FOR OFFICIAL USE

N5

National Qualifications 2019

Mark

X823/75/01 Engineering Science

FRIDAY, 17 MAY

1:00 PM – 2:50 PM

X8237501

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.

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 ©

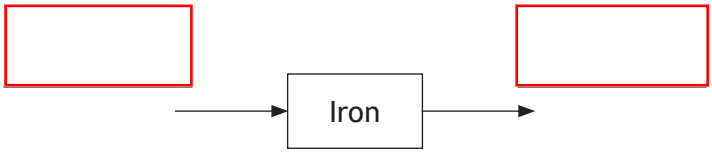
X823750101

SECTION 1 — 20 marks

Attempt ALL questions

1. An iron is shown.

(a) Complete the system diagram below by stating the **main** input energy and the **main** output energy for the iron. **2**



The iron uses feedback to monitor the output.

(b) State the type of control that uses feedback. **1**

A thermistor could be used as part of a temperature sensing circuit.

(c) Draw the symbol for a thermistor. **1**

2. A soldering iron and circuit board are shown below.

When the soldering iron was switched on for 270 seconds it used 6750 J of energy.

Calculate the power used. **2**

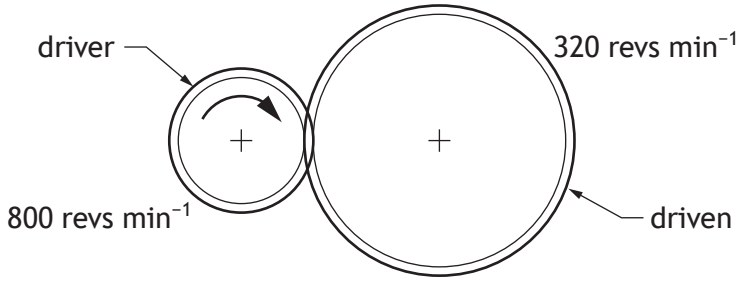
3. Pneumatic circuits can use both main air and pilot air.

Describe the function of

(a) main air **1**

(b) pilot air. **1**

4. A simple gear train is shown below.

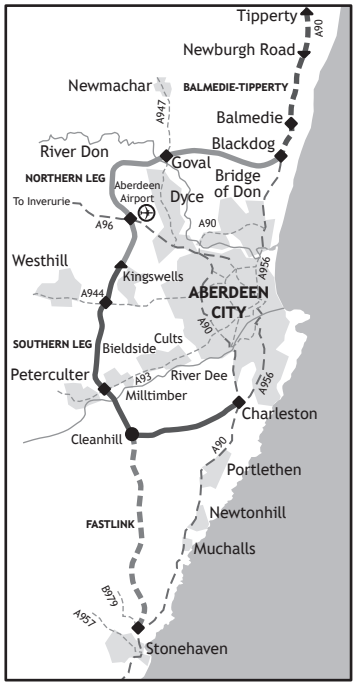


(a) Calculate the velocity ratio of this simple gear train. **2**

The driver gear in the diagram above rotates clockwise.

(b) State the direction of rotation of the **driven** gear. **1**

5. Engineers are involved in large scale projects such as the Aberdeen city bypass road shown below.



Key

- populated areas
- Balmedie - Tipperty
- Fastlink
- southern leg
- northern leg
- bypass
- road
- river

(a) State the branch of engineering that would be responsible for

(i) designing the connecting roads **1**

(ii) monitoring the impact to local wildlife during construction. **1**

(b) Describe two **positive** social impacts of a city bypass. **2**

1

2

[Turn over

6. The Boolean equation for a logic circuit is shown below.

$$(A + \overline{B}) \bullet C = Z$$

Draw the logic diagram for this Boolean equation. **3**

7. Hydropower is a source of energy which is used to generate electricity.

Describe one positive and one negative **environmental** impact of using hydropower as a source of energy. **2**

Positive

Negative

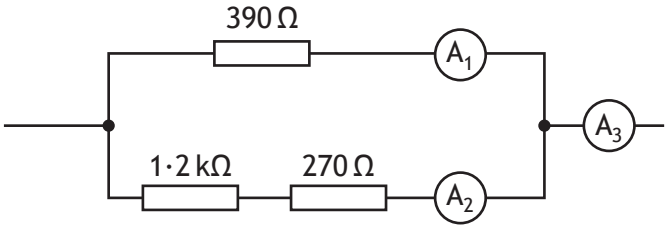
[Turn over

SECTION 2 — 90 marks

Attempt ALL questions

8. An interactive speaker used in a 'smart home' is shown.

Part of the circuit used in the speaker is shown below.



(a) Calculate the total resistance of this circuit. **3**

8. (continued)

The reading on ammeter A_1 is 0·031 A.

(b) (i) Calculate the voltage across the 390 Ω resistor. **2**

(ii) Calculate the current A_2. **3**

(iii) Calculate the current A_3. **1**

8. (continued)

The interactive speaker used in a 'smart home' can be considered to be an established technology.

An **emerging technology** is one that is new and still to be tried commercially within a product or system.

(c) Explain a possible impact of an **emerging technology** which you are familiar with. **2**

Emerging technology

Impact

[Turn over for next question

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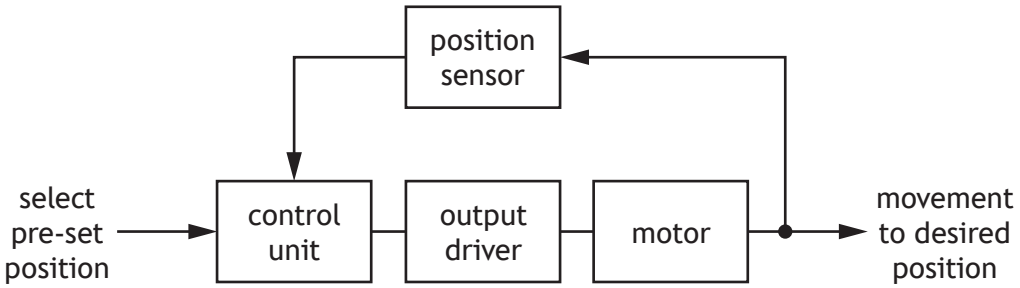
9. The angle of a hospital bed can be changed to a pre-set position as shown.

An incomplete sub-system diagram for the control of the bed movement is shown.



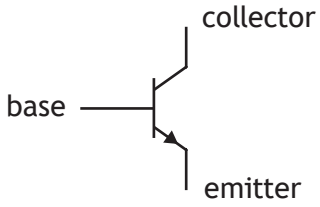
(a) Complete the sub-system diagram above by adding the system boundary. **1**

(b) Describe, with reference to the sub-system diagram, the control of the bed movement. **3**

The pre-set position is selected . . .

9. (continued)

An electronic engineer has selected the transistor shown below to be used as part of the output driver unit.



(c) Explain the switching function of the transistor shown above. **2**

Make reference to the base, collector and emitter connections.

A logic circuit is used in the operation of the bed. The truth table for the logic circuit is shown below.

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

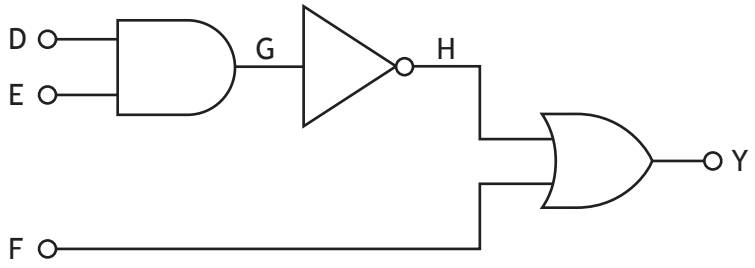
(d) Complete the Boolean equation for output Z in terms of inputs A and B. **3**

Z =

[Turn over

9. (continued)

The diagram for part of another logic circuit used in the operation of the bed is shown below.



(e) Complete the truth table for this logic circuit. **3**

D	E	F	G	H	Y
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			

[Turn over for next question

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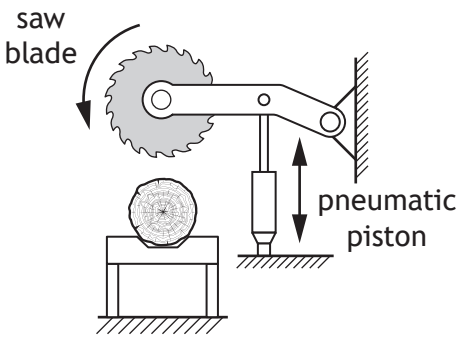
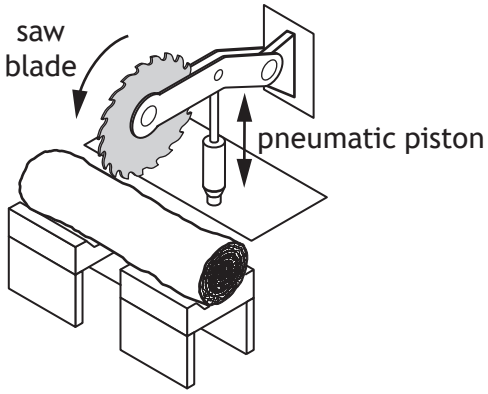
10. A pneumatic circuit is used in the operation of an industrial saw.



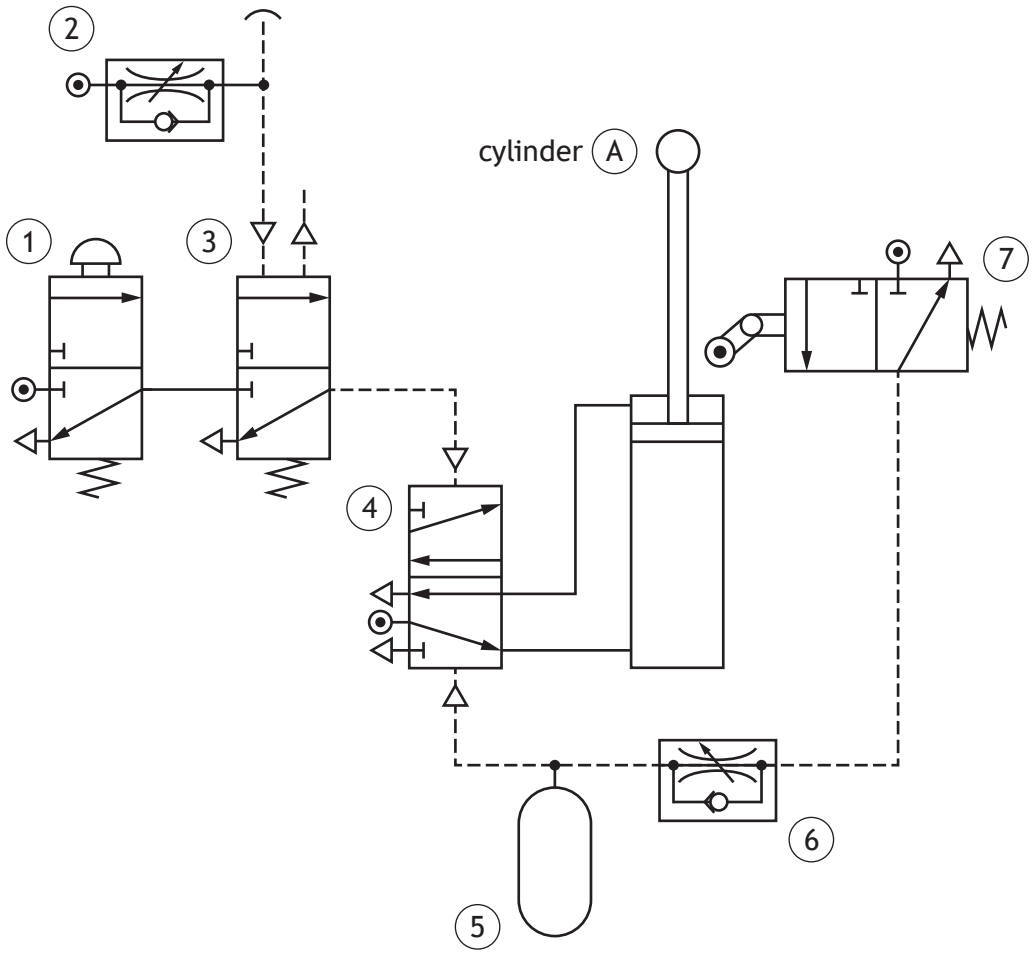


(a) State, with reference to the diagram above, the type of **motion** shown at the **2**

saw blade

pneumatic piston.

The pneumatic circuit used to control the movement of the saw is shown below.



10. (continued)

(b) Describe the operation of the circuit shown opposite. **3**

When an increase in pressure is detected by valve (3) . . .

The piston is to be instroked slowly and smoothly.

(c) Indicate on the circuit shown opposite, with an X, where a uni-directional restrictor should be connected. **1**

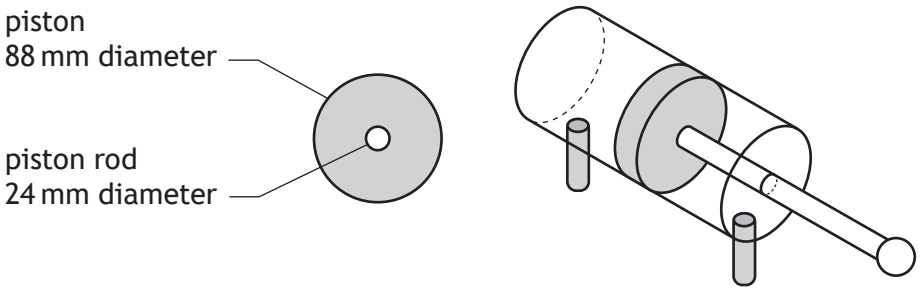
The roller trip on valve (7) is to be replaced with a solenoid and components (5) and (6) are to be removed. The solenoid will receive a signal from a microcontroller based circuit when the piston instrokes.

(d) Describe an advantage of using a microcontroller to control the movement of the piston. **1**

[Turn over

10. (continued)

The pneumatic cylinder used in the system is shown below.



(e) (i) Calculate the effective area of the piston when it instrokes. **3**

(ii) Calculate the force applied by the piston when it instrokes if air is supplied at a pressure of $0{\cdot}20\,N\,mm^{-2}$. **3**

[Turn over for next question

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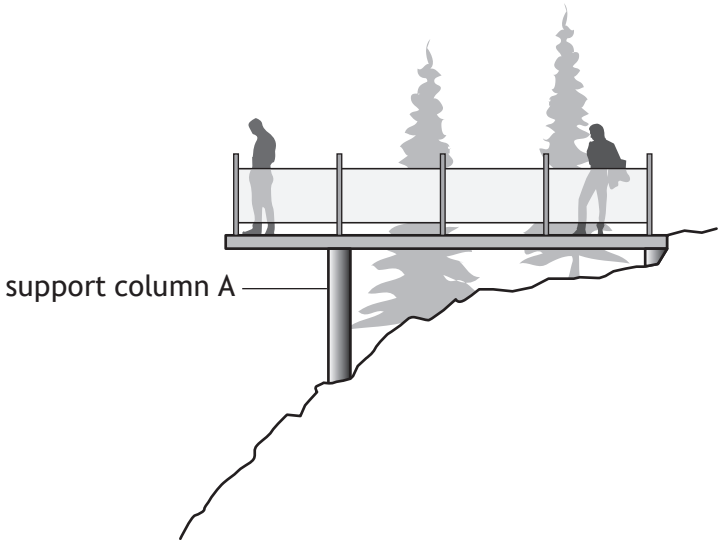
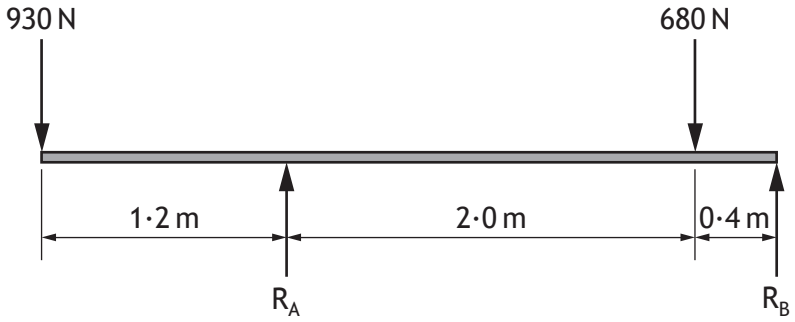
11. A viewing platform at a tourist destination is shown.



A free body diagram indicating the main forces acting on the platform is shown below.



(a) (i) Calculate the reaction force R_A by taking moments about R_B. **3**

11. (a) (continued)

(ii) Calculate the reaction force R_B. **2**

(b) State the term used to describe when forces acting on a structure are balanced. **1**

Support column A was tested by applying a force of 2500 N.

(c) Calculate the cross-sectional area of support column A when a stress of $0{\cdot}060\ N\ mm^{-2}$ was measured for this force. **3**

[Turn over

11. (continued)

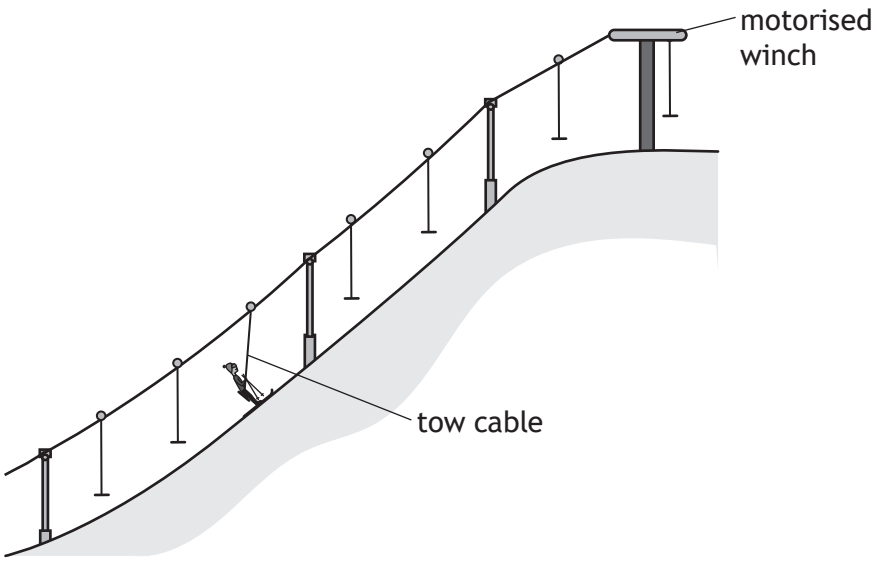
A visitor centre is to be built next to the platform. An electrical engineer works as part of a team designing the visitor centre.

(d) Describe two tasks an electrical engineer would carry out during the design. **2**

1

2

12. A ski tow used to move skiers to the top of a slope is shown below.



A motorised winch which is rated at 230 V, 12 A, is used in the operation of the tow.

(a) (i) Calculate the electrical energy used when the winch is operated for 1 minute and 20 seconds. **3**

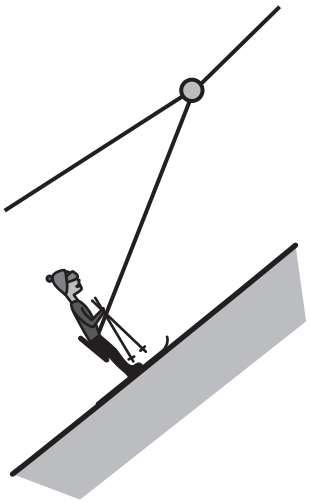
(ii) Calculate the output energy if the system is 64% efficient. **3**

12. (continued)

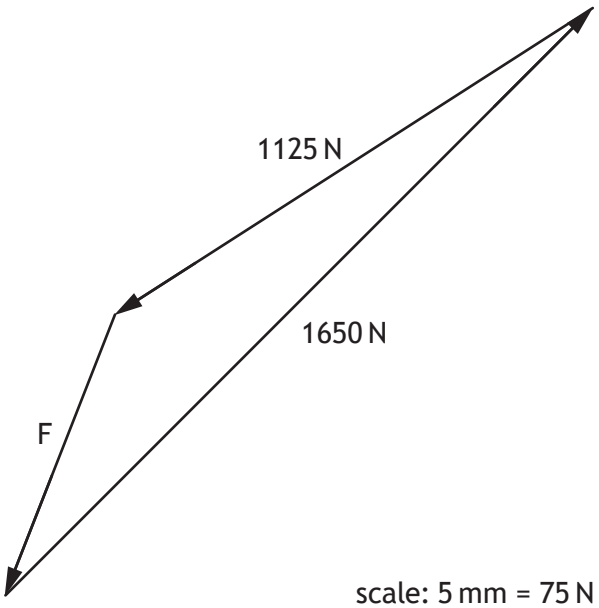
(b) Explain how the efficiency of the motorised winch could be increased. **2**

12. (continued)

A structural engineer analyses the forces exerted by a skier on the tow.



The triangle of forces scale drawing used in the analysis is shown below.



scale: 5 mm = 75 N

(c) Determine, with reference to the triangle of forces shown, the unknown force F. **1**

F = ____ N

12. (continued)

The tow cable has an original length of 2·7 m.

(d) Calculate the change in length of the cable when a strain of 0·0030 is experienced. **3**

[Turn over for next question

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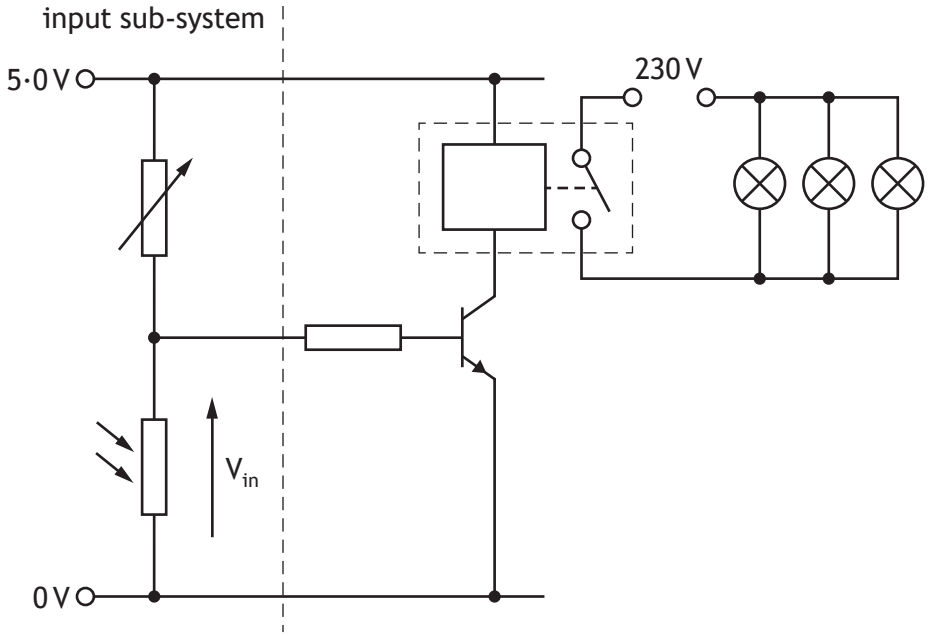
13. An automatic lighting system along the side of a path is shown.

A circuit designed to operate the lighting system is shown below.



(a) Describe two advantages of connecting the lamps in parallel instead of in series. **2**

1

2

13. (continued)

When the circuit was tested it was found that the transistor was destroyed. A diode is to be connected into the circuit to protect the transistor.

(b) Draw the symbol for a diode **on the circuit shown opposite** to protect the transistor. **2**

(c) Describe the operation of the **input sub-system** as the light level decreases. Make reference to the resistance of the LDR and the voltage, V_{in}. **2**

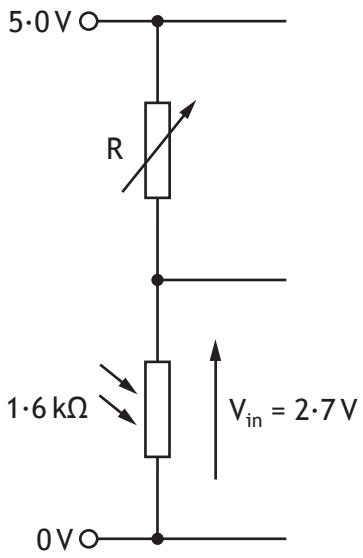
As the light level decreases . . .

(d) State the effect on V_{in} when the resistance of the variable resistor is decreased. **1**

[Turn over

13. (continued)

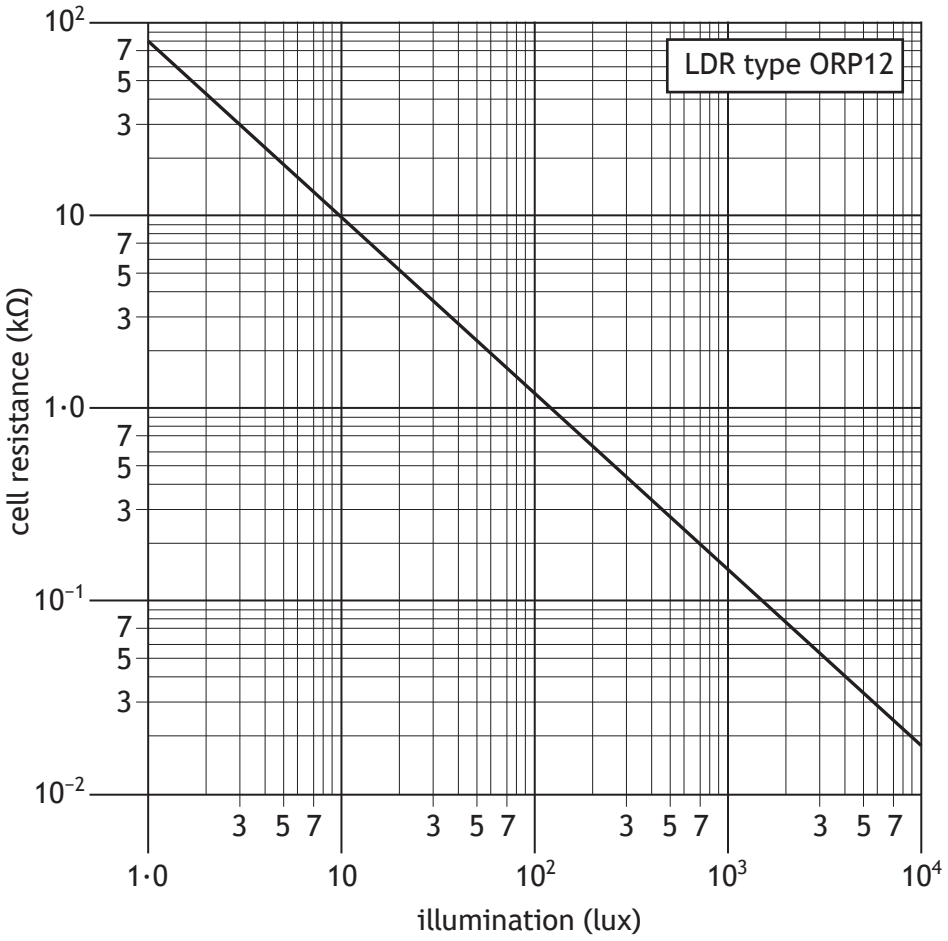
The input sub-system used to detect a change in light level is shown below.



(e) Calculate the resistance of the variable resistor (R) for the condition shown above. **4**

13. (continued)

The operating characteristics of the LDR used are shown on the graph below.



(f) Determine, with reference to the graph, the illumination level when the LDR has a resistance of 200 Ω. **1**

lux

[Turn over

13. (continued)

An electronic engineer used computer simulation when designing the circuit for the lighting system.

(g) Describe two advantages of using computer simulation, compared to building a circuit, when initially designing a solution. **2**

1

2

14. A mechanical harvester used to pick fruit on a farm is shown.

(a) Describe two **economic** impacts of the mechanical harvester. **2**

1

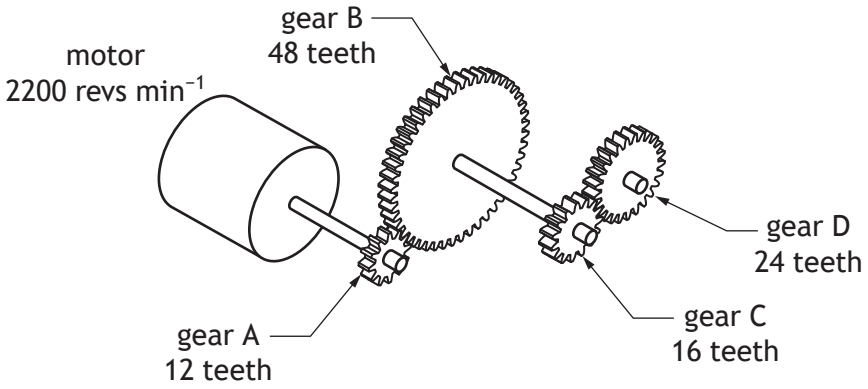
2

[Turn over

14. (continued)

A conveyor belt used to transport fruit along the machine is shown below.

Part of the conveyor belt mechanism is shown below.



(b) Calculate the output speed of gear D. **4**

[Turn over for next question

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15. A set of hair straighteners is shown.

A microcontroller is used to operate the hair straighteners using the following simplified sequence.

- When a push switch is operated the heating plates turn on.
- A buzzer will then sound for 0·8 seconds and then turn off.
- An LED will then repeatedly turn on for 0·3 seconds and turn off for 0·3 seconds until the correct temperature is reached.
- When the push switch is pressed again the heating plates turn off.
- The sequence will then repeat.

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

Input connection	Pin	Output connection
	7	Heating plates
	6	Buzzer
	5	LED
Temperature sensor (1 = correct temperature)	1	
Push switch	0	

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

Include **all** pin numbers and delay units in your flowchart. **9**

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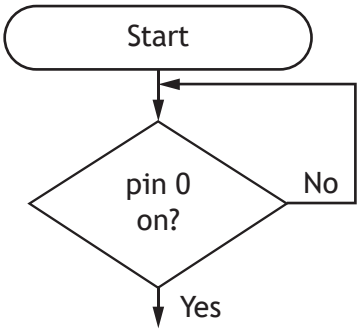
15. (a) (continued)

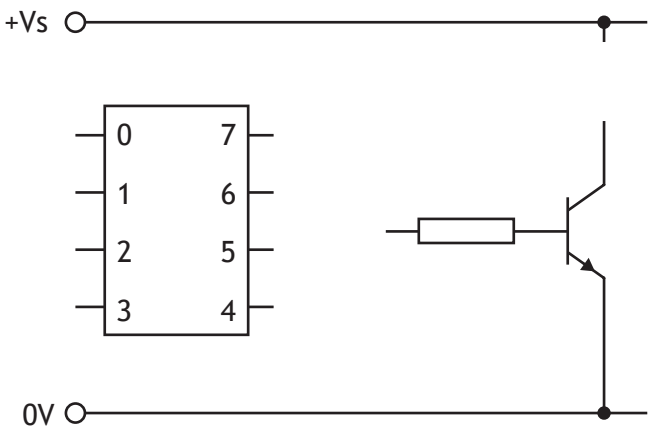


[Turn over for next question

15. (continued)

The buzzer is switched on by a transistor connected to pin 6 of the microcontroller.

(b) Complete the diagram below by adding the symbol for a buzzer **and** the connection to the microcontroller. **2**



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ADDITIONAL SPACE FOR ANSWERS

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