



ADVANCED (A2)
General Certificate of Education
2023

Technology and Design

Assessment Unit A2 1
assessing

Systems and Control or Product Design

[ATE11]

WEDNESDAY 7 JUNE, AFTERNOON

**MARK
SCHEME**

General Marking Instructions

Introduction

The main purpose of the mark scheme is to ensure that examinations are marked accurately, consistently and fairly. The mark scheme provides examiners with an indication of the nature and range of candidates' responses likely to be worthy of credit. It also sets out the criteria which they should apply in allocating marks to candidates' responses.

Assessment objectives

Below are the assessment objectives for GCE Technology and Design.

Candidates should be able to:

- AO1** Demonstrate specific knowledge and understanding, be able to apply that knowledge and understanding in combination with appropriate skills in their designing, communicate ideas and outcomes, and demonstrate strategies for evaluation.
- AO2** Apply skills, knowledge and understanding of relevant materials to produce suitable and appropriate outcomes; communicate ideas and outcomes, and demonstrate strategies for evaluation.

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 17- or 18-year-old which is the age at which the majority of candidates sit their GCE 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 unanticipated answers, 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 17- or 18-year-old GCE 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.

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. To avoid a candidate being penalised, marks can be awarded where correct conclusions or inferences are made from their incorrect calculations.

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

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.

- **Threshold performance:** Response which just merits inclusion in the level and should be awarded a mark at or near the bottom of the range.
- **Intermediate performance:** Response which clearly merits inclusion in the level and should be awarded a mark at or near the middle of the range.
- **High performance:** Response which fully satisfies the level description and should be awarded a mark at or near the top of the range.

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:

Level 1: Quality of written communication is basic.

Level 2: Quality of written communication is good.

Level 3: Quality of written communication is excellent.

In interpreting these level descriptions, examiners should refer to the more detailed guidance provided below:

Level 1 (Basic): The candidate makes only a limited selection and use of an appropriate form and style of writing. The organisation of material may lack clarity and coherence. There is little use of specialist vocabulary. Presentation, spelling, punctuation and grammar may be such that intended meaning is not clear.

Level 2 (Good): The candidate makes a reasonable selection and use of an appropriate form and style of writing. Relevant material is organised with some clarity and coherence. There is some use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are sufficiently competent to make meaning clear.

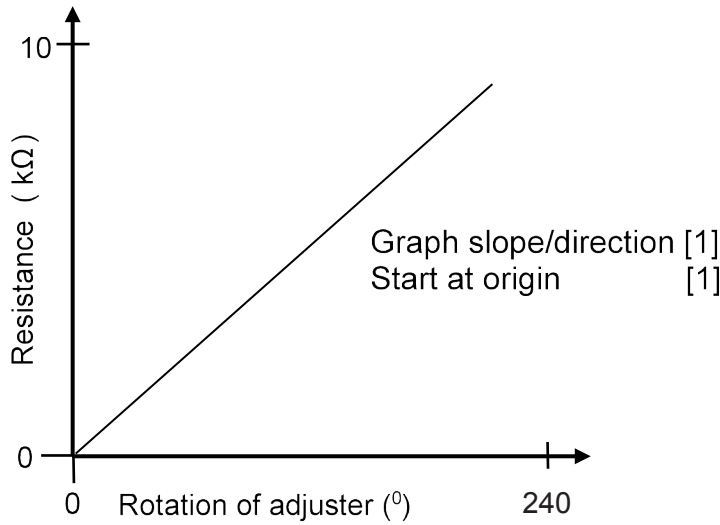
Level 3 (Excellent): The candidate successfully selects and uses the most appropriate form and style of writing. Relevant material is organised with a high degree of clarity and coherence. There is widespread and accurate use of appropriate specialist vocabulary. Presentation, spelling, punctuation and grammar are of a sufficiently high standard to make meaning clear.

Section A

AVAILABLE MARKS

Electronic and microelectronic control systems

1 (a) (i)

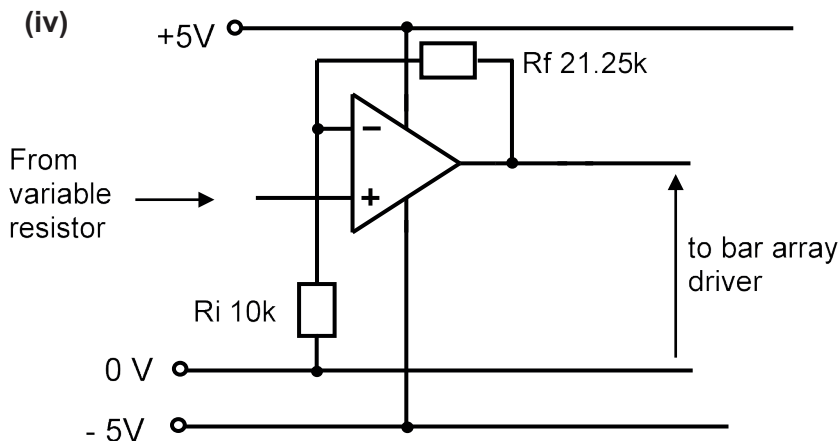


All relevant, valid responses will be given credit. [2]

(ii) The op-amp operates within an analogue range of voltages [1] that can continuously vary with input conditions. [1]
Award [2] for a full explanation and [1] for a limited explanation
All relevant, valid responses will be given credit. [2]

Each of the outputs on the bar array will be either on or off [1] depending on what outputs of the bar array driver are high or low. [1]
Award [2] for a full explanation and [1] for a limited explanation.
All relevant, valid responses will be given credit. [2]

(iii) Gain = V_o/V_{in}
= $5/1.6$ [1]
= 3.125 [1] [2]



correct non inverting amp [1] with dual 5V supply [1]
suitable ratio for Rf and Ri [1]
Rf and Ri in Kiloohm range [1]
labelling input and output [1]
All relevant, valid responses will be given credit. [5]

(b) Indicative content

**AVAILABLE
MARKS**

Characteristics

Op-amps typically have a high open loop gain making them suitable for detecting small changes in analogue voltages. This open loop gain can be tailored to suit specific requirements by the addition of feedback and input resistors. Therefore voltage gains of various amplitudes can be easily configured.

Op-amps are designed to be stable in closed loop operation which reduces the likelihood of voltage amplification errors due to 'drift'. However very high or low operating temperatures outside normal conditions will cause some degree of drift error.

Most op-amps are designed to limit the output current so as not to exceed a specified level thus protecting the op-amp and associated circuitry from damage. Some op-amps can survive direct short circuits on their outputs without damage.

Both AC and DC input voltages can be amplified provided the power supply requirement for the op-amp is appropriate. Most op-amps can operate with a dual voltage power supply.

Differential mode

An op-amp has two inputs, an inverting input and a non-inverting input. In differential mode the op-amp amplifies the difference between these two input signals. Since the open loop voltage gain of an operational amplifier is generally too high for most practical applications a differential amplifier uses feedback resistors to control the voltage gain of the amplifier. The resulting circuit is a combination of both inverting and non-inverting amplifiers where the value of the two input resistors (R_i) is the same and the value of the two feedback resistors (R_f) is the same.

		AVAILABLE MARKS
<p>Level 3 The candidate provides an excellent description of three characteristics of op-amps. The candidate then discusses in excellent detail the main features of an op-amp in differential mode. The written presentation is clear and precise and demonstrates excellent knowledge of the subject. Appropriate specialist terms and technological vocabulary are used throughout. The candidate uses excellent spelling, punctuation and grammar, and the form and style are of a high standard.</p>	[7]–[9]	
<p>Level 2 The candidate provides a good description of the characteristics of op-amps. The candidate then discusses in good detail the main features of an op-amp in differential mode. The written presentation is good and demonstrates a good knowledge of the subject. Some specialist terms and technological vocabulary are used throughout. The candidate uses good spelling, punctuation and grammar, and the form and style are of a good standard.</p>	[4]–[6]	
<p>Level 1 The candidate provides a basic description of the characteristics of op-amps. The candidate then discusses in basic detail the main features of an op-amp in differential mode. The written presentation is basic and demonstrates a basic knowledge of the subject. Little use is made of specialist terms and technological vocabulary. The candidate uses basic spelling, punctuation and grammar, and the form and style are of a basic standard.</p>	[1]–[3]	
Response not worthy of credit	[0]	

All relevant, valid responses will be given credit. [9]

(c) (i) $5V = 240^\circ$ for full rotation or $20.83\text{mV per }^\circ$ [1]

(If midpoint is 120° then 20° tilt to the right = 100°
Therefore $100^\circ = 100 \times 20.83$ [1]
 $= 2.083V$ [1] [3]

(ii) $255/5 \times 3$ [1]
 $= 153$ [1]
 $= 10011001$ [1] [3]

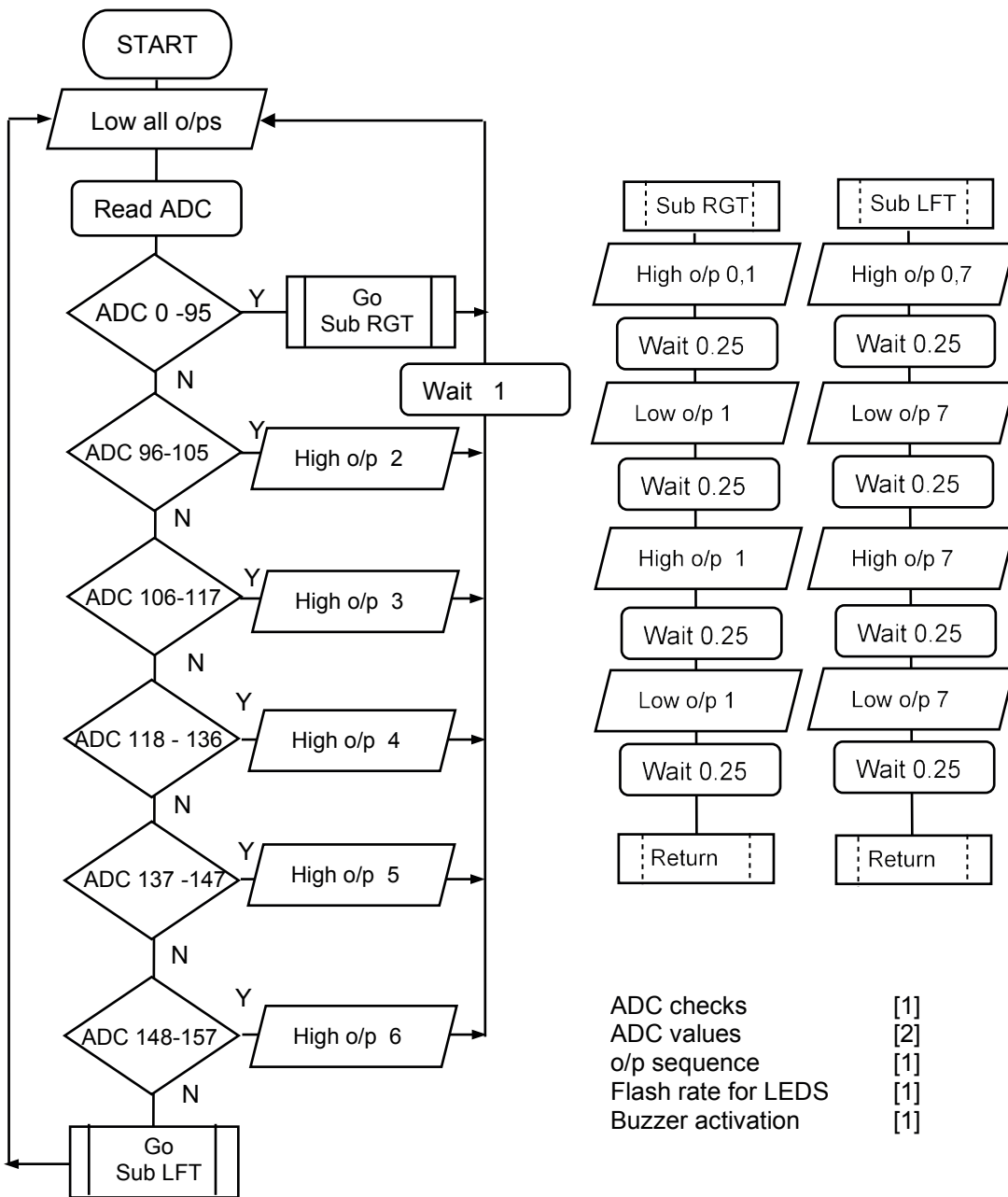
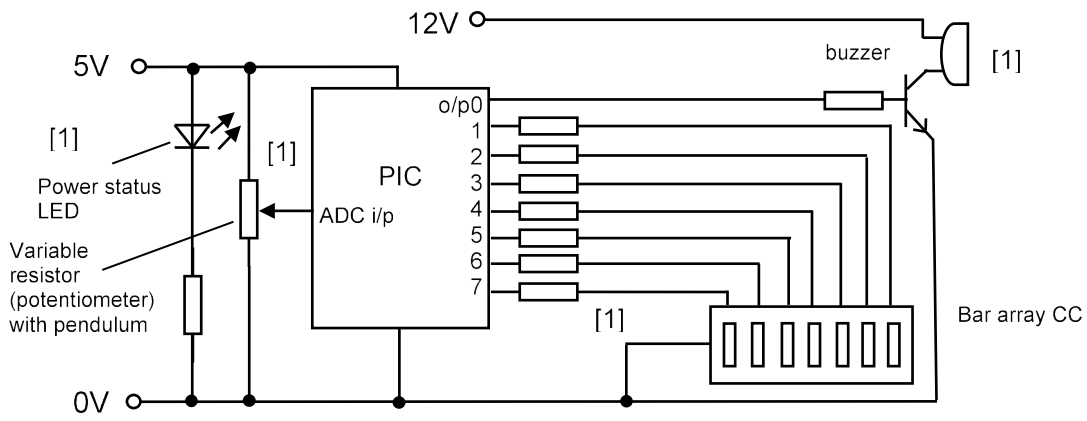
(iii) A higher resolution will provide a greater number of discrete digital values compared to an 8 bit converter. [1] Having a greater number of discrete values will result in greater conversion accuracy. [1]

Award [2] for a full explanation and [1] for a limited explanation [2]

All relevant, valid responses will be given credit.

(d) Sample answer

AVAILABLE MARKS



- ADC checks [1]
- ADC values [2]
- o/p sequence [1]
- Flash rate for LEDS [1]
- Buzzer activation [1]

ADC values – example calculation

$5V = 240^\circ$ for full rotation or $20.83mV$ per $^\circ$

Midpoint = $120^\circ = 2.5V = 127$

$10^\circ = 0.2083V$ or $255/5 \times 0.2083 = \text{digital equiv. } 10$

$20^\circ = 0.4166V$ or $255/5 \times 0.4166 = \text{digital equiv. } 21$

$30^\circ = 0.6249V$ or $255/5 \times 0.6249 = \text{digital equiv. } 31$

add or subtract 10, 21 or 31 for each $10^\circ, 20^\circ$ or 30° of tilt left/right
(96,106,117, 127, 137,148,158)

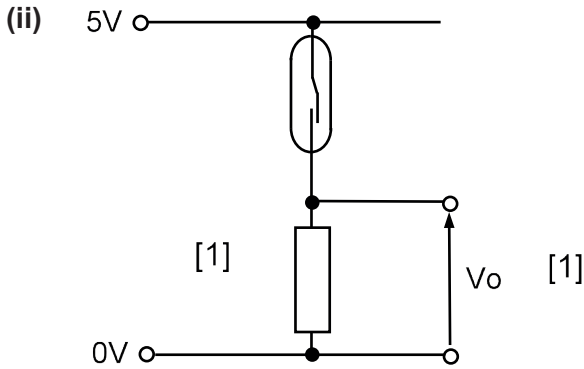
All relevant, valid responses will be given credit. [10]

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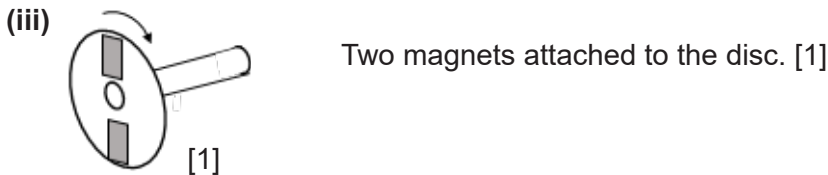
- 2 (a) (i) When a magnet is placed close to the reed switch, [1] the magnetic field causes the ferrous contacts (reeds) to move together and make contact. [1]

Award [2] for a full explanation and [1] for a limited explanation [2]

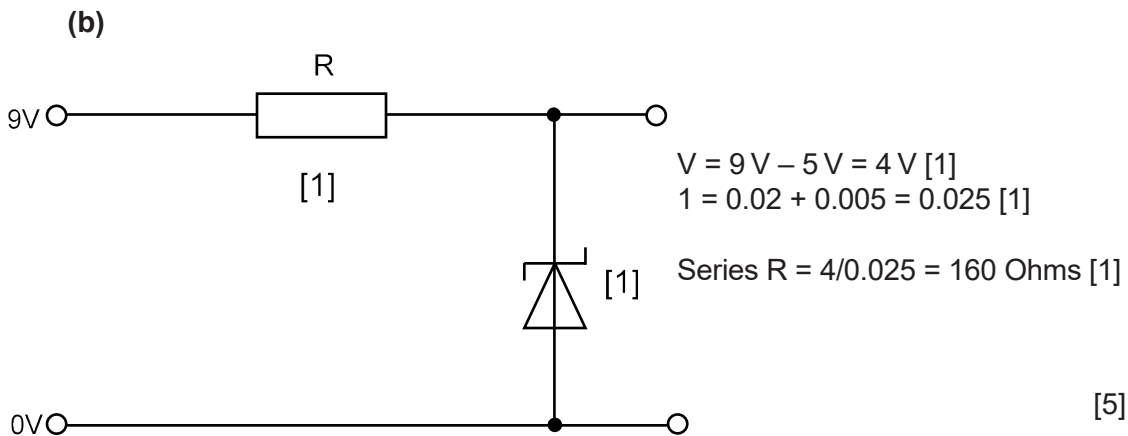
All relevant, valid responses will be given credit.



[2]

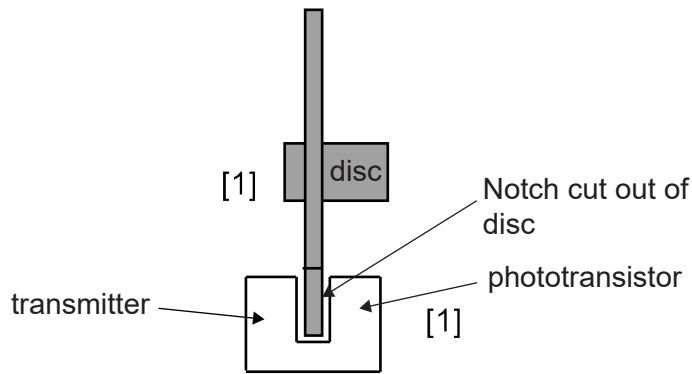


All relevant, valid responses will be given credit. [2]



(c) (i) sample answer

AVAILABLE MARKS

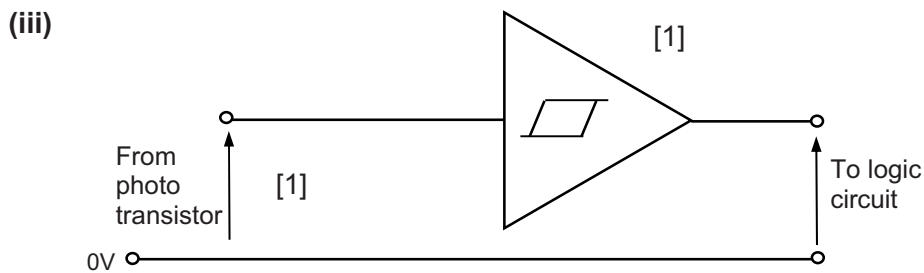


All relevant, valid responses will be given credit. [2]

(ii) As a phototransistor transitions from fully on to fully off it may output a voltage that is somewhere between low and high. [1] The inclusion of the Schmitt trigger will provide a clear distinction between low and high. [1]

Award [2] for a full explanation and [1] for a limited explanation [2]

All relevant, valid responses will be given credit.



[2]

(d) (i)

S3	S2	S1	pass	fail
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	1	0
1	0	1	1	0
1	1	0	1	0
1	1	1	1	0

[1]

[1]

[1]

[3]

(ii) for pass LED

	S_1S_2	$S_1\bar{S}_2$	$\bar{S}_1\bar{S}_2$	\bar{S}_1S_2
S_3	1	1	1	1
\bar{S}_3	1	0	0	0

[1]

minimised expression = $S_1.S_2 + S_3$ [1]

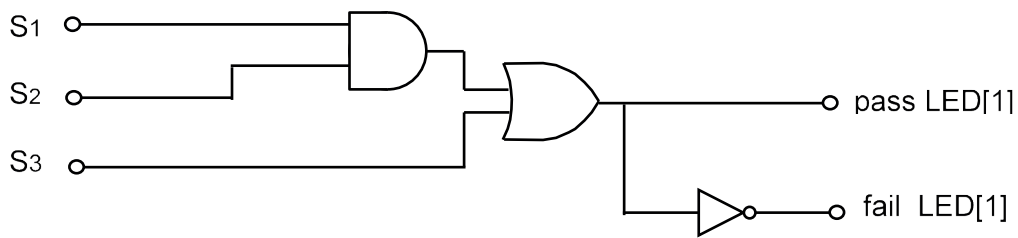
for fail LED

	S_1S_2	$S_1\bar{S}_2$	$\bar{S}_1\bar{S}_2$	\bar{S}_1S_2
S_3	0	0	0	0
\bar{S}_3	0	1	1	1

[1]

minimised expression = $\bar{S}_1.\bar{S}_3 + \bar{S}_2.\bar{S}_3$ [1] [4]

(iii)

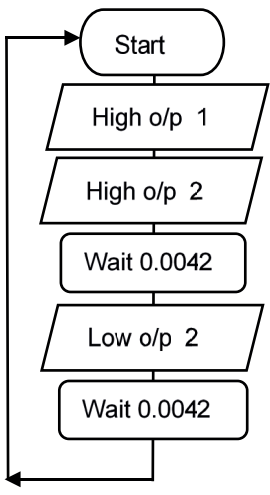
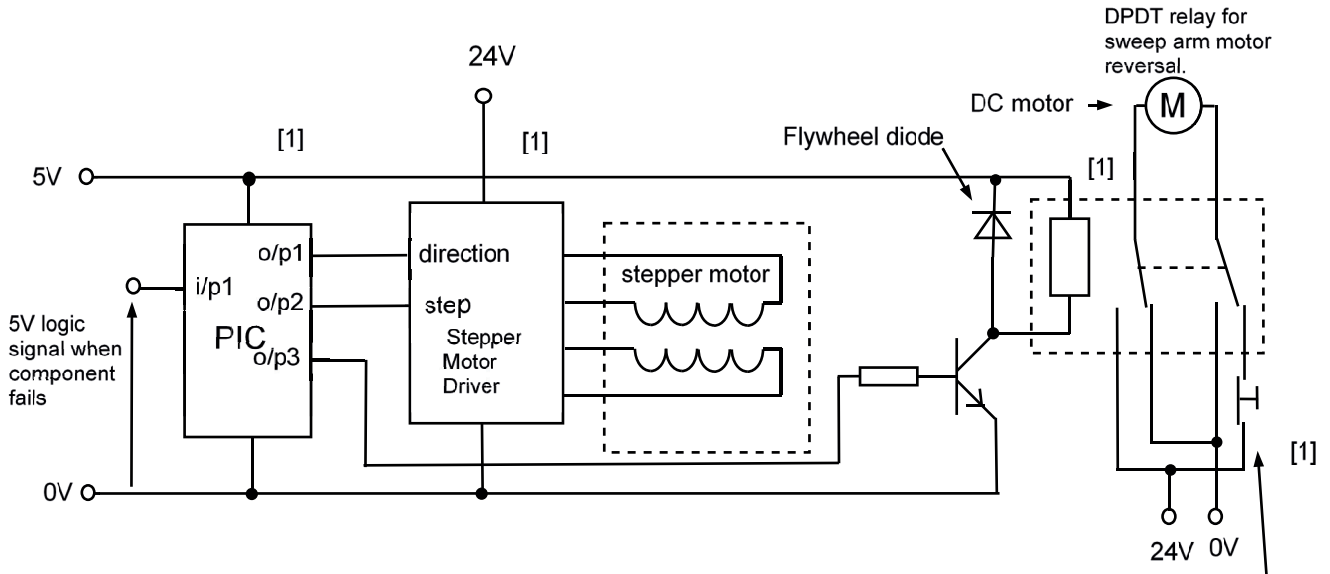


minimum number of gates [1]

All relevant, valid responses will be given credit. [3]

(e) $P(\text{LEDs}) = 0.03$ [1] $\times 3.2$ [1]
 $= 96 \text{ mW}$ [1] [3]

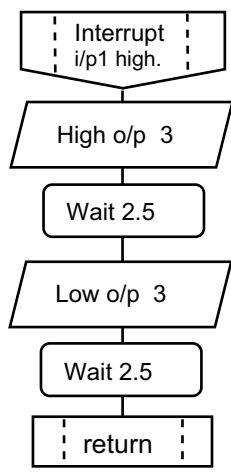
(f) Sample answer



The main program sets clockwise direction for the stepper and maintains the step frequency

step frequency
 $30\text{RPM} = 0.5\text{ RPS}$
 or $120\text{ steps} \times 1.5^\circ$
 or $120\text{ Hertz} = \text{on } 0.0042 \text{ off } 0.0042$

Stepper motor direction, step timing and sequence [3]



The interrupt will ensure that the arm moves immediately in a forwards direction for 2.5 seconds before returning. A limit switch is required to break the default relay circuit.

Interrupt set up and timing [3]

All relevant, valid responses will be given credit.

[10]

Total

AVAILABLE MARKS	
	40
	80

Section B

**AVAILABLE
MARKS**

Mechanical and Pneumatic

Answer **both** questions in this section.

- 3 (a) (i)** *Possible Risk*
Compressed air entering the blood stream [1]

Possible Procedure
Cover all open wounds [1]

Possible Risk
Moving parts causing injury to a user [1]

Possible Procedure
Ensure all cylinders have proper guards [1] [4]

All relevant, valid responses will be given credit.

- (ii)** Main features – ball, socket, correctly integrated

Very good sketch of the main features of the ball and socket. with very good annotation.	3
Good sketch of the main features of the ball and socket with good annotation.	2
Limited sketch of the main features of the ball and socket with limited annotation.	1
For a response not worthy of credit	0

[3]

Possible Explanation:
Ball and socket joints would be used in products like the selfie stick due to the fact that they allow 360 degree movement. [1]

All relevant, valid responses will be given credit.

- (iii)** Main features – inner and outer race, cage and roller

Very good sketch of the main features of a roller bearing with very good annotation.	3
Good sketch of the main features of a roller bearing with good annotation.	2
Limited sketch of the main features of a roller bearing with limited annotation.	1
For a response not worthy of credit	0

[3]

$$\begin{aligned}
 \text{(b) (i) } VR &= \frac{\text{DRIVEN}}{\text{DRIVER}} = \frac{180}{120} \times \frac{90}{180} \times \frac{180}{160} \times \frac{120}{100} \times \frac{90}{100} \times \frac{100}{125} \times \frac{50}{100} \times \frac{125}{50} \\
 &= 1.5 \times 0.5 \times 1.125 \times 1.2 \times 0.9 \times 0.8 \times 0.5 \times 2.5 \quad [1] \\
 &= 0.91 \quad [1] \qquad [2]
 \end{aligned}$$

$$\begin{aligned}
 \text{(ii) } VR &= \frac{\text{DRIVEN}}{\text{DRIVER}} \\
 &= \frac{180}{160} \times \frac{120}{100} \times \frac{90}{100} \\
 &= 1.125 \times 1.2 \times 0.9 \\
 &= 1.22 \qquad [1]
 \end{aligned}$$

$$\begin{aligned}
 \text{Efficiency} &= \frac{MA}{VR} \times 100 \\
 &= \frac{0.36}{1.22} \times 100 = 29.5\% \quad [1] \qquad [2]
 \end{aligned}$$

(c) Indicative content:

Relevant Factors:

Working conditions

Oils have to operate under different working conditions and therefore present different properties. It is necessary to select the correct type of oil for specific jobs. Thin oils have a low viscosity and flow easily through small holes and clearances. Thick oils have a high viscosity and offer more resistance to flow. Thick oils are capable of avoiding being squeezed out of bearing surfaces at high pressure.

Temperature

Oil is affected by temperature – the hotter an oil gets, the lower the viscosity. It is essential that your oil matches the working temperature of the system. Appropriate oil selection will match the working environment therefore ensuring effective operation of the transmission system.

Speed

The speeds involved determine the viscosity required at the systems operating temperature. Oil must be suitably selected to match the speed requirements of the gearing system otherwise corrosion and wear could extend to the disadvantage of the mechanical system.

Corrosion Prevention

How effective will the oil be in preventing corrosion within the given system? This ensures the oil selection prevents any corrosion of a mechanical appliance and is of particular importance for mechanical appliances which operate in sea conditions.

Classification Selected (any one of the following):

SAE number	Oil thickness	Application
10	Extra-light	Low pressure.
20	Light	Sewing machines, printers etc
30	Medium	General purpose, e.g. engines.
40	Medium-heavy	Bearings
50	Heavy	
60, 75, 140, 250	Extra heavy	High pressure, e.g. transmission and parts

<p>Level 3 The candidate discusses relevant factors in excellent depth and selects a suitable SAE with application. The written presentation is clear and precise and demonstrates excellent knowledge of the issues to be considered. Appropriate specialist terms and technological vocabulary used throughout. The candidate uses excellent spelling, punctuation and grammar and the form and style are of a high standard.</p>	[7]–[9]
<p>Level 2 The candidate discusses relevant factors in good depth and selects a suitable SAE with application. The written presentation is good and demonstrates a good knowledge of the issues to be considered. Some specialist terms and technological vocabulary are used throughout. The candidate uses good spelling, punctuation and grammar and the form and style are of a good standard.</p>	[4]–[6]
<p>Level 1 The candidate discusses relevant factors in basic depth with basic reference to SAE with application. The written presentation is basic and demonstrates a basic knowledge of the issues to be considered. Little use is made of specialist terms and technological vocabulary. The candidate uses spelling, punctuation and grammar with basic accuracy and the form and style are of a basic standard.</p>	[1]–[3]
Response not worthy of credit	[0]

[9]

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MARKS

(d) (i) Possible Advantage (Any one of the following)

Positive drive.
Easy to maintain.

Possible Disadvantage (Any one of the following)

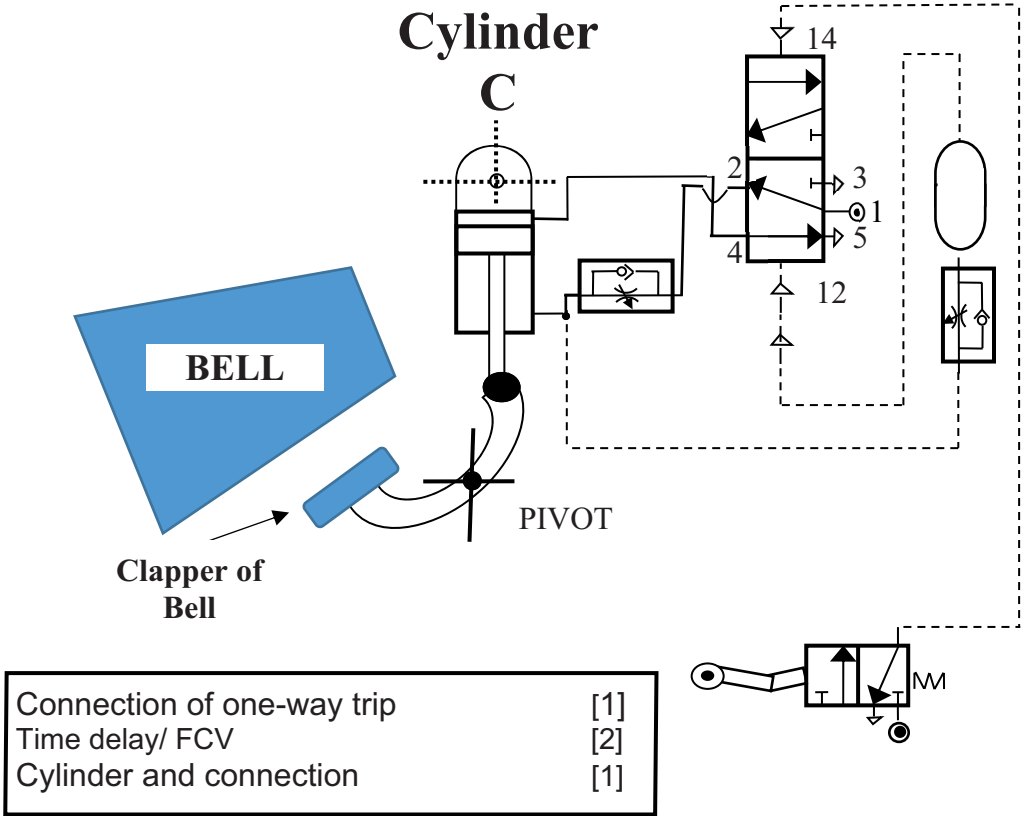
Chain drives can be noisy.
They require frequent lubrication.

(2 x [1])

[2]

All relevant, valid responses will be given credit.

(ii) Possible solution:



[4]

(e) (i) See A3 Mark scheme

[4]

(ii) See A3 Mark scheme

[6]

40

4 (a) (i) Selection of Seal: Garter Seal [1]

Possible Justification:

A garter seal was selected due to its compressive spring exerting inward radial forces which will keep the seal extremely tight and prevent any oil leakage. [1] [2]

(ii) Annotation to include lever, drum and band

Very good sketch of a band brake with a method of activation along with very good annotation.	3
Good sketch of a band brake with a method of activation along with good annotation.	2
Limited sketch of a band brake with no method of activation along with limited annotation.	1
For a response not worthy of credit	0

[3]

(iii) Gain in PE = mgh [1]

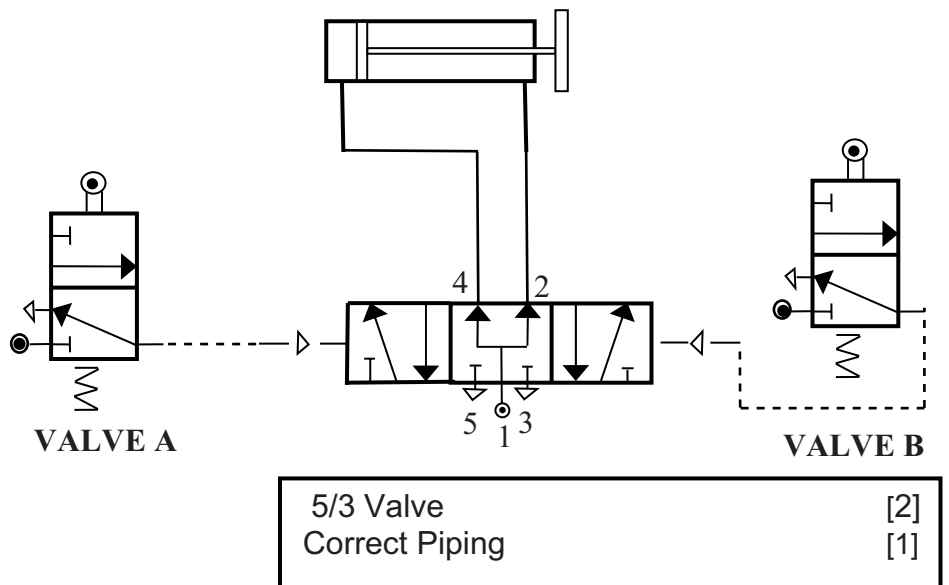
$$127660 = 2000 \times 9.82 \times ?$$

$$2000 \times 9.82 = 19640 \quad [1]$$

$$127660/19640 = 6.5\text{m} \quad [1] \quad [3]$$

(b) See A3 Mark scheme [10]

(c) (i)



Possible Explanation:

The 5/3 valve allows a high level of accuracy due to the fact that it has internal spool. [1] The internal spool can be stopped in any location allowing the connected cylinder to be stopped at a precise location. [1]

Award [2] for a full explanation and [1] for a limited explanation.

All relevant, valid responses will be given credit. [5]

(ii) Force Cylinder A = Pressure × Area
 = 0.5 × Area ($\pi 30^2$) [1]
 = 0.5 × 2826
 = 1413N [1]

Force of B1 and B2 = 706.5N each

B1 radius $706.5 = P \times A$

$$A = \frac{706.5}{0.5} = 1413$$

$$r^2 = \frac{1413}{3.14}$$

$$r = 21.21 \text{ mm [1] [3]}$$

(iii) D = 20mm
 S = 60mm
 d = 10mm
 Gauge Pressure = 4
 Atmospheric Pressure = 1.5

$$\text{Volume} = \frac{S \times D^2 \pi}{4}$$

$$\text{Volume} = 60 \times 20^2 \times 3.14 / 4$$

$$\text{Volume} = 18840 \text{ mm}^3 \quad [1]$$

$$\text{Volume} = \frac{S \times (D^2 - d^2) \times \pi}{4}$$

$$\text{Volume} = 60 \times 20^2 - 10^2 \times 3.14 / 4$$

$$\text{Volume} = 14130 \text{ mm}^3 \quad [1]$$

$$\text{Total volume} = 18840 + 14130 = 32970 \text{ mm}^3 \quad [1]$$

Volume = Piston Volume × (Gauge Pressure + Atmospheric Pressure)
 × No. of Cycles

$$\text{Volume} = 32970 \times (4 + 1.5) \times 10$$

$$\text{Volume} = 1813350 \text{ mm}^3 \quad [1] \quad [4]$$

(d) See A3 Mark scheme [10]

Total

**AVAILABLE
MARKS**

40

80

Section C

AVAILABLE
MARKS

Product Design

- 5 (a) It is important for a company producing hoverboards to get their product to the right place at the right time as this will provide them with the opportunity of maximising sales [1] and potential profits. [1]

Award [2] for a full explanation and [1] for a limited explanation. [2]

All relevant, valid responses will be given credit.

- (b) (i) Market pull is an approach which attempts to provide products that the market demands. [1] In contrast technology push is an approach which attempts to interest the market in new products based on new technological solutions. [1] [2]

Award [2] for a full explanation and [1] for a limited explanation.

All relevant, valid responses will be given credit.

- (ii) Fad products have generally a short life cycle, experiencing rapid growth and a very steep decline. [1] In contrast the basic products have a much longer life cycle with a much slower growth rate and little or no decline compared to fad products. [1] [2]

Award [2] for a full explanation and [1] for a limited explanation.

All relevant, valid responses will be given credit.

- (c) (i) Any **two** main characteristics associated with the opinion leaders for example:

- Opinion leaders (celebrities, magazines, early adopters) are the next most likely adopters of a fashion product after the fashion innovators
 - Opinion leaders often copy the fashion innovators and (put their spin on it) by changing the product into a more popular style.
 - Opinion leaders can have a strong influence on a product. This can result in an increase in production and the product being available in more retail outlets.
- (2 × [1]) [2]

All relevant, valid responses will be given credit.

- (ii) Fashion innovators are often trend setters and want to be seen to adopt the latest model of a new product. [1] In contrast laggards often dislike the change brought about by the introduction of the latest model of a new product and will usually only accept the change when forced to. [1] [2]

Award [2] for a full response and [1] for a limited response.

All relevant, valid responses will be given credit.

(d) Indicative content:

AVAILABLE
MARKS

Baylis

Rather than using batteries or an electric source Baylis powered a radio by winding a crank up for several seconds (using stored energy in a spring). This technology was then further developed and refined and combined with solar power to create a radio which offered up to 15 hours of playtime. This technology has impacted on product design as it has opened up the opportunity to be implemented in a range of electronic devices. His ideas for design and innovation can be shown in his design of a shoe to generate electricity while the wearer walked to charge batteries. But his idea for pedestrian power was not a great success, although there is much interest in piezoelectric materials today. In addition he set up the Trevor Baylis Foundation to 'promote the activity of invention by encouraging and supporting inventors and engineers', to advise on intellectual property protection and help people to get the value they want from their ideas.

Memphis

The Memphis movement helped to change the slick, black, humourless design of the 1970s with its minimalist design all of which were visually similar and in the eyes of the Memphis group devoid of personality and individualism. They had a strong impact on the design of furniture, architecture, household items, and clothes. They created limited production creations of unusual objects and functional designs featuring plastic laminate surfaces, bright colours and bold patterns. In addition, they encapsulated post-modernist design in the 1980s challenging perceptions of 'good design' through their gaudy ornamental and decorative products.

Apple

One of the major influences that Apple brought to product design was the focus on creating product forms that offered a clarity of function devoid of superfluous detail. At its core was the principle of simplicity which was to make products intuitively obvious and easy to use. This was not merely the shallow simplicity that comes from an uncluttered look and feel and surface of a product, but the deep simplicity that comes from knowing the complexities of its engineering and the function of every component. In addition, Apple embraced minimalism but avoided allowing this to make their products look cold. Apple also challenged many to think about the role of design. Apple's view was that, design was not just about what a product looked like on the surface. It had to reflect the product's essence. As a result, the process of designing a product at Apple was integrally related to how it would be engineered and manufactured. To do so required total collaboration between the designers, the product developers, the engineers and the manufacturing team.

<p>Level 3 The candidate has provided an excellent description of how the designer Trevor Baylis and the design movements of Memphis and Apple have influenced product design. The written presentation is clear and precise and demonstrates excellent knowledge of the subject to be considered. Appropriate specialist terms and technological vocabulary are used throughout. The candidate uses excellent spelling, punctuation and grammar, and the form and style are of a high standard.</p>	[7]–[9]
<p>Level 2 The candidate has provided a good description of how the designer Trevor Baylis and the design movements of Memphis and Apple have influenced product design. The written presentation is good and demonstrates good knowledge of the subject to be considered. Some specialist terms and technological vocabulary are used throughout. The candidate uses good spelling, punctuation and grammar, and the form and style are of a good standard.</p>	[4]–[6]
<p>Level 1 The candidate has provided a basic description of how the designer Trevor Baylis and the design movements of Memphis and Apple have influenced product design. The written presentation is basic and demonstrates basic knowledge of the subject to be considered. Little use is made of specialist terms and technological vocabulary throughout. The candidate uses spelling, punctuation and grammar, with basic accuracy and the form and style are of a basic standard.</p>	[1]–[3]
Response not worthy of credit	[0]

[9]

All relevant, valid responses will be given credit.

- (e) (i) Any **two** different environmental reasons why it is so important for product designers and manufacturers to consider the management of waste for example:
- To prevent valuable resources being used up.
 - To prevent pollution issues with leaching of harmful materials from landfills and ash from incinerators.
 - Management of waste reduces the need to find expensive industrial disposal options.
- (2 × [1]) [2]

All relevant, valid responses will be given credit.

- (ii) Any **two** different ways in which product designers and manufacturers can start to address environmental concerns through the disposal of their products for example:
- Implement a scheme of return or take back of old products.
 - Redesign of components or products for disassembly and recycling.
 - End-of-life programmes designed to reuse or harvest materials back into the market where they are made into new products.
- (2 × [1]) [2]

All relevant, valid responses will be given credit.

AVAILABLE
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(iii) Manufacturing process of Sand Cores for Aluminum Castings (Voxeljet).

This is an environmentally friendly process as it uses an inorganic binder. [1] The inorganic materials used only emit water vapour during the casting process which significantly improves air quality. [1]

Award [2] for a full explanation and [1] for a limited explanation. [2]

All relevant, valid responses will be given credit.

(f) Any **two** different ways in which CAD could be employed in the design of the hoverboard for example:

- CAD used to provide exploded views to highlight specific features to clients.
- CAD used in virtual stress modelling to determine key dimensions.
- CAD used to create files that can be rapid prototyped to demonstrate key features of the hoverboard.

(2 × [1]) [2]

All relevant, valid responses will be given credit.

(g) Price skimming could be the pricing strategy. The company could set a very high price at first [1] and then lower this price over the period of the product life cycle. [1]

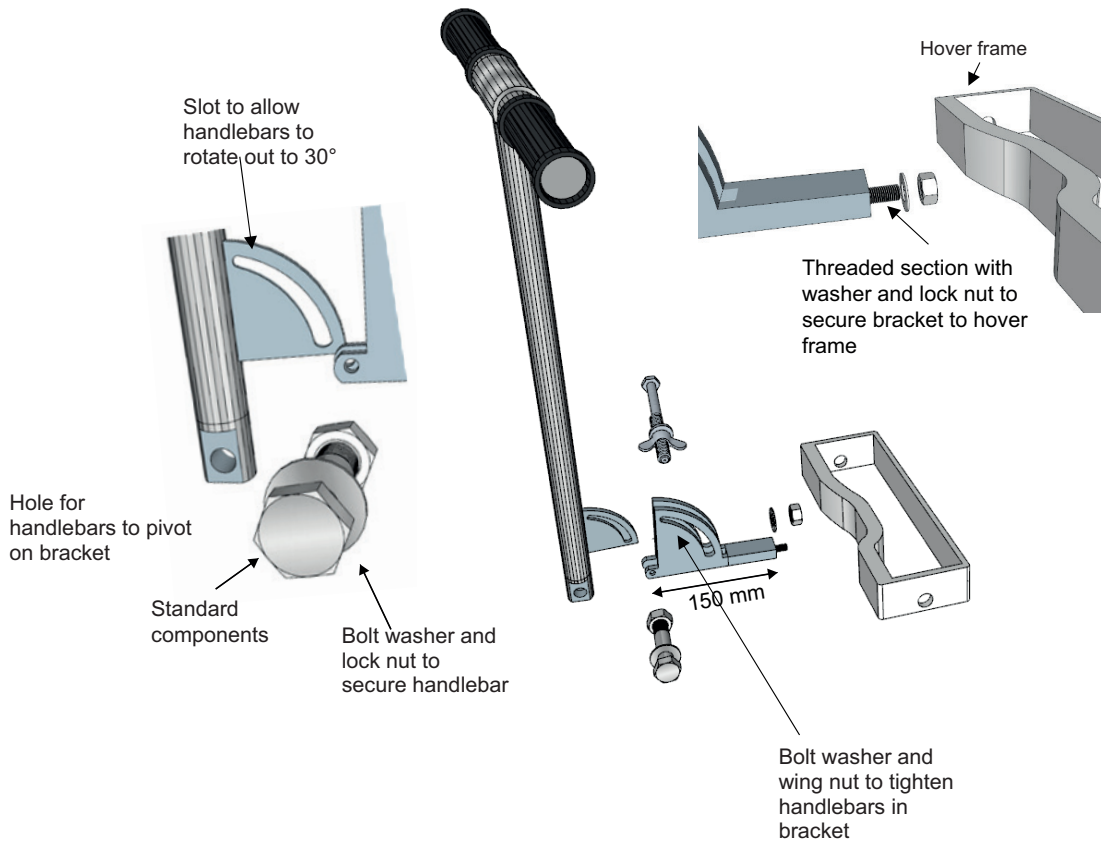
Award [2] for a full explanation and [1] for a limited explanation.

This could be justified on the basis that there may be little or no existing competition. [1] [3]

All relevant, valid responses will be given credit.

(h) Sample Answer

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Annotation on how the above design has minimised the use of materials and processes and how it is suitable for large scale production could include some of the following points:

- The use of an aluminum alloy could reduce the material profile of the brackets whilst maintaining the mechanical properties required of the design.
- The dimensional profile of the brackets is reflective of the functional requirements of the design.
- The use of standard components (bolts, nuts and washers) will reduce the need for specialist processes.
- Manufacturing the design in large numbers using a casting method will reduce the number of secondary processes required.

All relevant, valid responses will be given credit.

Detailed annotated sketches of an appropriate design that would allow the user without the use of hand tools, to quickly move and secure the handlebars at a convenient angle for the user, up to a maximum of 30° from the vertical. The design is securely connected to the frame of the hoverboard and holds the handlebars at a distance of 150 mm from the frame. There is a clear explanation on how the design has minimised the use of materials and processes and how the design is suitable for large scale production.	[7]–[10]
Both the sketches and the annotation are good. The design has limitations with regards to, if the user could without the use of hand tools, quickly move and secure the handlebars at a convenient angle for the user, up to a maximum of 30° from the vertical. There are limitations with regards to if, the design is securely connected to the frame of the hoverboard and holds the handlebars at a distance of 150 mm from the frame. There is a limited explanation on how the design has minimised the use of materials and processes and how the design is suitable for large scale production.	[4]–[6]
Limited sketches lacking detail and appropriate annotation. Difficulties in determining if the user could without the use of hand tools, quickly move and secure the handlebars at a convenient angle for the user, up to a maximum of 30° from the vertical. Difficulties in determining if the design is securely connected to the frame of the hoverboard and holds the handlebars at a distance of 150 mm from the frame. Little or no explanation on how the design has minimised the use of materials and processes and how the design is suitable for large scale production.	[1]–[3]
Response not worthy of credit	[0]

[10]

40

- 6 (a) The inception stage is the first stage of the product life cycle and begins long before the product is to be introduced to the market. [1] This stage really focuses on ensuring that the project is both worth doing and possible to do. [1]

Award [2] for a full explanation and [1] for a limited explanation. [2]

All relevant, valid responses will be given credit.

- (b) (i) Any **two** characteristics associated with market development for example:

- Repositioning the product into different market segments.
- Moving into completely new markets.
- Market development is considered to be risky as there is no prior knowledge of the market.

(2 × [1]) [2]

All relevant, valid responses will be given credit.

(ii) Any **two** characteristics associated with product development for example:

- Changing or developing existing products.
- Developing new products from the basis of the old classic model.
- Product development is used to differentiate products from competitor products in competitive markets.

(2 × [1]) [2]

All relevant, valid responses will be given credit.

(c) (i) The volume of sales expected during the growth stage would rise rapidly as the product has been accepted by the market. [1] In comparison, the volume of sales expected during the maturity stage would be lower due to market saturation. [1] [2]

Award [2] for a full response and [1] for a limited response.

All relevant, valid responses will be given credit.

(ii) The marketing costs expected during the introduction stage would be high due to the intense use of different media to launch the product. [1] In comparison, the marketing costs expected during the decline stage could be low as the company does not regard it as cost effective. [1] [2]

Award [2] for a full response and [1] for a limited response.

All relevant, valid responses will be given credit.

(d) (i) Any **two** characteristics associated with responsible sourcing when selecting a material for example:

- To ensure communities local to the extraction and manufacture have been given adequate consideration.
- To ensure that the materials have been extracted and processed in an environmentally sensitive manner.
- Applying a responsible sourcing strategy can help achieve sustainability objectives.

(2 × [1]) [2]

All relevant, valid responses will be given credit.

(ii) Any **two** characteristics associated with recycling content when selecting a material for example:

- Using a material with a higher recycled content will result in a reduction of energy being used .
- It can result in a reduction of emission of greenhouse gases.
- Using a higher content of recycled material will ultimately result in less material having to be extracted.

(2 × [1]) [2]

All relevant, valid responses will be given credit.

(e) Any **two** benefits of (QRM) which could be used to persuade the company to adopt this approach for example:

- Using QRM may reduce waiting time for the company [1] which may result in improved customer satisfaction and repeat business. [1]

- Using QRM can increase the company's cash flow. [1] Delivering products quicker, getting paid quicker improves cash flow giving the company more flexibility. [1]
- Using QRM will give the company greater flexibility [1] and a greater opportunity to respond to market changes. [1]

Award [2] for a full explanation and [1] for a limited explanation.

(2 × [2])

[4]

All relevant, valid responses will be given credit.

- (f) Any **two** advantages associated with the use of sales promotion as a way of increasing product sales for example:

- Sales promotion can result in a relatively quick increase in sales figures.
- Sales promotions are recognised and accepted in the market.
- Sales promotions entice consumers to continue purchasing.

(2 × [1])

[2]

Any **two** disadvantages associated with the use of sales promotion as a way of increasing product sales for example:

- Consumers wait for the promotion deals to be announced and then purchase the product.
- Promotions mostly build short-term sales volume, which is difficult to maintain.
- A sales promotion could have a negative effect on the quality image of the product.

(2 × [1])

[2]

All relevant, valid responses will be given credit.

- (g) (i) ICT may be used as a final quality check to include, testing the product (by sensors and computers) [1] to ensure it is within the correct tolerances and to the correct standard. [1]

Award [2] for a full description and [1] for a limited description.

[2]

All relevant, valid responses will be given credit.

- (ii) ICT may be used in the delivery of a QA system to ensure that staff training, administrative procedures [1] and quality monitoring of the product at various stages of manufacture, are to the highest standard. [1]

Award [2] for a full description and [1] for a limited description.

[2]

All relevant, valid responses will be given credit.

- (h) (i) One example of a product which incorporates moral factors in its design would be computer software. [1] The design is such that it provides the opportunity for the user to use software to filter on-line material or restrict or block access to specific sites on-line. [1]

Award [2] for a full description and [1] for a limited description

[2]

All relevant, valid responses will be given credit.

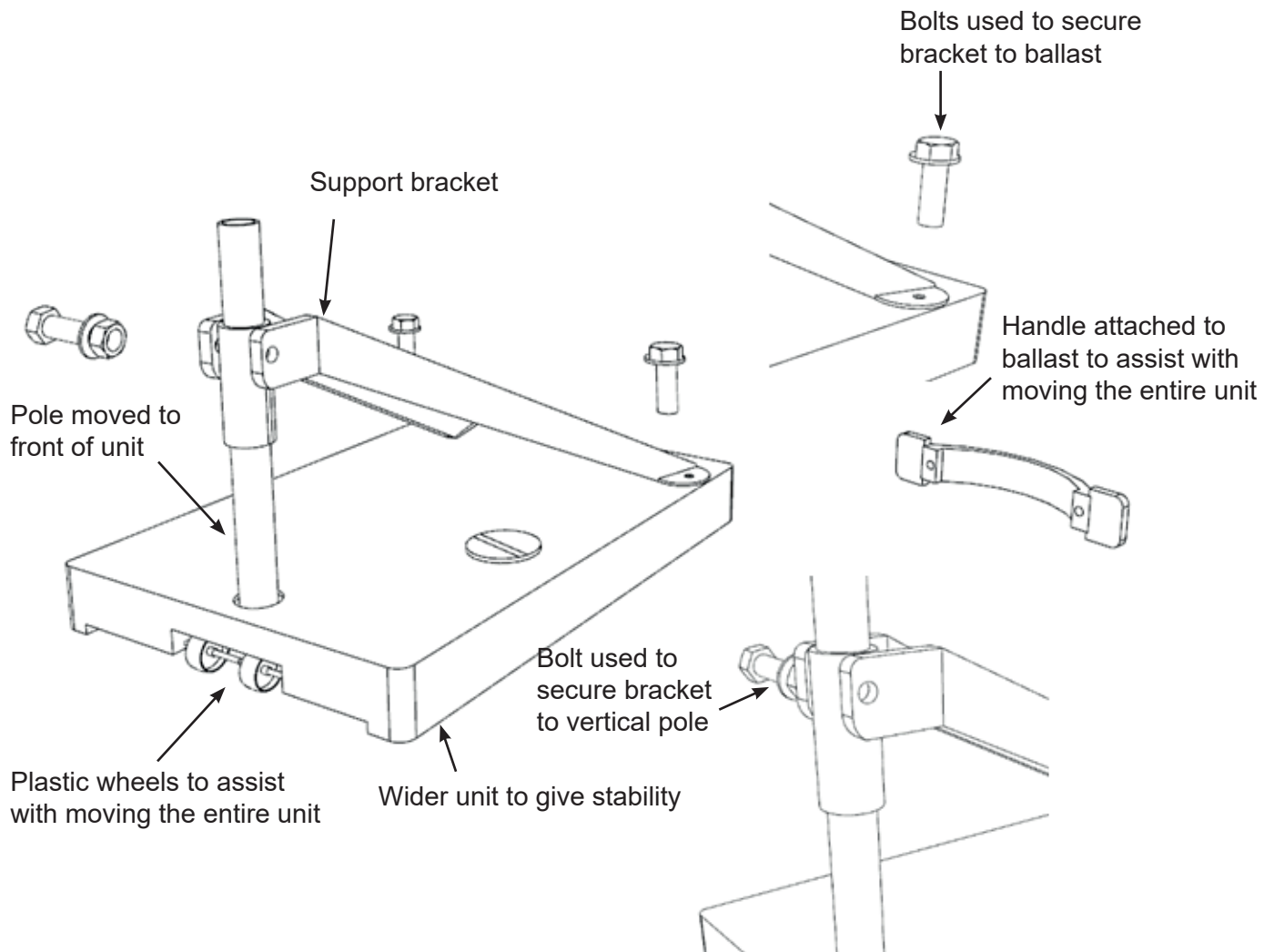
- (ii) The design of a car within a specific make and model can demonstrate consideration given to economic factors with the various options [1] (interior finish, built-in technological features, engine capacity, standard/sport packs). [1]

Award [2] for a full description and [1] for a limited description. [2]

All relevant, valid responses will be given credit.

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MARKS

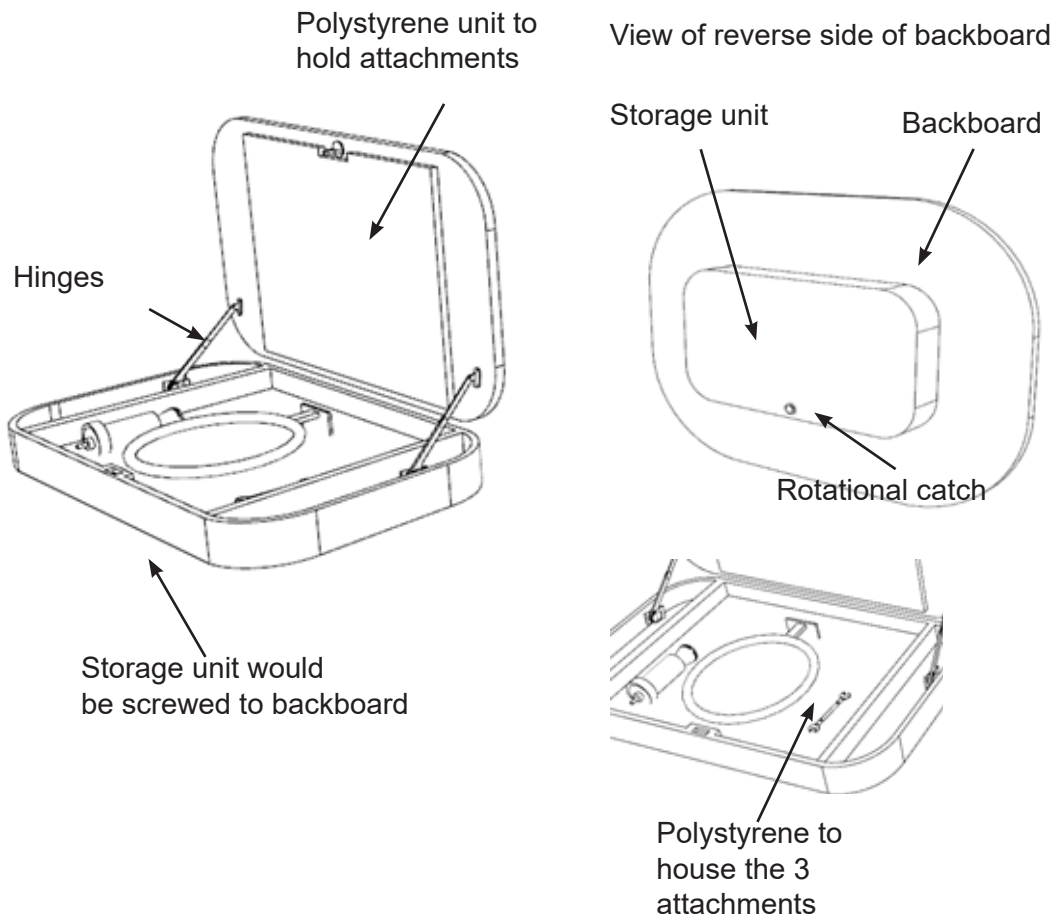
(i) (i) **Sample answer.**



Detailed annotated sketches of an appropriate redesign which make it easier to move the basketball stand, gives improved stability and provides support to the vertical pole.	[4]–[5]
Both the sketches and annotation are good. The idea represents an improvement but there are some limitations about the redesign and if it makes it easier to move the basketball stand, if it gives improved stability and if it provides support to the vertical pole.	[3]
Limited sketches lacking detail and appropriate annotation. Difficulties in determining if the redesign makes it easier to move the basketball stand and if it improves stability and provides support to the vertical pole.	[1]–[2]
For a response not worthy of credit	[0]

[5]

(ii) Sample answer



Detailed annotated sketches of an appropriate design which would enable the attachments to be securely housed, quickly removed and replaced and provide protection from outdoor weather conditions.	[4]–[5]
Both the sketches and annotation are good. The idea represents an improvement. There are some limitations about the design and if it would enable the attachments to be securely housed, quickly removed and replaced and provide protection from outdoor weather conditions.	[3]
Limited sketches lacking detail and appropriate annotation. Difficulties in determining if the design would enable the attachments to be securely housed, quickly removed and replaced and provide protection from outdoor weather conditions.	[1]–[2]
For a response not worthy of credit	[0]

[5]

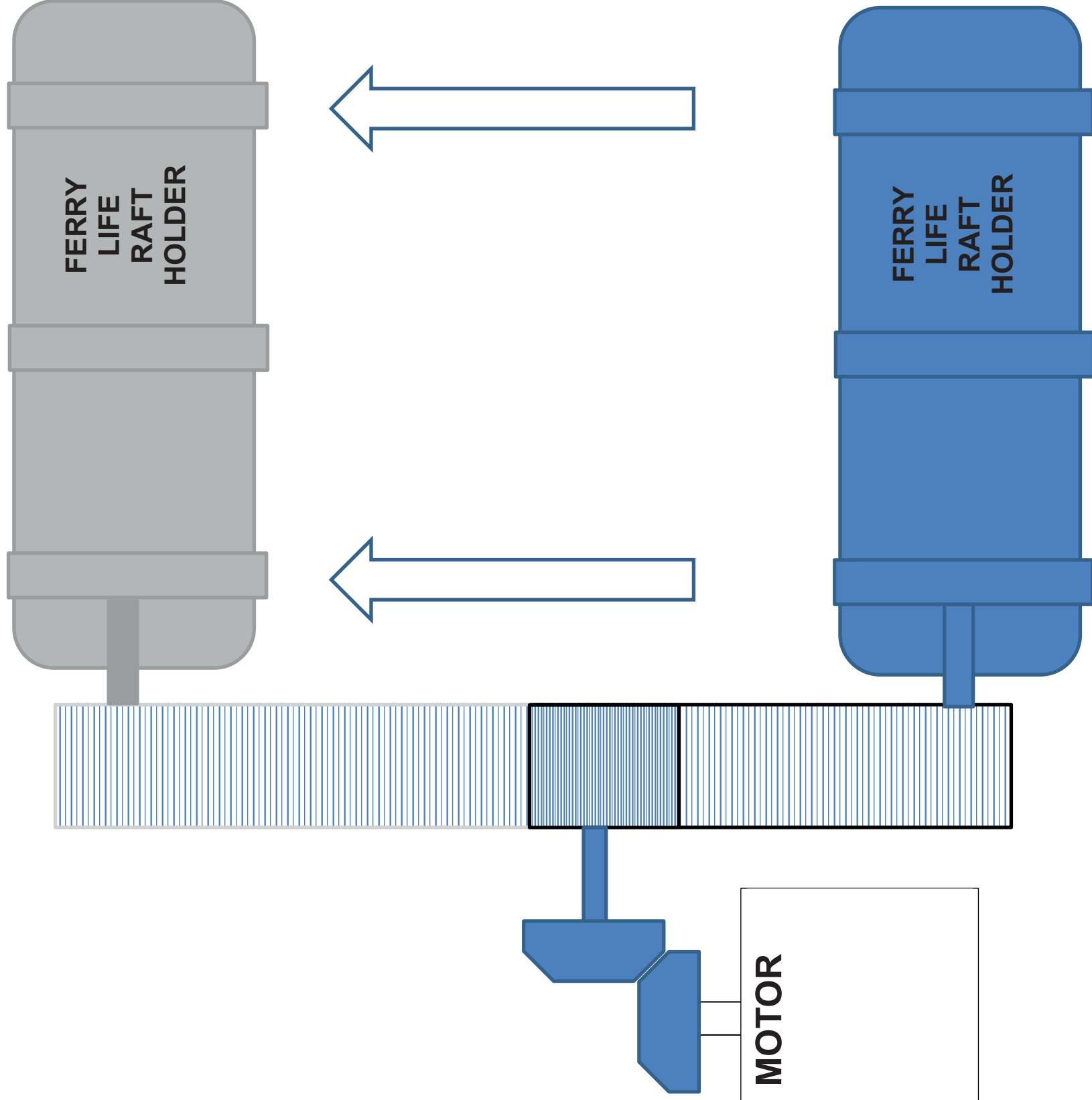
Total

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40

80

3(e)(i) Sample Answer:



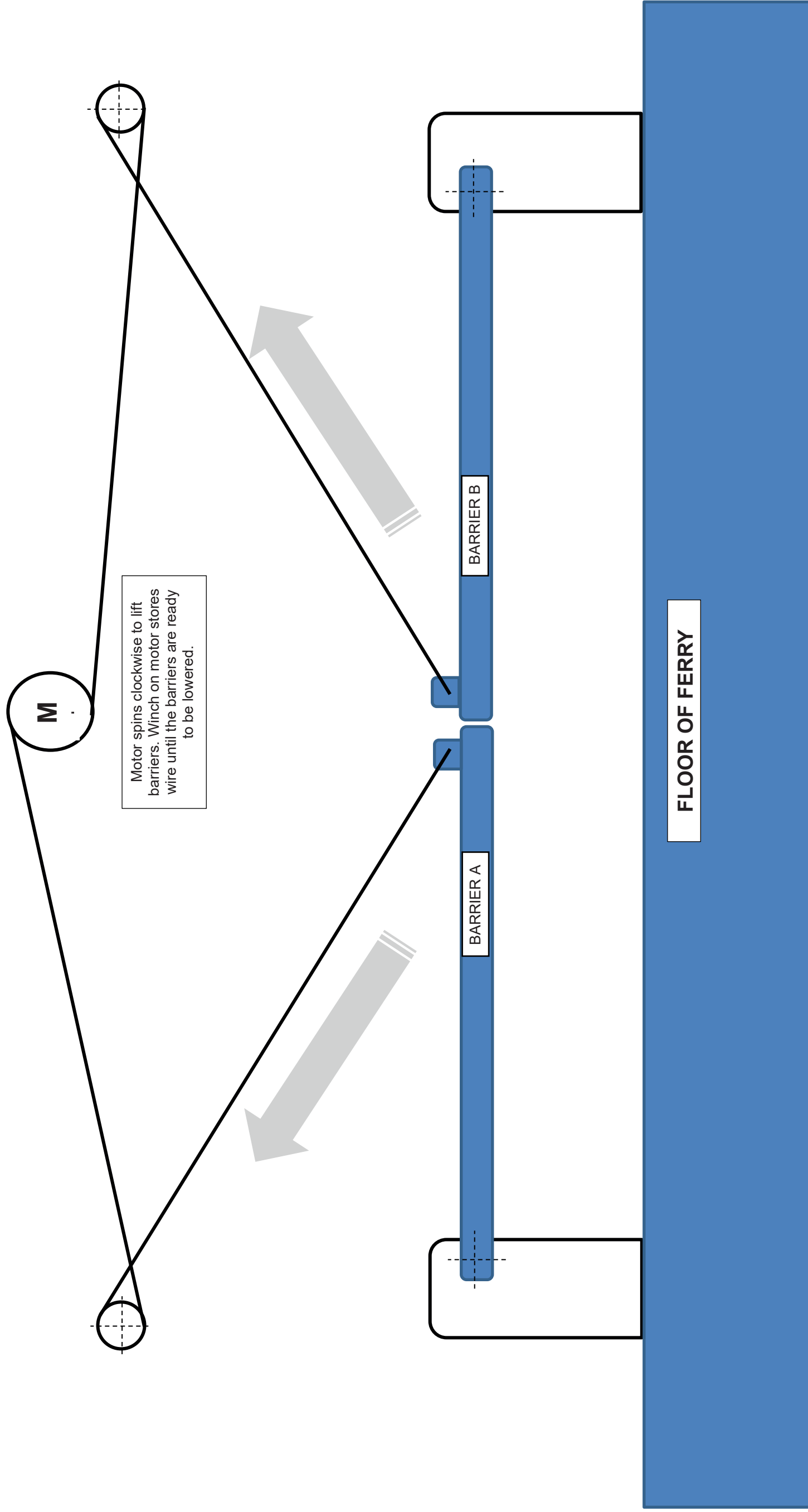
Mechanism: Rack and Pinion
Bevel Gears

[2]
[2]

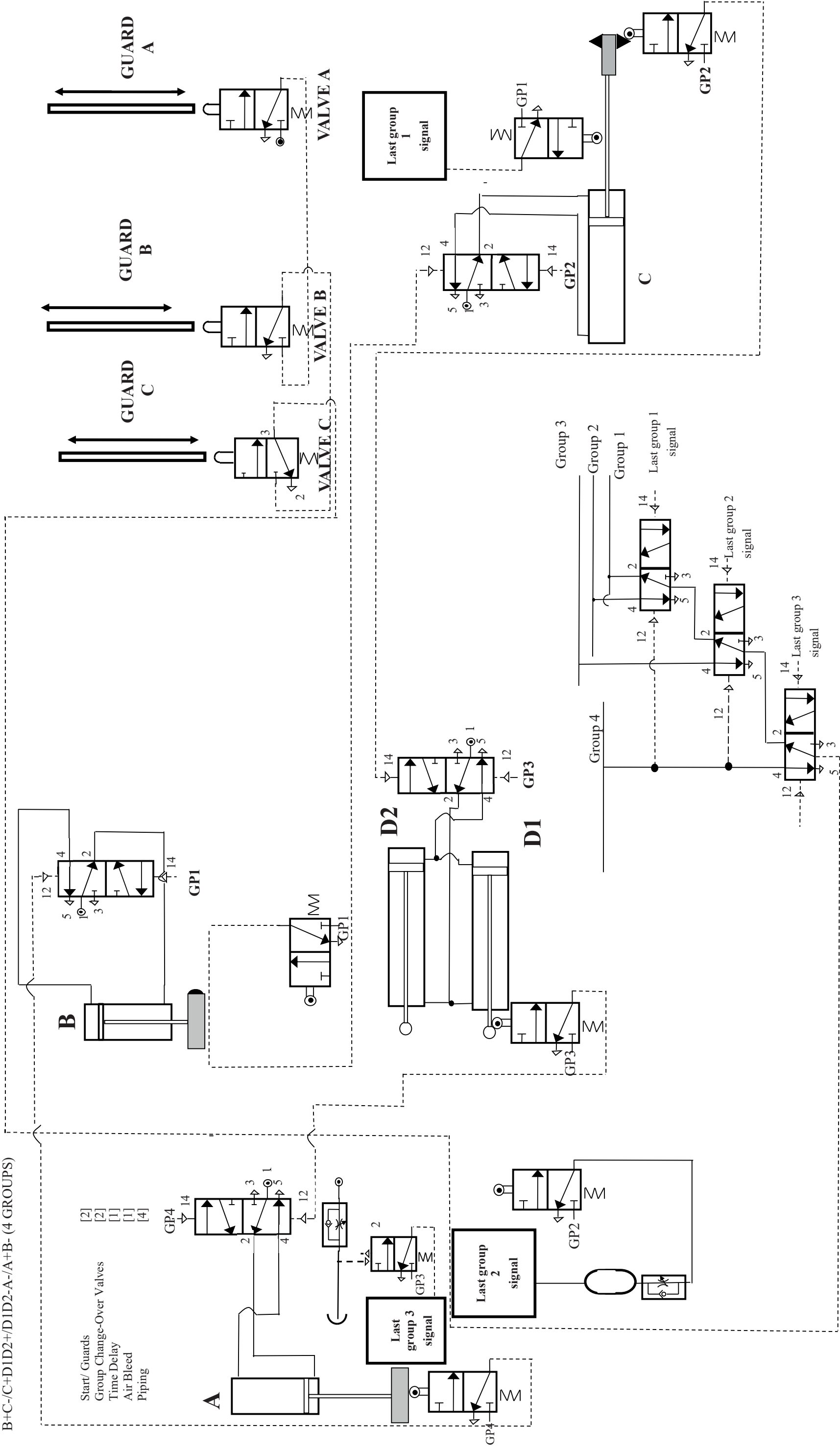
Sample Answer:
Rack and Pinion.
With motor attached
via bevel gears. Will
allow movement
over the large
distance. Life raft
holder is connected
to rack.

appropriate mechanism to lift barrier A and barrier B together [3]
appropriate mechanism to lower barrier A and barrier B together [3]

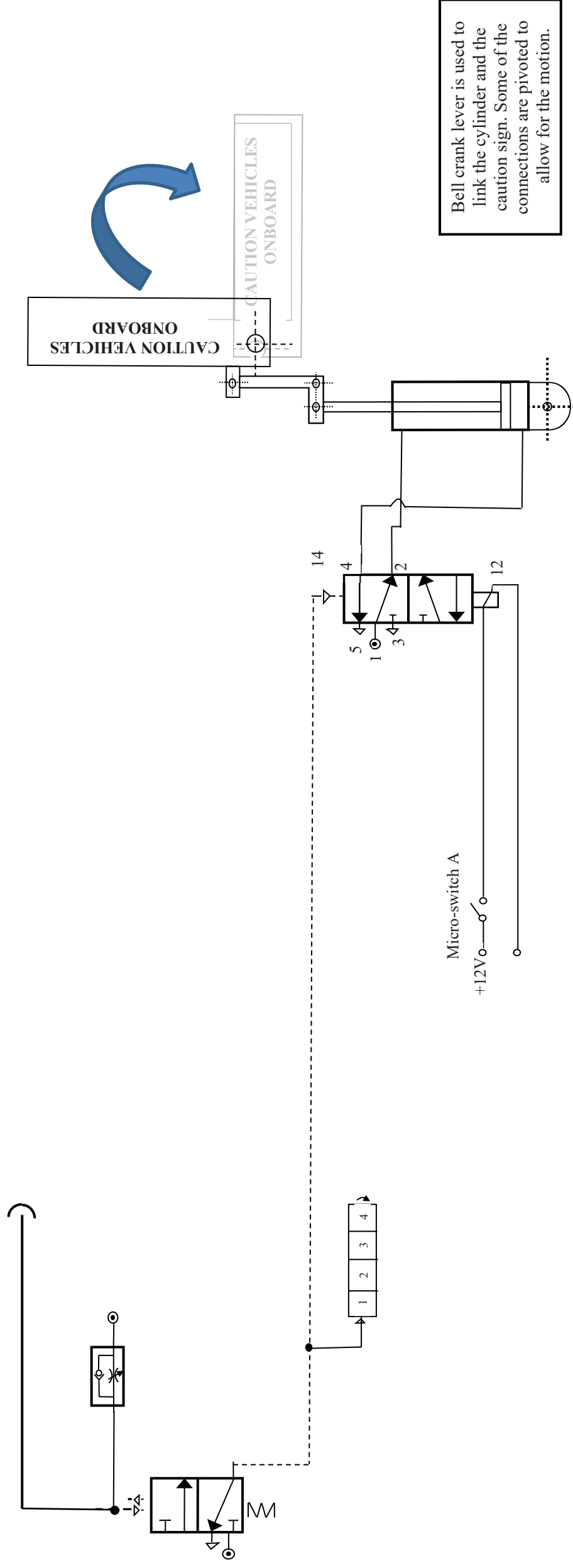
3(e)(ii)



4(b) Mark scheme
 B+C-/D1D2+/D1D2-/A+/A- (4 GROUPS)



4(d) Sample Answer



- Correct drawing and piping of air bleed [2]
- Counter Linked [1]
- Correct piping of 5PV [1]
- Mechanism selected and connections (sample Bell Crank 2 marks for the levers and 2 marks for the pivot points) [4]
- Lever [4]
- Solenoid connection [2]