



National
Qualifications
2026

2026 Engineering Science

Advanced Higher

Question Paper Finalised Marking Instructions

These marking instructions have been prepared by examination teams for use by Qualifications Scotland appointed markers when marking external course assessments.

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General marking principles for Advanced 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 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) QUALIFICATIONS SCOTLAND 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

Question			Expected response	Max mark	Additional guidance
1.	(a)		$V_{out} = -R_f \left(\frac{V_0}{R_0} + \frac{V_1}{R_1} + \frac{V_2}{R_2} \right)$ $= -11.5 \left(\frac{5.00}{41.7} + \frac{5.00}{20.8} + \frac{5.00}{10.4} \right)$ $= -9.672166....$ $= -9.67 \text{ V (3 s.f.)}$	2	1 mark: Correct form of calculation for D-A converter. 1 mark: Answer and units.
	(b)	(i)	$V_{out} = -R_f \left(\frac{V_1}{R_0} \right)$ $= -115 \left(\frac{5.00}{41.7} \right)$ $= -13.7889688....$ $= -13.8 \text{ V (3 s.f.)}$	1	1 mark: Answer and units. Award this mark for 13.8 V, if previous answer has been penalised for being positive.
		(ii)	$V_{out} = -R_f \left(\frac{V_1}{R_0} \right)$ $= -115 \left(\frac{5.00}{20.8} \right)$ $= -27.64423....$ Op-amp saturates at $\pm 14.4 \text{ V}$, and $-27.6 < -14.4$, so $V_{out} = -14.4 \text{ V}$	2	1 mark: Calculated -27.6 V 1 mark: Answer and units. Note that output would be less than the negative saturation voltage if the op-amp circuit permitted. State: -14.4 V for V_{out} An answer of -14.4 V with no working can be awarded both marks if (b)(i) is determined correctly, or is a value that, when doubled, would saturate the op-amp. If the value for (b)(i) is not correct and would not saturate the op-amp when doubled, award FTE for the first mark. The second mark cannot be awarded as there is no working to support -14.4 V as an answer. Similar arguments for 14.4 V, if answer for parts (a) and (b)(i) are consistently positive.

Question			Expected response	Max mark	Additional guidance
2.	(a)				
		(i)	See network diagram above.	1	All arrows from left to right.
		(ii)	See network diagram above.	3	1 mark: Earliest start and finish times correct for all stages except B and J. 1 mark: Latest start and finish times correct for all stages except B and J. 1 mark: Floats correct for all stages except B and J.
		(iii)	A, D, F, H, J	1	

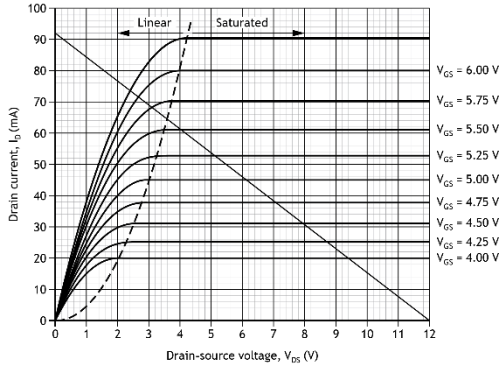
Question		Expected response	Max mark	Additional guidance
2.	(b)	1. Analyse Project Performance • evaluate project outcomes: Compare actual results against project objectives and goals • identify lessons learned: Analyse successes and failures to inform future projects • document findings: Create a comprehensive project evaluation report • conduct post-project reviews: Gather feedback from stakeholders to identify areas for improvement 2. Complete Paperwork • finalise documentation: Ensure all project documents, including contracts, change orders, and reports, are complete and accurate • archive project records: Store project documentation in a secure and accessible location • update project management software: Record final project status and outcomes in the project management tool 3. Reallocate/Release Resources • transition resources: Reassign team members and equipment to new projects or return them to the organization's pool • manage resource contracts: Ensure all contracts with external resources are terminated or renegotiated as needed • release unused resources: Dispose of or return any surplus equipment or materials 4. Sign Off Project • obtain formal approval: Secure final sign-off from key stakeholders, including project sponsors and clients • conduct a handover ceremony: Officially transfer project deliverables and responsibilities to the client or relevant department • close out contracts: Ensure all contractual obligations are fulfilled and any outstanding payments are made • celebrate project success: Recognize the contributions of the project team and celebrate the achievement of project goals	2	1 mark: Description of an activity for one of the steps, 1-4. 1 mark: Description of an activity for one of the other steps, 1-4. Candidate is not required to identify the step that the described activity belongs to. Ignore step title if the activity belongs to another step. Full marks can only be awarded for two activities from different steps.

Question			Expected response	Max mark	Additional guidance
3.			$1.2 \text{ kg min}^{-1} = \frac{1.2}{60} \text{ kgs}^{-1}$ $(\dot{m}c\Delta T)_{hot} = (\dot{m}c\Delta T)_{cold}$ By ratio of capacities: $\frac{1.2}{60} \times \frac{1}{2} \times (150 - 100)$ $= \dot{m}_{water} \times 1 \times (78.3 - 20)$ Or exact value from data booklet: $\frac{1.2}{60} \times \frac{4180}{2} \times (150 - 100)$ $= \dot{m}_{water} \times 4180 \times (78.3 - 20)$ $\dot{m}_{water} = 8.57 \times 10^{-3} \text{ kgs}^{-1} \text{ (3 s.f.)}$	3	1 mark: Conversion of flow rate from kg min⁻¹ into kg s⁻¹. 1 mark: Either ratio of specific heat capacities OR values from data booklet and ratio. 1 mark: Answer and units.

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	Demand peaks around 6:00pm as this is the time people start getting home from work and most households prepare an evening meal which creates demand. Demand drops significantly after 9:00pm and continues at a low level until 6:00am when much of the population begins to wake, and the working day starts.	1	1 mark: Discussion of peak and low point, noting how household demand of the grid varies over this time.
		(ii)	CCGT is presently crucial to meeting UK demand and its capacity must be high enough to compensate for times when there is little or no production from wind and solar. Hydro, including pumped storage can help to meet some shortfall when it is available. The latter's capacity is relatively low and takes hours to be re-established once depleted, so is of limited value to compensate for lack of solar or wind capacity over days. Conventional hydro capacity at all scales is also weather dependent; generating reserves are dependent on rainfall. Interconnectors linking generating capacity in several surrounding European countries to the grid enable power to be imported and exported in amounts that can be varied continuously to balance generation and demand. This supply is also responsive.	2	1 mark: CCGT capacity can respond rapidly to meet wide variations in demand and production from sources such as wind and solar. A total of 1 mark from: 1 mark: Hydro, including pumped storage can help to meet some shortfall. The latter's capacity is relatively low and takes hours to be re-established once depleted. 1 mark: Electricity is imported from the continent at peak times, and to support base load generation if there are significant planned outages of generating capacity or a shortfall of solar and wind generation.

Question			Expected response	Max mark	Additional guidance
4.	(b)		Calculate current for secondary winding of transformer: $I = \frac{P}{V} = \frac{110 \times 10^3}{11 \times 10^3} = 10 \text{ A}$ Calculate transmission power loss: $P_{\text{loss}} = I^2 R$ $= 10^2 \times 494 \times 10^{-6} \times 12 \times 10^3$ $= 592.8$ $= 593 \text{ W}$ Calculate efficiency: $\eta = \frac{P_{\text{out}}}{P_{\text{in}}} = \frac{P_{\text{in}} - P_{\text{loss}}}{P_{\text{in}}}$ $\eta = 1 - \frac{P_{\text{loss}}}{P_{\text{in}}}$ $= 1 - \frac{592.8}{110 \times 10^3}$ $= 0.99461\dots$ $= 0.99 \text{ (2 s.f.)}$	3	1 mark: Determine the current flow in the cable from the transformer. 1 mark: Determine the resistive power loss along the cable. 1 mark: Determine the transmission efficiency.

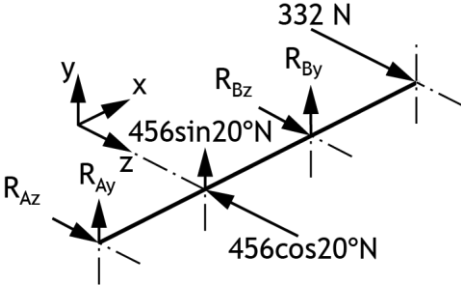
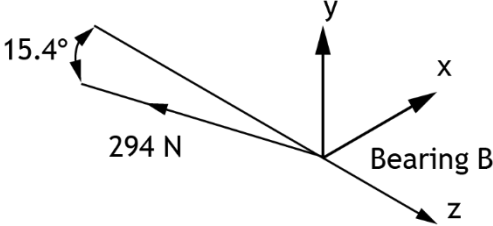
Question			Expected response	Max mark	Additional guidance
5.			For equilibrium (running at constant speed), taking clockwise torque as positive. $F_{tC} \times r_C - F_{tB} \times r_B = 0$ $F \cos 20^\circ \times \frac{60}{2}$ $- 3.25 \cos 25^\circ \times \frac{120}{2} = 0$ $F = 3.25 \times \frac{60 \cos 25^\circ}{30 \cos 20^\circ}$ $F = 6.269.....$ $F = 6.27 \text{ kN (3 s.f.)}$	3	1 mark: Two tangential force components correct. 1 mark: Two radii correct. 1 mark: Answer and units. There is potential for FTE for the third mark if either of the first two marks are not awarded, but torque balance is correctly applied using incorrect values for either force or radius.

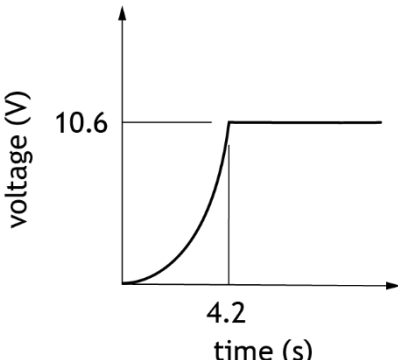
Question			Expected response	Max mark	Additional guidance
6.	(a)		when $V_{DS} = 0$, $I_D = \frac{12 - 0}{130}$ $= 92.30769.... \times 10^{-3}$ $= 92.3 \text{ mA}$  $V_{DS} = 7.1 \text{ V}$, $I_D = 38 \text{ mA}$	2	1 mark: Load line correct. 1 mark: Drain-source voltage and Drain current correct. FTE if load line is incorrect.

Question			Expected response	Max mark	Additional guidance
6.	(b)		$\frac{12 - V_{GS}}{R_1} = \frac{V_{GS}}{R_2}$ $R_1 = \left(\frac{12 - 4.75}{4.75} \right) R_2$ $R_1 = \frac{29}{19} R_2$ $\frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{650 \times 10^3}$ $\frac{19}{29} \frac{1}{R_2} + \frac{1}{R_2} = \frac{1}{650 \times 10^3}$ $\frac{48}{29} \frac{1}{R_2} = \frac{1}{650 \times 10^3}$ $R_2 = \frac{48}{29} \times 650 \times 10^3$ $R_2 = 1.08 \times 10^6$ $R_1 = \frac{29}{19} \left(\frac{48}{29} \times 650 \times 10^3 \right)$ $R_1 = 1.64 \times 10^6$ $R_1 = 1.64 \text{ M}\Omega, R_2 = 1.08 \text{ M}\Omega$	3	1 mark: Calculate required resistor ratio. 1 mark: Use design requirement to calculate one resistor value 1 mark: Calculate second resistor value.

Question			Expected response	Max mark	Additional guidance
7.	(b)		At a point 50 m from LHE $500 \times 50 - 10 \times 50 \times 25 - M_B = 0$ $M_B = 25000 - 12500$ $M_B = 12500 \text{ kNm (3 s.f.)}$ $M_B = 12.5 \text{ MNm (3 s.f.)}$	3	1 mark: Bending moment due to reaction at A. $500 \times 50 \dots$ 1 mark: Bending moment due to UDL over 50 m. $\dots - 10 \times 50 \times 25 \dots$ Must have the opposite sense of the first term. 1 mark: Answer and units. This may be written more generally. For $0 \leq x < 80$ $R_A x - \omega x (x/2) - M_B = 0$ $M_B = R_A x - \omega x^2/2$ $R_A = 500 \text{ kN}, \omega = 10 \text{ kNm}^{-1},$ $x = 50 \text{ m}$

Question			Expected response	Max mark	Additional guidance
8.	(a)		$PCD_{sun} = m \times N_{sun} = 3 \times 18 = 54$ $PCD_{planet} = m \times N_{planet} = 3 \times 45 = 135$ $PCD_{ring} = 2 \times \left(\frac{PCD_{sun}}{2} + PCD_{planet} \right)$ $= 2 \left(\frac{54}{2} + 135 \right)$ $= 324$ $N_{ring} = \frac{PCD_{ring}}{Z} = \frac{324}{3} = 108$	3	1 mark: Calculate PCDs for the sun and planet gears. 1 mark: Calculate the required PCD for the ring gear. 1 mark: Calculate the required number of teeth for the ring gear.

Question		Expected response	Max mark	Additional guidance
8.	(b)	 Forces in Y-X plane Take moments about A, +ve moment is clockwise. $-(456 \times \sin 20^\circ \times 0.225) - (R_{By} \times 0.225 \times 2) = 0$ $R_{By} = -77.98059... \text{ N}$ Forces in Z-X plane Take moments about A, +ve moment is clockwise. $-(456 \times \cos 20^\circ \times 0.225) + (R_{Bz} \times 0.225 \times 2) + (332 \times 0.225 \times 3) = 0$ $R_{Bz} = -283.75008... \text{ N}$ $ R_B = \sqrt{R_{By}^2 + R_{Bz}^2} = \sqrt{(-77.98059..)^2 + (-283.75008..)^2} = 294.270.... = 294 \text{ N (3 s.f.)}$ $\theta = \tan^{-1} \left(\frac{-77.98059...}{-283.75008...} \right) = 15.3667... = 15.4^\circ \text{ (3 s.f.)}$ 	6	1 mark: Correct resolution of 456 N gear force. 1 mark: Equilibrium equation in Y-X plane. 1 mark: Equilibrium equation in Z-X plane. 1 mark: Two force components correct from equilibrium equations. 1 mark: Calculation of resultant force from two force components. 1 mark: Line of action of force clearly defined relative to xyz - a stated angle value is not sufficient if it is not referenced to the geometry of the system in some way.

Question			Expected response	Max mark	Additional guidance
8.	(c)	(i)	$V_2 = -2t$	1	
		(ii)	$V_3 = -\frac{1}{RC} \int V_2 dt$ $= -\frac{1}{(1.1 \times 10^6)(1.5 \times 10^{-6})} \int (-2t) dt$ $= -\frac{20}{33} \left(-2 \frac{t^2}{2}\right) + c$ $V_3 = \frac{20}{33} t^2$ $V_3 = 0.61t^2 \text{ (2 s.f.)}$	2	1 mark: Substitution of v_2, resistor and capacitor values. 1 mark: Final simplified answer.
		(iii)	$V_3 = \frac{20}{33} t^2$ When $V_3 = 10.6$ $t = \sqrt{\frac{10.6}{\left(\frac{20}{33}\right)}}$ $= 4.182 \dots$ $t = 4.2 \text{ s (2 s.f.)}$ 	3	1 mark: Positive parabolic increase in voltage from 0 V. 1 mark: Saturation voltage indicated by flat portion of graph when voltage reaches 10.6 V (indication of value of voltage not necessary). 1 mark: Saturation point (4.2, 10.6) at $t = 4.2$ s indicated on graph and axes labelled.

Question			Expected response	Max mark	Additional guidance
8.	(c)	(iv)	$V_2 = -\frac{1}{RC} \int V_1 dt$ $\frac{dV_2}{dt} = -\frac{1}{RC} V_1$ $\frac{d}{dt}(-2t) = -\frac{V_1}{(1 \times 10^6)(330 \times 10^{-9})}$ $-2 = -\frac{100}{33}(V_1)$ $V_1 = 660 \times 10^{-3}$ $V_1 = 660 \text{ mV (2 s.f.)}$	2	1 mark: Substitution of V_2, resistor and capacitor values. 1 mark: Answer and units.
	(d)		$\text{INT}(12 \times 37 / 10) = 44$ $\text{INT}(12 \times 44 / 10) = 52$ $52 + 10 = 62$ $62 + 10 = 72$	2	1 mark: Two values calculated from condition when $x < 50$. 1 mark: Third and fourth values calculated. Allow FTE if they are 10 and 20 greater than the second value.
	(e)		The value of x never changes from the initial value of 5. $11 \times 5 / 10 = 5.5 \text{ and } \text{INT}(5.5) = 5$	1	

Question			Expected response	Max mark	Additional guidance
9.	(a)		$I_{xx} = \frac{h^3(a^2 + 4ab + b^2)}{36(a + b)}$ $= \frac{1.8^3(1.5^2 + 4(1.5)(2) + 2^2)}{36(1.5 + 2)}$ $= \frac{5913}{7000}$ $= 844.714 \dots \times 10^{-3}$ Maximum stress is on bottom surface. $y = 1.8 - 0.857 = 943 \times 10^{-3} m$ $\sigma = \frac{My}{I}$ $= \frac{415 \times 10^3 \times 943 \times 10^{-3}}{844.714 \dots \times 10^{-3}}$ $= 463.28698 \dots \times 10^3$ $= 463 \text{ kNm}^{-2} \text{ (3 s.f.)}$	5	1 mark: Identify correct dimensions from description when substituting for second moment of area. 1 mark: Calculate second moment of area. 1 mark: Selection of bottom surface as point of maximum stress. 1 mark: Calculate distance from neutral axis to bottom surface. 1 mark: Selection of formula and calculate stress.

Question			Expected response	Max mark	Additional guidance
9.	(b)		$\delta_{max} = \delta_{\text{simply supported beam}} + \delta_{\text{cantilever}}$ $\delta_{max} = \frac{FL^3}{48EI} + \frac{F\left(\frac{L}{2}\right)^3}{3EI}$ $\delta_{max} = \frac{FL^3}{48EI} + \frac{FL^3}{48EI}$ $\delta_{max} = \frac{FL^3}{24EI}$	4	1 mark: Select correct deflection equations from the data booklet. Substitutions for the third mark can be accepted at this stage without showing data booklet equations. 1 mark: Identify that the deflection is the sum of the deflection of the centre of the long span plus the deflection of the end of the cantilever. 1 mark: The load on the cantilever is F/2. The length of the cantilever is L/2. 1 mark: Correct algebra for final deflection.
	(c)		$\delta_{max} = \frac{FL^3}{24EI}$ $= \frac{5.15 \times 10^6 \times 60^3}{24 \times 196 \times 10^9 \times 23.5}$ $= 10.06... \times 10^{-3} \text{ m}$ $= 10 \text{ mm (2s.f.)}$ OR $\delta_{max} = \frac{FL^3}{24EI}$ $= \frac{5.15 \times 10^6 \times (60 \times 10^3)^3}{24 \times 196 \times 10^3 \times 23.5 \times 10^{12}}$ $= 10.06... \text{ mm}$ $= 10 \text{ mm (2s.f.)}$	2	1 mark: Selection of E value from data booklet and use of consistent units for force, length and second moment of area. $196 \text{ kNm}^{-2} = 196 \text{ GNm}^{-2}$ OR $23.5 \text{ m}^4 = 23.5 \times 10^{12} \text{ mm}^4$ $60 \text{ m} = 60 \times 10^3 \text{ mm}$ 1 mark: Answer and units.
	(d)	(i)	$\text{resolution} = \frac{V_{max}}{2^n - 1}$ $= \frac{2.55}{2^{10} - 1}$ $= 2.4926686... \times 10^{-3}$ $= 2.49 \text{ mV (3 s.f.)}$	1	

Question			Expected response	Max mark	Additional guidance
9.	(d)	(ii)	$\frac{x}{2^n - 1} = \frac{V_{in}}{V_{max}}$ $x = (2^{10} - 1) \left(\frac{2.15}{2.55} \right)$ $x = 862.529...$ $x = 863$ $x = \%1101011111$ If the rounded answer for the resolution for part (d)(i) is used: $x = \frac{V_{in}}{V_{res}}$ $x = \left(\frac{2.15}{2.49 \times 10^{-3}} \right)$ $x = 863.45...$ $x = 864$ $x = \%1101100000$	3	1 mark: Calculate a value for x. (Using a rounded value of resolution gives 863.45....). Follow through possible if part (d)(i) answer is incorrect. 1 mark: Round the calculated value up to the nearest whole number, since the ADC in the data booklet would reach this value before completing the conversion. 1 mark: Convert the value to the decimal equivalent. (Follow through possible for second and third marks).
	(e)		The resistance of an active strain gauge changes in response to changes in the applied load; a passive strain gauge is unaffected by changes in the applied load. Both are affected by temperature. A passive gauge is wired into each potential divider in the bridge circuit in series with an active gauge so that the temperature effects on the active and passive gauges cancel each other and the voltage from each potential divider varies due to strain alone.	2	1 mark: Resistance of a strain gauge is affected by temperature as well as strain. 1 mark: Any change in the passive gauge resistance due to temperature is matched by the change in resistance of the active gauge due to temperature, so the output voltage from the voltage divider is unaffected by temperature but varies with strain on the active gauge.

Question			Expected response	Max mark	Additional guidance
9.	(f)		$\frac{12 - V_1}{R} + \frac{12 - V_1}{R_1} - \frac{V_1}{1.2 \times 10^6 - R} - \frac{V_1}{R_2} = 0$ $V_1 = V_2$ $= \frac{120.0}{120.0 + 120.0} \times 12.0 = 6.0$ $\frac{12 - 6}{R} + \frac{12 - 6}{120.6} - \frac{6}{1.2 \times 10^6 - R} - \frac{6}{119.4} = 0$ $\frac{1}{R} - \frac{1}{1.2 \times 10^6 - R} + \frac{1}{120.6} - \frac{1}{119.4} = 0$ $\frac{1}{R} - \frac{1}{1.2 \times 10^6 - R} - 83.3354... \times 10^{-6} = 0$	3	1 mark: Apply KCL and Ohm's Law appropriately. 1 mark: Resistance of potentiometer between wiper and 0V connection is $1.2 \times 10^6 - R \, \Omega$. $a = 1.2 \times 10^6$ 1 mark: Identify $V_1 = 6.0 \, \text{V}$ and simplify $b = 83.3 \times 10^{-6}$

[END OF MARKING INSTRUCTIONS]