



Rewarding Learning

ADVANCED
General Certificate of Education
2016

Technology and Design

Assessment Unit A2 1

assessing

Systems and Control

and

Product Design

[AV211]

MONDAY 23 MAY, MORNING

**MARK
SCHEME**

General Marking Instructions

Introduction

Mark schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of students in schools and colleges.

The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes, therefore, are regarded as part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

In all cases, correct alternative responses will be given full credit.

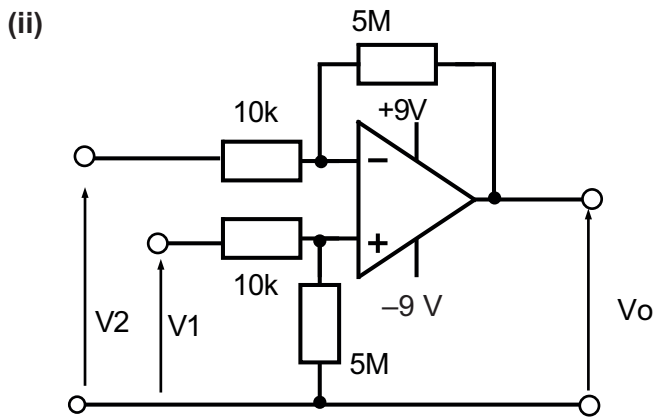
AVAILABLE
MARKS

Section A

- 1 (a) (i) Resistance changes as the gauge is deformed. [1]
- (ii) The active axis is the direction along the gauge where sensitivity is highest and the passive axis (usually at 90° to the active axis) is the direction along the gauge where sensitivity is lowest. [2]
- (iii) Increased temperature will cause an increase in resistance of a gauge. However it is difficult to distinguish if the change in resistance of a strain gauge is due to deformation of the gauge or increasing temperature. [2]

- (b) (i) 4.5 volts [1]
- (ii) $V1 = 120.3/240.3 \times 9$
 $= 4.506$ volts [2]

- (c) (i) $V1 - V2 = 0.006$
 Gain = $3/0.006$
 $= 500$ [2]



[4]

- (d) (i) Karnaugh Map. [1]

(ii)

Qc	Qb	Qa	A	B	C	D
0	0	0	1	0	0	0
0	0	1	0	1	0	0
0	1	0	0	0	1	0
0	1	1	0	0	0	1
1	0	0	0	0	1	0
1	0	1	0	1	0	0
1	1	0	1	0	0	0
1	1	1	0	0	0	0

[1] for correct Qa, Qb and Qc. [1] for corresponding A, B, C and D [2]

(iii) $A = \bar{Q}_a \cdot \bar{Q}_b \cdot \bar{Q}_c + \bar{Q}_a \cdot Q_b \cdot Q_c$

$B = Q_a \cdot \bar{Q}_b$

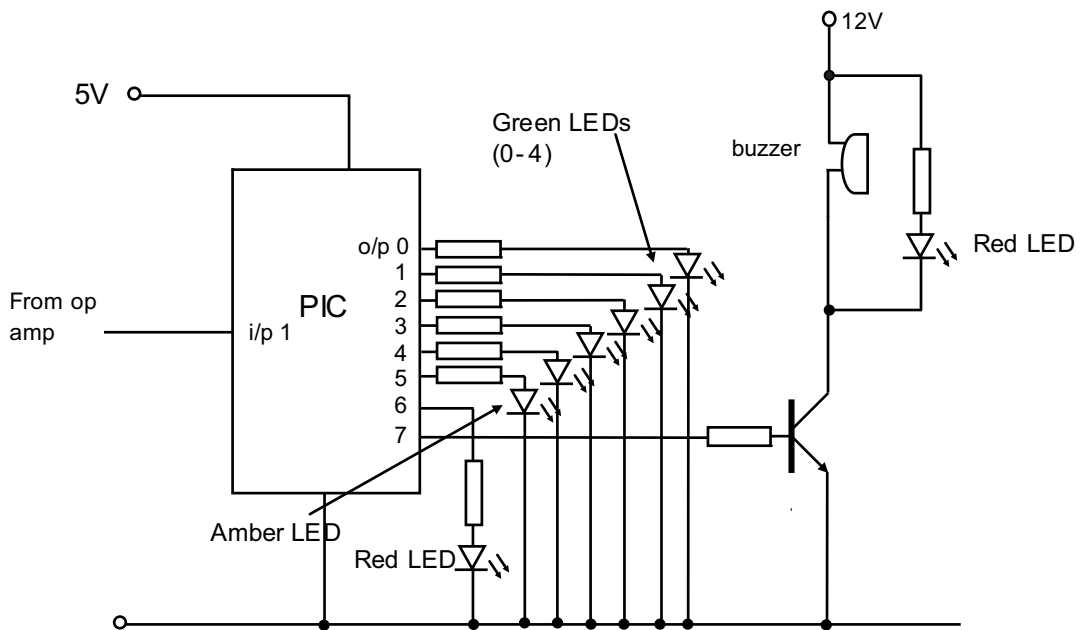
$C = \bar{Q}_a \cdot Q_b \cdot \bar{Q}_c + \bar{Q}_a \cdot \bar{Q}_b \cdot Q_c$

$D = Q_a \cdot Q_b \cdot \bar{Q}_c$

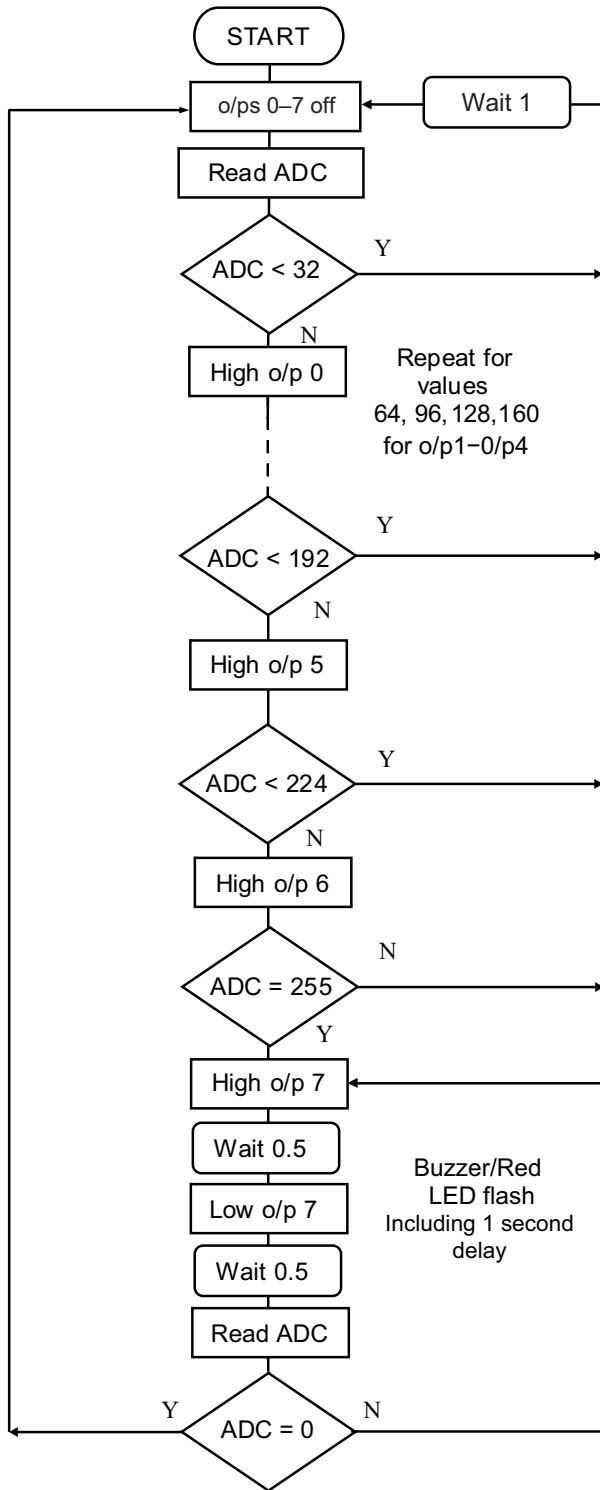
Note only B can be minimised.

[4]

(e) Sample answer



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[10]

- (f) Answer to include a structured and coherent written presentation with reference to any three of the following:
1. Flexibility – programmable systems provide opportunities to change control functions during development whereas hard-wired systems tend to have a specified range of fixed functions.
 2. Versatility – programmable systems such as PICs can have a range of digital and analogue inputs and outputs that can be configured. Hard-wired systems tend to have a fixed number of inputs and outputs.
 3. Cost for standard hard-wired components can be considerably lower compared to programmable systems that can incur higher costs such as download interfaces and software.
 4. Fault finding on hard-wired systems generally confined to the circuit hardware itself whereas programmable systems may require additional software debugging.

A hard-wired circuit solution could be chosen in preference to a PIC for a simple 0–99 counter. While the hard-wired circuit will have more components the dedicated counter and decoder integrated circuits are reliable and low cost. The PIC required to drive 2 digits would require at least 14 outputs and the associated programming. The hard-wired counter can run at higher speeds whereas the PIC circuit may be limited by the clock speed. [5]

Quality of written communication [4]

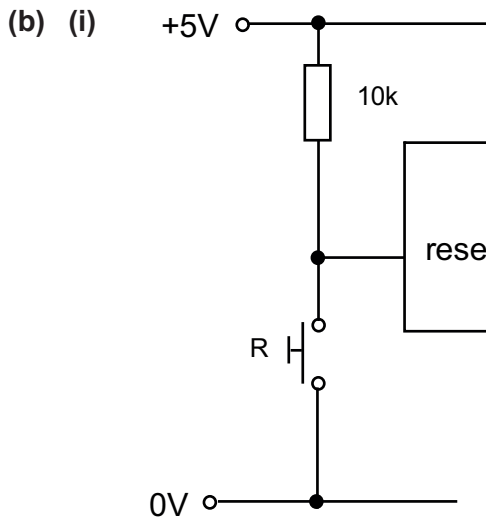
Level of response not worthy of credit.	[0]
Poor selection and use of a writing form and style appropriate to the content. The content is poorly organised and little use is made of appropriate technological vocabulary. The writing is barely legible and the spelling, grammar and punctuation are inaccurate.	[1]–[2]
Good selection and use of a writing form and style appropriate to the content. The content is organised and use is made of appropriate technological vocabulary. The writing is legible and the spelling, grammar and punctuation are suitable.	[3]
Very good selection and use of a writing form and style appropriate to the content. The content is well organised and good use is made of appropriate technological vocabulary. The writing is clearly legible and the spelling, grammar and punctuation are very accurate.	[4]

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2 (a) (i) Resistance decreases as light levels increase [1]

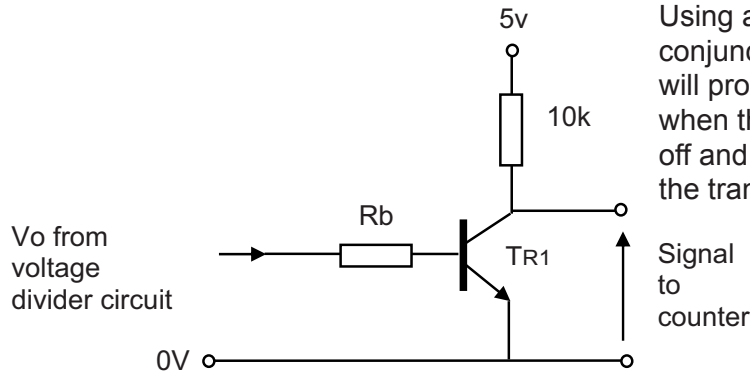
(ii) At 60 kΩ $V_o = 50/110 \times 5 = 2.27$ volts [2]



[2]

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(ii)



Using a 10k resistor in conjunction with the transistor will provide close to 5 volts when the transistor is switched off and close to 0 volts when the transistor is switched on.

[4]

(c) (i) The four LEDs when lit will give the appearance of a segment (one LED would appear as a spot of light) [1]

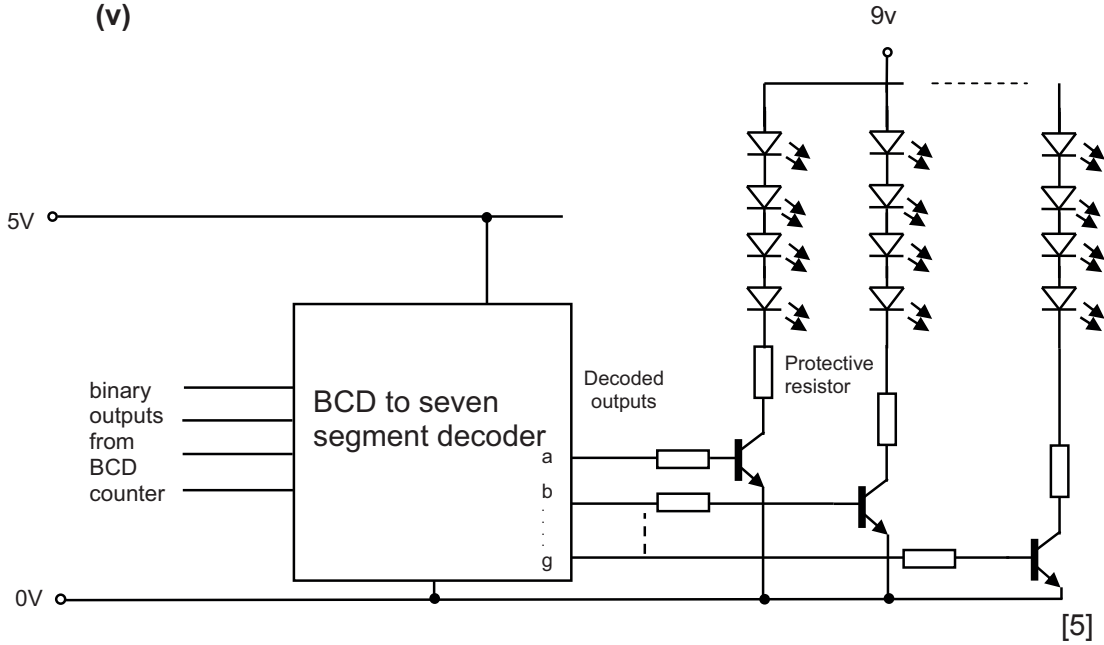
(ii) Common anode connection – all anodes are connected together (to a common power supply) [2]

(iii) Protective resistor value = $9 - (1.8 \times 4)/0.015 = 120$ ohms [2]

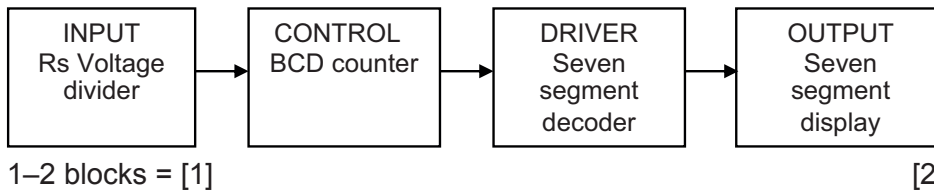
(iv) Total power dissipated by six segments = $7.2 \times 0.015 \times 6 = 648$ mW [2]

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(v)



(vi)

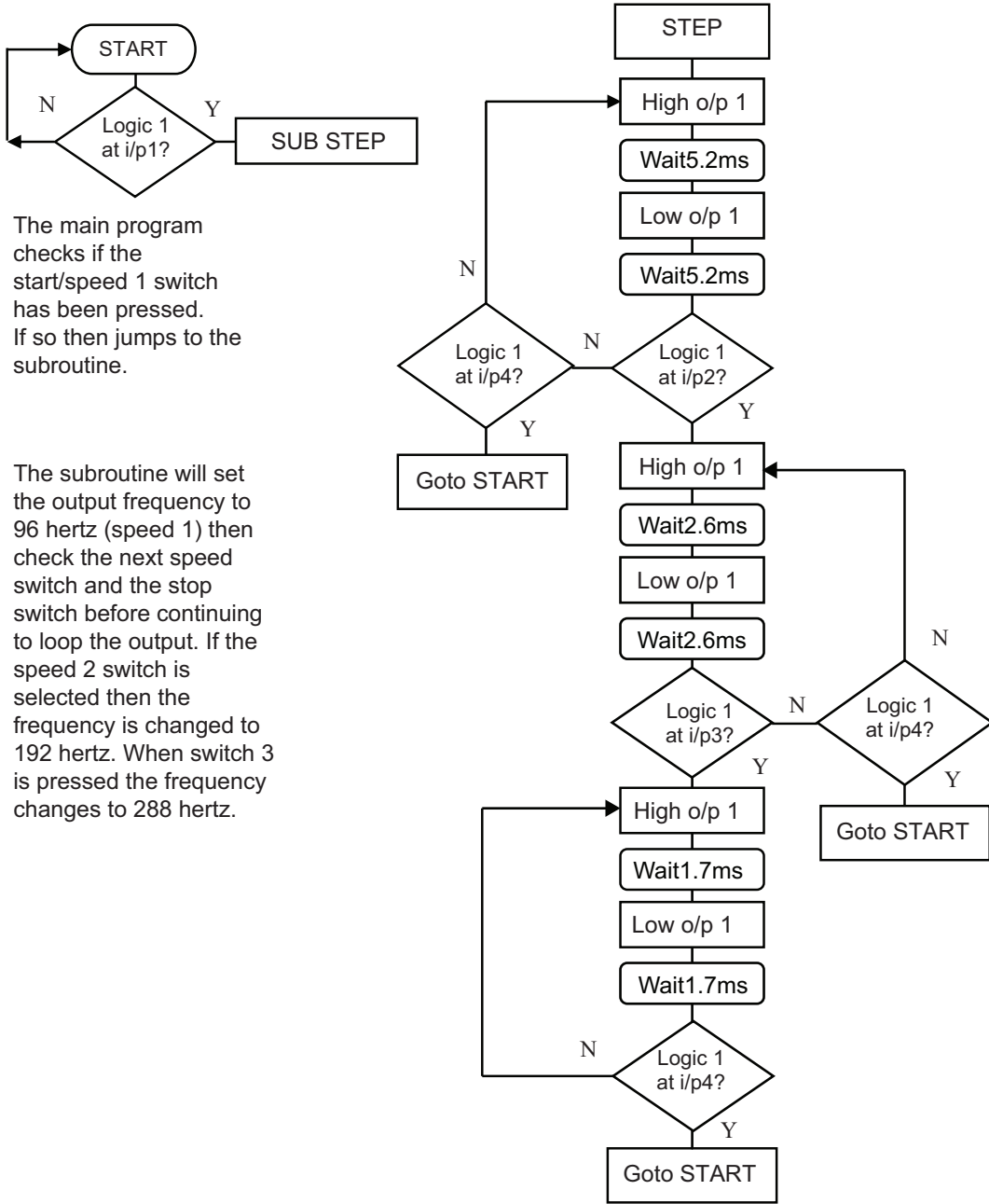
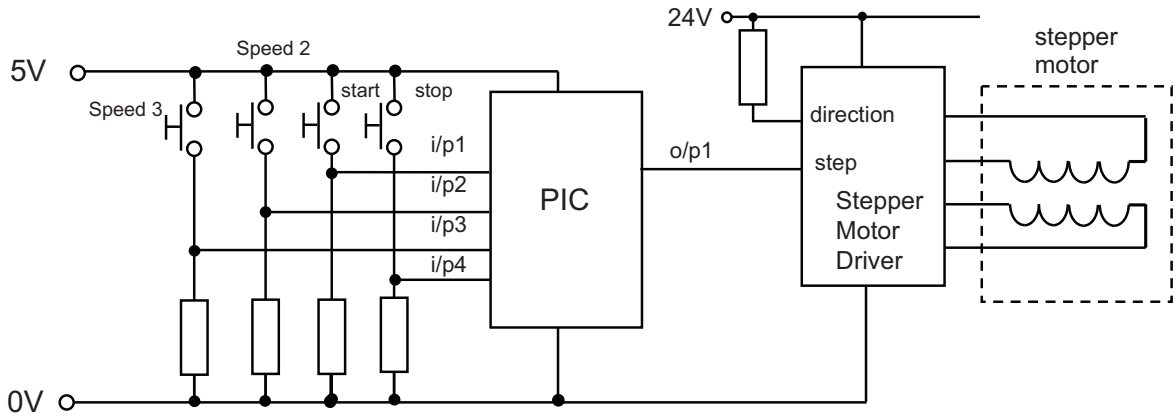


(vii) Open loop – there is no feedback evident in the system. [2]

(d) (i) The treadmill system requires precise control at a consistent speed which can be achieved using a stepper motor and driver. Stepper motors offer good torque capabilities at lower RPM which is required when the treadmill is running at a lower speed. [2]

(ii) $30 \text{ m/min} = 0.5 \text{ m/s}$
 $0.5 \text{ m/s} \div 250 \text{ mm} = 2 \text{ revolutions per second}$
 $2\text{RPS} = (48 \times 2) \text{ steps}$
 Answer = 96 steps per second. [3]

(e) Sample answer



The main program checks if the start/speed 1 switch has been pressed. If so then jumps to the subroutine.

The subroutine will set the output frequency to 96 hertz (speed 1) then check the next speed switch and the stop switch before continuing to loop the output. If the speed 2 switch is selected then the frequency is changed to 192 hertz. When switch 3 is pressed the frequency changes to 288 hertz.

[10]

Section A

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Section B

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- 3 (a) (i)** (1) Has only one gear per shaft. [1]
- (2) The compound gear train has a driver gear and a driven gear with intermediate gears fixed on a common shaft. [1]
- (ii)** Torque = force × distance from the turning point
 120 Nm = f × 0.6 m
 200 N = force [2]
- (iii)** Velocity = 0.14 × 1800/60 = 4.2 m/s
 Kinetic energy = $\frac{1}{2} \times \text{mass} \times v^2$
 3.528 J = 0.5 × mass × 4.2²
 3.528 J = 8.82 × mass
 Mass = 0.4 kg [3]

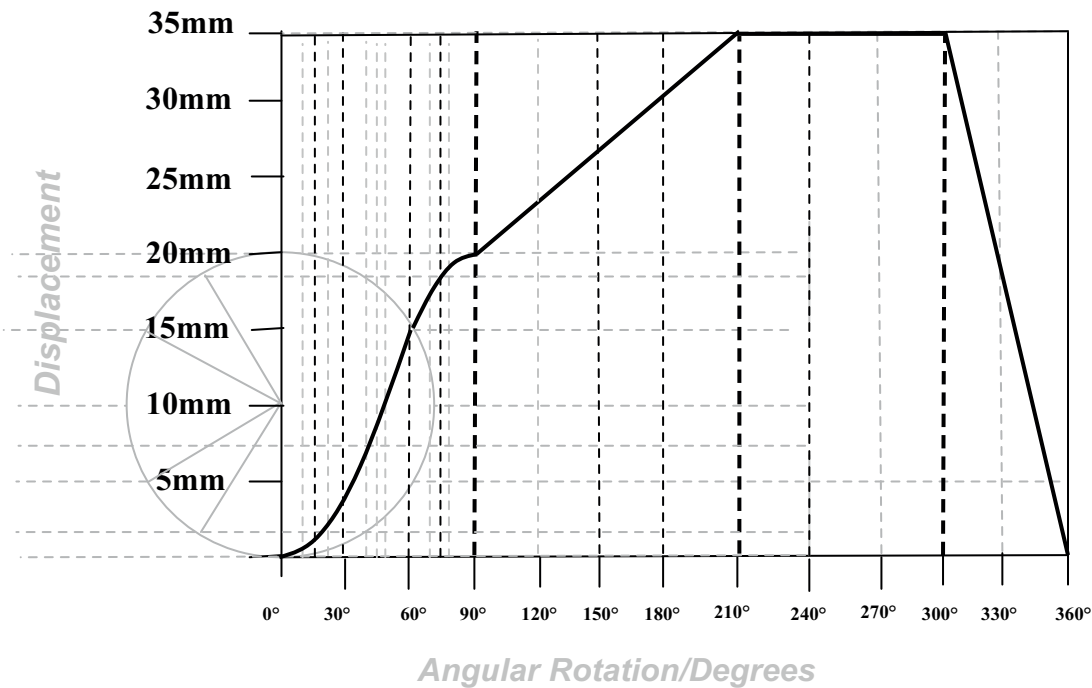
(b)

Level of response not worthy of credit.	[0]	
A poor explanation of the main features of the universal joint using an annotated sketch indicating a method of fixing the joint to a drive shaft.	[1]	
A limited explanation of the main features of the universal joint using an annotated sketch indicating a method of fixing the joint to a drive shaft.	[2]	
Clear explanation of the main features of the universal joint using an annotated sketch indicating a suitable method of fixing the joint to a drive shaft.	[3]–[4]	[4]

- (c)** Any **two** from each:
- Garter**
- Compression garter springs exert outward radial forces, while extension garter springs exert inward radial forces. Overall force is powerful.
 - Garter springs are typically manufactured with either carbon steel or stainless steel wire.
- O-Ring**
- O-rings operate a mechanical gasket in the shape of a torus; it is a loop of elastomer
 - O-rings are designed to be seated in a groove and compressed during assembly between two or more parts, creating a seal at the interface.
 - Available in thermoplastics/rubber
 - Are cost-effective. [4]
- Selection: O-ring. [1]

For a response not worthy of credit.	[0]
Poor selection and use of a writing form and style appropriate to the content. The content is poorly organised and little use is made of appropriate technological vocabulary. The writing is barely legible and the spelling, grammar and punctuation are inaccurate.	[1]–[2]
Good selection and use of a writing form and style appropriate to the content. The content is organised and use is made of appropriate technological vocabulary. The writing is legible and the spelling, grammar and punctuation are suitable.	[3]
Very good selection and use of a writing form and style appropriate to the content. The content is well organised and good use is made of appropriate technological vocabulary. The writing is clearly legible and the spelling, grammar and punctuation are very accurate.	[4]

(d) (i)



0–90° Simple Harmonic Motion rise 20mm	[2]
90–210° Uniform Velocity Rise 15mm	[1]
210–300° Dwell	[1]
300–360° Uniform Velocity Fall 35mm	[1]

[5]

(ii) See A3 sample answer

[5]

- (e) (i) Modified bell crank linkage that is connected to cylinder with appropriate connectors i.e. splined shaft and holder.

Level of response not worthy of credit.	[0]
Poor selection of mechanism choice and drawing/annotation. The content is poorly organised. No connectors.	[1]–[2]
Good selection of mechanism choices and use of drawing/annotation. The content is organised. Suitable connectors.	[3]
Very good selection of mechanism (i.e. linkage) and use of a drawing/annotation. The content is well organised. Suitable connectors.	[4]–[5]

[5]

- (ii) Suitable pulley and linkage system.

Level of response not worthy of credit.	[0]
Poor selection of mechanism choice and drawing/annotation. The content is poorly organised.	[1]–[2]
Good selection of mechanism choices and use of drawing/annotation. The content is organised. Connector points used	[3]
Very good selection of mechanisms and use of a drawing/annotation. The content is well organised. Connector points fully used.	[4]–[5]

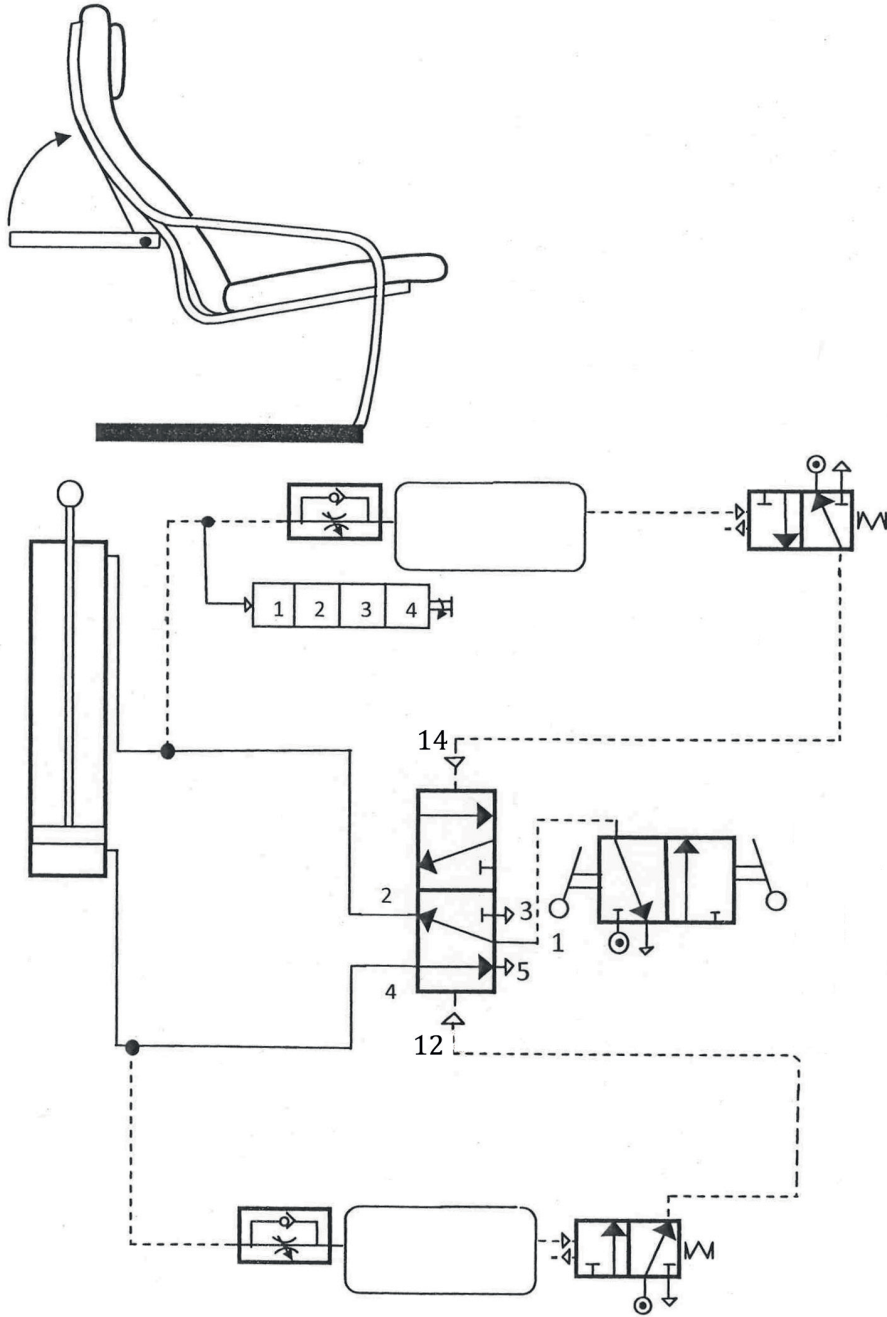
[5]

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- 4 (a) (i) Any **two**:
- Loose piping can be very dangerous to all users.
 - Fingers can get trapped from moving cylinders.
 - Injured skin, which could enable compressed air to enter the blood stream. [2]
- (ii) Answer: A vacuum pump is a device that removes gas molecules from a sealed volume in order to leave behind a partial vacuum.
Application: Milking machine or other suitable application. [3]
- (b) (i) Ans = $1130.4 \div 0.1 = 11\,304$
 $11\,304 = 3.14 \times 60 \times 60$
 Diameter = $60 + 60 = 120$ mm [3]
- (ii) Volume = $\frac{S \times D^2 \times \pi}{4} - \frac{S \times (D^2 - d^2) \times \pi}{4}$
- Volume = $300 \times 80^2 \times 3.14/4 - 300 \times (80^2 - 25^2) \times 3.14/4$
 Volume = $1507200 - 1360012.5$
 Volume = 147187.5 mm^3 [3]
- Consumption = Volume \times gauge pressure + atmospheric pressure [2]
 $147187.5 \times (5 + 1) = 883125 \text{ mm}^3$
- (c) See A3 Mark Scheme [17]

(d) (i)



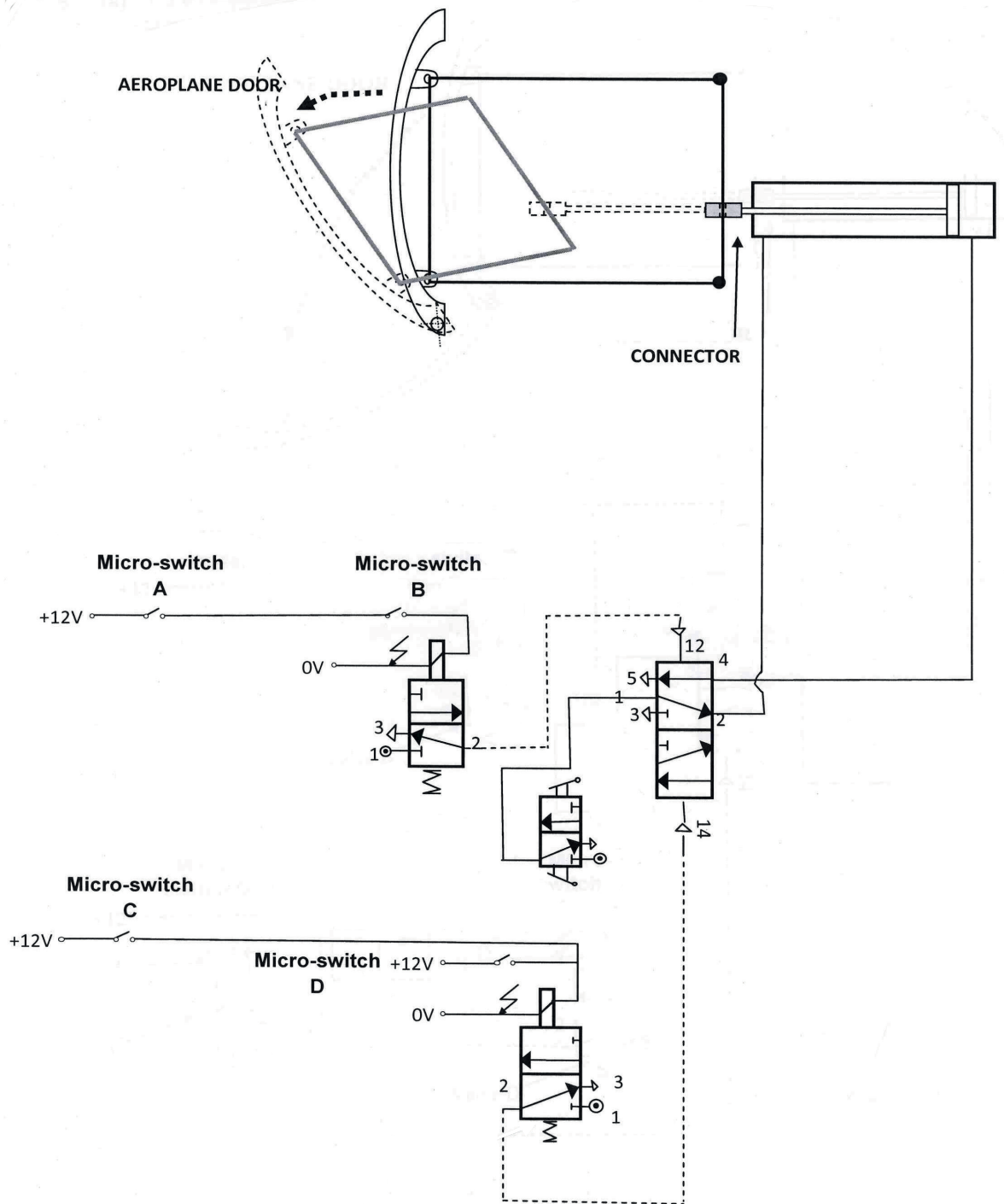
Start [1]
 Counter Pulsed [1]
 Control [1]
 Detection by non-contact method [2]

[5]

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- (ii) Parallel Linkage [2]
- Isolator Valve [1]
- A and B with piping [1]
- C or D with piping [1]

AVAILABLE MARKS



[5]

Section B

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Section C

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Product Design

- 5 (a) It is so important for a company to get their product to the right place at the time as this will provide them with the opportunity of maximising sales and potential profits. [1]
- (b) (i) Any **two** main advantages associated with the use of telephone interviews for example:
- Telephone interviews can be an effective way of making contact with respondents and conducting short interviews which do not require any visual stimulus.
 - Quick gathering of information over any geographical distance.
 - An experienced interviewer with a good script can interview up to 50 respondents a day. [2]
- (ii) Any **two** main disadvantages associated with the use of telephone interviews for example:
- Non-phone owners are excluded from the research.
 - The participant cannot see, feel or taste the product which may influence the research.
 - May be difficult to reach the participant as many people use call screening to accept only calls that they are expecting. [2]
- (c) (i) The type of information gained by researching demographic trends may be based on the human population in terms of age, gender, occupation and income. This might influence future decisions of the company by determining volume of production, model type, styles and range of functions. [2]
- (ii) The type of information gained by researching life style changes may be an understanding of the characteristics and habits of a population, for example the nature and type of food now consumed, eating out versus preparing your own food for picnics, frequency of and attendance of social events. This might influence future decisions of the company in terms of production levels, styling and design of the cool box and the range of functions embedded in the product. [2]
- (d) (i) Any **two** main characteristics associated with fashion innovators, for example:
- Fashion innovators adopt a new product first.
 - Fashion innovators are interested in innovation and unique features.
 - Marketing or promotion should emphasise the newness and distinctive features of the product. [2]
- (ii) Any **two** main characteristics associated with a late adopter, for example:
- Very slow to adopt or invest in a new product.
 - They approach new products with a high degree of scepticism.
 - The late adopters are often enticed when a fashionable product is marked for reduction or clearance. [2]

(e) Any **five** of the Six R's and with reference to practical examples, e.g.

Reduce – The smart car reduces the material used to produce the overall vehicle. Not only has it reduced the number of components but it has reduced the number of manufacturing processes and assembly processes needed.

Recycle – design for ease of disassembly and ensure that materials are clearly labelled for recycling purposes. The Dyson cleaner has a high percentage of high grade recyclable materials. In addition the electrical parts of the product have been designed to be fully recyclable.

Reuse – The product can be reused after its initial function, for example the design of the reusable ink cartridge or in some cases the product may be reused for something entirely different.

Repair – The desktop computer is a product that has been designed with repair in mind. All sub-assemblies are able to be replaced/repared with parts supplied on a cost effective basis.

Rethink – The Ford company has rethought its design for the new F-150 truck using smart data to create a vehicle 700lbs lighter than its previous model. In addition, rethinking through the life cycle assessment helped Ford to see it was more sustainable to incorporate recycled materials from sources in industry rather than materials grown across the globe.

Refuse – the customer has the right to refuse to purchase the product if they feel that the company with its design and manufacture has not done everything in its powers to address environmental issues. Take for example consumers choosing not to use as many plastic bags. [5]

Level of response not worthy of credit.	[0]
Poor selection and use of a writing form and style appropriate to the content. The content is poorly organised and little use is made of appropriate technological vocabulary. The writing is barely legible and the spelling, grammar and punctuation are inaccurate.	[1]–[2]
Good selection and use of a writing form and style appropriate to the content. The content is organised and use is made of appropriate technological vocabulary. The writing is legible and the spelling, grammar and punctuation are accurate.	[3]
Very good selection and use of a writing form and style appropriate to the content. The content is well organised and good use is made of appropriate technological vocabulary. The writing is clearly legible and the spelling, grammar and punctuation are very accurate.	[4]

Quality of written communication [4]

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(f) Any **two** of the life cycle stages.
E.g. Mobile phone

1. Extraction of materials needed for the product. – By 2017 it is estimated that 400 million ‘green cell phones’ will be produced with at least 50% recycled content. ‘Greener phones’ are very important because they employ more responsible raw materials and reduce the dependency on extraction of materials.
 2. The processing of materials – Results show the materials/process phase contributes the greatest impact in the life cycle of a mobile phone, accounting for 59% of the energy requirement. The next greatest impact is in the use phase, accounting for 29%.
 3. The manufacture and distribution of the product – Key parts such as processing power and memory can be reused in new applications. This will have an impact on materials, manufacture and distribution of the product due to the extension of its life span.
 4. The use of the product – Advances in mobile phone technologies will offer further resource efficiency opportunities, such as reduction in weight and convergence with other items like cameras and MP3 players as the specifications of these items improve.
 5. End of life considerations – There are opportunities at end of life for refurbishment and reuse, either in domestic or overseas markets, as well as growing interest in finding new uses for mobile phones at the end of their initial use phase.
- 2 × [2] [4]

(g) (i) Two main characteristics associated with the life cycle of a fad product for example:

- Fad products offer the shortest life cycle.
- Characteristic of rapid growth followed by a very steep decline in sales.

[2]

(ii) Two main reasons why basic products have a long product life cycle.

- Because there is a sustained need for the product in the market.
- They do not generally decline unless there is a major innovation to replace the need for the product.

[2]

(h) (i) **Sample Answer** – An injection moulded plastic bracket which could be press fitted into the lid of the cool box. [4]

Level of response not worthy of credit.	[0]
Poor sketches with little or no annotation. Difficulties in deciding if the design is low cost, suitable to be used to quickly prop up the lid of the cool box and can be attached to the inside of the lid.	[1]–[2]
Annotated sketches are limited. The design is suitable and consideration is given to cost, ability to prop up the lid and how it can be attached to the inside of the lid.	[3]
Detailed annotated sketches. The design is suitable and full consideration is given to cost, ability to prop up the lid and how it can be attached to the inside of the lid.	[4]

- (ii) **Bullet point 1.** Answer based on a 2D drawing side profile of person sitting on the cool box with a red cross indicating that this is unsuitable.

Level of response not worthy of credit.	[0]
The graphical information conveys that the cool box is unsuitable for any member of the family to sit on	[1]
Good quality graphical information which clearly conveys that the cool box is unsuitable for any member of the family to sit on.	[2]

- Bullet point 2.** Answer based on a view of the lid covered and a connection to the 12V socket and a method (red diagonal line) to indicate that this is not recommended.

Level of response not worthy of credit.	[0]
The graphical information conveys that the top of the cool box should not be covered when connected to the 12 volt socket in the car.	[1]
Good quality graphical information which clearly conveys that the cool box should not be covered when connected to the 12 volt socket in the car.	[2]

- Bullet point 3.** Answer based on 2D drawing to convey drinks/liquids sitting on the cool box lid when closed and a method (red diagonal line) to indicate that this is not recommended.

Level of response not worthy of credit.	[0]
The graphical information conveys that all drinks and liquids should not be set on the top of the cool box containing the electrical components for the product.	[1]
Good quality graphical information which clearly conveys that all drinks and liquids should not be set on the top of the cool box containing the electrical components for the product.	[2]

[6]

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- 6 (a) Incremental products are essentially part changes, improvements or additional features to an existing product. [1]
- (b) (i) The basic principle of wave as a renewable energy source is as follows:
- Waves are created by the force of the wind over the water and so can be big or small depending on the strength and speed of the wind. [1]
Wave power turbines harness the kinetic energy that is in the up and down movement of the water's surface [1] to make mechanical or electrical energy. [1] [3]
- (ii) The basic principle of solar as a renewable energy source is as follows:
- Photovoltaic cells convert light energy directly into electrical energy. [1]
These cells need to be exposed to intensive and continuous sunlight. [1]
They are often arranged in long rows in huge solar farms. [1] [3]
- (c) The type of information that might arise from market analysis might be, for example:
- Define further their current markets for the ladder.
 - Identifying opportunities for exploiting or introducing any new trends or products in the range of ladders. [2]
- The type of information that might arise from price research might be, for example:
- Research may determine competitors' prices for the similar model of ladder.
 - Research may determine what price the market will bear for this specific ladder. [2]
- (d) (i) **Three** ways in which CAD may have been employed in the design of the ladder for example:
- CAD used to produce technical details of the ladder for production.
 - 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 sliding mechanism for the ladder. [3]
- (ii) Any **two** ways in which other ICT systems may have been employed in the design and manufacture of the ladder, for example:
- Stock control of completed ladders manufacturing.
 - Monitoring and forward ordering of bought in components.
 - ICT used to implement quality control tests on materials and on partially and fully manufactured and assembled products. [2]

- (e) Two main aspects associated with fixed consumer panels –
- Fixed consumer panels are a selected group of people male and female representing the product's target audience.
 - This panel will not change in personnel and will give feedback on existing and proposed new products. [2]
- Two main aspects associated with product clinics –
- A product clinic is an office or allocated space where potential purchasers/consumers are asked to meet.
 - Purchasers/consumers discuss and evaluate the features and attributes of an existing product or a prototype of a proposed product. [2]
- (f) Explain **two** main characteristics associated with the Memphis movement, for example:
- It was a reaction to 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 created limited production creations of unusual objects and functional designs featuring plastic laminate surfaces, bright colours and bold patterns.
 - They encapsulated post-modernist design in the 1980s, challenging perceptions of 'good design' through their gaudy ornamental and decorative products. [4]
- (g) (i) Example: Kitchen hinges – When kitchen hinges are manufactured measuring devices in the form of gauges (electronic) are used to test a sample from a batch to ensure that the key or important measurements are within an acceptable tolerance. [2]
- (ii) Example: Kitchen doors – When holes have to be accurately drilled in the same position repeatedly a jig can be used to assist. The jig is a fixed frame which allows the operator to quickly place the material in position for drilling to ensure speed of operation, accuracy and repeatability thus assisting quality control. [2]
- (iii) Example: Electric guitar – a very accurate profile of the guitar is generated in the form of templates using a CNC machine. These templates are then placed on the selected wood, drawn around and cut out using table saws and routers. These templates aid accuracy and ensure consistency during manufacture thus assisting quality control. [2]

- (h) • **Sample Answer.** A telescopic aluminium section which could be positioned using a series of drilled holes and a double ball and spring arrangement.

Level of response not worthy of credit.	[0]
Poor sketches with little or no annotation. Difficulties in deciding if the design is suitable and would allow the user to extend the length of one of the legs. Difficulty in deciding if the design has a suitable means of attachment to the ladder.	[1]–[2]
Annotated sketches are limited. The design has elements which are suitable and consideration is given to how the user would extend the length of one of the legs. Limited consideration is provided as to how the design is attached to the ladder.	[3]
Detailed annotated sketches. The design is suitable, and would allow the user to extend the length of one of the legs. An appropriate means is provided as to how the design is attached to the ladder.	[4]–[5]

[5]

- **Sample Answer.** A one piece injection moulded tray with suitable depth to accommodate basic hand tools. The tray could be hooked onto the step of the ladder and support legs of the tray could be designed to have interference press-on flaps to envelop the box section leg of the ladder.

Level of response not worthy of credit.	[0]
Poor sketches with little or no annotation. Difficulties in deciding if the design is suitable for holding a small number of basic tools and can be quickly clipped securely onto the ladder.	[1]–[2]
Annotated sketches are limited. The design is suitable and some consideration is given to it holding a small number of basic tools and how it can be quickly clipped securely onto the ladder.	[3]
Detailed annotated sketches. The design is suitable to hold a small number of basic tools and can be quickly clipped securely onto the ladder.	[4]–[5]

[5]

Section C

Total

**AVAILABLE
MARKS**

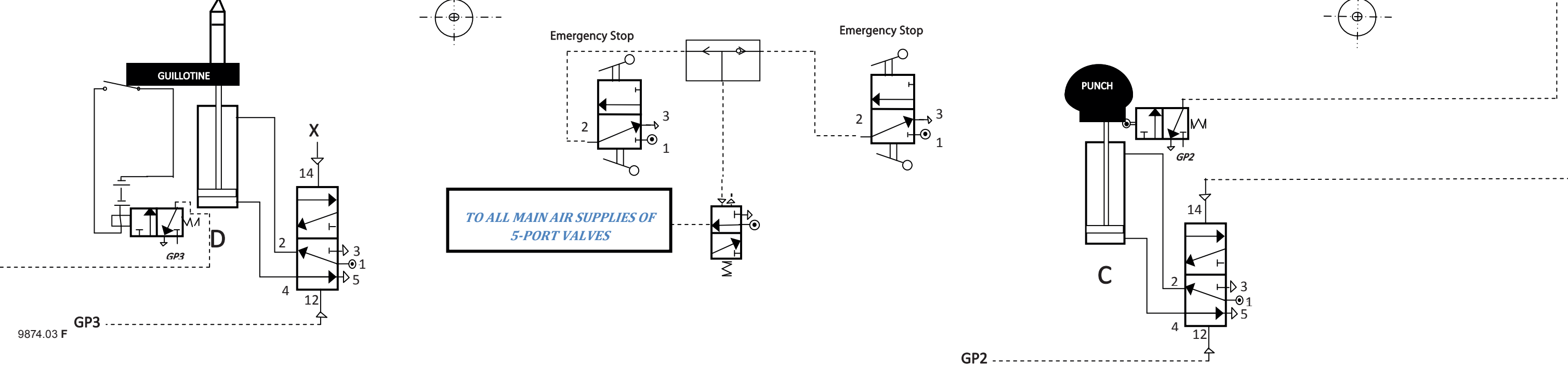
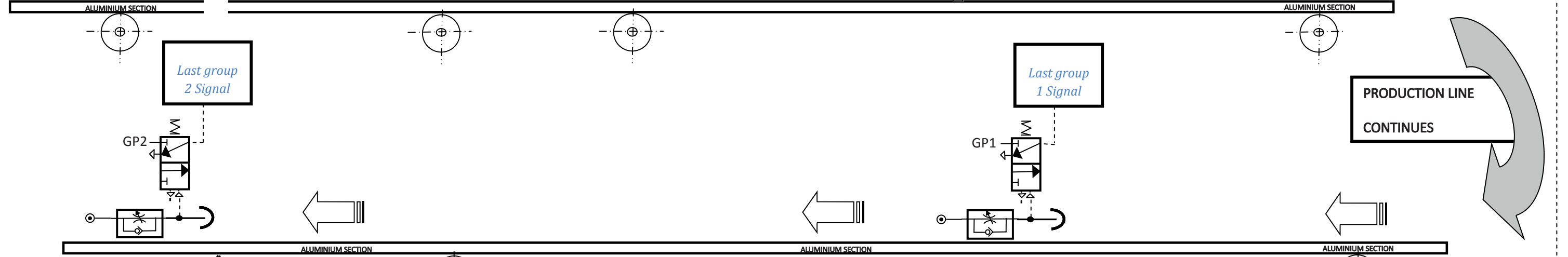
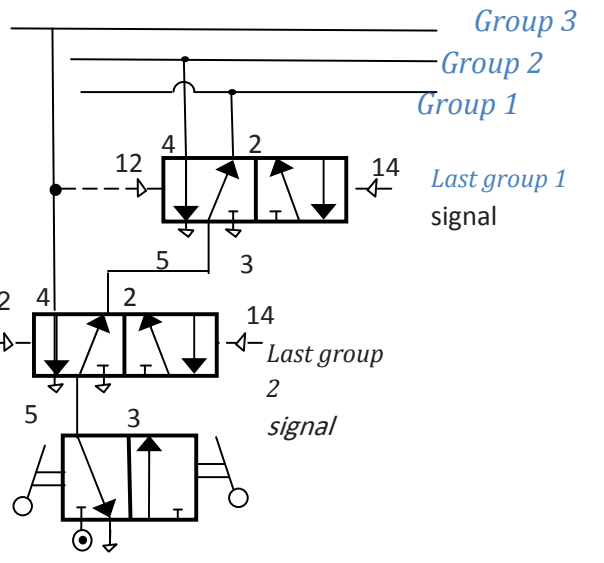
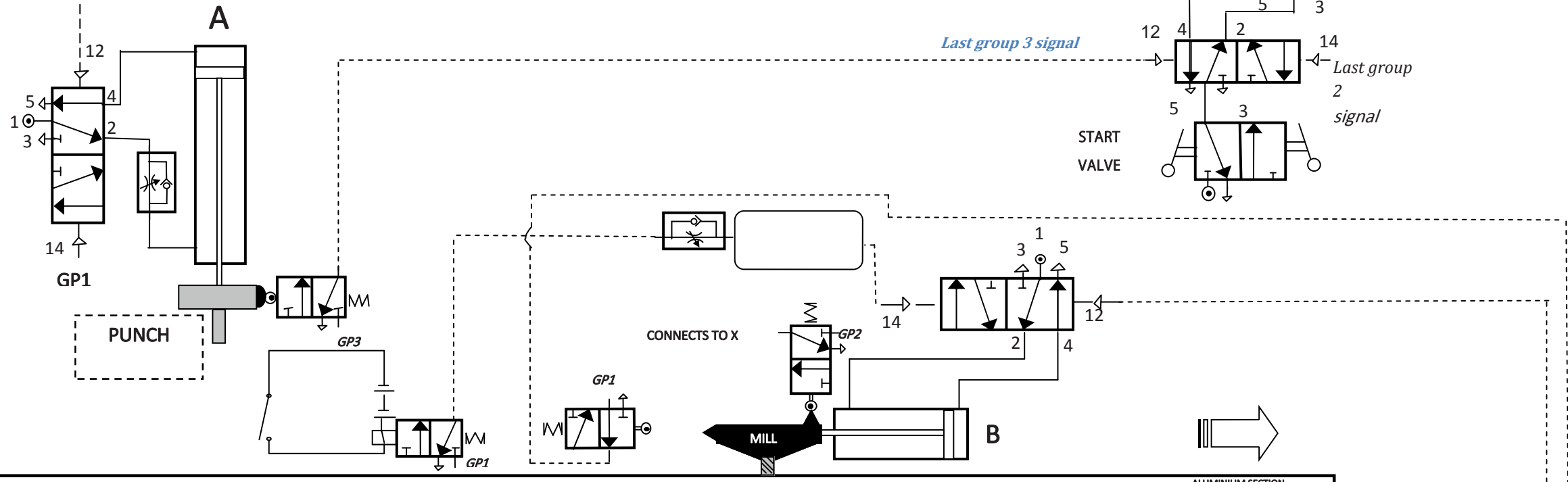
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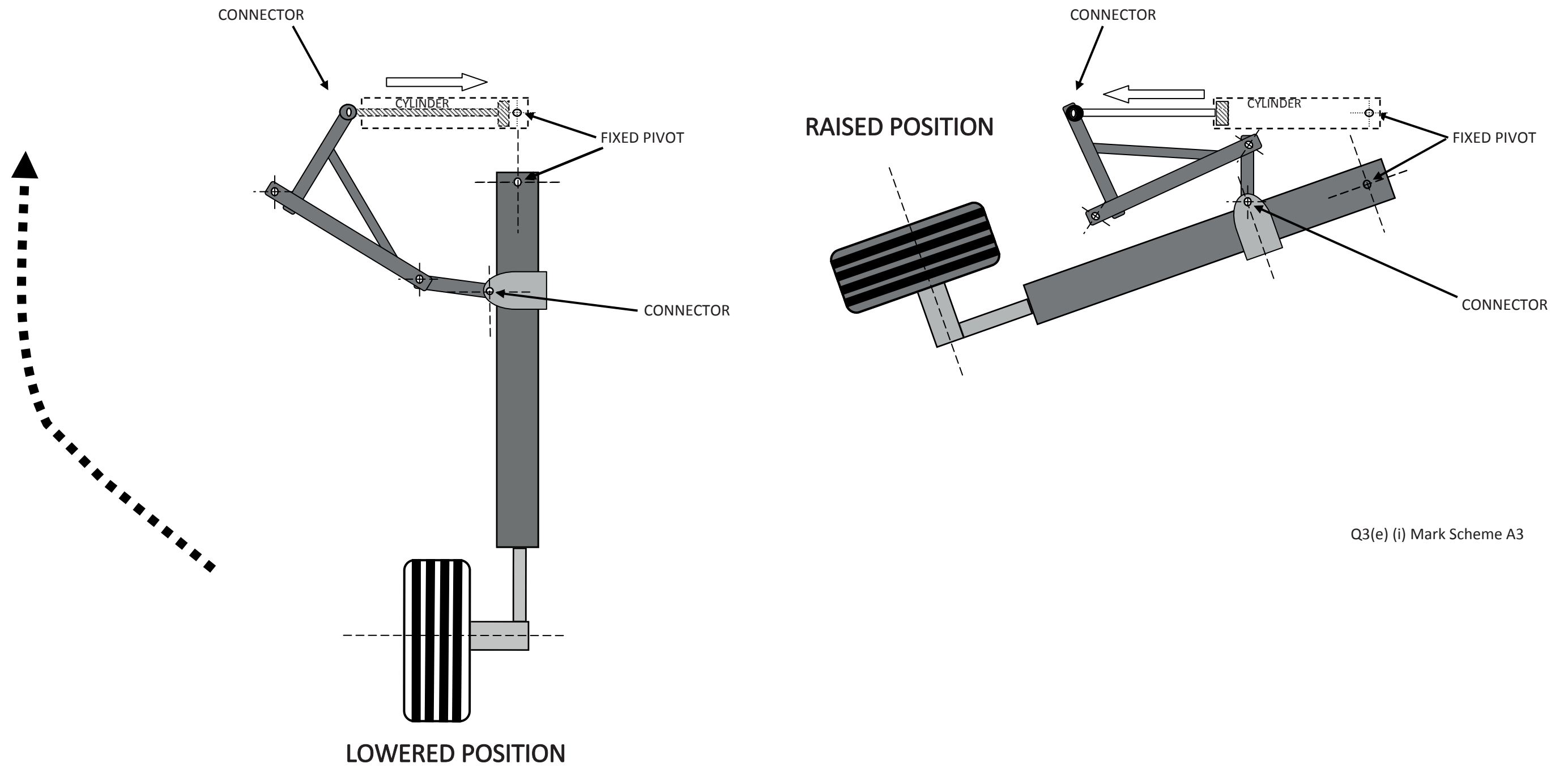
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ANSWER 4 (c)

- SAMPLE ANSWER: 3 GROUPS
- A+B+C+ / C- B- D+ / D- A- [8]
 - START VALVE [1]
 - EMERGENCY STOPS [1]
 - A+ SPEED CONTROL [1]
 - MICRO [1]
 - TIME DELAY [1]
 - AIR BLEED [2]
 - PIPING [2]



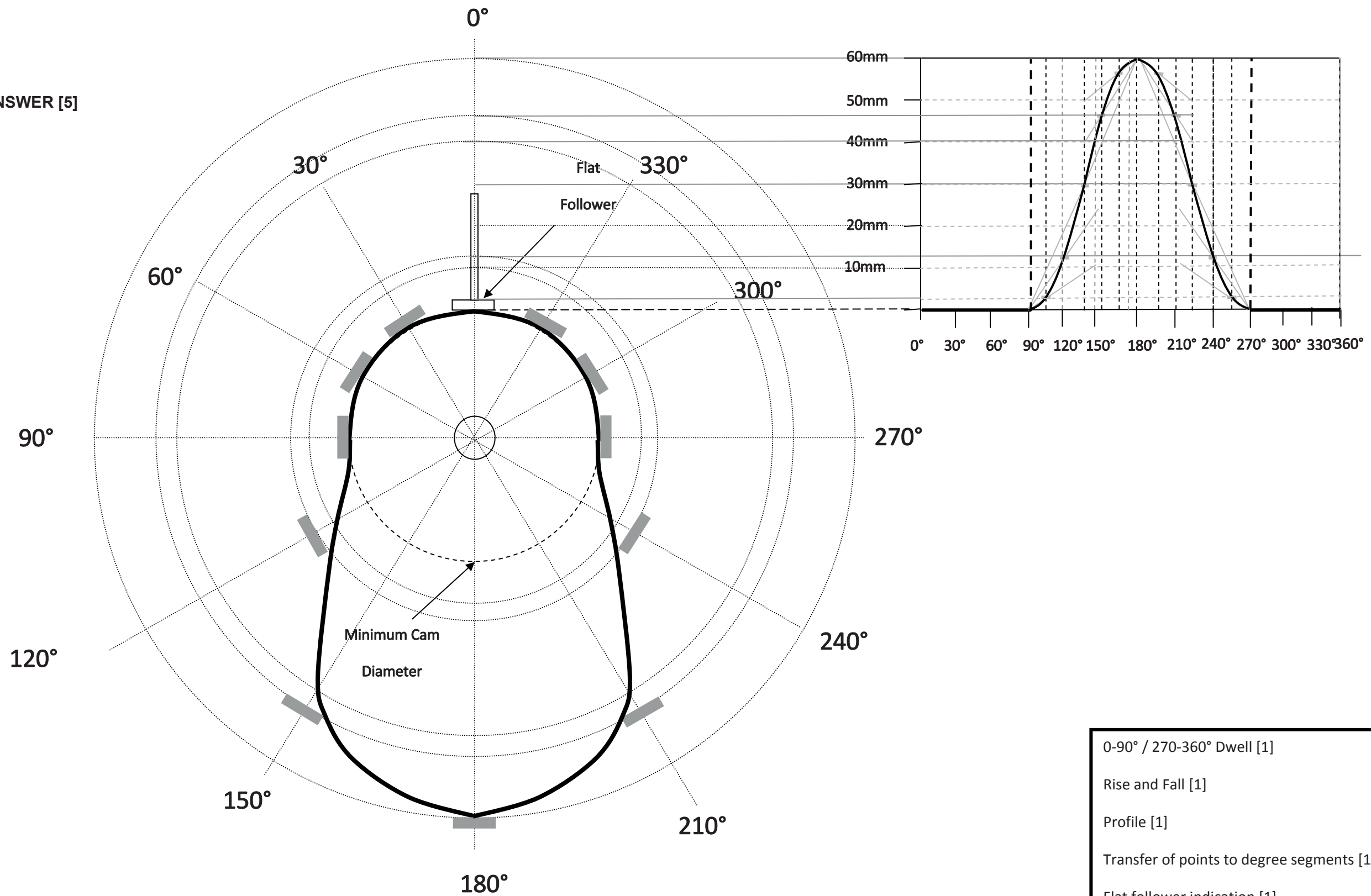
ANSWER 3 (e)(i)



Q3(e) (i) Mark Scheme A3

ANSWER 3 (d)(ii)

(ii)
ANSWER [5]



- 0-90° / 270-360° Dwell [1]
- Rise and Fall [1]
- Profile [1]
- Transfer of points to degree segments [1]
- Flat follower indication [1]

Pro forma answer 3(d)(ii)