FOR OFFICIAL USE

Total Marks

X036/201

NATIONAL QUALIFICATIONS 2007

FRIDAY, 1 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 (2007 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.

SCOTTISH QUALIFICATIONS AUTHORITY

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SECTION A

Attempt ALL questions (Total 60 marks)

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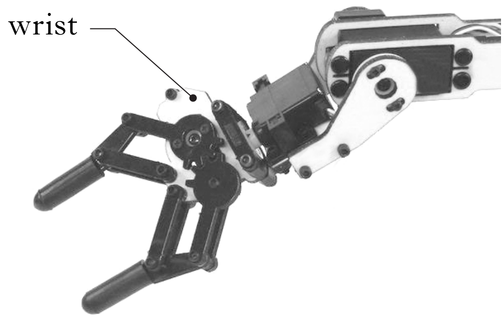
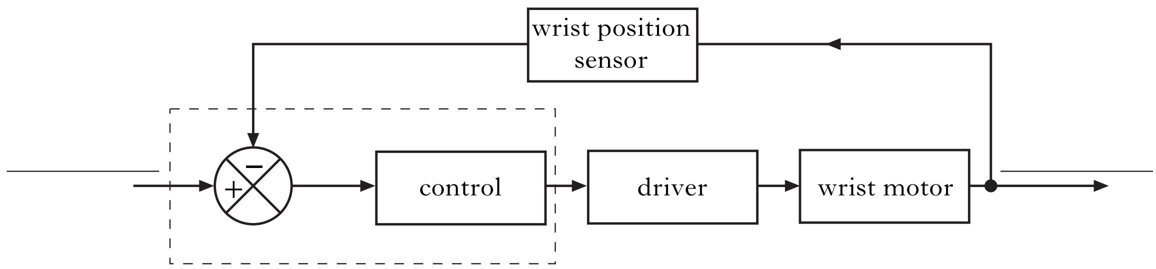
1. The wrist on a robotic arm turns to its correct position when a move signal is received.



(*a*) Complete the control diagram below for the movement of the wrist.



2

(*b*) State the name of a suitable input transducer that could be used for the wrist position sensor.

____ **1**

(*c*) Describe the operation of the error detector with reference to the input and feedback signals.

____

____

____ **2**

The robotic arm is used as part of a sequential control system.

(*d*) Describe what is meant by "sequential control".

____

____ **1**

(6)

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Marks

2. An electric water heater takes 6 minutes to heat 10 kg of water to a temperature of 80 °C. The water heater operates from 230 V and 35 A.

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

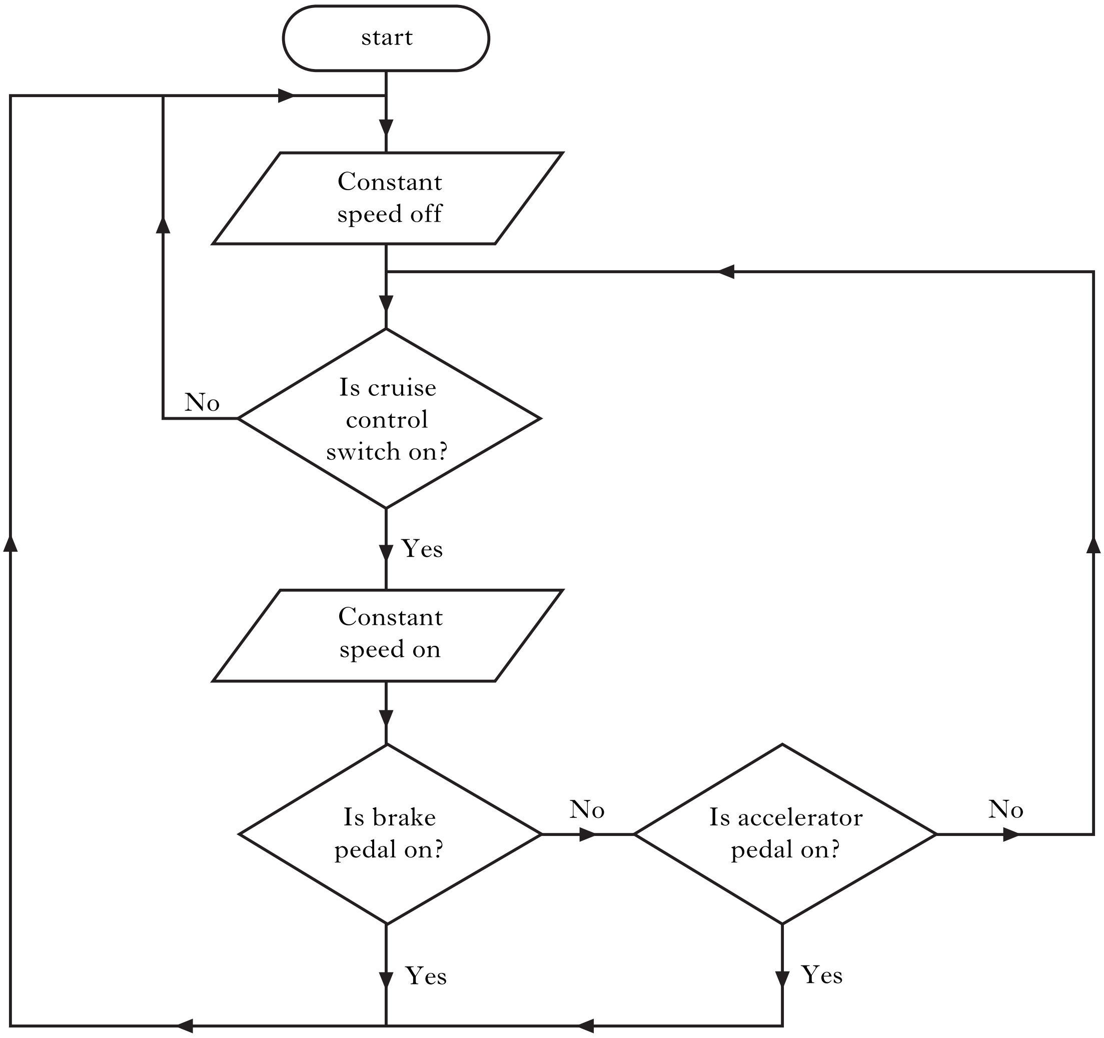
the electrical energy used by the water heater; **3**

(*b*) the starting temperature of the water. (Apply the law of conservation of energy and assume no energy losses.) **4**

(7)

[Turn over

3. A microcontroller is used in the cruise control system of a car. The simplified flowchart for the operation of the cruise control system and the input and output connections are shown in Figure Q3(*a*).



Input connection	Pin	Output connection
	7	constant speed
	6	
	5	
	4	
	3	
accelerator pedal	2	
brake pedal	1	
cruise control switch	0	

Figure Q3(*a*)

Marks

3. (continued)

(*a*) Complete, with reference to the flowchart in Figure Q3(*a*) and the Data Booklet, the PBASIC program for the cruise control system.

init:	____________________	*'set DDR*
main:	low 7	*'constant speed off*
check:	____________________	*'test cruise control switch*
	____________________	*'constant speed on*
	if pin1 = 1 then main	*'test brake pedal*
	____________________	*'test accelerator pedal*
	____________________	*'loop to "check"*

5

A simplified block diagram for the microcontroller used is shown in Figure Q3(*b*).

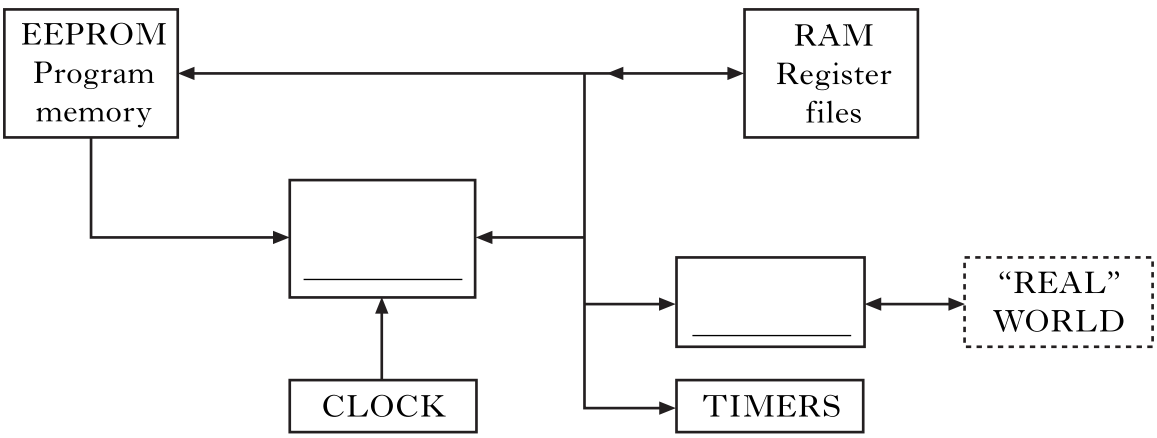


Figure Q3(*b*)

(*b*) Complete the block diagram in Figure Q3(*b*) for the microcontroller. **2**

EEPROM memory is used to store the program within the microcontroller.

(*c*) (i) State the **full** name of this memory type.

____ **1**

(ii) State **one** advantage of using this type of memory in the microcontroller.

____ **1**

(9)

Marks

4. The circuit for an alarm system is shown in Figure Q4.

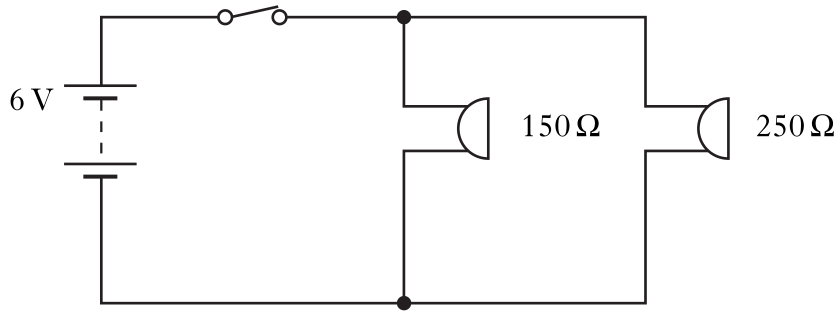


Figure Q4

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

(i) the circuit resistance; **2**

(ii) the total current in the circuit; **1**

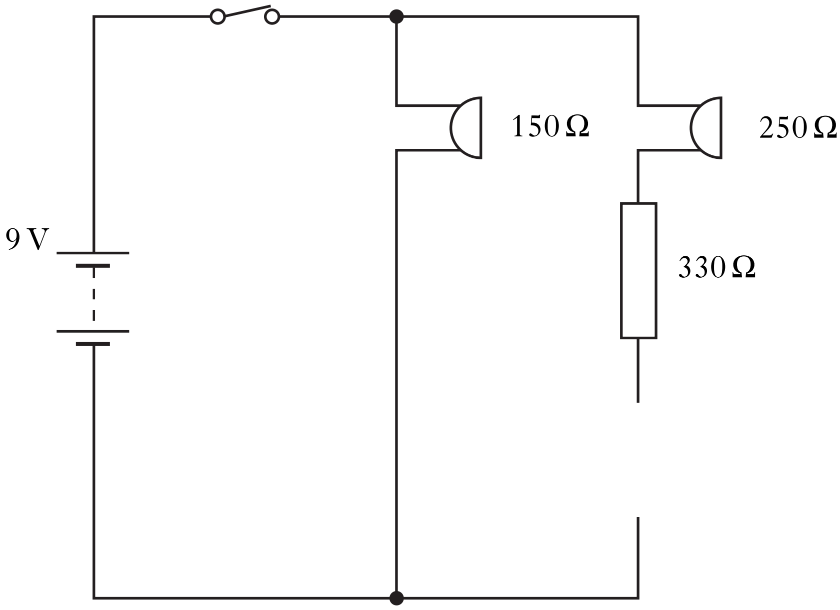
(iii) the current through the 150 Ω buzzer when the switch is closed. **2**

Marks

4. (continued)

The circuit is modified to include an LED that will indicate when the 250 Ω buzzer is operating.

(*b*) Complete the circuit diagram below by adding the symbol for an LED in its correct position.



2

(*c*) Describe the effect the modification to the circuit will have on the **operation** of the 250 Ω buzzer.

____

____ **1**

(8)

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5. The proposed circuit used to control an automatic hot water tap is shown in Figure Q5. An LDR is positioned under the tap to sense when a user's hand is present and a solenoid is used to open the tap.

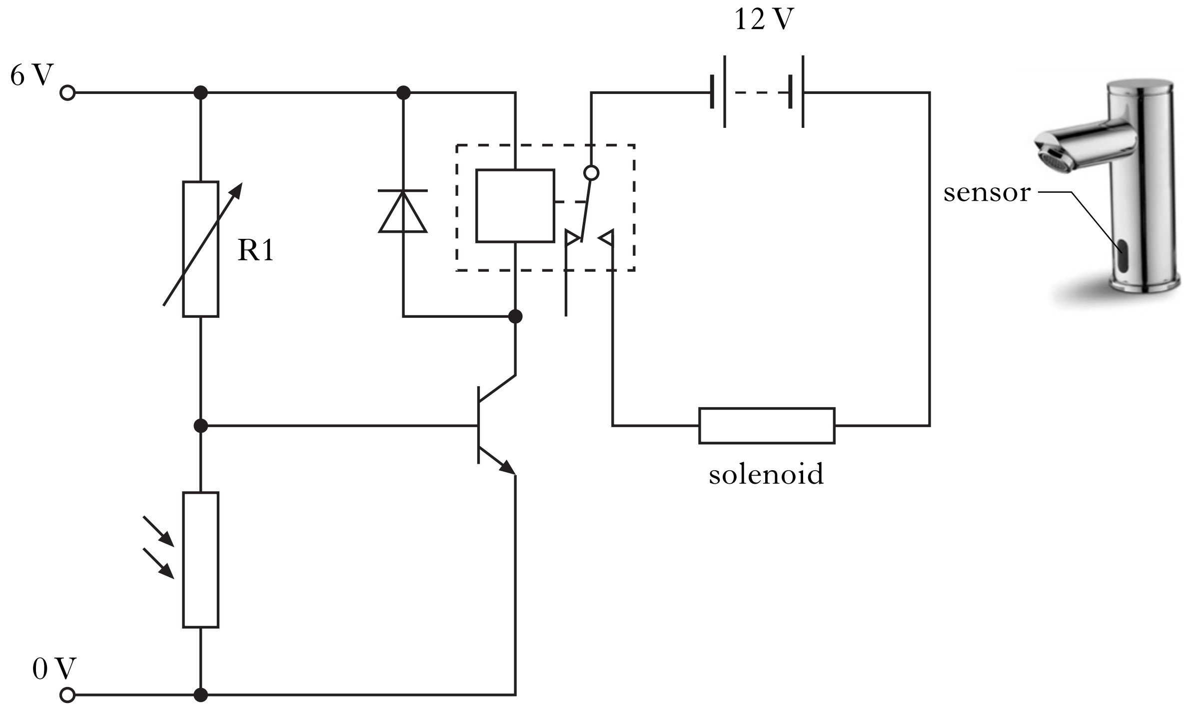


Figure Q5

(*a*) (i) Determine, with reference to the Data Booklet, the resistance of the LDR for a light level of 50 lux.

______________________________ **1**

(ii) State the function of the variable resistor in the circuit.

______________________________ **1**

(*b*) Calculate the resistance R1 that will produce a voltage drop of 0·7 V across the LDR at this light level.

3

(*c*) (i) State the type of relay used in the circuit.

______________________________ **1**

(ii) State the function of the relay in the circuit.

______________________________ **1**

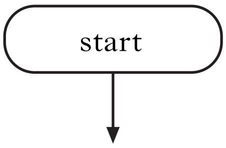
Marks

6. A dishwasher is programmed to follow the operation given below.

Is start switch pressed?

Wash cycle: Open water valve
After five minutes switch heater on
After five minutes switch heater off
Repeat wash cycle three times
Close water valve
End

Draw, with reference to the Data Booklet, the flowchart for the operation of the dishwasher.



7

(7)

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Marks

7. The belt drive system used in a chairlift is shown in Figure Q7.

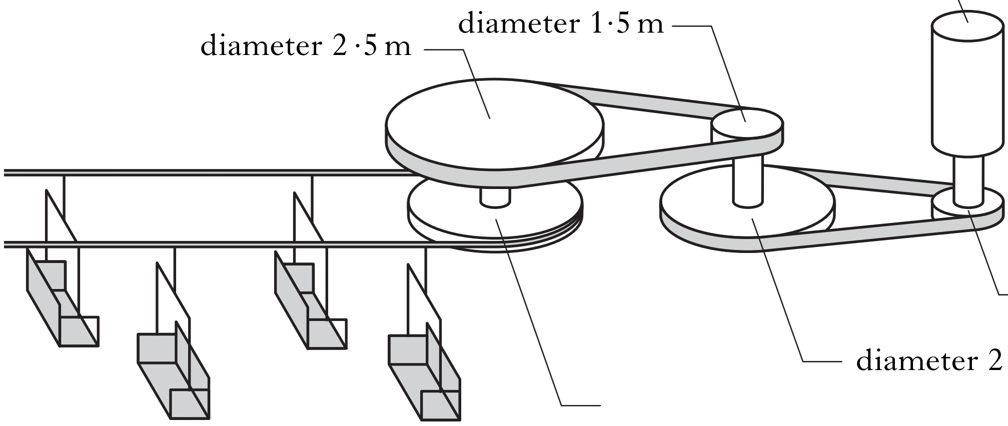

Figure Q7

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

(i) the total velocity ratio for the drive system; **3**

(ii) the rotational speed of the chairlift pulley in rev/min when the motor speed is 30 rev/min. **2**

(*b*) Calculate the linear speed in **m/s** at which the chair will travel if the effective diameter of the chairlift pulley is 2·2 m. **3**

(*c*) State **one** method of altering the flat **belt** that would reduce slippage in the system. **1**

Marks

8. The design for a pneumatic door is shown in Figure Q8.

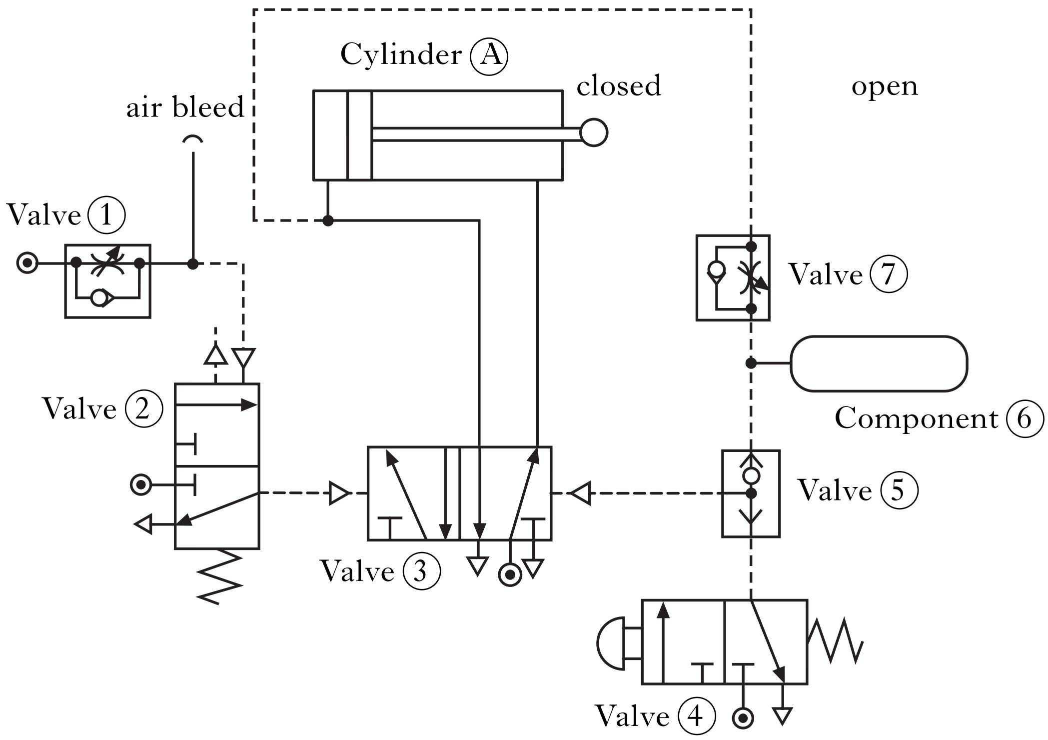

Figure Q8

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

When the air bleed is covered, ______________________

____

____

____

______________________ **4**

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

(i) Valve 2 ______________________

(ii) Valve 5 ______________________ **2**

(*c*) State the function of valve 7 and component 6 in the circuit.

______________________ **1**

(7)

[*END OF SECTION A*]

[Turn over

SECTION B

Attempt any TWO questions (Total 40 marks)

Marks

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9. A buggy has been developed to transport goods. A sub-system diagram for the buggy is shown in Figure Q9(*a*).

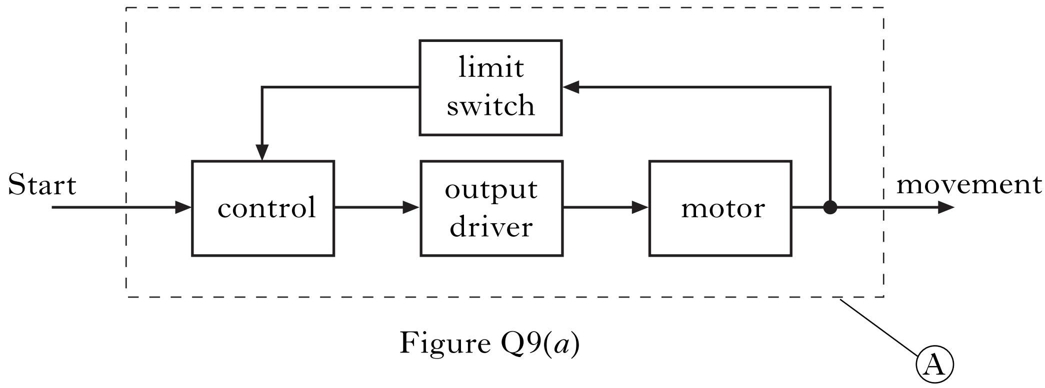


Figure Q9(*a*)

(*a*) With reference to Figure Q9(*a*):

(i) state the name of the type of control shown;

____________________________ **1**

(ii) state the name of box A ;

____________________________ **1**

(iii) explain the purpose of the limit switch on the buggy.

____

____________________________ **1**

9. (continued)

An electrical circuit has been developed to allow the buggy to move in a forward or reverse direction.

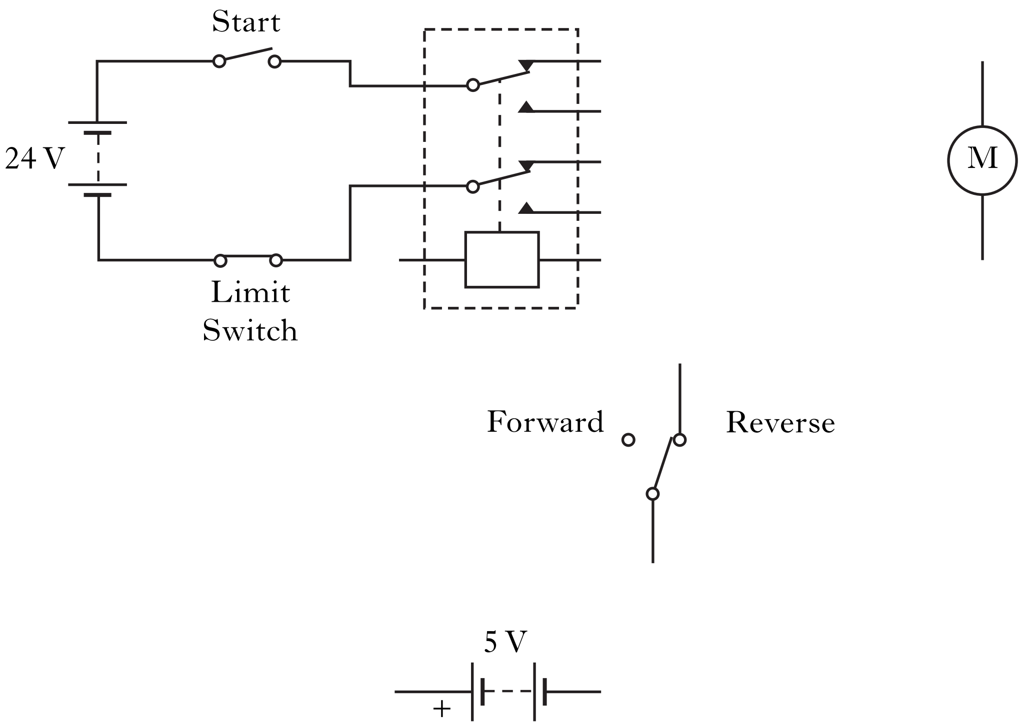


Figure Q9(*b*)

(*b*) Complete the electrical circuit in Figure Q9(*b*) to allow the buggy motor to **reverse**. **4**

The 24 V circuit uses one normally open and one normally closed switch.

(*c*) Explain the difference between a normally open and a normally closed switch.

____

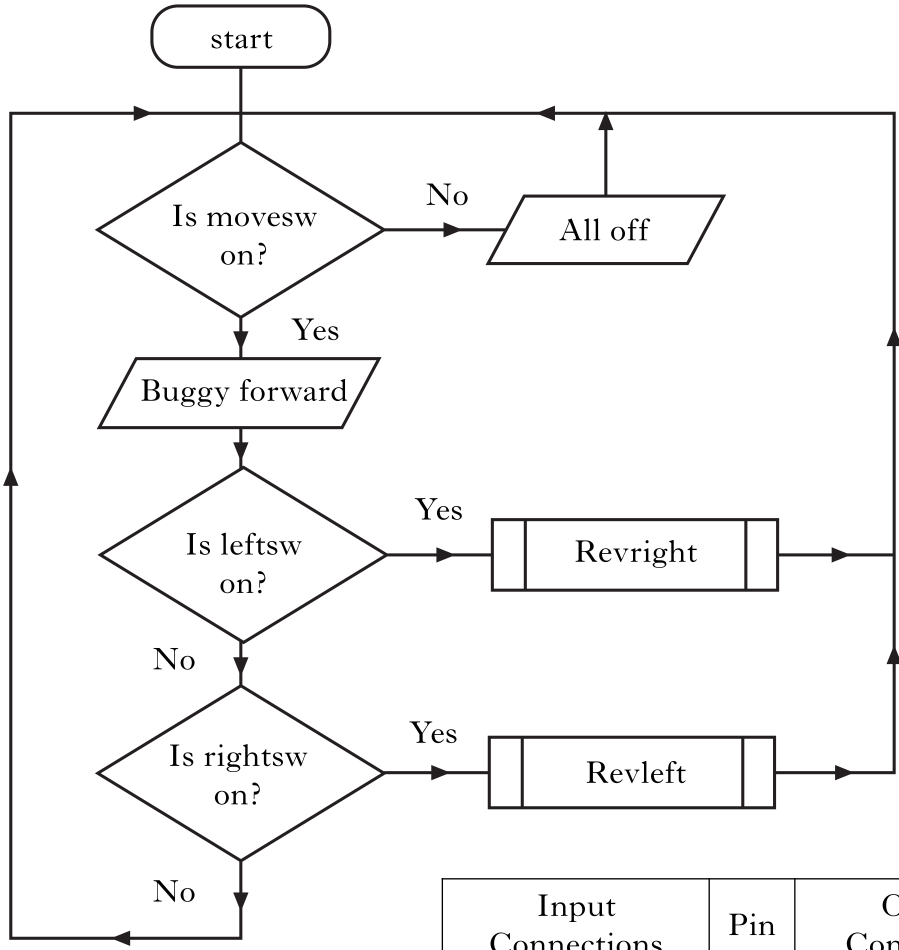
____

____ **2**

[Turn over

9. (continued)

A second buggy is operated by a microcontroller. The flowchart for the operation of the buggy and the input and output connections are shown in Figure Q9(*c*).



Input Connections	Pin	Output Connections
	7	Motor 1 forward
	6	Motor 1 reverse
	5	Motor 2 forward
	4	Motor 2 reverse
	3	
rightsw	2	
leftsw	1	
movesw	0	

Figure Q9(*c*)

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Marks

9. (continued)

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

(*d*) Complete, with reference to the flowchart and the input/output connections, the missing PBASIC program commands.

init:	____________________	*'set up DDR (7 – 4 outputs 3 – 0 inputs)*
main:	____________________	*'test move switch*
	____________________	*'switch all outputs off*
	goto main	*'loop to main*
fwd:	let pins=%10100000	*'buggy forward*
	if pin1=1 then revr	*'test leftsw*
	____________________	*'test rightsw*
	goto main	*'loop to main*
revr:	gosub revright	*'jump to sub-procedure revright*
	goto main	*'loop to main*
revl:	____________________	*'jump to sub-procedure revleft*
	goto main	*'loop to main*

5

[Turn over

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Marks

9. (continued)

The program listing for the sub-procedure ‘revright’ is listed below.

```
revright:      let pins = %01010000
               pause 3000
               let pins = %10000000
               pause 5000
               return
```

(*e*) Draw the flowchart for the ‘revright’ sub-procedure. **5**

(*f*) State the function of a ‘bus’ in a microcontroller.

____

____ **1**

(20)

10. A pneumatic system is used to raise and lower an examination table in an animal hospital. The logic circuit used for the control of the pneumatic system is shown in Figure Q10(*a*).

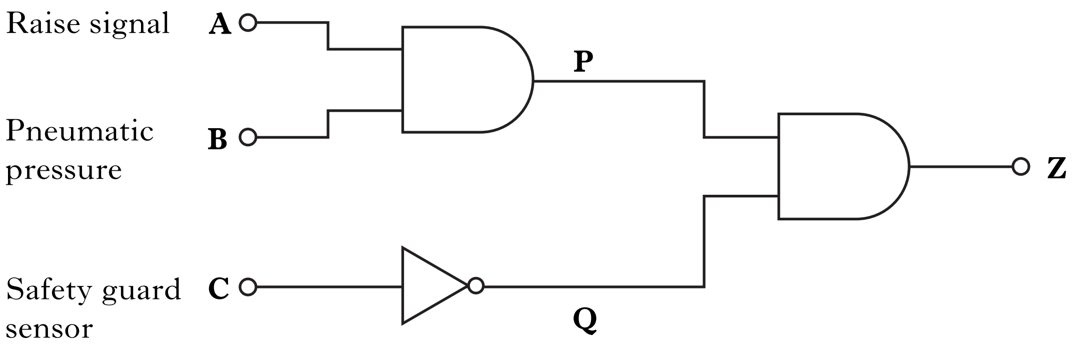

Figure Q10(*a*)

(*a*) With reference to the logic circuit shown in Figure Q10(*a*):

(i) write a Boolean expression for the lifting system output (Z), in terms of inputs A, B, C;

Z = **2**

(ii) complete the truth table for the logic circuit;

A	B	C	P	Q	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

(iii) state, with reference to the Data Booklet, the **full** name of the two ICs required to construct the logic circuit.

IC1: 7408 ____________________________________

IC2: 7404 ____________________________________ **2**

[Turn over

10. (continued)

(*b*) Complete, with reference to the Data Booklet, the wiring diagram Figure Q10(*b*) for the logic circuit shown in Figure Q10(*a*). **4**

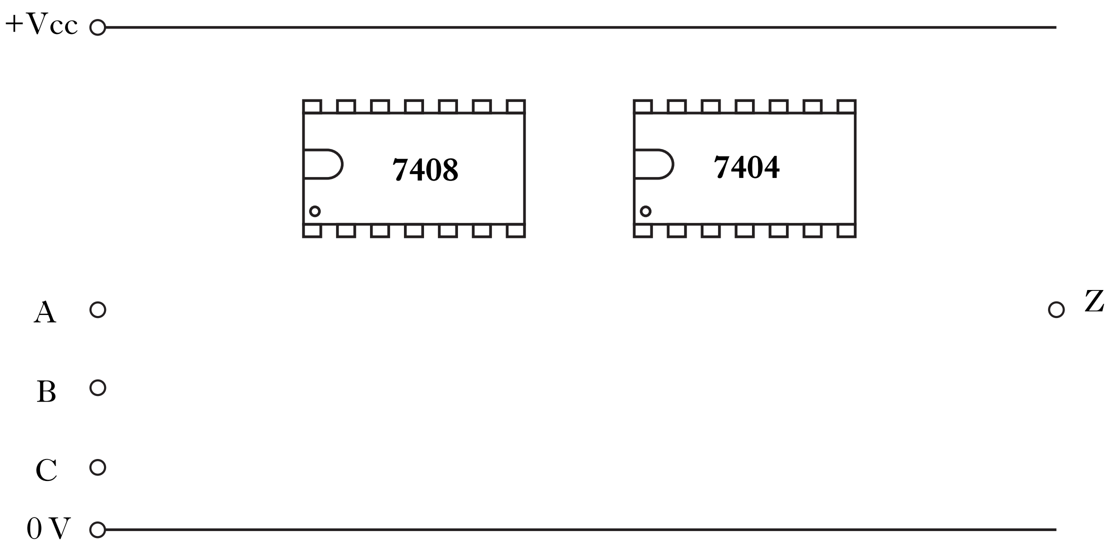

Figure Q10(*b*)

A double acting cylinder, as shown in Figure Q10(*c*), is used to raise and lower the table.

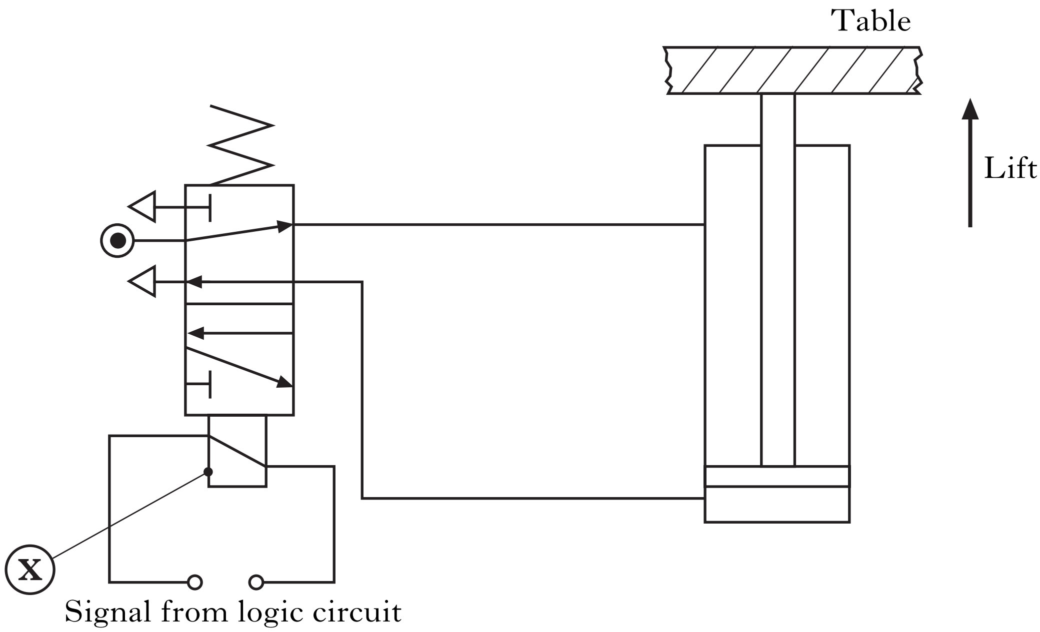

Figure Q10(*c*)

Marks

10. (continued)

(*c*) (i) State the **full** name of the pneumatic valve used to control the operation of the double acting cylinder. **1**

(ii) Explain the reason for the choice of actuator **X** for the valve in this system. **1**

(*d*) Draw, on Figure Q10(*c*), the symbol for the pneumatic component that will allow the piston to **instroke slowly**. **3**

(*e*) Calculate the **diameter** of the piston required to lift a 500 N load, if air is supplied at a pressure of 0·5 N/mm^2. (Ignore the weight of the table.) **4**

(20)

[Turn over

Marks

11. The maximum drop on a roller coaster is 50 m as shown in Figure Q11(*a*).

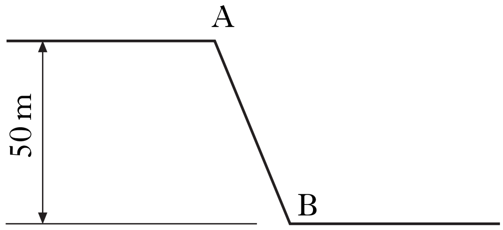

Figure Q11(*a*)

A carriage of mass 150 kg holding four passengers with an average mass of 75 kg is raised to position A on the roller coaster.

(*a*) Calculate, for a **full** carriage:

(i) the potential energy at position A; **3**

(ii) the maximum velocity at position B. (Apply the law of conservation energy and assume no energy losses.) **4**

Marks

11. (continued)

Not all of the potential energy of the full carriage is converted to kinetic energy at position B.

(*b*) (i) State one form of energy loss.

____ **1**

(ii) State a cause for this energy loss.

____

____ **1**

(iii) Suggest a method of reducing this energy loss.

____

____ **1**

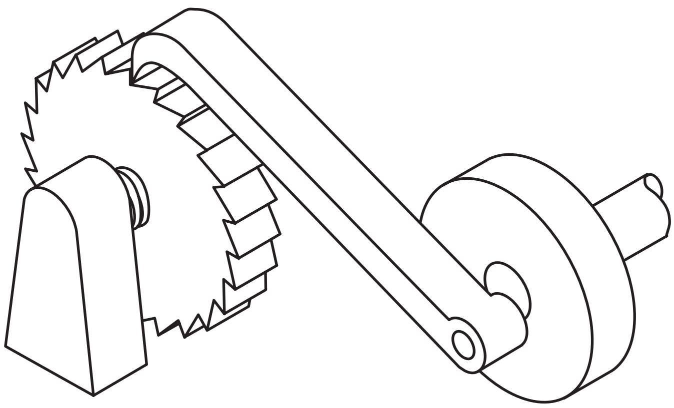

Figure Q11(*b*)

The mechanism shown in Figure Q11(*b*) was used to help raise the carriage safely to position A.

(*c*) (i) State the name of the mechanism shown in Figure Q11(*b*).

____ **2**

(ii) Indicate, on Figure Q11(*b*), the direction of free rotation of the mechanism. **1**

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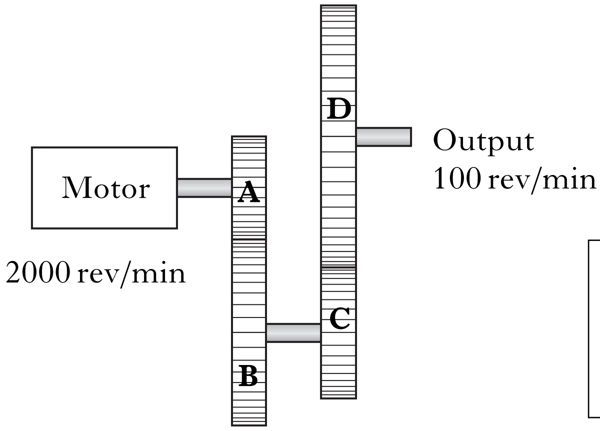
11. (continued)

Marks

A motor is used to raise the carriage to position A using the drive mechanism shown in Figure Q11(*c*).



Gear A – 10 teeth
Gear B – 40 teeth
Gear C – 15 teeth
Gear D – ?

Figure Q11(*c*)

(*d*) If the output speed is 100 rev/min, calculate:

(i) the velocity ratio for the drive mechanism; **2**

(ii) the number of teeth on gear D. **3**

(*e*) Gear D is replaced with a smaller gear with fewer teeth. Describe how this gear affects:

(i) the output speed;

______

______ **1**

(ii) the output torque.

______

______ **1**

(20)

[*END OF QUESTION PAPER*]

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