Rewarding Learning

ADVANCED
General Certificate of Education
January 2011

Technology and Design

Assessment Unit A2 1

assessing

Systems and Control

[AV211]

WEDNESDAY 26 JANUARY, MORNING

MARK SCHEME

General Marking Instructions

These mark schemes are intended to ensure that the AS/A2 examinations are marked consistently and fairly. The mark schemes provide examiners with an indication of the nature and range of candidate responses likely to be worthy of credit. They also set out the criteria which they should apply in allocating marks to candidates' responses. The mark schemes should be read in conjunction with these general marking instructions which apply to all papers.

Quality of candidates' responses

In marking the examination papers, examiners will be looking for a quality of response reflecting the level of maturity which may reasonably be expected of 17-18-year-olds which is the age at which the majority of candidates sit their AS/A2 examinations.

Flexibility in marking

The mark schemes which accompany the specimen examination papers are not intended to be totally prescriptive. For many questions, there may be a number of equally legitimate responses and different methods by which the candidates may achieve good marks. No mark scheme can cover all the answers 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 for the paper concerned.

Positive marking

Examiners are encouraged to be positive in their marking, giving appropriate credit for valid responses 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 for 17-18-year-old candidates. Conversely, marks should only be awarded for valid responses and not given for an attempt which is completely incorrect and inappropriate.

Types of mark schemes

Mark schemes for questions which required 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. These questions are indicated on the cover of the examination paper.

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.

Quality of written communication

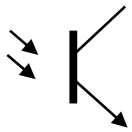
Quality of written communication is taken into account in assessing candidates' responses to all questions that require them to respond in extended written form.

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

AVAILABLE MARKS

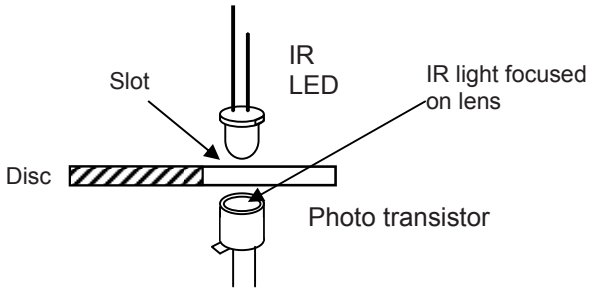
Section A

1 (a) (i)



[1]

(ii) Sample answer

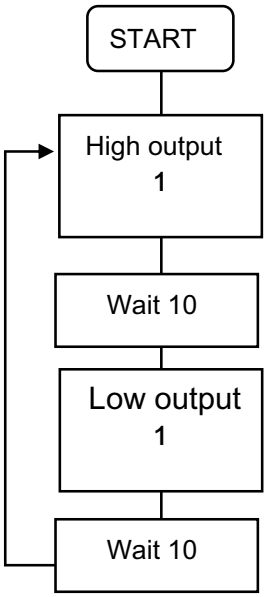


[3]

(iii) Sketch showing a reed switch and magnet or other sensor with no physical contact – with justification [3]

(b) (i) To ensure that pulses are only counted for the duration of the 10 second pulse. [2]

(ii) Sample answer



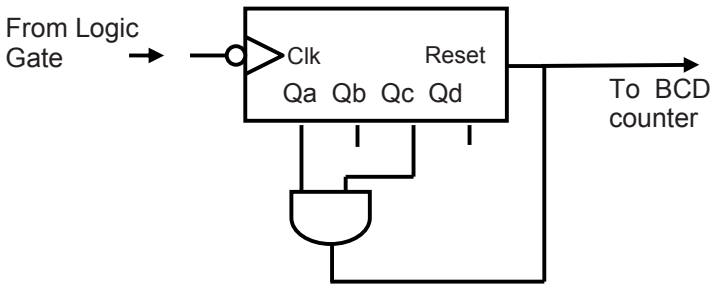
[3]

(iii) For 10 k.p.h. there will be 5 pulses per second for 10 seconds

Therefore 50 pulses in total. Divide by 5 requirement [4]

AVAILABLE MARKS

(c) (i)



[5]

(ii) Answers likely to refer to the following:

- Visibility – LED displays have excellent visibility in low light conditions. LCD displays do not perform well in low light conditions and must be backlit. Example – LED information screens at bus stops/train stations
- Power consumption. LCD displays have a lower power consumption and are used in applications that rely on battery power. Example – bicycle computers or calculators.
- Durability. The thin film layers used to make LCD screens can be easily damaged if exposed to impact. LED displays are often cased in thermosetting plastic making them suitable for tougher environments. Example – motorcycle gear selector display. [5]

[4]

Quality of written communication

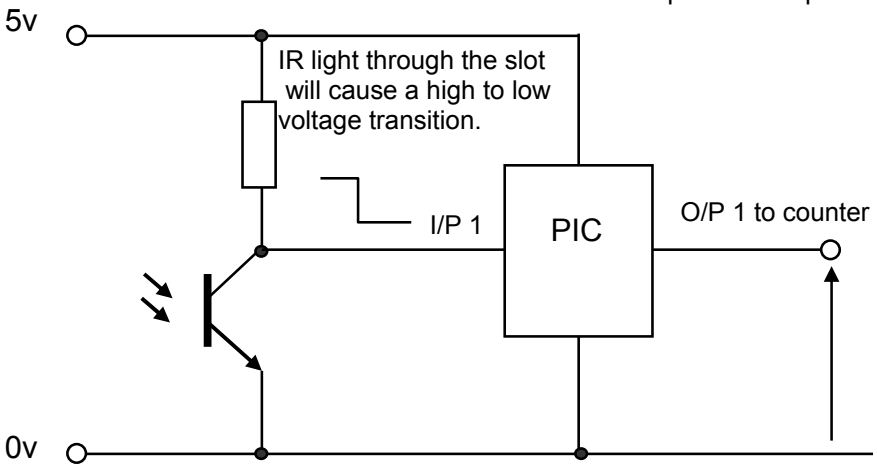
A response which is not worthy of any credit.	0
Poor selection and use of a writing form and style appropriate to the content. The content is poorly organised and little use is made of appropriate Technological vocabulary. The writing is barely legible and the spelling, grammar and punctuation is inaccurate.	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 is 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 is accurate.	4

(iii) Bullet point 1
sample answer could include

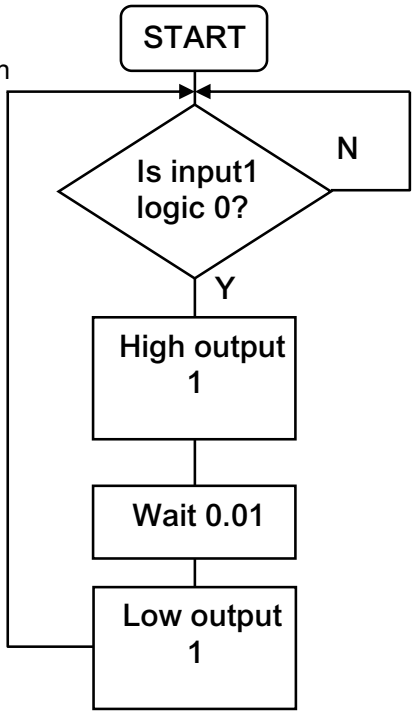
- A PIC based circuit with programme
- A monostable with appropriate component values
- Using the output from the timing circuit. [4]

AVAILABLE MARKS

Bullet point 2 sample answer.



PIC will detect the change in voltage level and produce a 10ms pulse at output 1.



[6]

AVAILABLE MARKS

40

AVAILABLE MARKS

2 (a) (i)

Stage	C	B	A		F
1	0	0	0		0
2	0	0	1		0
3	0	1	0		1
4	0	1	1		1
5	1	0	0		0
6	1	0	1		1
7	1	1	0		1
8	1	1	1		0

[4]

(ii)

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

$F = A'B + BC' + AB'C$ [4]

(iii) suitable gate arrangement [2]

(iv) Any two of the following:
- DC motors do not require positional circuits
- DC motors have a high torque capacity
- DC motors have a high RPM capacity [4]

(b) (i) As light increases the resistance of the LDR will decrease. [1]

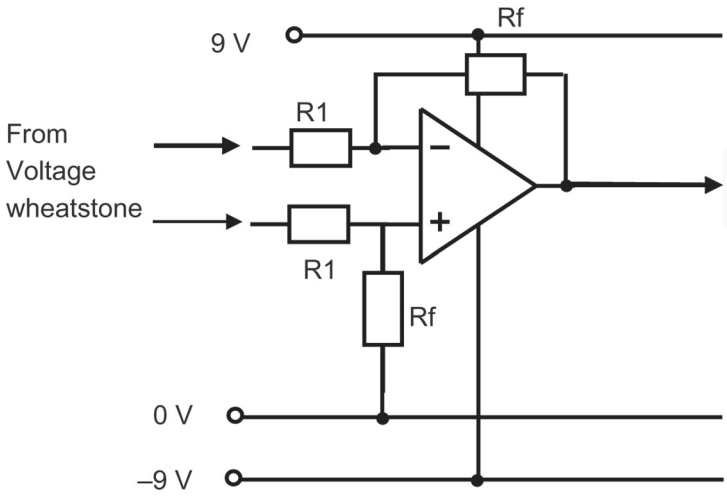
(ii) At 80Ω Vo = 0.37 volts At 8 kΩ Vo = 4.44 volts [2]

(iii) power dissipated = 5/1080 X5 = 23 mW [2]

(c) (i) Input Voltage range for unsatisfactory to excellent is 2.5 V − 2.49 V or 0.01 V
Required output voltage range is 0–5 V therefore Gain = 500
[3]

(ii) Gain of difference amplifier could be 500 therefore Rf = 5 MΩ and R1 = 10 kΩ
Overall gain of amplifier system = 500

AVAILABLE MARKS



[6]

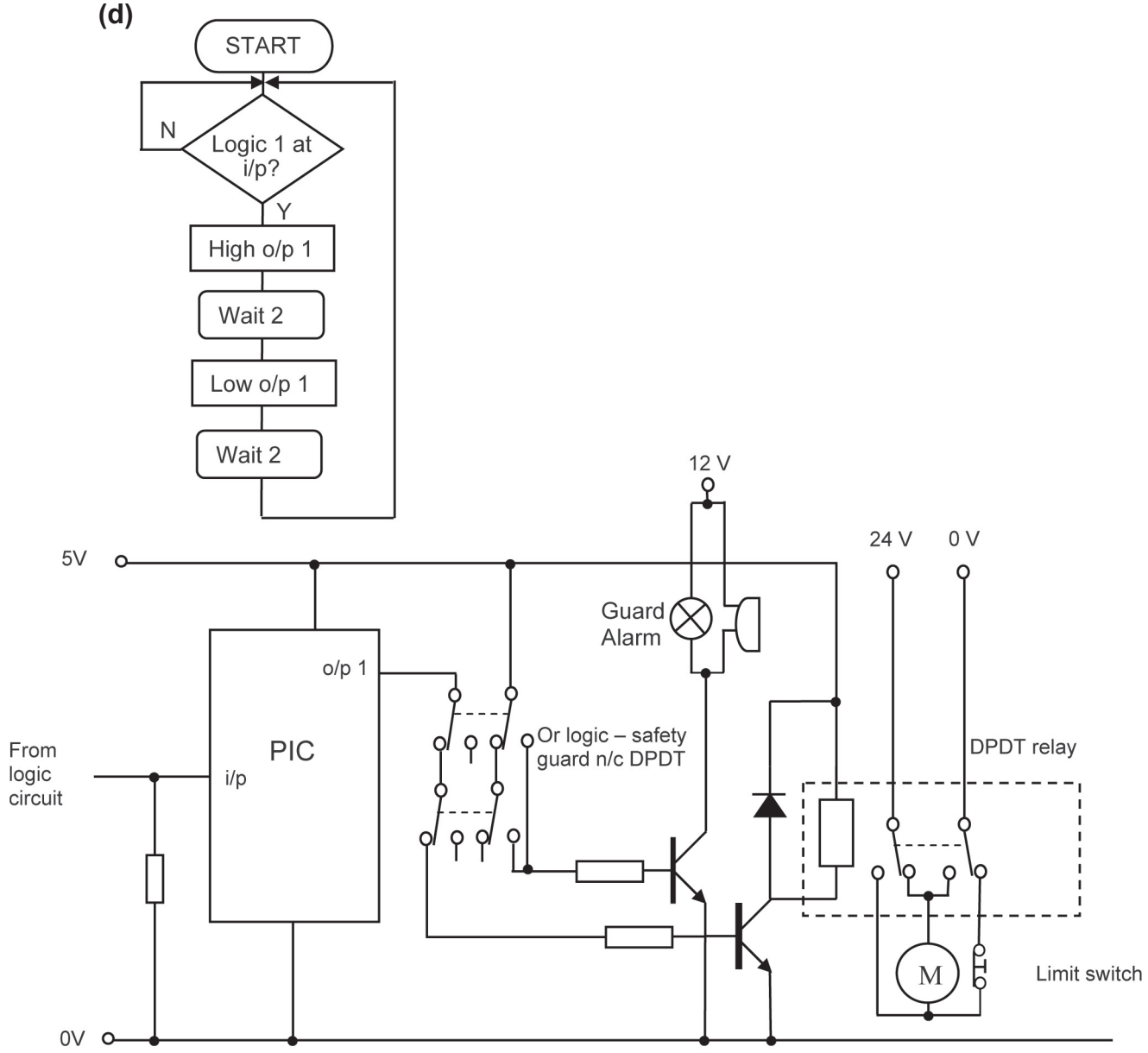
(iii)

INPUT	CONTROL	OUTPUT
Voltage divider	Op Amps	Voltmeter

Continuous output system

[2]

(d)



[10]

AVAILABLE MARKS

Section B

AVAILABLE MARKS

3 **(a)** Pitch point.
Ans = Sketch showing the point of tangency of the pitch circles of two meshing gears. [2]

(b) **(i)** Using an annotated sketch name and draw a suitable coupling which will transmit rotary motion between the two aligned shafts, **A** and **B**. Show how the coupling is attached to the shafts.

Ans = A muff or split coupling
Name [1]

Drawing arrangement of the two halves with bolts in recess. [2]
Key and keyway [1]

(ii) Using an annotated sketch outline the main features of a drum brake.

Outer Drum [1]
Brake shoes [1]
Spring [1]
Hydraulic/lever/cam operation. [1]

(c) **(i)** Calculate the output torque for the compound gear train shown in **Fig. 3 (b)** if the input torque is 180 Nm.

$$\text{output torque} = \text{input torque} \times \frac{\text{Product of driven teeth}}{\text{Product of driver teeth}}$$

output torque $= 180 \times (26 \times 32 \times 40/16 \times 18 \times 16)$
output torque $= 180 \times 33280/4608$
output torque $= 1300$ Nm [3]

(ii) Assuming no power loss, calculate the power from the output shaft if it rotates at 240 rev/min (r.p.m.).

Ans = $P = T\omega$
$P = T = 1300 \times \omega = 2\pi/60 \times 240$ r.p.m.
$P = 1300 \times 25.12$
$P = 32656\,W$
$P = 32.7\,kW$ [3]

(d) Using an annotated sketch draw a roller bearing to support the shaft and a suitable housing to accommodate and secure this bearing while making provision for lubrication.

AVAILABLE MARKS

Drawing of bearing – outer race/inner race roller and cage [2]
Housing – recess for bearing [1]
Secure the bearing – grub screw and flat [1]
Provision for lubrication – drilled hole with dust cap [1]

(e) Describe and fully justify a suitable seal and housing for the following:

- Side plate to the main gearbox housing – gasket which is a mechanical seal which fills the space between the side plate and the housing. It may require a sealant. The gasket would have the eight holes removed to correspond with side plate for the bolts. A gasket can fill any irregularities in the mating surfaces and therefore saves money by allowing "less than perfect" mating surfaces to be sealed. It is also suitable given the profile of the two surfaces to be sealed. In addition gaskets have the ability to withstand high compressive loads when tightened by bolts.
- Output shafts to the main gearbox housing – O-ring which is seated in a groove in the shaft and a shoulder in the housing which creates a seal at the interface. O-rings are inexpensive and easy to make, reliable, and have simple mounting requirements. They can seal tens of (thousands of psi) pressure. O-rings can be made from materials may be subjected to high or low temperatures, vibration, abrasion, and movement. [5]

QWC [4]

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(f) Design a gearbox using only gears with teeth between 20 and 100 that will provide an output speed of 240 r.p.m. from an input of 7680 r.p.m. in order to drive the shafts. (State clearly the number of teeth for each of the gears on shafts A, B, C, D and E).

AVAILABLE MARKS

7680 r.p.m to 240 r.p.m ratio of 32: 1 This may be achieved by the following		
4 : 1	20 T	Shaft A
	80T 20T	Shaft B
	Idler	Shaft C
4 : 1	20T	Shaft D
2 : 1	80T 20T	Shaft E
	40 T	Shaft F

- Then with the minimum number of additional gears to the gearbox show how with moving the gear stick forward, you could increase the output speed by one third in order to fulfil the second speed. (State clearly the output speed and the number of teeth for each additional gear used).

This may be achieved by the following

7680 r.p.m to 320 r.p.m ratio of 24 : 1 This may be achieved by the following		
3 : 1	20 T	Shaft A
	60T 20T	Shaft B
	Idler	Shaft C
4 : 1	20T	Shaft D
2 : 1	80T 20T	Shaft E
	40 T	Shaft F

Moving the gear stick forward would disengage the 4:1 ratio and engage a 3 : 1 ratio positioned behind it. [10] 40

4 **(a)** Briefly distinguish between open and closed loop systems

Ans = Open loop describes a system in which the building blocks connect in a linear way i.e. operator pressing a valve to operate a cylinder to stamp boxes, a closed loop describes a system with feedback [2]

(b) **(i)** Explain how the circuit in **Fig. 3 (a)** operates from the activation of the push button 3 PV. (Your answer should include a detailed explanation of the operation of component X).
When the push button 3PV is activated air goes to 14 side of the 5PV causing the DAC to go positive. The exhaust air is controlled by a flow regulator which helps to maintain an air pressure to the pressure sensitive 3PV (X) until the cylinder is at the end of outstroke. When exhaust pressure falls the pressure at the 12 side of the pressure sensitive 3PV (X) also falls. This valve was 'off' given the unconventional way it is piped up (main

air port 3 and exhaust 1) Due to the drop in pressure the spring return turns the valve 'on'. This enables the main air to flow to the 12 side of the 5PV to send the DAC negative. [4]

AVAILABLE MARKS

(ii) In order to determine a suitable compressor the air consumption for the double acting cylinder needs to be calculated. Using the data in the table below calculate the air consumption for this cylinder in litres per minute.

Volume = piston area × stroke compression ratio

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

Piston Area = $15 \times 8^2 \times 3.14/4 + 15 \times (8^2 - 1^2) \times 3.14/4$

Piston Area = 753.6 + 741.8

Piston Area = 1495.4 cm^2 [3]

Volume = piston area × stroke × compression ratio

Volume = 1495.4 × 15 × 20 × gauge pressure + atmospheric pressure

Volume = 1495.4 × 20 × 4 + 1

Volume = 149540 × cc/min [2]

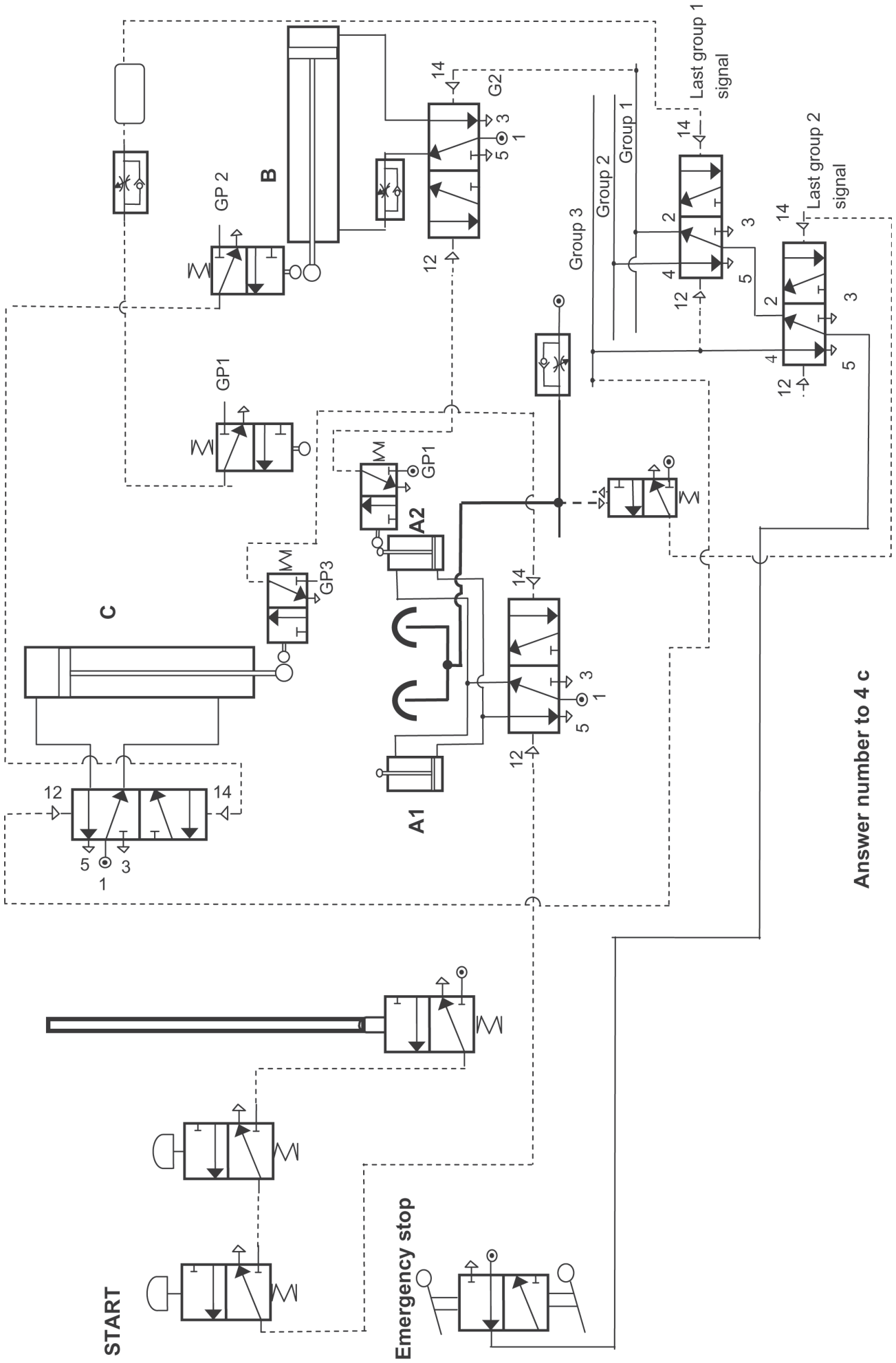
Ans = 149.54 litres per minute. [1]

(c) The following sequence begins when the start switch is activated:

On the proforma provided (answer No **4(c)**) draw a suitable interlocking/cascade sequential pneumatic circuit to achieve the desired sequence.

Ans = Method of activating guard	[2]
Method of activating AND logic	[1]
Method of activating cylinder A1– and A2–	[1]
Method of activating cylinder B+ time delay	[3]
Method of activating cylinder B–	[1]
Method of activating cylinder C+	[1]
Method of activating dual air bleed for C–	[3]
Method of activating cylinder A1+ and A2+	[1]
Group changeover valves	[3]
Emergency stop	[2]

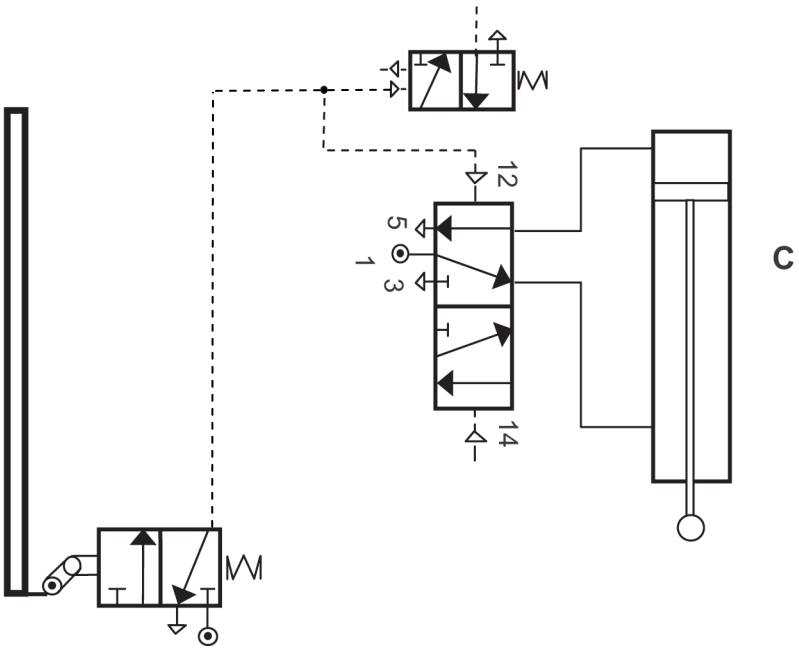
See sample answer below



(d) On the proforma provided (answer number **4(d)**) design and draw a pneumatic system which will:

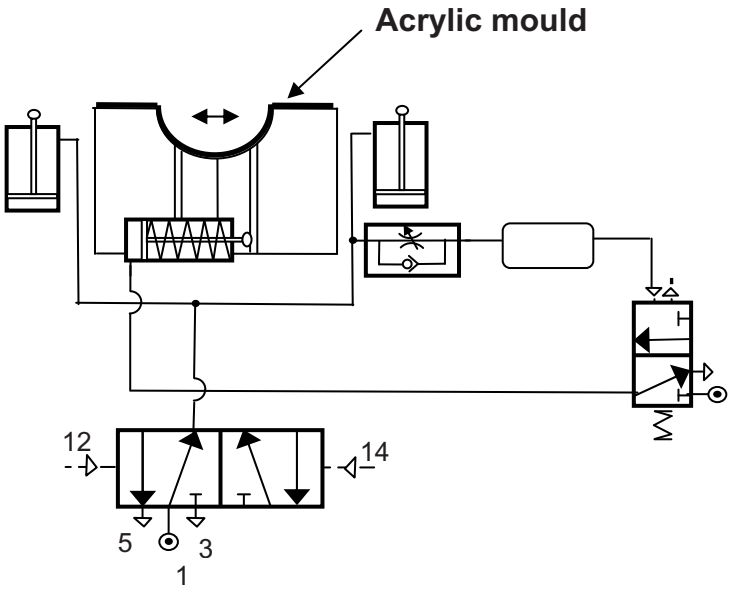
- Return cylinder C to the negative position if the guard is accidentally lifted at any stage of the operation.
- Release the newly formed acrylic mould.

Bullet point 1 – Sample answer



[5]

Bullet point 2 – Sample answer



[5]

Total

AVAILABLE MARKS

40

80