Curriculum Council
Government of **Western Australia**

WACE Examination, Sample 2008

ENGINEERING STUDIES

Section 2, Systems and Control

Stage 2

Provisional Marking Guidelines

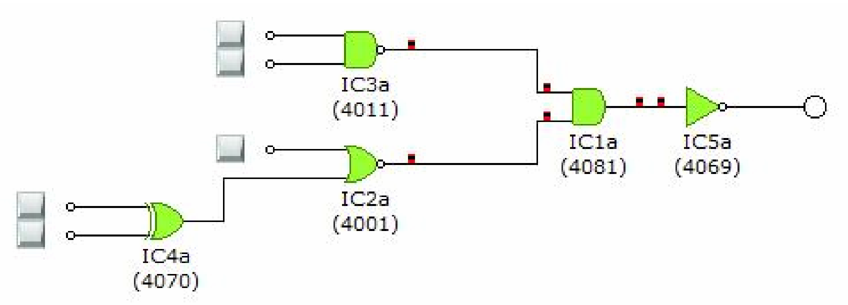
File No: 2008/17462

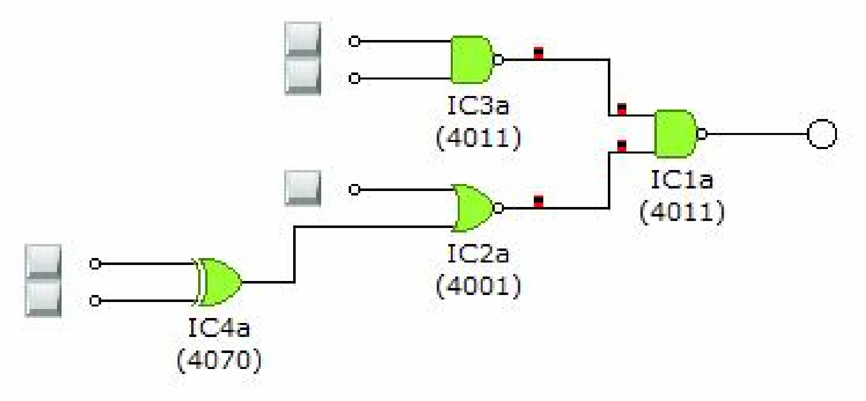
Section 2: Systems & Control

Part A: Multiple Choice Questions (Stage 2 and Stage 3)

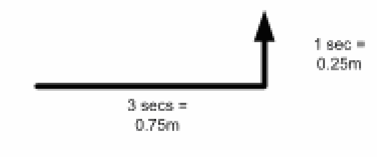
Section 2 — Systems and control			
1	B	Branch in the flow of computation operation	**1**
2	C	Analogue to Digital Converter	**1**
3	D	Adjusts the inputs to a device depending on its outputs	**1**
4	C	A set of instructions that are repeatedly executed a set number of times	**1**
5	D	Allows a computer to open and close a control valve	**1**
6	B	A potentiometer	**1**
7	B	LDR	**1**
8	D	Analogue	**1**
9	A	Limit the current through a circuit	**1**
10	C	Closed loop	**1**

Part B: Written (Stage 2 only)

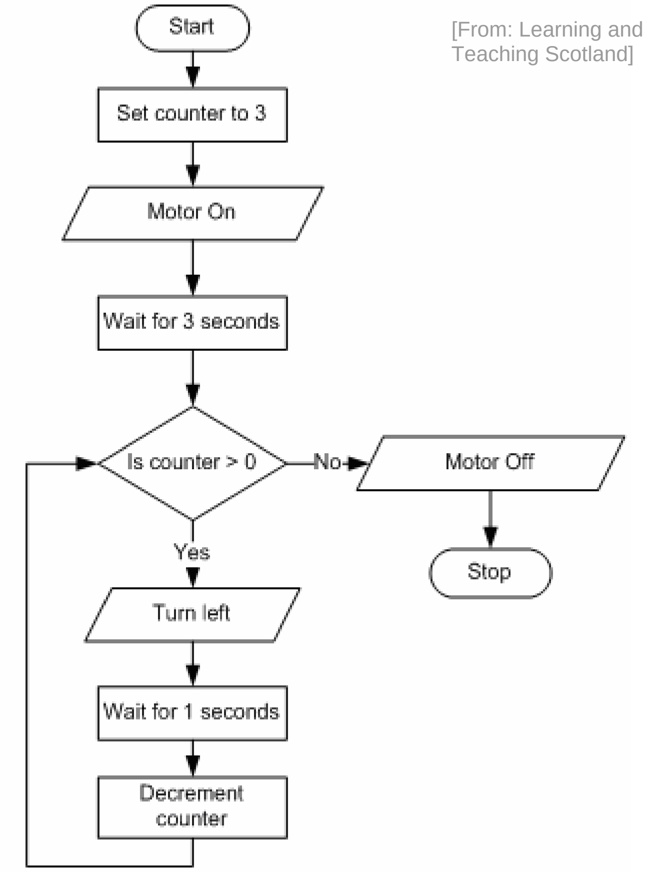
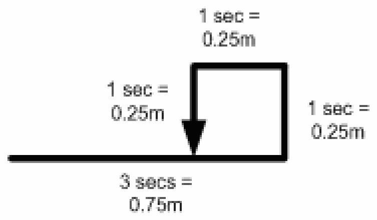
	Section 2 — Systems and control	
1a	G1 is an NAND gate G2 is a NOR gate:. G3 is an AND gate:. G4 is a XOR gate: *For each gate: 1 mark for correct type* *[4 lines]*	**[4 marks]**
1b	A Truth table is a table of logic values (H/L or 0/1 or T/F) that describes all the possible combinations of input values to a logic circuit and the corresponding values of each output to the circuit. A Truth table can be used to assist with the design of a required logic operation in a digital circuit. *2 marks for description, 2 marks for sample use*. *[6 lines]*	**[4 marks]**
1c	The value of Z would be defined for any combination of A, B, C, D and E. All combinations of inputs are included in the table *2 marks for value of Z for given input values of A, B, C, D and E* *2 marks if all combinations of inputs are mentioned.* *[4 lines]*	**[4 marks}**
1d	Option 1: add a NOT gate  IC3a (4011) IC1a (4081) IC5a (4069) IC2a (4001) IC4a (4070) Option 2: change AND to NAND	

<table>
<tr><td></td><td>

<i>3 marks for each solution, deduct up to 2 marks if drawing is untidy.</i>
<i>[1/4 page]</i></td><td><b>[6 marks]</b></td></tr>
<tr><td><b>1e</b></td><td>A | B | C | (A &amp; B) v ~C
---+---+---+--------------
0) T | T | T | T
1) T | T | F | T
2) T | F | T | F
3) T | F | F | T
4) F | T | T | F
5) F | T | F | T
6) F | F | T | F
7) F | F | F | T
<i>8 marks if fully correct, deduct 1 mark for each error, min is zero.</i>
<i>[10 lines]</i></td><td><b>[8 marks]</b></td></tr>
<tr><td><b>1f</b></td><td>Some advantages would be:
More reliable
Less effort to assemble
Smaller space required
<i>[2 marks each to a maximum of 4 marks]</i>
<i>[3 lines]</i></td><td><b>[4 marks]</b></td></tr>
</table>

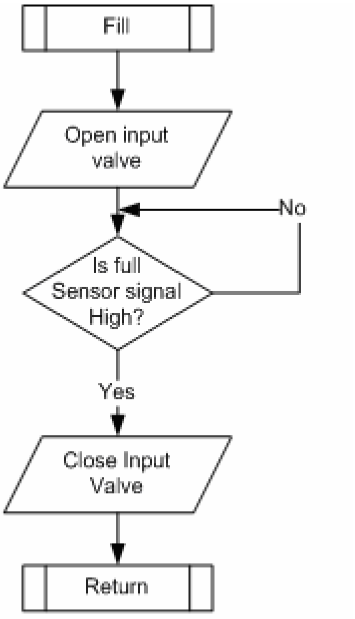
<table>
<tr><th colspan="3">Section 2 — Systems and control</th></tr>
<tr><td><b>2a</b></td><td>

<i>1 mark for shape, 1 mark for labels (time or distance)</i>
<i>[1/4 page]</i></td><td><b>[2 marks]</b></td></tr>
</table>

2b	 Start Set counter to 3 Motor On Wait for 3 seconds Is counter > 0 No Motor Off Stop Yes Turn left Wait for 1 seconds Decrement counter [From: Learning and Teaching Scotland] Loop should only include turn left and wait 1sec commands, must include a counter increment – could count up or down. *1 mark for counter initialization, 5 marks for correct loop, 2 marks for decrement/increment counter inside loop, 2 marks for neat/clear diagram.* *[1 page]*	**[10 marks]**
2c	 1 sec = 0.25m 1 sec = 0.25m 1 sec = 0.25m 3 secs = 0.75m *2 marks for shape, 2 mark for labels (time or distance)* *[1/4 page]*	**[4 marks]**
2d	Initial move is 3 secs (= 0.75 m) 5 moves of 1 sec (= 0.25m) = 5secs (1.25m) Total time is 8 secs (2.0 m) *1 mark for initial move, 2 marks for 5 moves, 1 mark for total.*	**[4 marks]**
2e	Final direction is West	

	All or no marks *[5 lines]*	**[4 marks]**
2f	Wheels might slip on surface so actual distance will be less than computed distance. Buggy's speed may not be uniform - need to allow for acceleration and de-acceleration when staring and stopping *3 marks for each reasonable problem* *[5 lines]*	**[6 marks]**

Section 2 — Systems and control		
3a	GND – to connect to 0 volt Vcc – to connection to 5V power supply for the chip *1 mark each* *[2 lines]*	**[2 marks]**
3b	A subroutine is a separate set of instructions that that be executed by referring to its name. After the execution is complete the execution thread continues with the next instruction in the main program after the subroutine call. Subroutines are useful in this application as the Fill, Mix and Empty operations contain sets of instructions that that are to be executed many times. They also make the main program easier to understand and test. The subroutines may also be tested individually if required. *2 marks if a separate set of instructions are identified* *2 marks if the execution thread is mentioned.* *2 marks for each of the two uses for subroutines* *[12 lines]*	**[8 marks]**

3c	 Fill Open input valve No Is full Sensor signal High? Yes Close Input Valve Return [Adapted from: Scottish Qualifications Authority] *Correct logic – 4 marks* *Correct symbols – 2 marks* *Neat diagram – 2 marks* *[1/2 page]*	**[8 marks]**
3d	A Wait 10 secs B Motor forward off C Wait 8 secs D Motor backward off E Decrement count F Is count > 0 *2 marks for each correct label, 1 mark if partially correct*. *[6 lines]*	**[12 marks]**

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ENGINEERING STUDIES

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Stage 3

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Section 2: Systems & Control

Part A: Multiple Choice Questions (Stage 2 and Stage 3)

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1	B	Branch in the flow of computation operation	**1**
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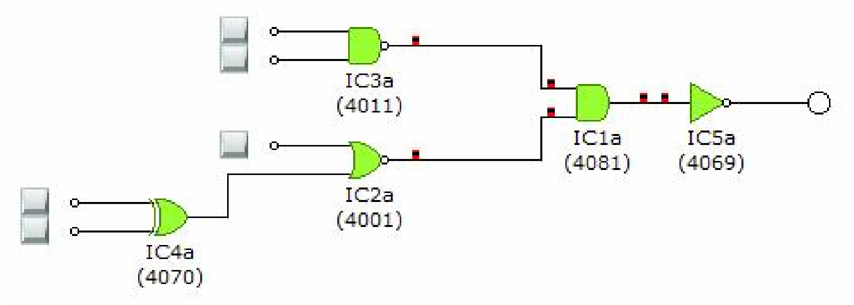
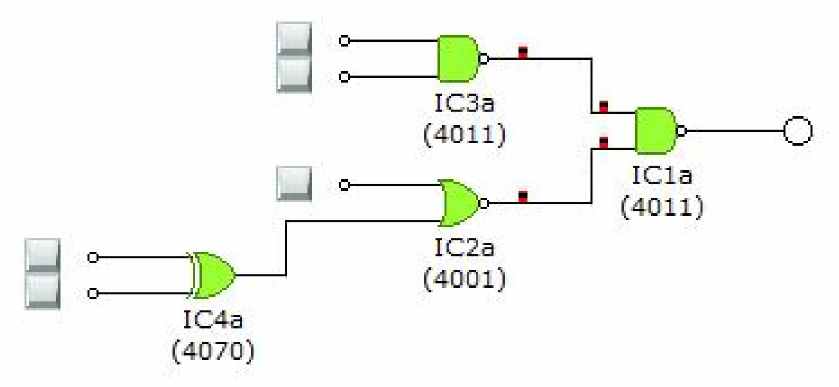
7	B	LDR	**1**
8	D	Analogue	**1**
9	A	Limit the current through a circuit	**1**
10	C	Closed loop	**1**

Part B: Written (Stage 3 only)

<table>
<tr><th colspan="3">Section 2 — Systems and control</th></tr>
<tr><td><b>1a</b></td><td>G1 is an NAND gate: the output is low when both inputs are high, otherwise the output is high.
G2 is a NOR gate: the output is high when both inputs are low, otherwise low.
G3 is an AND gate: the output is high only when both inputs are high, otherwise low.
<i>For each gate 1 mark for name, 1 mark for description of operation</i>
<i>[8 lines]</i></td><td><b>[6marks]</b></td></tr>
<tr><td><b>1b</b></td><td>A Truth table describes the output of a logic circuit for all possible inputs.
It contains one column for each input signal and plus one column for each output.
There are as many rows as there are combinations of inputs
It can be used to assist in the design of the required logic operation in a digital circuit or program.
<i>1 mark for each comment</i>
<i>[8 lines]</i></td><td><b>[4 marks]</b></td></tr>
<tr><td><b>1c</b></td><td>A | B | C | D | ~(A & B) & ~(C v D)
---+---+---+---+--------------------
0) T | T | T | T | F
1) T | T | T | F | F
2) T | T | F | T | F
3) T | T | F | F | F
4) T | F | T | T | F
5) T | F | T | F | F
6) T | F | F | T | F
7) T | F | F | F | T
8) F | T | T | T | F
9) F | T | T | F | F
10) F | T | F | T | F
11) F | T | F | F | T
12) F | F | T | T | F
13) F | F | T | F | F
14) F | F | F | T | F
15) F | F | F | F | T
<i>8 marks if fully correct, deduct 1 mark for each error, min is zero</i>
<i>[20 lines]</i></td><td><b>[8 marks]</b></td></tr>
</table>

1d	Alternative 1: add a NOT gate  IC3a (4011) IC1a (4081) IC5a (4069) IC2a (4001) IC4a (4070) Alternative 2: change AND to NAND  *2 marks for each solution. There may be other reasonable solutions* *[2/3 page]*	**[4 marks]**
1e	Various options, for example: Use a DC volt meter set to a 0-5V range, with ground connected to 0V rail. Use a logic probe with ground connected to 0V rail. Then using jumper leads patch the inputs A, B, C and D to 5V and 0v rails to cover all combinations of inputs. Record output level (at Z) using the measuring device for each case. *1 marks for device, 1 marks for connection, 2 marks for connecting inputs to 0 or 5V* *[6 lines]*	**[4 marks]**
1f (i)	For each device: 4 inputs and 1 output , i.e. 5 pins x 2 plus Vcc (power supply)and Gnd (Ground) therefore 12 pins *1 mark for number, 1 mark for correct descriptions* *[3 lines]*	**[2 marks]**
1f (ii)	Some advantages would be: More reliable Less effort to assemble Smaller space required *1 mark each to a maximum of 2 marks* *[3 lines]*	**[2 marks]**

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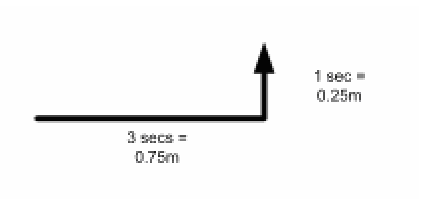


1 mark for shape, 1 mark for labels (time or distance)

[1/4 page]

</td><td><b>[2 marks]</b></td></tr>
<tr><td><b>2b</b></td><td>

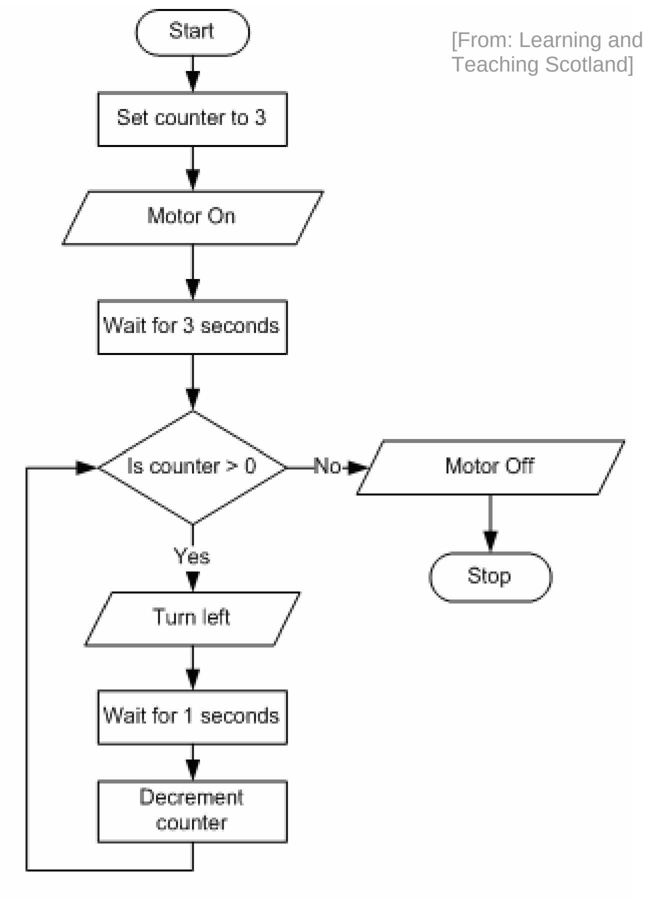
Total time = 4 secs

Total distance = time * speed = 4 * 0.25 = 1.0m

1 mark for correct expression, 1 mark for answer

[3 lines]

</td><td><b>[2 marks]</b></td></tr>
<tr><td><b>2c</b></td><td>



[From: Learning and Teaching Scotland]

Loop should only include turn left and wait 1sec commands, must include a counter increment – could count up or down.

1 mark for counter initialization, 2 marks for correct loop, 1 mark for decrement/increment counter inside loop, 2 marks for neat/clear diagram..

[1 page]

</td><td><b>[6 marks]</b></td></tr>
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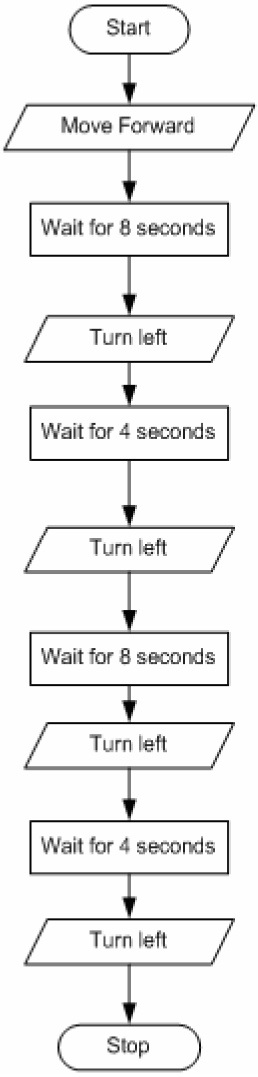
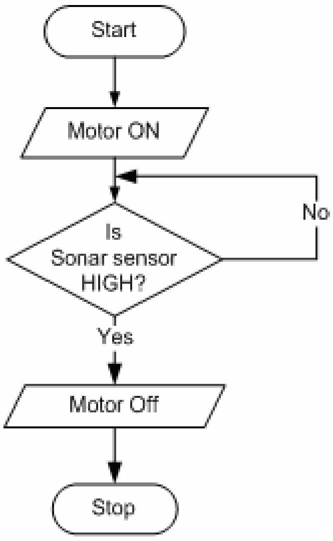
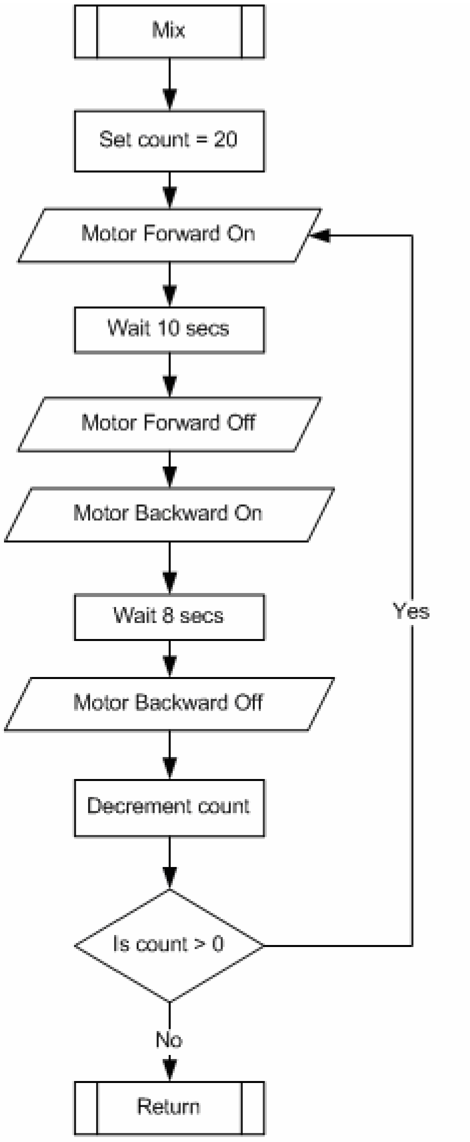
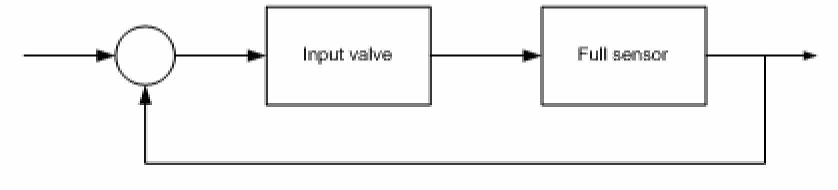
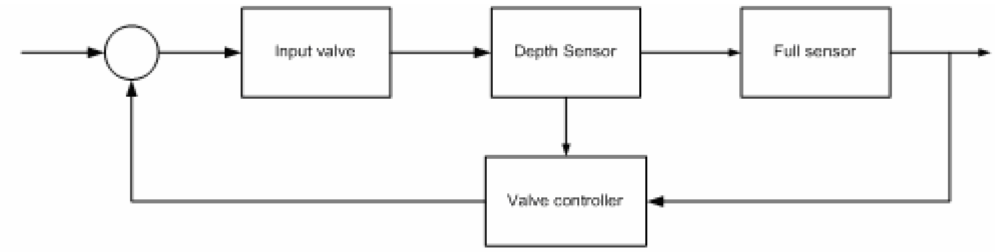
2d	 Start Move Forward Wait for 8 seconds Turn left Wait for 4 seconds Turn left Wait for 8 seconds Turn left Wait for 4 seconds Turn left Stop [From: Learning and Teaching Scotland] *Correct calculation of two travel times from given distances (1 mark each = 2 marks)* *4 turn left commands (2 marks)* *2 wait 4 secs commands (1 mark)* *2 wait 8 secs commands (1 mark)* *Correct sequence (3 marks)* [1 page]	**[9 marks]**
2e	Various solutions are possible: The student should identify the problem and explain what it is and suggest a reasonable strategy/design change to avoid it. Example 1: The speed of movement may not be constant as it will take time to accelerate the buggy to full speed as well as to stop it from full speed. We could use a stepper motor to drive the wheels so that we know how far the wheels will rotate at each output pulse to the motors. Example 2: The speed of movement may not be constant as it will take time to accelerate the buggy to full speed as well as to stop it from full speed. Could a measurement wheel trailing behind the buggy that would give a pulsed signal	

	as it rotated. These signals could be counted by the micro controller to compute the distance travelled. *Identify the problem – 2 marks* *Provide a viable solution - 3 marks.* *[8 lines]*	**[5 marks]**
2f	There are various possibilities, like this:  Start Motor ON No Is Sonar sensor HIGH? Yes Motor Off Stop [From: Learning and Teaching Scotland] 1 mark for motor on, 1 mark for motor off, 1 marks for correct loop, 1 mark for correct conditional, 2 mark for neat diagram. [1/2 page]	**[6 marks]**

Section 2 — Systems and control		
3a	GND – to connect to 0 volt Vcc – to connection to 5V power supply for the chip 1 mark each [2 lines]	**[2 marks]**
3b (i)	When a subroutine call is reached the path of execution is switched to the subroutine. [2 lines]	**[1 mark]**
3b (ii)	When a subroutine completes the execution returns to the instruction immediately following the subroutine call. [2 lines]	**[1 mark]**
3b (iii)	By using a return (or equivalent) statement. [2 lines]	**[1 mark]**
3b (iv)	When the same set of instructions need to be executed several times from different parts of the program. 1 mark for mentioning same set of instructions, 1 mark for several uses.	**[2 marks]**

	[3 lines]	
3b (v)	Any one of, or similar: Subroutine can be tested in isolation Same code can be reused Can reduce the complexity of a program by braking it down into modules [2 lines]	**[1 mark]**
3c	 Mix Set count = 20 Motor Forward On Wait 10 secs Motor Forward Off Motor Backward On Wait 8 secs Motor Backward Off Decrement count Is count > 0 Yes No Return [Adapted from: Scottish Qualifications Authority] *Correct logic – 8 marks (correct sequence 3 marks, correct use of counter 2 marks, count increment or decrement 1 mark, remembered to turn motors off 2 marks)* *Correct symbols – 1 marks* *Neat diagram – 1 marks* *[1 page]*	**[10 marks]**

3d	(i)  *Must show two blocks, and feedback (2 marks)* *[1/4 page]* (ii) Control loop is CLOSED, and strategy is ON/OFF. *(2 marks)* *[2 lines]*	**[4 marks]**
3e	(i) Mixture level in tank – need depth gauge *(1 mark)* *[2 lines]* (ii) The difference between the full height (where the full sensor is positioned) and the measured depth can be used to set the open/close value of the valve so that as this difference gets smaller the valve starts to close off, being fully closed when the full sensor trips. *(3 marks if strategy seems reasonable, partial marks possible)* *[4 lines]* (iii) Diagram should include the depth sensor (or whatever used), and a block for the controller that will use both the depth and full sensor signals to control the valve.  Input valve Depth Sensor Full sensor Valve controller 1 mark for each new block, 2 marks for reasonable connections. [1/3 page]	**[4 marks]** **[4 marks]**