FOR OFFICIAL USE

N5

National Qualifications 2014

Mark

X723/75/01 Engineering Science

THURSDAY, 15 MAY
1:00 PM – 2:30 PM

* X 7 2 3 7 5 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 in this section.

SECTION 2 — 70 marks
Attempt ALL questions in this section.

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.

Show all working and units where appropriate.

You should refer to the National 4/5 Engineering Science Data Booklet which you have been given.

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 ©

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

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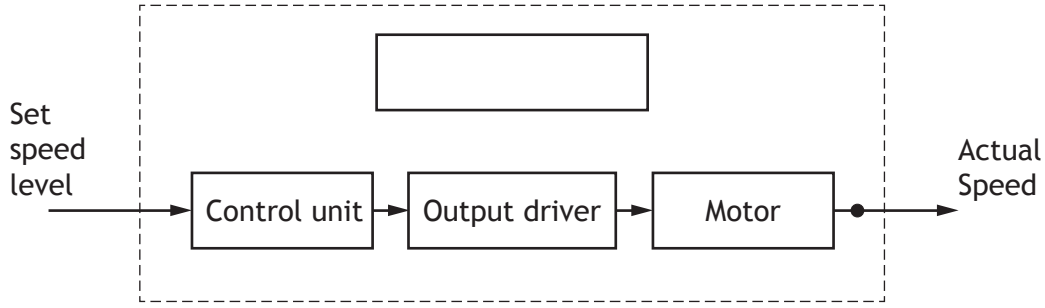
MARKS | DO NOT WRITE IN THIS MARGIN

SECTION 1 — 20 marks

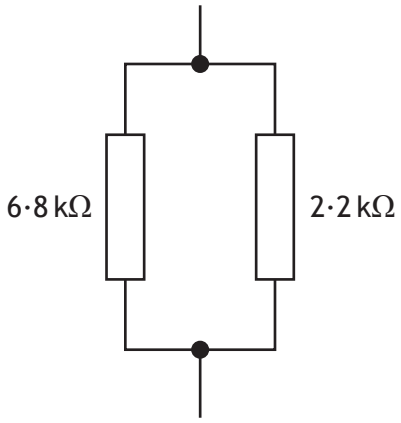
Attempt ALL questions

1. A closed loop system is used to control the speed of a motor.

Complete the sub-system diagram shown below. **2**



2. Two resistors are connected in parallel as shown in the diagram below.



Calculate their combined resistance. **2**

Show all working and final unit.

3. New cars are manufactured in a factory.

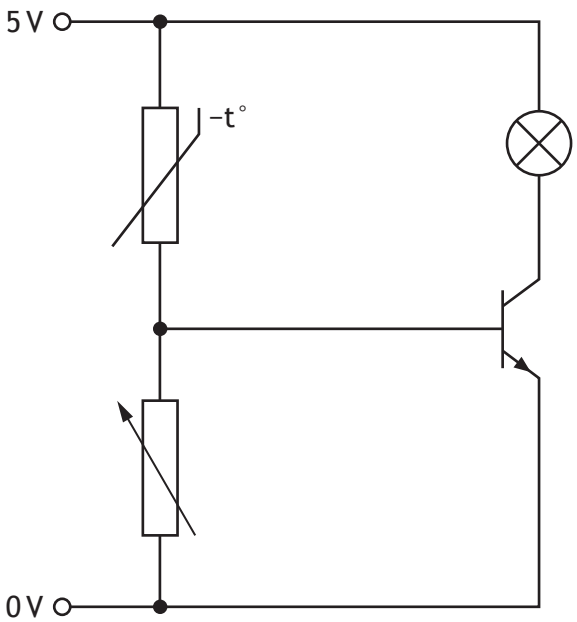
State what type of engineer would be responsible for developing:

(a) the gear box; **1**

(b) the lubricants used in the gear box. **1**

Total marks 2

4. A circuit to operate a lamp is shown.



(a) State the **function** of the transistor in the circuit. **1**

(b) Describe the input conditions that will operate the lamp. **1**

Total marks 2

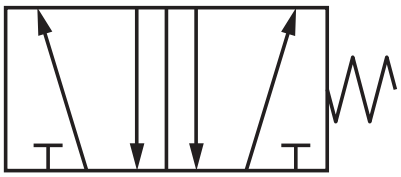
MARKS | DO NOT WRITE IN THIS MARGIN

5. A 2 m long steel bar is stretched by 0·003 m when a tensile force is applied.
Calculate the strain in the bar. **2**
Show all working.

6. Complete the pneumatic symbol below by adding:

(a) main air; **1**

(b) a diaphragm actuator. **1**



Total marks 2

7. Microcontrollers are used in many control systems.

State **two** reasons why microcontroller based systems are often less expensive to manufacture than **hard-wired** circuits. **2**

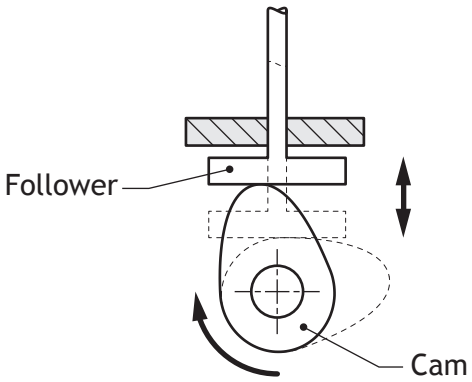
1 _____

_____

2 _____

_____

8. The cam and follower in the diagram below are used to convert motion.



State the type of **motion** of:

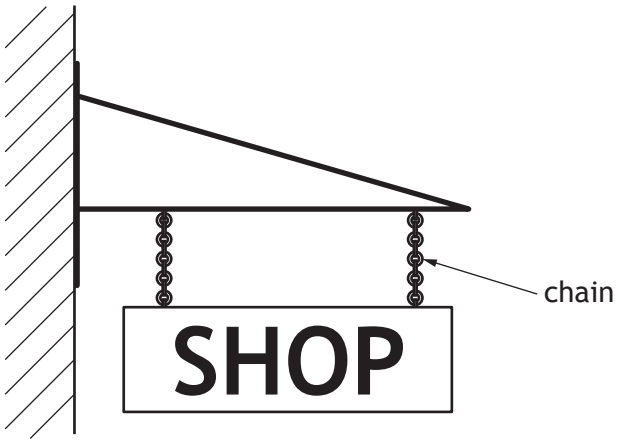
the cam; _____

the follower. _____ **2**

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

9. A shop sign is hung from a frame structure by two chains.



(a) State the type of force acting on the chain. **1**

_____

(b) State a reason for a triangle being used in the frame structure. **1**

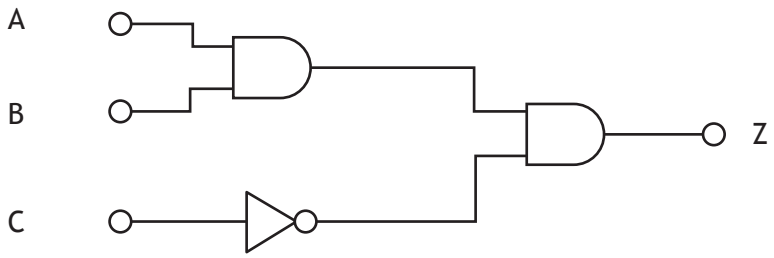
_____

_____

Total marks 2

MARKS | DO NOT WRITE IN THIS MARGIN

10. The logic diagram for a security system is shown below.



Complete the truth table for the logic diagram. **2**

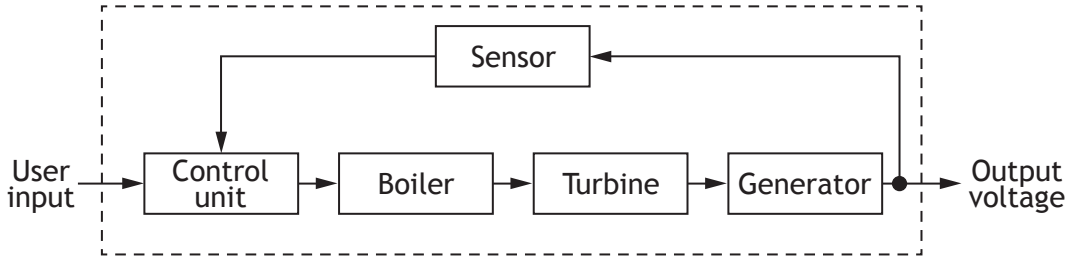
A	B	C	Z
0	0	0	0
0	0	1	
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	
1	1	1	0

[Turn over

SECTION 2 — 70 marks

Attempt ALL questions

11. A simplified sub-systems diagram of a biomass power station is shown below.



(a) Describe, with reference to the sub-system diagram, the operation of the power station. **4**

(b) State the type of control used in this system. **1**

Electricity is increasingly being produced from renewable sources rather than using fossil fuels.

(c) Describe **two** positive **environmental** impacts renewable energy sources have over fossil fuels. **2**

1

2

11. (continued)

The power station is found to be 44% efficient.

(d) Calculate the output energy produced when 13 MJ is supplied. **2**
Show all working and final unit.

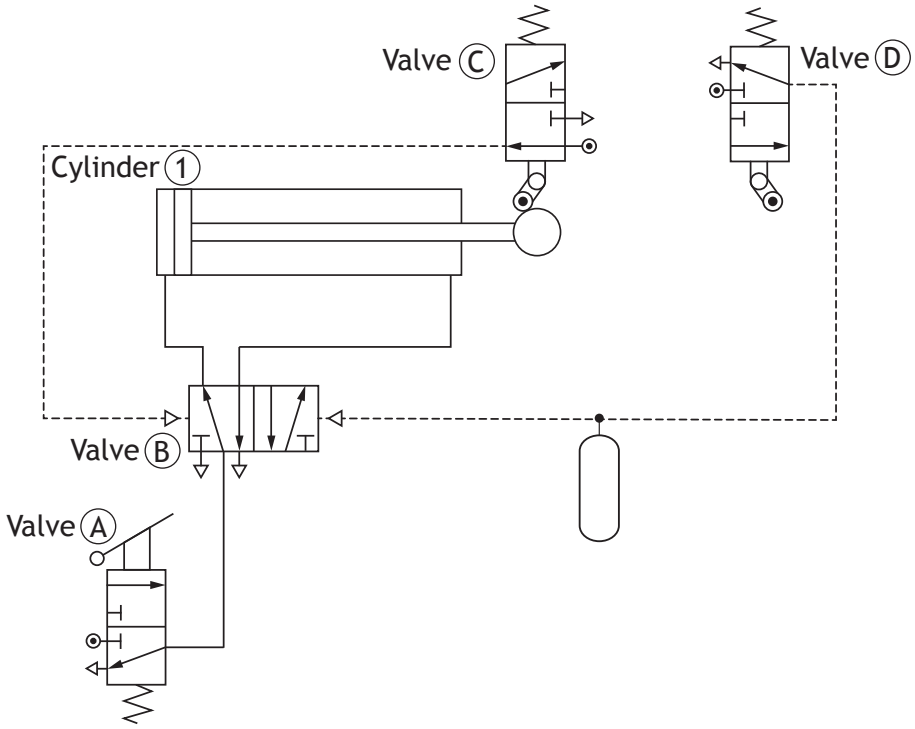
Total marks 9

[Turn over

MARKS | DO NOT WRITE IN THIS MARGIN

12. A pneumatic circuit used to punch holes in steel sheets is shown below.

(a) Draw a uni-directional restrictor in the correct position to form an **adjustable** time delay. **3**



(b) Describe, using appropriate terminology, the operation of the circuit. **3**

12. (continued)

The piston in cylinder (1) has a diameter of 20 mm and is supplied with air at a pressure of 2 N mm^{-2}.

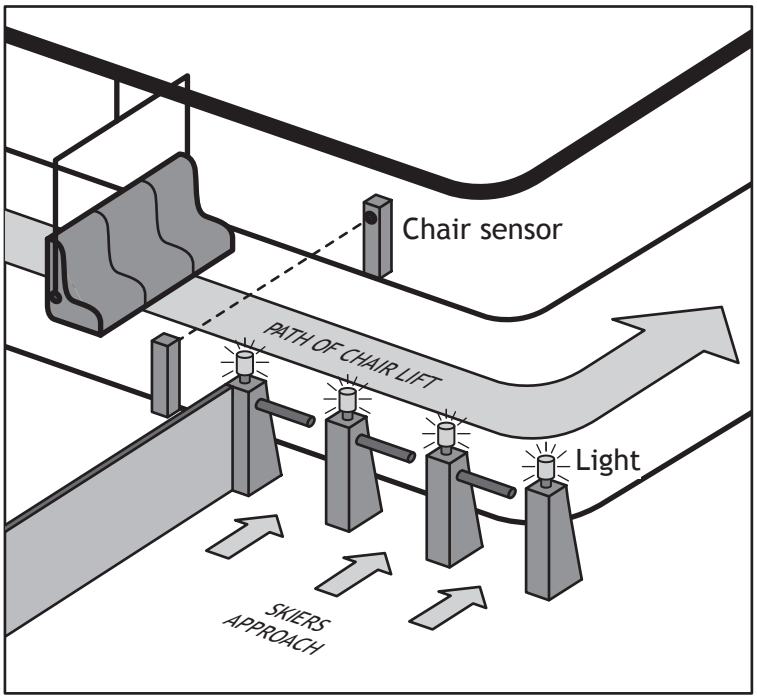
(c) Calculate the outstroking force of the cylinder.

Show all working and final unit. **3**

Total marks 9

[Turn over

13. A chair lift system at a ski resort is operated by a microcontroller.



The system must perform the following sequence.

- When the chair sensor is triggered warning lights flash 4 times over a 2 second period.
- The barriers will then open.
- The system will pause for 3 seconds to allow the skiers through.
- The barriers will then close.
- The sequence will repeat.

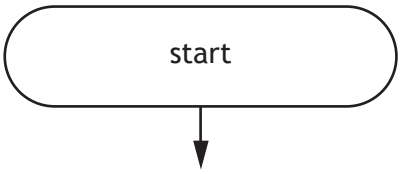
Input and output connections to the microcontroller are shown in the table below.

Input Connection	Pin	Output Connection
	2	Barriers (1 = open)
	1	Warning lights
Chair sensor (1 = chair sensed)	0	

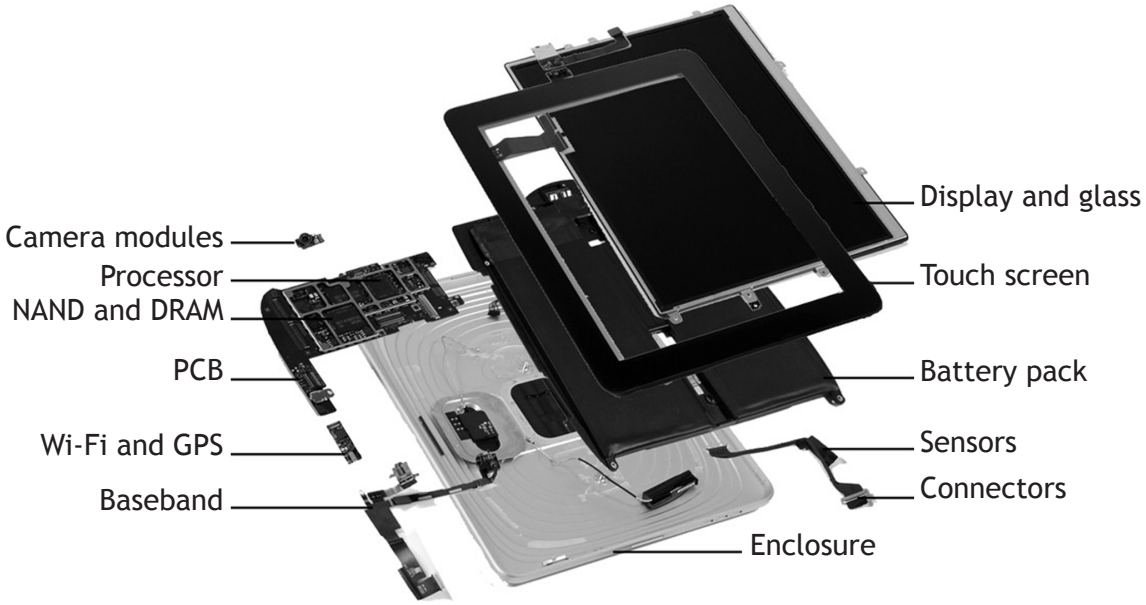
Complete the flowchart opposite for the control sequence with reference to the Data Booklet and input/output connections. **10**

Include all pin numbers.

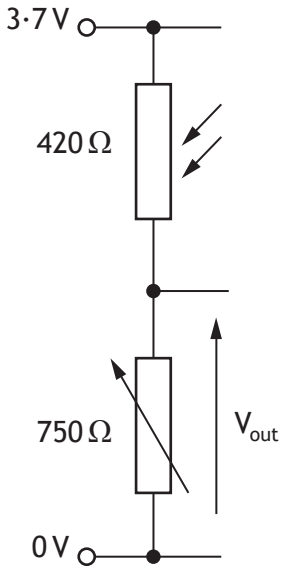
13. (continued)



14. An electronic engineer is working on the circuitry for a tablet computer.



To sense light levels the following circuit is used.



(a) Draw, on the diagram above, the symbol for a voltmeter connected to measure V_{out}. **2**

14. (continued)

(b) Calculate V_{out}. **3**

Show all working and final unit.

The light level changes and V_{out} becomes 3 V.

(c) Calculate the power used by the 750 Ω variable resistor. **2**

Show all working and final unit.

14. (continued)

Tablet computers have many advantages over normal desktop computers.

(d) Describe **one** environmental advantage. **1**

_____

_____

Total marks 8

[Turn over for Question 15 on *Page eighteen*

DO NOT WRITE ON THIS PAGE

15. The bicycle and rider shown below have a combined mass of 80 kg and are travelling at a velocity of 8 m s^{-1}.

(a) Calculate the kinetic energy of the rider and bicycle. **2**

Show all working and final unit.

The brakes have an initial temperature of 10 °C and a mass of 0·4 kg.

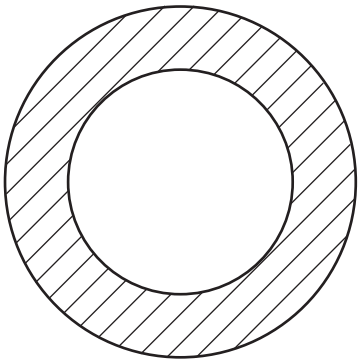
(b) Calculate the **final** temperature of the brakes when the bicycle and rider stop. The brakes have a specific heat capacity (c) of 900 J kg^{-1} K^{-1}. **4**

Assume all kinetic energy from Q15(a) will be converted into heat energy in the brakes.

Show all working and final unit.

15. (continued)

The illustration below shows the cross-section of member A.



Area = 200 mm^2

(c) Calculate the stress in member A when a tensile load of 1200 N is applied. **2**
Show all working and final unit.

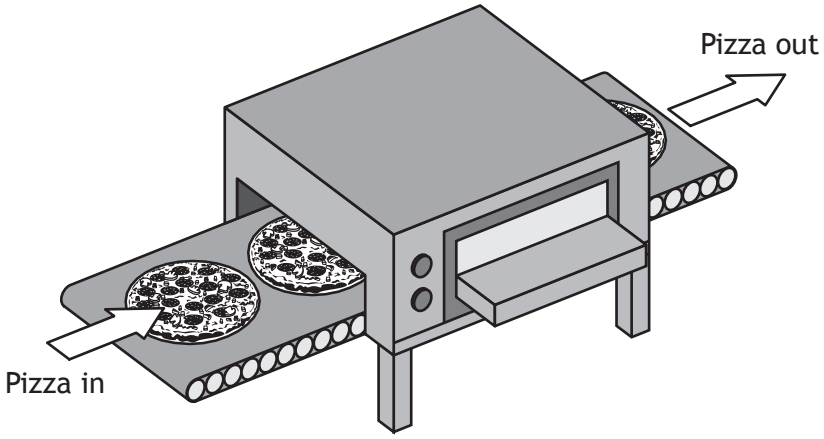
(d) Describe, for the same load, how the stress in member A could be reduced. **1**

A number of engineers were involved in the design of the bicycle.

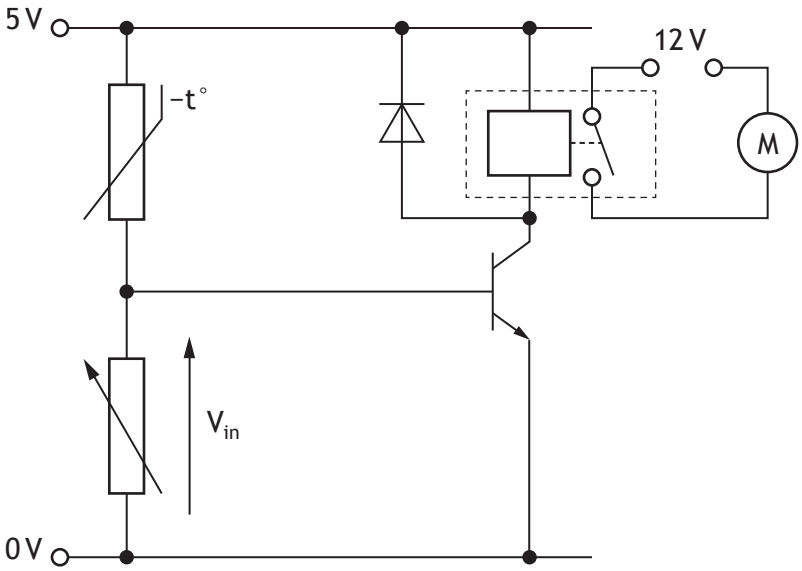
(e) Describe the role that a mechanical engineer may have had in the **development** of the bicycle. **2**

Total marks 11

16. Pizzas are cooked when they move through an oven on a motorised conveyor.



An electronic circuit will switch on the conveyor when the oven **increases** to a set temperature.



(a) Describe, as the temperature increases, the **operation** of the:

(i) input sub-system; **2**

16. (a) (continued)

(ii) process and output sub-systems. **2**

(b) Describe the **function** of the following components in the circuit.

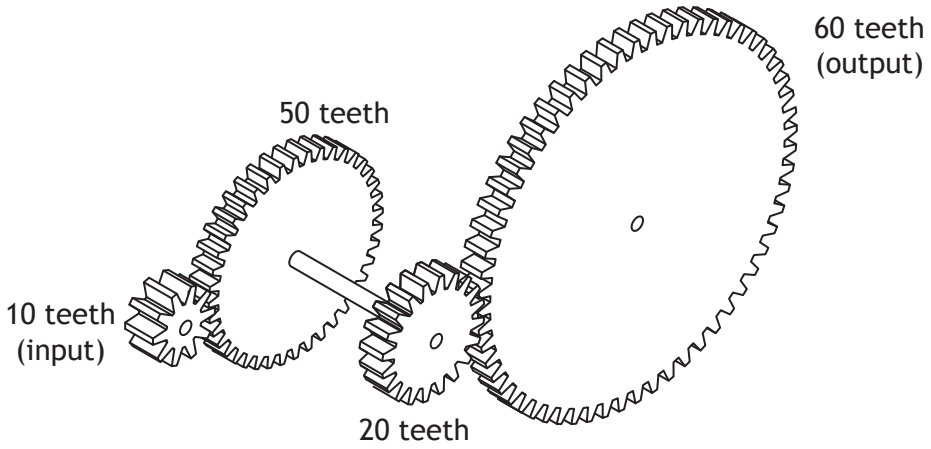
(i) relay **1**

(ii) diode **1**

[Turn over

16. (continued)

To drive the conveyor, the motor is connected to a compound gear train.



(c) Describe an advantage of a compound gear over a simple gear train. **1**

(d) Calculate the speed of the output gear when the input rotates at 250 rev min^{-1}.

Show all working and final unit. **4**

(e) Describe how friction in a mechanical system could be reduced. **1**

Total marks 12

[Turn over for Question 17 on *Page twenty-four*

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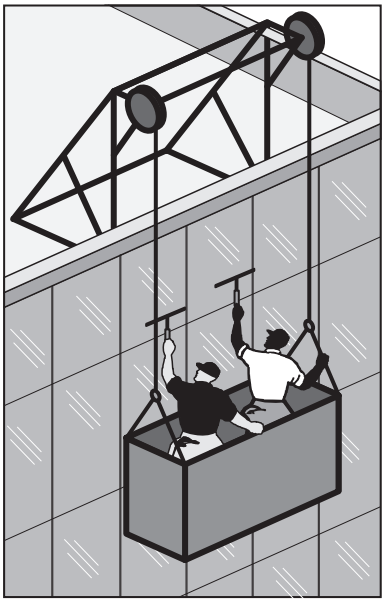
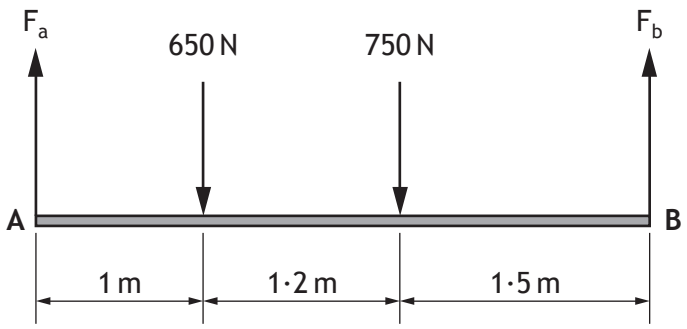
17. A window-cleaning platform is used on an office block.



The diagram below shows the forces acting on it.



(a) State the full name of the type of diagram shown above. **1**

MARKS

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(b) Calculate, by taking moments about A, the force F_b. **3**
Show all working and final unit.

(c) Calculate the force F_a. **2**
Show all working and final unit.

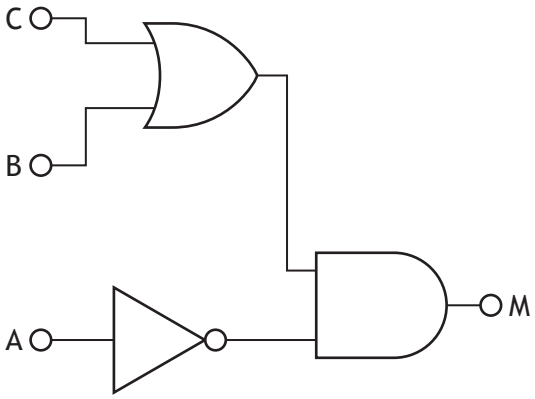
The maximum strain allowed for a cable is 0·0015.

(d) Calculate the maximum allowable extension in a 2 m length of cable. **2**
Show all working and final unit.

[Turn over for Question 17 (e) on *Page twenty-six*

17. (continued)

An electronic circuit is used to operate the movement of the platform.
The logic diagram for the circuit is shown below.



(e) Complete a Boolean equation for the circuit. **3**

M =

Total marks 11

[END OF QUESTION PAPER]

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWERS

ACKNOWLEDGEMENTS

Question 2—97379894 Tetiana Yurchenko/Shutterstock.com

Question 14—Image of an exploded diagram of a generic tablet is taken from **www.everythingabouttablets.net/inside-a-tablet-or-what-makes-those-tablets-tick/**. Reproduced by kind permission of Everything About Tablets.

Question 15—85658470 ollyy/Shutterstock.com