Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Secondary Education
June 2007

DESIGN AND TECHNOLOGY **3546/H**
(SYSTEMS AND CONTROL TECHNOLOGY)
Written Paper
Higher Tier

H

Wednesday 13 June 2007 1.30 pm to 3.30 pm

For this paper you must have:
- a pen, a pencil, a ruler, an eraser and a pencil sharpener.

Time allowed: 2 hours

Instructions

- Use blue or black ink or ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **seven** questions.
  Answer **all** the questions from Section A.
  Answer **one** question from Section B.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show the working of your calculations.

Information

- The maximum mark for this paper is 125.
- The marks for questions are shown in brackets.
- A list of formulae and other information, which you may wish to use in your answers, is provided on page 2.
- All dimensions are given in millimetres unless otherwise stated.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use			
Question	Mark	Question	Mark
1		5	
2		6	
3		7	
4		8	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

You may use the following information when answering the questions.

Pneumatics: $\text{Force} = \text{Pressure} \times \text{Area}$

Ratio of Simple Gears: $\text{Gear Ratio} = \dfrac{\text{Number of teeth on driven gear}}{\text{Number of teeth on driver gear}}$

Velocity Ratio: $\text{Velocity Ratio} = \dfrac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$

$\text{Output speed} = \dfrac{\text{Input speed}}{\text{Gear/Velocity ratio}}$

Forces: $\text{Moments} = \text{Force} \times \text{Distance}$

Sum of clockwise moments = sum of anti-clockwise moments

Series Resistance: $R_T = R_1 + R_2 + R_3$

Parallel Resistance: $\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$ OR $R_T = \dfrac{R_1 \times R_2}{R_1 + R_2}$

Potential Difference: $V = I \times R$

Transistors: $\text{Current Gain} = \dfrac{\text{Collector Current}}{\text{Base Current}}$

Amplifier Gain: $Av = \dfrac{\text{Change in output voltage}}{\text{Change in input voltage}}$

Area of circle = πr^2 $\quad \pi = 3.142$

Resistor Colour Code

Colour	Number	Number of Zeros
Black	0	
Brown	1	0
Red	2	00
Orange	3	000
Yellow	4	0,000
Green	5	00,000
Blue	6	000,000
Violet	7	0,000,000
Grey	8	00,000,000
White	9	000,000,000

E12 Resistor preferred values

10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and decades thereafter.

LEAVE MARGIN BLANK

Turn over for the first question

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SECTION A

Answer **all** questions in this section.

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.

.....

(1 mark)

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

.....

(1 mark)

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

.....

(1 mark)

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

In Space **A** on the simplified diagram, design a suitable system that will open and close the carriage door.
Draw and label all components and mountings.

Your design must show

- a suitable system to close and open the door *(3 marks)*
- suitable mounting of the system to the fixed beam *(1 mark)*
- suitable mounting of the system to the door *(1 mark)*
- labelled components and mountings. *(2 marks)*

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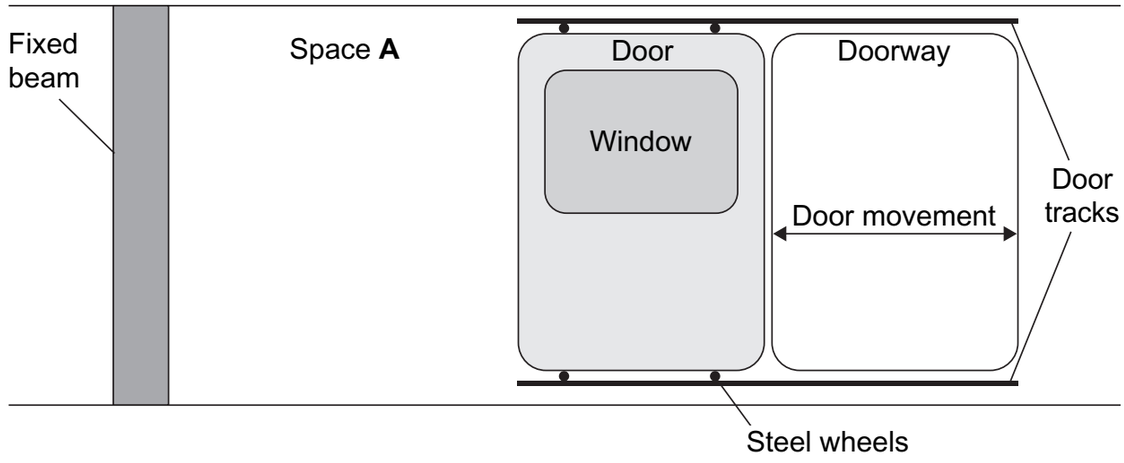
Train Carriage



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

.....

.....

.....

(2 marks)

(d) (i) Give **two** reasons for your choice of system.

Reason 1 .....

(1 mark)

Reason 2 .....

(1 mark)

(ii) Name a specific component that could be used to sense that the door has hit an obstruction.

.....

(2 marks)

(iii) Give **two** other Health and Safety issues that should be considered when designing the door system.

Issue 1 .....

Issue 2 .....

(2 marks)

Question 1 continues on the next page

(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?

.....

.....

.....

.....

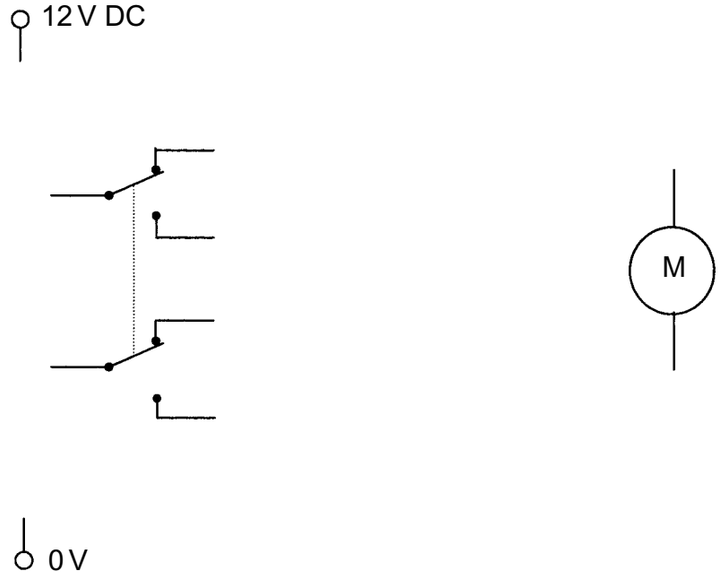
(2 marks)

(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)*



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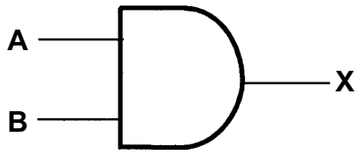
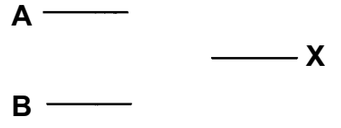
2 This question is about using logic gates to control a train door.

(a) (i) Complete the following by naming the logic gates shown and drawing the symbol where appropriate.

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

HIGH = 1

LOW = 0

Logic Gate Symbol	Name of Logic Gate	Truth Table
 *(1 mark)*	*(1 mark)*	**A** **B** **X** 0 0 0 0 1 1 0 1 1 *(3 marks)*
 *(1 mark)*	**NOT**	**A** **X** 0 1 1 *(1 mark)*
 *(1 mark)*	*(1 mark)*	**A** **B** **X** 0 0 0 1 1 0 1 1 1 1 *(2 marks)*

Question 2 continues on the next page

(b) It has been decided to operate the train door using push button switches.

In this system

- three push button switches operate the 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

Construct a logic circuit on the page opposite to open the door using **two** 2-input logic gates to complete the logic circuit.

Marks will be awarded for

- logic gate symbols *(2 marks)*
- inputs to gates *(4 marks)*
- output to door *(1 mark)*
- neatness. *(2 marks)*

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Turn over for the next question

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 door signals if it hits an obstruction.

The following inputs are available.

	Input	State
Inside Push Button	1	Button pressed by passenger
	0	Button not pressed
Outside Push Button	1	Button pressed by passenger
	0	Button not pressed
Driver Control	1	Safe for doors to open
	0	Not safe – doors stay closed
Passenger Sensor	1	A passenger is in the way
	0	No passenger in the way
Door Sensor	1	Door is closed
	0	Door is not closed

Draw a flowchart on the opposite page that

- waits until the signal from the driver that states that it is safe for the doors to open
- opens the doors when a passenger presses *either* push button
- waits 10 seconds then closes the door
- if the door hits an obstruction it should open and wait another 10 seconds before closing
- repeats the cycle.

Add the missing lines with arrowheads and the states to the decision box outputs of the flowchart on the opposite page.

Marks will be awarded for each

- correct output state of the decision boxes *(4 x 2 marks)*
- correct connecting line drawn with arrows. *(6 x 1 mark)*

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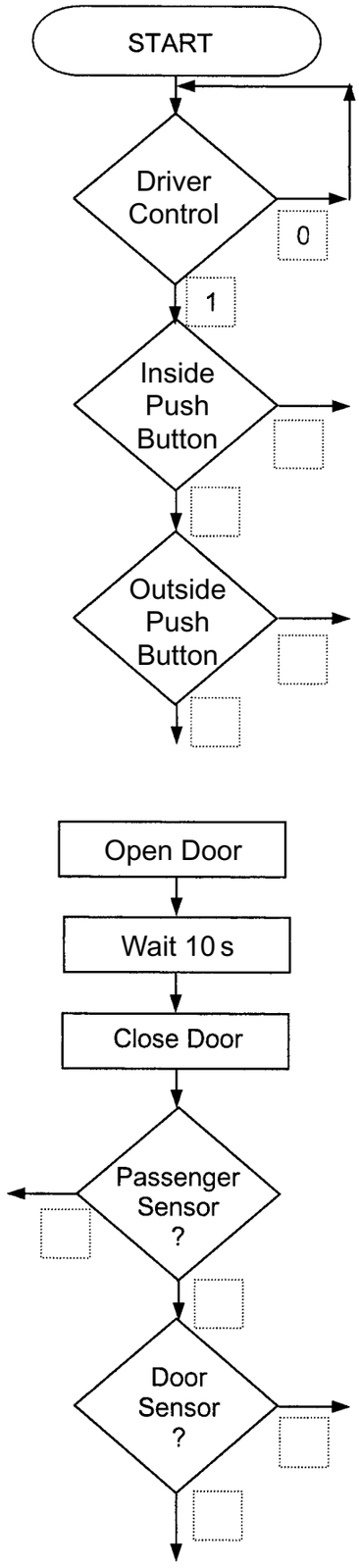
Note
- 1 = YES, 0 = NO



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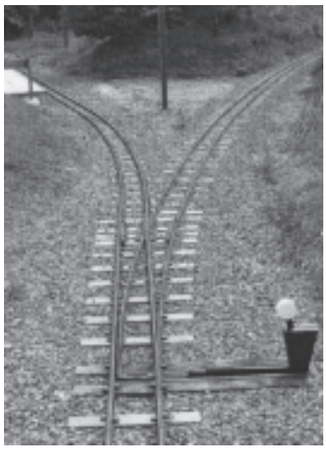
Turn over ►

4 This question is about a system for remotely changing the points on an outdoor model railway.

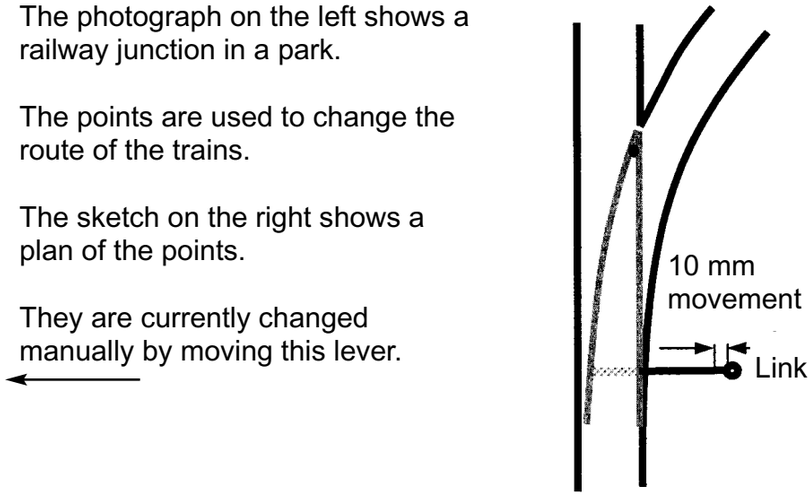


The photograph on the left shows a railway junction in a park.

The points are used to change the route of the trains.

The sketch on the right shows a plan of the points.

They are currently changed manually by moving this lever.



(a) Draw a system block diagram to operate the point from 10 metres away.

INPUT	PROCESS	OUTPUT

(3 marks)

(b) Explain how your system would operate the points from 10 metres away.

.....

.....

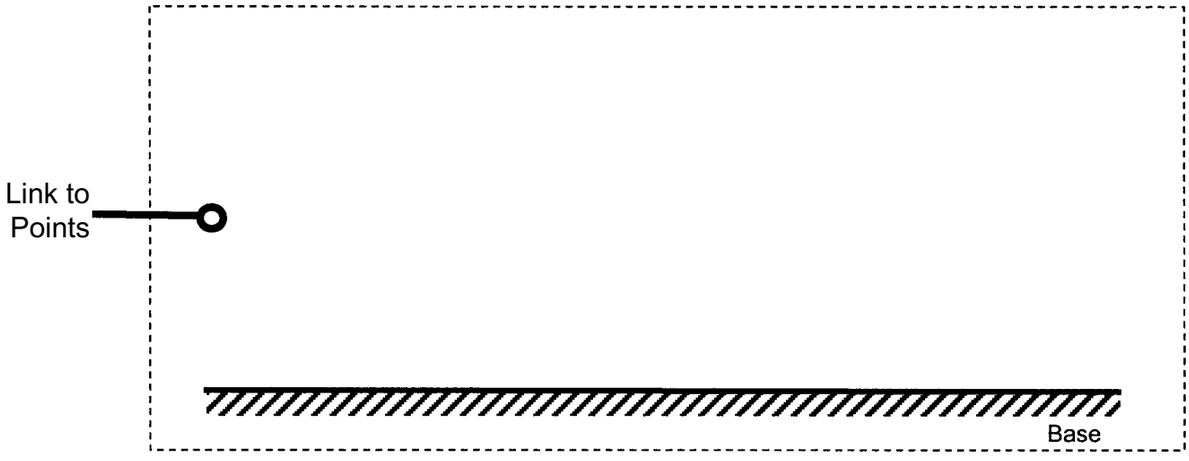
(2 marks)

(c) In the box below draw your system OUTPUT from part (a) that will operate the points by moving the link 10 mm.

Attach your system to the link shown in the box below.

Marks will be awarded as follows:

- 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)*

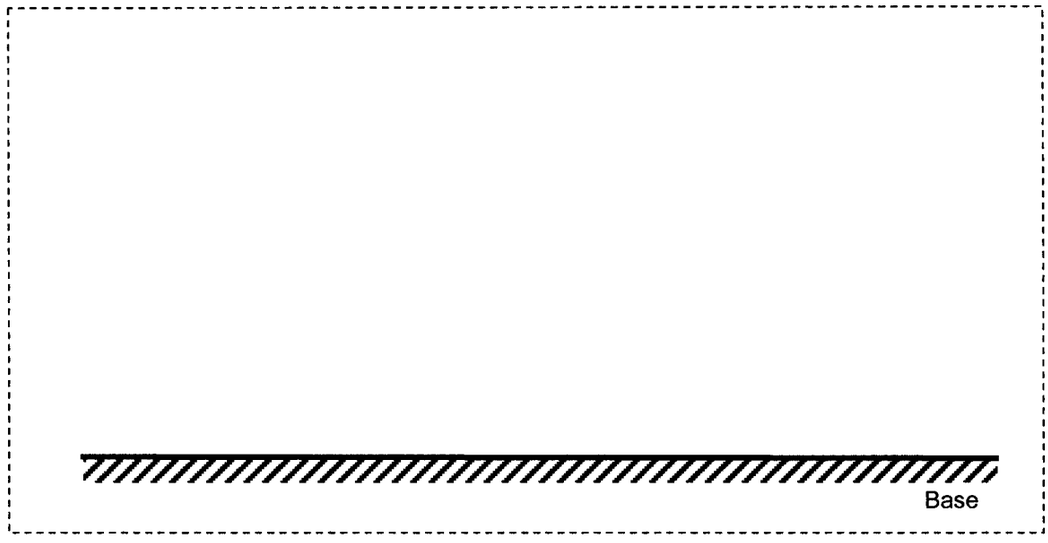


Question 4 continues on the next page

(d) Draw your system INPUT from part (a) in the box below.

Marks will be awarded as follows:

- a suitable INPUT device able to operate the points *(3 marks)*
- a suitable mounting of the device to the base. *(1 mark)*



(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)*

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*?

.....

(1 mark)

(ii) Give **two** reasons for your answer.

.....

.....

(2 marks)

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

.....

(1 mark)

(ii) Give **two** reasons for your answer.

.....

.....

(2 marks)

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

.....

.....

.....

(3 marks)

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

Requirement 1 .....

Requirement 2 .....

(2 marks)

Question 5 continues on the next page

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

Reason 1 .....

Reason 2 .....

(2 marks)

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

Suggest **two** ways that they could do this.

Suggestion 1 .....

Suggestion 2 .....

(2 marks)

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6 This question is about a box-sorting system.

An automated conveyor-belt system sorts boxes as they are unloaded from a train.

Design a system to sort the boxes.

- Boxes that are higher than 400 mm should carry on along conveyor belt 1.
- Boxes that are 400 mm or lower should be sent along conveyor belt 2.

Add your design to the existing drawing opposite.

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)*
- notes and sketches to explain your designs on the drawing below. *(2 marks)*

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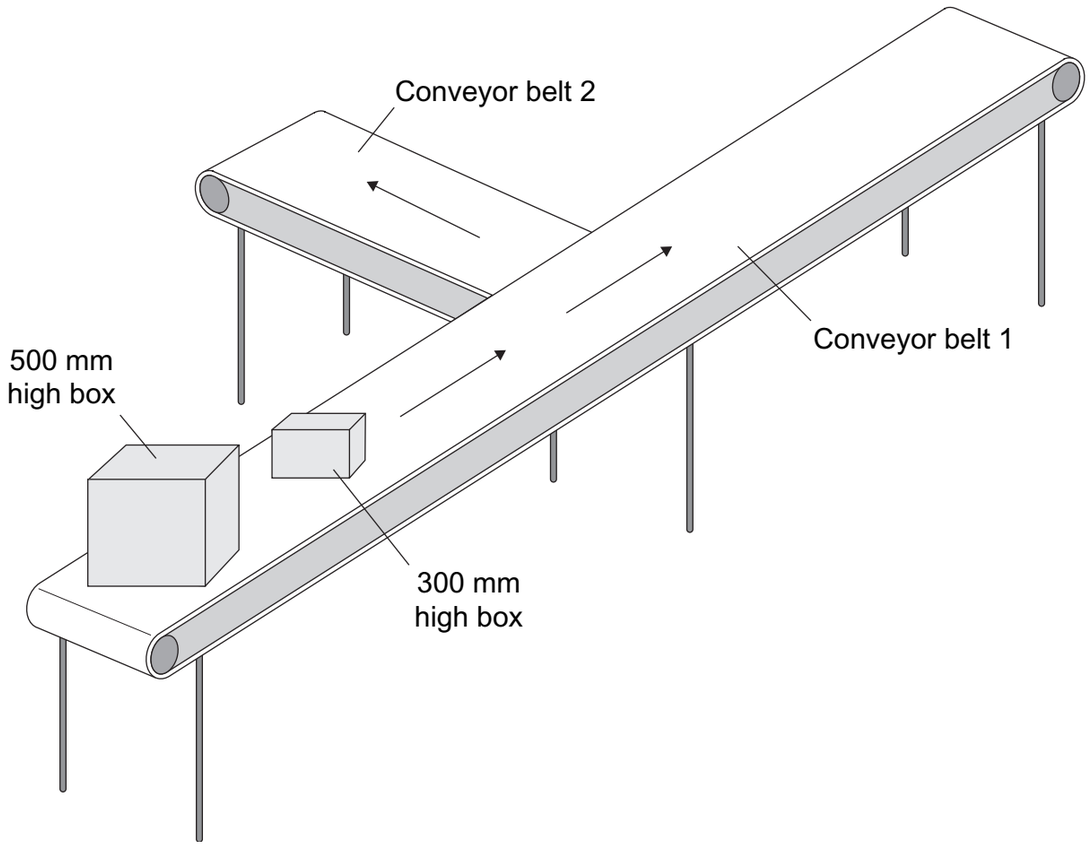

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END OF SECTION A QUESTIONS

Turn Over For Section B Questions

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SECTION B

Answer **either** Question 7 (below) about mechanisms

or Question 8 (page 21) about pneumatics.

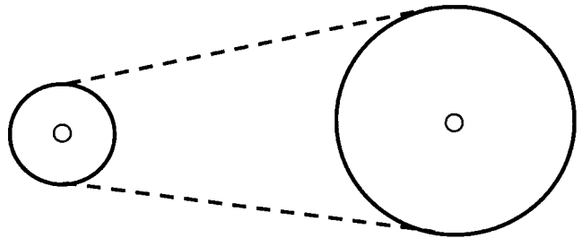
Do **not** answer both questions.

EITHER

7 This question is about mechanisms and mechanical components.

The chain and sprocket shown below 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.



16 teeth 32 teeth

The motor spins at 10 000 revolutions per minute (rpm).

(a) Calculate the speed of the fan.

Formula .....

Calculation .....

Answer with units .....

(4 marks)

(b) Discuss the use of chain drives compared with other drive systems.

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.....

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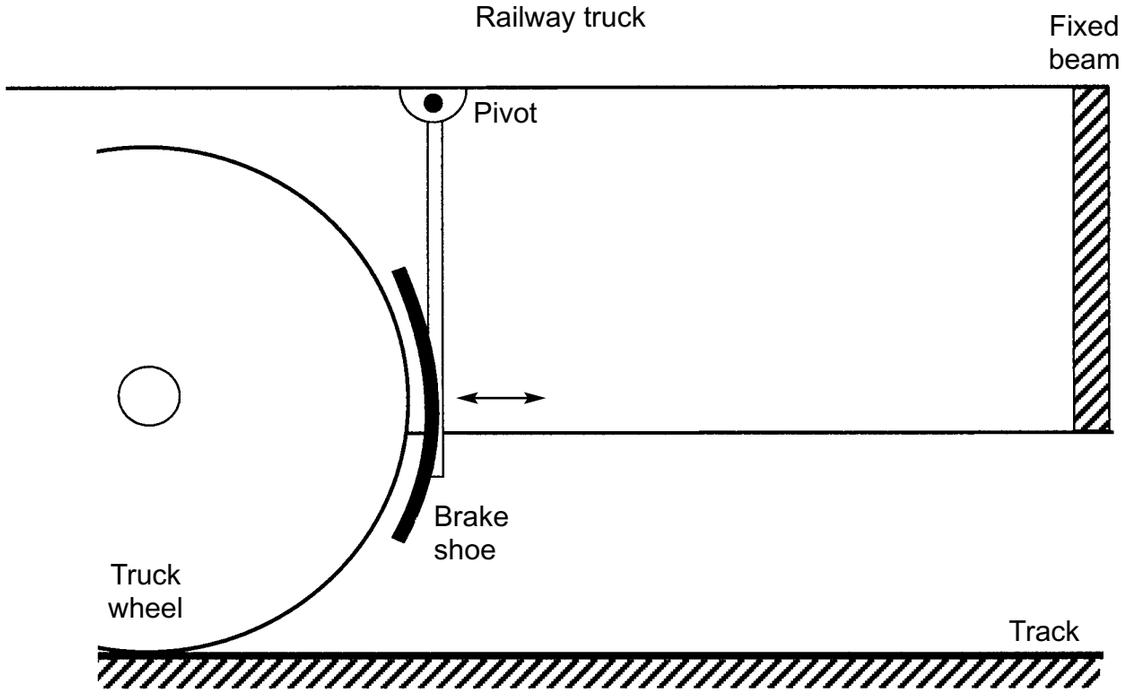
.....

.....

(4 marks)

(c) This part of the question is about a hand brake for a railway truck.

Part of the truck is drawn below.



(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.

Complete the diagram to ensure that

- your solution will prevent the truck moving when the user lets go of the operating handle
- all parts you add are labelled.

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)*

(ii) State **two** advantages of your mechanism shown above for this application.

1 .....

2 .....

(2 marks)

Question 7 continues on the next page

LEAVE MARGIN BLANK

(iii) Explain how your response to part (c)(i) could be modified to make it easier for the user to apply the hand brake.

.....

.....

.....

(2 marks)

20

Do **not** answer Question 8 if you have answered Question 7.

OR

8 This question is about pneumatics and pneumatic components.

(a) Air going into a cylinder is at a pressure of 2 N/mm^2 and the area of the piston is 50 mm^2.

What force does the cylinder exert?

Give units where applicable.

Formula .....

Calculation .....

Answer with units .....

(4 marks)

(b) Discuss the use of electrically operated valves compared with manually operated valves.

.....

.....

.....

.....

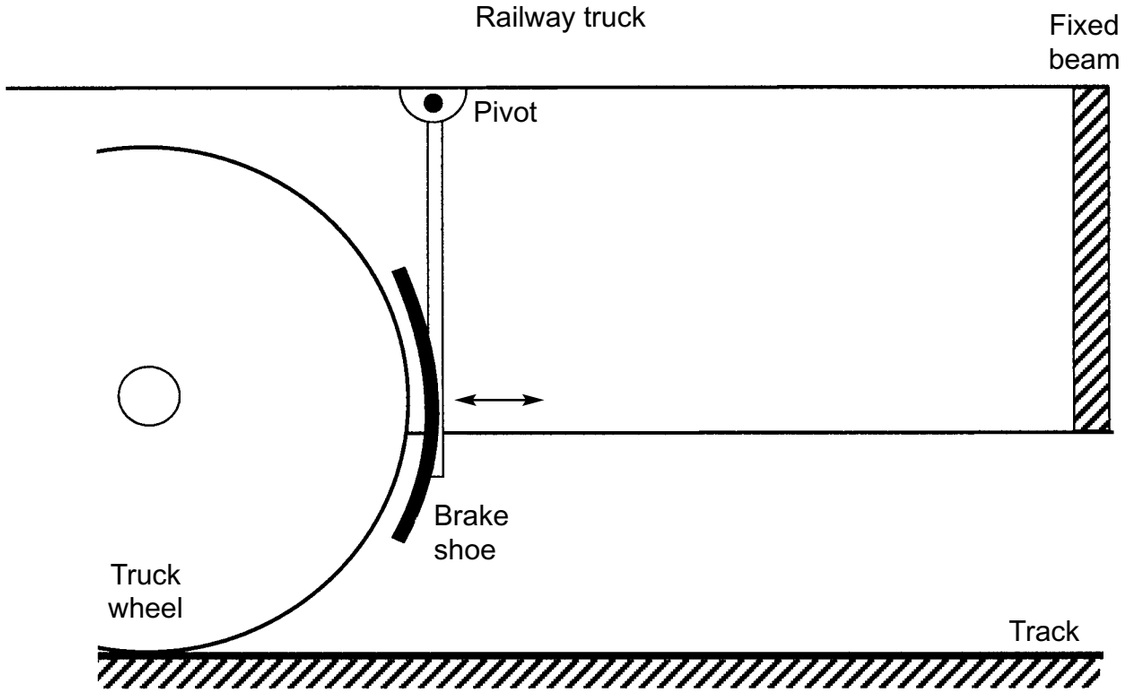
.....

(4 marks)

Question 8 continues on the next page

(c) This part of the question is about a pneumatic brake for a railway truck.

Part of the truck is drawn below.



(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.

Complete the diagram to ensure that

- your solution will prevent the truck moving when the user lets go of the operating valve
- all parts you add are labelled.

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)*

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

1 .....

2 .....

(2 marks)

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

.....

.....

.....

(2 marks)

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END OF QUESTIONS

There are no questions printed on this page

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