National
Qualifications
2016

2016 Engineering Science

National 5

Finalised Marking Instructions

General Marking Principles for National 5 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. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) 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.

(d) Full marks are always given for a correct final answer but 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.

(e) 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

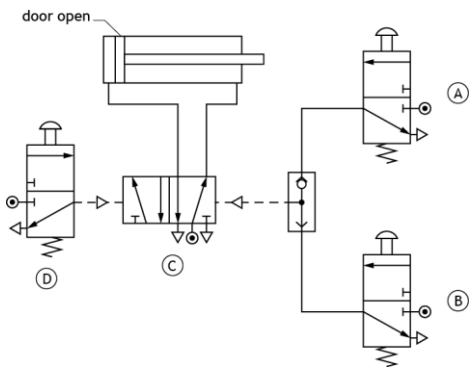
Section 1

Question			Expected Answer(s)	Max Mark	Additional Guidance
1.			Closed loop is self-monitoring and will adjust the output according to changing conditions	**1**	Descriptive response. Accept: has feedback loop (adjusts itself/checks output)

Question			Expected Answer(s)	Max Mark	Additional Guidance
2.			Fewer parts Increased reliability Simplified/faster assembly Can be reprogrammed Re-usable Upgradable – system's features can be quickly/easily changed Reduced stock inventory (one microcontroller circuit can be repurposed)	**2**	1 mark per each correct descriptive response. Accept – easier to fix mistakes Not smaller or cheaper on its own. Not programmable

Question			Expected Answer(s)	Max Mark	Additional Guidance
3.				**3**	1 Mark for each correct output.

A	B	C	Z
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Question			Expected Answer(s)	Max Mark	Additional Guidance
4.	(a)			**2**	1 Mark for correct shuttle valve symbol. 1 Mark for all piping (port to port). If no shuttle drawn then ignore lack of T piece. Do not accept two pipes to 5/2 actuator. Ignore pilot lines.
	(b)		Pilot	**1**	

Question			Expected Answer(s)	Max Mark	Additional Guidance
5.			Dimension(s) Force(s)	**2**	Accept: Magnitude and direction/ angle of the forces (2 marks)

Question			Expected Answer(s)	Max Mark	Additional Guidance
6.	(a)	(i)	Idler	**1**	
		(ii)	It makes gear A and gear C turn in the same direction (without affecting the output speed).	**1**	Descriptive response Accept change the (output) direction Not keep the direction the same on its own
	(b)		VR = speed of input/speed of output VR = 1200/720 VR = 5:3 (5/3) 1·7:1 (1·67)	**2**	1 Mark for using the correct substitution. 1 Mark for the correct answer from working (ignore any units) Do not accept 1·6●

Question			Expected Answer(s)	Max Mark	Additional Guidance
7.			$\sigma = \frac{F}{A}$ $\sigma = \frac{5000}{1962}$ = 2·5 Nmm^{-2} (2 sf) (2·55 Nmm^{-2}) (0·0025 kN mm^{-2})	**2**	1 mark for substitution 1 mark for correct answer from working with units 2·5 MPa (MNm^{-2}) 2548419PA

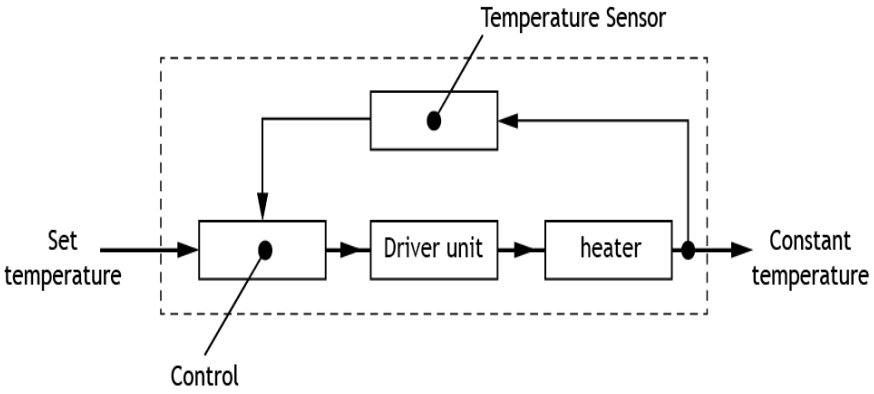
Question			Expected Answer(s)	Max Mark	Additional Guidance
8.	(a)		Acts as a switch	**1**	1 Mark. Accept: amplifying current turn on/switch on heater.
	(b)		Protect/limit the current (to the transistor)	**1**	1 Mark

Question			Expected Answer(s)	Max Mark	Additional Guidance
9.			Chemical	**1**	

Section 2

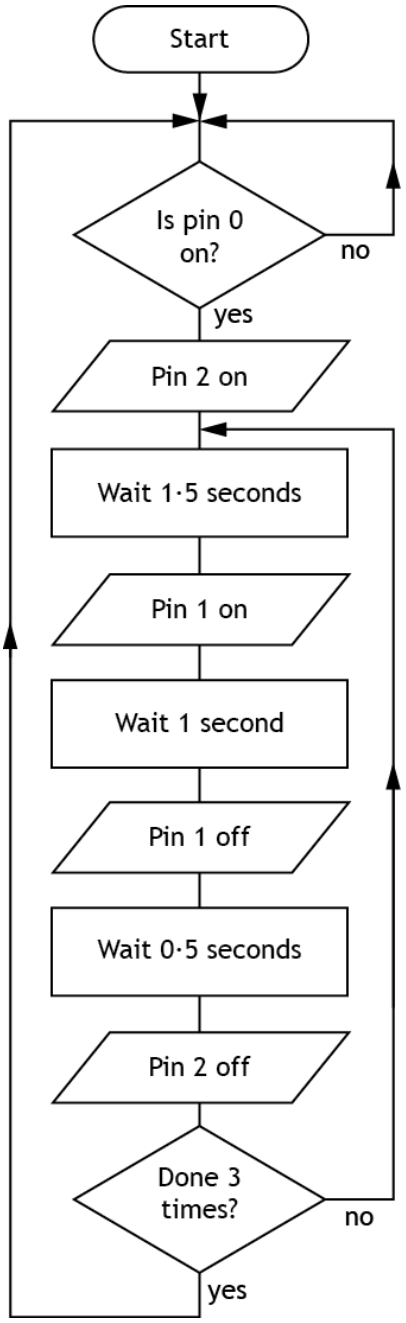
Question			Expected Answer(s)	Max Mark	Additional Guidance
10.	(a)		Designing control circuits. Calculating values of components. Selecting the correct components to use. Produce a microcontroller program. Test circuits using computer simulation.	**2**	1 mark for each correct descriptive response. No mark for generic "developing" "creating" "circuit" or "electronics" on its own. Accept: calculate power supply/ motor values Building or wiring not be accepted without reference to prototyping
	(b)		120 + 330 = 450Ω $R_T = \frac{(R1 \times R2)}{(R1 + R2)}$ $R_T = \frac{(390 \times 450)}{(390 + 450)}$ $R_T = 210\Omega\,(2sf)\,(209\Omega)$	**3**	1 mark for series branch total (ignore units) Accept 3 resistors in parallel calculation – 2 marks maximum 1 mark for substitution (allow FTE). 1 mark for answer from working with unit.
	(c)		$V = IR$ $12 = I \times 390$ $I = \frac{12}{390}$ $I = 0 \cdot 031A\,(31mA\ 2sf)$	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for answer from working with unit.
	(d)		$\sigma = \frac{F}{A}$ $0 \cdot 42 = \frac{310}{A}$ $A = \frac{310}{0 \cdot 42}$ $A = 740mm^2\ \ 2sf\ \ (738mm^2)$	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for answer from working with unit.

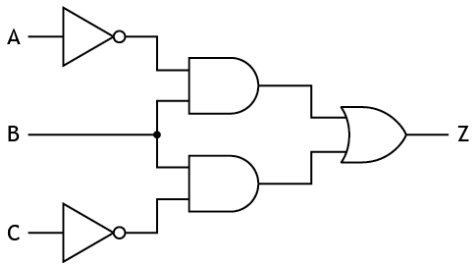
Question			Expected Answer(s)	Max Mark	Additional Guidance
11.	(a)	(i)	Items can be quickly produced thus saving time and money. Jobs will be created in the design and manufacture of the hardware used and that will produce wealth. Lower running costs (than other methods) Parts can be cheaper to print than to manufacture	**1**	Descriptive response relating to economic advantage. Jobs/employment descriptions need economic advantage. Not cheap on its own. Must be justified or a comparison
		(ii)	Initial setup/training/running/ consumables/maintenance costs. Loss of business/revenue for some companies. Parts can be slow/more expensive to manufacture	**1**	Descriptive response relating to economic disadvantages. Jobs/employment descriptions need economic disadvantages. Not more expensive on its own Do not accept the same point for (a)(i) and (ii) (max 1 mark)
	(b)		See below	**3**	"temperature sensor" 1 mark Accept: heat sensor, thermistor, thermocouple or thermostat. thermometer - 0 mark "control" - 1 mark Feedback loop from output arrow with an arrow head (anywhere) through sensor to enter control sub-system (anywhere) 1 mark

Question			Expected Answer(s)	Max Mark	Additional Guidance
					
	(c)		If the feedback signal is greater than/equals the set level the control unit will switch off the heater. 2 marks If the feedback signal falls below the set level the control unit will switch the heater on. 2 marks	**2**	Feedback compared to set level – 1 mark Switching of heater – 1 mark (switching action has to be specific, correct and related to the comparison) Not accept – if hot/cold switch heater off/on

Question			Expected Answer(s)	Max Mark	Additional Guidance
	(d)		Input speed × input size = output speed × output size 1500 × 16 = output speed × 48 Output speed = 500 rev min^{-1} Input speed x input size = output speed × output size 500 × 12 = 150 × D D = 40 teeth **OR** $VR = \frac{input\ speed}{output\ speed}$ $VR = \frac{1500}{150}$ VR = 10:1 $10 = \frac{48}{16} \times \frac{D}{12}$ $D = \frac{10}{3} \times 12$ $D = 40$	**4**	1 mark for substitution. 1 mark for answer, unit not required. 1 mark for substitution. 1 mark for answer from working. Ignore any unit. 1 mark for calculating velocity ratio 1 mark for substitution. 1 mark for transposition. 1 mark for answer from working with unit. Ignore any unit.

Question			Expected Answer(s)	Max Mark	Additional Guidance
12.	(a)		When a signal from the microcontroller actuates valve 1, pilot air actuating valve 2. This causes the piston to outstroke …air flow (through the uni-directional restrictor and reservoir) creating a time delay …. ..when valve 3 is actuated the piston will then instroke.	**3**	1 mark for each descriptive statement. 1 mark – outstroke condition 1 mark – time delay 1 mark – instroke condition
	(b)		Cross shown on left cylinder pipe.	**1**	Accept on the left hand exhaust port.

Question			Expected Answer(s)	Max Mark	Additional Guidance
	(c)			**8**	All pin numbers must be correct where applicable. • (pin) 0 on decision, feedback loop with yes/no and arrow. 1 mark • (pin) 2 on **and** off. 1 mark • all three delays 1 mark Accept PBASIC/C alternatives (pause 1500 / delay 1500) • (pin) 1 on **and** off. 1 mark • x3 times decision with yes / no labelled. 1 mark • fixed loop with arrow to return point. 1 mark • Continuous loop with arrow. 1 mark • All symbols correct. 1 mark Credit given for a series of roar/ arm movement without a fixed loop. Ignore any additional steps including symbols used.

Question			Expected Answer(s)	Max Mark	Additional Guidance
13.	(a)		18 (kN)	**1**	Accept 17kN to 19kN Units not required
	(b)		$\varepsilon = \frac{\Delta l}{l}$ $0.00030 = \frac{\Delta l}{127}$ Δl = 0·00030 x 127 Δl = 0·038 m (38 mm)	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for answer from working with unit.
	(c)		Construction will result in heavy vehicles which may damage roads. Use of construction equipment will cause pollution and increase noise levels. Vehicles access up hillside to erect pylon damage wildlife and affect natural beauty.	**2**	One environmental explanation based response. One environmental cause (1 mark) and its effect (1 mark) No credit for generic cause based statements such as "during construction" / "construction site" Sound/noise to be taken as an effect and not a cause,
	(d)			**3**	Both NOT gates. 1 mark Both AND gates with correct connections. 1mark OR gate with correct connections. 1 mark

Question			Expected Answer(s)	Max Mark	Additional Guidance
14.	(a)		E_e = ItV E_e = 13 x 60 x 230 E_e = 180 kJ (2sf) (179400 J)	**2**	1 mark substitution. 1 mark for answer from working with unit.
	(b)		$\eta = \frac{E_{out}}{E_{in}}$ $0 \cdot 64 = \frac{E_{out}}{180000}$ $E_{out} = 0 \cdot 64 \times 180000$ $E_{out} = 120 kJ\,(2 sf)\,(115200 J)$	**3**	1 mark substitution. Allow FTE from (a). 1 mark for transposition. 1 mark for answer from working with unit. (accept 114816J or 110kJ 2 sf)
	(c)		Reduce the friction in the pump by lubricating all moving parts.	**2**	Explanation response. Cause – 1 mark Effect - 1 mark Reduce friction. 1 mark Lubricate moving parts. 1 mark Do not accept lubrication without named part
	(d)		Easier/cheaper/quicker/safer to design/test/modify the gear system without having to physically build it. Highlight errors without damage to components	**1**	Descriptive answers only. Easier/cheaper/quicker/safer must be qualified Not test/check gears on its own Not computer modelling based aspects such as fitting and assembly etc.

Question			Expected Answer(s)	Max Mark	Additional Guidance
15.	(a)		*As the temparature decreases*: .. the resistance of the thermistor increases ..Vin will increase. The transistor/relay will switch..... … switching the 12V circuit/ heater.	**4**	Voltage divider explanation - maximum of 2 marks Transistor/relay switching – maximum 1 mark 12V circuit/heater circuit switching – maximum 1 mark Apply follow through error.
	(b)		Protect the transistor	**2**	Explanation response. Protection / route for back emf. 1 mark ..the transistor. 1 mark
	(c)		Allows the user to change the temperature required to activate the circuit.	**1**	Accept change the sensitivity.
	(d)		$\frac{V1}{V2} = \frac{R1}{R2}$ $\frac{0 \cdot 70}{V2} = \frac{0 \cdot 84}{10 \cdot 0}$ $V2 = \frac{0 \cdot 7}{0 \cdot 084}$ $V = 8 \cdot 3V\left(2sf\right)$	**3**	1 mark substitution. 1 mark for transposition. 1 mark for answer from working with unit. Using ohms law also acceptable.

Question			Expected Answer(s)	Max Mark	Additional Guidance
16.	(a)		$\Sigma CWM = \Sigma ACWM$ $(R_A \times 3 \cdot 0) = (60 \cdot 0 \times 1 \cdot 5) + (4 \cdot 0 \times 7 \cdot 0)$ $R_A \times 3 \cdot 0 = 90 + 28$ $R_A = \frac{118}{3 \cdot 0}$ $R_A = 39kN\,(2sf)\,(39 \cdot 3kN)$	**3**	1 mark substitution. (If R_B is calculated then 2 marks maximum. 1mk transposition 1mk final answer with unit.) 1 mark for transposition. 1 mark for answer from working with unit.
	(b)		$\Sigma F_{vertical} = 0$ $\Sigma F_{up} = \Sigma F_{down}$ $39 + R_B = 60{\cdot}0 + 4{\cdot}0$ R_B = 25kN (2 sf) 24.7kN	**2**	1 mark substitution. Allow FTE 1 mark for answer from working with unit. Accept taking moments about A.
	(c)		D – Tension E - Compression	**2**	1 mark for each correct answer. (Accept Tie and Strut)
	(d)		Reducing/no fossil fuels being used This will result in the reduction/ no CO_2 emissions/greehouse gasses.	**2**	Explain based responses relating to environmental impact Cause – 1 mark Effect - 1 mark Cause: Reduction of fossil fuel usage. 1 mark Effect: Reduction of CO_2 emissions 1 mark Do not accept pollution Gasses/emissions must be specific to CO_2 or greenhouse

[END OF MARKING INSTRUCTIONS]