National
Qualifications
2025

2025 Engineering Science

National 5

Question Paper 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) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(c) Where a candidate makes an error at an early stage in a multi-stage calculation, award marks for correct follow-on working in subsequent stages. Do not award marks if the error significantly reduces the complexity of the remaining stages. Apply the same principle in questions which require several stages of non-mathematical reasoning.

(d) SQA presents all units of measurement in a consistent way, using negative indices where required (for example ms^{-1}). Candidates can respond using this format, or solidus format (m/s), or words (metres per second), or any combination of these (for example metres/second).

(e) For numerical questions, candidates should round their answers to an appropriate number of significant figures. However, award marks if their answer has up to two figures more or one figure less than the expected answer. (Note: the use of a recurrence dot, e.g. $6.6^{\bullet}$, would imply an infinite number of significant figures and would therefore not be acceptable.)

(f) Unless a numerical question specifically requires candidates to show evidence of their working, award full marks for a correct final answer (including unit) on its own.

(g) Award marks where a labelled diagram or sketch conveys clearly and correctly the response required by the question.

(h) Award marks regardless of spelling if the meaning is unambiguous.

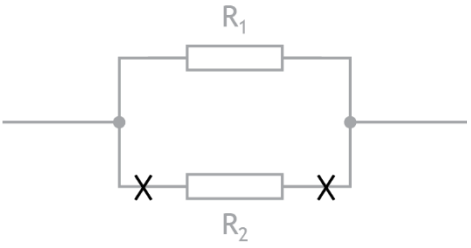
(i) Where a question asks for or requires a specific number of reasons, examples, points, etc and the candidate provides more than the required number then each incorrect response negates a correct response.

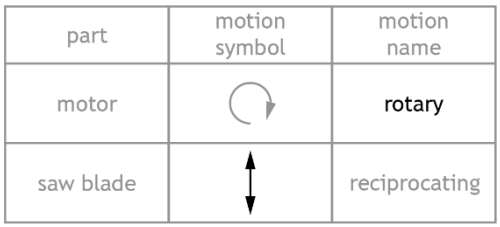
(j) Where a question asks candidates to **describe**, they must provide an account or structure of characteristics and/or features, in the context of and appropriate to the question.

(k) Where a question asks candidates to **explain**, they must relate cause and effect, or provide a relationship between two aspects, in the context of and appropriate to the question.

Marking instructions for each question

Section 1

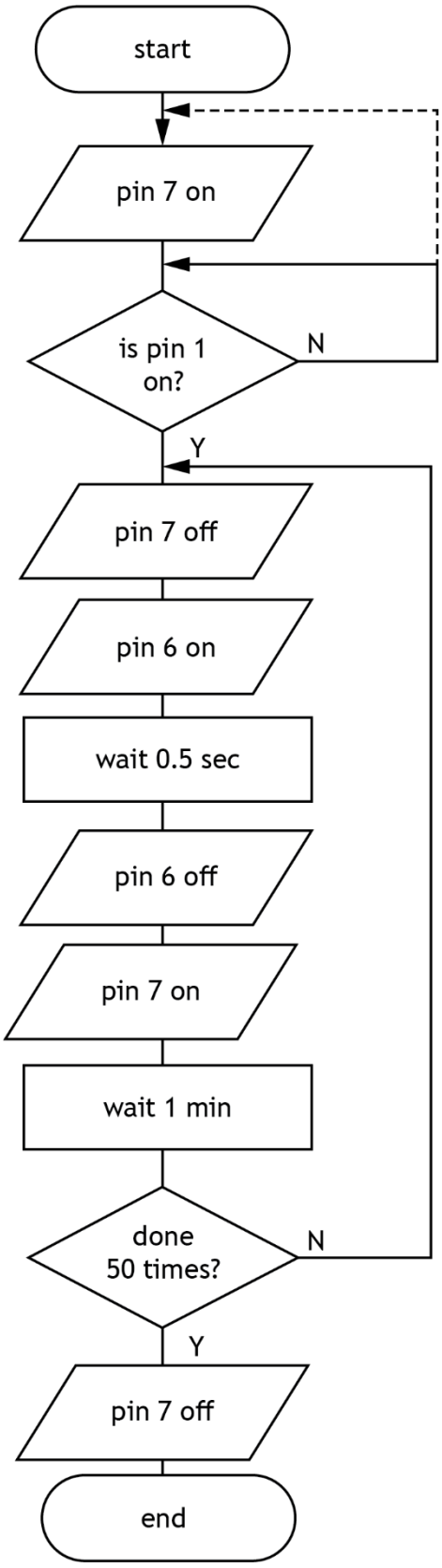
Question			Expected response	Max mark	Additional guidance
1.	(a)		Parallel	**1**	
	(b)	(i)		**1**	Straight lines not required on symbol.
		(ii)		**1**	Accept the cross or an ammeter shown wired in series between either node and resistor R_2.
2.	(a)		(Line) 5 or 7	**1**	Only a single line number required. Accept the line number indicated on the program.
	(b)		15 (times)	**1**	
	(c)		Fixed/ Finite (loop)	**1**	
3.	(a)		Structural	**1**	
	(b)		Electronic	**1**	
	(c)		Mechanical	**1**	
4.	(a)		Compound (gear)	**1**	
	(b)		Clockwise	**1**	
	(c)		$Velocity\ Ratio = \frac{Speed\ of\ Input}{Speed\ of\ Output}$ $Velocity\ Ratio = \frac{180}{45}$ $Velocity\ Ratio$ = 4 : 1	**2**	1 mark for substitution. 1 mark for correct answer from given working. Accept 4. Ignore any units.

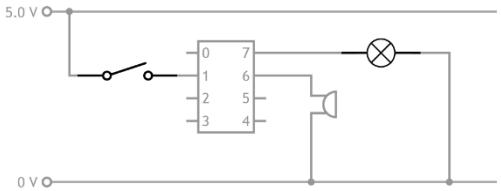
Question			Expected response	Max mark	Additional guidance
5.				**2**	Accept rotational. 1 mark -  or
6.	(a)			**2**	1 mark – input. 1 mark – output. Do not accept any additional words.
	(b)		Open loop	**1**	
7.			It does not produce pollution/CO_2 (when in use)/does not contribute towards global warming. Reduces the need to burn fossil fuels. Clean source of energy. Wildlife disrupted/habitats destroyed. Flow of water/flooding may erode the land/riverbank. Unattractive dam site/pylons spoiling natural landscape.	**2**	1 mark for each different appropriate environmental description. Do not accept renewable/does not use fossil fuel on its own. Accept habitats created.

Section 2

Question			Expected response	Max mark	Additional guidance
8.	(a)		AND (control)	**1**	
	(b)		*When valve 2 is actuated* Valve 3 changes state and cylinder A and cylinder B outstroke. Piston B actuates valve 4. Pilot air changes the state of valve 3 causing cylinder A and B to instroke. Piston A actuates valve 1 and the sequence will repeat.	**4**	Descriptive response. 1 mark for valve 3 actuation and cylinder A and B outstroking. 1 mark for piston B actuating valve 4. 1 mark for valve 3 actuation and cylinder A and B instroking. (Apply FTE if only one cylinder movement described previously.) 1 mark for valve 1 actuation and sequence restart/reset. Apply FTE from each previous description.
	(c)		The microcontroller program can be easily updated/reprogrammed …without needing to change the pneumatic circuit. A microcontroller would need fewer (pneumatic) components ….reducing the cost of the circuit. The microcontroller program will allow a set number of piston movements …allowing accurate test results to predict performance.	**2**	Descriptive response relating to a positive reason for using a microcontroller in the context of a pneumatic circuit. 1 mark for cause. Do not accept easier to change on its own. 1 mark for effect.

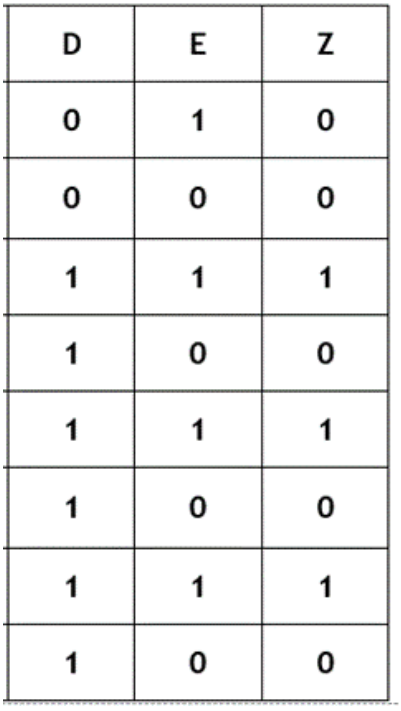
Question			Expected response	Max mark	Additional guidance
8.	(d)	(i)	$A_{eff} = \frac{\pi \times D^2}{4} - \frac{\pi \times d^2}{4}$ $A_{eff} = \frac{\pi \times 64^2}{4} - \frac{\pi \times 12^2}{4}$ A_{eff} = 3216.990877 - 113.0973355 (1024π - 36π) A_{eff} = 3103.893542 (988 π) **= 3100 mm^2 (2 sf)**	**3**	1 mark for piston area. 1 mark for piston rod area. (Apply FTE for 2nd calculation repeating incorrect use of radius/ diameter.) 1 mark for correct answer from working with unit. Accept 0.0031 m^2. 2 marks maximum if diameters/radii are subtracted prior to squaring in an area formula. [2124 mm^2 (4 sf)].
		(ii)	$P = \frac{F}{A}$ $P = \frac{680}{3100}$ P = 0.2193548387 **P = 0.22 Nmm^{-2} (2 sf)**	**2**	1 mark for substitution. Apply FTE for final area value in (d)(i). 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
9.	(a)			10	1 mark - (FIRST) Pin 7 on and off in correct position. 1 mark - Pin 1 on? with Y/N, loop and arrow in correct position. 1 mark - Pin 6 on and off in correct position. 1 mark - 0.5s delay in correct position with unit. 1 mark - (SECOND) Pin 7 on and off in correct position. 1 mark – 1 min (60s) delay in correct position with unit. 1 mark - x50 decision with Y/N in correct position. 1 mark - Loop with arrow (x50 decision) back to between pin 1 on and pin 7 off. 1 mark – end (stop). 1 mark - all correct symbols. Ignore any additional steps including their symbols.

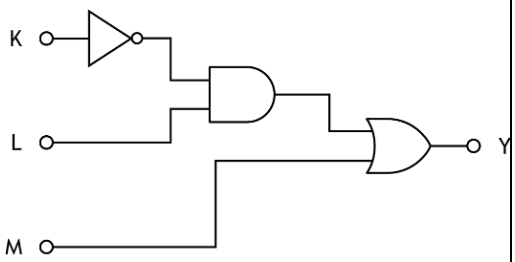
Question			Expected response	Max mark	Additional guidance
9.	(b)			**2**	1 mark for switch symbol wired between 5V and pin 1. Accept push to make switch. 1 mark for lamp symbol wired between pin 7 and 0V.
	(c)		Transistor	**1**	Accept relay (switch)/MOSFET. Do not accept driver.

Question			Expected response	Max mark	Additional guidance
10.	(a)		Survey/monitor the wildlife on site. Analyse the possible impact construction might have on residents. Advising on health & safety/ planning regulations/materials choice to protect the environment.	**1**	1 mark for a descriptive response relating to a design activity for an environmental engineer in the context of the slipway.
	(b)		Computer simulated model can be easily modified ….reducing cost/lead time of the project. The size of forces can be tested ….to ensure the slipway will be built strong enough. Different weather conditions can be modelled ….without causing physical damage/ human harm.	**2**	Descriptive response relating to the use of computer simulation during the design of the slipway. 1 mark for cause. 1 mark for effect.
	(c)		$E_p = mgh$ $2\,200\,000 = 27\,000 \times 9.8 \times h$ $h = \frac{2.2 \times 10^6}{27000 \times 9.8}$ $h = 8.314436886$ **h = 8.3 m (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
10.	(d)	(i)	$\text{Efficiency} = \frac{\text{E out}}{\text{E in}}$ $0.64 = \frac{E_{out}}{2200000}$ $E_{out} = 0.64 \times 2200000$ $E_{out} = 1408000$ **E_k = 1 400 000 J (1.4 MJ) (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
		(ii)	Lubricate the slipway/ lifeboat hull ….reducing the heat energy being created. Use a slippery material for the slipway ….reducing the friction/energy loss.	**2**	Descriptive response relating to increasing the efficiency of the lifeboat moving down slipway. 1 mark for cause with reference to the lifeboat/slipway. 1 mark for effect.
	(e)		$\sigma = \frac{F}{A}$ $\sigma = \frac{26000}{710}$ $\sigma = 36.61971831$ **σ = 37 Nmm^{-2} (0.037 kNmm^{-2}) (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.
	(f)		The stress (on the cable) will increase.	**1**	Descriptive answer relating to the stress increasing.

Question			Expected response	Max mark	Additional guidance
11.	(a)		Member A: compression/compressive. Member B: tension/tensile.	**2**	1 mark for member A – compression. Accept strut. 1 mark for member B – tension. Accept tie.
	(b)		$\varepsilon = \frac{\Delta l}{l}$ $0.00036 = \frac{\Delta l}{120}$ $\Delta l = 0.00036 \times 120$ $\Delta l = 0.0432$ **Δl = 0.043 mm (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(c)			**3**	1 mark for each correct column. 1 mark - column D = A OR B. 1 mark - column E = NOT C. 1 mark - column Z = D AND E. (Apply FTE)

D	E	Z
0	1	0
0	0	0
1	1	1
1	0	0
1	1	1
1	0	0
1	1	1
1	0	0

Question			Expected response	Max mark	Additional guidance
11.	(d)			**3**	1 mark - NOT gate with input connection. 1 mark - AND gate with both input connections. 1 mark – OR gate with both input and the output connections.
	(e)		$P = \frac{V^2}{R}$ $P = \frac{5.0^2}{470}$ P = 0.05319148936 **P = 0.053 W (53 mW) (2sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
12.	(a)		It will use less electricity/energy …therefore it will be cheaper to use. It is quicker at cooking food …so the running costs will be less.	**2**	Descriptive response with a positive economic impact of using the air fryer. 1 mark for cause (speed/energy usage). Do not accept more energy efficient on its own. 1 mark for effect (cheaper to use).
	(b)		$E_h = cm\Delta T$ $E_h = 3400 \times 0.75 \times 82$ $E_h = 209100$ **E_h = 210000 J (210 kJ) (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.
	(c)		*The user sets the temperature…* The temperature sensor monitors the actual temperature/feeds back to the control. The control sub-system compares the set level to the actual temperature level. If the (actual) temperature is below the set level the heating element will switch on. **OR** If the (actual) temperature is above the set level the heating element will switch off.	**3**	Descriptive response. 1 mark for feedback description. 1 mark for control comparison description. 1 mark for description of the heating element switching on when cold/staying or switching off when hot.

Question			Expected response	Max mark	Additional guidance
12.	(d)		330 + 820 = **1150Ω** $R_T = \frac{R1 \times R2}{R1+R2}$ $R_T = \frac{1150 \times 680}{1150+680}$ R_T = 427.3224044 **R_T = 430Ω (2 sf)** alternative method $\frac{1}{RT} = \frac{1}{R1} + \frac{1}{R2}$ $\frac{1}{RT} = \frac{1}{1150} + \frac{1}{680}$ R_T = 427.3224044 R_T = **430Ω (2 sf)**	**3**	1 mark for series resistance. 1 mark for substitution. Apply FTE for series resistance value. 1 mark for correct answer from given working with unit. 1 mark for series resistance. 1 mark for substitution. Apply FTE for series resistance value. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
12.	(e)		$V = IR$ $12 = I \times 680$ $I = \frac{12}{680}$ $I = 0.01764705882$ **$I = 0.018\,A$ (18 mA) (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(f)		Ammonia fuelled engines are new and untried … so they may be unreliable. Nuclear diamond battery charge may last 1000s of years … so portable products will never need recharged in their lifetime/no need for disposable batteries.	**2**	Descriptive answer relating to a positive or negative impact for an emerging technology. 1 mark for cause. 1 mark for effect. If an established or developing technology is named, such as AI, graphene, self-driving cars etc, then a maximum of 1 mark for a cause **and** effect. No mark for only stating an emerging technology.

Question			Expected response	Max mark	Additional guidance
13.	(a)		Free body (diagram)	**1**	
	(b)		$\Sigma CWM = \Sigma ACWM$ $(650 \times 0.8) + (890 \times 3) = 560 \times d$ $d = \frac{3190}{560}$ $d = 5.696428571$ **$d = 5.7\,m$ (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(c)		$\Sigma F_v = 0$ $R_A + 560 = 650 + 890$ $R_A = 1540 - 560$ **$R_A = 980$ N (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.
	(d)		820 (N)	**1**	Accept values in the range 810 N to 830 N. Accept 800 N (1 sf).
	(e)		$\Sigma F_v = 0$	**1**	Accept $\Sigma F_{up} = \Sigma F_{down}$ Accept $\Sigma F\uparrow = \Sigma F\downarrow$ Do not accept arrows on their own.
	(f)		Develop the charging circuit. Calculate the power required by the charging station. Simulate/test the charging circuit performance. Select components/values for the charging circuit.	**1**	Descriptive response during design phase. 1 mark for any appropriate response of an engineer's activity and electrical aspect relating to the charging station.

Question			Expected response	Max mark	Additional guidance
14.	(a)		*As the water temperature increases…* The thermistor's resistance will drop. This will cause the voltage V_{in} to lower. When the voltage V_{in} drops the transistor will switch off. The LED switches off.	**4**	Descriptive response. 1 mark for resistance of thermistor decreasing. 1 mark for voltage V_{in} decrease. Accept voltage across thermistor description. 1 mark for transistor switching off. 1 mark for LED turning off. Apply FTE from each previous description.
	(b)		Limit the current drawn ... to protect the transistor.	**2**	1 mark for cause (limiting current). 1 mark for effect (protecting the transistor).

Question			Expected response	Max mark	Additional guidance
14.	(c)		$\frac{V_1}{V_2} = \frac{R_1}{R_2}$ $\frac{V_1}{2.1V} = \frac{4.8\ k}{3.5\ k}$ $V_1 = \frac{4.8\ k \times 2.1}{3.5\ k}$ $V_1 = 2.88\,V$ $V_s = 2.88 + 2.1$ $V_s = 4.98$ V_s **= 5.0 V (2 sf)** Alternative method $V = IR$ $2.1 = I \times 3.5$ $I = \frac{2.1}{3.5}$ $I = 0.6$ (mA) $V_2 = IR$ $V_2 = 0{\cdot}6 \times 4.8$ $V_2 = 2.88\,V$ $V_s = 2.88 + 2.1$ $V_s = 4.98$ V_s **= 5.0 V (2 sf)**	**4**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working. 1 mark for correct answer from given working with unit. Apply FTE from value of V_1. 1 mark for substitution. 1 mark for correct answer from given working. 1 mark for correct answer from given working. Apply FTE for current value. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
14.	(d)		$In_{speed} \times in_{size} = out_{speed} \times out_{size}$ $1500 \times 52 = \text{output speed} \times 12$ $\text{output speed} = \frac{1500 \times 52}{12}$ **output speed = 6500 revs min^{-1}** Alternative method $\text{Gear ratio} = \frac{Out_{size}}{In_{size}}$ $GR = \frac{12}{52}$ $Out_{sp} = 1500 \div \frac{12}{52}$ OR $Out_{sp} = 1500 \times \frac{52}{12}$ **output speed = 6500 revs min^{-1}**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit. Do not accept RPM. 1 mark for gear ratio (any order). 1 mark for correct transposition for given ratio. 1 mark for correct answer with unit from given working.
	(e)		Use an idler (gear). Add a gear between the gear A and gear B.	**1**	Accept use a compound gear.

[END OF MARKING INSTRUCTIONS]