FOR OFFICIAL USE

N5

National Qualifications 2026

Mark

X823/75/01 Engineering Science

FRIDAY, 24 APRIL

1:00 PM – 2:50 PM

X823750 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

Scottish candidate number

Total marks — 110

SECTION 1 — 20 marks
Attempt ALL questions.

SECTION 2 — 90 marks
Attempt ALL questions.

Show all working and units where appropriate.
You should refer to the National 4/5 Engineering Science Data Booklet which you have been given.
The number of significant figures expressed in a final answer should be equivalent to the least significant data value given in the question. Answers that have two more figures or one less figure than this will be accepted.
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.
Use **blue** or **black** ink.
Do not remove any exam materials. You must leave this booklet on your desk; if you do not, you could lose all the marks for this paper.

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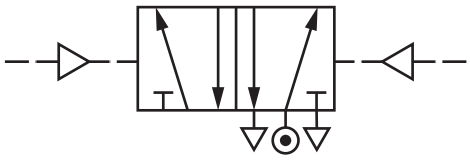
SECTION 1 — 20 marks

Attempt ALL questions

1. The symbol for a 5/2 valve is shown.



Complete the table below by naming the air type symbols shown on the valve. **3**

Air type symbol	Name of air type

MARKS | DO NOT WRITE IN THIS MARGIN

2. A drone is shown.

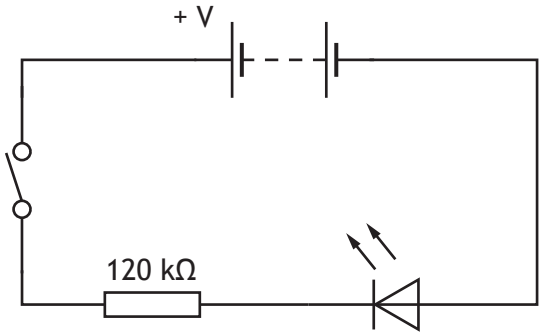
The drone has a mass of 1.2 kg and travels at 15 ms^{-1}.

Calculate the kinetic energy of the drone. **2**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

3. A circuit diagram is shown.



(a) State the name given to the arrangement of the components connected in the circuit. **1**

_____

(b) Draw, on the circuit diagram shown above, the symbol for a voltmeter connected to measure the supply voltage. **2**

During testing the LED did not light when the switch was pressed.

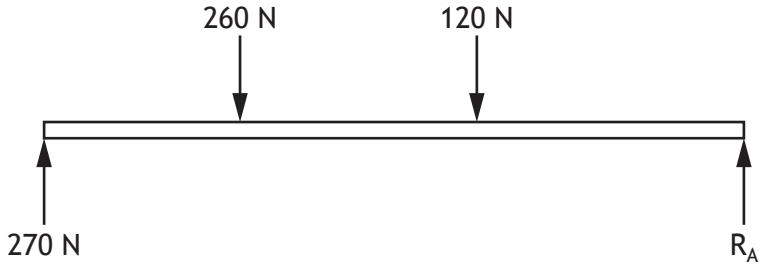
(c) Describe why the LED did not light. **1**

_____

_____

MARKS | DO NOT WRITE IN THIS MARGIN

4. An incomplete free body diagram of a beam in equilibrium is shown.



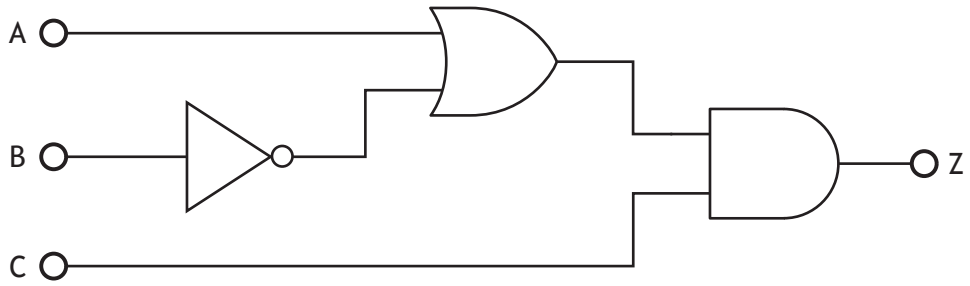
(a) Calculate the reaction force R_A. **2**

(b) State one other piece of information that should be included on the free body diagram. **1**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

5. A logic diagram is shown.



Complete the Boolean equation for output Z in terms of inputs A, B and C. **3**

Z = _____

6. A piece of metal is tested by applying a large force along its length.

(a) State what happens to the **length** of the metal when it is in **tension**. **1**

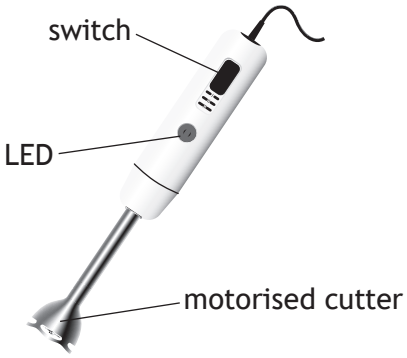
_____

(b) State what happens to the **length** of the metal when it is in **compression**. **1**

_____

MARKS | DO NOT WRITE IN THIS MARGIN

7. A hand blender is shown.



An incorrect system diagram for the hand blender is shown below.

(a) Describe two errors that were made when completing the system diagram. **2**

Error 1 _____

_____

Error 2 _____

_____

The hand blender operates without the use of feedback.

(b) State the type of control used in the hand blender. **1**

_____

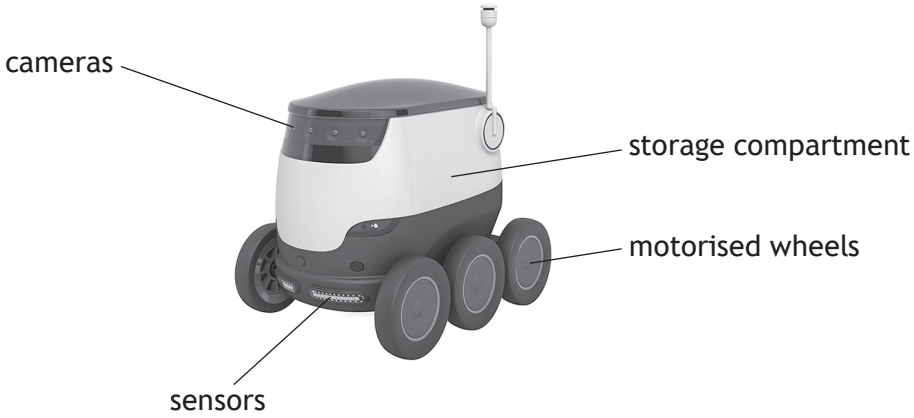
[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

SECTION 2 — 90 marks

Attempt ALL questions

8. A battery powered robot used to deliver shopping to customers is shown.



Different engineering branches were involved in the **development** of the robot.

(a) (i) Describe a task an **electronic** engineer would have completed in the development of the robot. **1**

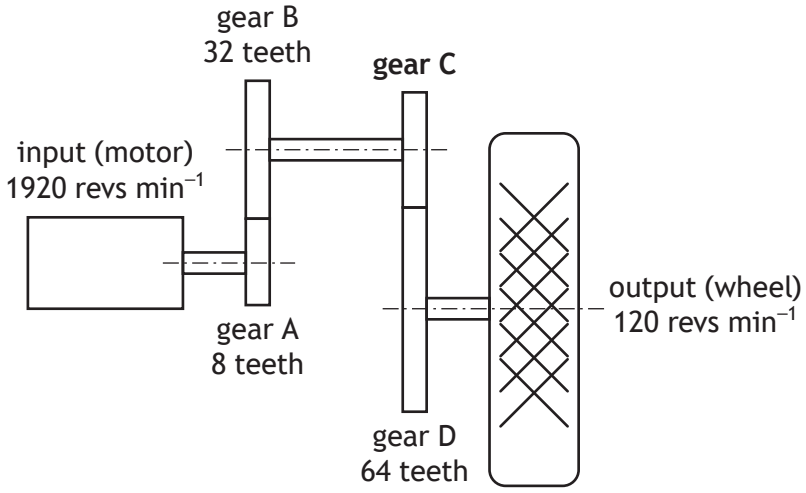
(ii) Describe a task an **electrical** engineer would have completed in the development of the robot. **1**

(b) Explain a **social** impact of using the robot to deliver shopping. **2**

8. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

The drive mechanism used in the movement of the delivery robot is shown.



(c) State the name of this drive mechanism. **1**

_____

(d) Calculate the number of teeth on **gear C**. **4**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

8. (continued)

A range of materials considered for the gears in the drive mechanism is shown in the table below.

Material	Strength	Self-lubricating
A	low	yes
B	low	no
C	high	yes
D	high	no

Material C was chosen for the gears.

(e) Describe an advantage of using a material for the robot gears that is:

(i) high strength _____ **1**

_____

_____

(ii) self-lubricating. _____ **1**

_____

_____

MARKS | DO NOT WRITE IN THIS MARGIN

9. A slingshot ride in a fairground is shown.

(a) Describe two tasks a **structural** engineer would have undertaken during the **development** of the slingshot ride. **2**

1. _____

_____

2. _____

_____

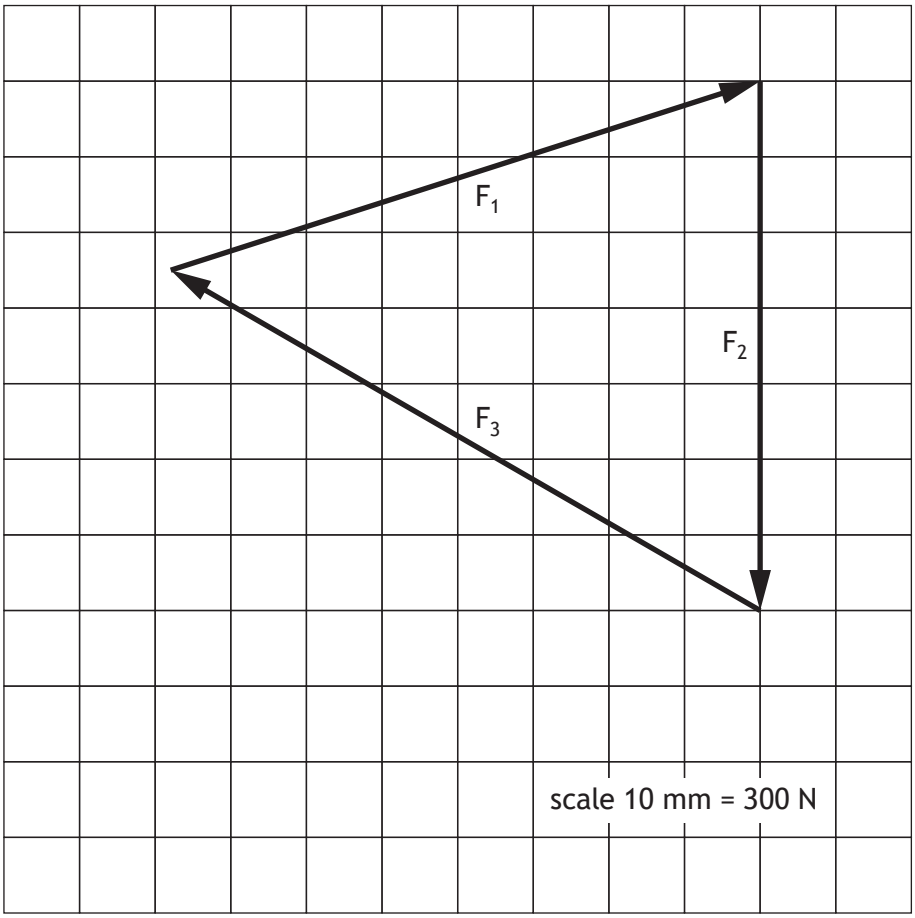
At the start of the slingshot ride a bungee cord is stretched by 6.2 m before it is released.

(b) Calculate the original length of the bungee cord when a strain of 0.17 is experienced. **3**

[Turn over

9. (continued)

The forces acting on the cage at the start of the slingshot ride are shown on the scale diagram below.



(c) Complete, with reference to the scale diagram, the table shown below for the forces acting on the cage. **2**

Force	F_1	F_2	F_3
Magnitude	2460 N	N	N

9. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

During the ride the cage and riders have a potential energy of 110 kJ at a height of 43 m.

(d) Calculate the total mass of the cage and riders. **3**

At its highest point, the slingshot ride has an output energy of 140 kJ.

(e) Calculate the input energy if the slingshot ride is 0.32 (32%) efficient. **3**

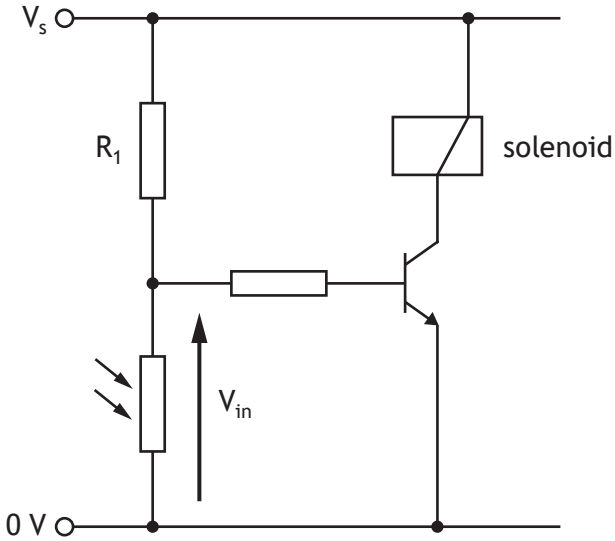
[Turn over

DO NOT WRITE IN THIS MARGIN

10. A machine for making pancakes is shown.

The machine is activated when a user places their hand in front of a sensor.

Part of the circuit used to activate the machine is shown below.



MARKS | DO NOT WRITE IN THIS MARGIN

10. (continued)

(a) Describe the operation of the circuit shown on the opposite page. Make reference to the light level, the resistance of the LDR, and the voltage V_{in}. **5**

When the user covers the LDR . . . _____

_____

_____

_____

_____

_____

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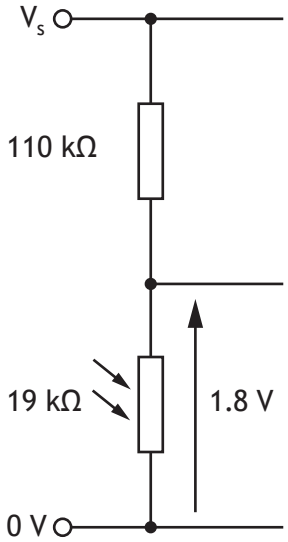
[Turn over

10. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

The sensing circuit is shown below.



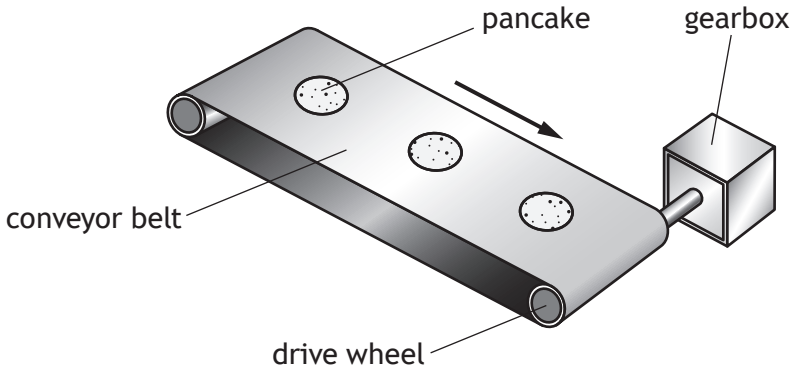
(b) Calculate the supply voltage (**V_s**). **4**

(c) Describe one alteration to the sensing circuit that would allow different operating light levels to be set. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

10. (continued)

A motorised conveyor belt used to move the pancakes through the machine is shown.



(d) Describe two tasks a **mechanical** engineer would complete during the **development** of the motorised conveyor belt. **2**

1. _____

_____

2. _____

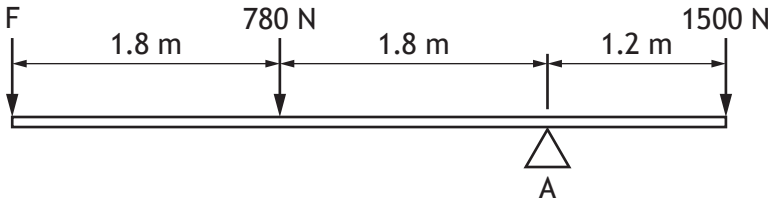
_____

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

11. A television camera and crane are shown.

A simplified free body diagram for the camera and crane is shown below.

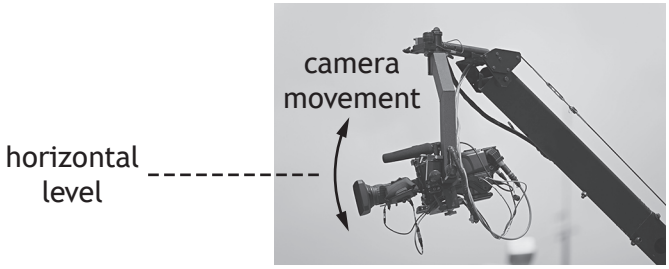


(a) State the name given to a group of forces that act on an object but do not meet at a single point, such as is shown on the free body diagram. **1**

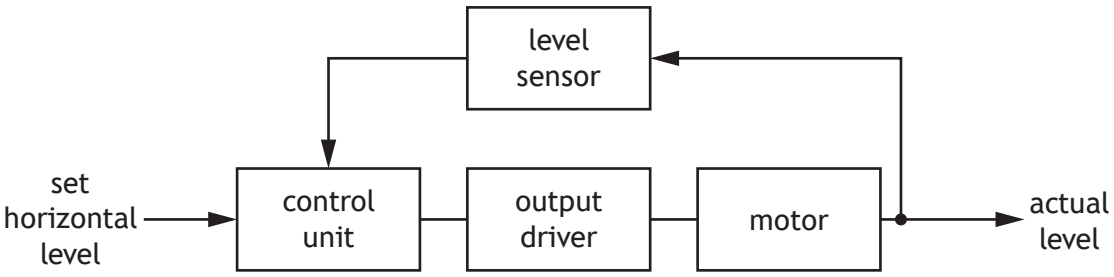
(b) Calculate the force F by taking moments about point A. **3**

11. (continued)

A motorised levelling system ensures the camera is horizontal.



An incomplete sub-system diagram for the levelling system is shown below.



(c) Complete the sub-system diagram by adding the system boundary. **1**

(d) Describe, with reference to the sub-system diagram, the operation of the levelling system. **4**

The horizontal level is set . . . _____

_____

_____

_____

_____

_____

_____

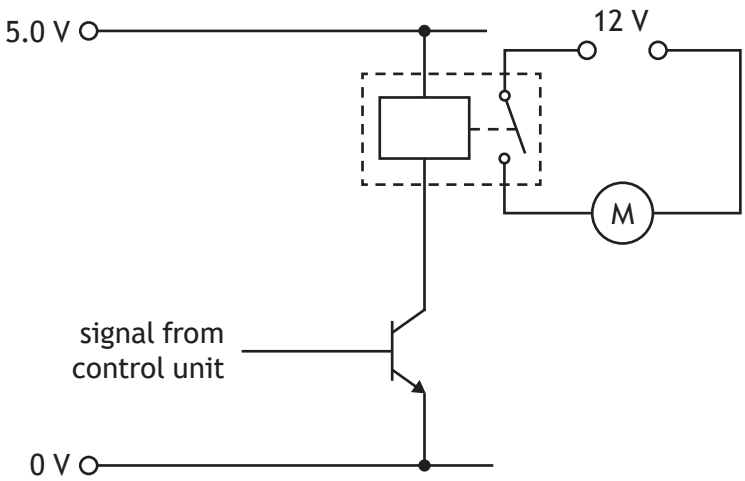
_____

_____

[Turn over

11. (continued)

The circuit diagram for the output driver and motor is shown.



(e) Complete the circuit diagram shown above by adding the symbol for a diode connected to protect the transistor. **3**

[Turn over for next question

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12. An electric toothbrush is shown.

The electric toothbrush is operated by a microcontroller.

Input and output connections to the microcontroller are shown in the table below.

Input connection	Pin	Output connection
	5	LED
	4	motor
battery level sensor (charged = 1)	2	
start switch	1	

The electric toothbrush operates using the following sequence:

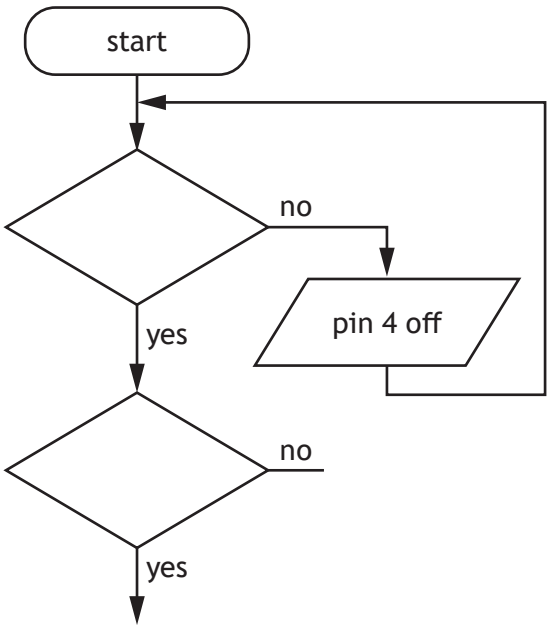
- When the start switch is pressed, the battery level sensor is checked. If it is not pressed, the motor will be off.
- If the battery level is charged, the motor will turn on and the sequence will return to the start.
- If the battery level is not charged, the LED will turn on for 0.5 seconds and off for 0.4 seconds. This will repeat twenty times.
- The sequence will then return to the start.

MARKS | DO NOT WRITE IN THIS MARGIN

12. (continued)

(a) Complete the flowchart for the sequence shown opposite, with reference to the data booklet and input/output connections.

Include **all** pin numbers and the delay unit in your flowchart. **10**



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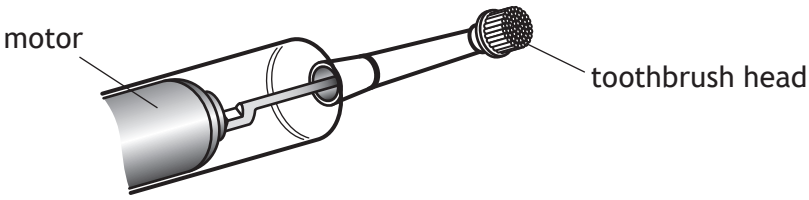
12. (continued)

MARKS | DO NOT WRITE IN THIS MARGIN

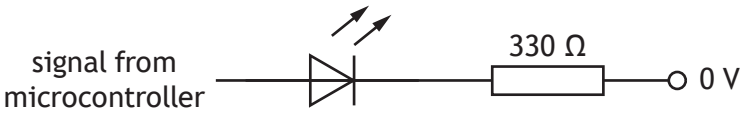
The motor and toothbrush head are shown below.



(b) Complete the table below for the motion of the motor and toothbrush head. **2**

Part	Motion symbol	Motion name
motor		
toothbrush head		

Part of the circuit for the LED is shown.



(c) Calculate the voltage across the 330 Ω resistor when the current flowing through the LED is 11 mA. **2**

(d) Describe an **economic** impact, apart from the initial cost, of **using** an electric toothbrush. **1**

* X 8 2 3 7 5 0 1 2 4 *

MARKS | DO NOT WRITE IN THIS MARGIN

13. An air source heat pump used to replace a gas boiler for heating a home is shown.

The air source heat pump takes heat from the outside air, which is then used to warm the home. Installing the air source heat pump will have an impact on climate change.

(a) Explain what this impact will be. **2**

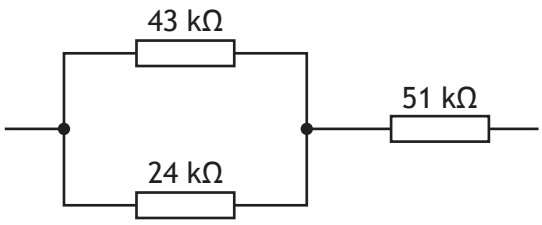
The air source heat pump sits on four supports.

(b) Calculate the cross-sectional area of one support if a stress of 14 N mm^{-2} acts on it when a force of 220 N is applied. **3**

[Turn over

13. (continued)

Part of a circuit used in the air source heat pump is shown.



(c) Calculate the total resistance of the circuit shown above. **3**

(d) (i) Calculate the current flowing through the 51 kΩ resistor when 48 V was measured across it. **3**

(ii) Indicate, with a cross (**X**) on the circuit shown above, where an ammeter would be connected to measure the current flowing through the 51 kΩ resistor. **1**

MARKS | DO NOT WRITE IN THIS MARGIN

13. (continued)

The air source heat pump is operated by a microcontroller.

(e) Describe two advantages of **using** a microcontroller compared to a hard-wired electronic circuit in the operation of the air source heat pump. **2**

1. _____

_____

2. _____

_____

[Turn over

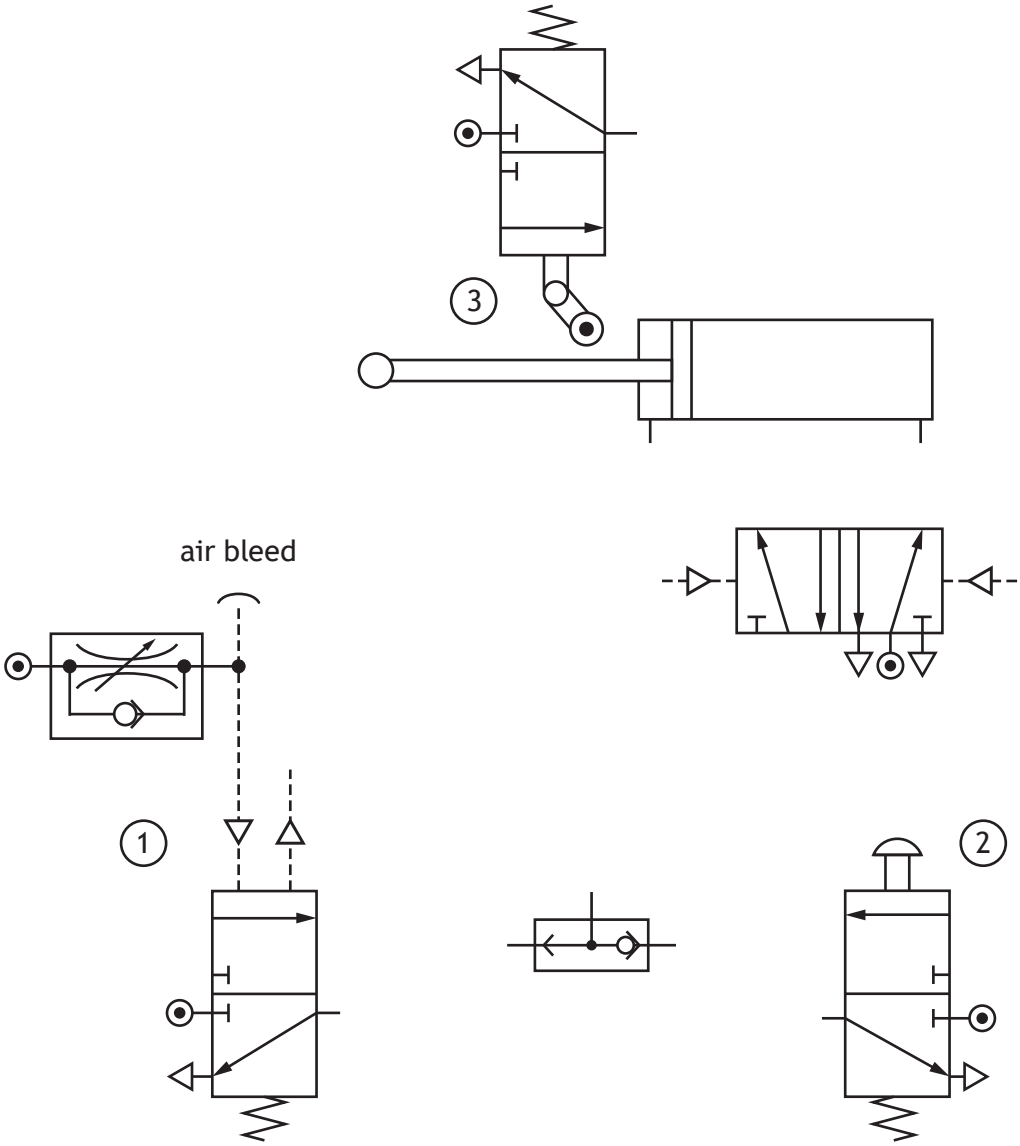
MARKS | DO NOT WRITE IN THIS MARGIN

14. Pneumatics is used in part of a food production factory.

An incomplete pneumatic circuit is shown below.

(a) (i) Complete the piping of the pneumatic circuit to instroke the piston in the cylinder when valve (1) **or** when valve (2) is actuated.

The piston will outstroke when valve (3) is actuated. **5**



(ii) State the name of the actuator that is operated by the signal from the air bleed. **1**

_____

MARKS | DO NOT WRITE IN THIS MARGIN

14. (continued)

The piston in the cylinder has a cross sectional area of 420 mm^2 and instrokes with a force of 65 N.

(b) Calculate the air pressure supplied to instroke the piston. **2**

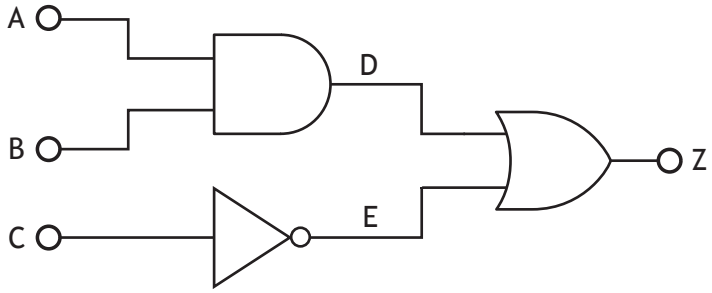
During production a piston moves food a distance of 0.18 m with a force of 34 N.

(c) Calculate the work done by the piston. **2**

[Turn over

14. (continued)

A different part of the food production process is controlled electronically. A logic diagram used in part of the control is shown.



(d) Complete the truth table, shown below, for this logic diagram. **3**

A	B	C	D	E	Z
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

[END OF QUESTION PAPER]

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ADDITIONAL SPACE FOR ANSWERS

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