**ADVANCED**
**General Certificate of Education**
**2012**

# Technology and Design

## Assessment Unit A2 1

*assessing*

## Systems and Control

### [AV211]

**TUESDAY 22 MAY, AFTERNOON**

# MARK SCHEME

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

**Section A**

**1** **(a)** **(i)** The resistance of a strain gauge changes when it is deformed. [1]

**(ii)** The strain gauge pattern is arranged so that deformation in direction B causes a change in length and/or cross sectional area of the foil. This in turn will cause a change in resistance and is known as the active axis. Deformation of the gauge in the direction of A causes little or no change in the length/cross sectional area and hence little or no change in resistance. This is called the passive axis. [2]

**(iii)** Two strain gauges are placed close together with the active axis at 90° to each other. Both experience changes due to temperature, only one experiences change due to strain.
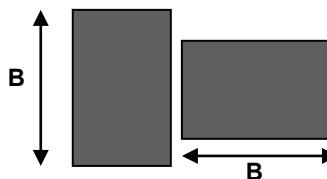


[3]

**(b)** **(i)** The difference of the outputs of two voltage dividers sharing a common source. [2]

**(ii)** V1 = 120.6/240.7 × 9 V
= 4.51 V [2]

**(c)** **(i)** Gain = 4 V/0.01 V
= 400 [2]

**(ii)**
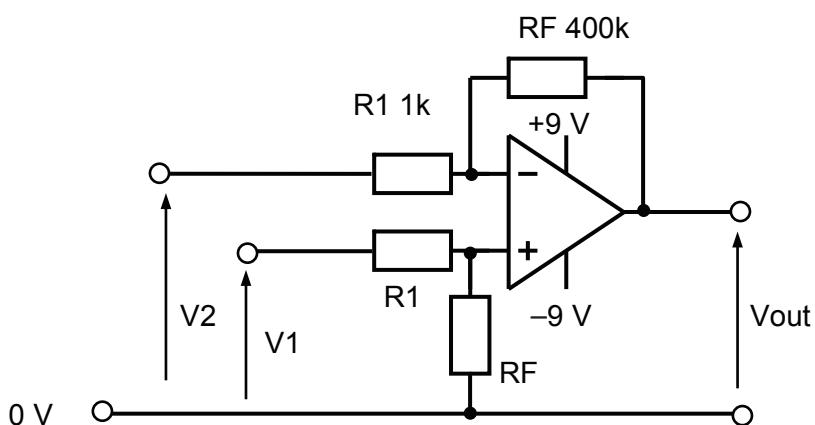


[4]

**(d) (i)**         225/4 = 63.75

63.75 × 0.8 = 51

63.75 × 2.4 = 153                                                    [2]

**(ii)**



[3]

**(iii)**

possible flow chart answer

START

High o/p 7     Switch pump on

Read ADC

o/ps 0–5 off

ADC <51 — Y

N

ADC <102 — High o/p 0

Y

N

ADC <153 — High o/p 1

N

ADC <204 — High o/p 2

Y

N

ADC < 255 — High o/p 3

Y

N

N — ADC =255 — High o/p 4

Y

High o/p 6     Switch alarm on

Low o/p 7     Switch pump off

High o/p 5

FLASH
RED
LED

Wait 0.25

low o/p 5

Wait 0.25
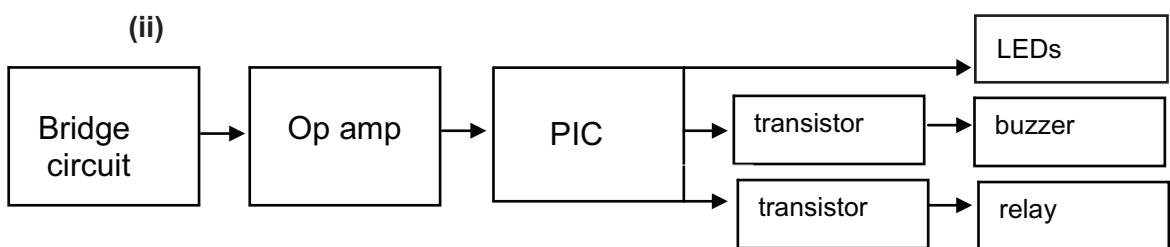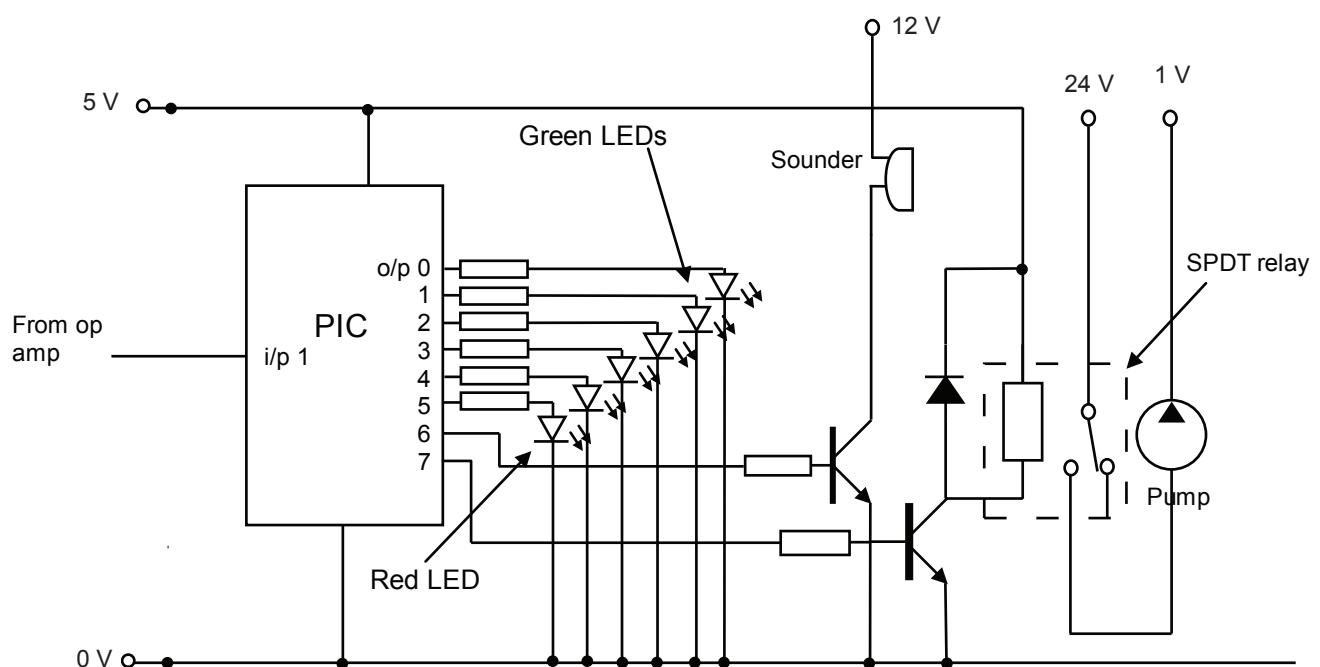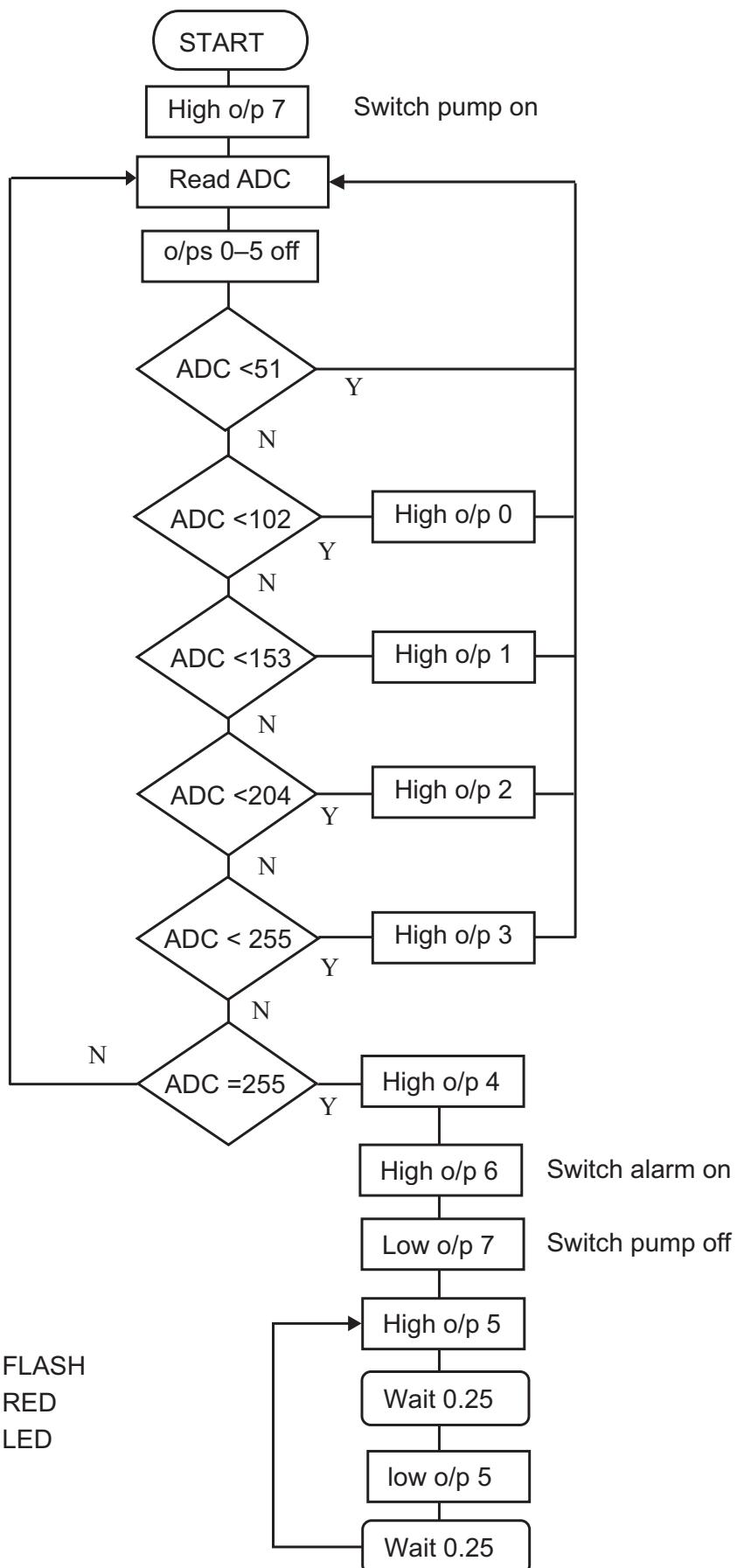
[10]

**(e)** Answer to include a structured and coherent written presentation with reference to the following features:

PICs
- Flexibility – to change control functions during development.
- Versatility – range of logic functions easily achieved such as latching and counting.
- ADCs often available on board – ease of interface with sensors.

Hard wired
- Cost for standard components can be considerably lower, e.g. 555 timers.
- Fault finding is confined to circuit (no software bugs).
- Reliability due to extensive testing of standard components.

A PIC solution can be chosen in preference to a hard wired circuit where a low component count is necessary, for example A PIC with on board ADC can replace a number of standard components.
Also circuits with multiple inputs or mixed analogue/digital inputs and outputs can be easily accommodated with PICs. [5]

| | |
|---|---|
| Zero should be awarded for 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 very accurate. | [4] |

Quality of written communication [4]

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**2 (a) (i)**

| Qc | Qb | Qa | A | B | C | D | E |
|----|----|----|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |

[3]

Karnaugh maps

**(ii)** Logic expressions for outputs
A, B and C
$A = Qa'Qb'Qc' + QaQb'Qc' + Qa'QbQc'$
$B = QaQb'Qc' + Qa'QbQc' + QaQbQc'$
$C = Qa'QbQc' + QaQbQc' + Qa'Qb'Qc$

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

$A = Qa'Qc' + Qb'Qc'$

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

$B = QaQc' + QbQc'$

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

$C = Qa'Qb'Qc + QbQc'$

[6]

**(iii)**



[3]
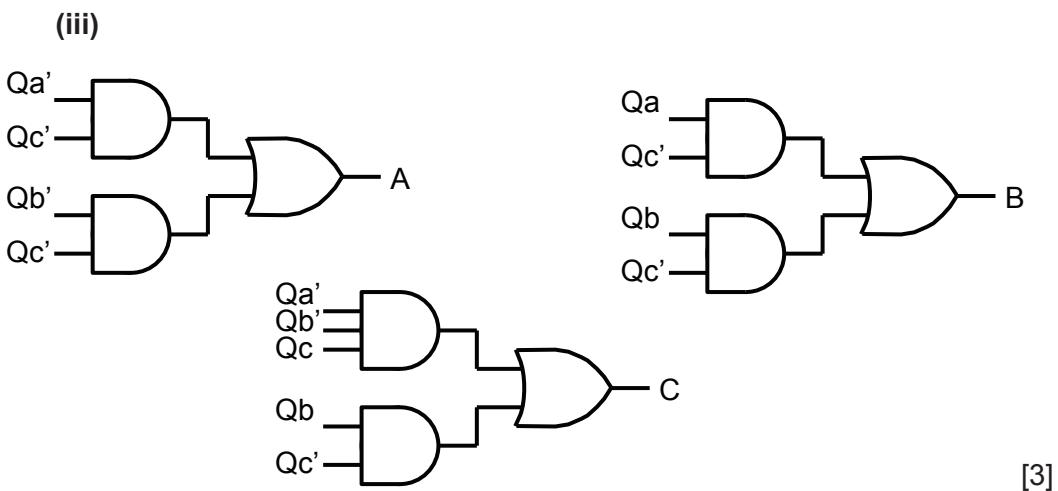
**(b)** LED displays can have a high visibility even in the bright daylight conditions in the theme park. LCD displays require backlighting.
LED type displays are usually encased in a tough plastic providing good resistance to shock and weathering. [2]

**(c) (i)** Total voltage drop across LEDs = 10
therefore 2 V across resistor
R = 2 V/20 mA = 100 Ω

Power = 20 mA × 2 = 0.04 watts [3]

**(ii)** Total power dissipated = 10 V × 20 mA
= 0.2 W [2]

**(d) (i)**
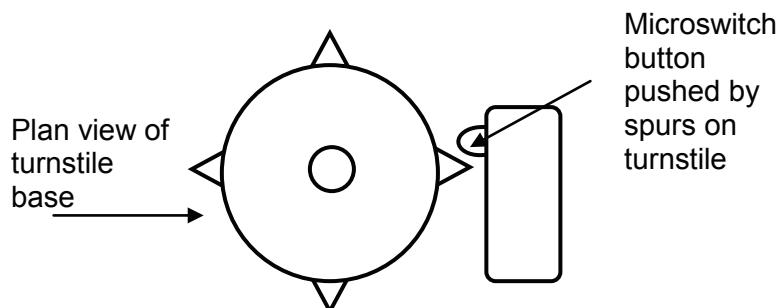


[2]

**(ii)**
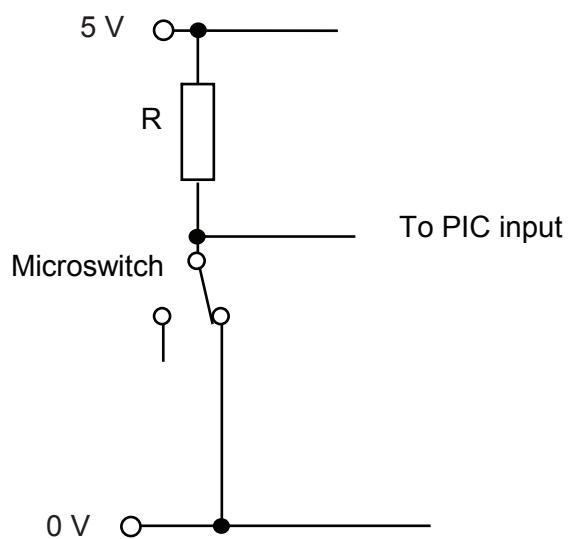


[2]

**(iii)** A likely cause is switch 'bounce', which is a feature of mechanical type switches. The switch contacts effectively open and close more than once each time the switch is activated. One solution would be to add a short time delay on the PIC output. [3]

**(e) (i)** BCD counters automatically reset after 9 characters avoiding the need to display hexadecimal values. Decimal displays are much easier for people to read. [2]

**(ii)** **Appropriate diagram showing one or more anodes connected together** [2]

**(iii)**



PIC program



[10]

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**Section A** **80**

8
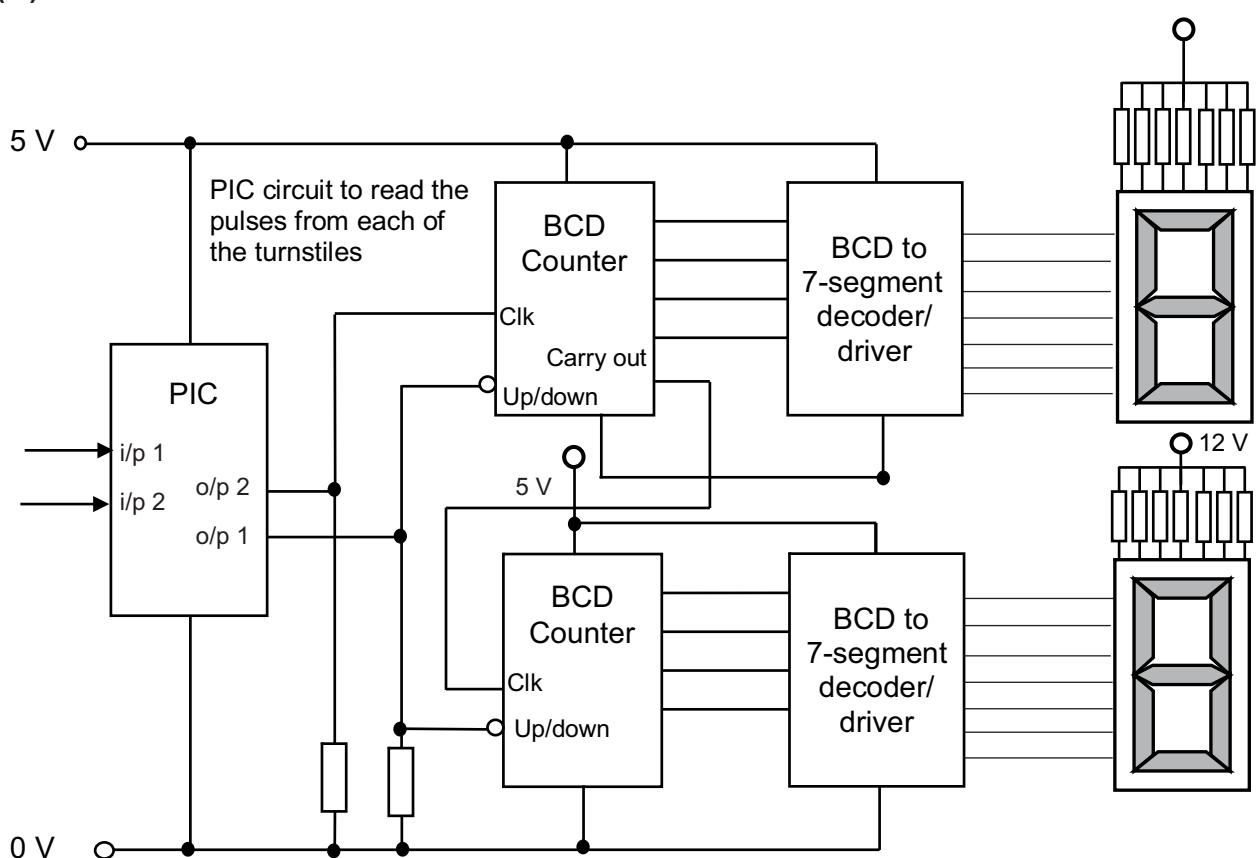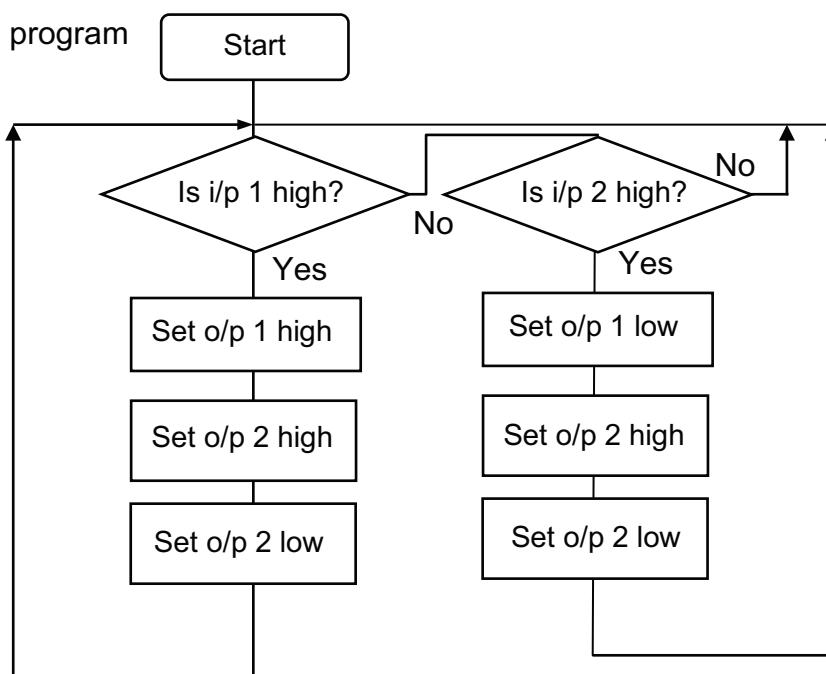
**3** **(a)** Any **one** main safety issue associated with the use of a Mechanical control system.

- Trapped fingers or clothing – guards around moving parts.
- Serious injury due to revolving parts – guards, signs. [1]

**(b)** **(i)** The bolts which secure the head onto the body of the engine are set to a torque of 80 Nm and the mechanic applies a force 400 mm from the centre turning point. Calculate the minimum force required to slacken the bolt.

Torque = force × distance from the turning point
80 Nm = f × 0.4 m
200 N   = force [2]

**(ii)** The piston in the chainsaw engine moves 180 mm at a speed of 3000 rpm. If the piston has a mass of 0.3 kg, calculate the kinetic energy for the piston ignoring friction.

Kinetic energy = $\frac{1}{2}$ × mass × $v^2$        Velocity = 0.18 × 3000/60 = 9 m/s

KE   = 0.5 × 0.3 × 9²

KE   = 12.15 J [4]

**(c)** Roller element bearings are used to support the pin in the connecting rod. With reference to **Fig. 3(c)** below produce an annotated sketch of an appropriate roller element bearing which would provide suitable support for the pin.

Drawing of bearing – outer race/inner race needles and cage [3]
Appropriate choice of bearing [1]   [4]

**(d)** Gaskets and seals are used on various parts of the chainsaw.

**(i)** Briefly explain the purpose of a gasket and give one main reason why they are used.

The purpose of a gasket is to make a seal between 2 surfaces to stop oil from escaping. [1]

Any **one** reason why they are used from the following:
- It provides a tighter fit between two pieces of an assembly, reducing the potential for leaking.
- Gaskets save money by allowing "less-than-perfect" mating surfaces on machine parts which can use a gasket to fill irregularities.
- They allow for assembly and disassembly of components or parts for maintenance. [1]   [2]

**(ii)** Name and produce an annotated sketch of a suitable seal for the petrol cap. This seal will help prevent petrol leaks when the cap is screwed into the threaded hole of the tank.

Name O-ring
Drawing of O-ring – seating around the cap. [2]

**(e)** With the use of an annotated sketch draw a band brake. Include in your sketch a method to activate this brake.

Drawing and annotation of the following:
Band and drum/wheel
Pivot points for the band
Method of activation – lever or handle or other method [3]

**(f)** Discuss the merits of using each of the following clutches; cone, centrifugal or diaphragm. Select an appropriate clutch for the chainsaw and justify your choice.

Cone clutches offer a smooth engagement, wear well and are very durable. They are able to transmit relatively high torques for its overall size. Like diaphragm clutches, cone clutches need a manual input to move the driver shaft.

Centrifugal clutches are automatic, relatively simple and inexpensive in construction. The activation of this clutch can vary depending on rpm and they can be prone to overheating if continually started and stopped.

Diaphragm clutches are suitable for very high speeds, easily engaged, are compact with fewer parts required than with other clutches.

Centrifugal would be the most suitable clutch for the chainsaw. It is automatic and would simply use the rpm from the engine. [5]

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|---|---|
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Quality of written communication [4]

**(g)** With the use of an annotated sketch draw a ball and socket joint. Explain how the ball and socket joint enables the guard to remain in a set position.

Sketch of ball and annotation.
Sketch of socket and annotation.
Explanation – The interference fit between the ball and socket ensures that the ball sits in place to hold the guard in the set location. [3]

**(h)** ● A means of enabling the operator to quickly adjust the angle at X. When a handle which is fixed to leg A is rotated by the operator, leg B will move in or out in order to set a comfortable height to work from.

Sample solution



Leg
A

Leg
B

X
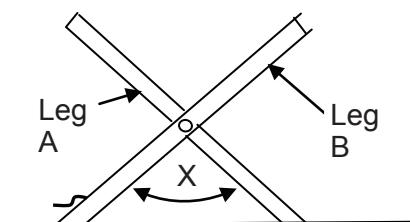
Clearly annotated and appropriate drawing of a worm and meshing housing.
The worm would be secured in a housing, free to rotate at one end towards the bottom of leg A. On leg B a meshing worm housing which pivots (allowing swivel to take account of the angular rotation) is attached. The worm goes the whole way through this housing and has a handle fixed to the end allowing for user adjustment. [5]

● A means of enabling the log to be clamped and secured in position for cutting. When the operator presses down on the foot pedal this will make the rubber pads squeeze in to clamp the log.

Clearly annotated and appropriate drawing of a cantilever braking system including fixed points, lower and upper linkage arm, pivot pulling points and the use of a cable which is operated by pressing down on the foot pedal. [5]  [10]

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**4** **(a)** Components which are the input, control and output for the circuit.

Input – Lever set reset 3PV
Control – Roller trip 3PVs and 5PV
Output – DAC [3]

**(b)** **(i)** Identify each of the two mistakes and explain what corrective measures need to be taken in order for the circuit to function.

No. 1 – Valve A is not piped up correctly. It supplies air to Valve B without being pressed. Port 3 in valve A needs to be disconnected and connected to port 2.
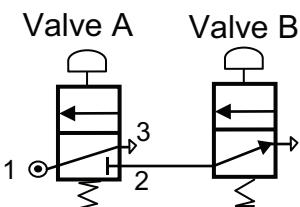


No. 2 – Flow control not providing restriction on the air bleed and 3PV permanently on. Turn the flow control around the other way and adjust accordingly.
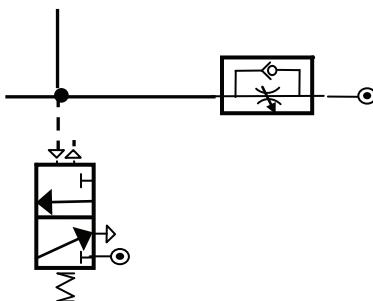


[4]

**(ii)** Calculate the work done by the hopper cylinder if the force required to open the hopper is 1852 N and the distance moved by the force is 400 mm.

**W = F × L        1852 N × 0.4 = 740.8 J** [2]

**(iii)** By selecting **(d) 18 mm (D) 32 mm at 3 bar**
Difference = $3 \times 3.14 \times 9^2$ = 763 N [4]

**(c)** See pro forma sample answer

Method of activating start 3 PV [1]
Emergency stops [2]
Method of activating cylinder A1A2+ [1]
Method of activating cylinder B+ [1]
Method of activating cylinder C+ [1]

Method of activating cylinder C– [1]
Method of activating cylinder B– [1]
Method of activating cylinder A1A2– [1]
Method of activating cylinder D+ slowly [2]
Time delay [1]

Method of activating cylinder D– [1]
Group changeover valves [4]

**(d)** ● A pneumatic system which will enable cylinder D to outstroke either from the sequence (signal from C+) or after inspection when the buckle is replaced and detected in its original position and the foot operated valve is pressed.
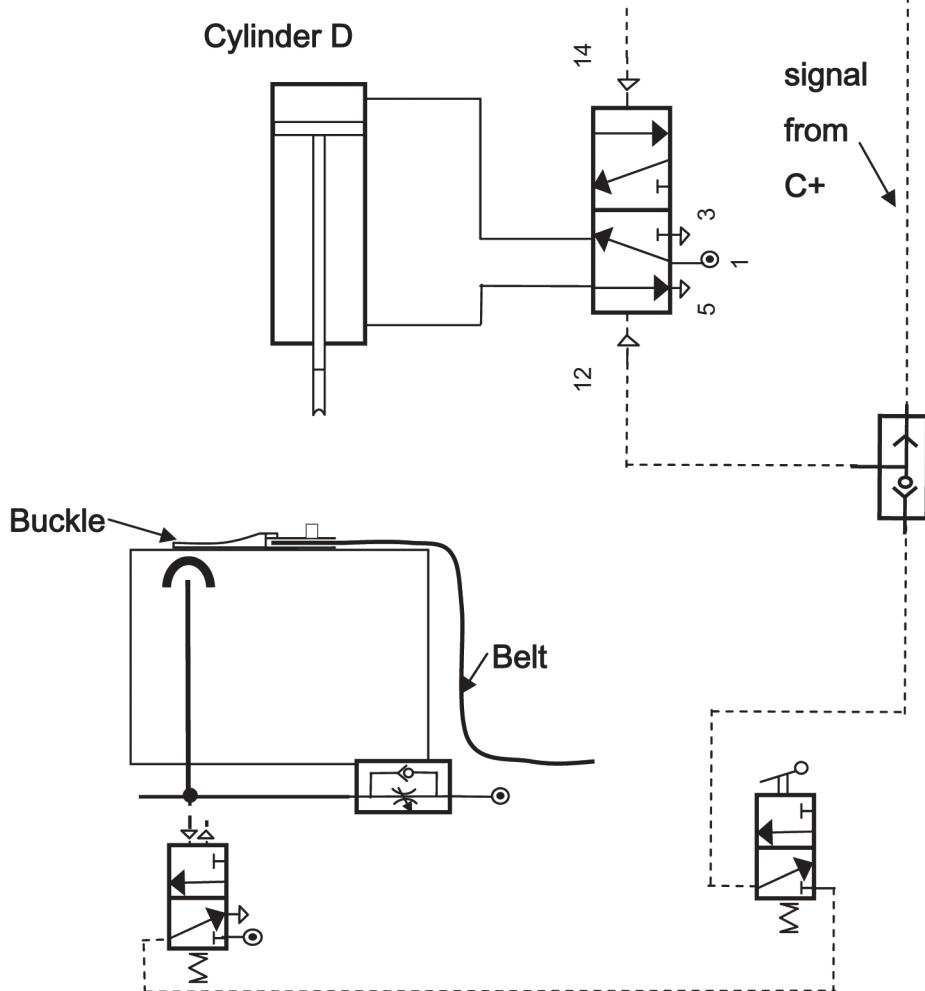


[5]

● A pneumatic system which controls the speed of cylinder D and automatically returns the cylinder to the instroke position after a time delay.



[5]
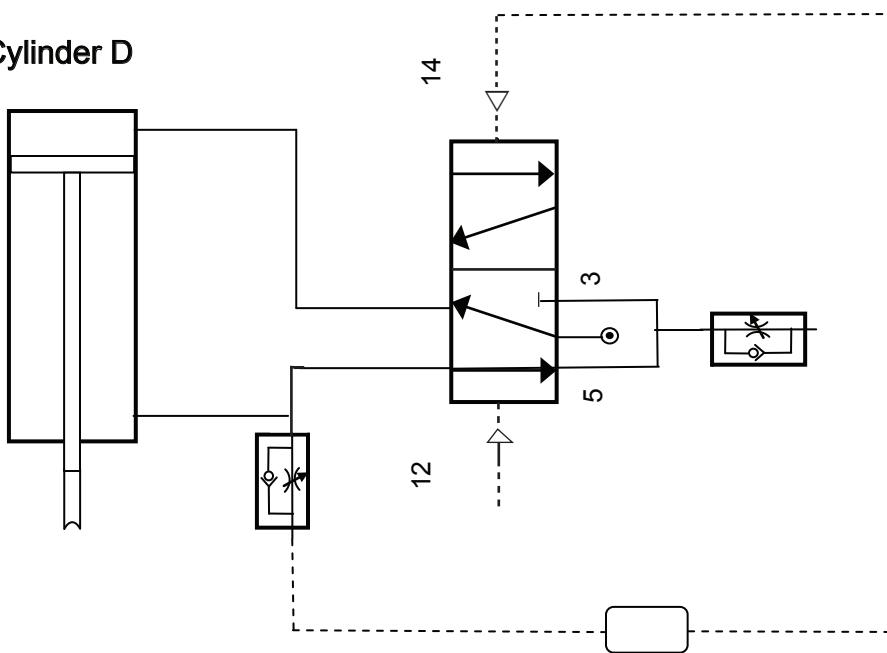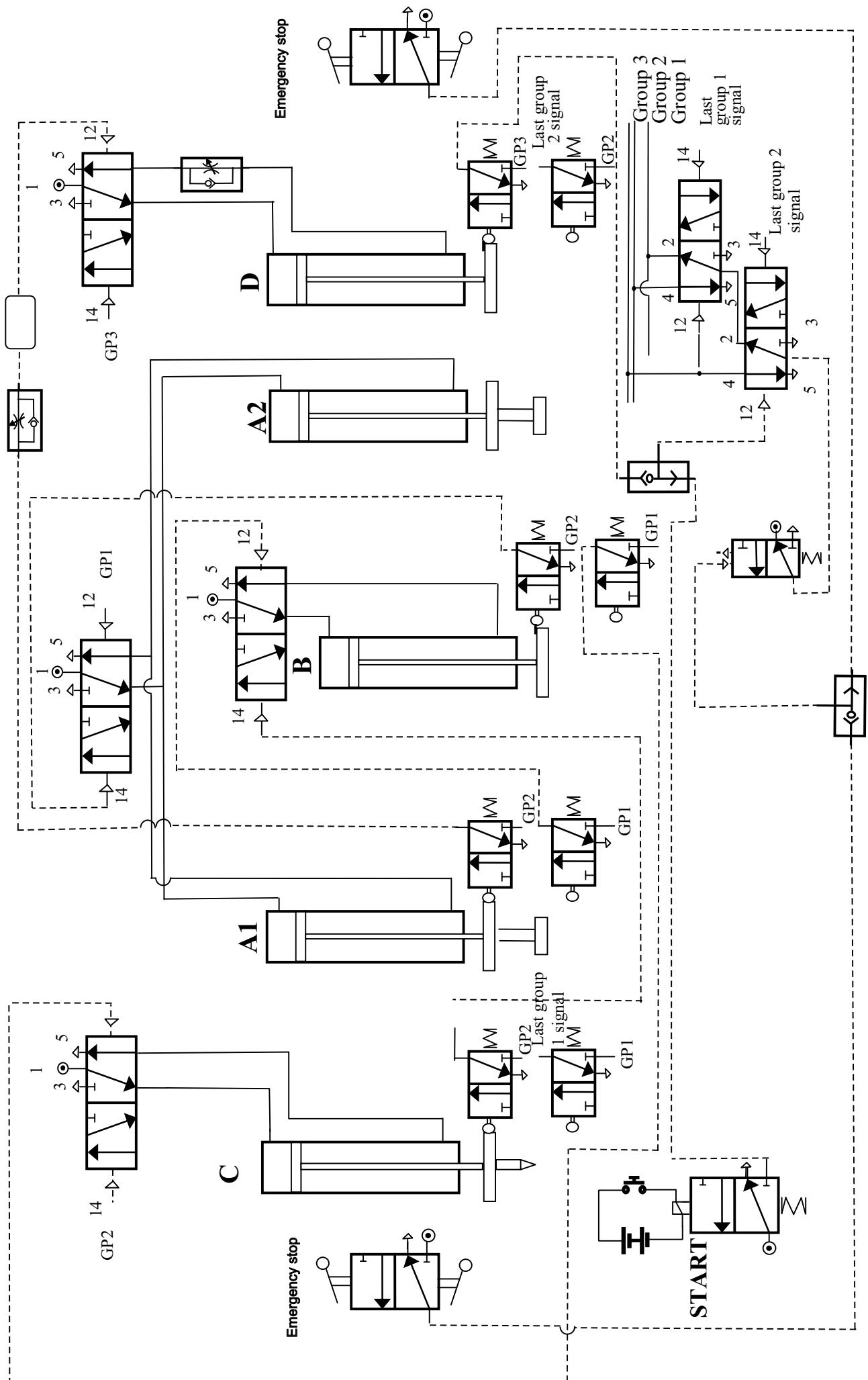
Pro forma Sample Answer number to 4 (c)

Emergency stop

Last group 2 signal

Group 3
Group 2
Group 1

Last group 1 signal

Last group 2 signal

GP3

GP2

GP1

A2

A1

B

C

D

Last group 1 signal

Last group 2 signal

GP1

GP2

START

Emergency stop