2010 Technological Studies

Standard Grade – Credit

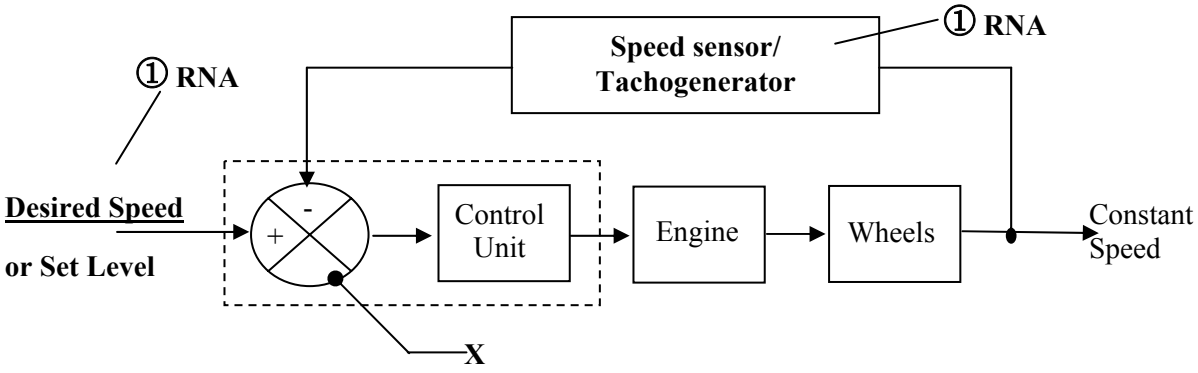
Finalised Marking Instructions

Mark Allocation

Marks	
KU	**RNA**

1. A manufacturer wants to use a cruise control system to keep a car's speed constant even when it goes up and down hills. The system should allow a driver to take their foot off the accelerator once the desired speed has been set.

(a) Complete the **control** diagram below for the cruise control system.



2
1
0

(b) State the name of the control diagram symbol **X**.

Error detector ① **KU**

1
0

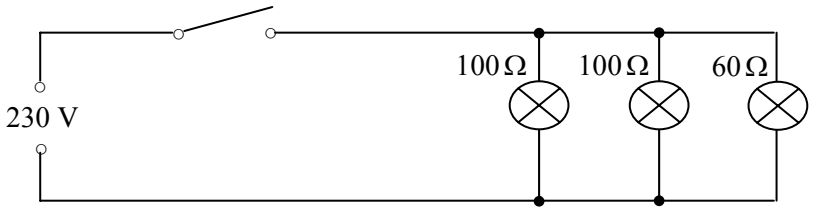
(c) This control system makes use of a feedback loop. State the type of control produced by this automatic system.

Closed loop ① **KU**

1
0

	Marks	
	KU	RNA

2. An interior designer wants three lamps to come on when a switch is activated. The lighting circuit is shown below.



(a) State two reasons why it is good practice to have the lamps wired in **parallel** rather than in series.

(i) **Other remains lit if one breaks** ① **KU**

(ii) **Easy to spot the faulty lamp/be brighter** ① **KU**

	2
	1
	0

(b) Calculate, showing all working and units, the total resistance of the lighting circuit shown above.

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

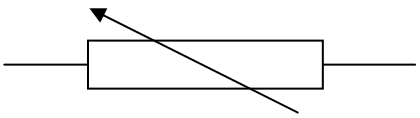
$$= \frac{1}{100} + \frac{1}{100} + \frac{1}{60}$$ ① **RNA substitution**

$$= 0{\cdot}0367$$

$$R_t = 27{\cdot}27\ \Omega$$ ① **RNA correct answer from given working**

	2
	1
	0

The designer wants the brightness of the lights to be altered using the following component.



(c) State the name of the component shown above.

Variable resistor ① **KU**

	1
	0

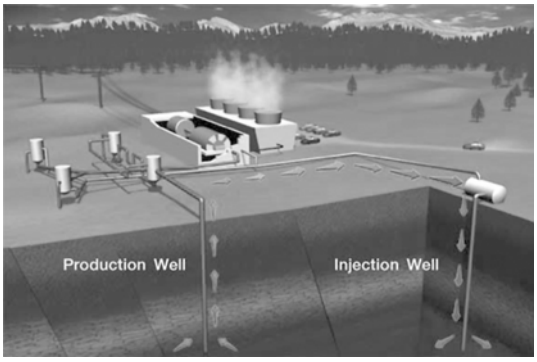
(d) State the name of the device that is used to measure current in a circuit.

Ammeter ① **KU**

	1
	0

Marks	
KU	RNA

3. A geothermal power plant uses the heat in the earth to help produce electricity.



(a) Calculate the heat energy absorbed by 100 litres of water which is pumped into the earth at 10°C and comes out as steam at 240°C. (1 litre of water has a mass of 1 kg.)

E_h = **mc Δ T**

= **100 × 4190 × 230** ① **RNA substitution**
① **RNA temperature change**

E_h = **96370000 J**

= **96.37 MJ** ① **RNA correct answer from given working**

3 2 1 0

(b) For every 15 MJ of heat energy that comes from the ground, the power plant produces 5·34 MJ of electricity.

(i) Calculate the efficiency of the power plant.

η = $\frac{\text{Useful energy out}}{\text{Total energy in}} \times 100\%$

= $\frac{5 \cdot 34\text{MJ}}{15\text{MJ}}$ ① **RNA substitution**

= **35·6%** ① **RNA correct answer from given working**
or 0·356

2 1 0

(ii) Explain why a system, such as the power plant, will not be 100% efficient.

Energy is lost during production etc ①

1 0

	Marks	
	KU	RNA

3. (continued)

(c) Geothermal is a source of renewable energy. State two **other** examples of a renewable energy source.

1 **Solar, tidal, biomass, wind** **2**

① KU each (max 2) **1**

2 **hydro(electric) etc** **0**

(d) State two **disadvantages** of using fossil fuels, other than cost.

1 **Pollution** **2**

① KU each (max 2) **1**

2 **Dwindling supply etc** **0**

(e) State two ways that energy can be conserved in the home.

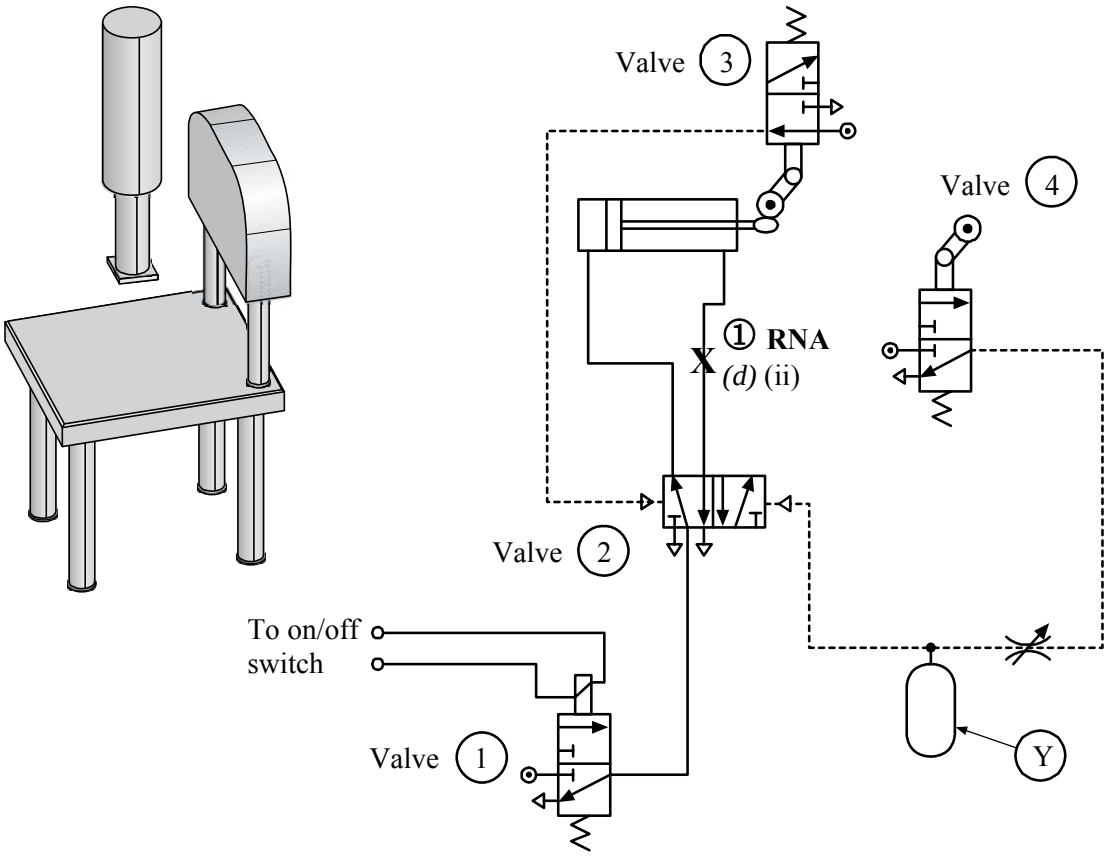
1 **Insulation** **2**

① KU each (max 2) **1**

2 **Switching off unused appliances etc** **0**

Marks	
KU	RNA

4. A test rig in a furniture factory is operated by the pneumatic circuit shown below.



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

*When Valve ① is actuated....***main air flows to valve 2 then causes the DAC to outstroke. When fully outstroked it actuates valve 4 sending a pilot signal towards valve 2. After a delay valve 2 actuates causing the DAC to instroke. This actuates valve 3 which sends a pilot signal to valve 2 causing it to change state and outstroke the piston. The sequence repeats until valve 1 is no longer actuated.**

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

	5
	4
	3
	2
	1
	0

	Marks	
	KU	RNA

4. (continued)

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

Valve ① **Solenoid/Spring Return/3/2 valve** ① KU for each part

Component (Y) **Reservoir** ① KU

	3
	2
	1
	0
	1
	0

(c) State two ways to vary the length of a pneumatic time delay.

1 **Adjust the restrictor** ① KU

2 **Change the volume of the reservoir** ① KU

	2
	1
	0

To reduce damage it was decided to slow the piston movement as it outstrokes. The piston should still instroke quickly.

(d) (i) State the **full name** of a pneumatic component that could be used to slow a piston in one direction.

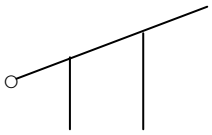
Uni-directional restrictor ① KU

	1
	0

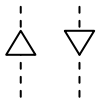
(ii) Mark (X) on the pneumatic circuit where this component should be inserted.

	1
	0

(e) State the name of the following pneumatic actuators.



Lever ① KU

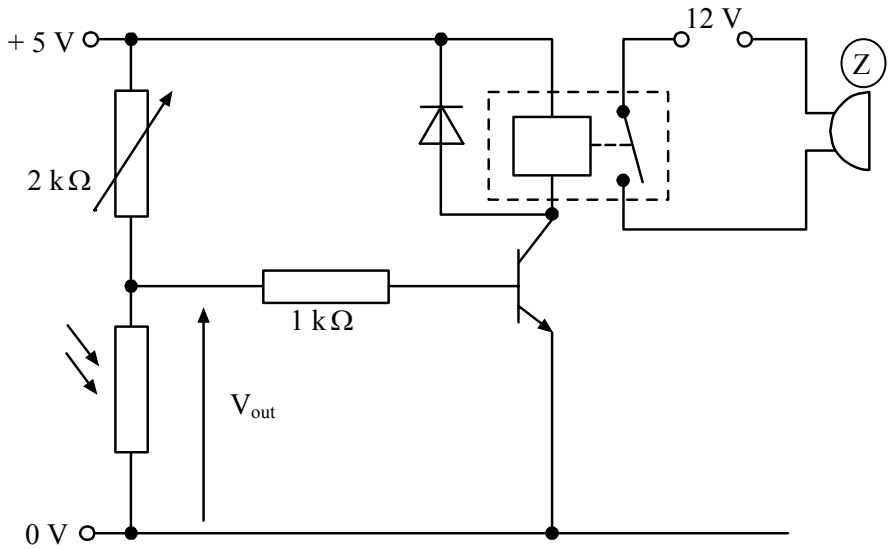


Diaphragm ① KU

	2
	1
	0

	Marks	
	KU	RNA

5. A prototype circuit for a parking sensor in a car is shown below.



(a) (i) State the name of component (Z) shown in the circuit above.

Buzzer — ① **KU**

1	
0	

(ii) State the type of relay shown in the circuit above.

Single Pole Single Throw (SPST) — ① **KU**

1	
0	

(b) Describe the operation of the circuit.

As light level drops **the resistance of the LDR increases and V_{out} increases. When V_{out} is at the appropriate level (0·7 V) the transistor switches on. This causes the relay to turn on and the buzzer to sound.**

	3
	2
	1
	0

① RNA for each valid point up to 3 marks

(c) Calculate, with reference to the Data Booklet, the value of V_{out} when the light level on the LDR is 9 lux.

From the Data Booklet, R_{ldr} = 10 kΩ — ① **RNA correct value from Data Booklet**

$$V_{out} = \frac{R_1}{R_T} \times V_s$$

$$= \frac{10000}{12000} \times 5$$ — ① **RNA substitution**

Allow FTE

	3
	2
	1
	0

$$= 4{\cdot}167 \text{ V}$$ — ① **RNA correct answer from given working**

	Marks	
	KU	RNA

5. (continued)

(d) State the voltage at which a transistor saturates.

0·7 V ① **KU** | **1 0**

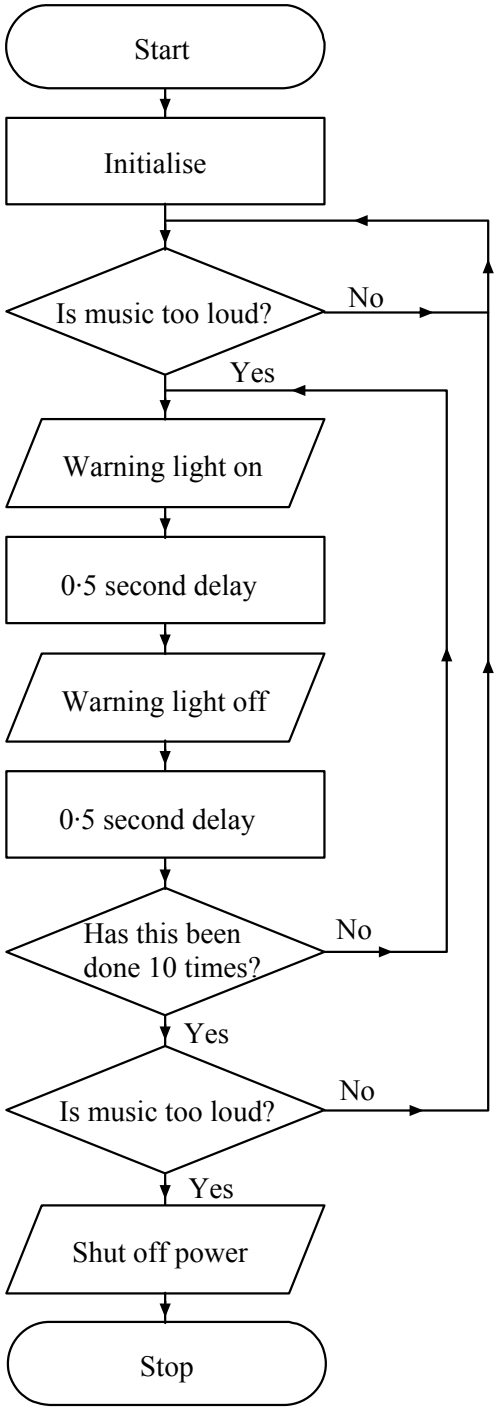
(e) A diode is normally wired in parallel across devices such as relays. State the purpose of the diode.

To protect the transistor ① **KU** | **1 0**

Marks	
KU	RNA

6. A music venue has a system to cut off the power supply if a band plays too loudly. The system is operated by a microcontroller.

A flowchart for the control system is shown below.



Marks	
KU	RNA

6. (continued)

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

Input Connection	Pin	Output Connection
	7	Power supply shut off (1 = shut off, 0 = power on)
	6	Warning light
	5	
	4	
	3	
	2	
	1	
Sound sensor (1 = loud, 0 = quiet)	0	

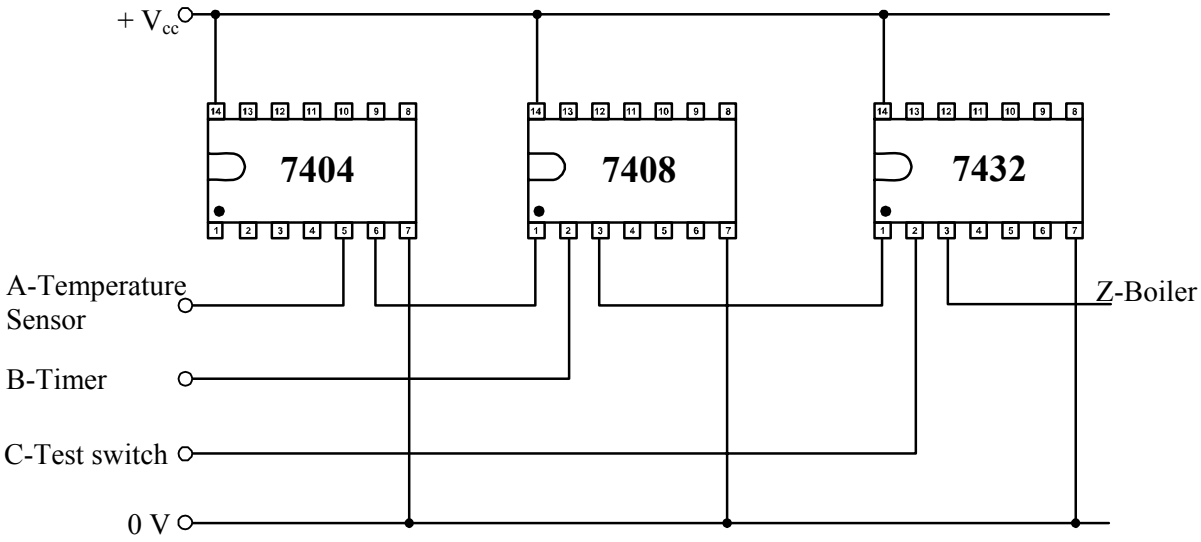
Complete, with reference to the flowchart, Data Booklet, and the input/output connections, the PBASIC control program.

```
init:     let dirs = %11110000      'set pins 7-4 as outputs, rest inputs
          let pins = 0              'all pins off
          symbol counter = b0       'define counter address b0

main:     if pin0 = 0 then main     'if sound level is quiet then jump to main
                                    'set for … next loop to 10
          for counter = 1 to 10                          ① RNA
          high 6                                         ① RNA
          pause 500
① RNA     low 6                                          ① RNA
for both  pause 500
          next counter                                   ① RNA

          if pin0 = 0 then main                          ① RNA

          high 7                                         ① RNA

          end                                            ① RNA
```

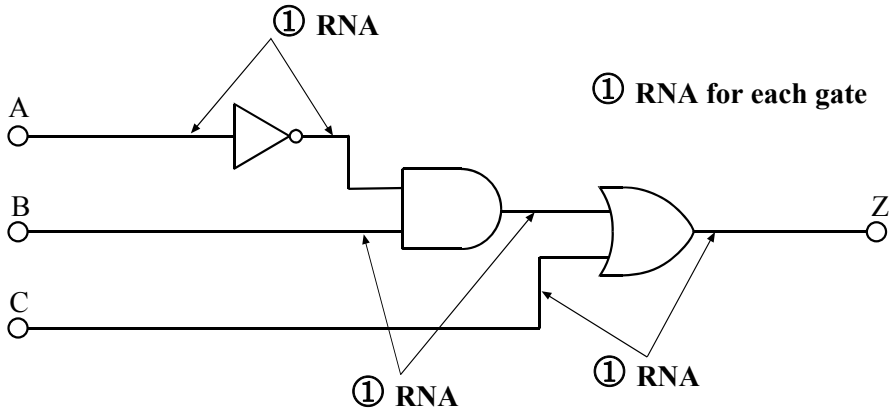
	8
	7
	6
	5
	4
	3
	2
	1
	0

Marks	
KU	RNA

7. Part of an electronic circuit used to control a central heating system is shown below.



(a) Complete, with reference to the Data Booklet and the wiring diagram, the logic diagram for the central heating system.



	6 5 4 3 2 1 0

	Marks	
	KU	RNA

7. (continued)

(b) TTL Integrated Circuits (ICs) are used in the prototype but CMOS ICs are chosen for the final product.

State two **advantages** of CMOS ICs over the TTL ICs.

1 **Low power consumption, high fan out,** — **2 / 1 / 0**

2 **various power supplies etc** — ① **KU each up to 2**

(c) An engineer designed and tested the circuit using a computer simulation.

State two reasons why new circuits are often tested on a computer first.

1 **Easier to change, no faulty components,** — **2 / 1 / 0**

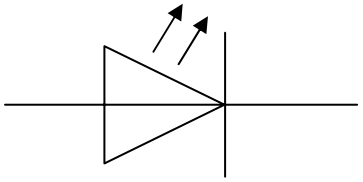
2 **quicker to construct etc** — ① **KU each up to 2**

(d) The engineer assembled the circuit on a breadboard and used an LED to show a high output.

(i) State the full name of an LED.

Light Emitting Diode — ① **KU** — **1 / 0**

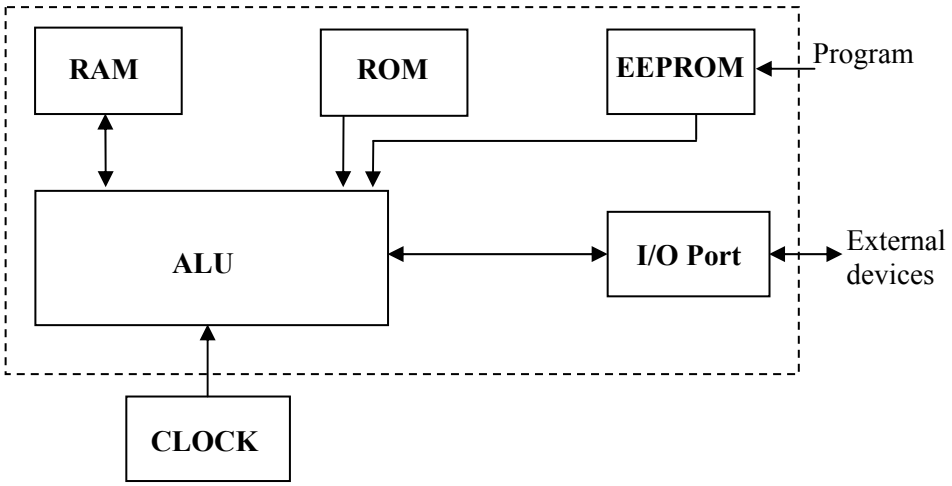
(ii) Draw the symbol for an LED below.



① **KU** — **1 / 0**

	Marks	
	KU	RNA

8. A simplified diagram of a microcontroller system is shown below.



(a) (i) State the **full name** of the following microcontroller sub-systems.

I/O PORT **Input/Output port** ① **KU**

EEPROM **Electronically Erasable Programmable Read Only Memory** ① **KU**

2 1 0

(ii) Describe the difference between RAM and ROM.

RAM is a temporary form of storage, data lost when power switches off etc

ROM is a permanent form of storage, cannot be changed etc

2 1 0

① **KU for each correct description (1 of each)**

(b) (i) State the name of the connections that are used to transfer data from one microcontroller sub-system to another.

Bus (buses) ① **KU**

1 0

(ii) Describe the function of the ALU.

Does all internal calculations, processes data ① **KU**

1 0

(c) (i) Convert the following binary number to decimal.

%10001011 **139** ① **RNA**

1 0

(ii) Convert the following decimal number to binary.

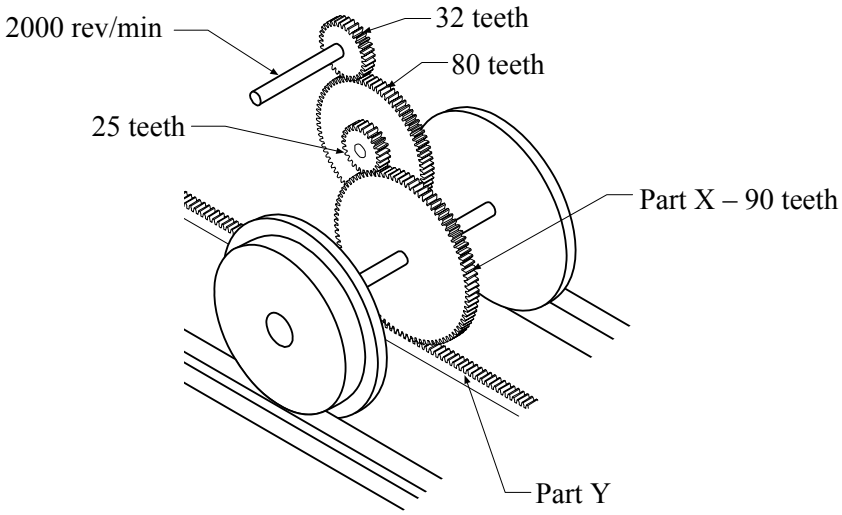
102 % **(0)1100110** ① **RNA**

1 0

	Marks	
	KU	RNA

9. A model train climbs a steep slope at an amusement park.

A simplified diagram of the train drive system is shown here.



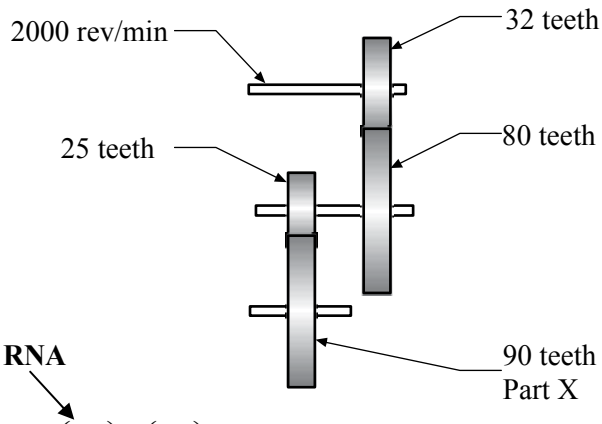
(a) State the names of the labelled parts of the drive system in the diagram above.

Part X **Pinion** ① **KU**

Part Y **Rack** ① **KU**

	2
	1
	0

(b) A simplified diagram of the train drive system is shown. Calculate the speed of the 90 tooth gear.



① **RNA**

Output Speed = $2000 \times \left(\frac{32}{80}\right) \times \left(\frac{25}{90}\right)$ ← ① **RNA** ① **RNA substitution**

= **<u>222 rev/min</u>** ① **RNA correct answer from given working**

OR

① **RNA substitution**

Speed$_{80T}$ = 2000 × 32/80 = <u>800 rev/min</u> ① **RNA correct answer from given working**

Speed$_{90T}$ = 800 × 25/90 = <u>222 rev/min</u> ① **RNA correct answer from given working**

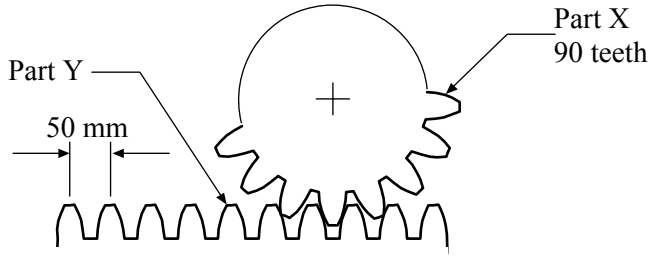
① **RNA substitution**

	4
	3
	2
	1
	0

	Marks	
	KU	RNA

9. (continued)

(c) Calculate the linear speed of the train along the track. The pitch of Part Y is 50 mm.

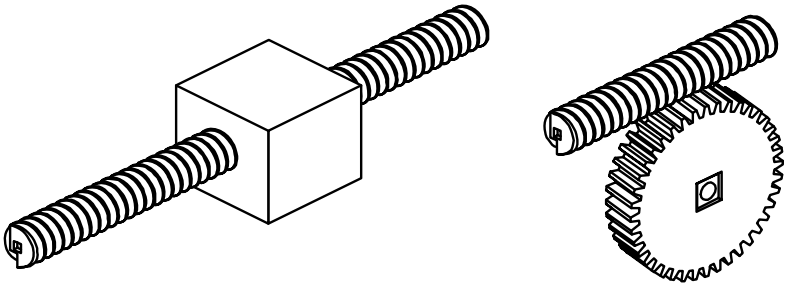


Speed = pitch × revs × teeth

= 50 × 222 × 90 ① **RNA substitution (allow FTE)** — **2**

= 1000000 mm/min ① **RNA correct answer from given working** — **1**
999000 mm/min — **0**

(d) State the names of the mechanisms below.



(i) Worm and **nut** ① **KU** — **2**

(ii) Worm and **wheel** ① **KU** — **1**, **0**

ignore order

(iii) State an advantage in the use of a worm in a lifting system.

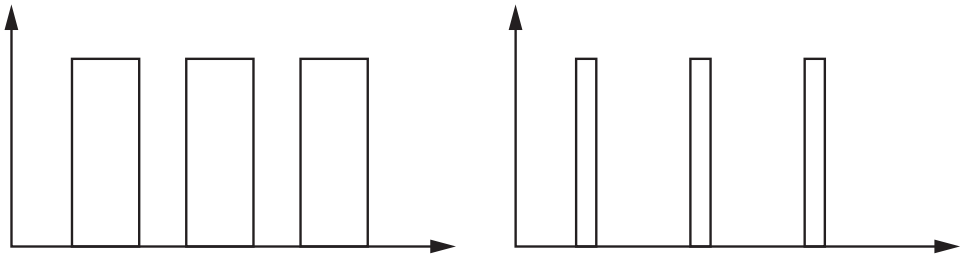
No overhaul, large speed change between input and output etc ① **KU** — **1**, **0**

increase torque

	Marks	
	KU	RNA

10. A microcontroller operates the motors in a robotic dog. To make the dog move in a life-like way the motors must be able to turn at a slower speed.

(a) Describe, with the aid of a sketch, or sketches, how a microcontroller program can be used to make a motor turn at a slower speed.

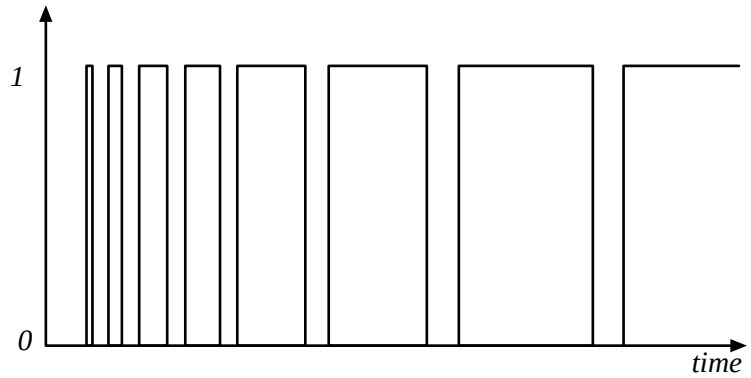


① **KU for mark and space correctly identified or defined**
① **KU for pulsed signal drawn or defined, or PWM stated**
① **KU for describing or drawing a changing ratio of mark and space for slowing**

KU	RNA
3 **2** **1** **0**	

To reduce damage to the robotic toy the program uses a "soft start" technique when operating the motors. The "soft start" is illustrated in the diagram below.

The diagram below shows the output signal to the motor.



(b) Describe, with reference to the diagram, what will happen to a motor when the "soft start" is used.

The motor will gradually speed up ①

KU	RNA
	1 **0**

[END OF MARKING INSTRUCTIONS]