



General Certificate of Secondary Education

Design and Technology (Systems and Control Technology) 3546

Higher Tier

Mark Scheme

2007 examination – June series

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(3546) Higher

Section A

1 This question is about an automated train carriage door.

The door opens and closes using wheels on tracks at the top and bottom of the doorway.

(a)

(i) Give one reason why the train door is made from aluminium.

Suitable reason, e.g. lightweight/Easy to form (1 mark)

(ii) Give one reason why the door wheels are made from steel.

Suitable reason, e.g. hardwearing. (1 mark)

(iii) Suggest a suitable material for the door track.

Suitable material, e.g. Steel, brass, stainless steel, nylon
No – Metal, Plastic, Wood (1 mark)

(3 marks)

(b) The simplified diagram shows a sliding train carriage door. It is in the open position.

Design a suitable system that will open and close the carriage door.

Your design must show

A suitable mounting system to close and open the door

Suitable mounting of the system to the beam

Suitable mounting of the system to the door

A suitable power source

Labelled components and mountings.

A system capable of opening and closing the door (3 marks)

A system capable of moving the door (2 marks)

An attempt at a system (1 mark)

(3 Marks)

Suitable mounting of system to the fixed beam (1 mark)

Suitable mounting of system to the door (1 mark)

Correctly labelled components and mountings. (2 marks)

(7 marks)

(c) Describe how the system you have drawn in Space A operates.

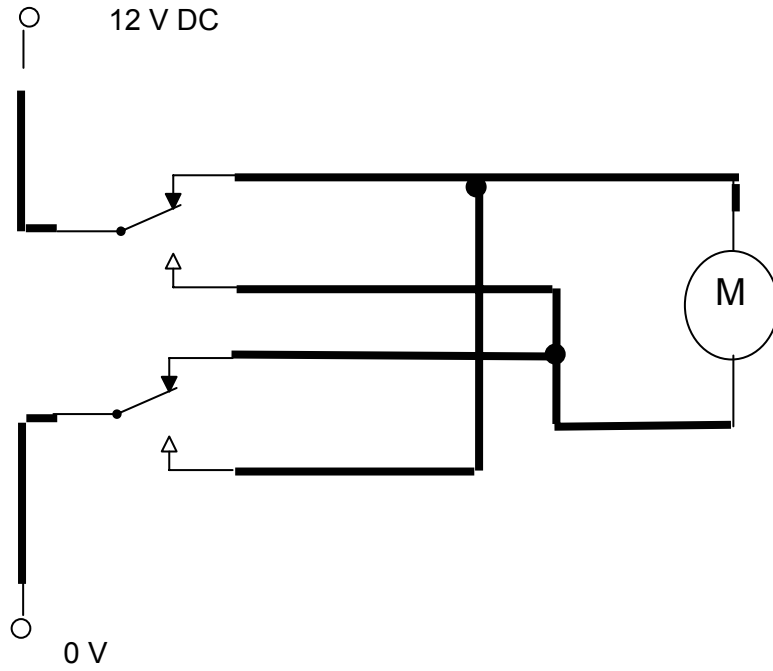
A clear description of the operation (2 marks)

An attempt at a description mentioning a component (1 mark)

e.g. The motor rotates the crank which makes the connecting rod open the door.

(2 marks)

- (d)
- (i) **Give two reasons for your choice of system.**
Reason 1 – e.g. reference to - reliable, strength, function (1 mark)
Reason 2 – e.g. it moved the door both ways (1 mark) **(2 marks)**
- (ii) **Name a specific component that could be used to sense that the door has hit an obstruction.**
A suitable component, e.g. push switch, LDR (2 marks)
An attempt, e.g. switch, light / dark sensor (1 mark) **(2 marks)**
- (iii) **Give two other Health and Safety issues that should be considered when designing the door system.**
Issue 1 e.g. should not open when moving (1 mark)
Issue 2 e.g. moving parts covered (1 mark) **(2 marks)**
- (e) **In use it was found that the door opened and closed too quickly.
What could be added to your system to slow down the movement of the door?**
A suitable qualified response e.g. gearbox, restrictor, resistor (2 marks)
An attempt, single word answer (1 mark) **(2 marks)**
- (f) **A Double Pole Double Throw (DPDT) switch can be used to control the forward and reverse direction of a motor.
Complete the diagram below to show a reversing circuit.
Marks will be awarded for
power supply connected to switch (2 marks)
switch connected to the motor (4 marks)**



One mark for each correct connection.
Accept other solutions.

(6 marks)

26 marks

2 This is a question about using logic gates to control a train door.

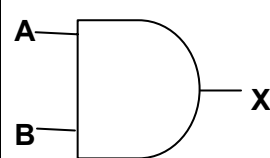
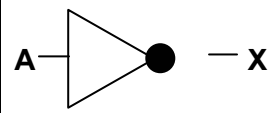
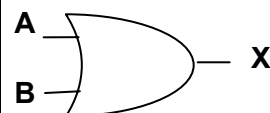
(a)

(i) Complete the following table by naming the logic gates shown.

(ii) Complete the truth tables for the three logic gates.

HIGH = 1

LOW = 0

Logic Gate symbol	Name of Logic Gate	Truth Table															
	<p style="text-align: center;">AND</p> <p style="text-align: right;">(1 mark)</p>	<table style="margin-left: auto; margin-right: auto;"> <tr> <td>A</td> <td>B</td> <td>X</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>0</td> </tr> <tr> <td>1</td> <td>0</td> <td>0</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </table> <p style="text-align: right;">(3 marks)</p>	A	B	X	0	0	0	0	1	0	1	0	0	1	1	1
A	B	X															
0	0	0															
0	1	0															
1	0	0															
1	1	1															
 <p style="text-align: right;">(1 mark)</p>	<p style="text-align: center;">NOT</p>	<table style="margin-left: auto; margin-right: auto;"> <tr> <td>A</td> <td>X</td> </tr> <tr> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> </tr> </table> <p style="text-align: right;">(1 mark)</p>	A	X	0	1	1	0									
A	X																
0	1																
1	0																
 <p style="text-align: right;">(1 mark)</p>	<p style="text-align: center;">OR</p> <p style="text-align: right;">(1 mark)</p>	<table style="margin-left: auto; margin-right: auto;"> <tr> <td>A</td> <td>B</td> <td>X</td> </tr> <tr> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>1</td> <td>1</td> <td>1</td> </tr> </table> <p style="text-align: right;">(2 marks)</p>	A	B	X	0	0	0	0	1	1	1	0	1	1	1	1
A	B	X															
0	0	0															
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1	1	1															

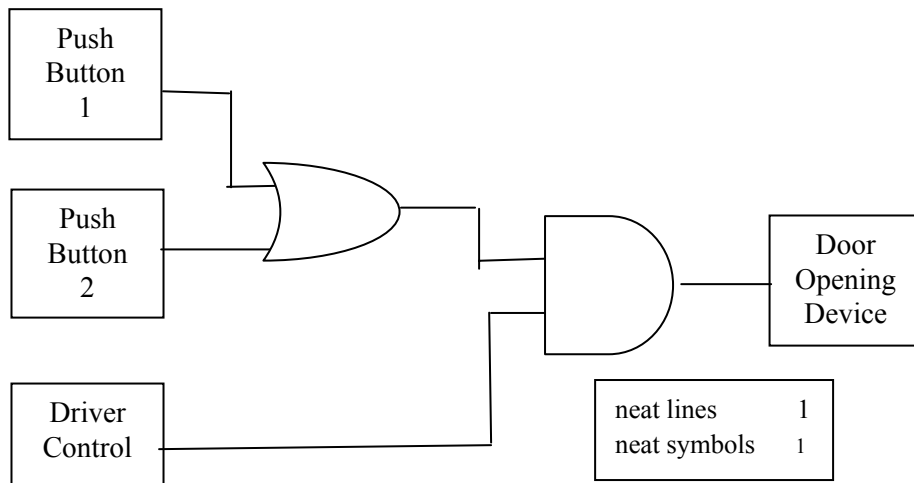
(10 marks)

- (b) It has been decided to operate the train door using push button switches.
 Three push button switches operate this system (inside/outside/driver control).
 The door is opened by passengers pressing a push button switch next to the door.
 The door opening device operates and the door opens.
 The door should open when Push button switch 1 or push button switch 2 is pressed and the driver operates a control.

Input	State	Output
Push Button Switch	Button pressed by user	1
	Button not pressed	0
Driver Control	Safe to open door	1
	Not safe to open door	0

Marks will be awarded for

- Logic gate symbols (2 marks)
 Inputs to gates (4 marks)
 Output to door (1 mark)
 neatness (2 marks)



(9 marks)

19 marks

3

This question is about constructing a flowchart to control the train door.

The signal from the driver ensures that the doors can only open when it is safe.

The passenger sensor on the edge of the doors signals if it hits an obstruction.

Marks will be awarded for

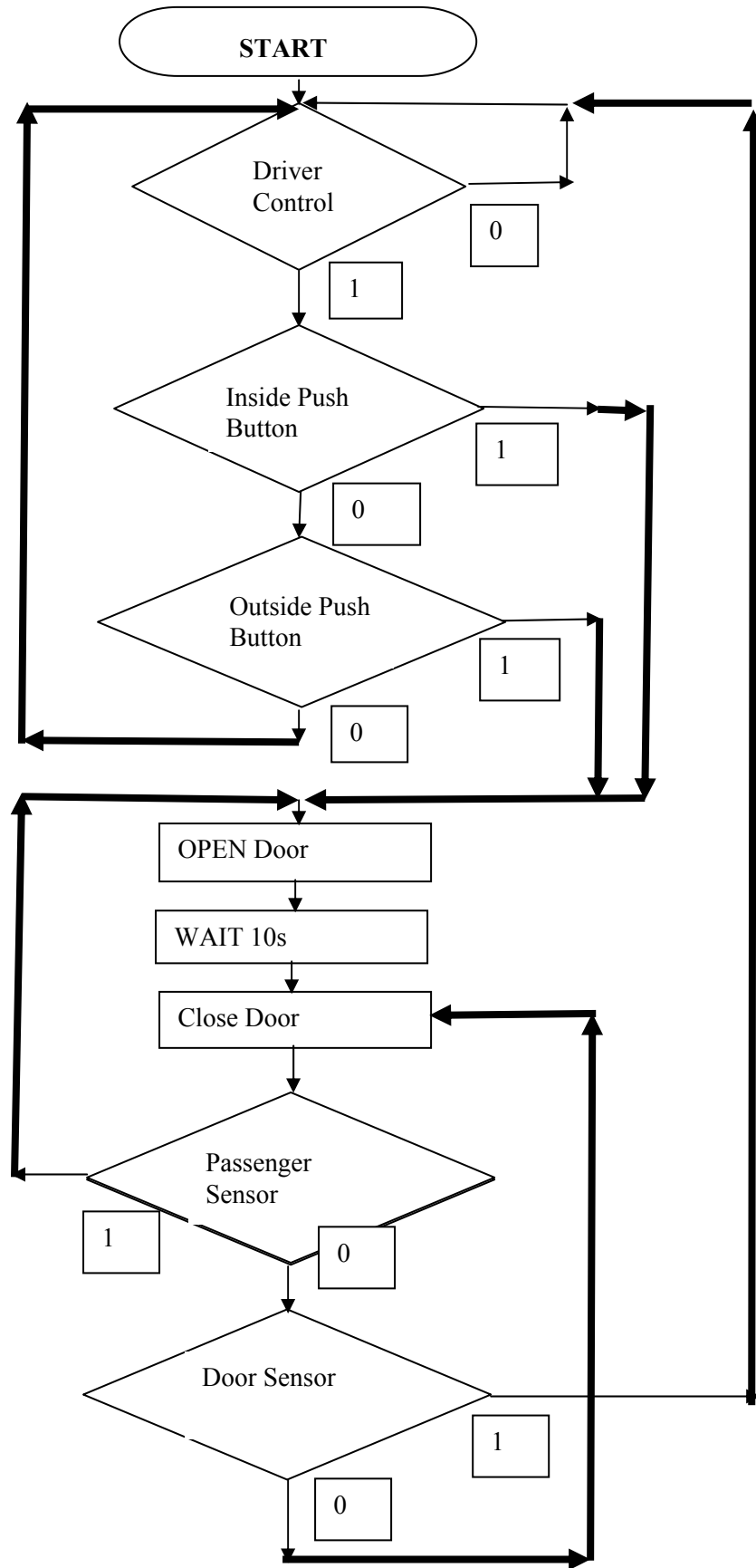
- **each correct output state of the decision boxes**
(4x2 marks)
- **each correct connecting line drawn with arrows.**
(6x1 marks)

1 = YES

0 = MP

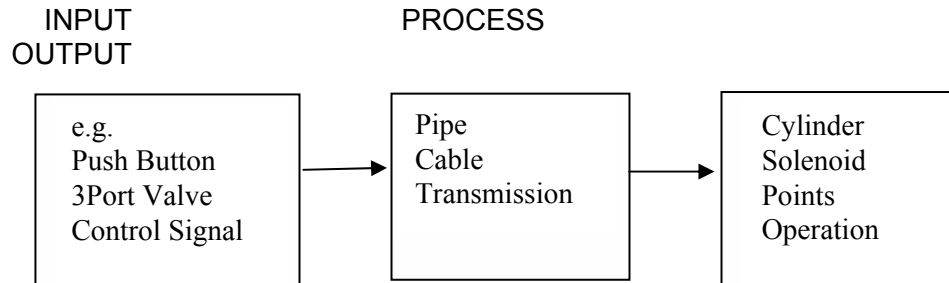
QUESTION 3 CONTINUES ON NEXT PAGE

3



14 Marks

- 4** This question is about a system for remotely changing the points on an outdoor model railway.
- (a)** Draw a system block diagram to operate the point from 10 meters away.



Allow Push button operated, 1 mark for each correct box
 3 P.V. S.A. Cylinder (3 marks)

- (b)** Explain how your system would operate the points from 10 meters away. (2 marks)
 A well explained system able to operate the device from 10m. 2 marks
 A suitable system able to operate the device 1 mark
 (max 2 marks) (2 marks)

- (c)** In the box below draw your system OUTPUT from part (a) that will operate the points by moving the link 10mm. The following marks will be awarded (3 marks)
 A suitable system able to operate the points (3 marks)
 A suitable method of mounting your device to the base (1 mark)
 A suitable power source (1 mark)
 Suitable system drawn 3 marks
 e.g. Solenoid, Cylinder, Rack and Pinion
 System able to move point 2 marks
 An attempt at a recognisable system 1 mark
 (max 3 marks)
 Suitable mounting of device to base 1 mark
 Power supply mentioned 1 mark
 (5 marks)

- (d)** Draw your System INPUT from part (a) in the box below. Marks will be awarded as follows: (3 marks)
 A suitable INPUT device able to operate the points (3 marks)
 A suitable mounting of the device to the base. (1 mark)
 A well explained device able to operate the points 3 marks
 e.g. Push switch, Lever, 3 port valve
 A suitable device able to operate the device 2 marks (max 3 marks)
 An attempt at a system 1 mark
 A suitable mounting of the system to base 1 mark
 (4 marks)

(e) Using notes and sketches explain how a sensor could be used to sense the train at a certain location on the track.

Marks will be awarded as follows:

A suitable sensor able to sense the train (3 marks)

A suitable method of mounting the sensor to the track. (2 marks)

Well detailed system e.g. reed switch / LDRs / Air Bleed 3 marks

A suitable system capable of working 2 marks

An attempt at describing a system 1 mark

(Max 3 marks)

A suitable method of mounting the system to the track 2 marks

An attempt at mounting to track 1 mark

**(marks)
19 marks**

5 This question is about design issues for railway systems.

(a)

(i) What advantage would an automatic door system on a train give the passengers?

A suitable advantage, e.g. easier to open (1 mark)

(ii) Give two reasons for your answer.

Two suitable reasons, e.g.
can open when carrying shopping as hands are full
disabled people may not be able to open a manual door (2 marks)

(b)

(i) What advantage would an automatic train door system on a train give the train company?

A suitable advantage, e.g. better image as more modern/trains
leave on time/safer – all doors controlled (1 mark)

(ii) Give two reasons for your answer.

2 suitable reasons, e.g.
perceived as more modern/luxury
trains leave on time/safer – as all doors controlled (2 marks)

(c) Suggest how passengers could escape from the train if the automatic door system fails.

Full description or list 3 methods, e.g.
Emergency exits / well signed exits / break glass hammers/floor
lights etc help to get out. In case of impact, all doors open
automatically (3 marks)

(d) State two maintenance requirements of the automatic train door system.

Two requirements given, e.g. adjustment, lubrication / electrical /
mechanical checks (2 marks)

(e) Give two reasons why electric trams are more environmentally friendly than most cars.

Two reasoned arguments, e.g. less energy, less pollution, less congestion, quieter. (2 marks)

(f) A local council wants to encourage car drivers to use trains or trams.

Suggest two ways that they could do this.

Two suggestions e.g. subsidise fares, congestion charge, pedestrian areas accept any reasonable answer. (2 marks)

15 marks

6 This question is about a box sorting system.

Design a system to sort the boxes.

Boxes that are higher than 400mm should carry along conveyor belt 1.

Boxes that are lower than 400mm should be sent along conveyor belt 2.

Marks will be awarded as follows:

The method of sensing the height of a box (5 marks)

The method of sending the lower boxes along conveyor belt 2 (5 marks)

Use of notes and sketches to explain your designs on the drawing (2 marks)

The method of sensing height of box.

Indicate position of sensor	1 mark
Shows LDR / switch	1 mark
Shows Light source / Switch lever	1 mark
Dimensions shown of sensor	1 mark
Method of mounting shown	1 mark

(5 marks)

The method sending the short boxes along the conveyor

Method of mounting shown	1 mark
Power Supply / Prime mover e.g. Motor, Cylinder	1 mark
Limit to travel	1 mark
Ability to divert box	1 mark
Explanation of control by sensor	1 mark

(5 marks)

Well Labelled and Comments 2 marks

Some labels 1 mark

(max 2 marks)

(2 marks)

12 marks

Section B

- 7 This question is about mechanisms and mechanical components.**
The chain and sprocket shown is part of a drive system for a cooling fan in a tram.
The smaller sprocket is connected to an electric motor and the larger sprocket is connected to the fan.
The motor spins at 10 000 revolutions per minute (rpm).
- (a) Calculate the speed of the fan.**
- Formula –
 Output speed = $\frac{\text{Input Speed}}{\text{Gear/Velocity Ratio}}$ 1 mark
- Calculation $\frac{10\ 000}{2}$ 1 mark
- Answer with units = 5 000 rpm 1 +1 mark **(4 marks)**
- (b) Discuss the use of chain drives compared with other drive systems.**
 Gears, Vee Belt, Toothed belt etc
 e.g.
 it does not slip 1 mark
 it needs adjustment or an idler/jockey sprocket 1 mark
 it requires lubrication 1 mark
 Chain and sprocket is made from steel, durable 1 mark **(4 marks)**
- (c) This part of the question is about a hand brake for a railway truck.**
- (i) Draw a mechanical device between the fixed beam and the Brake shoe that will allow the driver to manually apply the Brake shoe to the wheel. Marks will be awarded for**
Designing a mechanical device that will force the Brake shoe onto the wheel (4 marks)
Fixing the device to the Fixed beam and the Brake shoe (2 marks)
Quality of notes and sketches. (2 marks)
- A system that will prevent the truck moving when let go. 1 mark
 A system that can apply sufficient force 1 mark
 A system that will move the brake to the wheel 1 mark
 A recognisable system 1 mark
 (max 4 marks) **(4 marks)**
- A well designed fixing of the device to the beam 1 mark
 A well designed fixing of the device to the shoe 1 mark
 (max 2 marks) **(2 marks)**
- High quality notes 1 mark
 High quality sketches 1 mark
 (max 2 marks) **(2 marks)**
- Other solutions to be awarded on merit **(8 marks)**

- (ii) **State two advantages of your mechanism shown above this application.**
 2 advantages, e.g.
 Brake holds if operator lets go of crank,
 good mechanical advantage 2 marks **(2 marks)**
- (iii) **Explain how your response to part (c) (i) could be modified to make it easier for the user to apply the hand brake.**
 Suitable solution, e.g. longer crank/finer pitched thread.
 Full answer 2 marks
 An attempt 1 mark **(2 marks)**
- 20 marks**

- 8** **This question is about pneumatic components and circuits.**
- (a) **Air going into a cylinder is at a pressure of 2N/mm² and the area of the piston is 50mm².
 What force does the cylinder exert?
 Give units where applicable.**
- | | | | |
|-------------------|-------------------------|------------|------------------|
| Formula | Force = Pressure x Area | 1 mark | |
| Calculation | Force = 2 x 50 | 1 mark | |
| Answer with units | Force = 100 N | 1 +1 marks | (4 marks) |
- (b) **Discuss the use of electrically operated valves compared with manually operated valves.**
- | | | |
|---|--------|------------------|
| e.g. manually operated valves are simpler | 1 mark | |
| e.g. electrically operated valves can be controlled by PIC/or computer controlled | 1 mark | |
| e.g. electrically operated valves can be operated remotely | 1 mark | |
| e.g. manual valves are cheaper | 1 mark | (4 marks) |
- (c) **This part of the question is about a pneumatic brake for a railway truck.**
- (i) **Draw a pneumatic device between the fixed beam and the Brake shoe that will allow the driver to manually apply the Brake shoe to the wheel.
 Marks will be awarded for**
- | | |
|---|------------------|
| Designing a pneumatic device that will force the Brake shoe onto the wheel | (4 marks) |
| Fixing the device to the Fixed beam and the Brake shoe | (2 marks) |
| quality of notes and sketches | (2 marks) |
| A system that will prevent the truck moving when let go. | 1 mark |
| A system that can apply sufficient force | 1 mark |
| A system that will move the brake to the wheel | 1 mark |
| A recognisable system | 1 mark |
| | (max 4 marks) |
| A well designed fixing of the Device to the beam | 1 mark |
| A well designed fixing of the Device to the shoe | 1 mark |
| | (Max 2 marks) |

High quality notes 1 mark
High quality sketches 1 mark
(Max 2 marks)

Other solutions to be awarded on merit. **(8 marks)**

(ii) State two advantages of your pneumatic device shown above for this application.

2 Advantages, e.g. fail safe, can be operated remotely **(2 marks)**

(iii) Explain how your response to part (c) (i) could be modified to apply the brake if the air supply failed.

A suitable solution, e.g. spring holding brake on, air release.

Full answer 2 marks

An attempt at an answer 1 mark **(2 marks)**

(Max 2 marks)

20 marks