FOR OFFICIAL USE

National
Qualifications
SPECIMEN ONLY

Mark

SQ13/H/01 Engineering Science

Date — Not applicable

Duration — 2 hours

* S Q 1 3 H 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day Month Year

D D M M Y Y

Scottish candidate number

Total marks — 90

SECTION 1 — 20 marks

Attempt ALL questions.

SECTION 2 — 70 marks

Attempt ALL questions.

Write your answers clearly in the spaces provided in this booklet. Additional space for answers is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting.

Numerical answers should include units, and be rounded to an appropriate number of significant figures.

Show all working and units where appropriate.

You should refer to the Higher Data Booklet which you have been given.

Use **blue** or **black** ink.

Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

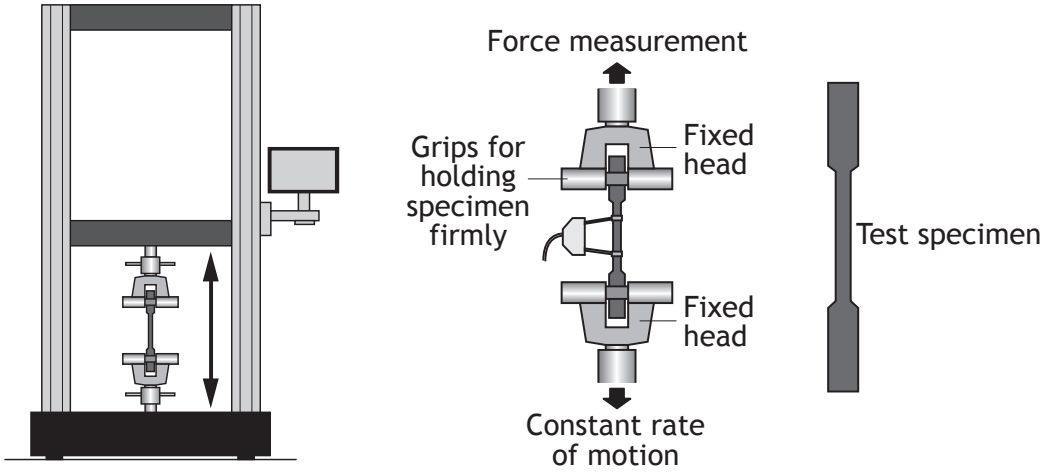
SQA ©

SECTION 1 — 20 marks

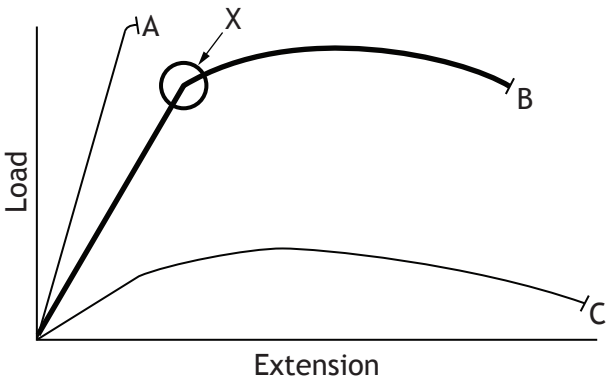
Attempt ALL questions

MARKS | DO NOT WRITE IN THIS MARGIN

1. A structural engineer has asked for a tensile strength test to be carried out on three metal specimens (A, B and C) using the equipment shown.



The results are displayed on the load extension graph shown below.



(a) (i) State which of these metals has the highest value of Young's Modulus. **1**

_____

(ii) Describe what this means. **1**

_____

(b) Describe, using appropriate terminology, the way in which metal B responds to loading around X. **2**

_____

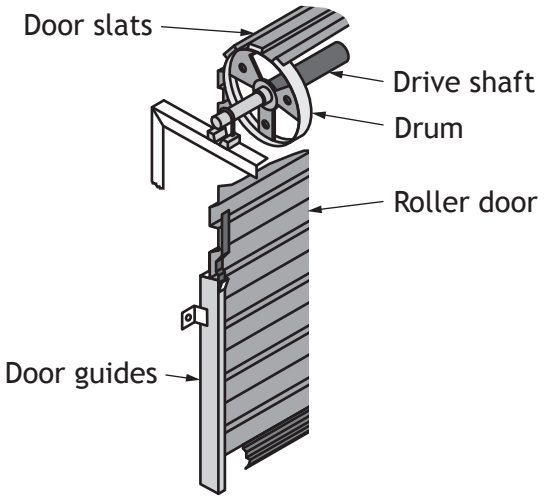
_____

2. A mechanical engineer is developing the drive and control system for the automatic garage roller door shown.

The door is to be opened and closed using a direct current motor controlled by a microcontroller.

The motor rolls the door slats around a drum to open and close it as shown.

For safety, the garage door must slow down gradually and stop when it is fully open or closed.

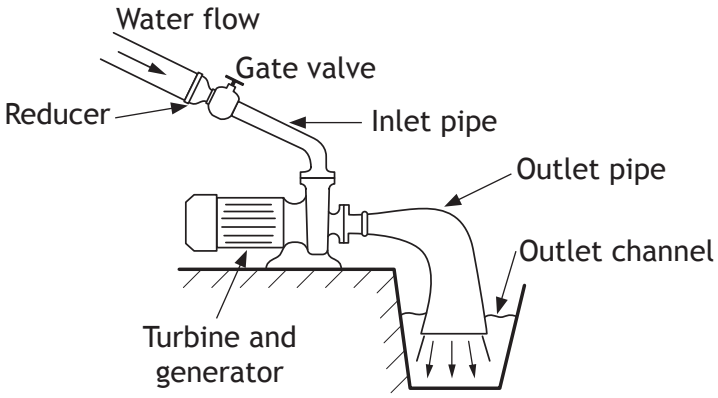


(a) Sketch a graph of the pulses sent to the motor by the microcontroller as the door approaches being fully closed. Label both axes of the graph, a mark and a space. You should show at least 6 pulses. **3**

The diameter of the drum is 0·186 m and the force required to be applied to the roller slat is 127 N.

(b) Calculate the torque supplied by the drive shaft. **2**

3. An energy engineer is carrying out an audit on the micro-hydro system shown.



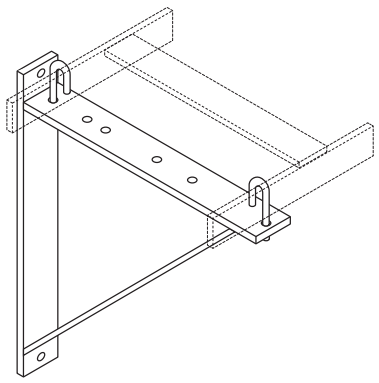
The engineer measured the electrical output from the generator to be 22 A at 230 V. The mass of water flowing through the inlet pipe into the generator was 2500 kg every second at an average flow rate of 3·2 ms^{-1}.

(a) Calculate the efficiency of the system. **3**

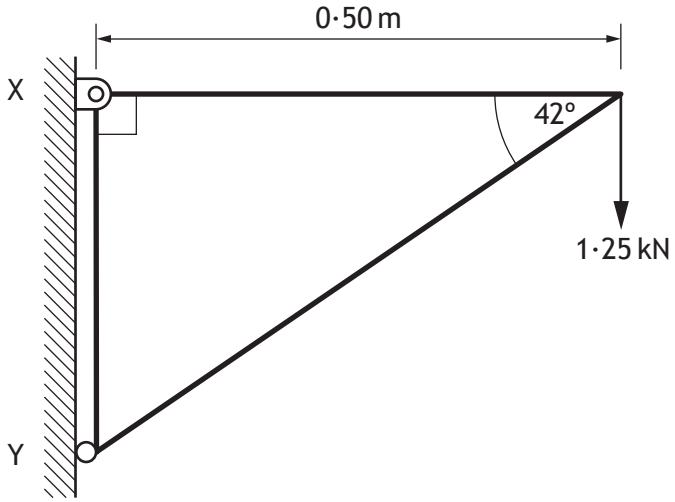
(b) (i) Explain why it is impossible to achieve 100% efficiency in any system. **1**

(ii) Describe **one** modification that could be made to this system to improve its efficiency. **1**

4. A structural engineer has been asked to reduce the cost of manufacturing the cable support bracket shown below.



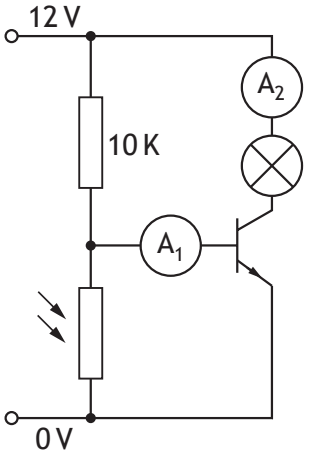
To examine the loading and fixing of the bracket, the engineer drew the loading diagram below:

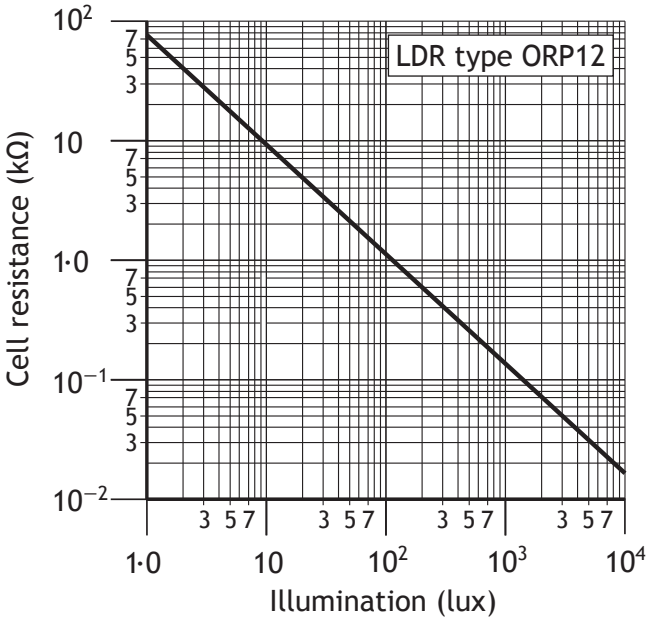


Calculate the magnitude and direction of the reaction at Y. **3**

5. An engineering technician is testing the circuit shown below to determine the gain of the bipolar junction transistor (BJT).

MARKS DO NOT WRITE IN THIS MARGIN





(a) Determine the light level to fully saturate the transistor. Refer to the graph shown, which shows how the resistance of the LDR responds to light level. Assume $V_{BE} = 0{\cdot}7\,V$. **2**

The two currents measured at A_1 and A_2 were 1·2 mA and 110 mA respectively.

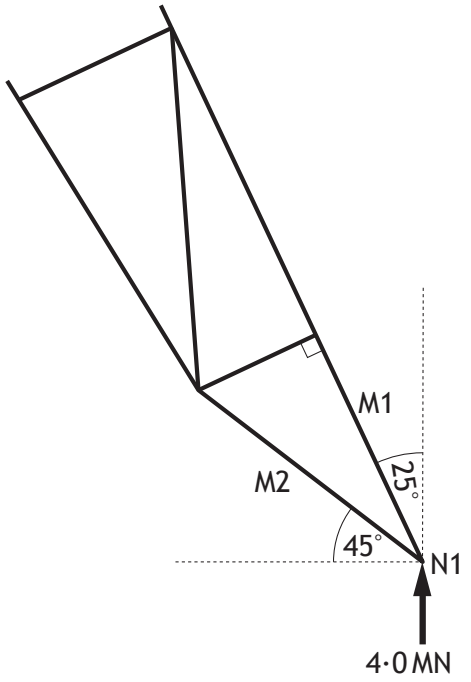
(b) Calculate the h_{FE} value. **1**

SECTION 2 — 70 marks

Attempt ALL questions

1. A new railway station is being built. A structural engineering company has been asked to produce detailed information about a possible station roof.

Detail from a proposed design for one of the roof's steel support legs is shown.



(a) Node N1 is in static equilibrium. M2 is a tie.

Calculate the magnitude of the forces in members M1 and M2. **5**

1. (continued)

(b) Describe **three** examples of how a structural engineer would **apply** knowledge of materials, and/or skills in carrying out calculations, in the design of the structure shown above. **3**

Example 1 _____

_____

_____

Example 2 _____

_____

_____

Example 3 _____

_____

_____

(c) Describe **two** positive **economic** impacts and **one** negative **economic** impact that the station project might have on the local community **during the construction phase**. **3**

Positive impact 1 _____

_____

_____

Positive impact 2 _____

_____

_____

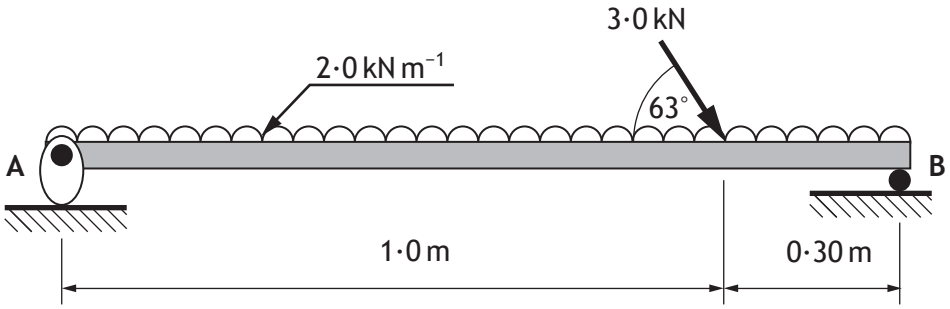
Negative impact _____

_____

_____

1. (continued)

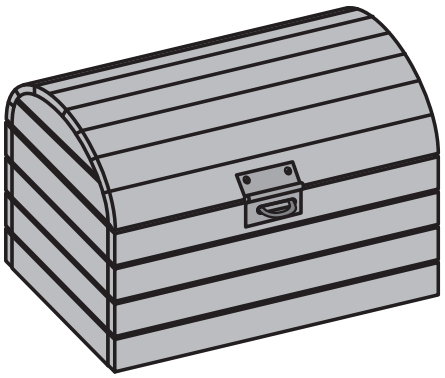
During the design phase, a scale model of a particular loading condition was constructed, as shown below.



(d) Determine the magnitude and direction of the reaction at A. **4**

MARKS | DO NOT WRITE IN THIS MARGIN

2. The research and development department of a toy company has appointed an engineering team to redesign the wooden treasure chest shown.



The new version will have an electronically controlled locking system and may be constructed from a different material.

(a) The development team includes a mechanical engineer and an electrical/electronic engineer.

For each type of engineer, state **one specialist skill** and **one piece of specialist knowledge** which they could contribute to the redesign. **4**

Mechanical engineer

Specialist skill _____

_____

Specialist knowledge _____

_____

Electrical/electronic engineer

Specialist skill _____

_____

Specialist knowledge _____

_____

(b) Suggest an alternative material which could be used instead of wood to construct the treasure chest, and explain why it would be an improvement. **1**

_____

_____

_____

2. (continued)

The first prototype developed has an electronic control system with three inputs and one output.

The inputs are:

- a micro-switch (L) which goes low when the lid is opened
- a lock/unlock switch (O) which goes high when set to the unlock position
- a secret security button (S) which goes high when it is pressed

The output is:

- a buzzer (B) which sounds when it goes high

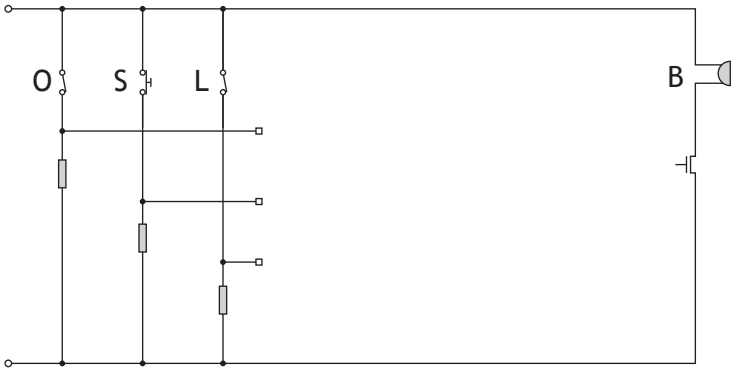
The buzzer must **not** sound when the lid is shut.

The buzzer must **not** sound when the lid is unlocked by its owner, while the secret security button is pressed.

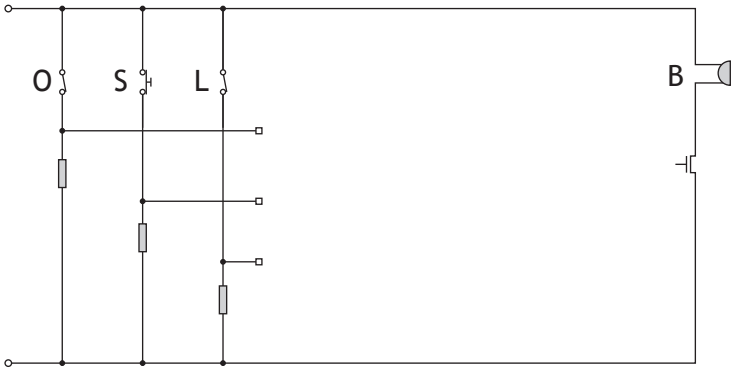
(c) (i) Write a Boolean expression for the buzzer **not to sound** (in its simplest form). **1**

$\overline{B}$=

(ii) Complete the circuit diagram below to carry out this function using only a combination of AND, OR and NOT gates. **3**



(iii) Redraw the circuit diagram using only two-input NAND gates to carry out the same function. Cross out any redundant gates. **3**



2. (continued)

A second prototype uses a microcontroller to process a three digit code to control the locking system.

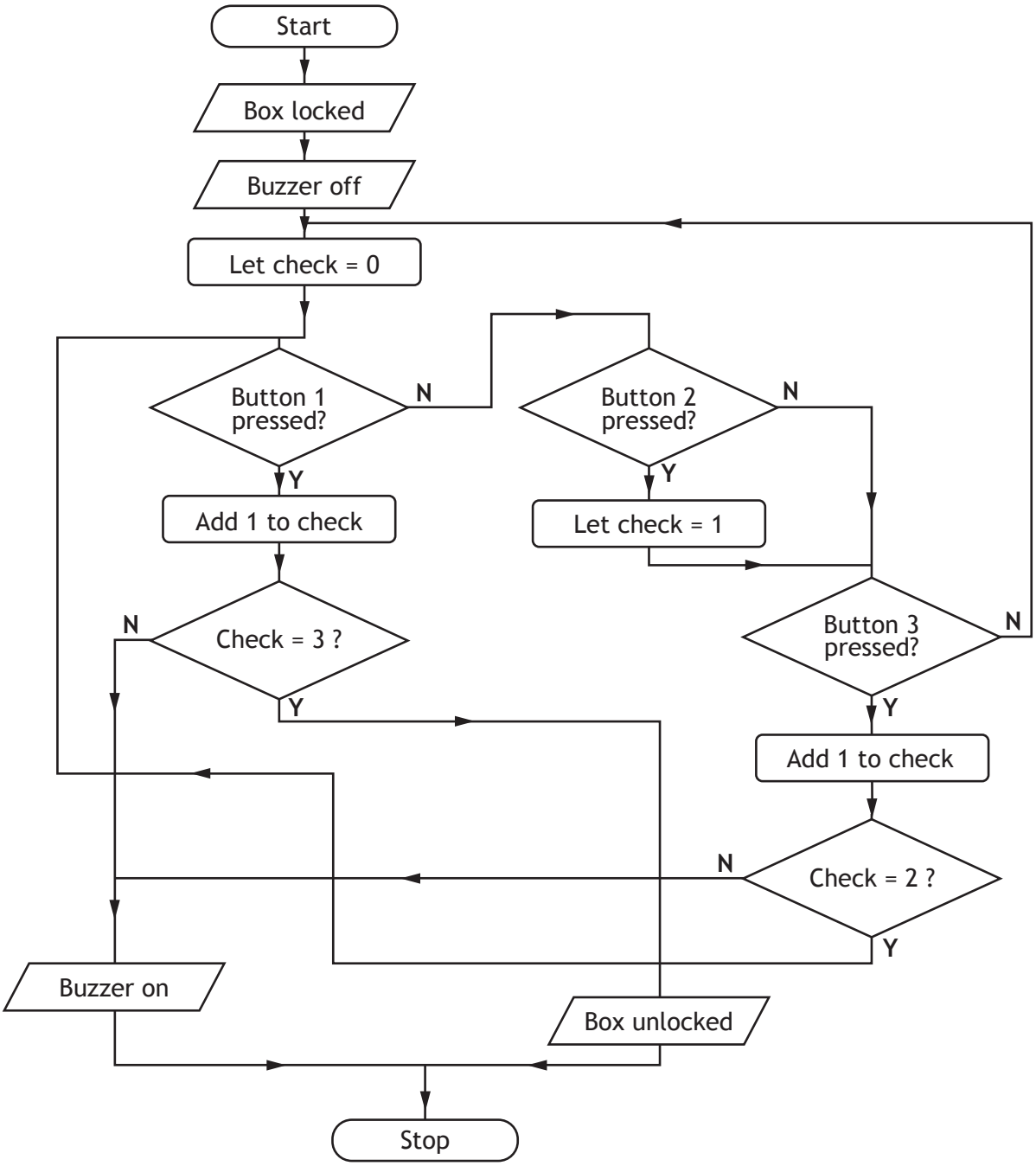
Each button can only be pressed once; when pressed, it latches on and stays high.

(d) The partly completed table below lists all possible codes that could be entered. Only one of these codes will open the box without sounding the buzzer.

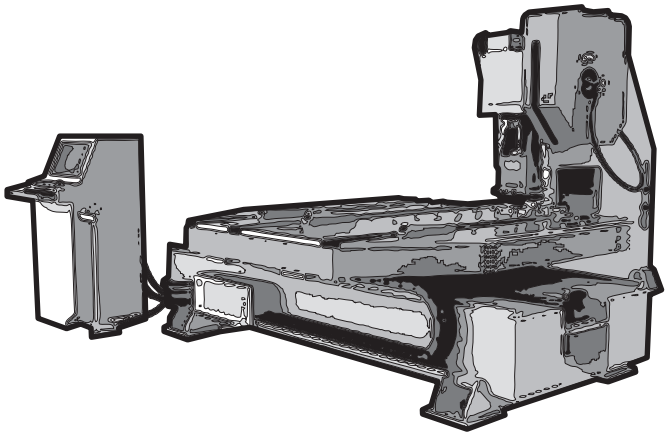
Code	Buzzer sounds	Box unlocked	Correct code?
123	✓	✗	no
132			
213	✓	✗	no
231			
312			
321	✓	✗	no

Use the flowchart on the following page to complete the table above, and so identify the correct code to open the box without sounding the buzzer. **3**

2. (d) (continued)



3. A punch press for making aluminium cans is shown below. A sequential pneumatic circuit is used to control two cylinders. Cylinder A opens and closes a clamp which holds a piece of aluminium alloy, and cylinder B lowers and raises the head which punches out the can.



During the design stage of the machine, the team of engineers must consider the sustainability of their design.

(a) Describe **two** aspects of the design of this machine which could improve its sustainability. **2**

1 _____

_____

2 _____

_____

The cylinders are sequentially controlled to repeat the following four steps in a continuous loop:

1. Cylinder A outstrokes (A+)
2. Cylinder B outstrokes (B+)
3. Cylinder B instrokes (B−)
4. Cylinder A instrokes (A−)

(b) (i) Complete the circuit on the following page, to carry out this sequence.

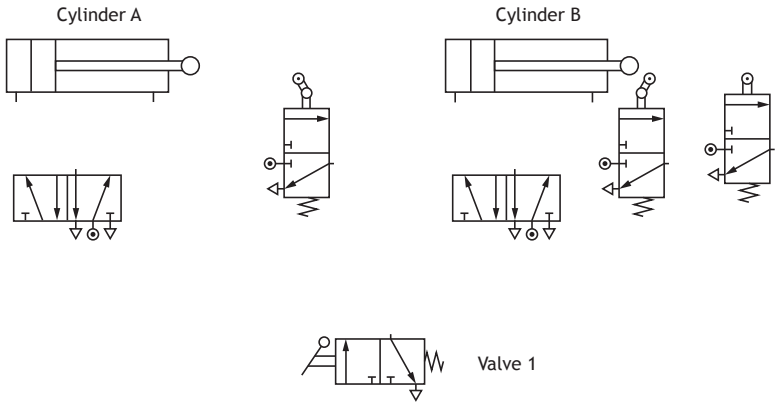
You may use the **top diagram for rough working**.

Use the **lower diagram for your final version**. **6**

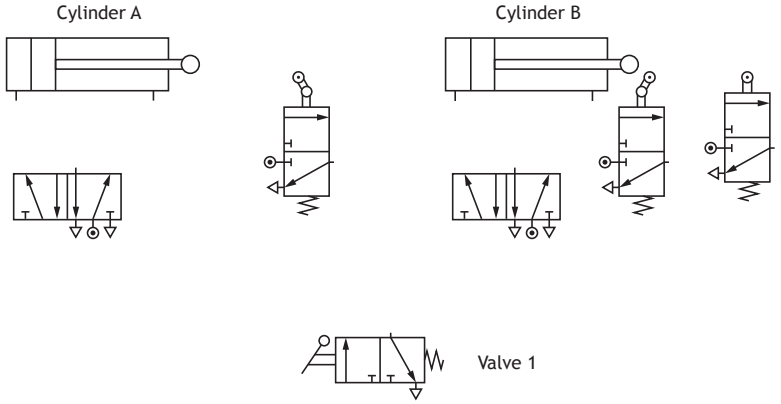
3. (b) (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

For rough working only



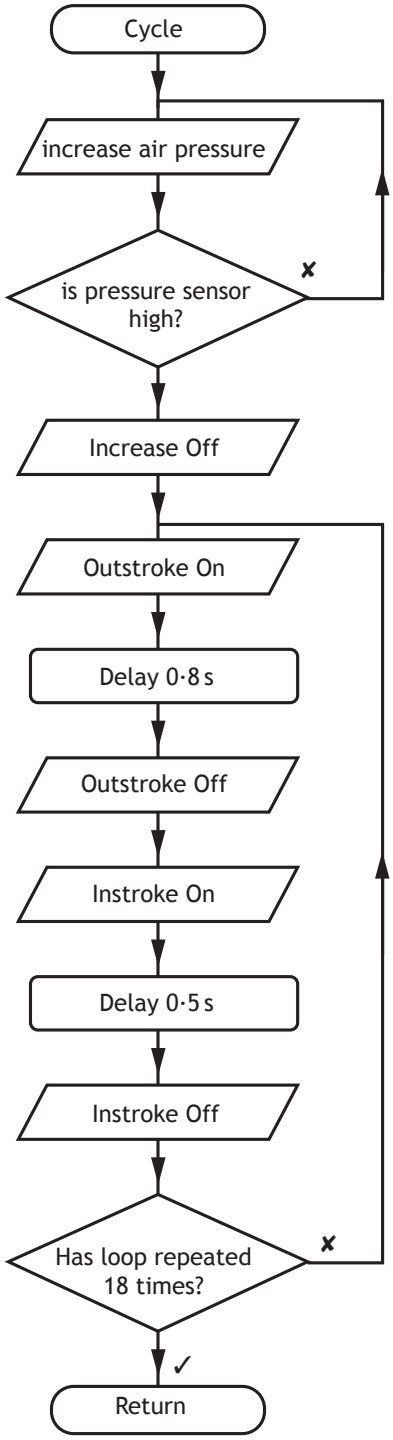
Final version



(ii) As a safety feature, the designer of the machine decided to add an extra valve to the circuit. In this new system, two valves have to be actuated together for the sequence to start, producing AND control. Add the valve and actuators to your circuit diagram above and connect it to the rest of the circuit to produce this type of control. **2**

3. (continued)

In an alternative design, the punch press is controlled by a microcontroller which provides the sequence of operations required to punch out the can shape. Part of the program sequence is the sub-procedure *cycle*, as described in the flowchart and input/output table below.



Input	Pin	Output
	7	Air pressure increase
	6	Outstroke actuator
	5	Instroke actuator
Pressure sensor	1	

(c) Using a high level language appropriate for programming microcontrollers, write program code which will carry out the sequence required. **4**

3. (c) (continued)

MARKS DO NOT WRITE IN THIS MARGIN

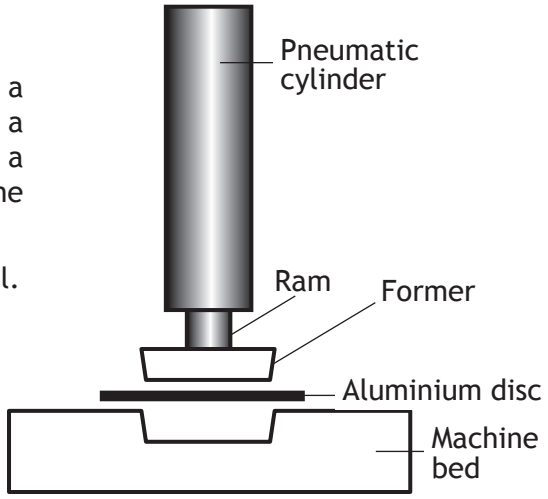
Write your program code here

3. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

To make the base of the can, a pneumatic ram and former presses a disc of aluminium alloy into a suitably shaped cavity in the machine bed as shown.

Aluminium alloy is a ductile material.



(d) Explain why being ductile makes the alloy suitable for this application. **1**

The ram is made from alloy steel and applies a force of 6·0 kN to make the aluminium alloy cup. The result of this pressure is **compressive** stress which causes a small change in the length of the ram.

The ram has a diameter of 65 mm and an original length of 120 mm.

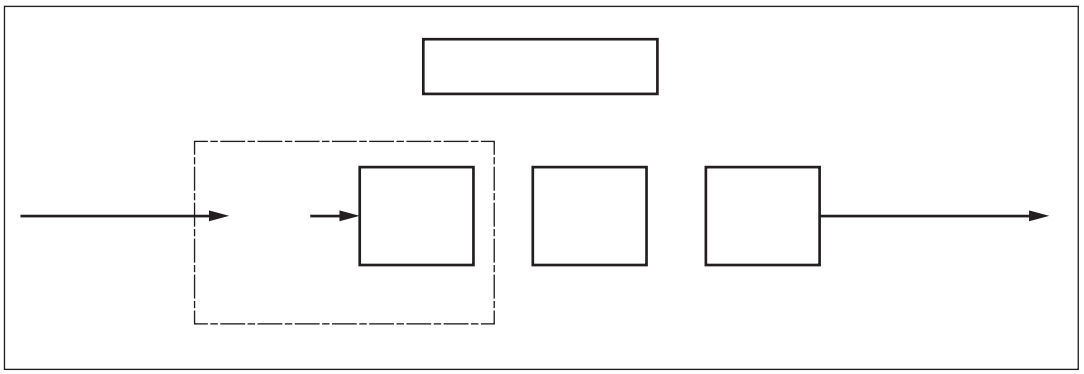
(e) Calculate:

(i) the change in length of the ram during the pressing operation; **3**

(ii) the strain energy within the ram due to this change in length. **2**

4. The laser level device shown below has an automatic electronic control system. The system uses an accelerometer to sense whether the laser beam is horizontal. If it is not horizontal, a motor adjusts the laser levelling platform position.

(a) Complete a labelled control diagram for this device.

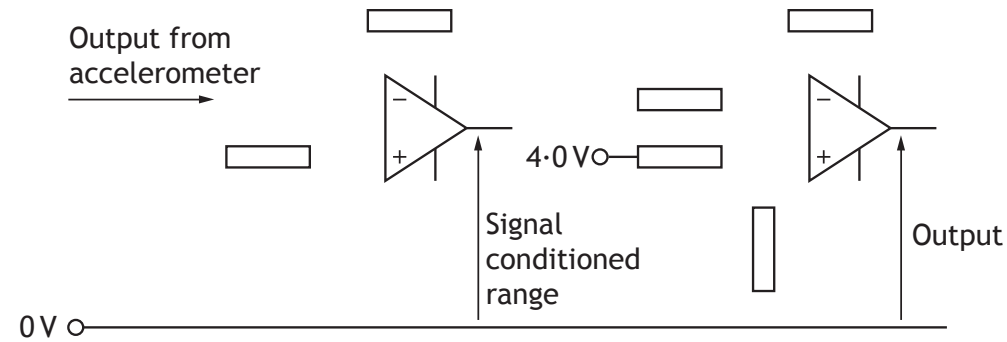


4. (continued)

An electronic engineer designing an op-amp control system for the device has developed the following specification:

- the voltage which represents the laser being horizontal is 4·0 V
- the accelerometer produces an output in the range 10–30 mV
- the output from the accelerometer must be amplified to a range of 2·0–6·0 V
- the amplified range should be compared to the desired level voltage (4·0 V), and the difference between them amplified by 3·0 to produce the output.

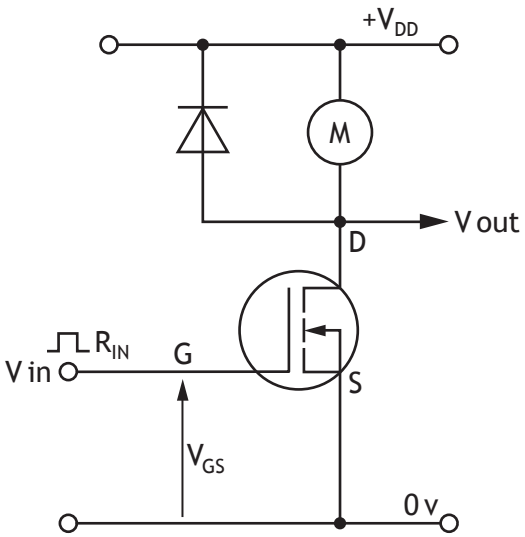
(b) Complete the op-amp control system below. Show all working and component values. You do not need to show the +ve and –ve supplies to the op-amps. **6**



Show working here

4. (continued)

An electronic engineer decided that one of the platform levelling motors would be controlled using the circuit shown below. The motor is controlled by a microcontroller using Pulse Width Modulation (PWM) and it is important the control system uses as little power as possible. The motor has a power rating of 12 V 200 W and the n-channel MOSFET has an R_{DS} value of 0·1 Ω and is fully saturated.



(c) Explain why the electronic engineer might choose to use a MOSFET rather than a BJT for this particular application. **4**

(d) Describe an emerging technology which may significantly change the design of transistors and other electronic components in the near future. **1**

4. (continued)

(e) A particular levelling motion takes 2·3 s.

Calculate the energy dissipated in the MOSFET during the levelling motion. **3**

[END OF SPECIMEN QUESTION PAPER]

ADDITIONAL SPACE FOR ANSWERS

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National
Qualifications
SPECIMEN ONLY

SQ13/H/01 Engineering Science

Marking Instructions

These Marking Instructions have been provided to show how SQA would mark this Specimen Question Paper.

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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 <u>always</u> 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) 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.

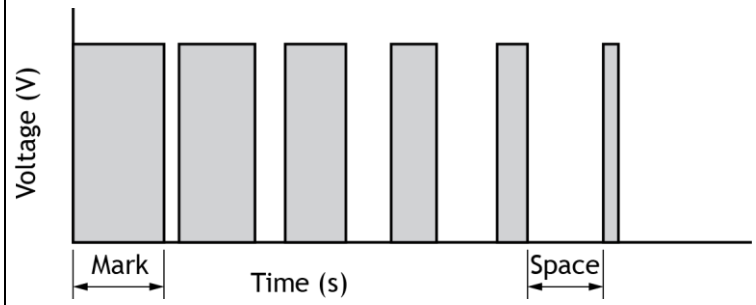
(j) Candidates may answer programming questions in any appropriate programming language. Marks should be awarded, regardless of minor syntax errors, as long as the intention of the coding is clear.

(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.

Marking Instructions for each question

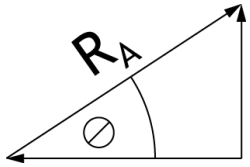
SECTION 1

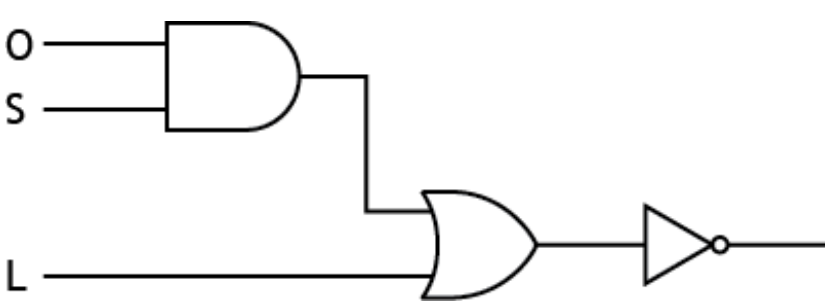
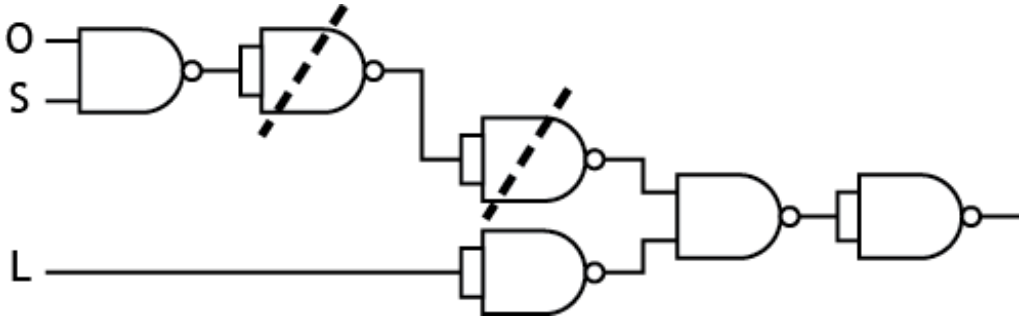
Question			Expected response	Max mark	Additional guidance
1	a	i	A	1	1 mark for identifying A.
1	a	ii	Extends least for given loading.	1	1 mark for valid description.
1	b		Yields/changes from elastic to plastic. Beyond X, small extra loading leads to large increase in length.	2	1 mark for description. 1 mark for correct use of terminology (yield, elastic, plastic).
2	a			3	1 mark for labelled axes. 1 mark for labelling of mark and space. 1 mark for showing clearly increasing space and decreasing mark.
2	b		$T = F \times r = 127 \times 0{\cdot}093$ $= 11{\cdot}8$ Nm	2	1 mark for correct formula and substitution. 1 mark for correct answer and units.
3	a		$E_k = 1/2 \times m \times v^2 = 0{\cdot}5 \times 2500 \times (3{\cdot}2)^2 = 12\,800$ J (per second) $E_e = I\,V = 22 \times 230 = 5060$ J (per second) Efficiency = 5060 / 12 800 = 0·40 (40%)	3	1 mark for calculating input kinetic energy. 1 mark for calculating output electrical energy. 1 mark for calculating efficiency.

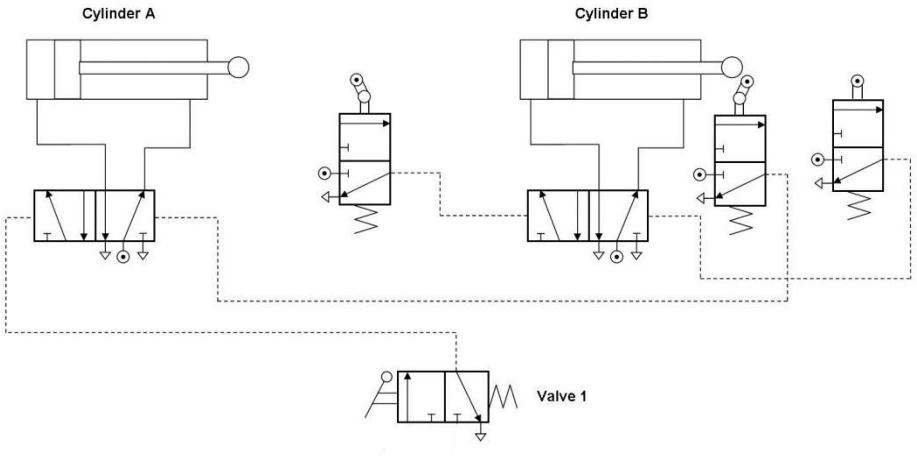
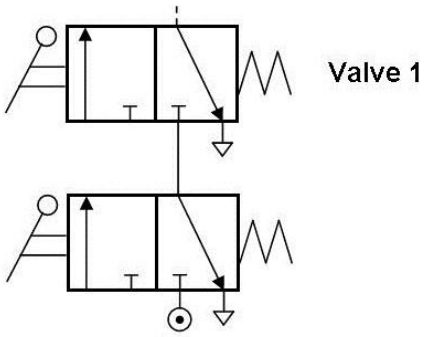
Question			Expected response	Max mark	Additional guidance
3	**b**	**i**	Some energy will always be converted into non-useful forms.	**1**	1 mark for identifying conversion to non-useful forms of energy.
3	**b**	**ii**	Any plausible suggestion: eg using improved bearings to reduce the friction in the turbine, or redesigning the turbine blades to be more effective.	**1**	1 mark for any plausible suggestion. Suggestion must contain specific detail—e.g. "reducing friction" is too vague—and must be functionally possible.
4			XY = 0·5 $\tan(42^\circ)$ = 0·45 m ΣM = 0 so 0·5 × 1250 = 0·45 × R_Y so R_Y = 1390 N = 1·4 kN (to 2 significant figures), in direction →	**3**	1 mark for calculating length. 1 mark for magnitude (1·4 kN), 1 for direction (to the right).
5	**a**		assume saturation voltage = 0·7 V R1/R2 = V1/V2 $\Rightarrow$ 10K / R_{ldr} = 11·3 / 0·7 $\Rightarrow$ R_{ldr} = 10K × 0·7 / 11·3 = 0·62 kΩ from graph, this corresponds to around 180–200 lux	**2**	1 mark for calculating the LDR resistance. 1 mark for reading the value from graph (must give units). (allow any answer in the range 150–250)
5	**b**		$h_{FE} = I_c / I_b$ = 110 / 1·2 = 92	**1**	

SECTION 2

Question			Expected response	Max mark	Additional guidance
1	a		$\Sigma F_h = 0$, $\Rightarrow M2_h - M1_h = 0$ $\Rightarrow M2 \cos(45^\circ) - M1 \sin(25^\circ) = 0 \Rightarrow 0{\cdot}707\ M2 - 0{\cdot}4225\ M1 = 0$ [eqn1] $\Sigma F_v = 0$ $\Rightarrow -M2_v + M1_v - 4.0 = 0$ $\Rightarrow -M2 \sin(45^\circ) + M1 \cos(25^\circ) - 4.0 \times 10^6 = 0$ $\Rightarrow -0{\cdot}707\ M2 + 0{\cdot}906\ M1 - 4.0 \times 10^6 = 0$ [eqn 2] $0{\cdot}906\ M1 - 0{\cdot}4225\ M1 - 4.0 \times 10^6 = 0$ [eqn 1 + eqn 2] $\Rightarrow 0{\cdot}484\ M1 = 4.0 \times 10^6$ $\Rightarrow M1 = 8{\cdot}26 \times 10^6$ N = 8·3 MN (to 2 significant figures) from eqn 1, $M2 = 0{\cdot}4225/0{\cdot}707 \times 8{\cdot}26 = 4{\cdot}9$ MN (to 2 significant figures)	5	1 mark for equation based on horizontal force components. 1 mark for equation based on vertical force components. 1 mark for obtaining a formula for M1 or M2 by substitution/simultaneous eqns. 1 mark for M1 (magnitude and unit). 1 mark for M2 (magnitude and unit). Equations may be expressed in various ways, depending (e.g.) on which directions are taken as positive.
1	b		Possible answers could include: • calculating the internal stress in each member, and using this to produce the correct shape and cross section of these members • applying a suitable factor of safety of the structure from expected loadings and consequences • selecting a material with suitable properties for the support legs	3	1 mark for each valid response, which must: • refer to properties of materials or some type of calculation • be relevant to the structure given
1	c		For positive impact, any two of the following: • creating work for local sub-contractors (jobs) • buying supplies from local businesses • temporary accommodation for workers bringing income to landlords, hotels, B&Bs, etc • wages going to local workers would boost local economy For negative impact, any one of the following: • construction work makes access difficult for local businesses	3	1 mark for any valid responses — must relate to construction phase and be economic impacts

Question			Expected response	Max mark	Additional guidance
			• contractor vehicles may cause damage to roads, creating repair bills for local council		
1	**d**		UDL: 2000 × 1·3 = 2600 N at 0·65 m (midpoint) moments about B: (3000 × sin63 x 0·3) + (2600 × 0·65) = V_A × 1·3 $\Rightarrow V_A$ = 1917 N H_A = 3000 × cos63 = 1362 N $R_A = \sqrt{(1362^2 + 1917^2)}$ = 2351 N tanθ = 1917/1362 $\Rightarrow$ θ = 55˚ 	**4**	1 mark for UDL (2600 at 0·65) 1 mark for V_A 1 mark for R_A 1 mark for angle
2	**a**		Possible responses could include: Electrical/electronic engineer: programming (skill), understanding of components (knowledge). Mechanical engineer: design of lock mechanism (skill), knowledge of properties of materials.	**4**	1 mark for each reasonable skill or knowledge — must be relevant to the type of engineer (do not accept generic skills, such as analysis, design …), and must be relevant to the context.
2	**b**		Any reasonable suggestion, with reason given; eg plastic would be lighter and could be manufactured cheaply.	**1**	Mark given for a relevant reason — no mark for naming a material only.
2	**c**	**i**	$\bar{B}$ = O·S + L	**1**	

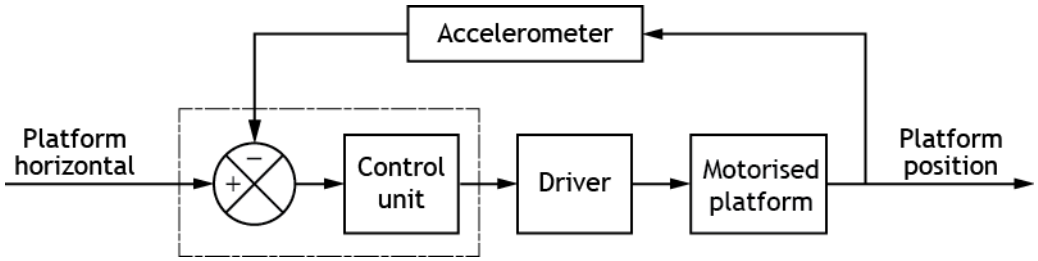
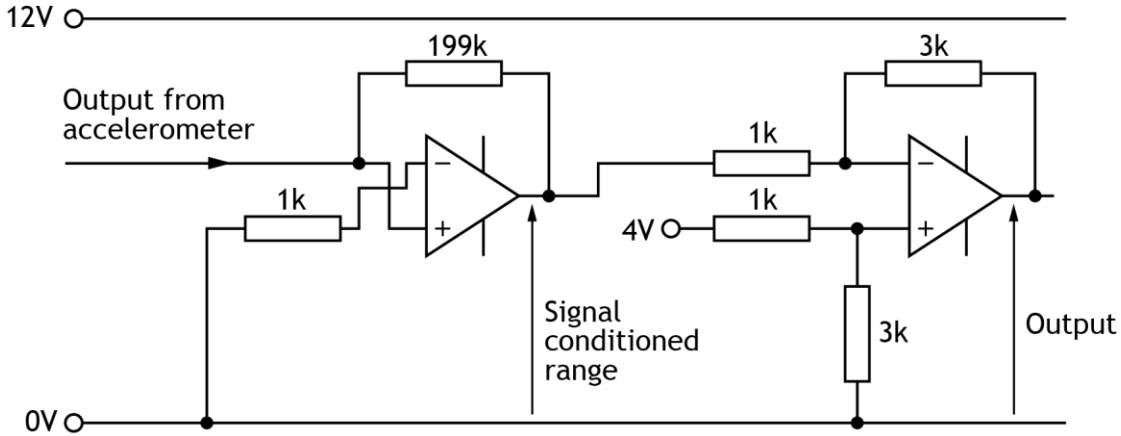
<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>2</td><td>c</td><td>ii</td><td> 
</td><td>3</td><td>1 mark for AND gate combining O and S
1 mark for OR gate to combine L
1 mark for NOT gate to produce not B
(if answer to 7(c)(i) is incorrect, marks can be awarded for 7(c)(ii) if the diagram is consistent with the Boolean expression, unless the answer to 7(c)(i) significantly reduces the complexity of the solution – see General Marking Principle (c))</td></tr>
<tr><td>2</td><td>c</td><td>iii</td><td> 
</td><td>3</td><td>1 mark for NAND replacement of AND
1 mark for NAND replacement of OR
1 mark for crossing out redundant NANDs
(marks may be awarded for any other solution given, as long as it is consistent with 7(c)(ii) – see note above)</td></tr>
<tr><td>2</td><td>d</td><td></td><td>
<table>
<tr><th>Code</th><th>Buzzer sounds</th><th>Box unlocked</th><th>Correct code?</th></tr>
<tr><td>123</td><td>✓</td><td>x</td><td>no</td></tr>
<tr><td>132</td><td>✓</td><td>x</td><td>no</td></tr>
<tr><td>213</td><td>✓</td><td>x</td><td>no</td></tr>
<tr><td>231</td><td>x</td><td>✓</td><td>yes</td></tr>
<tr><td>312</td><td>✓</td><td>x</td><td>no</td></tr>
<tr><td>321</td><td>✓</td><td>x</td><td>no</td></tr>
</table>
</td><td>3</td><td>1 mark for each correctly completed row of the truth table</td></tr>
<tr><td>3</td><td>a</td><td></td><td>Using re-usable materials/parts
Designing the machine to keep its energy demands as low as possible</td><td>2</td><td>Any two relevant issues related to sustainability</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
3	b	i		6	1 mark for both pipes from Cylinder A to the 5/2 valve. 1 mark for both pipes from Cylinder B to the 5/2 valve. 1 mark each for each of the four connections between valves, but maximum of 2 marks out of 4 marks if full lines are given in place of pilot lines.
3	b	ii		2	1 mark for the valve (including actuators) 1 mark for the connection

Question			Expected response		Max mark	Additional guidance

3	c		PBASIC solution:
			
			cycle:
			repeat
			  high 7
			until pin1=0
			low 7
			
			for i = 1 to 18
			  high 6
			  pause 800
			  low 6
			  high 5
			  pause 500
			  low 5
			next i
				Arduino C solution:
				
				do {
				  val = digitalRead(1)
				  digitalWrite (7, HIGH)
				} (while val==1)
				digitalWrite (7,LOW)
				
				for(int counter=0;counter<18,counter++) {
				  digitalWrite (7, LOW)
				  digitalWrite (6, HIGH)
				  delay (800)
				  digitalWrite (6, LOW)
				  digitalWrite (5, HIGH
				  delay (500)
				  digitalWrite (5, LOW)
				}
					4	Note: answer may be in any appropriate programming language — these answers in PBASIC and Arduino C exemplify possible solutions. Other solutions may also be valid.
						1 mark for initial loop and condition
						1 mark for checking the pressure sensor
						1 mark for looping 18 times
						1 mark for contents of loop
						Do not penalise syntax errors, so long as the intention of the coding is clear

3	d		Ductile means that the material is able to be shaped by pressure		1	
3	e	i	$\sigma = F/A = 6000 / (3{\cdot}14 \times 32{\cdot}5^2) = 1{\cdot}81$ N mm^{-2} For alloy steel, E = 200 kN mm^{-2} $\Rightarrow$ strain = $1{\cdot}81 / (200 \times 10^3)$ change in length = strain × length = $(1{\cdot}81 \times 120) / (200 \times 10^3) = 0{\cdot}0011$ mm		3	1 mark for stress (σ) 1 mark for strain 1 mark for change in length
3	e	ii	$E_s = 0{\cdot}5\ F \times = 0{\cdot}5 \times 6000 \times 0{\cdot}0011 = 0{\cdot}0033$ J		2	1 mark for formula and substitutions 1 mark for answer

Question			Expected response	Max mark	Additional guidance
4	a			6	1 mark for labelling driver and motorised platform 1 mark for labelling control unit 1 mark for labelling input and output, and adding all connecting arrows 1 mark for completing the feedback loop 1 mark for accelerometer 1 mark for details of error detector
4	b		 Non-inverting op-amp gain = 2/0·01 = 200 (1 mark) 200 = 1 + R_F/R_1 => R_F/R_1 = 199 (so, any values in this ratio) (1 mark) Difference amp gain = R_F/R_1 = 3 (so, any values in this ratio) (1 mark)	6	3 marks for working (as shown) 2 marks for completing diagram (as shown) 1 mark for showing all resistor values on diagram

Question			Expected response	Max mark	Additional guidance
4	c		• BJT switching is current-dependent, MOSFET switching is voltage-dependent, so suits this application (1) • BJT consumes power whenever it is switched, so a MOSFET is more efficient (1) • Input is from a micro-controller, which is low current, so suits MOSFET (1) • MOSFETS are suited to high current applications, like driving a motor (1)	4	1 mark for each of these key points, although they may be expressed in different terms of order
4	d		Any reasonable description, eg the use of organic components, graphene nano-tubes, quantum dot technology, bioelectronics.	1	Naming an emerging technology is not enough to award a mark; simple description of how it could be used is required.
4	e		$I_D = P/V = 200 / 12 = 16{\cdot}67$ A (1 mark) $P = I^2R = 16{\cdot}67^2 \times 0{\cdot}1 = 27{\cdot}8$ W (1 mark) $E = P \times t = 27{\cdot}8 \times 2{\cdot}3 = 64$ J (1 mark)	3	

[END OF SPECIMEN MARKING INSTRUCTIONS]