



# H

Higher  
Coursework  
Assessment Task



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## 2019 Engineering Science Assignment

### Higher

## Finalised Marking Instructions

Scottish Qualifications Authority 2019

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

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## Marking instructions

Marking instructions are provided for this specimen assessment task. In line with SQA's normal practice, they are addressed to the marker. They will also be helpful for those preparing candidates for course assessment.

Marking instructions will not be provided with annual assessment tasks, as candidate evidence will be submitted to SQA for external marking. They will be provided to markers and then published on the SQA website after marking is complete.

## 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.

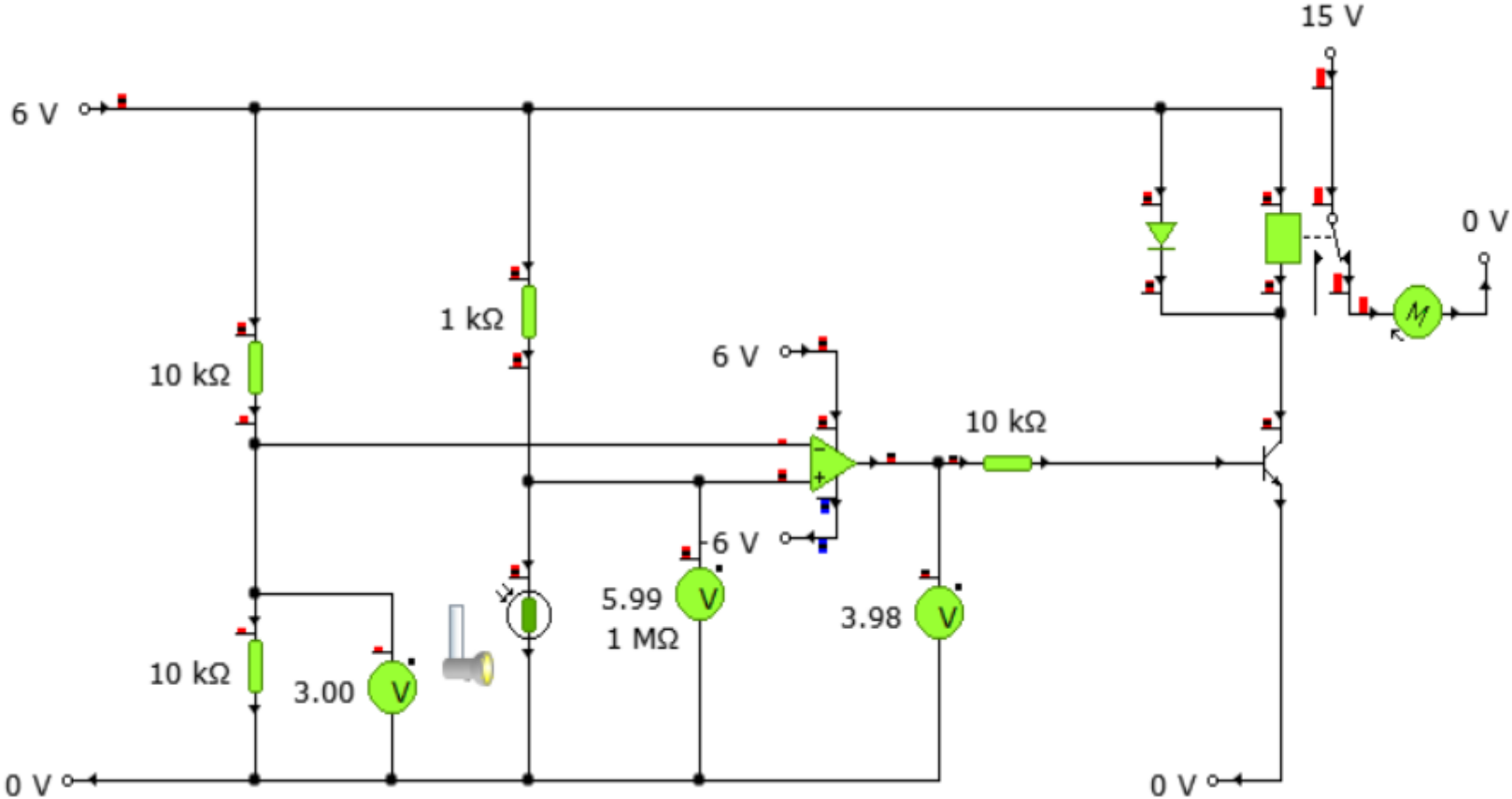
Task 1 – flavoured ice drinks machine

Task		Expected answer(s)	Max mark	Additional guidance
1.	(a)		3	<p>1 mark - for NOT A and OR B.</p> <p>1 mark - for exclusive OR.</p> <p>1 mark - for AND.</p> <p>No marks for a simulated answer.</p>
	(b)		2	<p>1 mark - All gates in correct sequence and position.</p> <p>1 mark - Inputs and connections to allow testing.</p> <p>Output indicator not required.</p> <p>Allow simplification.</p>

Task		Expected answer(s)						Max mark	Additional guidance
(c)		A	B	C	D	Expected Results	Actual Results	1	<p>Correct results in Actual Results column. Allow follow through error (FTE) from circuit in 1b.</p> <p>If no inputs are shown in 1b, no marks should be awarded.</p>
		0	0	0	0	0	1		
		0	0	0	1	1	1		
		0	0	1	0	1	1		
		0	0	1	1	0	1		
		0	1	0	0	0	1		
		0	1	0	1	1	1		
		0	1	1	0	1	1		
		0	1	1	1	0	1		
		1	0	0	0	0	0		
		1	0	0	1	0	1		
		1	0	1	0	0	1		
		1	0	1	1	0	0		
		1	1	0	0	0	1		
		1	1	0	1	1	1		
		1	1	1	0	1	1		
		1	1	1	1	0	1		
(d)		OR gate NAND equivalent was used instead of an AND gate NAND equivalent.						1	<p>1 mark - for explanation based answer must refer to OR gate being wrong and should be an AND gate.</p>

Task 2 – fast pass machine

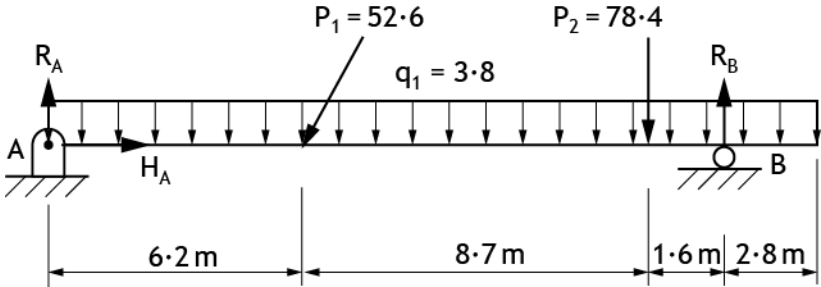
Task		Expected answer(s)	Max mark	Additional guidance												
2.	(a)		2	<p>1 mark - Input - both voltage dividers, with correct components, power supply, correct values.</p> <p>1 mark - Process - op-amp with supply, voltmeters, correct values.</p> <p>Candidates may have voltmeter readings set to read only as volts and not millivolts.</p>												
	(b)	<table border="1"> <thead> <tr> <th>Planned test</th> <th>Expected result</th> <th>Actual result</th> <th>Amendments made</th> </tr> </thead> <tbody> <tr> <td>Reduce the light level to the minimum setting.</td> <td>Op amp output should saturate positive.</td> <td>Op amp output is negative.</td> <td>Swap the LDR position with the fixed resistor, or swap the input connections on the op amp.</td> </tr> <tr> <td>Alter the light level until op amp changes state.</td> <td>Op amp output should change state at 3V.</td> <td>Op amp does not change state at 3V.</td> <td>Change the fixed resistor values so that they are equal.</td> </tr> </tbody> </table>	Planned test	Expected result	Actual result	Amendments made	Reduce the light level to the minimum setting.	Op amp output should saturate positive.	Op amp output is negative.	Swap the LDR position with the fixed resistor, or swap the input connections on the op amp.	Alter the light level until op amp changes state.	Op amp output should change state at 3V.	Op amp does not change state at 3V.	Change the fixed resistor values so that they are equal.	4	<p>1 mark - Actual result - op amp output is <b>negative</b>.</p> <p>1 mark - Amendment - Swap the LDR position with the fixed resistor, or swap the input connections on the op amp.</p> <p>1 mark - Actual result - op amp does not change state at 3V.</p> <p>1 mark - Amendment - Change the fixed resistor values so that they are equal.</p>
Planned test	Expected result	Actual result	Amendments made													
Reduce the light level to the minimum setting.	Op amp output should saturate positive.	Op amp output is negative.	Swap the LDR position with the fixed resistor, or swap the input connections on the op amp.													
Alter the light level until op amp changes state.	Op amp output should change state at 3V.	Op amp does not change state at 3V.	Change the fixed resistor values so that they are equal.													

Task	Expected answer(s)	Max mark	Additional guidance
(c)	 <p>The screenshot shows a circuit simulation. On the left, a 6V DC source is connected to a 10kΩ resistor. This resistor is connected to the non-inverting input (+) of an operational amplifier. The inverting input (-) of the op-amp is connected to a 1kΩ resistor, which is also connected to a 6V DC source. The op-amp's output is connected to a 10kΩ resistor, which is connected to the base of a transistor. The transistor's emitter is connected to ground (0V), and its collector is connected to a relay coil. A diode is connected in parallel with the relay coil, with its cathode to the collector and its anode to ground. The relay is also connected to a motor (M) and a 0V terminal. A 1MΩ resistor is connected between the 6V source and the op-amp's inverting input. A 3.00V voltmeter is connected across a 10kΩ resistor in the input network. A 5.99V voltmeter is connected across the 1MΩ resistor. A 3.98V voltmeter is connected across the 10kΩ resistor in the op-amp's output network. A 6V source is also shown connected to the op-amp's inverting input.</p>	1	<p>1 mark - Screenshot of simulation showing transistor and relay with correct throw position, diode and motor.</p> <p>Allow FTE based on candidate's response in test table 2b.</p> <p>Ignore exploding components.</p>

Task		Expected answer(s)				Max mark	Additional guidance
(d)		Planned test	Expected result	Actual result	Amendments made	3	1 mark - for first Actual result, accept transistor explodes. 1 mark - for first amendment. 1 mark - for second Actual result. Apply FTE from 2c.
		Reduce the light level to minimum.	Motor should turn.	Motor does not turn.	Connect motor to the other throw on the relay switch and diode turned round.		
		Alter the value of both the LDR and the fixed resistor to 6 kΩ.	The motor should turn on under different lighting conditions.	The motor turns on under different lighting conditions.	None required.		
(e)		<p>Specification i was met once the LDR and fixed resistor was changed positions changing it from a light sensor to a dark sensor.</p> <p>Specification ii was met as the motor slows when turned off when light is sensed.</p> <p>Specification iii was not met as the fixed resistor has to be swapped to a variable resistor in series with the LDR.</p>				4	<p>Each specification point should be stated if it meets the specification or not to gain a mark.</p> <p>1 mark - Evaluative comment about specification point i, indicating if the specification was met.</p> <p>1 mark - Evaluative comment about specification point ii, indicating if the specification was met.</p> <p>1 mark - Comment about specification point iii, indicating if the specification was met.</p> <p>1 mark - Amendment of circuit to meet specification point iii.</p> <p>Evaluative comments should be descriptive and indicate amendment made.</p> <p>Allow FTE based on candidate's response in test table 2b.</p>

Task 3 – water flume ride

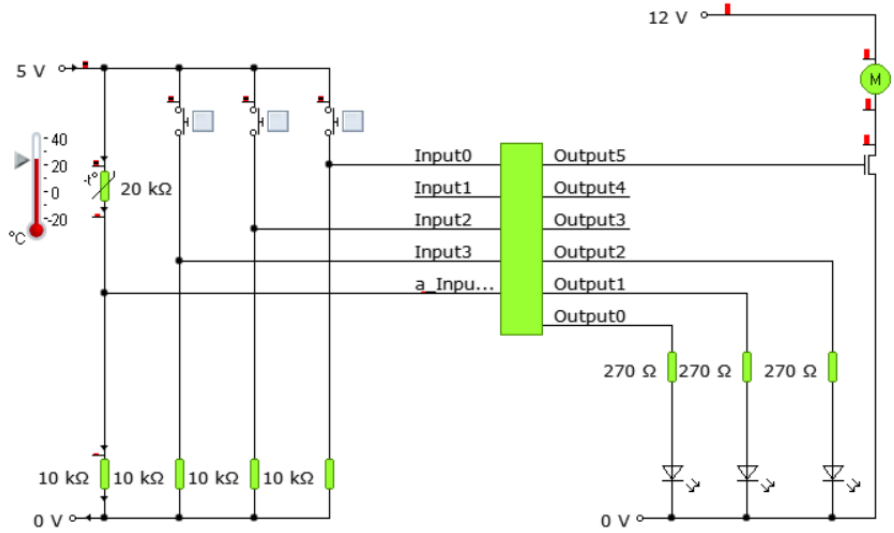
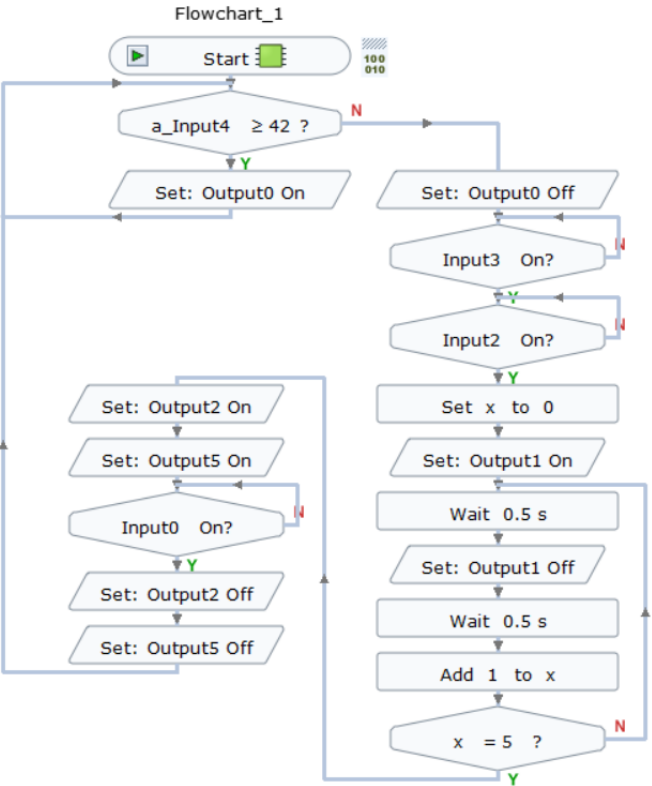
Task	Expected answer(s)	Max mark	Additional guidance
<p>3. (a)</p>		<p>6</p>	<p>Components V1-4 and C1-2 should be indicated. If multiple component labels or actuators are missing/wrong, apply FTE.</p> <p>1 Mark - Connection of both 5/2 valves to each cylinder with cylinder outstroke direction shown.</p> <p>1 Mark - Connection of V2 to 5/2 valve to give C1+.</p> <p>1 Mark - Connection of V4 to 5/2 valve to give C2+.</p> <p>1 Mark - Connection of V3 to 5/2 valve to give C2-.</p> <p>1 Mark - 'OR' connection of V1 and V3 with shuttle valve to give C1-.</p> <p>1 Mark - <b>BOTH</b> uni-directional restrictors connected to outstroking exhaust, orientation of component symbol not required.</p> <p>Symbols should be drawn fully. Block diagrams should have component names fully labelled. eg plunger, 3/2 spring return valve.</p>

Task	Expected answer(s)	Max mark	Additional guidance
3. (b)	 <p style="text-align: center;"><b>Calculate the reactions at the supports of a beam</b></p> <p>1. A beam is in equilibrium when it is stationary relative to an inertial reference frame. The following conditions are satisfied when a beam, acted upon by a system of forces and moments, is in equilibrium.</p> <p><math>\Sigma F_x = 0</math>: <math>H_A - P_1 \cos(63) = 0</math></p> <p><math>\Sigma M_A = 0</math>: The sum of the moments about the pin support at the point A:  <math>- q_1 \cdot 19.3 \cdot (19.3/2) - P_1 \sin(63) \cdot 6.2 - P_2 \cdot 14.9 + R_B \cdot 16.5 = 0</math></p> <p><math>\Sigma M_B = 0</math>: The sum of the moments about the roller support at the point B:  <math>- R_A \cdot 16.5 + q_1 \cdot 19.3 \cdot (16.5 - 19.3/2) + P_1 \sin(63) \cdot 10.3 + P_2 \cdot 1.6 = 0</math></p> <p>2. Calculate reaction of roller support at the point B:  <math>R_B = (q_1 \cdot 19.3 \cdot (19.3/2) + P_1 \sin(63) \cdot 6.2 + P_2 \cdot 14.9) / 16.5 = (3.8 \cdot 19.3 \cdot (19.3/2) + 52.6 \cdot 0.89106.2 + 78.4 \cdot 14.9) / 16.5 = 131.30 \text{ (kN)}</math></p> <p>3. Calculate reaction of pin support at the point A:  <math>R_A = (q_1 \cdot 19.3 \cdot (16.5 - 19.3/2) + P_1 \sin(63) \cdot 10.3 + P_2 \cdot 1.6) / 16.5 = (3.8 \cdot 19.3 \cdot (16.5 - 19.3/2) + 52.6 \sin(63) \cdot 10.3 + 78.4 \cdot 1.6) / 16.5 = 67.31 \text{ (kN)}</math></p> <p>4. Solve this system of equations:  <math>H_A = P_1 \cos(63) = 52.60 \cdot 0.4540 = 23.88 \text{ (kN)}</math></p> <p>5. The sum of the forces about the Oy axis is zero:  <math>\Sigma F_y = 0</math>: <math>R_A - q_1 \cdot 19.3 - P_1 \sin(63) - P_2 + R_B = 67.31 \cdot 1 - 3.8 \cdot 19.3 - 52.6 \cdot 0.8910 - 78.4 + 131.30 \cdot 1 = 0</math></p> <p><b>A horizontal = 23.88 kN.</b>  <b>A vertical = 67.31 kN.</b>  <b>B vertical = 131.3 kN.</b></p>	2	<p>1 mark - Simulation which includes at least a UDL, a point load and supports.</p> <p>1 mark - Correct reactions at A and B.</p> <p>Allow FTE for incorrect values simulated/constructed.</p>

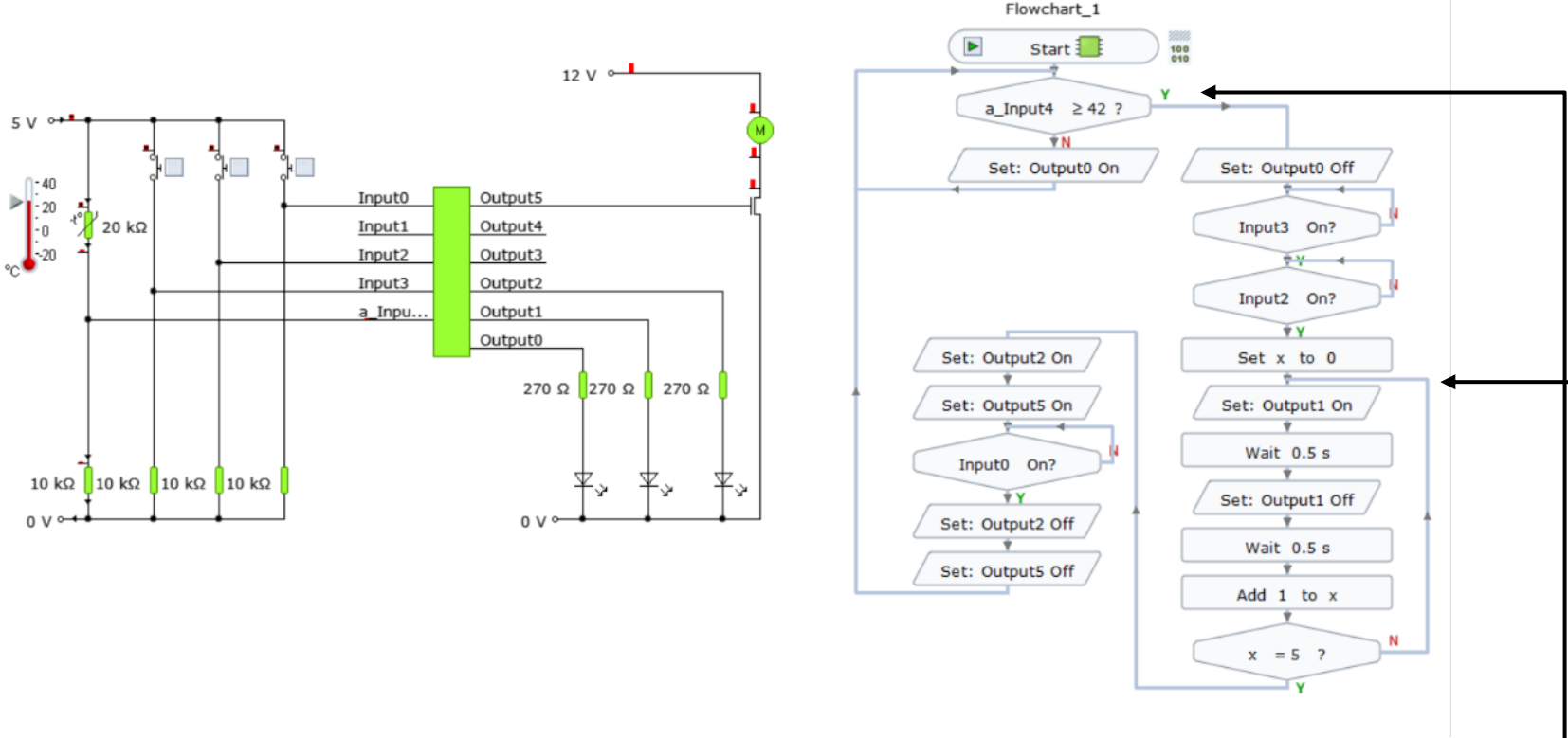
Task 4 – ride queue air conditioning control system

Task	Expected answer(s)	Max mark	Additional guidance
4.		6	<p>Control diagram construction:</p> <ul style="list-style-type: none"> <li>1 mark - Error detector (must be negative configuration).</li> <li>1 mark - Control box including system boundary, correct order (accept microcontroller or op-amp).</li> <li>1 mark - Driver box, correct order.</li> <li>1 mark - Motor box, correct order.</li> <li>1 mark - Feedback loop and temperature sensor, from correct position and direction, thermometer not acceptable.</li> <li>1 mark - Both input and output, with appropriate connections.</li> </ul> <p>Assume direction is left to right unless stated otherwise.</p>

Task 5 - roller coaster ride control

Task	Expected answer(s)	Max mark	Additional guidance
5. (a)		3	<p>1 mark - Inputs and values.</p> <p>1 mark - Outputs and values.</p> <p>1 mark - Flowchart.</p> 

Task		Expected answer(s)				Max mark	Additional guidance
(b)	Planned test	Expected result	Actual result	Amendments made	5	<p>1 Mark - Actual result - No light comes on.</p> <p>1 Mark - Amendment - Change the operator in the decision box from “greater than or equal to” to “less than or equal to” OR change Y/N.</p> <p>1 Mark - Actual result - The temperature warning light switches off.</p> <p>1 Mark - Actual result -The harness check complete indicator’ did come on, but did not flash.</p> <p>1 Mark - Amendment - Adjust the count loop to above “output 1 ON”.</p>	
	Adjust the thermistor temperature to its lowest value.	The ‘temperature warning’ indicator should be on.	No the light does not come on.	Change the Y/N Or change the “greater than or equal to” to “less than or equal to”.			
	Adjust the thermistor temperature to its highest value.	The ‘temperature warning’ indicator should switch off - the flowchart should progress to the next decision.	The temperature warning light switches off.	None required.			
	Press the ‘harness safety check complete’ switch and the ‘operator switch’ in sequence.	The ‘harness check complete’ indicator should flash five times.	The ‘harness check complete indicator’ did come on, but did not flash.	Adjust the count loop to above “output 1 ON”.			

Task	Expected answer(s)	Max mark	Additional guidance
(c)	 <p>The circuit diagram shows a temperature sensor (thermistor) connected to Input4. The sensor is part of a voltage divider with a 20 kΩ resistor. The output of the divider is connected to Input4. The sensor is also connected to a 5V supply through a 10 kΩ resistor. The circuit includes a 12V supply, a motor (M), and three LEDs connected to Output0, Output1, and Output2 through 270 Ω resistors. There are also four 10 kΩ resistors connected to the 5V supply.</p> <p>The flowchart, titled 'Flowchart_1', starts with a 'Start' block. It then checks 'a_Input4 ≥ 42?'. If 'Y' (Yes), it goes to 'Set: Output0 Off'. If 'N' (No), it goes to 'Set: Output0 On'. From 'Set: Output0 On', it checks 'Input3 On?'. If 'Y', it checks 'Input2 On?'. If 'Y', it sets 'x to 0', sets 'Output1 On', waits 0.5 s, sets 'Output1 Off', waits 0.5 s, adds 1 to x, and checks 'x = 5?'. If 'Y', it loops back to 'Set: Output0 On'. If 'N', it goes to 'Set: Output2 On', 'Set: Output5 On', checks 'Input0 On?'. If 'Y', it sets 'Output2 Off' and 'Output5 Off', then loops back to 'Set: Output0 On'. If 'N', it loops back to 'Set: Output0 On'.</p>	2	<p>1 mark - Changing the Y/N.</p> <p>OR</p> <p>Changing the “greater than or equal to” to “less than or equal to”.</p> <p>1 mark - Adjust the count loop to above “output 1 ON”.</p>

Task		Expected answer(s)	Max mark	Additional guidance
	(d)	<p>Specification point i was met as the warning indicator now turns on when the temperature is below a set value. This was achieved by changing the Y/N (changing the inequality).</p> <p>Specification point ii was met as the roller coaster could only be started by the operator when the input to activate the 'harness check complete' indicator is on.</p> <p>Specification point iii was met as when the operator switch is pressed in testing, the 'harness check complete' LED indicator flashes five times. This was achieved by moving the "NO" decision above "OUTPUT1 ON".</p> <p>Specification point iv was met as the 'ride on' indicator LED and the motor remain on until the off switch is pressed by the operator.</p> <p>The safety checks work effectively but the motor continues turning for some time after the off switch is pressed. This gradual slowing down is good for the comfort and safety of riders, but is not very effective as the coaster carriage would likely miss the platform for riders to get off.</p>	5	<p>1 mark - Evaluative comment about each specification point, indicating if the specification was met.</p> <p>1 mark - Evaluative comment(s) on the overall system or any specific improvements.</p> <p>Evaluative comments should be descriptive and indicate amendment made.</p> <p>Allow FTE based on candidate's response in test table 5b and amended flowchart in 5c.</p>

[END OF MARKING INSTRUCTIONS]