



*Rewarding Learning*

**ADVANCED SUBSIDIARY (AS)  
General Certificate of Education  
2011**

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## **Technology and Design**

**Assessment Unit A2 1**

*assessing*

**Systems and Control**

**[AV211]**

**WEDNESDAY 18 MAY, AFTERNOON**

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# **MARK SCHEME**

In all cases credit will be given to suitable alternative answers.

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MARKS

### Section A

1 (a) (i)  $120/7.5 = 16$  steps required [1]

(ii) Any **two** of the following:

- Positional accuracy is required to turn the columns by  $120^\circ$  – stepper motors provide positional accuracy.
- The display is likely to be rotated at a low RPM – stepper motors provide good torque at lower RPM.
- Ability to stop quickly – stepper motors do not overshoot. [2]

(b) (i) The **step** input controls the number of steps per second taken by the motor. Normally a short pulse will cause the motor to move by one step.

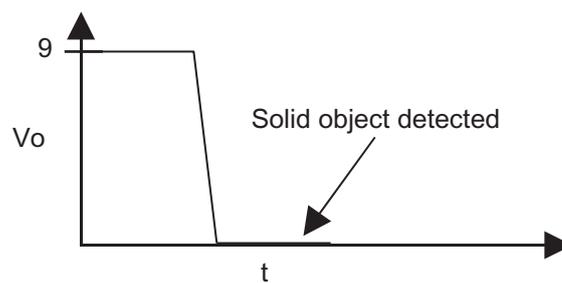
**Direction** – this input determines the direction of rotation of the stepper motor. e.g. If it is “pulled up” the motor will turn clockwise or “pulled down” – anticlockwise. [2]

(ii) 16 steps in 2 seconds therefore repetition rate is 8 pulses per second or 8 Hz. [2]

(c) (i) Photo transistor [1]

(ii) changes in ambient lighting will not significantly alter the operation of the circuit if Infrared light is used to switch the phototransistor on. [2]

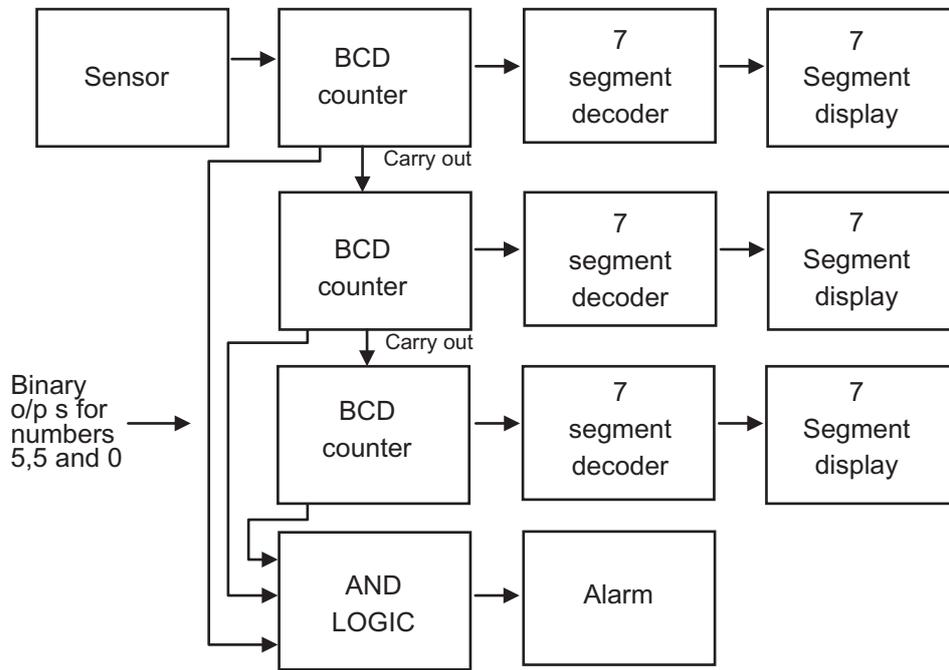
(iii) Sample answer



[2]

(d) (i) It can be argued that the system is Open loop because the position of the stepper motor is not being “checked” therefore the system has no information feedback. [4]

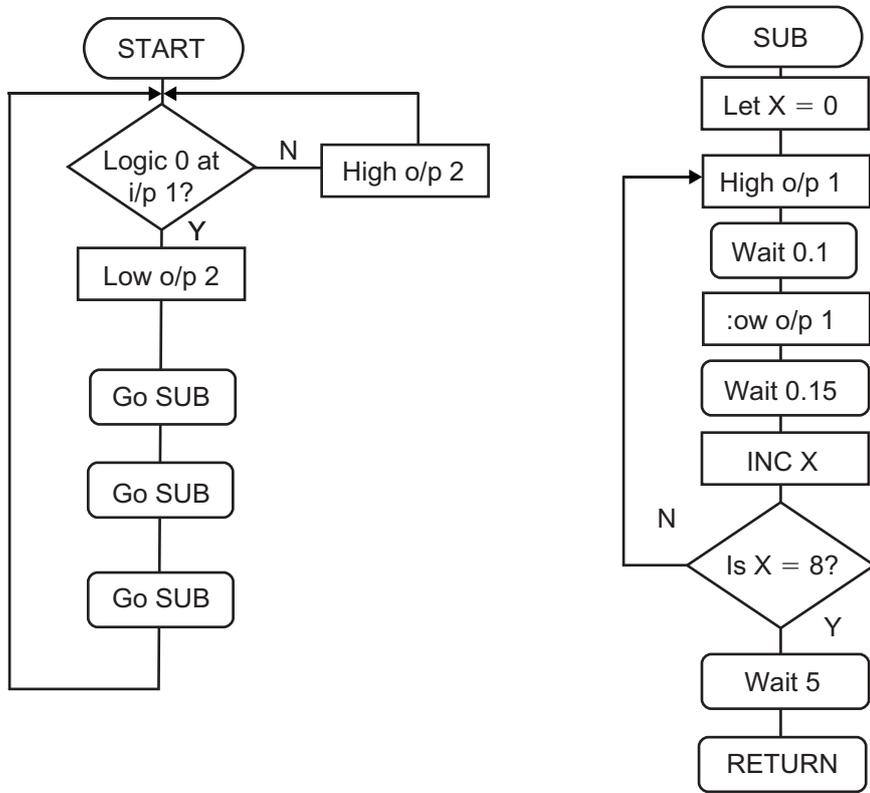
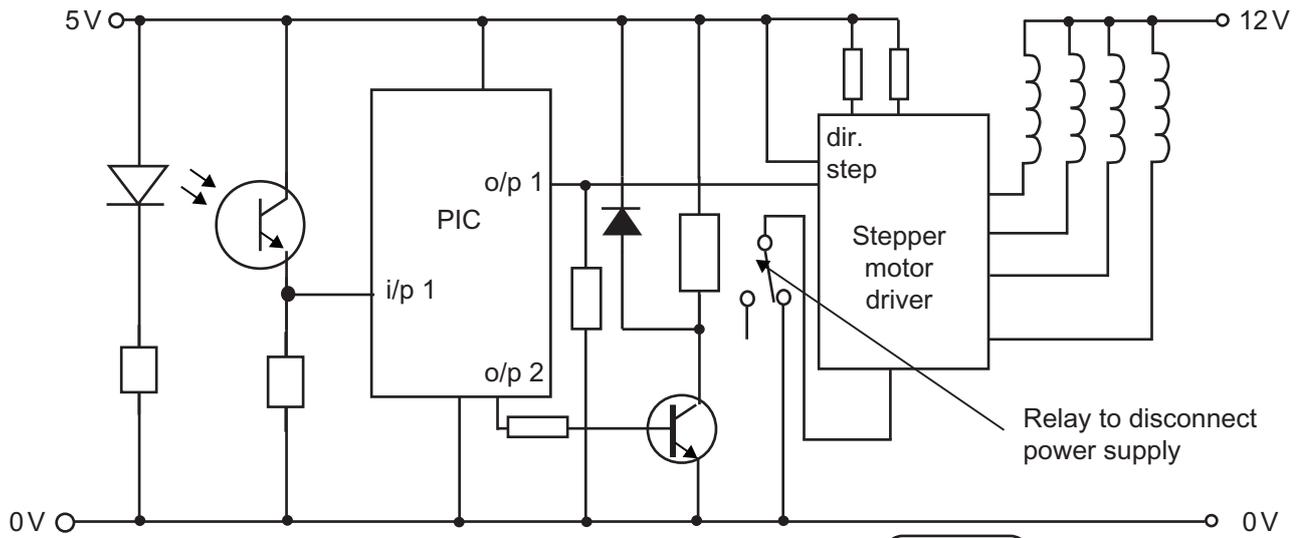
(ii) Sample answer



[5]

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(iii) Sample answer



[10]

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(e) Answer likely to refer to the following:

- Digital inputs to PICs require only two voltages e.g. 0V and 5V  
The input will be read as a logic zero if the input voltage is close to or at 0V and read as a logic one if the input voltage is close to at 5V.
- Analogue inputs can vary between 0V and 5V since the PIC has an on board analogue to digital convertor which can read the voltage as a digital value.

Answer likely to refer to the flexibility offered by mixed input PICs. While mixed I/O PICs may be more expensive they allow the user to interface to a greater range of input subsystems. Example of a system – system to count the number of pedestrians using a walkway during daylight and night time.

Justification of a PIC with mixed inputs likely to refer to the following: Digital input to detect people could be in the form of a pressure switch. Analogue input from a voltage divider utilising an LDR. This system would benefit from a PIC with mixed inputs since it requires a reading of the light level to be taken after each digital input to decide if it constitutes a day or night input. [5]

Quality of written communication.

A zero mark will be awarded for a response not worthy of credit.	0
Poor selection and use of a writing form and style appropriate to the content. The script content is poorly organised and little use is made of appropriate Technological vocabulary. The writing is barely legible and the spelling, grammar and punctuation is inaccurate.	1–2
Good selection and use of a writing form and style appropriate to the content. The script content is organised and use is made of appropriate Technological vocabulary. The writing is legible and the spelling, grammar and punctuation is accurate.	3
Very good selection and use of a writing form and style appropriate to the content. The script content is well organised and good use is made of appropriate Technological vocabulary. The writing is clearly legible and the spelling, grammar and punctuation is very accurate.	4

QWC [4]

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2 (a) (i) Diagram to show pressure plate acting on microswitch

[2]

(ii)

A	B	C	X	Y
0	0	0	1	0
0	0	1	1	0
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	0	1
1	1	1	1	0

[3]

(iii) K map for X

C	AB	00	01	11	10
0		1	0	0	0
1		1	1	1	1

$$X = C + A'.B'$$

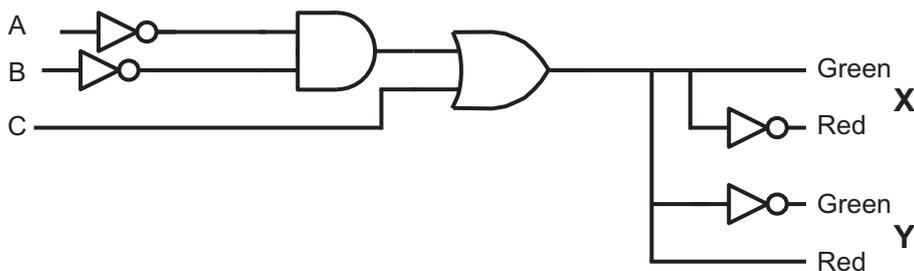
K map for Y

C	AB	00	01	11	10
0		0	1	1	1
1		0	0	0	0

$$Y = C'.B + C'.A$$

[4]

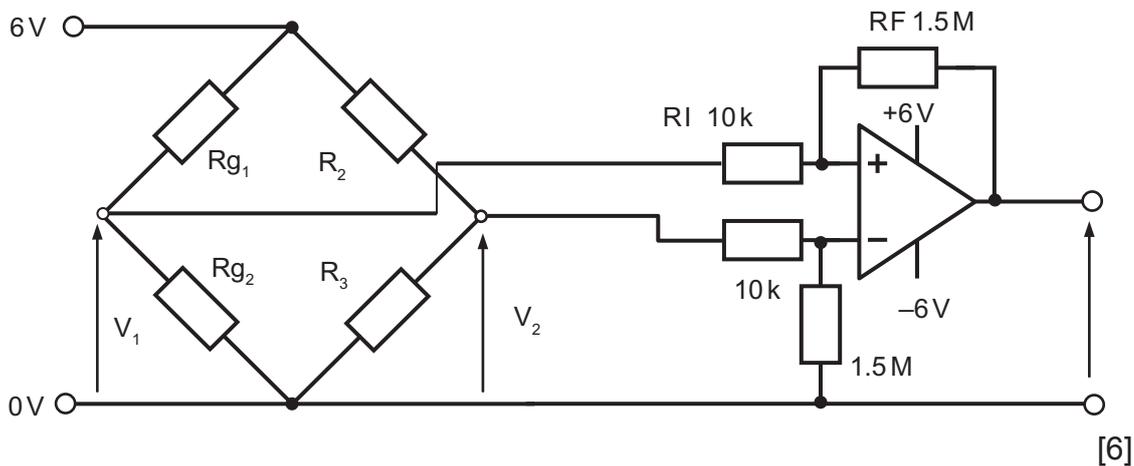
(iv) Logic Circuit



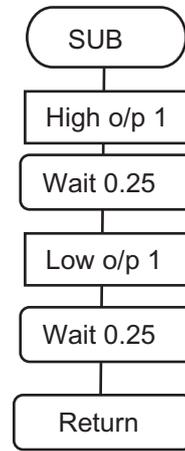
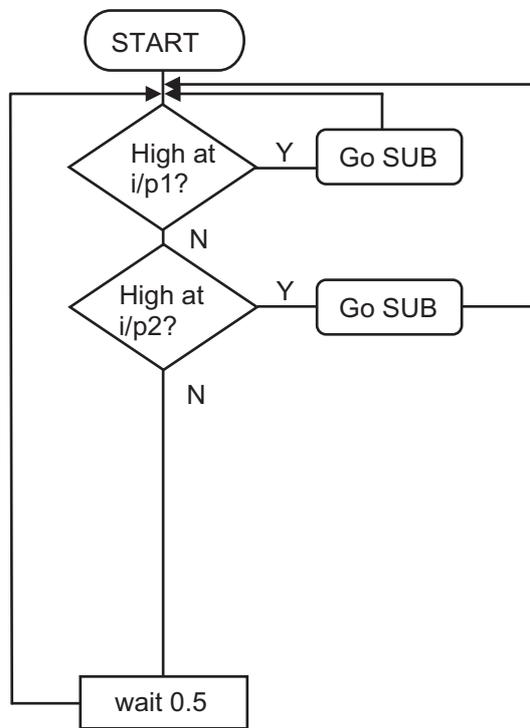
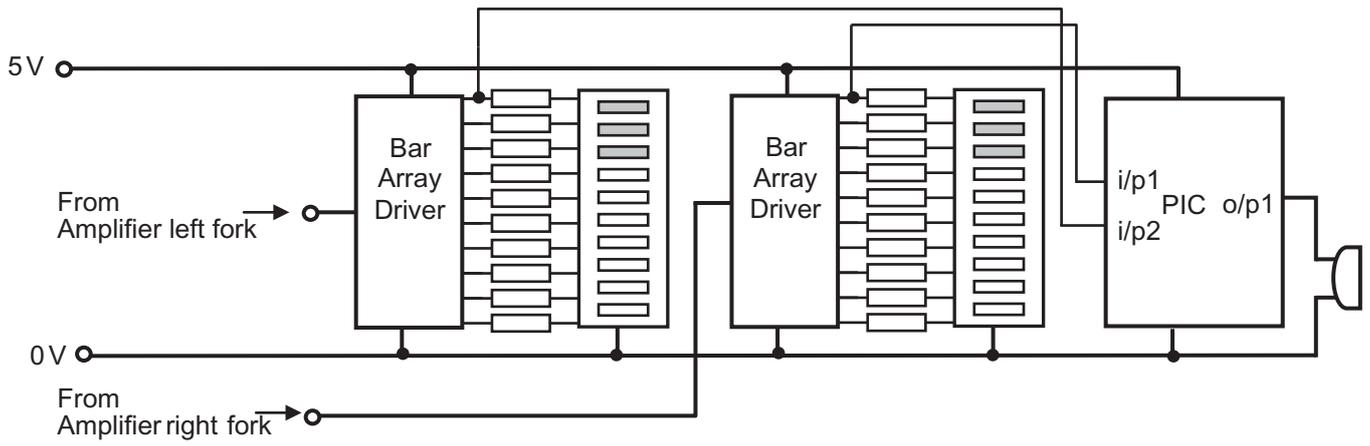
[4]

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- (b) (i) Resistance of the strain gauge changes when the gauge is stretched/compressed. Since materials that are deformed experience strain this change in resistance can be utilised to measure strain. [2]
- (ii) Drawing showing typical foil pattern on flexible plastic backing. [2]
- (iii) Changes in temperature can cause changes in resistance. By arranging the strain gauges close to each other but with the active axes perpendicular any changes due to temperature will not register. If both gauges are arranged in a voltage divider as part of a wheat stone bridge any resistance change due to strain will be read. [3]
- (c) (i) Wheatstone Bridge [1]
- (ii)  $V_1 = 3.015V$  and  $V_2 = 3V$  [3]
- (iii) Voltage difference =  $2.25 V_2 - V_1 = 0.015$  Therefore gain = 150

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(d) (i) possible solution



[10]

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## Section B

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- 3 (a) (i) Briefly describe the main difference between static and dynamic friction in relation to force.

Ans = **During movement the friction force required to maintain movement is less than the static friction.** [2]

- (ii) Calculate the velocity ratio from gear A to gear H.

$$\text{Velocity ratio} = \frac{\text{Teeth on driven gear}}{\text{Teeth on driver gear}}$$

$$\text{VR} = \frac{90 \times 90 \times 84 \times 96}{1 \times 1 \times 28 \times 24}$$

$$\text{VR} = 97200 \quad [2]$$

- (iii) Calculate the input torque from the shaft containing gear A if the output torque on the shaft containing the worm H is 486 Nm.

$$\text{Ans} = \text{Output torque} = \text{input torque} \times \text{VR}$$

$$486 = ? \times 97200 = 5 \times 10^{-03} \quad [3]$$

- (b) Using an annotated sketch draw a centrifugal clutch which could be used to transmit rotation through to the rear wheels of the quad.

Ans = Annotation [1]  
 Outer drum and shaft [1]  
 Inner linings and shaft [1]  
 Spring [1]

- (c) Discuss the merits of using each of the following bearings; plain, roller element and thrust. Select an appropriate bearing and justify your choice.

**Plain bearing use is based on the principle that the shaft rubs on the bearing (sacrificial material or lubricated film) and are used for radial loads, for lower speeds and are designed to wear away before the shaft. They require lubrication around the shaft if the bush is made of metal. Plain bearings are cheaper to manufacture and relatively quick to replace. Roller element use is based on the principle that the shaft rolls on balls/rollers and their races. Used mainly for radial loads they are more expensive than plain bearings and can be used for high speeds.**

**Thrust bearings use the same principle as roller elements but are used in situations where there are axial thrust loads. They are more expensive than roller bearings.**

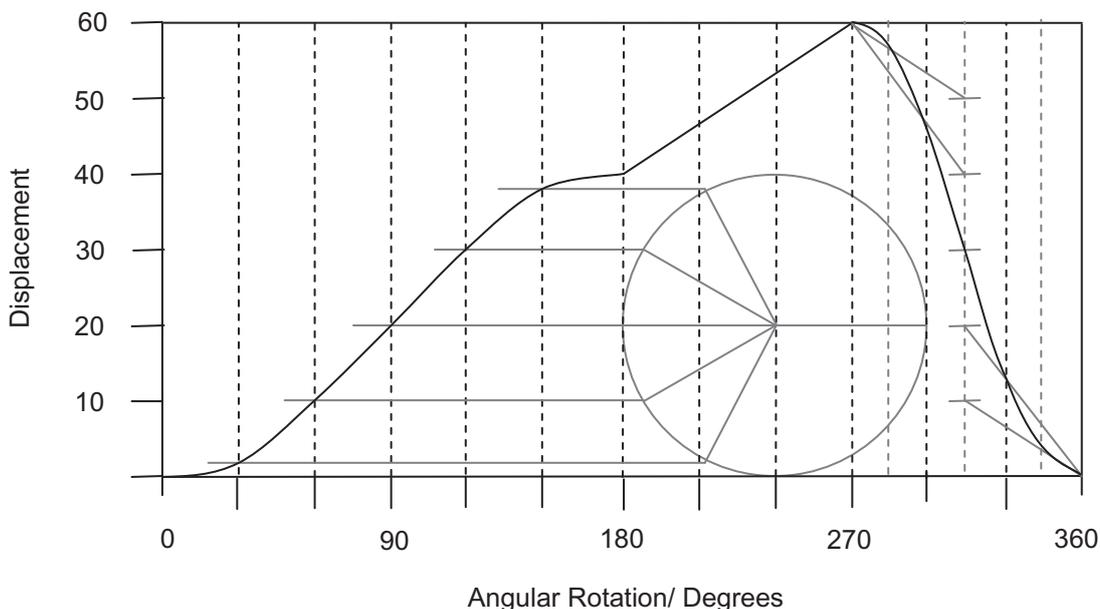
**Appropriate Bearing – Roller element. The situation requires a bearing to support radial loads at high speeds, with good wearing characteristics.** [5]

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QWC [4]

- (d) (i)** On the pro forma provided (answer number **3 (d)(i)**) complete the performance/displacement diagram which would accurately produce the following motion:
- construction 0–180 degrees rise 40 mm with simple harmonic motion [2]
  - drawing of D180–270 degrees rise 20 mm with uniform velocity [1]
  - construction 270–360 degrees fall 60 mm with uniform acceleration and retardation [2]



- (ii)** See pro forma sample answer [5]

- (e) ● A means of allowing the operator to increase or decrease the tension on the straps at A in order to secure the quad firmly on the trailer.

Sample Answer – ratchet and pawl mechanism – annotation showing how it is attached to the straps and the need for a handle to turn the ratchet. [5]

- A means of providing a positive drive through the two shafts A and B while allowing shaft B to have small axial movements.

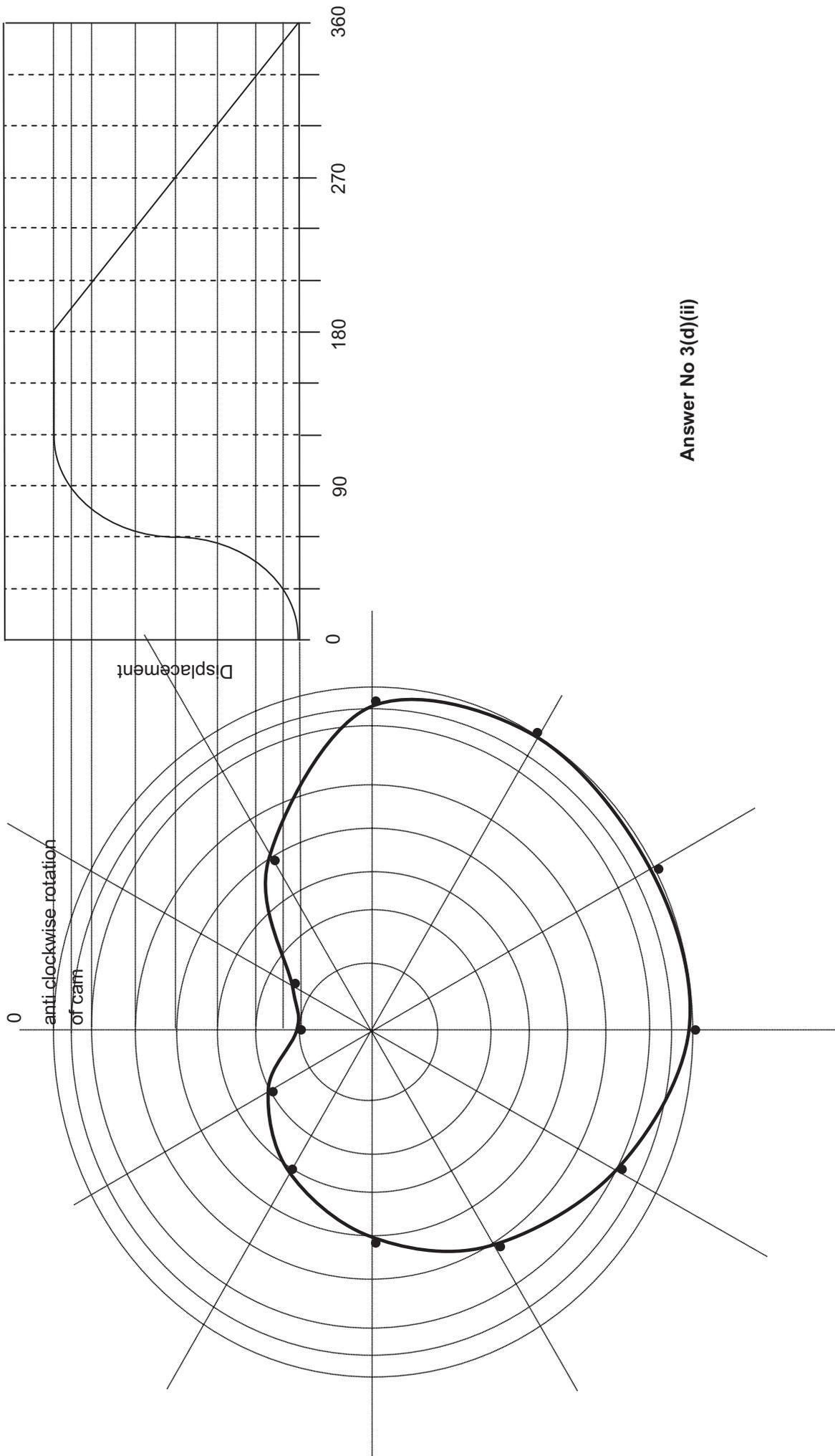
Sample Answer – A sketch of a sliding coupling showing female splined boss secured to shaft A by welding – Shaft B needs to be splined to allow for slight axial movement. [5]

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Answer No 3(d)(ii)



- 4 (a) Briefly explain the main function of a vacuum pump and a vacuum lifting cup.

Answer – a vacuum pump removes gas from an enclosed space leaving the container with a partial vacuum which is connected to vacuum lifting cups which lift objects by suction. [2]

- (b) Explain how the circuit in Fig. 4(a) operates starting from when the switch is pressed to operate valve A. (your answer should include a detailed explanation of the operation of valve C).

The switch when pressed operates the solenoid valve A and allows air to flow to the 14 side of the 5/3 valve C. This will enable the double acting cylinder to go positive only when the switch is being pressed. When the switch is released by the user the 5/3 valve will return to the centre state which is pressurised and as a result the cylinder has positional control i.e. It can hold any position between being fully outstroked or fully instroked. When the switch is pressed which controls valve B air is supplied to the 12 side of the 5/3 valve and the double acting will start to go negative. If the user releases contact with the switch the 5/3 valve will move to the central position and lock the cylinder at its current position. [5]

- (c) (i) Calculate the work done on the outstroke if the 600 N force loses 20% through inefficiency.

$$W = F \times L \quad 600 \times 0.15 = 90\text{J} - (20\%) = 72 \text{ J} \quad [2]$$

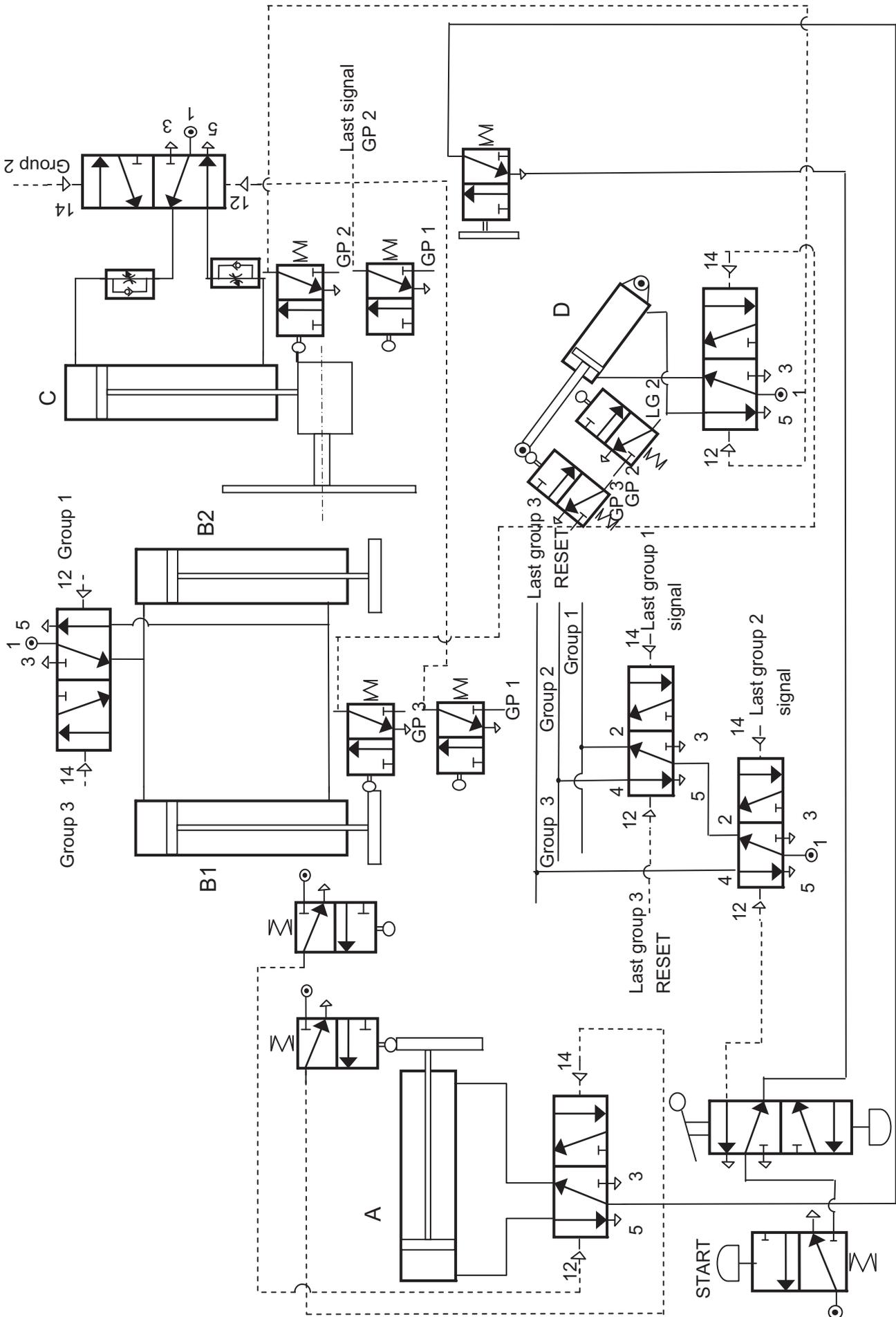
- (ii) Calculate the piston radius of this replacement double acting cylinder which will operate at the same air pressure and produce the same force. Assume  $\pi = 3.14$ .

$$\begin{aligned} F &= P \times A \quad \text{Total force} = 2009.6 \text{ N} \\ 2009.6 \text{ N} &= 0.4 \times A \\ 5024 &= A \\ 40 \text{ mm} &= \text{radius} \end{aligned} \quad [3]$$

- (iii) See pro forma sample answer

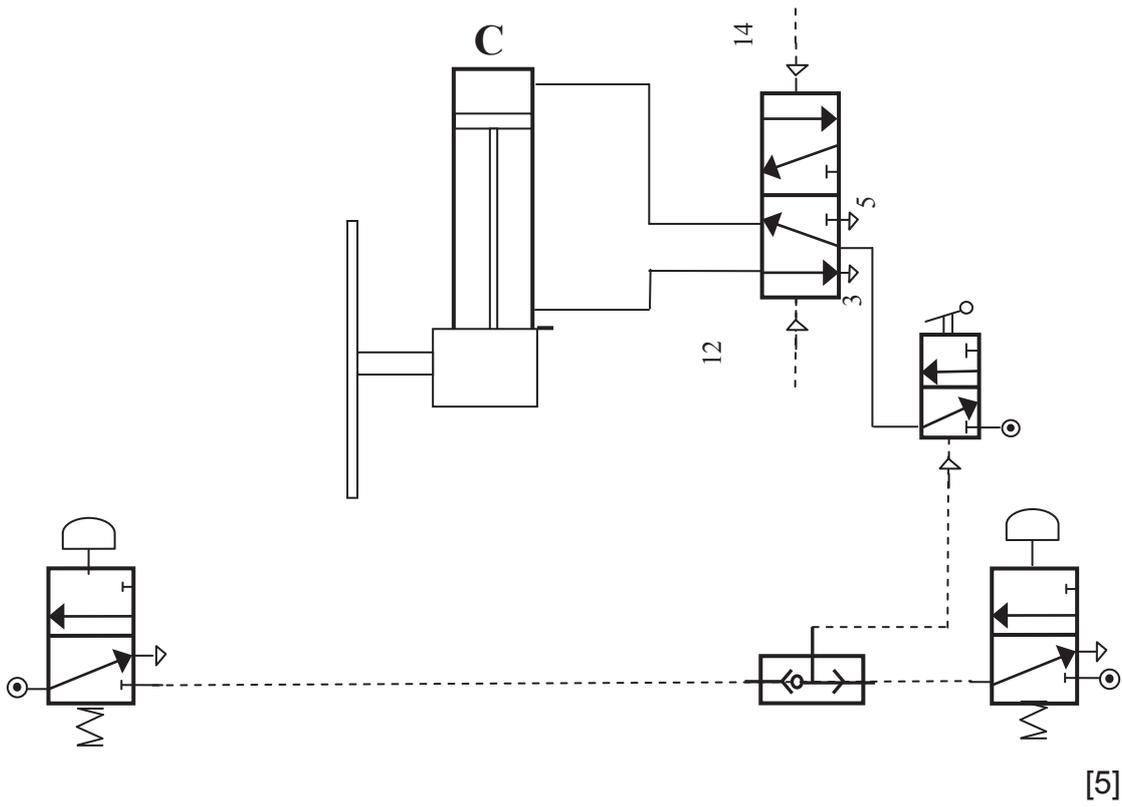
Ans = Valve X from Valve Z [1]  
 Method of activating 5PV [2]  
 Method of activating cylinder A+ A- [2]  
 Method of activating cylinder B+ [2]  
 Method of activating cylinder C+ [1]  
 Control of C slowly [2]  
 Method of activating cylinder C- [1]  
 Method of activating cylinder D- [1]  
 Method of activating cylinder B- [1]  
 Method of activating cylinder D+ [1]  
 Group changeover valves [4]

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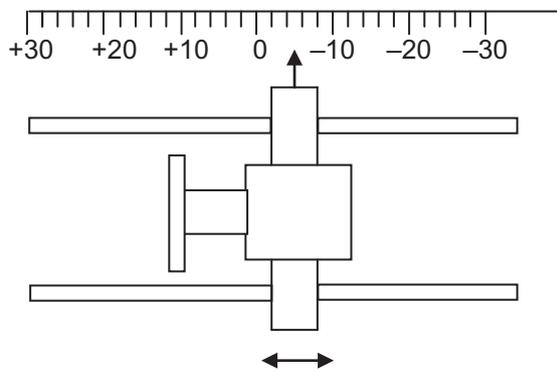
Answer No 4(c)(iii)

(d) Bullet point 1 – Sample answer



Bullet point 2 – Sample answer

Design and drawing of a toggle clamp or cam clamp



[5]

**Total**

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40

**80**