National
Qualifications
2022

2022 Engineering Science

National 5

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 for National 5 Engineering Science

Always apply these general principles. Use them in conjunction with the detailed marking instructions, which identify the key features required in candidates' responses.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

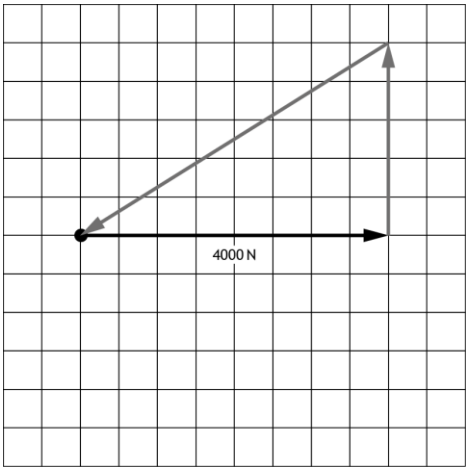
(b) Where a candidate makes an error at an early stage in a multi-stage calculation, credit should normally be given for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of nonmathematical reasoning.

(c) All units of measurement will be presented in a consistent way, using negative indices where required (eg ms-1). Candidates may respond using this format, or solidus format (m/s) or words (metres per second), or any combination of these (eg metres/second).

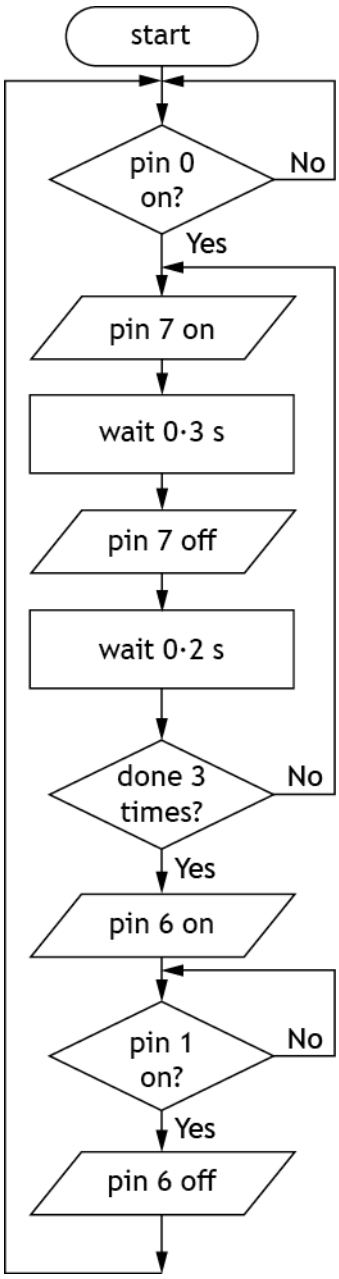
Marking instructions for each question

Section 1

Question			Expected response	Max mark	Additional guidance
1.	(a)		Simple	**1**	
	(b)		Idler	**1**	
2.	(a)		Sound/movement (air)	**1**	Accept noise/kinetic. Ignore any additional words. Do not accept wind.
	(b)		Open loop (control)	**1**	Do not accept open on its own
3.			Work done = Force × Distance Work done = 2200 × 12 Work done = 26400 Work done = **26000 J (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit. Accept Nm as unit.
4.	(a)		Acts as a (electronic) switch	**1**	Descriptive response of function. Accept amplifies current/signal.
	(b)		Emitter	**1**	
5.	(a)		$\varepsilon = \frac{\Delta l}{l}$ $\varepsilon = \frac{0.012}{25}$ ε = **0.00048 (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working. Ignore any unit.
	(b)		(material) C it is corrosion resistant and it is ductile/not brittle it is resistant to corrosion because it will be used outside it is ductile and so it will not snap	**2**	1 mark for material C. 1 mark for identification of both properties or justification of one. Do not accept strong. Allow FTE from chosen material.

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	Electronic	**1**	Do not accept electrical.
		(ii)	Structural	**1**	
		(iii)	Mechanical	**1**	
	(b)		Monitoring the sea life Monitoring the impact on the sea bed Check that the contractors are meeting legislation	**1**	Descriptive response during construction phase. 1 mark for any appropriate response of an engineer's activity and an environmental aspect. Accept land-based descriptions.
7.				**2**	1 mark for vertical line (2500N - 5 squares) upward joined nose to tail to 4000N. 1 mark for the inclined (4700N) force drawn to scale with arrow (slopping down to left) onto the end of the 4000N line. Allow FTE from incorrect vertical force. 1 mark for completing the triangle with an arrow (any direction).
8.			It does not produce greenhouse gases It does not pollute (when in use) Solar reduces the need to burn fossil fuels/extracting resources/fewer greenhouse gases Reduced effect on climate change/ carbon footprint (when in use) Spoils/disrupts the natural landscape Wildlife distrupted/habitats destroyed	**2**	Descriptive response. 1 mark for each environmental impact. Can be an advantage or disadvantage. Accept solar used in other contexts. Do not accept renewable/does not use fossil fuel/uses lots of land, on its own. Accept disruption/resources used during construction.

Section 2

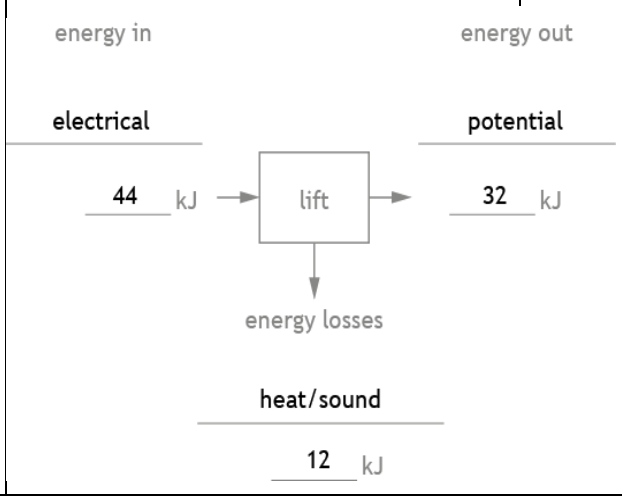
Question			Expected response	Max mark	Additional guidance
9.	(a)			**10**	Pin 0 on ? with Y/N, loop and arrow in correct position – 1 mark. Pin 7 on and off in correct position – 1 mark. Both delays in correct position (ignore incorrect values and unit) - 1 mark. Total delay time(s) with unit = 0.5 s per cycle - 1 mark. X3 decision with Y/N in correct position – 1 mark. Loop and arrow (x3 decision) back to before pin 7 on – 1 mark. Pin 6 on and off in correct position – 1 mark. Pin 1 on? with Y/N, loop and arrow in correct position – 1 mark. Accept decision feedback loop to before pin 6 on. Continuous loop to start with arrow – 1 mark. All marked symbols correct – 1 mark. Ignore any additional steps. accept on/off repeated 3 times max 2 marks.

Question			Expected response	Max mark	Additional guidance
9.	(b)		To go back to line 1/main/restart the program To create a continuous loop.	**1**	Descriptive response. 1 mark for looping program back to start. Accept reset the program. Do not accept go to main on its own.
	(c)		The program loops back to line 1/main/"let count = 0"/wrong line ...therefore it will reset the count/ the count will not pass 1/count will not reach 20.	**2**	1 mark for program looping back to the line 1 (cause). 1 mark for resetting the count (effect).
10.	(a)		*When the temperature decreases to a low temperature …* The resistance (of the thermistor) will increase. This will cause the voltage (V_1) to increase. When the voltage V_1 increases the transistor/relay will switch on. … turning on the LEDs and buzzer.	**4**	Descriptive response. 1 mark for resistance of thermistor increase. 1 mark for voltage V_1 increase. 1 mark for transistor switching on/ saturate or relay energising/switch on. 1 mark for both LEDs and the buzzer turning on. Apply FTE between each statement.
	(b)		The resistance of the variable resistor can be altered ...which will change the temperature that will give a warning.	**2**	1 mark for resistance can be adjusted (cause). Do not accept the resistance is different. 1 mark for a different temperature(s) to activate the circuit (effect).

Question			Expected response	Max mark	Additional guidance
10.	(c)		$\frac{V1}{V2} = \frac{R1}{R2}$ $\frac{0.84}{5.2} = \frac{R}{190}$ $R = 0.16154 \times 190$ $R = 30.6926$ $R =$ **31 kΩ (2 sf)** **OR** $V_R = IR$ $5.2 = I \times 190$ $I = 0.027368$ (mA) $V = IR$ $0.84 = 0.027368 \times R$ $R = \frac{0.84}{0.027368}$ $R = 30.6928$ $R =$ **31 kΩ (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit. 1 mark for calculating current. 1 mark for transposition (allow FTE.) 1 mark for correct answer from given working with unit.
	(d)		20 kΩ	**1**	1 mark for correct answer with unit. Accept 20 000 Ω.

Question			Expected response	Max mark	Additional guidance
10.	(e)		$\text{Input}_{\text{speed}} \times \text{in}_{\text{size}} = \text{output}_{\text{speed}} \times \text{out}_{\text{size}}$	**4**	
			$12 \times 96 = \text{output speed} \times 16$		1 mark for substitution.
			$\text{output speed} = \frac{1152}{16}$		
			output speed = 72 (revs min^{-1})		1 mark for correct answer from given working (unit not required).
			$12 \times \text{input speed} = 72 \times 120$		1 mark for substitution.
			$\text{input speed} = \frac{8640}{12}$		
			Input speed = **720 revs min^{-1} (2 sf)**		1 mark for correct answer from given working with unit. Allow FTE. Do not accept RPM.
			OR		
			$\frac{\text{output speed}}{\text{input speed}} = \frac{\text{A}}{\text{B}} \times \frac{C}{D}$		1 mark for first ratio (could be inverted).
			$\frac{12}{\text{input speed}} = \frac{12}{120} \times \frac{16}{96}$		1 mark for second ratio (same order as first ratio). Accept simplified ratios.
			$\text{input speed} = \frac{12}{\left(\frac{12}{120} \times \frac{16}{96}\right)}$		
			$\text{input speed} = \frac{12}{\left(\frac{1}{60}\right)}$		1 mark for transposition (12×60 if ratios inverted).
			input speed = **720 revs min^{-1} (2 sf)**		1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	$\Sigma CWM = \Sigma ACWM$ $(3.5 \times 5) + (F \times 7.5) = (2.1 \times 10)$ $17.5 + (F \times 7.5) = 21$ $F = \frac{3.5}{7.5}$ $F = 0.4666666667$ F = **0.47 kN (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
		(ii)	$\Sigma F_{vertical} = 0$ $3.5 + 0.47 = R_A + 2.1$ $R_A = 3.97 - 2.1$ $R_A = 1.87$ R_A = **1.9 kN (2 sf)**	**2**	1 mark for substitution. Allow FTE from part a(i). 1 mark for correct answer from given working with unit.
	(b)	(i)	More people will be able to use the station. Easier access/less effort for travellers to reach the platform/ walkway. Jobs created during installation/ maintenance.	**1**	Descriptive positive social response. Benefit must relate to the person/people – stated/implied and the context. Do not accept save people time/ jobs on its own.
		(ii)	Increase in profits by installing lifts. (Maintenance) jobs created giving income. (Easier access for everyone) so increased profit/customers in platform shops.	**1**	Descriptive positive economic response. Response must include cost/money benefit stated/inferred. Do not accept employment/increase in profit on its own.
		(iii)	The (lift) would be expensive to install/maintain. Increase in running costs.	**1**	Descriptive negative economic response. Response must include cost/money drawback stated/inferred. Do not accept employment/cost/ losses on its own.

Question			Expected response	Max mark	Additional guidance
11.	(c)			**3**	1 mark for input electrical energy and 44 (kJ). 1 mark for output potential energy and 32 (kJ). 1 mark for lost heat/sound energy and 12 (kJ). Allow FTE for energy losses value.

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>12.</td><td>(a)</td><td></td><td>
<table>
<tr><th>D</th><th>E</th><th>Z</th></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
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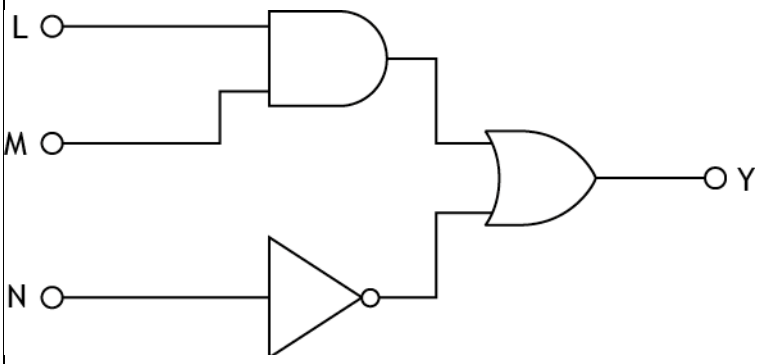
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
</table>
</td><td>3</td><td>1 mark per correct complete column.

Column D = NOT A

Allow for FTE

Column E = B OR D

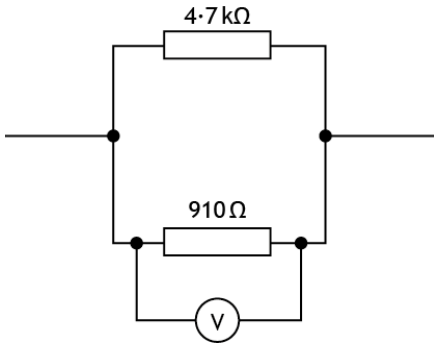
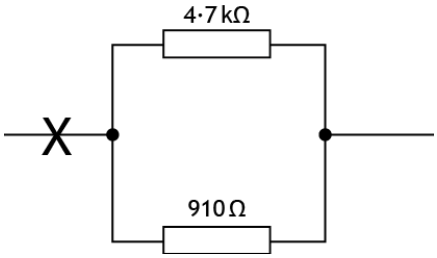
Column Z = C AND E</td></tr>
<tr><td></td><td>(b)</td><td></td><td>3</td><td></td></tr>
<tr><td colspan="3"></td><td> 
</td><td></td><td>1 mark for L and M wired individually to AND gate.

1 mark for N wired to NOT gate.

1 mark for OR gate output wired to Y and inputs to NOT and AND.

FTE – 1 mark OR gate wired to N and/or L and M if a previous gate(s) omitted.</td></tr>
</table>

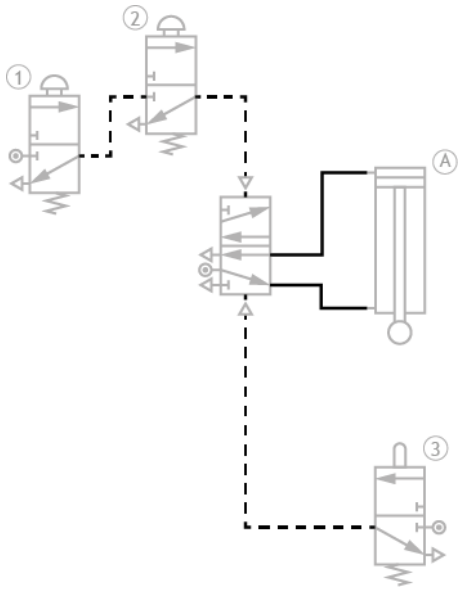
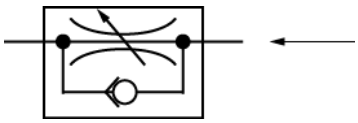
Question			Expected response	Max mark	Additional guidance
12.	(c)		Quicker to assemble the circuit Quicker to change the circuit Easier to see faults/issues with circuit Reduces cost as components will not be destroyed No risk of damage to actual components/user	**2**	Descriptive advantage. 1 mark for each relevant statement. Not speed, cost, safety, ease, on its own. Cost must relate to speed or no damaged components.
	(d)	(i)	$\sigma = \frac{F}{A}$ $0.84 = \frac{F}{190}$ $F = 0.84 \times 190$ $F = 159.6$ F = **160 N (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
		(ii)	Tensile/Tension	**1**	Accept Tie. Do not accept pulling force/gravity.
	(e)		The stress will decrease	**1**	

Question			Expected response	Max mark	Additional guidance
13.	(a)	(i)	$RT = \frac{R1 \times R2}{R1 + R2}$ $RT = \frac{4700 \times 910}{4700 + 910}$ RT = 762.3885918 Ω RT = **760 Ω** (2 sf) $\frac{1}{Rt} = \frac{1}{4700} + \frac{1}{910}$ Rt = 762.3885918 Ω Rt = **760 Ω** (2 sf)	**2**	1 mark for substitution with the same unit. 1 mark for correct answer from given working with unit. 1 mark for substitution with the same unit. 1 mark for correct answer from given working with unit.
		(ii)		**2**	1 mark for correct symbol. 1 mark for correct wiring across the 910 Ω resistor branch.
		(iii)		**1**	1 mark for X (ammeter) in correct series position. Accept X on the wire at either side. Do not accept X on a node.

Question			Expected response	Max mark	Additional guidance
13.	(b)		$V = IR_T$ $36 = 2 \times R_T$ $RT = \frac{36}{2}$ $R_T = 18\ (\Omega)$ $R = 18 - 5{\cdot}6$ $R = 12.4$ $R =$ **12 Ω (2 sf)** **OR** $V = IR$ $V = 2 \times 5.6$ $V = 11.2\ (V)$ $V_R = V_S - V$ $V_R = 36 - 11.2$ $V_R = 24.8\ (V)$ $V = IR$ $R = \frac{24.8}{2}$ $R = 12.4$ $R =$ **12 Ω (2 sf)**	**4**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working (units not required). 1 mark for correct answer from given working with unit. Allow FTE. 1 mark for voltage over 5.6 Ω resistor (units not required). 1 mark for voltage over R (units not required). 1 mark for transposition. 1 mark for correct answer from given working with unit. Allow FTE. If voltage divider ratio used mark as second guidance.

Question			Expected response	Max mark	Additional guidance
13.	(c)		$E_k = \frac{1}{2}mv^2$ $E_k = \frac{1}{2}64 \times 3.4^2$ Ek = 369.92 Ek = **370 J (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.
	(d)		Driverless cars have no human error ...therefore safer Driverless cars may not be fully tested ...which could cause an accident Cars can travel at an appropriate speed/distance between cars ...resulting improved road safety	**2**	Explanation relating to road safety. 1 mark for cause. 1 mark for effect. Do not accept no driver as a cause on its own.
14.	(a)		The water flow rate is set (by the user) The sensor detects the (actual water) flow rate. The control unit compares both flow rate (values). **OR** The control unit decides if the rate is too low/high/correct. The motor activates/the gear mechanism turns/the gate moves The gate moves up/opens when the rate is too low **OR** The gate lowers/closes when the rate is too high **OR** The gate will not move when the rate is correct	**5**	Descriptive responses. 1 mark for the external signal inputted/user setting of level. 1 mark for description of the sensing action/feedback from sensor. 1 mark for description of the control (comparison/decision making). 1 mark for description of the control of the motor/gear/gate. 1 mark for description of the correct gate movement for the condition described.

Question			Expected response	Max mark	Additional guidance
14.	(b)		$\text{Velocity Ratio} = \frac{\text{Speed of Input}}{\text{Speed of Output}}$ $14 = \frac{870}{\text{speed of output}}$ $\text{speed of output} = \frac{870}{14}$ speed of output = 62.14285 speed of output = **62 revs min^{-1} (2 sf)**	**3**	1 mark for substitution. Accept 14:1 for VR in substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit. Do not accept RPM.
	(c)		The program can be easily modified/ corrected It is reprogrammable Its more reliable because there are less components	**1**	Descriptive response relating to when in use. Do not accept cheaper/fewer components/reliable/quicker on its own. Do not accept easier/quicker to replace component.
	(d)		$\eta = \frac{\text{Power out}}{\text{Power in}}$ $0.85 = \frac{15}{\text{Power in}}$ $\text{Power in} = \frac{15}{0.85}$ Power in = 17.647 Power in = **18 MW (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(e)		Once in use Hydro power does not emit any greenhouse gases …therefore does not contribute to global warming When in use Hydro power reduces the need to use fossil fuels …therefore reducing greenhouse gases/carbon footprint/impact on climate change.	**2**	Explanation must relate to climate change and the use of Hydro. Do not accept pollution related responses. Do not accept construction based responses. 1 mark for cause. 1 mark for effect.

Question			Expected response	Max mark	Additional guidance
15.	(a)			**5**	Pipe connections must be port to port. 1 mark for ANDing valve ① to valve ② and piping pilot actuator on top of the 5/2 valve. 1 mark for piping up valve ③ to pilot actuator on the bottom of 5/2 valve. 1 mark for a pilot air line type for given piping into the 5/2. 1 mark for top pipe to DAC from 5/2 valve. 1 mark for bottom pipe to DAC from 5/2 valve. Allow FTE if incorrect 5/2 state outputs port are used. 1 mark max for DAC piping.
	(b)			**2**	1 mark for correct symbol of a uni-directional restrictor. 1 mark for correct orientation of by-pass route. Symbol need not be drawn on the given pipe.
	(c)		$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$ $1.4 = \frac{490}{\text{Area}}$ $A = \frac{490}{1.4}$ A = **350 mm^2 (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
15.	(d)		The area on the instroke is smaller (due to the piston rod), …resulting in the instroking force being smaller The area on the outstroke is larger (due to no piston rod), …resulting in the outstroking force being larger The two areas are different … therefore the outstroke force is larger	**2**	1 mark for cause (difference in area – stated or inferred). 1 mark for effect (specific effect on difference in force in/outstroke). Do not accept size in place of area. Do not accept forces will be different. Allow FTE.

[END OF MARKING INSTRUCTIONS]