

GCE A2

**Technology
and Design**

January 2010

Mark Scheme

Issued: April 2010

**NORTHERN IRELAND GENERAL CERTIFICATE OF SECONDARY EDUCATION (GCSE)
AND NORTHERN IRELAND GENERAL CERTIFICATE OF EDUCATION (GCE)**

MARK SCHEMES (2010)

Foreword

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 16- and 18-year-old 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 a 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.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

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Rewarding Learning

ADVANCED
General Certificate of Education
January 2010

Technology and Design

Assessment Unit A2 3

assessing

Module 6 – Systems and Control in Product Design

[A2V31]

WEDNESDAY 20 JANUARY, MORNING

**MARK
SCHEME**

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

AVAILABLE
MARKS

Section A

Answer either 1(a) or 1(b)

1 (a) Electronic and Microelectronic

- (i) Determine if the sequence described above is that of an open-loop or closed-loop system. Give **one** main reason in support of your answer.
Answer – open-loop system.

One main reason in support of your answer.

- No checking is carried out in the system to ensure something has been done. [2]

- (ii) Any **two** safety considerations from the following:

- all control circuitry and electrical connections must be well insulated
- adequate ventilation for cooling is required for the control system
- fail-safe circuitry should be incorporated [2]

- (iii) Any outline of **two** main reasons why riveting would be used to join the stainless steel housing to an internal box section frame from the following:

- produces a good surface finish
- does not facilitate removal easily for vandals
- cost effective process not requiring heat [2]

- (iv) **Two** main physical properties that makes stainless steel suitable for the housing from the following:

- corrosion resistant and a hard material
- availability in a range of stock lengths
- aesthetically pleasing finish

Two main mechanical properties that makes stainless steel suitable for the housing from the following:

- good ductility
- good hardness qualities
- good tensile strength [4]

- (v) **Bullet point 1**

Answer likely to include an infra-red beam and sensor which will trigger a 5-volt monostable with the components that provide the 50 millisecond time delay clearly identified. [5]

Bullet point 2

Answer to include a PIC circuit with an input from the token detection circuit and outputs to drive the solenoids and associated indicator lamps for the specified times. PIC circuits should be accompanied by appropriate programs. [12]

Bullet point 3

Answer likely to include a transistor used to switch on a relay which in turn will control the water heater. A method of detecting water in pipe, e.g. a float switch could be connected in series (or via a logic gate) with the heater circuit to ensure that the heater will only operate when water is present. [6]

Bullet point 4

Answer likely to include a counter with a 1-second clock input and appropriate gates to provide the sequence. Answer to include a driver circuit for the lamps. [5]

(b) Pneumatic and Mechanical

- (i) Determine if the sequence described above is that of an open-loop or closed-loop system. Give **one** main reason in support of your answer. Answer – open-loop system.

One main reason in support of your answer.

- No checking is carried out in the system to ensure something has been done. [2]

- (ii) Any **two** safety considerations from the following:

- all control circuitry and electrical connections must be well insulated
- adequate ventilation for cooling is required for the control system
- fail-safe circuitry should be incorporated [2]

- (iii) Any outline of **two** main reasons why riveting would be used to join the stainless steel housing to an internal box section frame from the following:

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- (iv) **Two** main physical properties that makes stainless steel suitable for the housing from the following:

- corrosion resistant and a hard material
- availability in a range of stock lengths
- aesthetically pleasing finish

Two main mechanical properties that makes stainless steel suitable for the housing from the following:

- good ductility
- good hardness qualities
- good tensile strength [4]

(v) **Bullet point 1**

Annotated sketch of a thrust bearing and housing.

[5]

Bullet point 2

Profile for Cam 1	Profile for Cam 2	Profile for Cam 3
Opens valve 1 for 135 degrees of cam rotation	valve 2 closed for 45 degrees of cam rotation	valve 3 closed for 240 degrees of cam rotation
Dwell valve closed for 45 degrees	valve 2 open for 90 degrees of cam rotation	valve 3 open for 60 degrees of cam rotation
Opens valve 1 for 60 degrees of cam rotation	valve 2 closed for 225 degrees of cam rotation	valve 3 closed for 60 degrees of cam rotation
Dwell valve closed for 60 degrees		
Opens valve 1 for 60 degrees of cam rotation		

[9]

Attachment to drive shaft

EG annotated sketch of a key and keyway.

[3]

Bullet point 3

Input 48 rpm to output ? in 6 minutes = 288 rpm to 1 rpm Ratio of 288:1					
	20T				Shaft A
8:1	160T	20T			Shaft B
6:1		120T	20T		Shaft C
6:1			120T	20T	Shaft D

[6]

Bullet point 4

Annotated sketch of crank and slider mechanism

[5]

Section A

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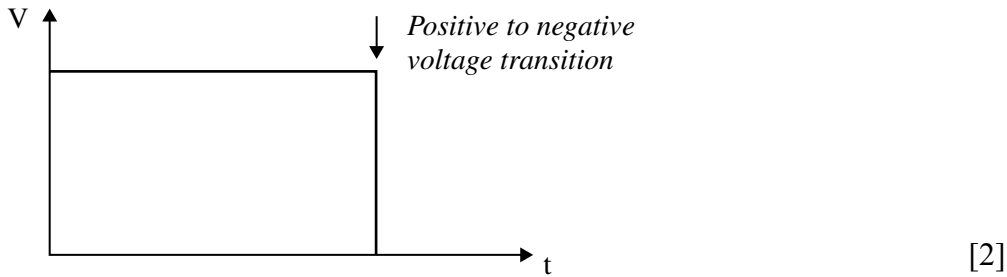
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Section B

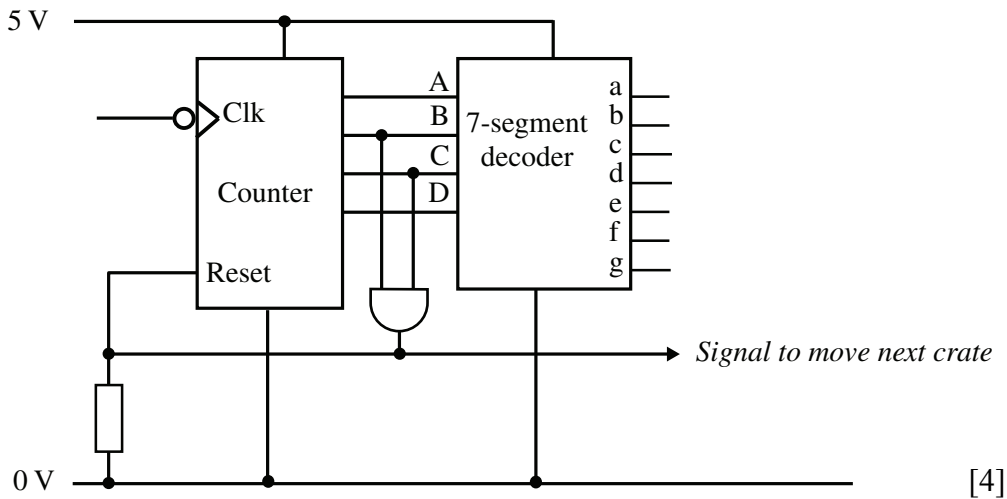
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2 (a) State the function of the Resistor labelled R1 in Fig. 2
Pull down resistor – to ensure that input does not “float” when not connected to the positive rail [1]

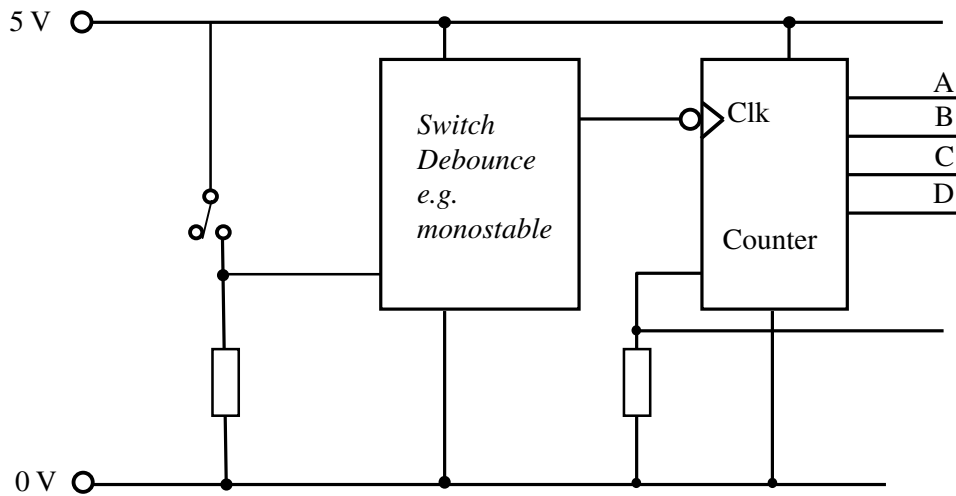
(b) The counter in Fig. 2 operates when a falling edge trigger is received at the clk input. Explain with the aid of a diagram what is meant by the term falling edge trigger.



(c) Explain with the aid of a diagram how the counter could be used to count the bottles in batches of six, resetting after each batch.



- (d) During testing it was found that the counter in **Fig. 2** was sometimes adding 2 or 3 to the count even though only one bottle was passing the microswitch. Explain a likely cause of this problem and suggest a modification to the circuit that would overcome this problem.
Mechanical switch contacts can “bounce” when operated causing a number of false signals.



[4]

- (e) Draw a truth table for the 7 segment decoder showing the inputs A, B and C with

<i>C</i>	<i>B</i>	<i>A</i>	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>	<i>e</i>	<i>f</i>	<i>g</i>	
0	0	0	1	1	1	1	1	1	0	0
0	0	1	0	1	1	0	0	0	0	1
0	1	0	1	1	0	1	1	0	1	2
0	1	1	1	1	1	1	0	0	1	3
1	0	0	0	1	1	0	0	1	1	4
1	0	1	1	0	1	1	0	1	1	5

the corresponding output a–g to the LED 7 segment display for 0 through to 5

[6]

- (f) It has been proposed that the LED 7 segment display in **Fig. 2** be replaced by an LCD type. State one advantage and one disadvantage (excluding cost considerations) of LCD type displays compared to LED type displays.

Advantage – more energy efficient

Disadvantage – difficult to see in bright light – needs backlight in dark conditions

[2]

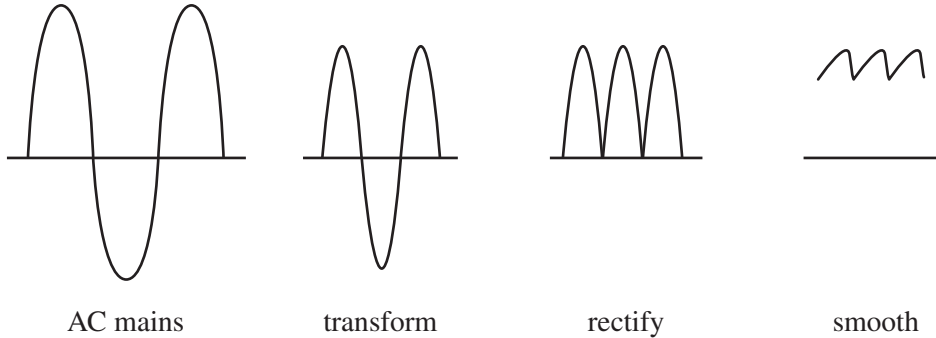
- 3 (a) (i) Briefly explain the function of the transform, rectify and smooth blocks shown in Fig. 3(a)

Transformation – transformer – to reduce the amplitude of the AC mains voltage.

Rectification – Diodes – Bridge rectifier – to make AC voltage positive.

Smoothing – Capacitor – to “flatten peaks” of the rectified voltage. [3]

- (ii) Sketch and label the output waveform for each block of the power supply shown in Fig. 3(a)



[4]

- (b) (i) Explain how the output voltage supplied to the electronic game will remain constant despite fluctuations in the input voltage from the unregulated supply.

Reference to reverse breakdown voltage [1]

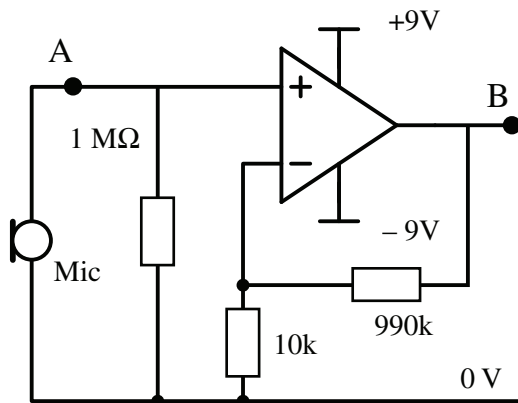
- (ii) An output current of 20 mA is required to operate the electronic game. Calculate an appropriate value for the Resistor R_s in Fig. 3(b)

$6/30 \text{ mA} = 200 \text{ ohms} [2]$

- (c) (i) With the aid of a diagram, briefly explain the operation of a ceramic type microphone.

Diagram to show Salt/crystal and diaphragm. Explanation of sound acting on diaphragm to piezo crystal resulting in electrical current [3]

- (ii) A non inverting amplifier is required to amplify the microphone voltage. Draw a suitable amplifier circuit based on the op amp shown in Fig. 3(a) and suggest suitable values for resistors R1 and Rf to achieve a gain of 100 given that $\text{gain} = 1 + R_f/R_1$. (R1 and Rf are used to provide feedback.)



[4]

- (iii) Briefly explain how a signal generator and an oscilloscope can be used to check the voltage gain of the amplifier in 3(c)(ii).

Replace microphone with reference voltage from the output of the signal generator.

Connect the oscilloscope to the output from the op amp and measure the voltage.

Compare the reference voltage with the measured voltage to calculate the gain.

[2]

Section B

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Section C

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- 4 (a) (i)** Multigrade oil is often chosen to lubricate gears. Briefly outline its main characteristics.
 Answer = Viscosity change [1]
 at differing temperature levels. [1]
- (ii)** Calculate the output torque on the auxiliary output shaft if the input torque on gear **C** is 150 N.
 Answer = $OT = IT \times VR$
 $60/40 = 1.5$ [1]
 $1.5 \times 150 = 225 \text{ Nm}$ [1]
- (iii)** Using an annotated sketch name and draw a method used to transfer the rotary motion from the motor to gear **C** via shaft **P** at an even rate.
 Answer = Constant velocity joint [1]
 Suitable annotated sketch of the constant velocity joint arrangement. [2]
 Or other suitable arrangement.
- (iv)** Calculate the overall velocity ratio from gear **C** to the wormwheel **L**.
 Answer = $C-E = 40/40 = 1$
 $F-H = 50/150 = 1/3$
 $J-K = 80/160 = 1/2$ [2]
 $1/6 \times 60 = 10$ [2]
- (v)** The bearings on the auxiliary output shaft experience both axial and radial loadings. Using an annotated sketch outline a suitable bearing and housing arrangement.
 Answer = Suitable annotated sketch of a double tapered roller bearing arrangement.
 Tapered rollers [1]
 Double [1]
 Overall arrangement [1]
 Housing [1]
- (vi)** Calculate the power supplied by the motor to shaft **P** to rotate it at an angular speed of 240 rev/min with a torque of 200 Nm.
 Answer = $P = T\omega$
 $200 \times \omega$
 $\omega = 2\pi \times 240/60 = 25.12 \text{ rad/s}$ [1]
 $25.12 \times 200 = 5024 \text{ W}$ [1]

- (vii) Block **W** on the conveyor belt has a mass of 5 kg. The conveyor belt is not horizontal and the block moves through a vertical height of 1 m over this distance. Assume $g = 9.81 \text{ m/s}^2$. Calculate the gain in potential energy.

Answer = Calculate the gain in potential energy.
 Gain in PE = mgh
 $5 \times 9.81 \times 1 = 49.05 \text{ J}$ [2]

- 5 (a) (i) Briefly describe a pneumatic component which could be used on cylinder D to hold and release the boxes.

Answer = Vacuum lifting cup. [1]
 Or other suitable answer

- (ii) Briefly explain **one** advantage and **one** disadvantage associated with the use of interlocking in sequential circuits.

Answer = Advantage – each step can only progress once the previous step has occurred and signalled it. [1]

Disadvantage – It can be awkward to position the signalling 3 PVs. [1]

Or other suitable answer.

See Sample Answer

- (b) The box travels along to a further manufacturing stage which utilises the incomplete circuit as shown in **Fig. 5(b)**. The circuit when complete is expected to perform the following operation:

S1 is pressed until cylinder **X** outstrokes which activities an outstroke of cylinder **Y**. After a short delay in time cylinder **Z** outstrokes pressing **S2** which enables it to instroke again.

- (i) One the proforma provided (Proforma Answer No **5(b)(i) & (ii)**) complete the circuit to achieve the desired circuit operation.

Answer = Correct operation of X
 Correct operation of Y [1]

Correct operation of Z
 Correct operation of time delay
 Correct operation of the return of Z [1]

See Sample Answer

- (ii) As a safety feature on the proforma provided (Proforma Answer No **5(b)(i) & (ii)**) show how cylinder Z can be de-activated pneumatically.

Answer = Inclusion of a 3 PV
 Manual method of operation [1]

ON/OFF operation of main air supply to the 5 PV [1]

- (c) The following sequence begins once a box is placed over the airbleed:
- Cylinder A outstrokes **slowly** to print a design on the box.
 - Cylinder A instrokes.
 - Cylinder B outstrokes **slowly** to push the box onto conveyor belt 1.
 - Cylinder D outstrokes and lifts the box.
 - Cylinder C outstrokes to move cylinder **D** above conveyor belt 2 and releases the box.
 - Cylinder C instrokes.
 - Cylinder B instrokes.
 - Cylinder D instrokes.

Method of activating cylinder A+	
Method of activating cylinder A–	[1]
Method of activating cylinder B+	
Method of activating cylinder D+	[1]
Method of activating cylinder C+	
Method of activating cylinder C–	[1]
Method of activating cylinder B–	
Method of activating cylinder D–	[1]
Slow action of A+ and B+	[1]
Group system suitably employed or alternative	[2]

See Sample Answer

- (d) Cylinder **Y** has a piston diameter of 40 mm and operates with an air pressure of 0.5 N/mm². Cylinder **Z** has a piston radius of 25 mm and operates with an air pressure of 1 N/mm². Calculate the piston rod diameter required for cylinder **Z** to instroke with three times the outstroke force of cylinder **Y**. Please assume $\pi = 3.14$.

Answer = Cylinder Y = $20 \times 20 \times 3.14 = 1256$ $1256 \times 0.5 = 628 \text{ N}$ $628 \times 3 = 1884 \text{ N required}$	[2]
Cylinder Z = $25 \times 25 \times 3.14 = 1962.5$ $1962.5 - 1884 = 78.5$ $78.5/3.14 = 25$ Radius = 5/diameter = 10 mm	[3]

Section C

Quality of Written Communication

Total

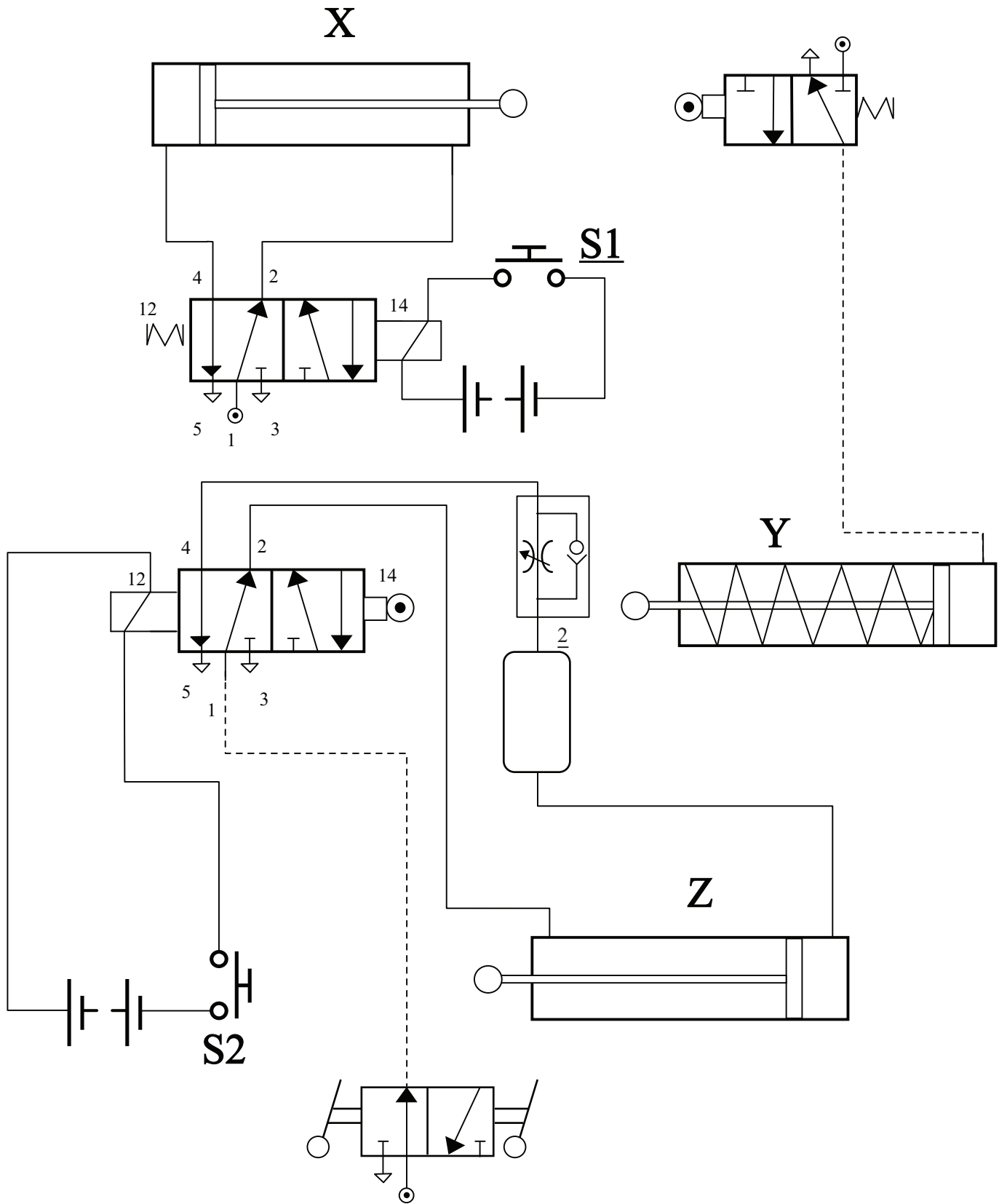
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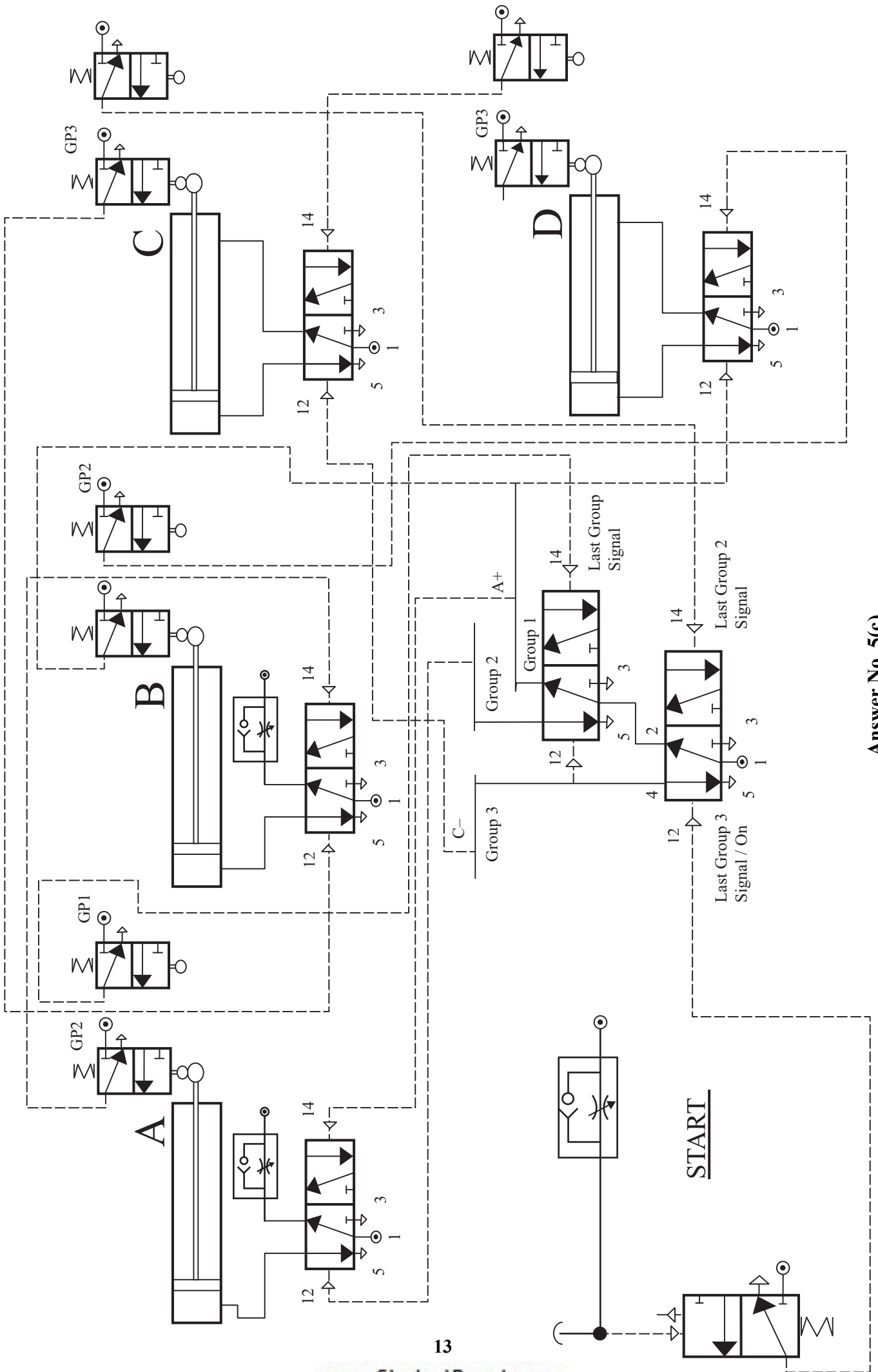
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4

80



Answer No. 5(b)(i) & (ii)



<p>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.</p>	<p>1–2</p>
<p>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.</p>	<p>3</p>
<p>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 Technology vocabulary. The writing is clearly legible and the spelling, grammar and punctuation is very accurate.</p>	<p>4</p>