N5

National
Qualifications
RESOURCE

X823/75/01 **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 National 5 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.

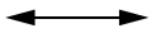
(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.

(b) 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 nonmathematical reasoning.

(c) 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

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>1.</td><td></td><td></td><td><table><tr><th>Motion name</th><th>Graphic</th></tr><tr><td>Linear</td><td></td></tr><tr><td>Reciprocating</td><td></td></tr><tr><td>Rotary</td><td></td></tr><tr><td>Oscillating</td><td></td></tr></table></td><td>3</td><td>1 mark for reciprocating graphic.

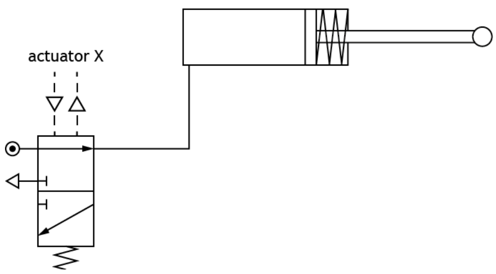
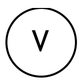
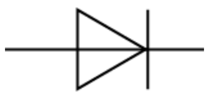
1 mark for rotary (motion).

1 mark for oscillating graphic.</td></tr>
<tr><td>2.</td><td></td><td></td><td>$\varepsilon = \frac{\Delta l}{l}$

$\varepsilon = \frac{0{\cdot}0021}{14}$

$\boldsymbol{\varepsilon}$ = 0·00015 (2 s.f.)</td><td>2</td><td>

1 mark for substitution.

1 mark for correct answer from given working. Unit should be ignored.</td></tr>
<tr><td>3.</td><td>(a)</td><td></td><td></td><td>1</td><td>1 mark for correct piping port to port.</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Diaphragm (valve).</td><td>1</td><td></td></tr>
<tr><td>4.</td><td></td><td></td><td>No unit for force.
Forces all act in the same direction/ force direction are wrong way round/reaction forces should be upwards.</td><td>2</td><td>1 mark for each error.</td></tr>
<tr><td>5.</td><td>(a)</td><td></td><td></td><td>1</td><td>1 mark for correct symbol
Ignore connecting wires.</td></tr>
<tr><td></td><td>(b)</td><td></td><td>Relay (switch).</td><td>1</td><td></td></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>1</td><td>1 mark for correct symbol
Accept line/no line through triangle
Do not accept LED.</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	1 Compression. 2 Tension.	**2**	Accept strut/compressive/squashed. Accept tie/stretched.
		(ii)	Make the structure more rigid.	**1**	Accept any inferred stability.
	(b)		Structural	**1**	
7.	(a)		Open loop does not have feedback where closed loop has feedback.	**2**	Must be descriptive response. 1 mark for no feedback. 1 mark for has feedback. Do not accept has a sensor on its own.
	(b)		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.

Section 2

Question			Expected response	Max mark	Additional guidance
8.	(a)		Separate the (external) inputs and outputs from the process.	**1**	
	(b)		The control unit compares the light level with the set light level. If the light level is below the set level the LED will turn on. **OR** If the light level is above the set level the LED will remain off.	**2**	Comparison of set level and light level. **(1 mark)** Result of comparison and effect on LED. **(1 mark)**
	(c)		Voltage Divider.	**1**	Accept potential divider.
	(d)		$\frac{V1}{V2}=\frac{R1}{R2}$ $\frac{1{\cdot}2}{V2}=\frac{3{\cdot}4}{14}$ $V2=\frac{1{\cdot}2}{0{\cdot}242857}$ $V2$ = 4·94 V_s = 4·94 + 1·2 V_s = 6·14 **V_s = 6·1 V (2 s.f.)**	**4**	1 mark for substitution. 1 mark for transposition. 1 mark for V2 from given working. 1 mark for correct answer from given working with unit.

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>8.</td><td>(e)</td><td></td><td>

D	E	Z
0	0	0
0	0	0
0	0	0
0	1	1
0	0	0
0	0	0
1	0	1
1	1	1

</td><td>3</td><td>1 mark for each correct column.

Allow FTE.</td></tr>
<tr><td></td><td>(f)</td><td></td><td>$(\overline{K} + \overline{L}) \bullet M$</td><td>3</td><td>1 mark for both NOTs.

1 mark for OR (with brackets).

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

Question			Expected response	Max mark	Additional guidance
9.	(a)		To measure the current flowing through the motor.	**2**	Measure current. **(1 mark)** Through the motor. **(1 mark)**
	(b)	(i)	$\frac{1}{RT}=\frac{1}{R1}+\frac{1}{R2}+\frac{1}{R3}$ $\frac{1}{RT}=\frac{1}{120}+\frac{1}{820}+\frac{1}{820}$ $RT=\frac{1}{0{\cdot}0083+0{\cdot}00122+0{\cdot}00122}$ RT = 93·118 ***RT* = 93 Ω (2 s.f.)** alternative method $Rp=\frac{(820\times820)}{(820+820)}$ Rp = 410 Ω $Rp=\frac{(120\times410)}{(120+410)}$ Rp = 92·83 Ω ***Rp* = 93 Ω (2 s.f.)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit. 1 mark for substitution. 1 mark for substitution. Allow FTE. 1 mark for correct answer from given working with unit.
		(ii)	V = I R 24 = I x 93 I = 24 ÷ 93 I = 0·25806 **I = 0·26 A (2 s.f.)**	**3**	1 mark for substitution. Allow FTE from part (i). 1 mark for transposition. 1 mark for correct answer from given working with unit.

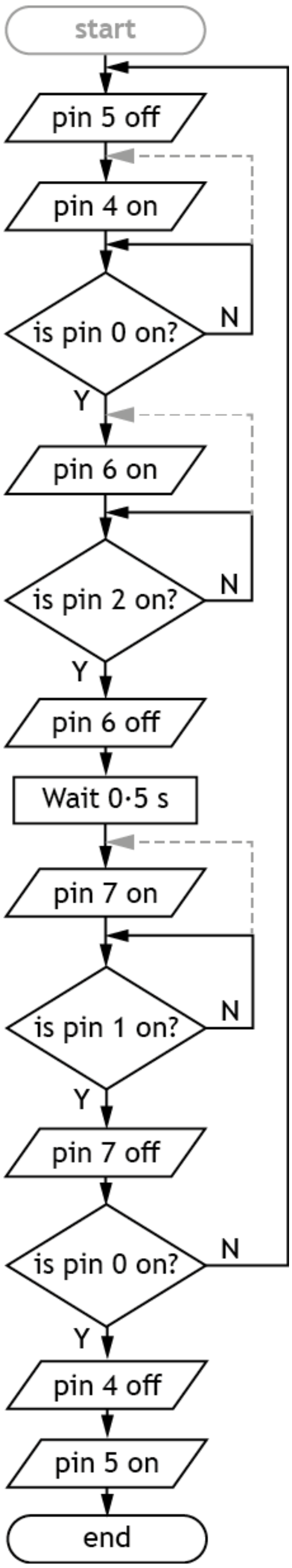
Question			Expected response	Max mark	Additional guidance
9.	(c)		Construction workers earn money. Shops may lose money. Increased revenue for local hotels. Installation company could make money.	1	Descriptive response. 1 mark for economic impact related to during construction. Impact can be positive or negative. Do not accept expensive to install.
	(d)		Journey time to get to a plane is reduced. Less stressful getting to a plane on time.	1	Descriptive response. 1 mark for social impact.
	(e)	(i)	The gear system to connect the motor to the walkway.	1	Descriptive response. Answer must be linked to a design based task of a mechanical engineer. **(1 mark)**
		(ii)	The power required to drive the motor.	1	Answer must be linked to a calculation based task of an electrical engineer. **(1 mark)**

Question			Expected response	Max mark	Additional guidance
10.	(a)		$E_h = c\ m\ \Delta T$ $E_h = 910 \times 1{\cdot}6 \times 25$ $E_h = 36\ 400$ $\boldsymbol{E_h}$ **= 36 kJ (2 s.f.)**	**2**	1 mark for substitution. 1 mark for correct answer from given working with unit.
	(b)	(i)	$120 \times 60 = 7200$ s $E_e = V\ I\ t$ $E_e = 230 \times 1{\cdot}1 \times 7200$ $E_e = 1\ 821\ 600$ $\boldsymbol{E_e}$ **= 1·8 MJ (2 s.f.)**	**3**	1 mark for time in seconds (unit not required). 1 mark for substitution. 1 mark for correct answer from given working with unit.
		(ii)	$Efficiency = \frac{E_{out}}{E_{in}}$ $0{\cdot}72 = \frac{E_{out}}{1800000}$ $E_{out} = 0{\cdot}72 \times 1\ 800\ 000$ $E_{out} = 1\ 296\ 000$ $\boldsymbol{E_{out}}$ **= 1·3 MJ (2 s.f)**	**3**	1 mark for substitution. Allow FTE from 10bi. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(c)		*When the temperature increases...* The thermistor resistance will decrease The voltage (V_{in}) will decrease. This will cause the transistor to switch off. Turning off the LED.	**4**	Descriptive response. 1 mark for thermistor resistance decreasing. 1 mark for V_{in} decreasing. 1 mark for transistor off. 1 mark for LED off. Apply FTE from each statement.
	(d)		To protect the LED	**1**	Descriptive response.

Question			Expected response	Max mark	Additional guidance
11.	(a)		1425 N **1400 N (2 s.f.)**	**1**	Apply scaling (10 mm = 150 N) to Force A on candidate's diagram if question has not been reproduced to correct size. Ignore units.
	(b)		$Stress = \frac{F}{A}$ $13 = \frac{680}{A}$ $A = \frac{680}{13}$ A = 52·308 mm^2 $\boldsymbol{A}$ **= 52 mm^2 (2s.f.)**	**3**	 1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.
	(c)		D Performs best in tension and is corrosion resistant.	**2**	1 mark for choice of material. 1 mark for justification with reference to tension and corrosion resistant.
	(d)		Forces on the structure can be simulated/without human risk. As a prototype does not need be built/simulating the zip slide can be cheaper.	**2**	1 mark cause. 1 mark effect.
	(e)		E_k = ½ mv^2 E_k = 0·5 x 75 x 13^2 E_k = 6338 $\boldsymbol{E_k}$ **= 6300 J (2s.f.)**	**2**	 1 mark for substitution. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
12.	(a)		*When the electrical switch is activated ...* Valve 1 will be actuated causing cylinder A and B to outstroke. After a set time delay valve 1 is actuated causing cylinder A and B to instroke. Or if valve 5 is actuated before the time delay is complete, pilot air will actuate valve 1 causing cylinder A and B to instroke.	**3**	Descriptive response. 1 mark for valve 1 actuated and both cylinders outstroke. 1 mark for time delay followed by both cylinders instroking. Allow FTE. 1 mark for **OR** valve 5 causing both cylinders to instroke. Allow FTE.
	(b)		Position D The pistons will outstroke at normal speed. Position E The pistons will outstroke slowly and smoothly. Position F Piston A will outstroke slowly. Piston B will outstroke at normal speed.	**3**	Descriptive response. Position D 1 mark for no change to outstroke speed. Position E 1 mark for pistons smooth movement. Position F 1 mark for piston A **only** outstroking slowly. Correct outstroking statements only.
	(c)		$A = \frac{\pi d^2}{4}$ $A = \frac{\pi 42^2}{4}$ A = 1385·44236 mm^2 $0 \cdot 50 = \frac{F}{1385 \cdot 44236}$ F = 0·50 × 1385·44236 F = 692·7211801 **F = 690 N (2s.f.)**	**4**	1 mark for Area (unit not required). 1 mark for substitution. Allow FTE for area. 1 mark for transposition. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
12.	(d)		P = IV 4·5 = I × 12 $I = \frac{4 \cdot 5}{12}$ I = 0·375 **I = 0·38 A (2s.f)**	**3**	 1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit.

Question			Expected response	Max mark	Additional guidance
13.	(a)		No fossil fuels being used after manufacture/which will result in the reduction of CO_2 emissions/greenhouse gasses.	**2**	Explanation response. 1 mark for cause. 1 mark for effect. Do not accept pollution. Gasses/emissions must be specific to CO_2 or greenhouse.
	(b)			**11**	Pin numbers must be correct where applicable. Pin 5 off and on positions. **(1 mark)** Pin 4 on and off positions. **(1 mark)** Pin 6 on and off positions. **(1 mark)** Pin 7 on and off positions. **(1 mark)** 0·5 s delay. **(1 mark)** Pin 0 on ? with Y/N, loop and arrow. **(1 mark)** Pin 3 on ? with Y/N, loop and arrow. **(1 mark)** Pin 2 on ? with Y/N, loop and arrow. **(1 mark)** Pin 0 on ? (second) with Y/N, loop and arrow. **(1 mark)** End. **(1 mark)** All marked symbols correct. **(1 mark)** Ignore any additional steps.

Question			Expected response	Max mark	Additional guidance
13.	(c)		Less lorry journeys/reducing CO_2 emissions. Less lorries on the road reducing congestion/resulting in less emissions from vehicles. Less lorries on the road/reducing wear and tear on roads. Food waste can be left for a long period of time/resulting in smells.	**2**	Explanation response. 1 mark for cause. 1 mark for effect.

Question			Expected response	Max mark	Additional guidance
14.	(a)		ΣCWM = ΣACWM $(11x1.8)+(37x6.1)+(28x8.6)=(R_Bx12.2)$ $19.8 + 225.7 + 240.8 = R_B \times 12.2$ $RB = \frac{486 \cdot 3}{12 \cdot 2}$ $R_B = 39.86$ **R_B = 40· kN (2s.f.)**	**3**	1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working with unit. If R_A is calculated correctly (36 kN) then 2 marks maximum.
	(b)		ΣFvertical = 0 ΣFup = ΣFdown $R_A + 40 = 11 + 37 + 28$ **R_A = 36 kN (2s.f.)**	**2**	1 mark for substitution. Allow FTE. 1 mark for correct answer from given working with unit. Accept taking moments about R_B.
	(c)		Lubricate/bearings/'slippier' material used. To reduce friction/energy loss(to heat/sound).	**2**	Explanation response. 1 mark for cause (lubrication). 1 mark for effect (reason).

Question			Expected response	Max mark	Additional guidance
14.	(d)		1980 x 12 = output speed x 108 $\text{output speed} = \frac{23760}{108}$ Output speed = 220 revs min^{-1} 220 x 16 = 55 x gear D $\text{gear D} = \frac{3520}{55}$ gear D = 64 (teeth) **OR** $VR = \frac{1980}{55}$ VR = 36 : 1 $36 = \frac{108}{12} \times \frac{D}{16}$ $D = \frac{36 \times 16}{9}$ Size of D = 64 (teeth)	**4**	1 mark for substitution. 1 mark for correct answer from given working (unit not required). 1 mark for substitution. 1 mark for correct answer from given working (ignore any units). 1 mark for calculating VR. 1 mark for substitution. 1 mark for transposition. 1 mark for correct answer from given working (ignore any units).
	(e)		Insert a (idler) gear between gears: A and B **OR** C and D	**2**	Must be a description response. 1 mark for using an additional gear. 1 mark for position of additional gear.

[END OF MARKING INSTRUCTIONS]