



National
Qualifications
2015

2015 Engineering Science

New Higher

Finalised Marking Instructions

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General Marking Principles for Higher Engineering Science

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this Paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

- (a) Marks for each candidate response must always be assigned in line with these General Marking Principles and the Detailed Marking Instructions for this assessment.
- (b) Marking should always be positive, ie marks should be awarded for what is correct and not deducted for errors or omissions.
- (c) 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 non-mathematical reasoning.
- (d) 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).
- (e) Answers to numerical questions should normally be rounded to an appropriate number of significant figures. However, the mark can be awarded for answers which have up to two figures more or one figure less than the expected answer.
- (f) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including unit) on its own.
- (g) A mark can be awarded when a candidate writes down the relevant formula **and** substitutes correct values into the formula. No mark should be awarded for simply writing down a formula, without any values.
- (h) Credit should be given where a labelled diagram or sketch conveys clearly and correctly the response required by the question.
- (i) Marks should be awarded regardless of spelling as long as the meaning is unambiguous.
- (j) Candidates may answer programming questions in any appropriate programming language. Marks should be awarded, regardless of minor syntax errors, as long as the intention of the coding is clear.
- (k) Where a question asks the candidate to “explain”, marks should only be awarded 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, marks should normally only be awarded for the final answer, and all rough working ignored.

Note: point (e) mark should only be applied when reducing the significant figures does not seriously affect the answer and there is clear evidence where the rounding occurred. Rounding errors may also lead to a slightly different answer than the one given but can be credited so long as there is clear evidence that the answer resulted from correct steps.

Marking Instructions for each question

Section 1

Question		Expected Answer(s)	Max Mark	Additional Guidance
1.	(a)	Young's Modulus of Elasticity	1	Accept Young's modulus or (E)
	(b)	Material A – brittle Material B – ductile	2	Accept for A – Elastic, strength, for B – plastic , malleability or other acceptable answer

Question		Expected Answer(s)	Max Mark	Additional Guidance
2.	(a)	Advantage – allows user to connect/disconnect drive to change gears, make adjustments, control speed, etc	2	Connect/disconnect without explanation (1) We are looking for an explanation of the advantage disadvantage not just a one or two word statement
	(b)	Disadvantage – may be complex and have more parts to go wrong or require regular maintenance as it will wear, or more expensive due to more parts and replacements. Can slip, use up energy as it slips	2	

Question		Expected Answer(s)	Max Mark	Additional Guidance
3.		<p>When the voltage on the gate is below gate threshold, there is in effect no channel, no current flow source drain</p> <p>Above the gate threshold voltage a channel is produced connecting the drain and source, producing a drain current.</p> <p>The greater the gate voltage, the better the device conducts, the bigger the drain current</p> <p>At saturation the MOSFET performs at its best, lowest source/drain resistance, highest drain current.</p>	3	<p>Some form of words to convey understanding of these points taken from schematic diagram or graph.</p> <p>Any three of these for 3 marks</p>

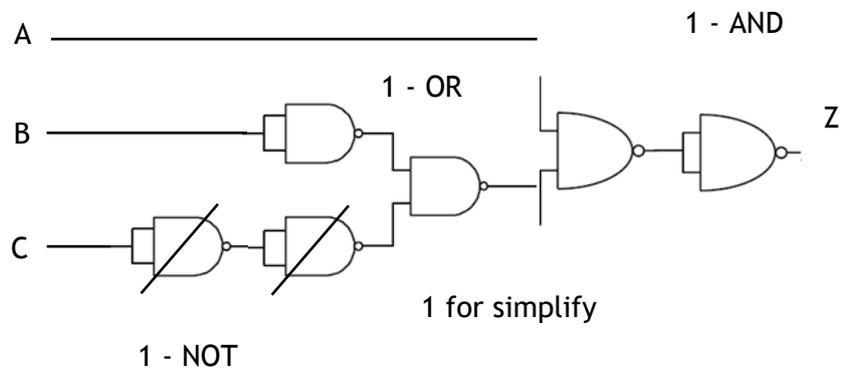
Question	Expected Answer(s)	Max Mark	Additional Guidance
4.	<p>Analogue –</p> <ul style="list-style-type: none"> • Calculate expected values at points in circuit. • Design driver circuits using transistors • Design signal processing circuits using op-amps and transistors <p>Digital</p> <ul style="list-style-type: none"> • Design logic circuits Boolean, gates, truth tables NAND conversion etc • Design digital sensing circuits • Design control systems using microcontrollers <p>Programming</p> <ul style="list-style-type: none"> • Plan programs for a required sequence • Write programs for microcontrollers • Calculate PWM values for required outputs <p>Power</p> <ul style="list-style-type: none"> • Design power supplies • Ensure Building circuits are compatible with Oven • Connect correctly to safety trip switch within consumer unit 	3	<p>Skills must be specialist to that area and not too general (Controlling devices using logic gates is not acceptable whereas using truth tables, Boolean expressions to design logic circuits would be). Generic skills all engineers and others have should not be accepted (communication, IT, problem solving, prototyping, testing etc)</p> <p>The expected answers are examples there will be other acceptable answers</p> <p>If candidates have given acceptable skills for more than one specialism eg digital and analogue then allocate the marks to the specialism which will give them most marks</p>

Question		Expected Answer(s)	Max Mark	Additional Guidance
5.		Civil Engineer - undertake analysis of existing structure, grounds work required, produce plans for new build, design new parts of structure.	2	Marks are allocated for two aspects of an appropriate engineering role. No marks are allocated for stating a type of engineer or simply listing knowledge or skills without relating these to this application.
		Electrical Engineer - undertake analysis of current and future electrical requirements, produce plans for electrical modifications.	2	These are examples any appropriate branch of Engineering Structural, Electronic, Energy, Environmental, mechanical etc would be acceptable so long as their role was suitably described.

Question		Expected Answer(s)	Max Mark	Additional Guidance
6.		<p>Power = VI</p> <p>Power = $75 \times 110 = 8250 \text{ W}$ (1)</p> <p>Recognise that due to efficiency the generator power is 95% of the diesel engine power</p> <p>Input = Output/efficiency</p> <p>$8250 \div 0.95$ (1)</p> <p>Power = 8684.2 W or 8.68 KW</p> <p>Answer and unit (1)</p>	3	<p>Potential for follow through errors here the most common one will be subtracting 5% this will give an answer of 7837.5W 7.84kW</p> <p>Answer should to 3 significant figures. Though if not and you can clearly see where rounding occurred from working then give mark.</p>

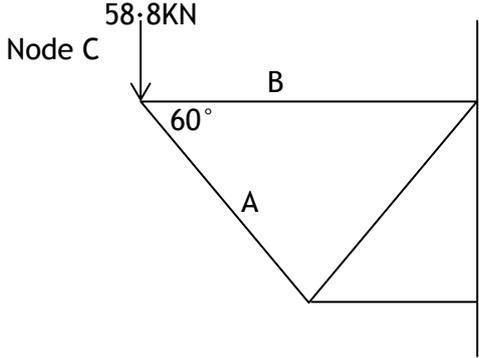
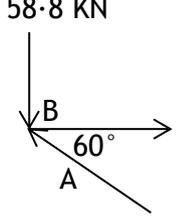
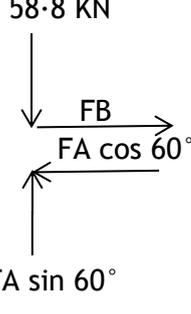
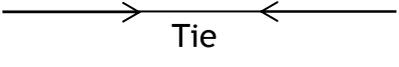
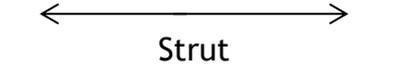
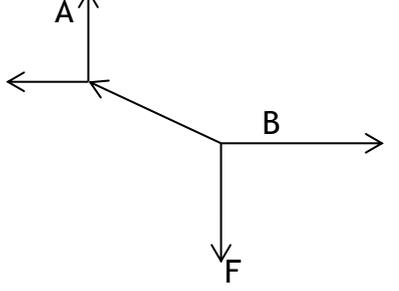
Section 2

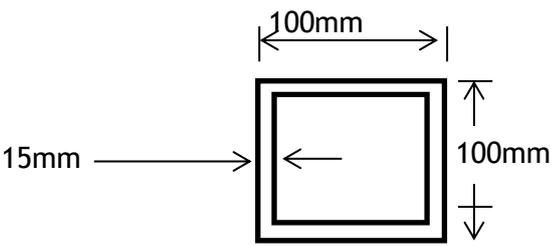
Question			Expected Answer(s)	Max Mark	Additional Guidance
7.	(a)	(i)	$Z = A.(B + \bar{C})$ 1 for correct AND 1 for correct OR 1 for correct inversion	3	Brackets are required to show OR condition $Z = (A.B) + (A.\bar{C})$ also correct if given 2 out of 3 given where one mistake is evident 1 out of 3 given where two mistakes is evident
		(ii)		4	NOT with connections drawn as NAND (1) Or with connections drawn from NANDs (1) AND with connections drawn from NANDs (1) Removing the two NOT gates in series (1) (follow through from Boolean must still include correct NAND conversion or simplification to achieve the mark)



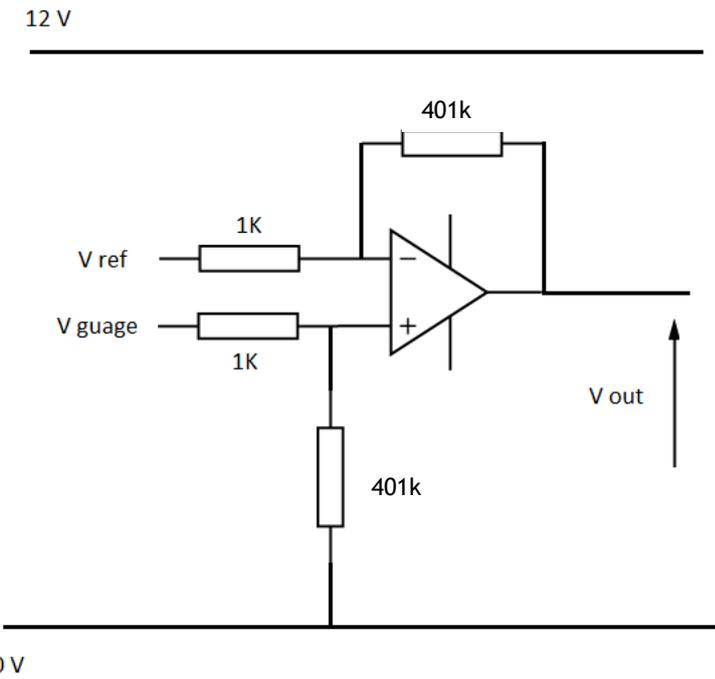
Question		Expected Answer(s)	Max Mark	Additional Guidance	
	(b)	(i)	Comparator (1) Difference (1)	2	Do not accept Differential for difference.
		(ii)	The Comparator: provides On/Off control. Motor is either fully on or off depending on the feedback signal The camera will be driven to the required position (1) The Difference amplifier: provides proportional control (output varies with error in some wording). When the camera lens approaches the correct position the camera lens movement slows down and therefore the camera lens is able to stop in the exact position with no overshoot. (1) Difference amplifier (1) Proportional control will take the camera lens accurately to the correct position and stop it there (1) Or the other way round they could say Comparator control will cause the camera to overshoot. It never stops in the exact position.	4	The language will vary if in your view it conveys understanding of the point then give the mark. The exception being the mark for difference.
	(c)		By changing the MARK/SPACE ratio.(1) Bigger MARK is compared to SPACE the faster it will go. (1) Bigger SPACE is compared to MARK slower it will go. (1)	2	Any two of these three. The descriptions of the ratio imply each other so only one of the two is required. They do have to state that speed depends on the size of MARK or SPACE value.

Question		Expected Answer(s)	Max Mark	Additional Guidance
8.	(a)	<p>Volume of tank = $l \times b \times h$ $= 3 \times 3 \times 1.5$ $= 13.5m^3$</p> <p>Therefore mass = $13.5m^3 \times 1000kg$ $= \underline{13500Kg}$ (1)</p> <p>Therefore Force = mass \times gravity $= 13500kg \times 9.8$ $= \underline{132300 N}$ (132.3 KN) (1)</p> <p>If there are four beams the total force will be divided by four</p> <p>$132300 \div 4$ (Beams) = <u>33075 N</u> or 33.08 KN (1)</p> <p>If the load is uniformly distributed across 3 metres therefore $33075 \div 3m = 11025 Nm^{-1}$</p> <p><u>11025 Nm⁻¹</u> or 11.03kNm⁻¹ answer and unit (1)</p>	4	<p>Units are not required for the mark for intermediate steps</p> <p>Accept $11036Nm^{-1}$ if they use 9.81 for gravity</p>

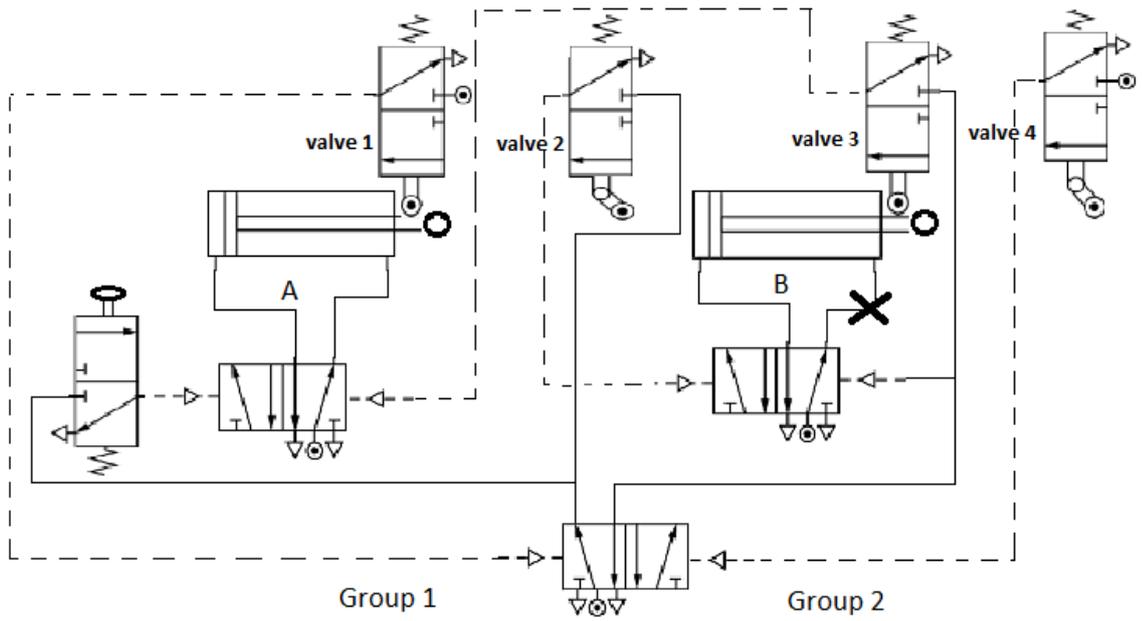
Question		Expected Answer(s)	Max Mark	Additional Guidance
(b)	(i)	   $\Sigma F_v = 0 \qquad \Sigma F_h = 0$ $58.8 \text{ kN} = F_A \sin 60^\circ \qquad F_B = F_A \cos 60^\circ$ $58.8 \text{ kN} = F_A \times 0.866 \qquad F_B = 67.9 \text{ kN} \times 0.5$ $67.9 \text{ kN} = F_A \text{ (STRUT)} \qquad F_B = 33.95 \text{ kN (Tie)}$ <p>Answer and unit (1) Answer and unit(1)</p> <p>nature of BOTH members (1)</p>	3	<p>For nature tension/compression or force arrows on members or node acceptable</p>   

Question	Expected Answer(s)	Max Mark	Additional Guidance
(ii)	 <p> $\delta = F/A$ Area 1 = $100 \times 100 = 10000\text{mm}^2$ Area 2 = $70 \times 70 = 4900\text{mm}^2$ both values (1) Total shaded area = $A1 - A2$ $= 10000\text{mm}^2 - 4900\text{mm}^2$ $= 5100\text{mm}^2$ (1) Force = 67900N (from b(i)) $= 67900\text{N} \div 5100\text{mm}^2$ $= 13.3\text{Nmm}^{-2}$ answer and unit (1) </p>	3	Units are not required for the mark for intermediate steps. Common error is using 85×85 as this internal size this gives an answer of 24.5Nmm^{-2} for 2 marks
(c)	<p> Potential Energy = mgh (output Energy) Mass from (a) $= 13500\text{kg} \times 9.8 \times 6$ $E_p = 793800\text{ J}$ (1) </p> <p> $E_{\text{eff}} = E_o \div E_i$ therefore $E_i = E_o \div E_{\text{eff}}$ $= 793800 \div 0.75$ $= 1058400\text{J}$ (1) </p> <p> $E_e = VI t$ therefore $VI = 230 \times 15$ $= 3450\text{W}$ (1) </p> <p> $t = E_p \div VI$ $= 1058400 \div 3450$ (1) $= 306.8$ seconds Answer and unit (1) </p>	5	Units are not required for the mark for intermediate steps. They may use another mass value common one is 4500kg, this produces a correct follow through answer of 102 seconds. They may also multiply the electrical energy value by 0.75 giving 2587.5W which earns the efficiency mark.

Question		Expected Answer(s)	Max Mark	Additional Guidance	
9	(a)	<p>Social - improved journey times, less frustration stuck in traffic, provides jobs and training. (any for 1)</p> <p>Economic - jobs workers will spend some salary locally, contractors will provide materials and services, attract larger numbers to the area, make it easier for businesses to cross the forth (any for 1)</p> <p>Environmental - Will reduce emissions caused by traffic jams, reduce environmental damage caused by deteriorating suspension bridge, provide habitats for wildlife (any for 1)</p>	3	Any acceptable answer for each aspect for 1 mark	
	(b)	(i)	$4/7\text{ths of } 5\text{ V} = 2.85\text{V}$ (1) wind speed = $2.85/0.07 = 40.8\text{ ms}^{-1}$ answer and unit (1)	2	
		(ii)	$5.5/7\text{ths of } 5\text{V} = 3.93\text{V}$ (1) wind speed = $3.93/0.07 = 56.1\text{ ms}^{-1}$ answer and unit (1)	2	
	(c)	<p>Voltage over Base protection resistor = $5 - 0.7 = 4.3\text{V}$ (1)</p> <p>$I_B = V/R = 4.3/1.5 \times 10^3$ = $2.866 \times 10^{-3}\text{ A}$ (1)</p> <p>$I_C = P/V = 1.4/5 = 0.28\text{ A}$ (1)</p> <p>Gain = $I_C/I_B = 280/2.866$ = 97.7 answer and no unit (1)</p>	4	<p>Units are not required for the mark for intermediate steps</p> <p>If they use 5V they will get 93.3 award 3 marks.</p>	

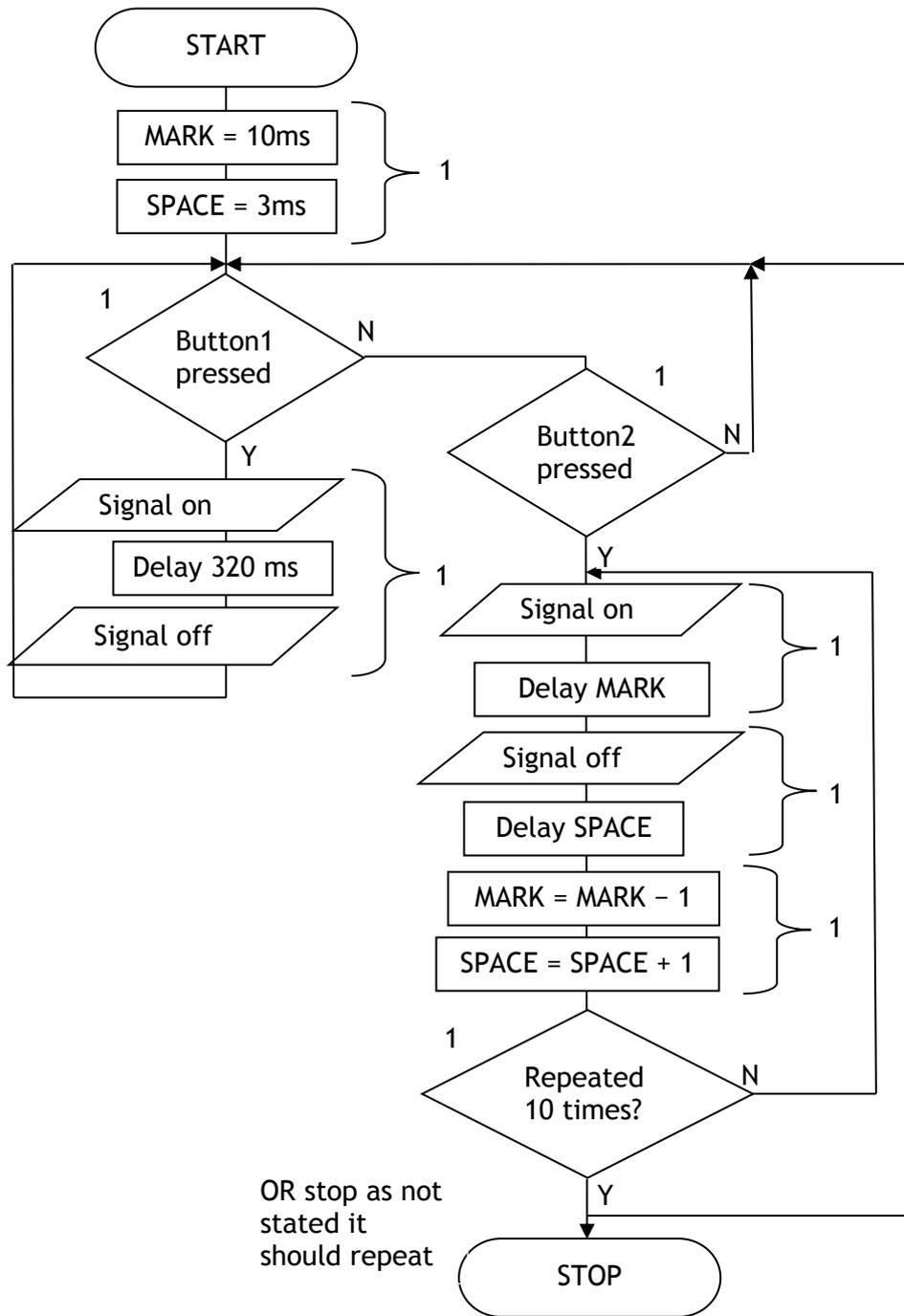
Question	Expected Answer(s)	Max Mark	Additional Guidance
(d)	<p>$V_{\text{gauge}} = 120 \cdot 5 / 240 \cdot 5 \cdot 12 = 6 \cdot 01247 \text{ V (1)}$</p> <p>$V_{\text{ref}} = 6 \text{ V}$ therefore difference = $0 \cdot 01247 \text{ V (1)}$</p> <p>Gain required from difference amp $= 5 / 0 \cdot 01247 = 401 \text{ (1)}$</p> <p>Difference amp circuit with correct resistor values for a gain of 401 (1)</p> 	4	<p>Units are not required for the mark for intermediate steps</p>
(e)	<p>Area of strand = $\pi D^2 / 4 = 3 \cdot 14 \times (13^2 / 4)$ $= 132 \cdot 7 \text{ mm}^2 \text{ (1)}$</p> <p>UTL = $FoS \times 4 \cdot 7 \times 10^6 = 47 \times 10^6 \text{ (1)}$</p> <p>UTS mild steel from Data booklet 430 N/mm^{-2} (1)</p> <p>Total area = total F/SWS = $47 \times 10^6 / 430$ $= 109 \times 10^3 \text{ mm}^2 \text{ (1)}$</p> <p>No of strands = $109 \times 10^3 / 132 \cdot 7 = 821 \cdot 4$ 822 strands. (1)</p>	5	<p>Units are not required for the mark for intermediate steps</p> <p>If they use yield stress do not give mark they will get 1601 strands as a follow through for 4 marks</p> <p>Rounding down to 821 strands is incorrect.</p>

Question	Expected Answer(s)	Max Mark	Additional Guidance
10. (a)	<p>As cylinder B has to out-stroke and then in-stroke while cylinder A remains out-stroked the air to valve 2 and valve 3 must be controlled (1) to prevent them both signalling cylinder Bs 5/2 valve at the same time.(1)</p> <p>Or when B out-strokes Its 5/2 valve will have both pilots active (1) so cylinder B will be locked in its present state (1)</p>	2	<p>This will be worded in many ways 2 marks are awarded for an understanding of the need for group air. and 1 mark for some understanding not deserving of 2 marks.</p>



Question		Expected Answer(s)	Max Mark	Additional Guidance
	(b)	<p>When the technician presses the button Group 1 air</p> <p>Sends a pilot signal (1) to make Cylinder A outstroke (1)</p> <p>Valve 2 then sends a pilot signal to make Cylinder B outstroke (1)</p> <p>Roller trip valve 4 then changes the supply to group 2 air (1)</p> <p>This sends a pilot signal to make Cylinder B in-stroke again (1)</p> <p>Then valve 3 makes Cylinder A in-stroke (1)</p> <p>Valve 1 returns the supply to Group 1 air (1)</p>	7	The language will vary as may the order of description. If in your view it conveys understanding of the function then give the mark.
	(c)	<p>In the exhaust line for B outstroke (x) (1)</p> <p>Because the speed will be reduced by restricting the cylinder exhaust out flow (1)</p> <p>Without compromising the force exerted or the smoothness and lack of jerkiness of the stroke (1)</p>	3	

Question	Expected Answer(s)	Max Mark	Additional Guidance
(d)	See flowchart below	8	Marks given for decision boxes include the associated lines. Yes, No labels if missing can be interpreted from the line. The first instance of using the wrong flowchart syntax should lose the mark subsequent occasions should gain the mark if the information is correct. Writing code or an algorithm is wrong technology at higher – zero marks



[END OF MARKING INSTRUCTIONS]