National
Qualifications
RESOURCE

X823/76/01 Engineering Science

Marking Instructions

Please note that these marking instructions have not been standardised based on candidate responses. You may therefore need to agree within your centre how to consistently mark an item if a candidate response is not covered by the marking instructions.

General marking principles for Higher 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.

(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) Candidates can answer programming questions in any appropriate programming language. Award marks where the intention of the coding is clear, even where there are minor syntax errors.

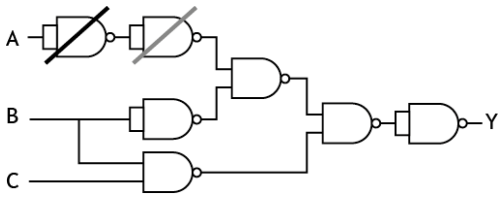
(j) For 'Explain' questions, only award marks where the candidate goes beyond a description, for example by giving a reason, or relating cause to effect, or providing a relationship between two aspects.

(k) Where separate space is provided for rough working and a final answer, only award marks for the final answer. Ignore all rough working.

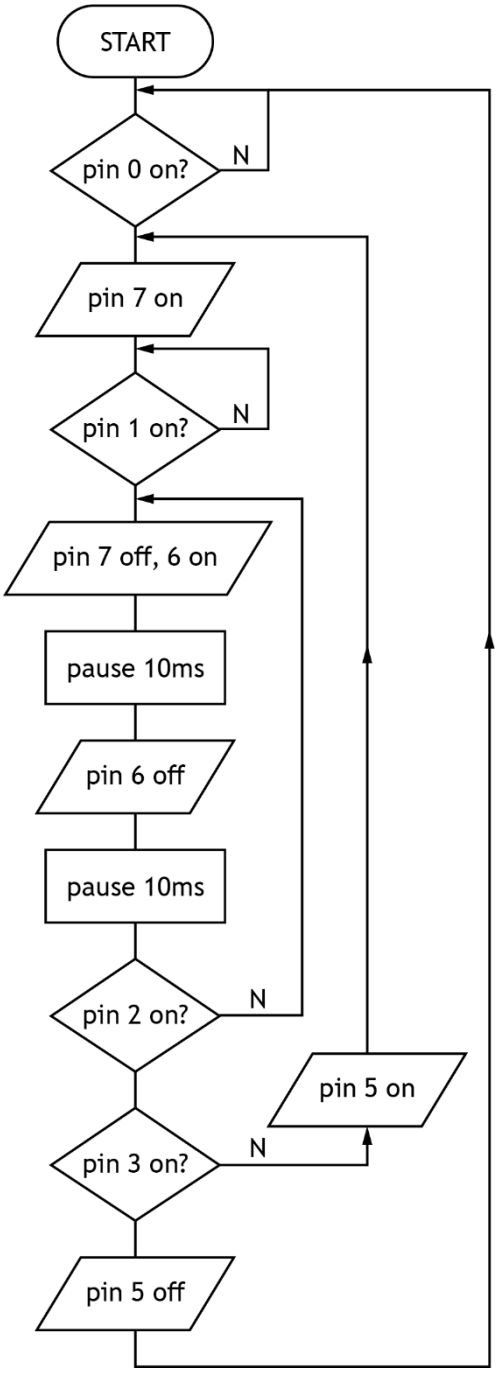
Marking instructions for each question

Section 1

Question			Expected response	Max mark	Additional guidance
1.	(a)		Material will stretch then when the load is removed it will return to its original shape.	**1**	
	(b)		Material will stretch and when the load is removed it will **not** return to its original shape.	**1**	
2.			V_{IN} = 12 x (270 / 600) V_{IN} = 5.4 V V_{OUT} = - (Rf / R_i) x V_{IN} V_{OUT} = - (27 / 12) x 5.4 V_{OUT} = -12.15 **V_{OUT} = -12 V (2s.f.)**	**3**	**1 Mark** for V_{IN}. **1 Mark** for identification of correct configuration. **1 Mark** for V_{OUT} with units.
3.			UDL 0.75 x 5.7 = 4.275 Moments at A (6.3sin65 x 1.5) + (4.275 x 2.85) = 5.7 x B B = 3.64 **B = 3.6 kN (2s.f.)** B is vertically upward.	**5**	**1 Mark** for UDL. **1 Mark** for vertical component of 6.3 kN. **1 Mark** for distance associated with UDL. **1 Mark** for B with units. **1 Mark** for stating or drawing direction.
4.			A structural engineer would know • material properties to help make the correct choice for a particular purpose • UDLs and their impact on a structure • about the environment the ship would operate in (temperatures, pressures, potential for corrosion, etc)	**2**	Must be a descriptive response. **1 Mark** for each response. Each piece of knowledge must be different and relate to question.

Question			Expected response	Max mark	Additional guidance
5.	(a)		$P = V^2 / R$ $R = V^2 / P$ $R = 12^2 / 4.6$ $R = 31.3043478$ **$R = 31\ \Omega$ (2s.f.)**	**1**	**1 mark** for final answer with units.
	(b)		$R_T = V / I$ $R_T = 12 / 0.38$ $R_T = 31.5789$ $R_{MOSFET} = R_T - R_{MOTOR}$ $R_{MOSFET} = 31.5789 - 31$ $R_{MOSFET} = 0.5789$ **$R_{MOSFET} = 0.58\ \Omega$ (2s.f.)**	**2**	**1 mark** for calculating R_T. **1 mark** for calculating R_{MOSFET} with units. Use of 31.3043478 acceptable for R_{MOTOR}.
	(c)		$P = I^2R$ $P = 0.38^2 \times 0.58$ $P = 0.083752$ **$P = 0.084$ W (2s.f.)**	**1**	**1 mark** for final answer with units.
6.				**4**	**1 Mark** for NOT. **1 Mark** for OR. **1 Mark** for AND. **1 Mark** for simplification indicated.

Section 2

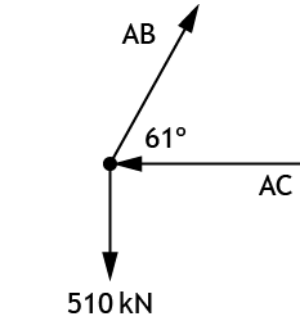
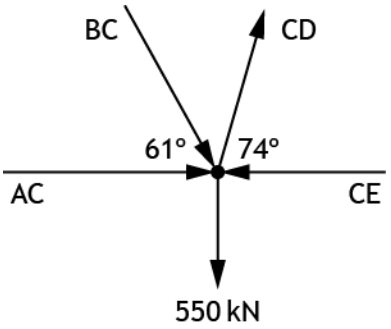
Question			Expected response	Max mark	Additional guidance
7.	(a)			**8**	**1 mark** for 1st decision including loop. **1 mark** for pin 7 on and decision. **1 mark** for pin 6 on and off. **1 mark** for pin 6 suitable delays. **1 mark** for PWM loop. **1 mark** for pin 3 on decision. **1 mark** for pin 5 on and loop. **1 mark** for pin 5 off and loop. Referencing names in flow chart is also acceptable. Delay/pause times must be equal.
	(b)		When pin 7 is on and pin 6 is off the motor will rotate clockwise. When pin 7 is on and pin 6 is on it will rotate anticlockwise. If pin 7 is off it will stop.	**3**	**1 mark** to be given if descriptions of CW and ACW movement are reversed.

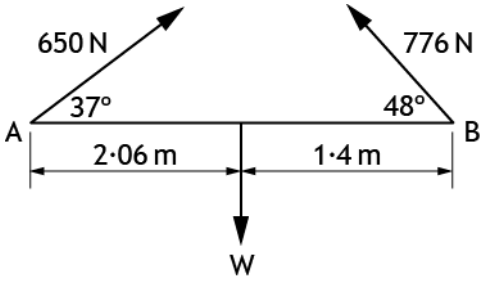
Question			Expected response	Max mark	Additional guidance
8.	(a)		When the light level is high the LDR will have a low resistance so the voltage across it will be small. As light level drops the resistance of the LDR will increase and so will the voltage across it. Op-amp 1 will switch positive when the voltage at the non-inverting input rises above the voltage at the inverting input and the LED will switch on.	**3**	**1 mark** for each relevant point **up to a maximum of 3**.
	(b)		R_{ldr} = 180 Ω V_{inv} = 5x (180/255) = 3.53 V $V_{non\text{-}inv}$ = 5x (750/2750) = 1.36 V V_{diff} = 120/60 x (3.53-1.36) V_{diff} = 4.3315 V_{diff} = **4.3 V (2s.f.)**	**4**	**1 mark** for resistance in the range 180-200Ω. **1 mark** for each calculation.
	(c)		Voltage reference at 3rd op-amp = 5x(450/940) = 2.393617021 = 2.3936 **= 2.4 V (2s.f).**	**2**	**1 mark** for identifying the three op-amps that need to be switched +ve. **1 mark** for the calculation of voltage.
	(d)		If the resistance is decreased the LEDs will come on at a higher light level. If the resistance is increased it will need to be darker before the LEDs come on. It will adjust the level of light required to switch the LEDs on.	**2**	
	(e)		V_{comp} = 8 x 0.85 = 6.8 V R = (6.8-2.3)/0.0052 = 865.3846 Ω **= 870 Ω (2s.f.)**	**3**	**1 mark** for output voltage from op-amp. **1 mark** for voltage over resistor. **1 mark** for the resistance.

Question			Expected response	Max mark	Additional guidance
8.	(f)		When the reading is less than 50 the program will jump to the label 'level1' and the m/s ratio will be set so that the LEDs are on all the time (are at full brightness). When the reading is between 50 and 99 the m/s ratio is changed so that the LEDs flash with slightly longer on time. This will keep them bright but not as bright as they were. When the reading is between 100 and 149 the m/s ratio will keep the LEDs off for proportionately longer so they will appear even dimmer. If the reading is 150 or over then the LEDs are off all the time.	**4**	**1 mark** for each suitable response.
	(g)		$Z = (A \oplus B) + (\overline{A \cdot D}) + (\overline{C} \cdot D)$	**4**	**1 mark** for XOR with A and B. **1 mark** for NAND with A and D. **1 mark** for AND with NOT C and D. **1 mark** for OR between the three expressions. Brackets around NAND and AND functions not required.

Question			Expected response	Max mark	Additional guidance
9.	(a)		$I_b = I_c/h_{FE}$ = 56/27 = **2.1 mA (2s.f.)**	**1**	
	(b)		V_{res} = I x R = 0.0021 x 1500 = 3.15 V V_{vr} = 3.15 + 0.7 = 3.85 = **4 V (1s.f.)**	**2**	**1 mark** for voltage across resistor. **1 mark** for voltage over variable resistor. Allow follow through error from (a).
	(c)		I_{vr} = 4 / 2500 = 1.6 mA I_{vr} = **1.6 mA (2s.f.)**	**1**	
	(d)		I_{therm} = 1.09 + 1.35 = 2.44 mA V_{vr} = 1.09 x 2500 = 2.725 V V_{therm} = 6.0 - 2.725 = 3.275 V R_{therm} = 3.27 / 0.00244 = 1342.213 = **1.3 kΩ (2s.f.)** Temperature = 210-225 °C	**5**	**1 mark** for current in thermistor. **1 mark** for voltage over variable resistor. **1 mark** for voltage over thermistor. **1 mark** for resistance of thermistor. **1 mark** for temperature from graph.
	(e)		Valve C is actuated by vA or vD+E. C1 outstrokes when vC is actuated and actuates vG. vH is actuated by vG or vD+E. When vH is actuated C2 outstrokes and actuates vK. After a delay vH+vC are actuated. Both cylinders then instroke. vC and vH are also actuated by vI. vK cuts off the air supply to vG and allows C2 to instroke.	**6**	**1 mark** for each relevant point.
	(f)		Fewer valves would be required meaning costs would reduce. The system could be reprogrammed to perform other tasks. It would be quicker and easier to make alterations if errors were found in the system.	**2**	**1 mark** for each relevant explanation. Each must have a cause and effect.

Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	Site surveying/research. Ground soil/core samples. Strata/geology research. Drainage impact assessment. Assessment of impact on traffic. Project management.	**2**	**1 mark** for each adequate descriptive response.
		(ii)	Monitoring contamination/pollutant levels for impact on nearby residents/wildlife/fauna. Monitoring air quality for dust levels for impact on nearby residents. Monitoring water quality for impact of pollution from construction work. Monitoring impact on fauna and wildlife. Monitoring waste management and recycling procedure to limit environmental impact. Monitoring noise levels for impact on nearby residents.	**1**	**1 mark** for adequate descriptive response.
	(b)	(i)	T = Fr = (924 x 3) x (0.5 x 12.4) = 17186.4 Nm = 17200 Nm (3s.f.) = **17.2 KNm (3s.f.)**	**2**	**1 mark** for 3 cutting blades and correct radius. **1 mark** for torque from values used.
		(ii)	n = 9.93/60 = 0.1655 revs sec^{-1} P = 2πnT = 2 x π x 0.1655 x 17200 = 17885.72 W = 17900 W (3s.f) = **17.9 KW (3s.f.)**	**2**	1 mark for calculating n. 1 mark for final answer.
	(c)	(i)	To support the load on a shaft as it rotates.	**1**	
		(ii)	A roller bearing will not wear out as quickly with a large load compared to a ball bearing due to increased surface area contact.	**1**	
	(d)		E_p after lift = 120000 x 9.8 x 42.6 = 50097600 J 50097600 = 88 x 910 x (T - 17) => T— 17 = 625.594 => T = **640 ℃ (2s.f.)**	**3**	

Question			Expected response	Max mark	Additional guidance
10.	(e)		<u>Node A</u> $\Sigma F_V = 0$ $\Rightarrow AB_V = 510$ kN AB = 510/sin61 = 583.11 kN **AB = 580 kN (2s.f.) (1 mark)** $AB_H = 583\cos 61 = 282.644$ kN $\Sigma F_H = 0$ $\Rightarrow$ AC = 282.644 kN **AC = 280 kN (2s.f.) (1 mark)** <u>Node C</u> $\Sigma F_V = 0$ $\Rightarrow CD_V = 583\times\sin 61 + 550$ = 1059.903 kN CD = 1060/sin74 = 1102.6167 kN **CD = 1100 kN (2s.f.)(1 mark)** TIE (tension) – **(1 mark)** $CD_H = 1103\cos 74 = 304$ kN $\Sigma F_H = 0$ CE = 283 + 283 + 304 = 870 kN **(1 mark)** STRUT (compression) – **(1 mark)**	**6**	 

Question			Expected response	Max mark	Additional guidance
11.	(a)		Improved journey times due to better traffic flow. Improved access and increased comfort to transport for rail passengers. Improved public access to amenities in city centre.	**4**	**2 marks** for each descriptive appropriate impact explained with cause (**1 mark**) and effect (**1 mark**).
	(b)	(i)		**2**	**1 mark** for three forces (including angles). **1 mark** for both dimensions.
		(ii)	W = 650sin37 + 776sin48 (**1 mark**) = 967.86 N **970 N (2s.f.)** (**1 mark**)	**2**	
	(c)		F_{CH} = 530cos65 + 776cos48 – 650cos37 = 224.12 N F_{CV} = 650sin37 + 776sin48 – 530sin65 = 487.52 N F_C = $\sqrt{224.12^2 + 487.52^2}$ = 536.57 N **540 N (2s.f.)** tan Θ = 224.12 / 487.52 => Θ = 24.69^O **25^O (2s.f.)**	**6**	**1 mark** for correct substitution. **1 mark** for answer. **1 mark** for correct substitution. **1 mark** for answer. **1 mark** for magnitude. **1 mark** for angle.
	(d)	(i)	A_{eff} = (π x 72^2/4) – (π x 67^2/4) = 545.8517 mm^2 σ = 32700 / 545.8517 = 59.9063 N mm^{-2} ε = σ/E = 59.9063/70000 = $8.558x10^{-4}$ Δl = $8.558x10^{-4}$ x 2700 = 2.3106 **= 2.3 mm (2 s.f.)**	**6**	**1 mark.** **1 mark.** **1 mark.** **1 mark** for E from data booklet, **1 mark** for calculation. **1 mark** for final answer.
		(ii)	Increase the effective area/tube thickness. Change to a stronger material.	**2**	

[END OF MARKING INSTRUCTIONS]