2012 Technological Studies

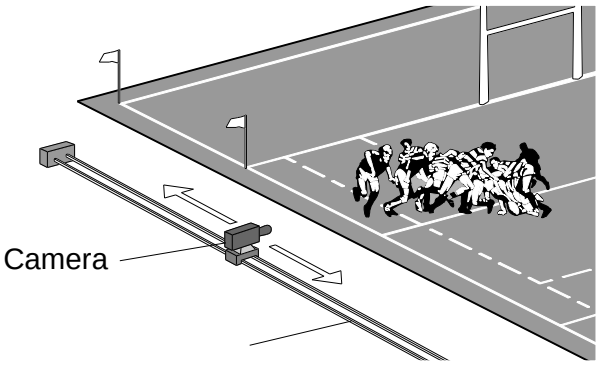
Standard Grade – Credit

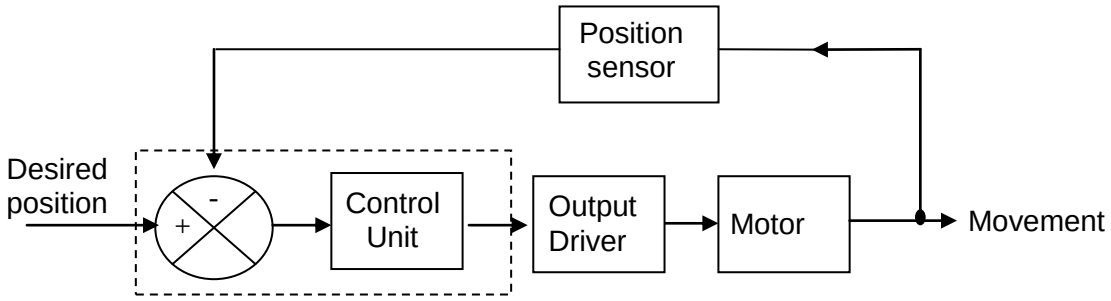
Finalised Marking Instructions

Mark Allocation

Marks	
KU	**RNA**

1. A mobile pitch-side camera system is used during a rugby match.





(a) Describe, with reference to the control diagram, the operation of the system.

The system moves the camera to the position set by the user ① **RNA**

The error detector compares the desired position with the actual position ① **RNA**

The O/P driver provides the power required to drive the motor ① **RNA**

The position sensor provides feedback ① **RNA**

(max 2)

plus any other valid point. Not "control right = moves right"

The camera system makes use of closed loop control.

(b) Explain the difference between an open loop and closed loop system.

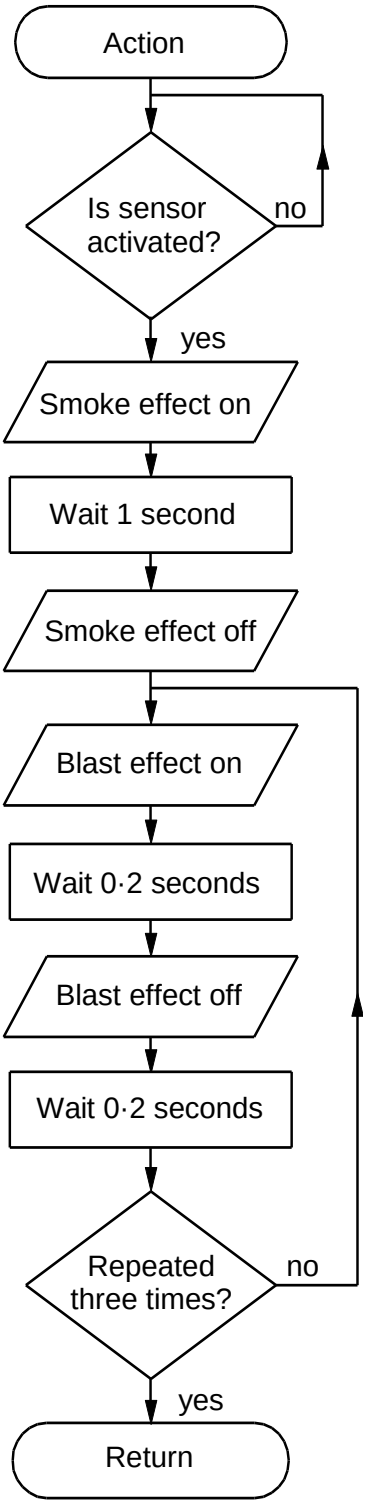
Closed loop has feedback ① **KU**

Open loop has no feedback ① **KU**

KU	RNA
	2
	1
	0
2	
1	
0	

2. An action film sequence uses a number of special effects operated by a microcontroller.

The program makes use of a **sub-procedure** “Action”, shown on the flowchart below.



Marks	
KU	RNA

2. (continued)

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

Input Connection	Pin	Output Connection
	7	Smoke effect
	6	Blast effect
	5	
	4	
	3	
	2	
	1	
Sensor	0	

Complete the PBASIC program for sub-procedure “Action”, with reference to the flowchart, Data Booklet, and the input/output connections.

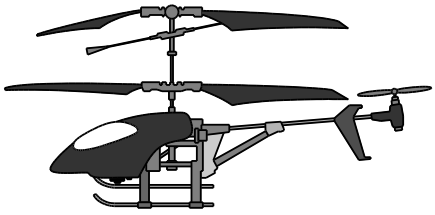
```
Init:     let dirs = %1100000          Alternative:
          symbol counter = b0          if pin 0 = 1 then jump
Action:   if pin 0 = 0 then action     goto action          ① RNA
① RNA                                  jump:
          high 7
① RNA     pause 1000
          low 7

① RNA     for counter = 1 to 3

          high 6
① RNA     pause 200
① RNA     low 6
          pause 200

① RNA     next counter
① RNA     return
```

	7
	6
	5
	4
	3
	2
	1
	0

	Marks	
	KU	RNA

3. A digital electronic system is used to control part of an electronic toy as shown in the truth table below.

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



(a) Complete, with reference to the truth table, a Boolean expression for **Z** in terms of **A**, **B** and **C**.

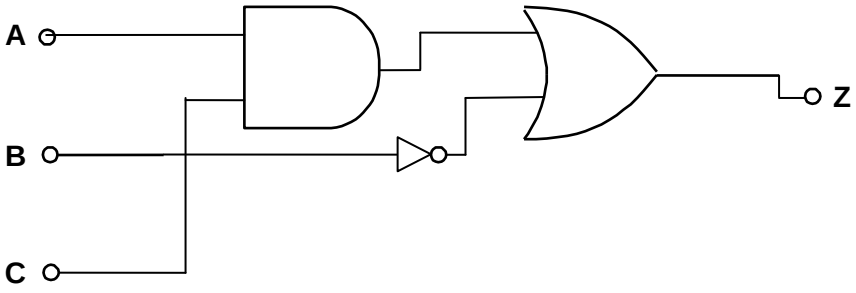
Z = $A \cdot \overline{B} \cdot C + A \cdot B \cdot C$ — **① RNA for ANDing inputs**

($A \cdot C$ ② RNA) — **① RNA for OR conditions**

	2
	1
	0

(b) Complete a logic diagram for the **following** Boolean expression.

Z = (**A•C) + $\overline{B}$**



	3
	2
1	**1**
0	**0**

① KU for 3 symbols

① RNA for connections to each gate

	Marks	
	KU	RNA

3. (continued)

(c) State, with reference to the Data Booklet, the **full name** of the following two ICs (Integrated Circuits) required to form part of the circuit.

IC Number **7408**
Full Name **Quad 2 input AND** ① **KU**

IC Number **7404**
Full Name **Hex Inverter** ① **KU**

	2
	1
	0

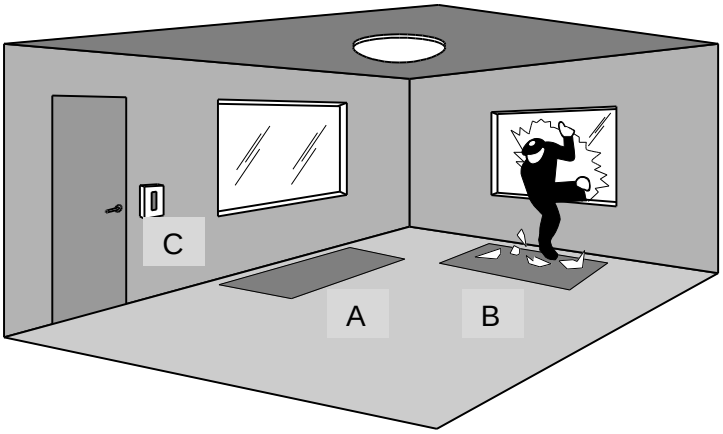
(d) State **two** characteristics of a 7400 series IC (Integrated Circuit).

High power consumption/high speed switching/unaffected by static/low fan out ① **RNA for each valid response**

	2
	1
	0

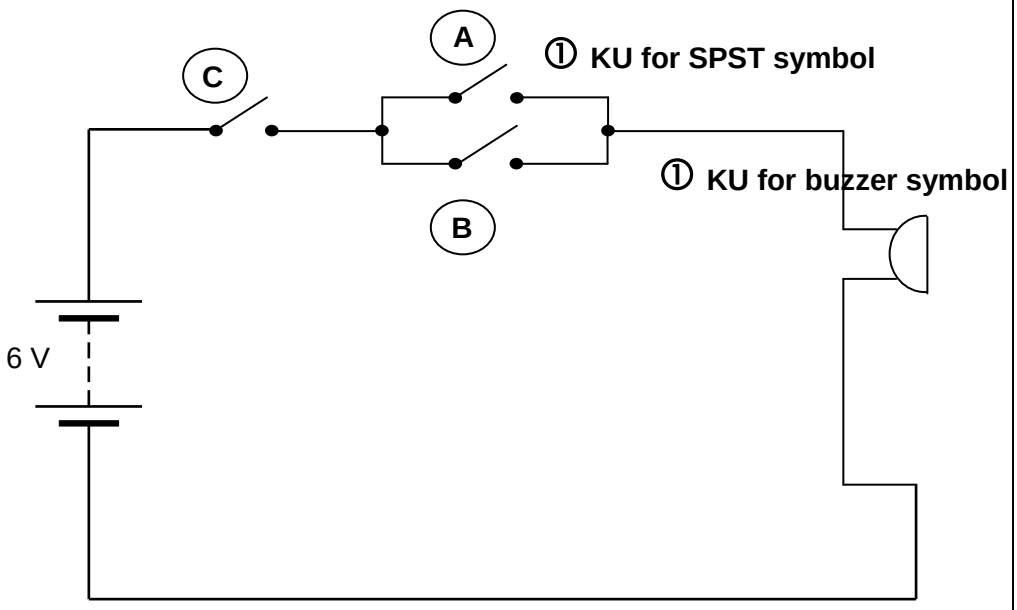
	Marks	
	KU	RNA

4. A prototype for a burglar alarm system is required.



A buzzer will sound if master switch **C** is on and either pressure switch **A** or **B** is also pressed.

(a) Complete the circuit below using three SPST switches and a buzzer.



① KU for SPST symbol

① KU for buzzer symbol

① RNA for connecting components in series to parallel

① RNA for connecting parallel switches

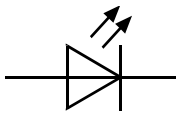
2	**2**
1	**1**
0	**0**

Marks	
KU	RNA

4. (continued)

The circuit is adapted so that an LED switches on when the system is active.

(b) Draw the symbol for an LED.



① KU — **1 0**

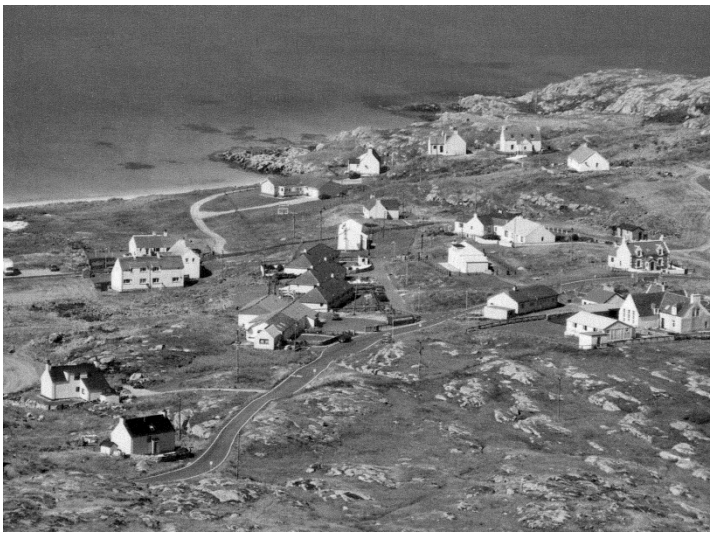
(c) Describe how an LED should be protected when wired in a circuit.

A resistor should be connected **in series**

① RNA **① RNA** — **2 1 0**

	Marks	
	KU	RNA

5. A Scottish island community is looking to become self sufficient in energy production.



(a) Describe an advantage that tidal power has over wind power.

It is predictable/negative aesthetics of wind power ① **KU** — **1 0**

(b) Describe how a wind turbine typically produces electricity.

Wind causes a turbine to turn ① **RNA** — **2 1 0**

Turbine causes a generator to turn and produce electricity ① **RNA**

(c) Describe **two** disadvantages of using **finite** energy sources.

Pollution/limited supply — **2 1 0**

① **RNA for each valid descriptive response**

	Marks	
	KU	RNA

5. (continued)

Holiday cottages on the island are installed with solar thermal panels to heat the cold water.

It was found that **100kg** of water at **10°C** entered the solar panels and absorbed 7 MJ of heat energy.

(d) (i) Calculate, with reference to the Data Booklet, the final temperature of the water.

E = MC ∆ T

7000 000 = 100 x 4190 x ∆ T ① **RNA for substitution**

∆ T = 16·7°C ① **RNA for answer from working(FTE)**

Final Temp = 10 + 16·7 = 26·7°C (27°C) ① **RNA**

		3
		2
		1
		0

(ii) Calculate the efficiency of the solar panels if the sun provided 11 MJ of heat energy.

① **RNA for substitution**

$$\eta = \frac{E_{out}}{E_{in}} = \frac{7\,MJ}{11\,MJ} = 0{\cdot}636$$

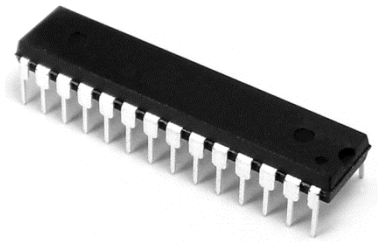
$$= 64\%$$

① **RNA for answer from working**

		2
		1
		0

	Marks	
	KU	RNA

6. Microcontrollers are increasingly used in electronic control systems.



(a) Explain why the microcontrollers are often used instead of hard-wired electronic circuits.

Easier to reprogram/requires fewer components/
shorter assembly time/etc ① **KU for each valid**
Smaller/cheaper must be qualified **explanation/answer**

2
1
0

(b) Complete the table below to match the microcontroller sub-system to its function.

Sub-system	Function	
Clock	**Synchronises the system/keeps all parts working in time with each other**	① **KU**
I/0 Port	*Links the microcontroller to the outside world*	① **KU**
EEPROM	**Stores the program**	① **KU**
ALU	**Performs calculations**	① **KU**

4
3
2
1
0

	Marks	
	KU	RNA

6. (continued)

(c) State the full name of EEPROM.

Electrically (Electronically), Eraseable, Programmable, Read-Only Memory ① **KU**

KU	RNA
1 0	

(d) Explain why sub-procedures are commonly used in a control program.

Reduce overall program size/make program easier to understand/reduces memory requirement

① **KU for each valid explanation/response**

KU	RNA
2 1 0	

Microcontrollers use binary numbers in their calculations and operations.

(e) (i) Convert the following decimal value number to an **8-bit** binary number.

56 = % **00111000** ① **RNA**

KU	RNA
	1 0

(ii) Convert the following binary number to decimal.

%11001101 = **205** ① **RNA**

KU	RNA
	1 0

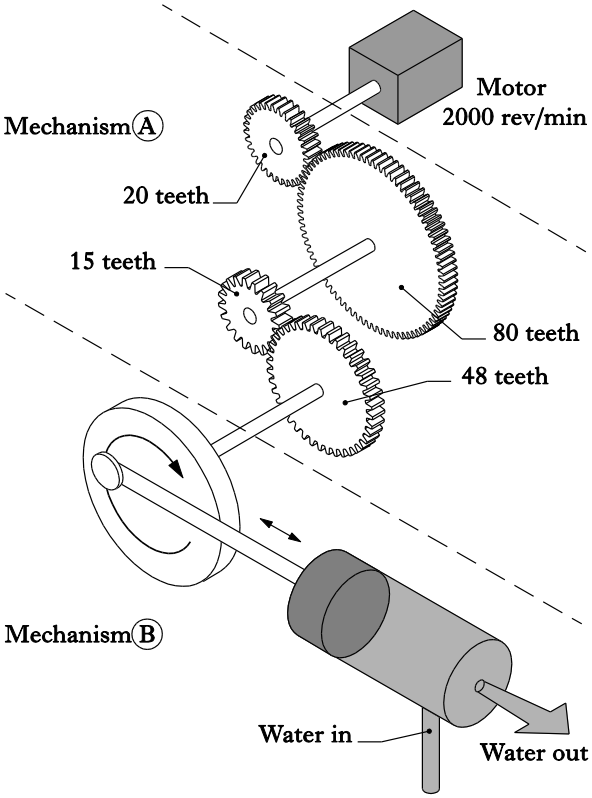
(f) State the name of a method of controlling the speed of a motor using a microcontroller.

PWM/Pulse Width Modulation ① **KU**

KU	RNA
1 0	

	Marks	
	KU	RNA

7. A solar powered water pumping system is being tested for use in developing countries.



The system consists of **two** separate mechanisms.

(a) State the name of the following mechanisms.

Mechanism (A) **Compound gear (train)** ① **KU** — **2**

Mechanism (B) **Crank & slider (any order)** ① **KU** — **1 0**

(b) Describe the change in motion produced by mechanism (B) .

Rotational to reciprocal — **1 0**

Any order

	Marks	
	KU	RNA

7. (continued)

(c) Calculate the output speed of mechanism (A) .

Output speed = $2000 \div \left(\frac{80}{20} \times \frac{48}{15}\right) = 156$ **rev/min**

① **RNA for substitution**

① **RNA for answer from working**

① **RNA for VR_1**

① **RNA for VR_2**

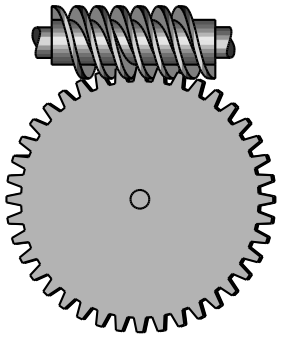
Alt:

$20 \times 2000 = 80 \times T_1$ ① **RNA** **$15 \times 500 = 48 \times T_2$** ① **RNA**

$T_1 = 500$ rev/min ① **RNA** **$T_2 = 156$ rev/min** ① **RNA**

	4
	3
	2
	1
	0

Mechanism (A) is decided to be too bulky and is replaced by the following mechanism.



(d) State the name of this mechanism.

Worm and wheel ① **KU**

1	
0	

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

Lubricating moving parts or bearings on shafts ① **KU** **correct description**

1	
0	

(f) State the names of **two** mechanisms that will convert rotational motion into linear motion.

1 **Rack and pinion** ① **KU**

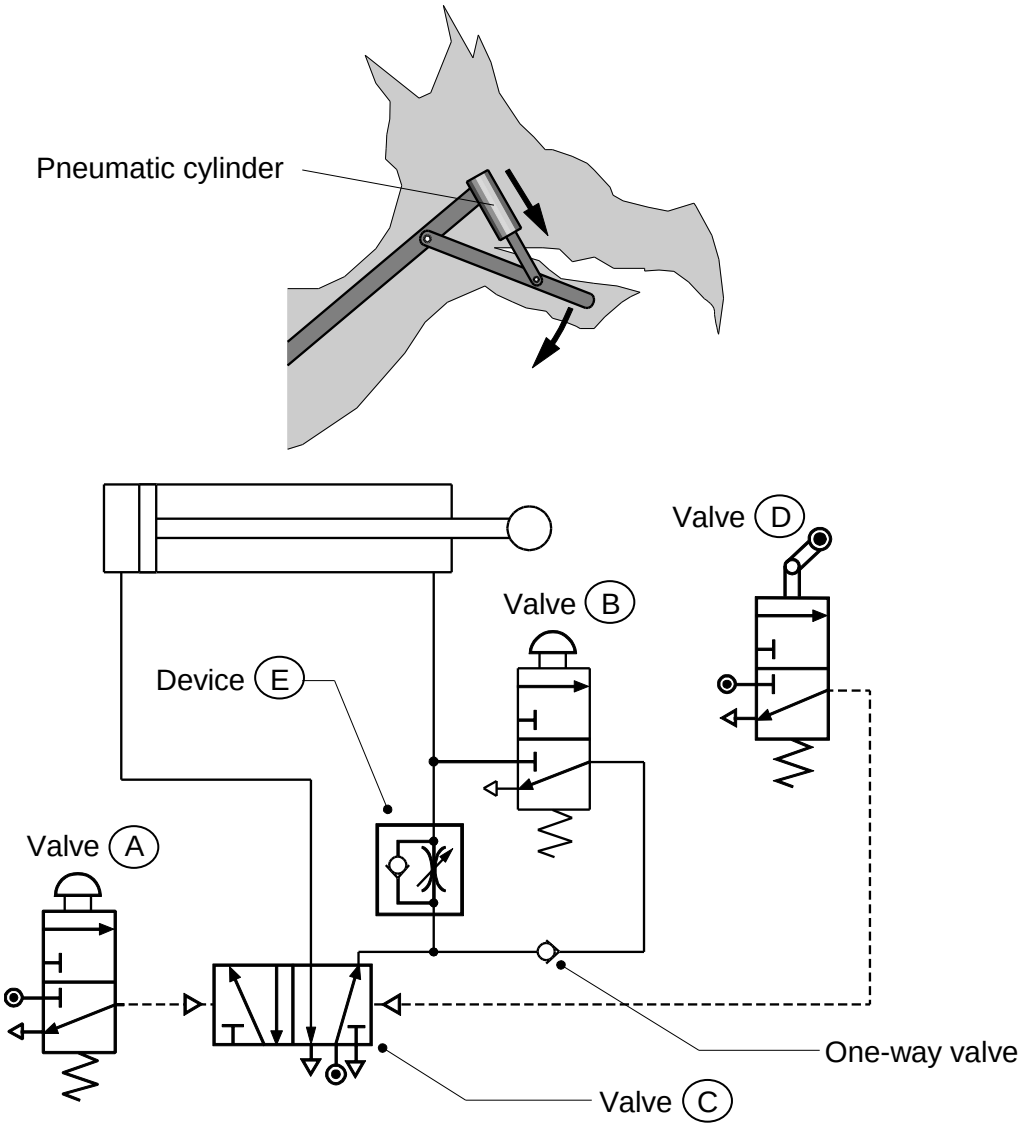
2 **Worm and nut** ① **KU**

Allow FTE from (b) if applicable

2	
1	
0	

	Marks	
	KU	RNA

8. A model dragon is used as part of a stage production.



The dragon's mouth is operated by pressing Valve (A), or by pressing Valve (A) and (B) together.

(a) Describe, using appropriate terminology, how the pneumatic circuit operates.

When Valve (A) is activated Valve (C) changes state causing the DAC to outstroke slowly. When the DAC is fully outstroked it actuates Valve (D) which sends a pilot signal to Valve (C). This caused Valve (C) to change state and instroke the DAC. If Valve (A) and Valve (B) are actuated the DAC will outstroke quickly.

5
4
3
2
1
0

① RNA for each valid point up to a (maximum of 5)

	Marks	
	KU	RNA

8. (continued)

(b) State the **full name** of the following components.

Valve (C) **5/2 / pilot / pilot** ① **KU for each term any order** — **3 2 1 0**

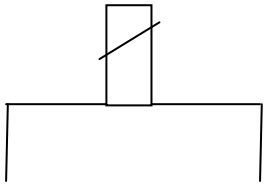
Device (E) **Uni Directional Restrictor** ① **KU** — **1 0**

It was decided to control the dragon's mouth with an electronic control system.

(c) (i) State the name of the actuator that is used for electronic control of a pneumatic valve.

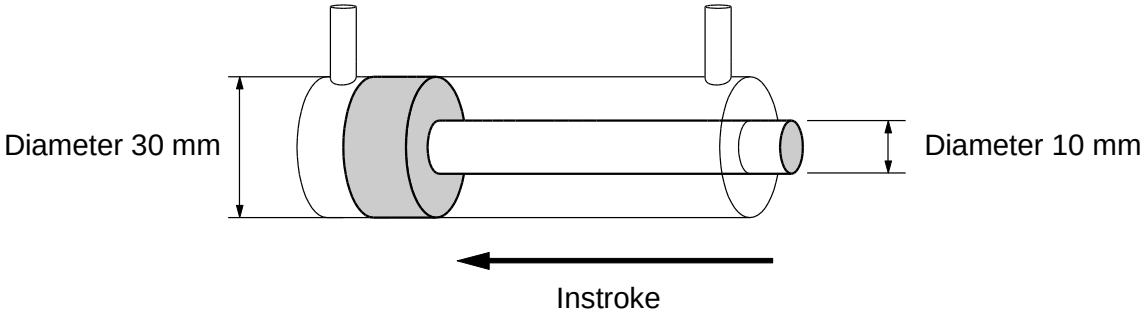
Solenoid ① **KU** — **1 0**

(ii) Draw the symbol for this actuator.



① **KU**
FTE from (c) (i) — **1 0**

Air pressure is supplied to the double-acting cylinder at 0·2 N/mm^2.



(d) Calculate the **instroking** force produced by the cylinder.

A = πr^2 = π x 15^2 = 706 mm^2
a = πr^2 = π x 5^2 = 78·5 mm^2 } ① **RNA for either calculation**

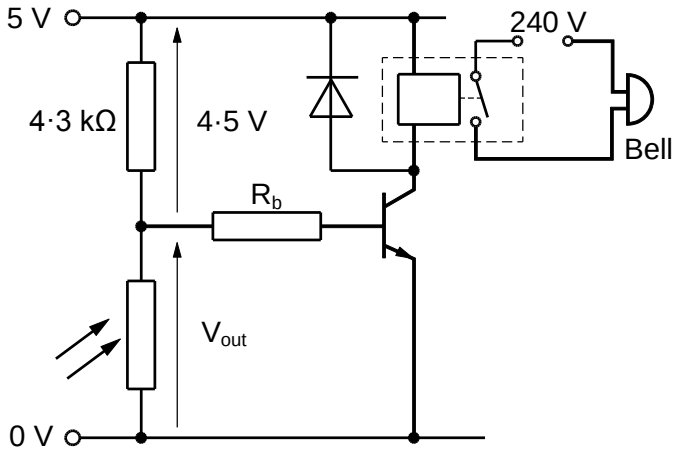
A_{TOTAL} = 706 - 78·5 = 627·5 mm^2 ① **RNA for answers** — **4 3**

F = P x A — **2**
= 0·2 x 627·5 ① **RNA for substitution (FTE)** — **1**
= 125·5 N ① **RNA for answer from working** — **0**

	Marks	
	KU	RNA

9. A game show contestant must perform a task without covering a light sensor. If it is covered then an alarm sounds.

The circuit is shown below.



(a) Calculate the resistance of the LDR when V_{out} is 0·5 V.

$$\frac{V_1}{V_2} = \frac{R_1}{R_2} \qquad \frac{V_1}{4 \cdot 3} = \frac{0 \cdot 5}{4 \cdot 5}$$

① **RNA for substitution**

$$V_1 = \frac{0 \cdot 5 \times 4 \cdot 3}{4 \cdot 5}$$

= 478 Ω ① **RNA for answer from given working**

	2
	1
	0

During the testing the light level is varied.

(b) (i) Determine, with reference to the Data Booklet, the resistance of the LDR at 20 Lux.

5 kΩ ① **RNA**

	1
	0

(ii) Calculate the base current (I_B) when V_{out} is 3·2 V and R_b is 1·5 kΩ.

$$I_B = \frac{V}{R} = \frac{3 \cdot 2 - 0 \cdot 7}{1500}$$

① **RNA for voltage calculation**

① **RNA for substitution**

= 0·0017A (1·7 mA)

① **RNA for answer from given working**

	3
	2
	1
	0

	Marks	
	KU	RNA

9. (continued)

(c) Explain the **function** of the following components that are often used in this type of circuit.

(i) Relay — **Allows the electronic circuit to control high powered electrical circuits** — ① **KU** — **1 0**

(ii) Base Resistor (R_b) — **Protects the transistor from high current** — ① **RNA** — **1 0**

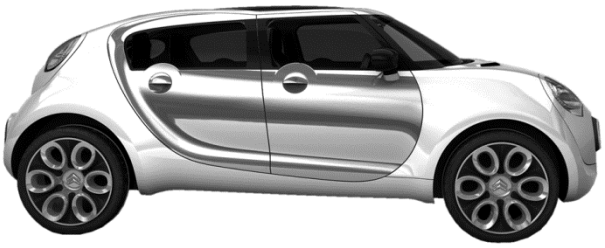
(iii) Diode — **Protects the transistor from back EMF/voltage** — ① **RNA** — **1 0**

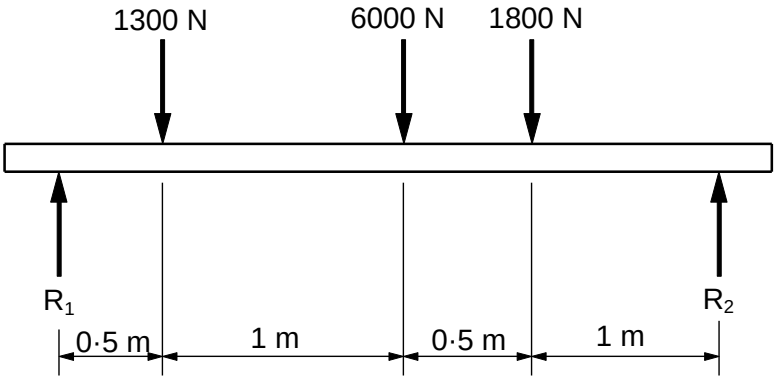
(d) Describe an advantage of testing an electronic circuit using computer simulation.

Components will not be damaged/quicker to fix or adapt design/etc — ① **RNA** — **1 0**

	Marks	
	KU	RNA

10. During the design of a new lightweight family car the forces acting on it are analysed.





The forces are shown on the diagram above.

(a) State the name of this type of diagram.

Free body (diagram) ① **KU** — **1 0**

(b) Calculate the reaction force at R_2.
(Take moments about R_1).

ΣCWM = ΣACWM

(1300 x 0·5) + (6000 x 1·5) + (1800 x 2) = R_2 x 3 ① **RNA for substitution**

650 + 9000 + 3600 = R_2 x 3

$\mathbf{R_2 = \frac{13250}{3}}$ ① **RNA for transposition**

= 4416·7 N ① **RNA for answer from given working** — **3 2 1 0**

[END OF MARKING INSTRUCTIONS]