Higher
Coursework
Assessment Task

Higher Engineering Science
Assignment
Finalised Marking instructions

These marking instructions have been prepared by examination teams for use by SQA appointed markers when marking external course assessments.

General marking principles

This information is provided to help you understand the general principles that must be applied when marking candidate responses in this assignment. These principles must be read in conjunction with the detailed/specific marking instructions, which identify the key features required in candidate responses.

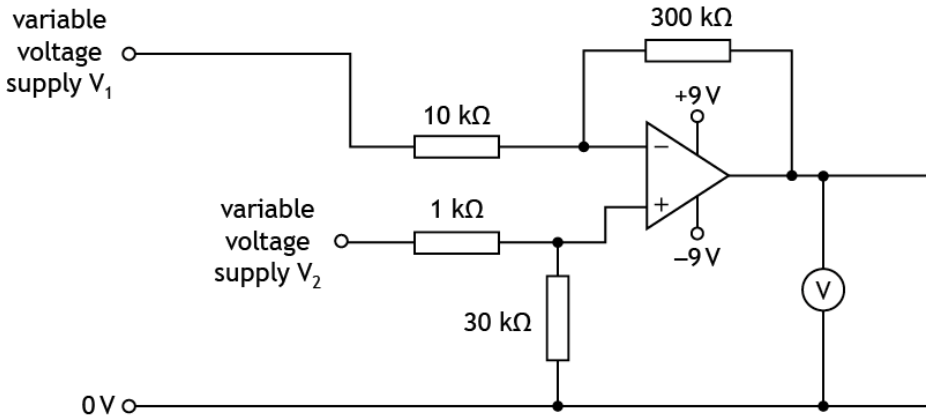
a Marks for each candidate response must always be assigned in line with these general marking principles and the specific marking instructions for this assessment.

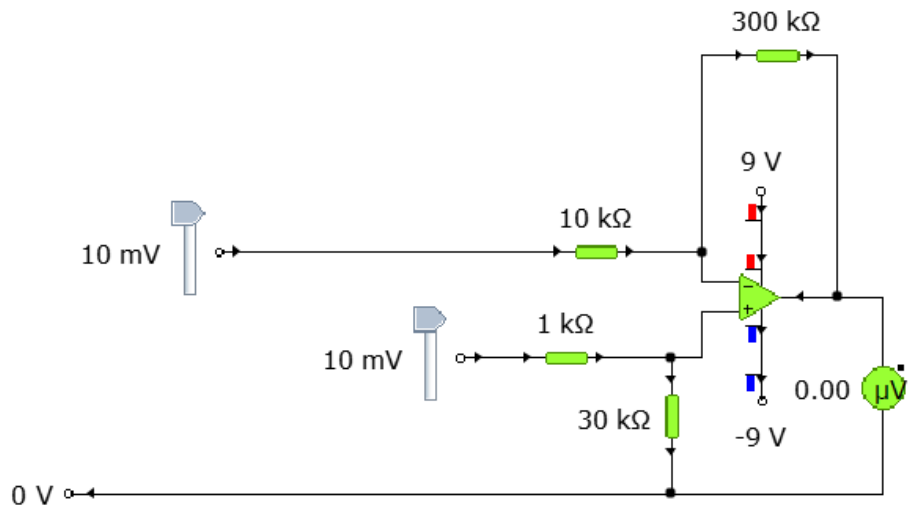
b Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

c If a specific candidate response is not covered by either the general marking principles or detailed marking instructions, you must seek guidance from your team leader.

Detailed marking instructions

Task			Expected answer(s)	Max mark	Additional guidance
1	a		The system must: **Input:** 1. Detect the wind direction 2. Sense the turbine head position 3. Send both signals to the control unit **Process:** 4. Use proportional control 5. Make use of negative feedback 6. Use closed loop control 7. Compare turbine head position with the wind direction 8. Use a driver to amplify the signal to the motor **Output:** 9. Start to move the motor/ turbine head quickly 10. Slow the motor as the turbine head position gets closer to the desired position 11. Turn the motor to rotate the turbine head 12. Stop the motor when the turbine head is in the correct position 13. Use a driver to spin the motor in both directions	6	1 mark for each correct point (max 6 points).

Task			Expected answer(s)	Max mark	Additional guidance
1	b			3	1 mark – op-amp in difference configuration with V1 connected to inverting input and V_2 connected to non-inverting input. 1 mark – R_f and R_i resistors correctly connected, with appropriate resistor values giving gain of 30. 1 mark – + 9 V and -9 V op-amp supplies (terminals not required).

Task			Expected answer(s)	Max mark	Additional guidance
1	c			2	FTE applied for correct simulation from design in Q1(b). 1 mark – input and output (variable supplies and voltmeter). 1 mark – op-amp (with resistor values and supply voltages from Q1(b)). Second mark not available if comparator configuration is used due to simplification of simulation.

<table>
<tr><th colspan="3">Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr>
<td>1</td><td>d</td><td></td>
<td>
<table>
<tr><th>Planned test</th><th>Expected result</th><th>Actual result</th><th>Amendments made</th></tr>
<tr><td>Set both V_1 and V_2 to 5 mV.</td><td>The output voltage is 0 V.</td><td>The output voltage is 0 V.</td><td>None required.</td></tr>
<tr><td>Set V_1 to 10 mV and set V_2 to 0 mV.</td><td>The output voltage should be + 300 mV.</td><td>The output voltage is -300 mV.</td><td>Alter the circuit by adding a further op-amp in an inverting configuration after the first op-amp.

OR

Swapping the inputs to the op-amp so that V_1 is connected to the non-inverting input and V_2 is connected to the inverting input.</td></tr>
<tr><td>Set V_1 to 4 mV and set V_2 to 6 mV.</td><td>The output voltage should be - 60 mV.</td><td>The output voltage is - 60 mV.</td><td>None required.</td></tr>
</table>
</td>
<td>4</td>
<td>Marked based on the circuit provided in 1(c).

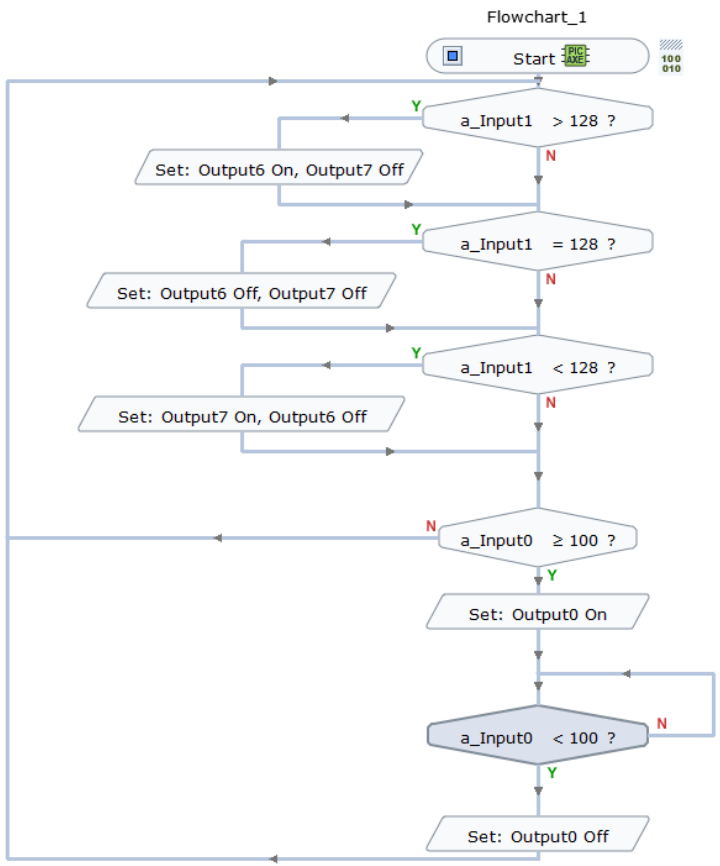
1 mark – correct actual result.

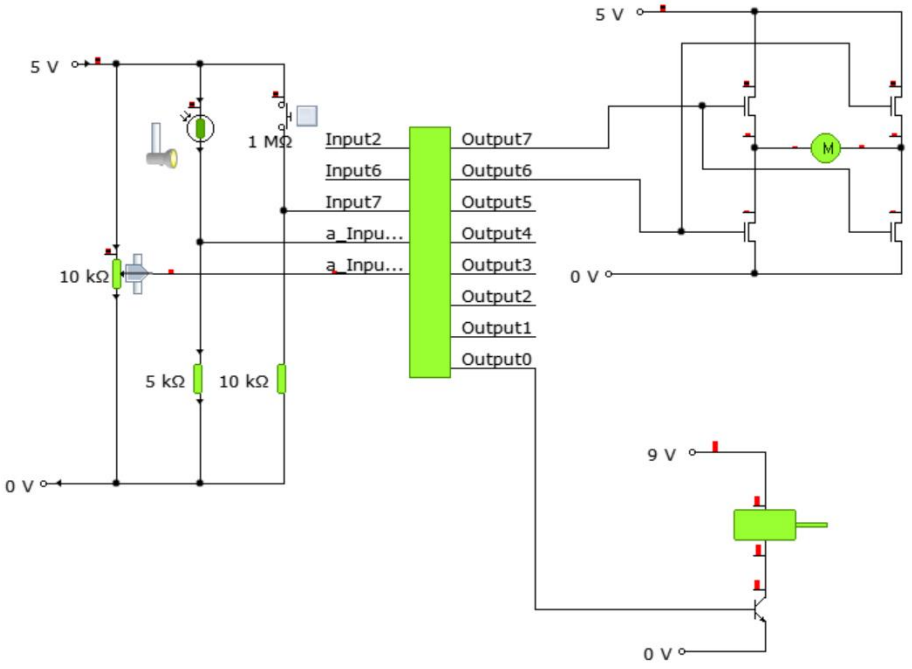
1 mark – correct actual result.

1 mark – correct amendment.

1 mark – correct actual result based on test 2 amendments.</td>
</tr>
</table>

Task			Expected answer(s)	Max mark	Additional guidance
1	e		iv – the op-amp initially had a gain of 30, achieved by the ratio of R_f and R_i values, 30:1. The circuit works as specified, and this specification is fully met. v – the op-amp has both a positive and negative supply voltage which allows for a positive or negative output voltage. As the circuit can produce both 300 mV and 60 mV output voltages, this specification point is met. Overall, the system performs well to meet the specification after amendments – the voltage changes polarity correctly as V_1 and V_2 are altered, the gain is correct, and the voltage magnitude increases and decreases as required. However, the system could be improved with an emergency braking system/ override switch to prevent any damage to parts. The system could be improved by adding warning lights/ buzzer when the turbine head is in motion.	4	1 mark – identification of how specification iv is met. 1 mark – describing how specification v is met. 1 mark – evaluative comments on overall effectiveness. 1 mark - practical suggestion for improvement.

Task			Expected answer(s)	Max mark	Additional guidance
2	a			4	1 mark – must match flowchart as given in task.

Task			Expected answer(s)	Max mark	Additional guidance
2	a				1 mark – digital input (switch with 10 kΩ resistor in series) and 5 V supply. 1 mark – two analogue inputs (10 kΩ potentiometer to analogue input 1, LDR and 5 kΩ resistor in series, to analogue input 0). 1 mark – output motor circuit with 5 V supply and solenoid circuit with 9 V supply.

<table>
<tr><th colspan="3">Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr>
<td>2</td><td>b</td><td></td>
<td>
<table>
<tr><th>Planned test</th><th>Expected result</th><th>Actual result</th><th>Amendments made</th></tr>
<tr><td>Activate the flowchart. Press the ‘master’ switch.</td><td>The robot program will run.</td><td>The robot program does run, but there is no ‘master’ switch decision to start it.</td><td>Decision box inserted to test input 7 (‘master’ switch) operation after start terminus.</td></tr>
<tr><td>Alter analogue input 1 maximum value, then activate the flowchart. Press the ‘master’ switch.</td><td>Output 7 switches on and the motor turns.</td><td>Output 6 switches on and the motor turns.</td><td>The outputs are inverted
ie ‘output 6 on, output 7 off’ to ‘output 6 off, output 7 on’ and therefore ‘output 6 off, output 7 on’ to ‘output 6 on, output 7 off’.

OR

The inequalities are inverted
ie ‘>’ to ‘<’ and therefore ‘<’ to ‘>’.</td></tr>
</table>
</td>
<td>7</td>
<td>Marks based on circuit given in the question.

1 mark – correct actual result with descriptive reference to the ‘master’ switch.

1 mark – correct amendment with location of decision.

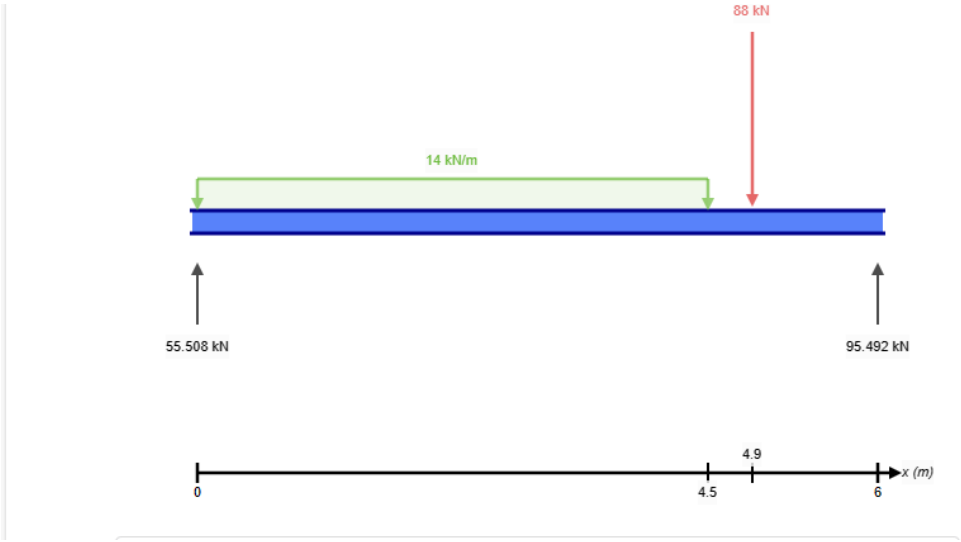
1 mark – correct actual result.

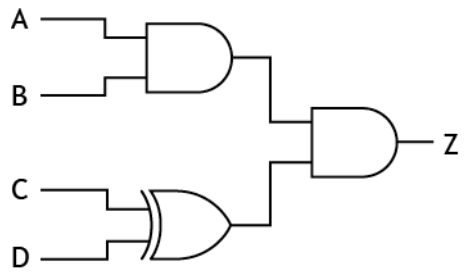
1 mark – correct first amendment.

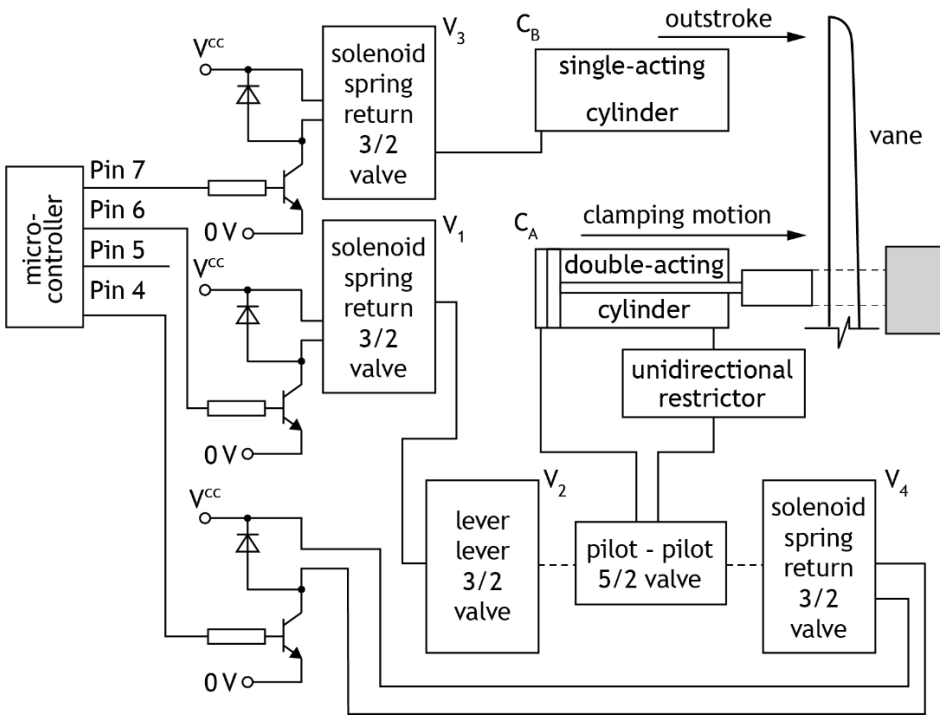
1 mark – correct second amendment.</td>
</tr>
</table>

Task			Expected answer(s)				Max mark	Additional guidance
2	b		Alter analogue input 0 LDR to the maximum light level, then activate the flowchart. Press the 'master' switch. Repeat this test.	The solenoid will energise and actuate each time.	The solenoid energises once and the transistor fails/ explodes. This was not repeatable.	An 18 kΩ base resistor is added to the transistor, and a diode in parallel with solenoid.		1 mark – correct actual result must refer to transistor, solenoid and repeatability. 1 mark – correct amendment with base resistor value 18 kΩ (or greater) and diode. Note: 1. MOSFET can replace transistor along with diode parallel to solenoid. 2. Collector resistor (value minimum 150 Ω) can be used to prevent failure of transistor. 3. Alternative simulation software may require different base resistor values (greater than 7.6 kΩ) and fly away diode parallel to solenoid.

Task			Expected answer(s)	Max mark	Additional guidance
2	c		**Specification point i.** The robot operated without pressing the 'master' switch. There was an error in the flowchart program, which was corrected by adding a decision box to confirm input 7 is on. The robot now works as specified, and specification i is now fully met. **Specification point ii.** The input control did enable the motor to switch on and off at the correct levels, but rotated in the wrong direction. This was corrected by changing outputs 6 to 'off' and output 7 to 'on' when analogue input 1's value is greater than 128. After this change, specification ii is fully met. However, to ensure the flowchart works fully, output 6 was changed to 'on' and output 7 changed to 'off' when analogue input 1's value was less than 128. **Specification point iii.** The solenoid did not operate as specified as the transistor was damaged as it turns on. This was corrected by adding a base resistor to prevent a large current flowing to the base of the transistor. Specification iv is now fully met.	4	1 mark – evaluative statement including the identification of the error and correction. 1 mark – evaluative statement including the identification of the error and correction. 1 mark – consequential amendment. 1 mark – evaluative statement including the identification of the error and correction.

Task			Expected answer(s)	Max mark	Additional guidance
3			 **Reactions** Results Verified Support at / X / Y / Mx 0 / 0 kN / 55.508 kN / 0 kN-m 6 / 0 kN / 95.492 kN / 0 kN-m	3	1 mark – simulation which includes UDL, point load and two supports (reaction forces acceptable). 1 mark – correct data entered on simulation. 1 mark – correct reactions at A (55.5 kN) and B (95.5 kN).

Task			Expected answer(s)	Max mark	Additional guidance
4	a			2	1 mark – both AND gates correct with connections. 1 mark – XOR correct with connections.

Task			Expected answer(s)	Max mark	Additional guidance
4	b			8	1 mark – V_3 with correct actuators, plus connection to C_B. 1 mark – single-acting cylinder, showing outstroke direction correctly. 1 mark – V_1 with correct actuators, connected to V_2. 1 mark – V_2 with correct actuators, connected to 5/2 valve. 1 mark – V_4 with correct actuators, connected to pin 4 and 5/2 valve. 1 mark – UDR on C_A outstroke exhaust. 1 mark – correct line types to indicate main air going to both cylinders and pilot air to 5/2 valve. 1 mark – connection of 5/2 valve to double-acting cylinder C_A.

<table>
<tr><th colspan="3">Task</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>4</td><td>c</td><td></td><td>
<table>
<tr><th>Planned test</th><th>Expected result</th></tr>
<tr><td>Set pin 6 high/ actuate V1, and actuate $V_{2.}$</td><td>Cylinder C_A slowly outstrokes.</td></tr>
<tr><td>Send a PWM signal with a mark:space ratio of 1:3 (25%) from pin 7.</td><td>Cylinder C_B instrokes and outstrokes repeatedly with the PWM ratio.</td></tr>
<tr><td>Set pin 4 high/ actuate V_4, and unactuate $V_{2.}$</td><td>Cylinder C_A instrokes.</td></tr>
</table>
</td><td>3</td><td>1 mark – correct test and expected result (no mark if valve or lever are not described as actuated, or speed of outstroke is not specified).

1 mark – correct test and expected result (must indicate correct duty cycle, must relate signal from pin 7/ valve V_3).

1 mark – correct test and expected result (V_2 unactuated must be specified).</td></tr>
</table>

[END OF MARKING INSTRUCTIONS]