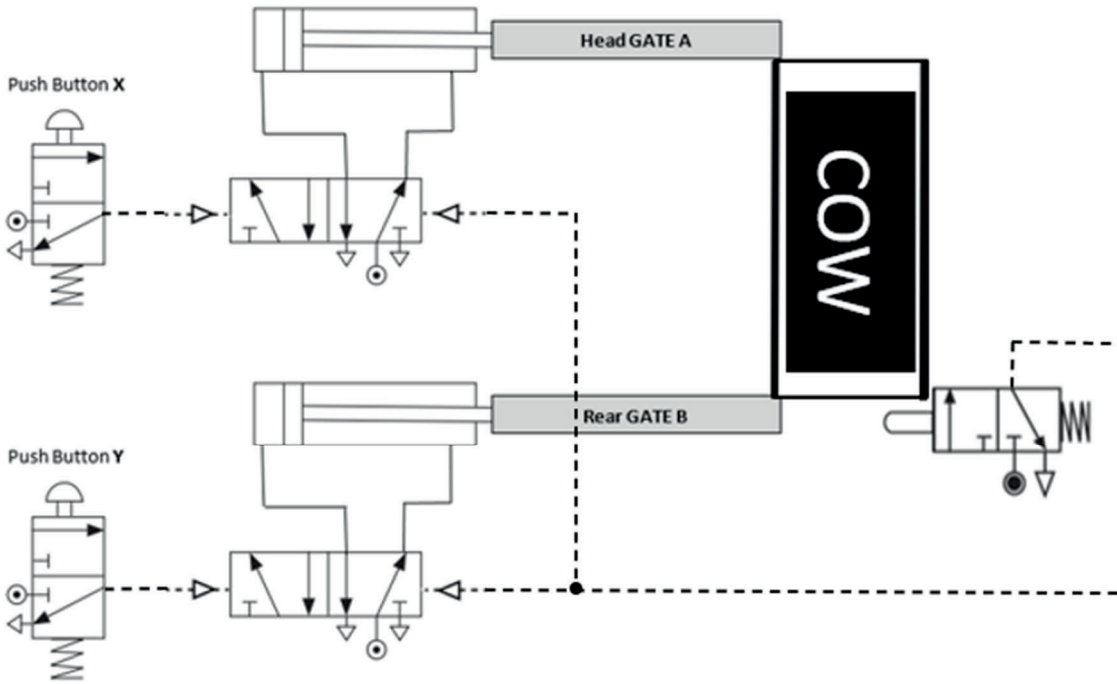
(vii)

$$F = P \times A$$
$$\text{Rod area} = \pi \times 5^2 = 78.5398 \text{ [1]}$$
$$\text{Area difference} = 1963.495 - 78.5398 = 1884.9555 \text{ [1]}$$
$$F = 0.6 \times 1884.9555 = 1130.97$$
$$F = 1130.97$$
$$F = 1131 \text{ [1] N [1]}$$

[4]

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(d) (i)



- Pilot line from **X** to 5/2 valve and **Y** to 5/2 valve [1]
- Pilot line from plunger operated 3/2 valve to 5/2 valve at gate **B** [1]
- Pilot line from plunger operated 3/2 valve to 5/2 valve at gate **A** [1]
- Use of dashed pilot line for at least one correct connection [1] [4]

(ii) **Name:**

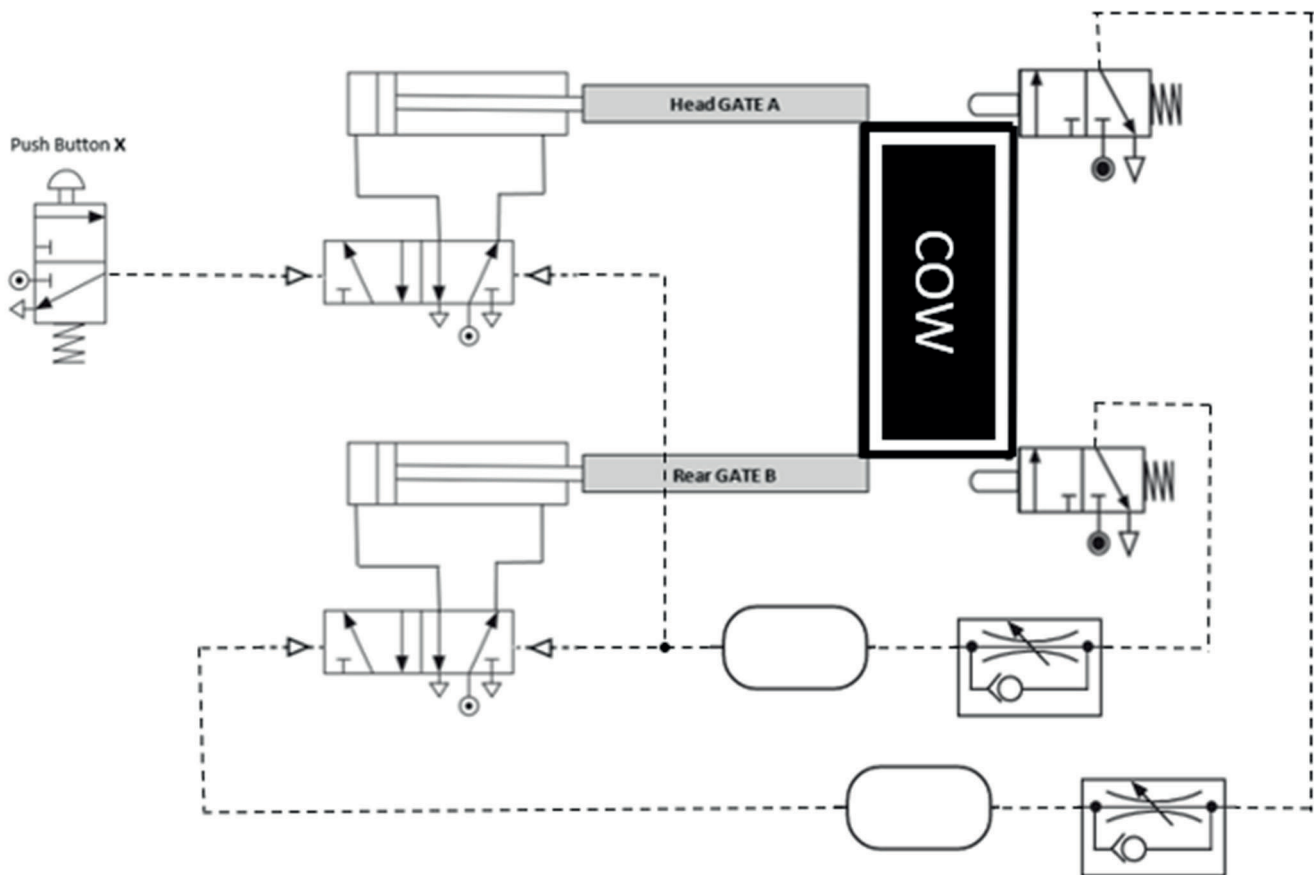
- D = Reservoir [1]
- E = Unidirectional flow restrictor [1]

Reason:

- Unidirectional flow restrictor slows air from the 3PV [1]
- Reservoir stores air [1]
- When used together, the time delay before gates A and B open can be adjusted [1]
- (3 × [1]) [5]

All relevant, valid responses will be given credit

(iii)



- Correct connection from push button X to top 5/2 valve [1]
- Addition of plunger/roller 3/2 valve for gate A at closed position [1]
- Addition of unidirectional flow restrictor and reservoir from 3/2 valve at gate A closed [1]
- Addition of unidirectional flow restrictor and reservoir from 3/2 valve at gate B closed [1]
- Correct connections for gate A closed plunger/roller 3/2 valve – bottom 5/2 valve gate B [1]
- Correct connections for gate B closed plunger 3/2 valve – both 5/2 valves gate A and gate B [1]

[6]

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(e) **Indicative Content:**

1. Pneumatic systems are inherently **safe**. Compressed air is a non-toxic, non-flammable gas, which makes it much safer than other power sources, such as electricity or hydraulic fluid. This is especially important in hostile environments, where there is a risk of fire or explosion.
2. Pneumatic systems are **lightweight and compact**. This makes them ideal for use in vehicles, where weight and space saving is essential.
3. Pneumatic systems are **easy to control**. The force and speed of a pneumatic system can be easily controlled by adjusting the pressure of the compressed air. This makes them well-suited for delicate tasks, such as taking samples.
4. Pneumatic systems are also relatively **inexpensive** to operate and maintain. This makes them a cost-effective choice.
5. Pneumatic systems are **quiet**. This is important where noise can be a distraction or a hazard. Pneumatic systems are much quieter than electric motors.
6. Pneumatic systems are **easy to troubleshoot**. This is important in hostile environments, where repairs can be difficult or impossible. Pneumatic systems have few moving parts.
7. Pneumatic systems are **reliable**. This is important in hostile environments, where failures can have serious consequences. Pneumatic systems are very reliable, and they are not susceptible to the same types of failures as electric motors or hydraulic systems.
8. Pneumatic systems are **versatile**. They can be used to power a wide variety of devices, from simple actuators to complex robots. This versatility makes them ideal for the diverse range of tasks required.
9. Pneumatic systems are **clean and emit few pollutants**. Pneumatic systems do not produce any harmful emissions, such as exhaust fumes or smoke. This makes them a safe and environmentally friendly choice.
10. Pneumatics systems are frequently used **instead of humans** in hostile environments due to their ability to operate safely and reliably in hazardous conditions, such as those involving extreme temperatures, dangerous materials, exposure to corrosive substance or confined spaces. Examples are mining, construction healthcare and space exploration.
11. Pneumatics systems can be **automated** to work efficiently in temperatures ranging from -20°C to 80°C , making them suitable for industries such as oil and gas, food processing , and chemical plants, where such temperature extremes are commonplace.

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Response Band	Description	Mark
When a response is not worthy of credit [0] should be awarded		
Basic [1]–[2]	Candidate responds by completely missing the focus of the question. This response may or may not be well written.	[1]
	Candidate response contains little content. It may list, but not explain, some reasons for using pneumatics in hostile environments. The response lacks clarity and coherence and is poorly organised. The level of written communication is basic.	[2]
Limited [3]–[4]	Candidate may provide a very poor description with limited or no discussion of some of the reasons for using pneumatics in hostile environments. Some reasons are given but tend to be very general rather than being specific to hostile environments. Some or all the reasons may be inaccurate/irrelevant. The level of written communication is limited but conveys some information. It is limited in technical vocabulary and specialist terms. Spelling, punctuation and grammar lack accuracy.	[3]
	Candidate may provide a poor description with somewhat limited discussion of some of the reasons for using pneumatics in hostile environments. Some reasons are given but tend to be general rather than being specific to a hostile environment. The level of written communication is somewhat limited but conveys some relevant information. Spelling, punctuation and grammar lack accuracy.	[4]
Satisfactory [5]–[6]	Candidate describes some of the reasons for using pneumatics in hostile environments. Some general reasons have been discussed. There may be some inaccuracies. The level of written communication is satisfactory and contains some technical vocabulary and specialist terms. The accuracy of spelling, punctuation and grammar is satisfactory.	[5]
	Candidate describes some reasons for using pneumatics in hostile environments and engages in some discussion of the reasons why pneumatics is useful. Some appropriate reasons for using pneumatics in hostile environments are discussed and/or described at relevant stages throughout the answer. There may be some inaccuracies. The level of written communication is very satisfactory and contains some technical vocabulary and specialist terms. The accuracy of spelling, punctuation and grammar is very satisfactory.	[6]
Good [7]–[8]	Candidate provides a good response of describing most or all their chosen reasons as to why pneumatics is useful in hostile environments. The level of written communication, technical vocabulary and specialist terms is generally good. The accuracy of spelling, punctuation and grammar is good.	[7]
	Candidate provides a very good response of describing most or all their chosen reasons as to why pneumatics is useful in hostile environments. The response is very well organised, clear and coherent. The level of written communication, technical vocabulary and specialist terms is very good throughout. The accuracy of spelling, punctuation and grammar is very good.	[8]

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Excellent [9]–[10]	Candidate provides a full description and discussion of 3 reasons as to why pneumatics is useful in hostile environments. All relevant reasons have been discussed and explained in depth at appropriate points throughout the answer. The level of written communication, technical vocabulary and specialist terms is excellent. The accuracy of spelling, punctuation and grammar is excellent.	[9]
	Candidate provides a very full description and discussion of 3 reasons as to why pneumatics is useful in hostile environments. All relevant reasons have been fully discussed and explained in depth at appropriate points throughout the answer. The level of written communication, technical vocabulary and specialist terms is excellent. The accuracy of spelling, punctuation and grammar is excellent.	[10]

(1 × [10])

[10]

Total

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50

100