National
Qualifications
2019

2019 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.

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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.

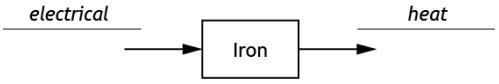
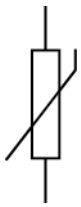
(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

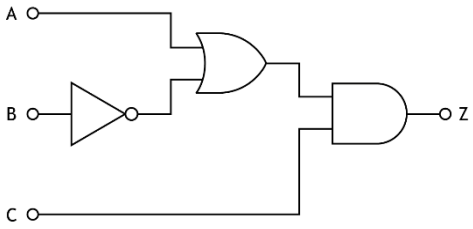
(b) Where a candidate makes an error at an early stage in a multi-stage calculation, credit should normally be given for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which 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)			**2**	1 mark for electrical as input. 1 mark for heat as output. Do not accept electricity/electric.
	(b)		Closed loop (control)	**1**	Do not accept closed on its own.
	(c)			**1**	1 mark for correct symbol. -t° not required. Small line must be parallel to long side of resistor. Do not accept an arrow on any end.
2.			$P = \frac{E}{t}$ $P = \frac{6750}{270}$ P = 25 **P = 25 W (2 sf)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.
3.	(a)		Air that operates a piston/cylinder.	**1**	Descriptive response of function. Accept instroke/outstroke/actuate a cylinder. Must specifically refer to operating (stated or inferred) a cylinder/ piston.
	(b)		Air used to actuate a valve.	**1**	Descriptive response of function. Must specifically refer to operating (stated or inferred) a valve.

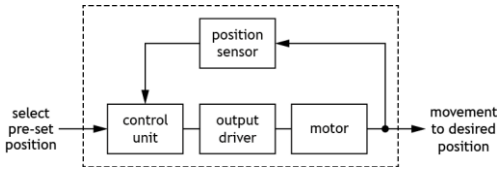
Question			Expected response	Max mark	Additional guidance
4.	(a)		$\text{Velocity Ratio} = \frac{\text{Speed of Input}}{\text{Speed of Output}}$ $\text{Velocity Ratio} = \frac{800}{320}$ Velocity Ratio = **5 : 2**	**2**	1 mark for substitution. 1 mark for correct answer from given working. Accept 2·5 : 1 or 2·5 Ignore any units.
	(b)		Anti-clockwise.	**1**	Do not accept other way or opposite way. Accept indication of direction on diagram.
5.	(a)	(i)	Civil.	**1**	
		(ii)	Environmental.	**1**	
	(b)		Less stressful journeys . Journey time quicker. City roads less congested. Areas bypassed will be quieter/safer. City will be less polluted to live in. Jobs created in the construction of the bypass/of housing in outlying areas.	**2**	1 mark for each descriptive response of positive social impact of a city bypass. Assume impact refers to bypass unless indicated in response. Do not accept quick on its own. Do not accept less congestion on bypass.
6.				**3**	1 mark for NOT gate wired to input B. 1 mark for OR gate wired to A and (NOT) B. 1 mark for AND gate wired to input C and A (OR) B. No FTE from gate.

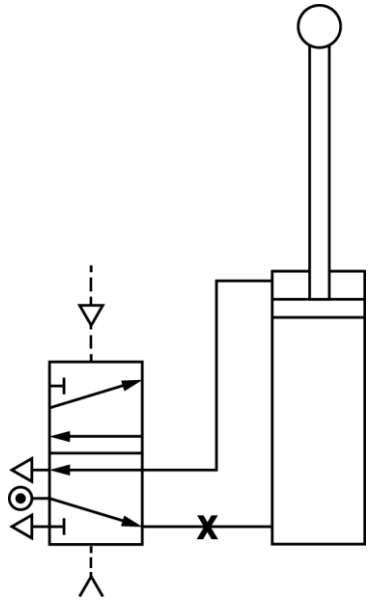
Question			Expected response	Max mark	Additional guidance
7.			Positive: It does not produce CO_2 when in use. Reduces the need to burn fossil fuels. Does not contribute towards global warming. No pollution/clean when in use. Negative: Wildlife disrupted/habitats destroyed. Flow of water/flooding may erode the land/river bank. Unattractive pylons/dam site spoiling natural landscape. Vehicles noise when accessing the dam site.	**2**	1 mark for a description of an appropriate positive environmental impact when in use. 1 mark for a description of an appropriate negative environmental impact when in use. Do not accept renewable/does not use fossil fuel on its own. Do not accept the same environmental impact of use as both positive and negative impact.

Section 2

Question			Expected response	Max mark	Additional guidance
8.	(a)		1200 + 270 = 1470 (Ω) $RT = \frac{R1 \times R2}{R1 + R2}$ $RT = \frac{1470 \times 390}{1470 + 390}$ RT = 308·2 **RT = 310 Ω (2 sf)**	**3**	1 mark for series resistance (unit not required). 1 mark for substitution Allow for FTE. 1 mark for answer with unit from given working.
	(b)	(i)	V = IR V = 0·031 x 390 V = 12·09 **V = 12 V (2 sf)**	**2**	1 mark for substitution. 1 mark for answer with unit from given working with unit.
		(ii)	V = IR 12 = I x 1470 $I = \frac{12}{1470}$ I = 0·00816 **I = 8·2 mA (2 sf)**	**3**	1 mark for substitution. Allow for FTE from (b)(i). 1 mark for transposition. 1 mark for correct answer from given working with unit.
		(iii)	A_3 = 0·0082 + 0·031 A_3 = 0·0392 **A_3 = 39 mA (2 sf)** **OR** V = IR 12 = I x 310 $I = \frac{12}{310}$ A_3 = 0.0387 **A_3 = 39 mA (2 sf)**	**1**	1 mark for answer with unit. Allow for FTE from (b)(ii). Allow for FTE from (a) and (b)(i).

Question			Expected response	Max mark	Additional guidance
	(c)		Graphene. Conducts electricity quickly. This would result in batteries charging quicker/circuits working quicker. Self driving car. Impact of emerging system is it may not be fully tested and so may have faults and this could cause an accident.	**2**	Accept impact for any emerging technology. 1 mark for cause. 1 mark for effect. If no technology named or the given example is clearly an established/ developing; 1 mark maximum for cause **and** effect.

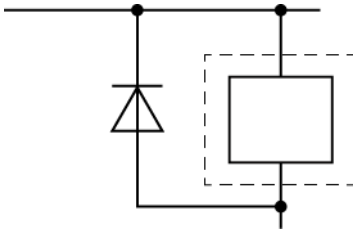
Question			Expected response	Max mark	Additional guidance
9.	(a)			**1**	Dashed box around process.
	(b)		*The pre-set position is selected...* The control unit compares the pre-set position with the actual position. The bed/motor will start to move (if it is not in the desired position). When the desired position is detected the motor will stop.	**3**	1 mark for comparison by control unit of positional sensor signal to pre-set value. 1 mark for motor starting. 1 mark for motor stopping in relation to desired position.
	(c)		When an appropriate input signal is applied to the base an output current will flow at the collector/emitter.	**2**	1 mark for input signal at base (cause). Accept voltage as signal. 1 mark for output current at collector/emitter based on given cause (effect).
	(d)		$Z = (\overline{A} \bullet \overline{B}) + (A \bullet B)$	**3**	1 mark $(\overline{A} \bullet \overline{B})$ with brackets. 1 mark $(A \bullet B)$ with brackets. 1 mark for OR-ing all statements. If just a single statement is given then bracket not required. accept alternatives such as $Z = \overline{A \oplus B}$ $Z = \overline{(A+B)} + (A \bullet B)$
	(e)		<table><tr><th>G</th><th>H</th><th>Y</th></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td></tr></table>	**3**	1 mark per correct complete column. Allow for follow through error. Column H = NOT G.. Column Y = F OR.

Question			Expected response	Max mark	Additional guidance
10.	(a)		Saw blade: **rotary.** Pneumatic piston: **reciprocating.**	**2**	1 mark for saw blade motion. 1 mark for piston motion. Accept rotational/reciprocal. Do not accept rotating.
	(b)		*When an increase in pressure is detected by valve 3…* …and when valve 1 is actuated (air is sent actuating valve 4), causing the piston to instroke… valve 7 is actuated then there is a time delay… …then valve 4 actuates causing the piston to outstroke.	**3**	1 mark for AND control with valve 1 and 3 causing the piston to instroke. 1 mark for time delay after valve 7 being actuated. 1 mark piston outstroke after valve 4 actuated and valve 7/time delay.
	(c)			**1**	X on lower pipe to double acting cylinder. Accept X on the bottom exhaust port of the 5/2 valve.
	(d)		The control of the piston movement could be easily changed/updated. The piston time delay could be easily changed/shortened. The piston time delay could be more consistent/accurate.	**1**	Descriptive response relating to advantage of microcontroller control of piston movement. Do not accept fewer components or cost savings.

Question			Expected response	Max mark	Additional guidance
10.	(e)	(i)	$A_{piston} = \frac{\pi d^2}{4}$ $A_{piston} = \frac{3 \cdot 14 \times 88^2}{4} = 6079 \ (mm^2)$ $A_{rod} = \frac{\pi d^2}{4}$ $A_{rod} = \frac{3 \cdot 14 \times 24^2}{4} = 452 \cdot 2 \ (mm^2)$ $A_{effective} = A_{piston} - A_{rod}$ $A_{effective} = 6079 - 452 \cdot 2$ $A_{effective} = 5627$ **$A_{effective}$ = 5600 mm^2 (2 sf)**	**3**	1 mark for area of rod (unit not required). 1 mark for area of piston (unit not required). 1 mark for correct subtraction answer with unit. Using the π function will give different intermediary values (6082 and 452·4) but same final answer to 2 sf.
		(ii)	$P = \frac{F}{A}$ $0 \cdot 20 = \frac{F}{5600}$ F = 0·20 x 5600 F = 1120 **F = 1·1 kN (2 sf)**	**3**	1 mark for substitution Allow FTE from part (e)(i). 1 mark for transposition. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	$\Sigma CWM = \Sigma ACWM$ $(R_A \times 2{\cdot}4) = (680 \times 0{\cdot}4) + (930 \times 3{\cdot}6)$ $R_A = \frac{3620}{2{\cdot}4}$ $R_A = 1508$ **R_A = 1·5 kN (2 sf)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
		(ii)	$\Sigma F_{vertical} = 0$ $930 + 680 = 1500 + R_B$ $R_B = 1610 - 1500$ $R_B = 110$ **R_B = 110 N (2 sf)**	**2**	1 mark for substitution Allow FTE from part a(i). 1 mark for correct answer from given working with unit. If moments used to determine R_B then accepted 101·7 N .
	(b)		Equilibrium.	**1**	Ignore additional description
	(c)		$\sigma = \frac{F}{A}$ $0{\cdot}06 = \frac{2500}{A}$ $A = \frac{2500}{0{\cdot}06}$ A = 41670 **A = 42000 mm^2 (2 sf)**	**3**	1 mark for substitution.. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(d)		Design how to connect the visitor centre to the national grid. Calculate the electrical power requirements of the visitor centre. Select appropriately rated cables. Calculate the lighting requirements/ plan the lighting layout.	**2**	1 mark for any appropriate descriptive response of an engineer's **task** (design/calculate/select/model…) **and** the electrical **aspect** (must be linked to design of visitor centre). Not design a circuit/wiring on its own. Not electronic or electrician related.

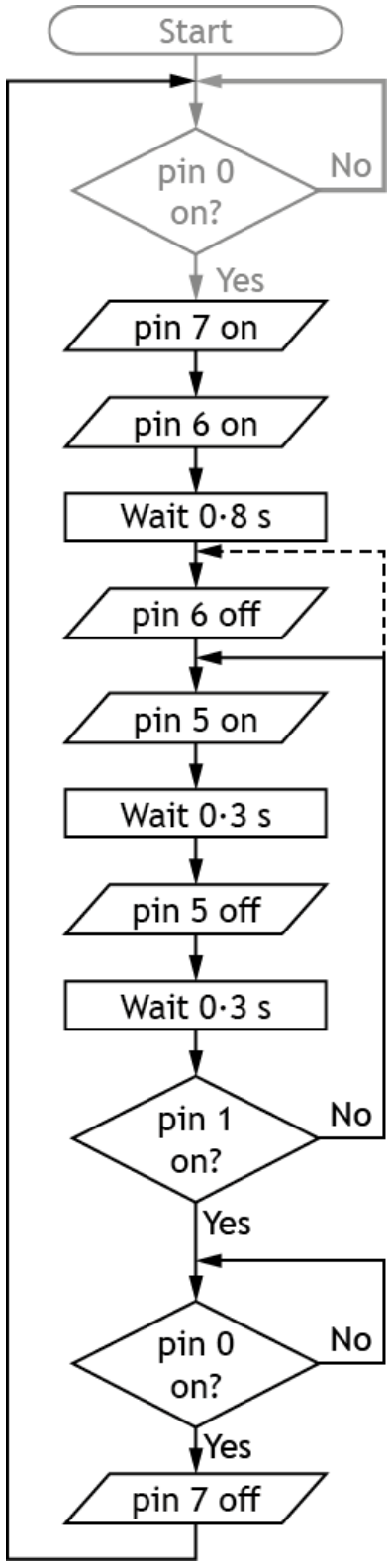
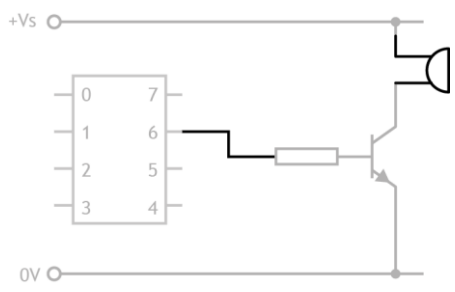
Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	time = 60 + 20 = 80 (s) E_e = V I t E_e = 230 x 12 x 80 E_e = 220800 **E_e = 220 kJ (2 sf)**	**3**	1 mark for determining time in seconds. Unit not required. 1 mark for substitution. Allow FTE for time. 1 mark for correct answer from given working with unit. Accept calculating energy from power x time.
		(ii)	$\eta = \frac{Eout}{Ein}$ $0 \cdot 64 = \frac{Eout}{220000}$ Eout = 0·64 x 220000 Eout = 140800 **Eout = 140 kJ (2 sf)**	**3**	1 mark for substitution Allow for FTE from part a(i). 1 mark for transposition.. 1 mark for correct answer from given working with unit
	(b)		Lubricate winch axles to reduce friction. Use a V belt so that there is less slippage/energy lost.	**2**	Explanation must relate to motorised winch modifications. 1 mark for cause that increases the efficiency of the winch. Accept use of lubrication/bearings/ toothed belt/V belt chain. 1 mark for effect on friction/energy losses from given cause.
	(c)		600 (N)	**1**	Unit not required
	(d)		$\varepsilon = \frac{\Delta l}{l}$ $0 \cdot 0030 = \frac{\Delta l}{2700}$ Δl = 0·003 x 2700 Δl = 8·1 **Δl = 8·1 mm (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
13.	(a)		All lamps will have maximum brightness/230 volts. If one lamp fails the rest will remain on.	**2**	Descriptive response. 1 mark for each advantage. Do not accept all lamps will be the same brightness/voltage on its own.
	(b)			**2**	1 mark for correct symbol (accept if line in centre of triangle is omitted. 1 mark for correct orientation and connection. Allow FTE.
	(c)		*As the light level decreases…* …the resistance (of the LDR) increases.. …voltage (V_{in}) will increase.	**2**	Descriptive response. 1 mark for resistance of LDR increase. 1 mark for input voltage increase. Apply FTE based on resistance response.
	(d)		V_{in} will increase.	**1**	No FTE from 13(c).

Question			Expected response	Max mark	Additional guidance
13.	(e)		$5 - 2{\cdot}7 = 2{\cdot}3$ (V) $\frac{R_1}{1{\cdot}6} = \frac{2{\cdot}3}{2{\cdot}7}$ $R_1 = \frac{2{\cdot}3}{2{\cdot}7} \times 1{\cdot}6$ R = 1·363 **R = 1·4 kΩ (2 sf)** **OR** $V_R = IR$ $2{\cdot}7 = I \times 1{\cdot}6$ I = 1·688 (mA) $V_R = 5{\cdot}0 - 2{\cdot}7 = 2{\cdot}3$ (V) V = IR $2{\cdot}3 = 1{\cdot}688 \times R_R$ $R = \frac{2{\cdot}3}{1{\cdot}688}$ R = 1·363 **R = 1·4 kΩ (2 sf)**	**4**	1 mark for voltage across variable resistor. Ignore unit. 1 mark for substitution (apply FTE and accept 5·0 V if V_1 is not calculated). 1 mark for transposition. 1 mark for correct answer from given working with unit. 1 mark for calculating current (ignore unit). 1 mark for calculating voltage V_R (ignore unit). 1 mark for transposition (allow FTE). 1 mark for correct answer from given working with unit.
13.	(f)		700 (lux)	**1**	Unit not required.

Question			Expected response	Max mark	Additional guidance
13.	(g)		Quicker to develop solution. Easier to change circuit during testing. Reduces cost of designing as components will not be destroyed. Safer as 230 V circuit can be tested without fear of electrocution. No risk of damage to any actual components.	**2**	Descriptive advantage. 1 mark for each relevant statement. Not faster, cheaper, easier or safer on its own. Do not accept testing can be carried out without an advantage. Cost responses must relate to speed or no damaged components.
14.	(a)		The harvester would be expensive to buy/maintain/run. Workers would lose their jobs therefore lose income. Harvester would be able to pick the fruit quicker/more fruit picked in a day meaning more profit. Increase profit for the farmer as wages would be reduced. Only ripe fruit would be picked therefore reducing waste increasing overall tonnage and profit. No need to house so many workers therefore increased profits. Workers would move away causing local shops to lose income.	**2**	1 mark for each appropriate economic description. Job and speed based responses must include reference to income/profit.

Question			Expected response	Max mark	Additional guidance
14.	(b)		$2200 \times 12 = \text{Output speed} \times 48$ $\text{Output speed} = \frac{26400}{48}$ Output speed = 550 (revs min^{-1}) $550 \times 16 = \text{Output speed} \times 24$ $\text{Output speed} = \frac{8800}{24}$ Output speed = 366·7 **Output speed = 370 revs min^{-1} (2 sf)** OR $\frac{output\ speed}{input\ speed} = \frac{A}{B} x \frac{C}{D}$ $\frac{\text{output speed}}{2200} = \frac{12}{48} \times \frac{16}{24}$ $\text{output speed} = \frac{12}{48} \times \frac{16}{24}$ x 2200 $\text{Output speed} = \frac{1}{6} \times 2200$ Output speed = 366·7 **Output speed = 370 revs min^{-1} (2 sf)**	**4**	1 mark for substitution. 1 mark for correct answer from given working (unit not required). 1 mark for substitution Allow FTE. 1 mark for correct answer from given working with unit. Do not accept RPM. 1 mark for first ratio. 1 mark for second ratio. 1 mark for transposition (2200/6 if ratios inverted). 1 mark for answer from working with unit.

Question			Expected response	Max mark	Additional guidance
15.	(a)			**9**	Pin numbers must be correct where applicable. Pin 7 on and off positions – 1 mark. Pin 6 on and off positions – 1 mark. All three delays positions (0·8 s and 2 x 0·3 s) with unit – 1 mark. Pin 5 on and off in positions – 1 mark. Pin 1 on ? with Y/N – 1 mark. Loop and arrow (Pin 1 on ?) back to before Pin 5 on – 1 mark. Pin 0 on ? with Y/N loop and arrow – 1 mark. Continuous loop to start with arrow – 1 mark. All marked symbols correct – 1 mark. Ignore any additional steps.
	(b)			**2**	1 mark pin 6 connection. 1 mark for buzzer symbol and connection.

[END OF MARKING INSRUCTIONS]