FOR OFFICIAL USE

X036110 11

Total Marks

X036/201

NATIONAL QUALIFICATIONS 2009

MONDAY, 8 JUNE 1.00 PM – 3.30 PM

TECHNOLOGICAL STUDIES INTERMEDIATE 2

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Date of birth
Day Month Year

Scottish candidate number

Number of seat

1 Answer all the questions in Section A and any **two** questions in Section B.

2 Read each question carefully before you answer.

3 Write your answers in the spaces provided.

4 **Show all working and units.**

5 Do **not** write in the margins.

6 **Do not sketch in ink.**

7 Reference should be made to the Standard Grade and Intermediate 2 Data Booklet (2008 edition) which is provided.

8 Before leaving the examination room you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.

Use blue or black ink. Pencil may be used for graphs and diagrams only.

DO NOT WRITE IN THIS MARGIN

SECTION A

Attempt ALL questions (Total 60 marks)

Marks

1. A pneumatic circuit used to raise and lower a bath seat is shown in Figure Q1.

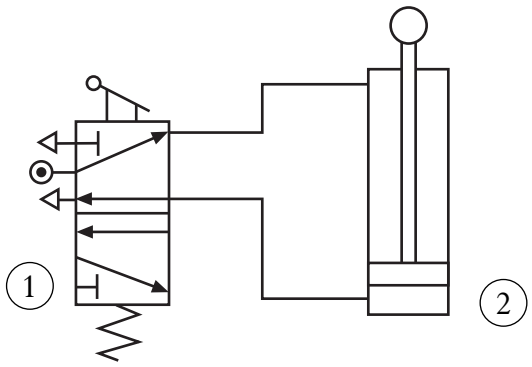


Figure Q1

(*a*) State the **full** name of the two pneumatic components shown in Figure Q1.

(1) _____

(2) _____ **2**

(*b*) (i) State the name of the component that could be used to control **only** the outstroke speed of the piston.

_____ **1**

(ii) Draw the symbol for this component.

1

(iii) Place an **X** on the circuit in Figure Q1 where this component should be connected. **1**

(*c*) State **one** advantage of using a pneumatic circuit to move the bath seat.

_____ **1**

(*d*) Describe one safety precaution, other than wearing goggles, that should be followed when working with a pneumatic circuit.

_____ **1**

(7)

Marks

2. A simplified block diagram for a microcontroller is shown in Figure Q2.

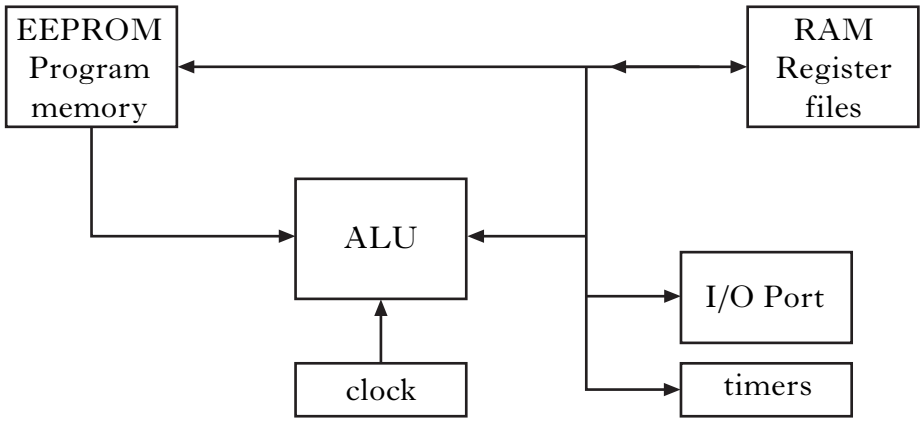


Figure Q2

(*a*) Describe the **function** of the following microcontroller sub-systems.

ALU (Arithmetic Logic Unit) _____

_____

clock _____

_____

I/O Port (Input/Output Port) _____

_____ **3**

(*b*) (i) State the **full** name of the **program** memory shown in Figure Q2.

_____

_____ **1**

(ii) State why RAM memory is **not** used to store a program in the microcontroller.

_____

_____ **1**

The PBASIC command shown below is used to set the input/output pins for the microcontroller.

```
let dirs = %00101100
```

(*c*) (i) State the pin numbers that are set as **outputs**.

_____ **1**

(ii) State what the % sign represents in the PBASIC command shown.

_____ **1**

(7)

Marks

3. A wiring diagram for a digital electronic circuit used in an alarm system is shown in Figure Q3.

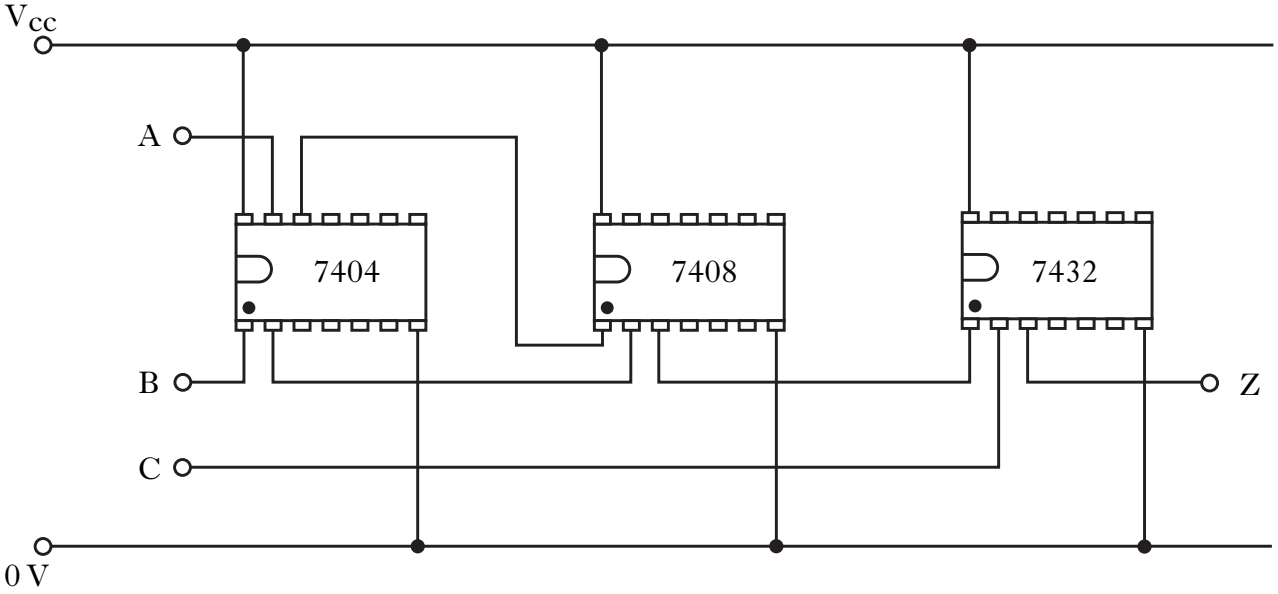


Figure Q3

(*a*) State, with reference to the Data Booklet, the **full** name of the two ICs given below.

7404 _____

7432 _____ **2**

(*b*) With reference to the Data Booklet:

(i) draw the logic circuit for the wiring diagram shown in Figure Q3;

A ○

B ○ ○ Z

C ○ **4**

(ii) write the Boolean expression for output Z, in terms of inputs A, B and C.

Z = _____ **3**

(9)

DO NOT WRITE IN THIS MARGIN

Marks

4. A skateboarder and ramp are shown in Figure Q4.

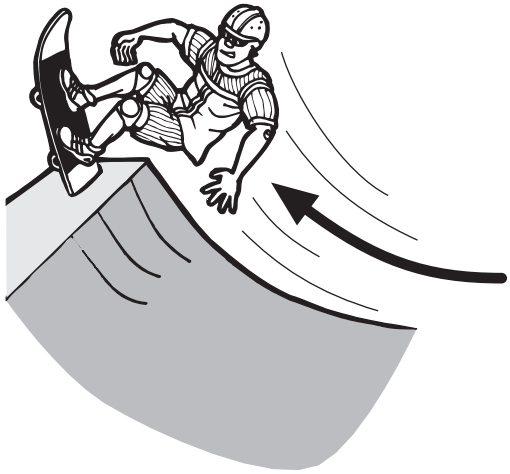


Figure Q4

The skateboarder and board have a combined mass of 70 kg and a velocity of 6 m/s at the bottom of the ramp.

(*a*) Calculate, showing all working and units:

(i) the kinetic energy of the skateboarder and board;

2

(ii) the maximum height the skateboarder and board could reach on the ramp. (Assume no energy losses.)

3

(*b*) Explain why the actual height reached by the skateboarder and board would be less than the answer in 4 (*a*) (ii).

_____

_____

2

(7)

[Turn over

Marks

5. An electrical circuit used to operate three lamps in a robotic arm is shown in Figure Q5.

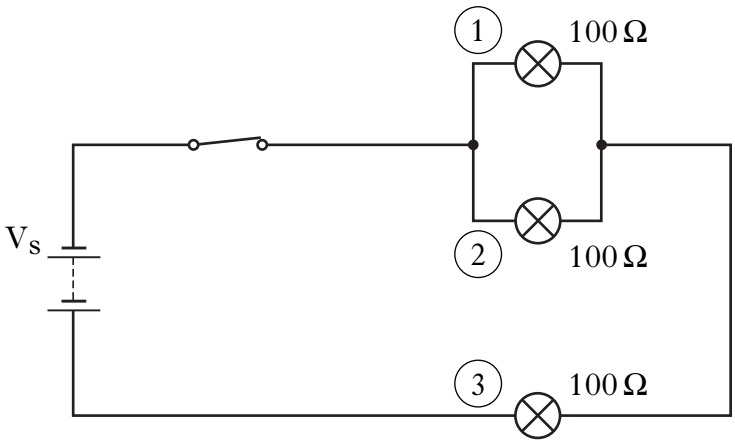


Figure Q5

(*a*) Explain why lamp (3) is brighter than lamps (1) and (2).

1

(*b*) Calculate:

(i) the total resistance of the parallel branch containing lamps (1) and (2);

2

(ii) the total circuit resistance;

1

(iii) the supply voltage, V_S, if 30 mA flows through lamp (1).

3

5. (continued)

Marks

(*c*) Calculate the power used by lamps (2) and (3) and complete the table below.

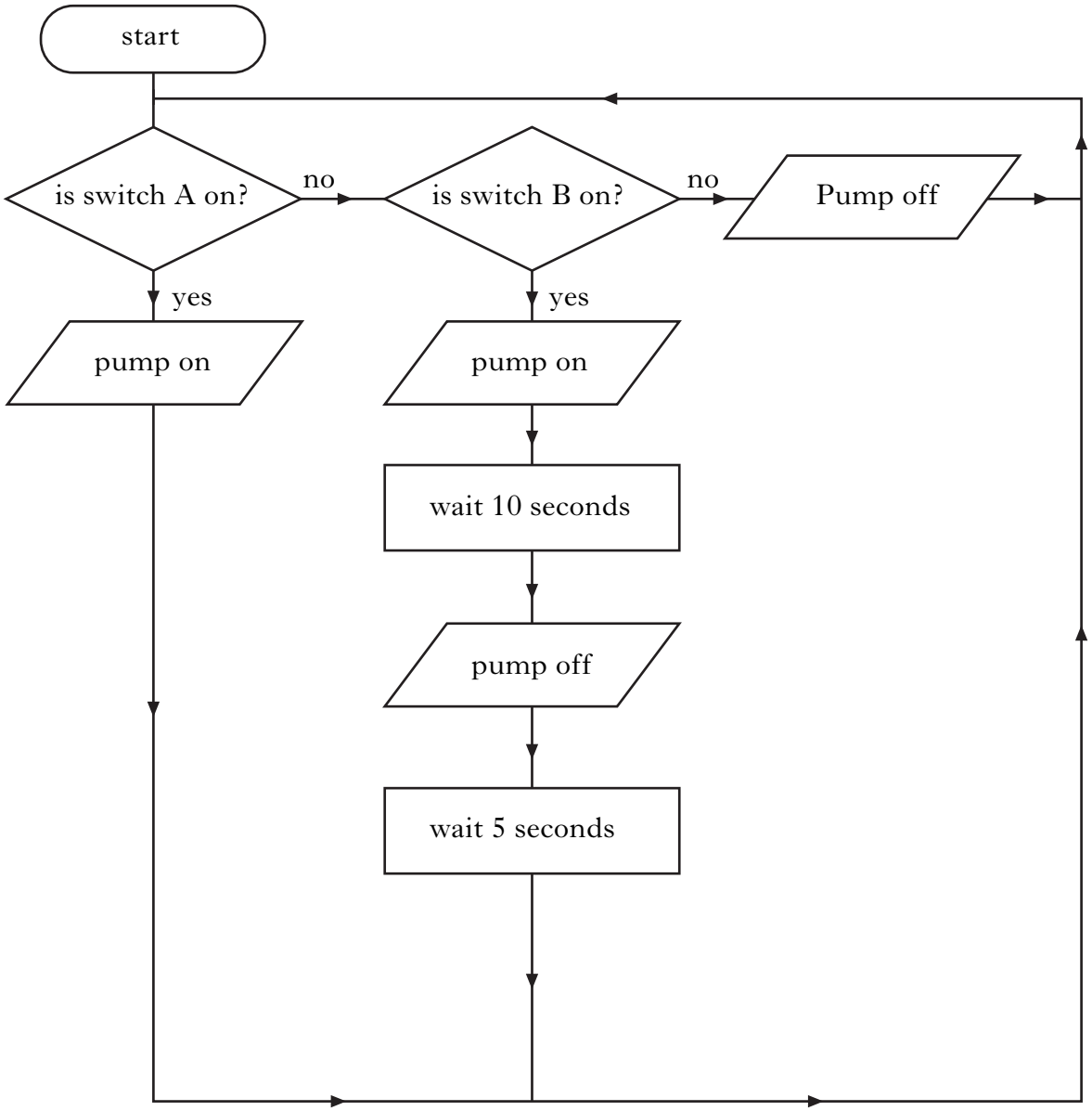
Lamp	Power
(1)	0·09W
(2)	
(3)	

3

(10)

[Turn over

6. A microcontroller is used in the pump system for a hot tub. A simplified flowchart for the operation of the pump and the input and output connections are shown in Figure Q6.



input connection	pin	output connection
	7	
	6	
	5	pump
	4	
	3	
	2	
switch B	1	
switch A	0	

Figure Q6

6. (continued)

Marks

An incomplete PBASIC program, to control the operation of the pump is listed below.

(*a*) Complete, with reference to the flowchart, Data Booklet and the input/output connections, the missing PBASIC commands.

```
init:     let dirs = %11110000      'set input/output connections
main:     _____________________     'test switch A
          _____________________     'test switch B
          high 5                    'pump on
          _____________________     'wait for ten seconds
          low 5                     'pump off
          pause 5000                'wait for five seconds
          goto main                 'loop to main
Pumpon:   _____________________     'pump on
          _____________________     'loop to main
Pumpoff:  low 5                     'pump off
          goto main                 'loop to main
```

5

The program is changed so that the pump will turn on and then off ten times before returning to the start.

(*b*) State the PBASIC instruction that could be used to repeat this sequence ten times.

_____

1

(*c*) Describe one advantage of using a microcontroller when compared to a hard wired electronic circuit.

_____

_____

1

(7)

[Turn over

Marks

7. An incomplete control diagram for an oven is shown in Figure Q7.

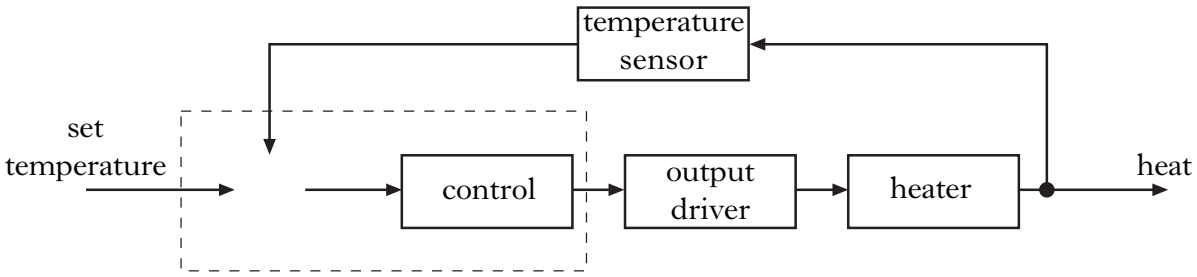


Figure Q7

(*a*) Complete the control diagram by adding the symbol for an error detector in the correct position. **1**

(*b*) Describe, using appropriate terminology, the operation of the oven system.

3

(*c*) (i) State the type of feedback used in the oven system.

1

(ii) Describe why this type of feedback is used.

1

(6)

Marks

8. A desk with two computers is shown in Figure Q8.

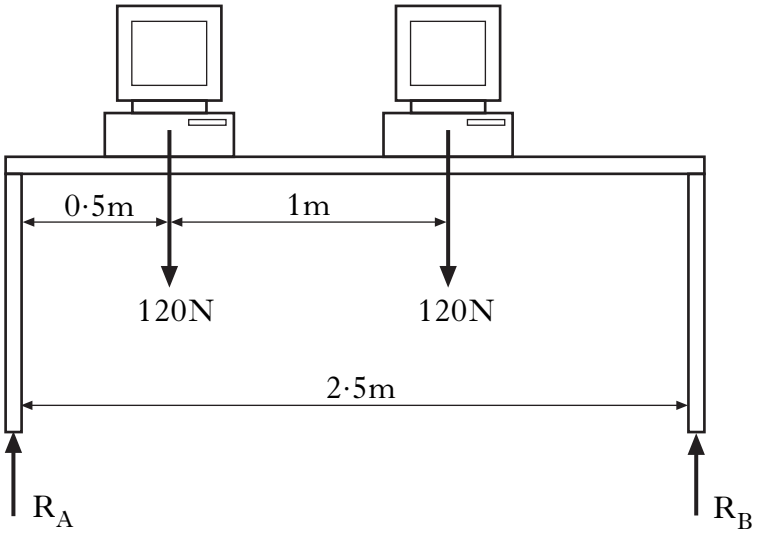


Figure Q8

(*a*) Draw a free body diagram for the arrangement shown in Figure Q8. **2**

(*b*) Calculate:

(i) the reaction forces R_A (take moments about R_B); **3**

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

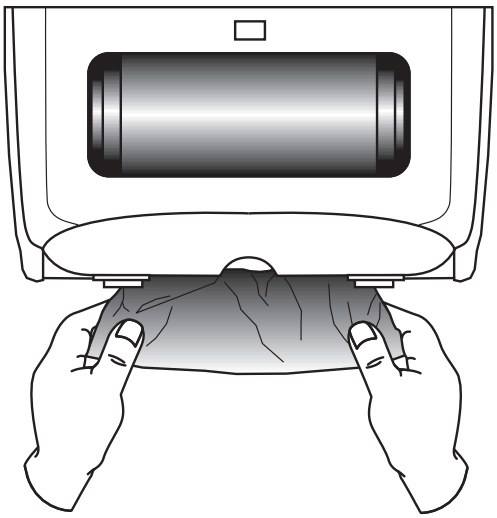
(7)

SECTION B

Attempt any TWO questions (Total 40 marks)

Marks

9. Figure Q9(*a*) shows a simplified sub-system diagram to control the motor in a hand towel dispenser.



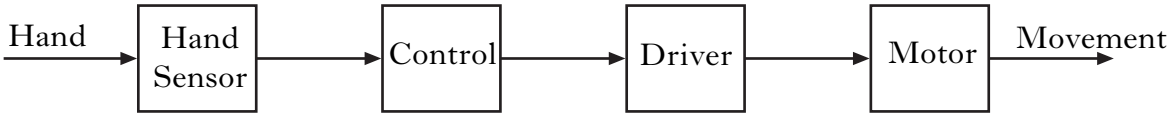


Figure Q9(*a*)

(*a*) (i) State the type of control shown in Figure Q9(*a*).

_____ **1**

(ii) Justify the answer given in (*a*) (i).

_____ **1**

(iii) Sketch the system boundary on Figure Q9(*a*). **1**

9. (continued)

Marks

Figure Q9(*b*) shows the circuit diagram used to control the motor.

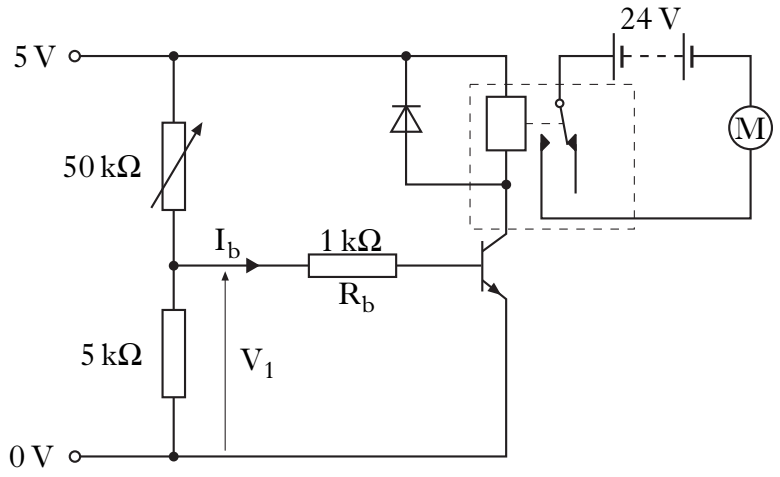


Figure Q9(*b*)

(*b*) Calculate the voltage V_1.

3

When the transistor is **saturated** V_1 was now found to be 1·5 V.

(*c*) Calculate:

(i) the voltage across R_b;

2

(ii) the base current I_b;

2

(iii) the collector current when the current gain $h_{FE} = 100$.

1

9. (continued) *Marks*

In this arrangement the motor can rotate in one direction only.

(*d*) State the name of the type of relay that would allow the motor to rotate in **both** directions.

_____ **1**

Figure Q9(*c*) shows the gear system used to control the output speed of the hand towels from the dispenser.

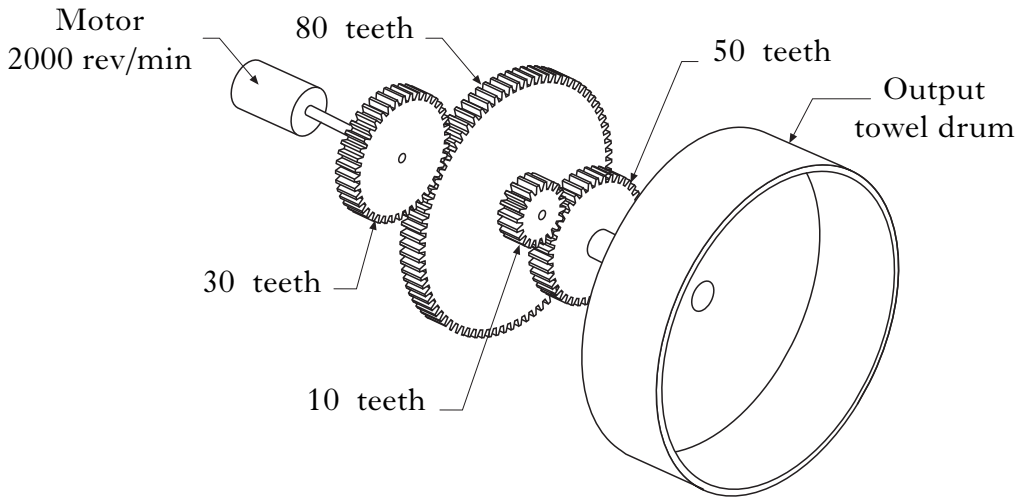


Figure Q9(*c*)

(*e*) State the name of the gear system shown in Figure Q9(*c*).

_____ **1**

(*f*) State the direction of rotation of the output if the motor turns in a clockwise direction.

_____ **1**

The motor rotates at 2000 rev/min.

(*g*) Calculate, for the gear values given in Figure Q9(*c*), the output speed.

4

Marks

9. (continued)

The output torque from the gear arrangement was found to be too low to dispense the towels.

(*h*) (i) State what is meant by the term **torque**.

_____ **1**

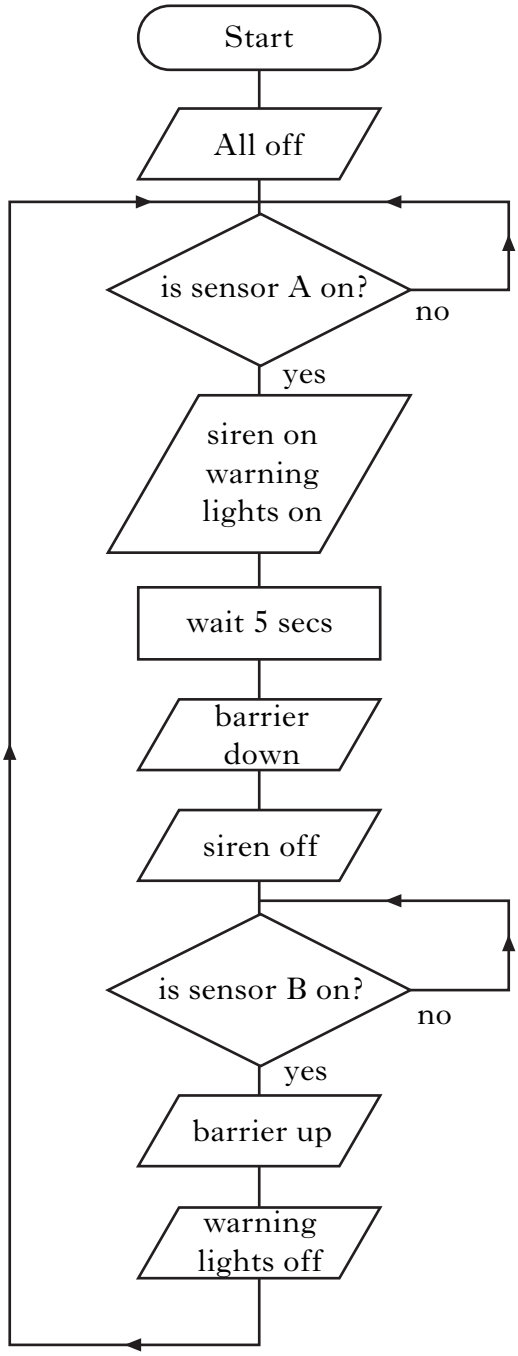
(ii) State a method of increasing the output torque of the gear system.

_____ **1**

(20)

[Turn over

10. A barrier system for a miniature railway in a park is controlled using a microcontroller. The flowchart for the barrier system and the input and output connections are shown in Figure Q10(*a*).



Input connection	Pin	Output connection
	7	warning lights
	6	siren
	5	barrier
	4	
	3	
	2	
sensor B	1	
sensor A	0	

Figure Q10(*a*)

Marks

10. (continued)

An incomplete program for the barrier system is listed below.

(*a*) Complete, with reference to the flowchart, Data Booklet and the input/output connections, the missing PBASIC commands.

```
init:    let dirs = %11110000      'set input/output connections
         _____________________     'all off
main:    _____________________     'test sensor A
         _____________________     'siren and warning lights on
         _____________________     'wait 5 seconds
         high 5                    'barrier down
         low 6                     'siren off
label:   if pin1 = 0 then label    'test sensor 2
         low 5                     'barrier up
         _____________________     'warning lights off
         goto main                 'loop to main
```

5

[Turn over

Marks

10. (continued)

A sub-procedure "flash" was created to control the number of times that the warning lights would operate. The program listing for the sub-procedure is listed below.

```
flash:
        for counter = 1 to 6
                high 7
                pause 500
                low 7
                pause 500
        next counter
        return
```

(*b*) Draw, with reference to the Data Booklet, the flowchart for the "flash" sub-procedure.

5

(*c*) State one advantage of using sub-procedures when developing a PBASIC program.

_____

_____

1

10. (continued)

Spring buffers are used to prevent damage to the train if it crashes at the end of the track. The train has a kinetic energy of 1 kJ which is converted to strain energy on impact.

(*d*) Calculate the **total** force exerted on the spring buffers if they are compressed by 500 mm on impact. (Assume no energy losses.)

3

Figure Q10(*b*) shows two children sitting on a seesaw in the park.

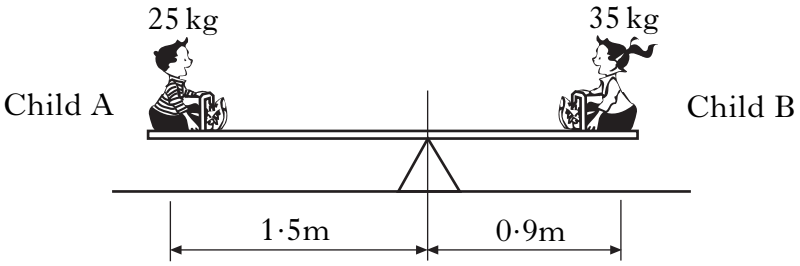


Figure Q10(*b*)

(*e*) Calculate the **weight** of each child in Newtons caused by gravity.

2

(*f*) (i) Calculate the clockwise and anticlockwise moment on the seesaw.

2

(ii) State the direction of movement of child A.

_____

1

(*g*) State the name of the term given to describe when all the forces acting on a system are balanced.

_____

1

(20)

Marks

11. A simplified hydroelectric power station is shown in Figure Q11(*a*).

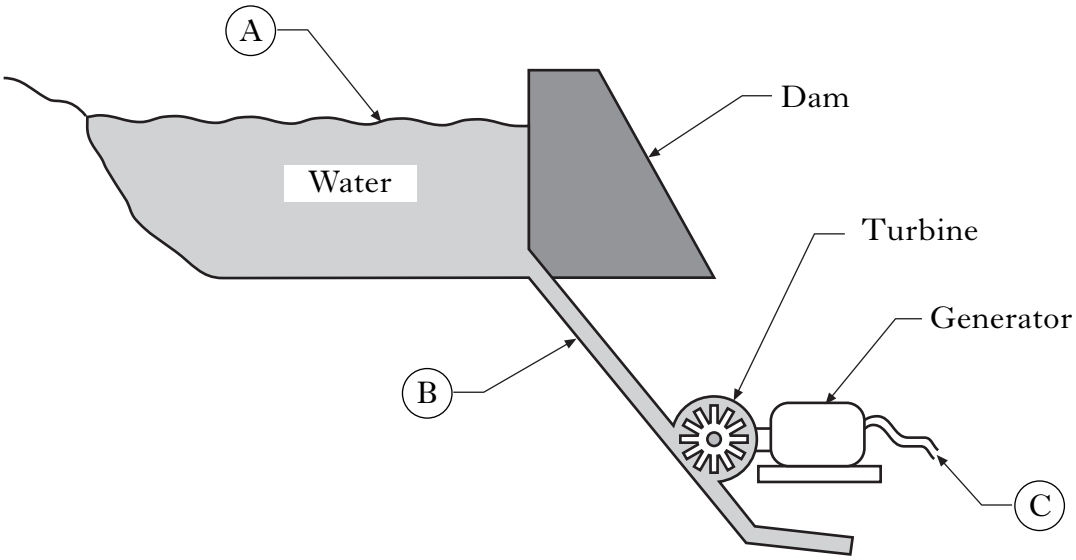


Figure Q11(*a*)

(*a*) State the **main** form of energy at positions (A), (B) and (C) in Figure Q11(*a*).

(A) : _____

(B) : _____

(C) : _____ **3**

Hydroelectric energy is described as renewable.

(*b*) State the name of **two** other renewable sources of energy.

1. _____

2. _____ **2**

11. (continued)

Marks

Figure Q11(*b*) shows the pneumatic circuit that is used to operate the water gates which control the flow of water through the power station.

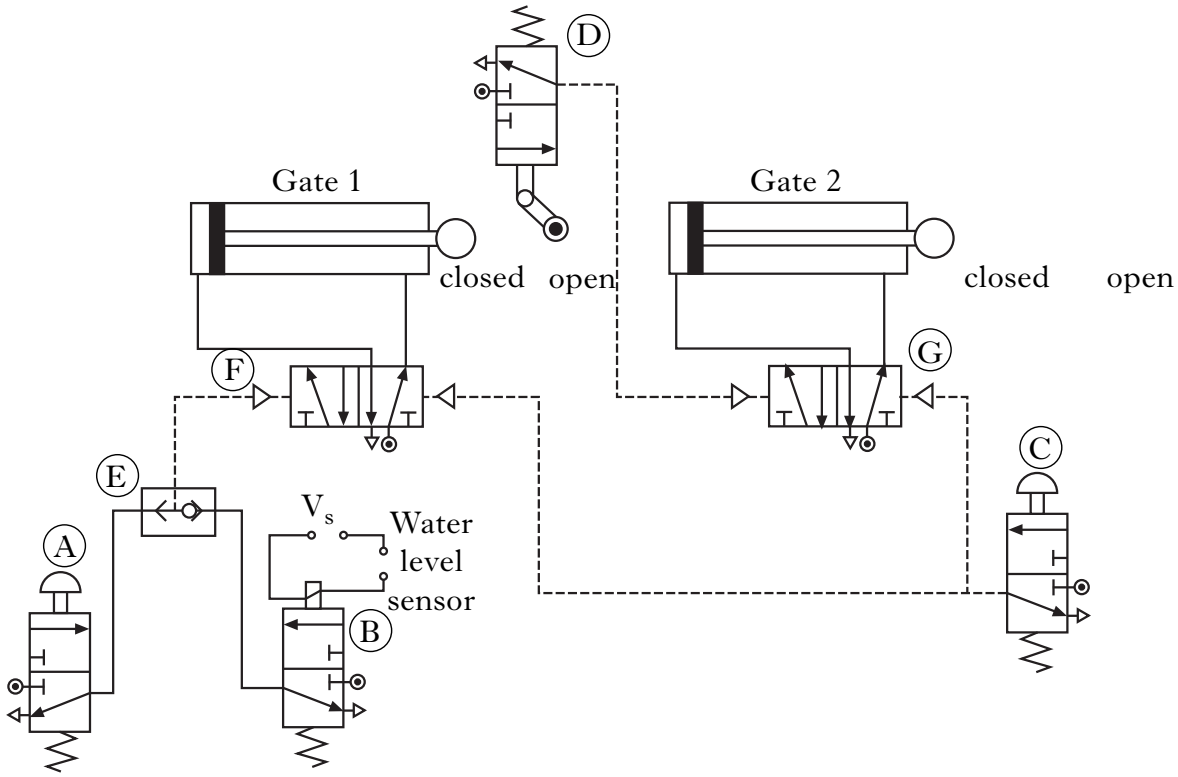


Figure Q11(*b*)

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

When the water level sensor produces a high signal, valve (B),

5

[Turn over

Marks

11. (continued)

The Boolean expression for an electronic control logic circuit used in a monitoring system in the hydroelectric station is:

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

From the Boolean expression:

(*d*) (i) draw the logic circuit

4

(ii) complete the truth table.

A	B	C	A·B	B·$\overline{C}$	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			

3

The 7400, 7404 and 7408 ICs are required to construct the circuit.

(*e*) (i) State which logic family these ICs belong to.

_____ **1**

(ii) State any **two** characteristics of this logic family.

1: _____

2: _____ **2**

(20)

[*END OF QUESTION PAPER*]

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