H

National
Qualifications
2025

2025 Engineering Science

Higher

Question Paper Finalised 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/rounding at an early stage in a multi-stage calculation, award marks for correct follow-on working in subsequent stages. Do not award marks if this 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. $6.\dot{6}$, 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) 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.

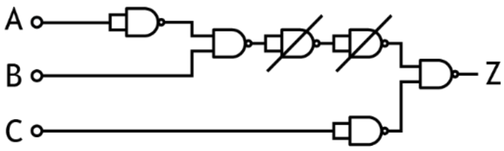
(j) For 'Describe' questions, candidates must provide a statement or structure of characteristics and/or features, in the context of and appropriate to the question.

(k) 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.

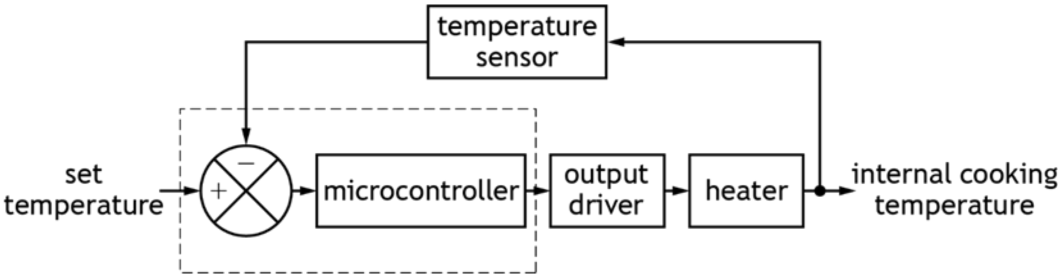
(l) Where separate space is provided for rough working and a final answer, only award marks for the final answer. Ignore all rough working.

Marking instructions for each question

Section 1

Question			Expected response	Max mark	Additional guidance
1.				**4**	1 mark for NOT plus connection. 1 mark for AND plus connections. 1 mark for OR plus connections. 1 mark for simplification.
2.	(a)		$V_o = \left(1 + \frac{R_f}{R_i}\right) \times V_i$ $V_o = \left(1 + \frac{270}{12}\right) \times 1.8$ $V_o = 42.3$ **V_o = 42 mV (2sf)**	**1**	1 mark for final answer with unit.
	(b)		By decreasing the value of R_f (Feedback resistance – 270kΩ). By increasing the value of R_i (Input resistance – 12kΩ). Decreasing the ratio of R_f to R_i.	**1**	1 mark for correct description of R_f or R_i.
	(c)		Summing amplifier	**1**	Accept summing.
3.			Length AB = 1.1 tan 35 Length AB = 0.770228292 m ΣM = 0 ΣCWM = ΣACWM B x 0.770228292 = 1.7 x 1.1 $B = \frac{(1.7 \times 1.1)}{0.770228292}$ B = 2.427851612 **B = 2.4 kN (2sf)** Direction = right to left horizontally ←	**4**	1 mark for length AB (1.1 tan 35) (no units required). 1 mark for substitution. Allow FTE from Length AB. 1 mark for magnitude with units. Allow FTE from substitution. 1 mark for direction (accept arrow at roller B).

Question			Expected response	Max mark	Additional guidance
4.				3	1 mark for error detector in negative configuration (correct + and – position). 1 mark for microcontroller/control unit (do not accept 'control' on its own or 'op-amp'). 1 mark for temperature sensor/heat sensor/thermostat/thermocouple/ thermistor (do not accept thermometer).



Question			Expected response	Max mark	Additional guidance
5.			$\Sigma F_V = 0$ $\Sigma F_{up} = \Sigma F_{down}$ $550 \sin 65 = (160 \sin 41) + F_{VR}$ $F_{VR} = (550 \sin 65) - (160 \sin 41)$ $F_{VR} = 393.4998382$ $\Sigma F_H = 0$ $\Sigma F_{right} = \Sigma F_{left}$ $(550 \cos 65) + (160 \cos 41) = F_{HR}$ $F_{HR} = 353.1935768$ $R^2 = F_{VR}^2 + F_{HR}^2$ $R = \sqrt{F_{VR}^2 + F_{HR}^2}$ $R = \sqrt{393.4998382^2 + 353.1935768^2}$ $R = 528.7606503$ **R = 530 N (2sf)** $\theta = \tan^{-1}\left(\frac{393.4998382}{353.1935768}\right)$ $\theta = 48.08980836$ **θ = 48° (2sf)**	4	 1 mark for F_{VR} (no units required). 1 mark for F_{HR} (no units required). 1 mark for R with units. Allow FTE from F_{VR} and F_{HR} 1 mark for Θ with units. Allow FTE from F_{VR} and F_{HR}.
6.			It reduces the risk of valuable cars getting damaged when filming. Only one car needs to be used on the set meaning money can be saved. Special effects can give the impression of a car being damaged or broken without actually having to damage a real car.	2	Accept any other acceptable response. Response must be descriptive.

Section 2

Question			Expected response	Max mark	Additional guidance
7.	(a)		Material C is more ductile than material B. Material C is not as strong as material A or B. Material C is less brittle than material B. Material C is more elastic than A and B. Material C is more plastic than B. Material C is less plastic than A.	**3**	1 mark for each description that compares one material against another. Only 1 mark available per property.

<table>
<tr><th>Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>(b)</td><td>
<table>
<tr><th>Member</th><th>Magnitude</th><th>Nature</th></tr>
<tr><td>AB</td><td>24 kN</td><td>Tie</td></tr>
<tr><td>AD</td><td>11 kN</td><td>Strut</td></tr>
<tr><td>BD</td><td>22 kN</td><td>Strut</td></tr>
<tr><td>BC</td><td>17 kN</td><td>Tie</td></tr>
</table>

Node A

$\Sigma F_V = 0$
$\Sigma F_{up} = \Sigma F_{down}$
$21 = AB \sin 62$

$AB = \frac{21}{\sin 62}$

AB = 23.78397106
AB = 24 kN (2sf)

$\Sigma F_H = 0$
$\Sigma F_{right} = \Sigma F_{left}$
AD = AB cos 62
AD = 24 cos 62
AD = 11.26731751
AD = 11 kN (2sf)

Node B

$\Sigma F_V = 0$
$\Sigma F_{up} = \Sigma F_{down}$
$AB \sin 62 = BD \sin 74$
$24 \sin 62 = BD \sin 74$

$BD = \frac{24 \sin 62}{\sin 74}$

BD = 22.04471719
BD = 22 kN (2sf) strut

$\Sigma F_H = 0$
$\Sigma F_{right} = \Sigma F_{left}$
AB cos 62 + BD cos 74 = BC
24 cos 62 + 22 cos 74 = BC
BC = 17.33133933
BC = 17 kN (2sf) tie
</td><td>7</td><td>
1 mark for magnitude of AB with unit.
1 mark for magnitude of AD with unit.
1 mark for magnitude of BD with unit.
1 mark for magnitude of BC with unit.
1 mark for horizontal of BD.
1 mark for nature of BD.
1 mark for nature of BC.

1 mark for AB with unit.

1 mark for AD with unit.
Allow FTE from AB

1 mark for BD with unit.
Allow FTE from AB.

1 mark for nature.

1 mark for magnitude F_{HBD} (22cos74).
Allow FTE from BD.

1 mark for BC with unit.
Allow FTE from AB and BD.

1 mark for nature.
</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
	(c)	(i)	Calculate • reaction forces using the sum of moments • the magnitude and nature of forces in members using nodal analysis • the cross-sectional area of materials using factor of safety/stress and strain/Young's Modulus Determine • if a member is in compression or tension using nodal analysis • appropriate materials with suitable material properties Simulate • the design using computer simulation software to calculate forces/test structural integrity	**2**	1 mark for each response. Must be a descriptive response relating skill to a specific purpose.
		(ii)	Select manufacturing methods that are eco-friendly to reduce the environmental impact. Select materials that are eco-friendly/sustainable. Determining a waste management plan for use during the construction. Introduction of low carbon technologies to reduce carbon footprint. Recommend adaptations to the design to limit the impact on the environment e.g. soil/water/ wildlife/plants	**2**	1 mark for each role described.

Question			Expected response	Max mark	Additional guidance
8.	(a)		$P = 2\pi \times n \times T$ $62000 = 2\pi \times n \times 230$ $n = \dfrac{62000}{2\pi \times 230}$ $n = 42.902636833$ **n = 43 revs sec^{-1} (2 sf)**	**1**	1 mark for answer with units. Do not accept RPM.

Question			Expected response	Max mark	Additional guidance
	(b)		Power required from battery $\eta = \frac{P_{out}}{P_{in}}$ $0.81 = \frac{(4 x 62000)}{P_{in}}$ $P_{in} = \frac{(4 x 62000)}{0.81}$ P_{in} = 306172.8395 *W* $P = \frac{E}{t}$ $306172.8395 = \frac{363000000}{t}$ $t = \frac{363000000}{306172.8395}$ t = 1185.604839 **t = 1200 s (2sf)** Alternative solution: $\eta = \frac{E_{out}}{E_{in}}$ $0.81 = \frac{E_{out}}{363000000}$ E_{out} = 0.81 x 363000000 E_{out} = 294030000 $P = \frac{E}{t}$ $248000 = \frac{294030000}{t}$ $t = \frac{294030000}{248000}$ t = 1185.604839 **t = 1200 s (2sf)**	**2**	1 mark for total power requirement. 1 mark for time with units. Allow FTE from P_{in} Alternative solution: 1 mark for E_{out}. 1 mark for time with units. Allow FTE from E_{out}

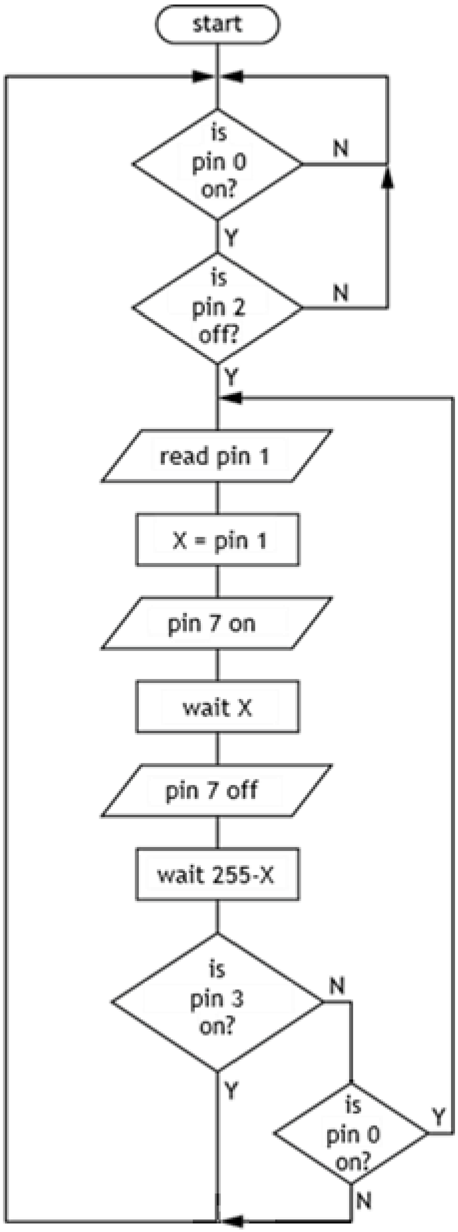
Question			Expected response	Max mark	Additional guidance
	(c)		Economic: Reduces running cost due to less electricity being used/reduced wear and tear. Lower operating costs and longer range would make the car more appealing, boosting sales. Social: Longer journey times would be possible allowing people to travel further without having to recharge.	2	1 mark for one economic relating to efficiency. 1 mark for one social relating to efficiency. Credit should be given for any other suitable response which is a description.
	(d)		$E_k = \frac{1}{2} \times mv^2$ $E_k = \frac{1}{2} \times 2200 \times \left(31^2 - 12^2\right)$ E_k = 898700 J Alternative method for E_k: $E_k = \left(\frac{1}{2} \times mv_{inital}{}^2\right) - \left(\frac{1}{2} \times mv_{final}{}^2\right)$ $E_k = \left(\frac{1}{2} \times 2200 \times 31^2\right) - \left(\frac{1}{2} \times 2200 \times 12^2\right)$ E_k = 898700 J $\eta = \frac{E_{recovered}}{E_k}$ $0.68 = \frac{E_{recovered}}{898700}$ $E_{recovered}$ = 898700 x 0.68 $E_{recovered}$ = 611116 **$E_{recovered}$ = 610 kJ (2sf)**	3	1 mark for the difference between 31^2 and 12^2 (either as shown or through finding the difference between two separate E_k calculations). 1 mark for calculation of E_k (no units required). Allow FTE from velocity change. 1 mark for $E_{recovered}$, units required. Allow FTE from E_k

Question			Expected response	Max mark	Additional guidance
	(e)		Reduces wear and tear which means fewer repairs. Reduces energy losses so makes the system more efficient.	2	1 mark for first cause and effect. 1 mark for second cause and effect. Credit to be given for any other suitably detailed explanation referring to failure or losses.
	(f)		$V_{out} = -\frac{R_f}{R_i} V_{in}$ $7 = -\frac{33}{33} V_{in}$ $V_{in} = \frac{7}{\left(-\frac{33}{33}\right)}$ $V_{in} = -7$ V $V_{out} = -R_f\left(\frac{V_1}{R_1}+\frac{V_2}{R_2}+\frac{V_3}{R_3}\right)$ $-7 = -R_f\left(\frac{5}{22}+\frac{5}{44}+\frac{0}{88}\right)$ $-7 = -R_f\left(\frac{20}{88}+\frac{10}{88}+\frac{0}{88}\right)$ $-7 = -R_f\left(\frac{30}{88}\right)$ $-R_f = \frac{-7}{\left(\frac{30}{88}\right)}$ $-R_f = -20.53333333$ $R_f = 20.53333333$ **R_f = 21 kΩ (2sf)**	**3**	1 mark for input to inverting amp/summing, no unit required. 1 mark for substitution. Accept without $\frac{0}{88}$. 1 mark for final answer with unit. Allow FTE from V_{in}/substitution.

Question			Expected response	Max mark	Additional guidance
9.	(a)		$V_{refA} = 5 \times \frac{22 + 4.7}{22 + 4.7 + 22}$ $V_{refA} = 5 \times \frac{26.7}{48.7}$ $V_{refA} = 2.741273101$ **V_{refA} = 2.7 V (2sf)**	**2**	1 mark for substitution. 1 mark for final answer with unit. Allow FTE from substitution.
	(b)	(i)	Saturation Voltage = 9 x 0.82 Saturation Voltage = 7.38 V Voltage across resistor = 7.38 — 0.7 Voltage across resistor = 6.68 V $V_{res} = I_b \times R_{res}$ $6.68 = I_b \times 12000$ $I_b = \frac{6.68}{12000}$ $I_b = 0.000556667$ **I_b = 0.56 mA (2sf)**	**3**	1 mark for saturation voltage. 1 mark for voltage across resistor. Allow FTE from saturation voltage. 1 mark for final answer with unit. Allow FTE from voltage across resistor.
		(ii)	$h_{FE} = \frac{I_c}{I_b}$ $230 = \frac{I_c}{0.000610}$ $I_c = 230 \times 0.000610$ $I_c = 0.1403$ **I_c = 0.14 A (2 sf)**	**1**	1 mark final answer with unit.

Question			Expected response	Max mark	Additional guidance
	(c)		When V_{heat} is between 0 V and V_{refB}: • op-amp B saturates positively/ op-amp A saturates negatively • transistor B on, heater on/ transistor A off, extractor fan motor off When V_{heat} is between V_{refB} and V_{refA}: • both op-amps saturate negatively/ op-amp B saturates negatively • transistors off and outputs off/ Transistor B off, heater off When V_{heat} is greater than V_{refA}: • op-amp B will remain saturated negatively/op-amp A saturates positively • transistor B off and heater off/ transistor A on, extractor fan motor on	**6**	1 mark for each relevant description, up to a total of 6. Max 2 marks awarded for each heat condition.
	(d)		Change fixed resistors to variable resistors in the voltage divider. The values of the resistances in the voltage divider must change so that the values of V_{refB} and V_{refA} can be altered.	**2**	1 mark for adaptation. 1 mark for justification. Accept use of microcontroller-based circuit with valid justification.

Question			Expected response	Max mark	Additional guidance
10.	(a)		$Z = A \cdot (\overline{B+C} + D)$ Alternative solution: $Z = A \cdot (\overline{B} \cdot \overline{C} + D)$	**4**	1 mark for A with AND function and brackets. 1 mark for B+C. 1 mark for the NOT with B+C. Allow FTE from B+C. 1 mark for OR D. Alternative solution: 1 mark for A with AND function and correct brackets. 1 mark for both $\overline{B}$ and $\overline{C}$. 1 mark for AND function between B and C. 1 mark for OR D.

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td></td><td>(b)</td><td></td><td>
</td><td>9</td><td>1 mark for pin 0 on? with y/n and loop with arrow to start.

1 mark for pin 2 off? with y/n and loop with arrow.

1 mark for read pin 1.

1 mark for reading from pin 1 stored in X.

1 mark for pin 7 high and low.

1 mark for wait X.

1 mark for wait 255-X.

1 mark for pin 3 on? with y/n loop with arrow to start and correct connections.

1 mark for pin 0 on? with y/n and loops with arrows.

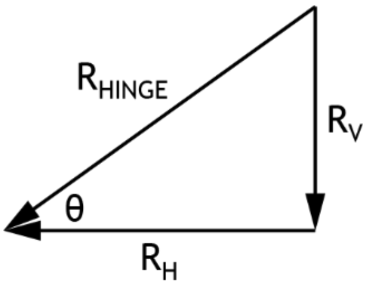
Ignore any additional steps.

Incorrect symbols – no mark awarded in the first instance, then allow FTE.</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
11.	(a)		$A = \frac{\pi d^2}{4}$ $A = \frac{\pi \times 22^2}{4}$ A = 380.1327111 mm^2 Safe working stress $\sigma = \frac{F}{A}$ $\sigma = \frac{42000}{380.1327111}$ σ = 110.4877291 Nmm^{-2} UTS = 300 Nmm^{-2} from data booklet $FoS = \frac{UTS}{SWS}$ $FoS = \frac{300}{110.4877291}$ FoS = 2.71523365 **FoS = 2.7 (2 sf)** Alternative method: $A = \frac{\pi d^2}{4}$ $A = \frac{\pi \times 22^2}{4}$ A = 380.1327111 mm^2 UTS = 300 Nmm^{-2} from data booklet Ultimate load = UTS x A Ultimate load = 300 x 380.1327111 Ultimate load = 114039.8133 N $FoS = \frac{UL}{SWL}$ $FoS = \frac{114039.8133}{42000}$ FoS = 2.71523365 **FoS = 2.7 (2 sf)**	**4**	1 mark for area (no unit required). 1 mark for safe working stress (no unit required). Allow FTE from area. 1 mark for UTS (no unit required). 1 mark for final answer (no units) Allow FTE from UTS/SWS. 1 mark for area (no unit required). 1 mark for UTS (no unit required). 1 mark for ultimate load (no unit required). Allow FTE from UTS/area. 1 mark for final answer (no units) Allow FTE for ultimate load.

Question			Expected response	Max mark	Additional guidance
	(b)	(i)	$A = (l_1 \times b_1) + (l_2 \times b_2)$ $A = (4 \times 75) + (4 \times 71)$ $A = 584\ mm^2$ $\sigma = \frac{F}{A}$ $\sigma = \frac{42000}{584}$ $\sigma = 71.91780822\ Nmm^{-2}$ $E = 196\ kNmm^{-2}$ from data booklet $\varepsilon = \frac{\sigma}{E}$ $\varepsilon = \frac{71.91780822}{196000}$ $\varepsilon = 0.000366927593$ $\varepsilon = \frac{\Delta l}{l}$ $0.000366927593 = \frac{\Delta l}{2.7}$ $\Delta l = 0.000366927593 \times 2.7$ $\Delta l = 0.000990704501$ **$\Delta l = 0.00099$ *m (2 sf)* (0.99mm)**	**5**	1 mark for area (no unit required). 1 mark for stress (no unit required). Allow FTE from area. 1 mark for E (no unit required). Units for σ and E must be aligned. 1 mark for strain (no unit required) Allow FTE from stress/E value. 1 mark for final answer (unit required). Allow FTE from strain.

Question			Expected response	Max mark	Additional guidance
	(b)	(ii)	The risk of loss of life due to failure is low. Cost implications of excessive material. Dynamic loading is very unlikely to exceed design loading. Lower likelihood of exposure to corrosion in factory interior.	**2**	1 mark for any valid statement that would indicate the FoS of 15 is too high/FoS of 2.5 is appropriate.
	(c)		UDL = 4.1 x 1.35 UDL = 5.535 kN $\Sigma M = 0$ $\Sigma CWM = \Sigma ACWM$ 5.535 x 1.425 = F sin 35° x 0.9 $\frac{5.535 \times 1.425}{0.9} = F \sin 35^o$ 8.76375 = F sin 35° $F = \frac{8.76375}{\sin 35^o}$ F = 15.27913186 **F = 15 kN (2sf)**	**3**	1 mark for UDL (no unit required). 1 mark for substitution. Allow FTE from UDL. 1 mark for final answer (unit required). Allow FTE from substitution.

Question			Expected response	Max mark	Additional guidance
	(d)		$R_V = 18 \sin 35^o - 6.48$ $R_V = 3.844375854$ kN $R_H = 18 \cos 35^o$ $R_H = 14.7447368$ kN $R_{hinge}^2 = R_V^2 + R_H^2$ $R_{hinge} = \sqrt{R_V^2 + R_H^2}$ $R_{hinge} = \sqrt{3.844375854^2 + 14.7447368^2}$ $R_{hinge} = 15.23766678$ **R_{hinge} = 15 kN (2sf)** $\tan\theta = \frac{R_V}{R_H}$ $\tan\theta = \frac{3.844375854}{14.7447368}$ θ = 14.61331626 **θ = 15° (2sf)**  	4	 1 mark for R_V (no unit required). 1 mark for R_H (no unit required). 1 mark for R_{hinge} (unit required). Allow FTE for R_V/R_H. 1 mark for **θ** (unit required). Also accept 75° if angle given to vertical.

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	When the push button is pressed… • a pilot signal changes the state of valve X, outstroking cylinder A • valve 2 actuates and sends a pilot signal which changes state of valve Y, outstroking cylinder B • ***valve 3 unactuates, cutting off the pilot signal to valve Z*** • valve 4 actuates and sends a pilot signal to change the state of valve Z • ***valve 5 unactuates, cutting off the pilot signal to valve X*** • a pilot signal is sent to change the state of valve Y, instroking cylinder B • at the same time, an air supply is sent to valve 5, and when cylinder B instrokes, valve 5 actuates • valve 5 sends a pilot signal to valve X, which changes state, and cylinder A instrokes • ***valve 3 actuates, sending a pilot signal to valve Z to reset the circuit***	**5**	1 mark awarded for each statement correctly describing the function of referred components in sequence of control, up to a maximum of 3 marks. Minimum of 2 marks reserved for statements in ***bold and italics***. Appropriate terminology i.e. outstroke/instroke/actuate/ change state should be used.
		(ii)	The function of valve Z is to control air flow in the system. This ensures that valves X and Y do not receive conflicting air signals, preventing the cylinders operating.	**2**	1 mark for cause. 1 mark for effect.
	(b)		Draws very little input current. Does not require a base resistor. Produces a high output current. It can drive larger loads.	**1**	1 mark for any valid advantage.
	(c)		The minimum required gate voltage for the MOSFET to conduct and switch on the output.	**1**	1 mark for minimum required voltage to switch on.

Question			Expected response	Max mark	Additional guidance
	(d)		$R_{thermistor}$ = 50kΩ V_{fixed} = 5 − 3.6 V_{fixed} = 1.4 V $\frac{V_{fixed}}{V_{thermistor}} = \frac{R_{fixed}}{R_{thermistor}}$ $\frac{1.4}{3.6} = \frac{R_{fixed}}{50000}$ $3.6 \times R_{fixed} = 1.4 \times 50000$ $R_{fixed} = \frac{1.4 \times 50000}{3.6}$ R_{fixed} = 19444.44444 **R_{fixed} = 19 *kΩ***	**3**	1 mark for $R_{thermistor}$ (no unit required). 1 mark for substitution (no unit required). Allow FTE from $R_{thermistor}$. 1 mark for R_{fixed} (unit required). Allow FTE from substitution.

Question			Expected response	Max mark	Additional guidance
	(e)		Rotational motor speed = $\frac{75}{60}$ Rotational motor speed = 1.25 rev sec^{-1} No. of teeth engaged = rotational motor speed x no.pinion teeth No. of teeth engaged = 1.25 x 36 No. of teeth engaged = 45 teeth sec^{-1} Linear speed = $\frac{\text{no. of teeth engaged per sec}}{\text{teeth per metre}}$ Linear speed = $\frac{45}{120}$ Linear speed = 0.375 **Linear speed =** 0.38 **ms^{-1}** (2 **sf)** Alternative method: Rotational motor speed x Pinion teeth =75 x 36 = 2700 teeth min^{-1} $\frac{\text{Teeth min}^{-1}}{\text{teeth m}^{-1}}$ = $\frac{2700}{120}$ = 22.5 m min^{-1} Linear speed = $\frac{22.5 \text{ m min}^{-1}}{60}$ Linear speed = 0.375 **Linear speed = 0.38 ms^{-1} (2 sf)**	**3**	1 mark for rotational motor speed (no unit required). 1 mark no. of teeth engaged (no unit required). 1 mark for linear speed (unit required). Allow FTE from speed and teeth engaged. Alternative method: 1 mark for teeth min^{-1} (no units required). 1 mark for m min^{-1} (no units required). 1 mark for linear speed (unit required). Allow FTE from speed and teeth engaged. Credit to be awarded for other valid methods of calculation.

Question			Expected response	Max mark	Additional guidance
	(f)		$P = \frac{V^2}{R_{motor}}$ $5.8 = \frac{15^2}{R_{motor}}$ $R_{motor} = \frac{15^2}{5.8}$ R_{motor} = 38.79310345 Ω $R_{total} = R_{DS} + R_{motor}$ R_{total} = 1.8 + 38.79310345 R_{total} = 40.59310345 Ω $V_s = I_{drain} \times R_{total}$ $I_{drain} = \frac{15}{40.59310345}$ I_{drain} = 0.369520897 **I_{drain} = 0.37 A (2 sf)** Alternative solution: $P_{motor} = V_{motor} \times I_{motor}$ $5.8 = 15 \times I_{motor}$ $I_{motor} = \frac{5.8}{15}$ I_{motor} = 0.3866666667 A $V_{motor} = I_{motor} \times R_{motor}$ $15 = 0.3866666667 \times R_{motor}$ $R_{motor} = \frac{15}{0.3866666667}$ R_{motor} = 38.79310345 Ω $R_{total} = R_{DS} + R_{motor}$ R_{total} = 1.8 + 38.79310345 R_{total} = 40.59310345 Ω $V_s = I_{drain} \times R_{total}$ $I_{drain} = \frac{15}{40.59310345}$ I_{drain} = 0.369520897 **I_{drain} = 0.37 A (2 sf)**	**3**	1 mark for R_{motor} (no unit required). 1 mark for R_{total} (no unit required). Allow FTE from R_{motor}. 1 mark for I_{drain} (unit required). Allow FTE from R_{total}. Alternative solution: 1 mark for R_{motor} (no unit required). 1 mark for R_{total} (no unit required). Allow FTE from R_{motor}. 1 mark for I_{drain} (unit required). Allow FTE from R_{total}.

[END OF MARKING INSTRUCTIONS]