General Certificate of Secondary Education
June 2008

DESIGN AND TECHNOLOGY   **3546/F**
(SYSTEMS AND CONTROL TECHNOLOGY)
Written Paper
Foundation Tier

F

Monday 9 June 2008   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 black ink or black ball-point pen. Use pencil only for drawing.
- Fill in the boxes at the top of this page.
- Answer **nine** questions.
  Answer **all** the questions from Section A.
  Answer **one** question from Section B.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- 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.

You may use the following information when answering the questions.

Pneumatics   Force = Pressure × Area

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

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

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

Forces   Moments = Force × 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   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 $\pi = 3.142$

Resistor Colour Code   E12 Resistor preferred values

Colour	Number	Number of Zeros	
Black	0		10, 12, 15, 18, 22, 27, 33, 39, 47,
Brown	1	0	56, 68, 82 and decades thereafter.
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	

TP/Jun08/3546/F

Turn over for the first question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Turn over ▶

SECTION A
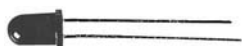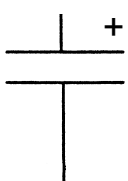
Answer **all** questions in this section.

1   This question is about making lights flash.

1   (a)   Each of the illustrations below shows a component that can be used in circuits.

For each illustration, name the component and draw the circuit symbol that represents it in a circuit diagram.

Some have been completed for you.

	Component	**Symbol**
	LED	
		+

(6 marks)

1 (b) The circuit diagram shown below will make the output flash.
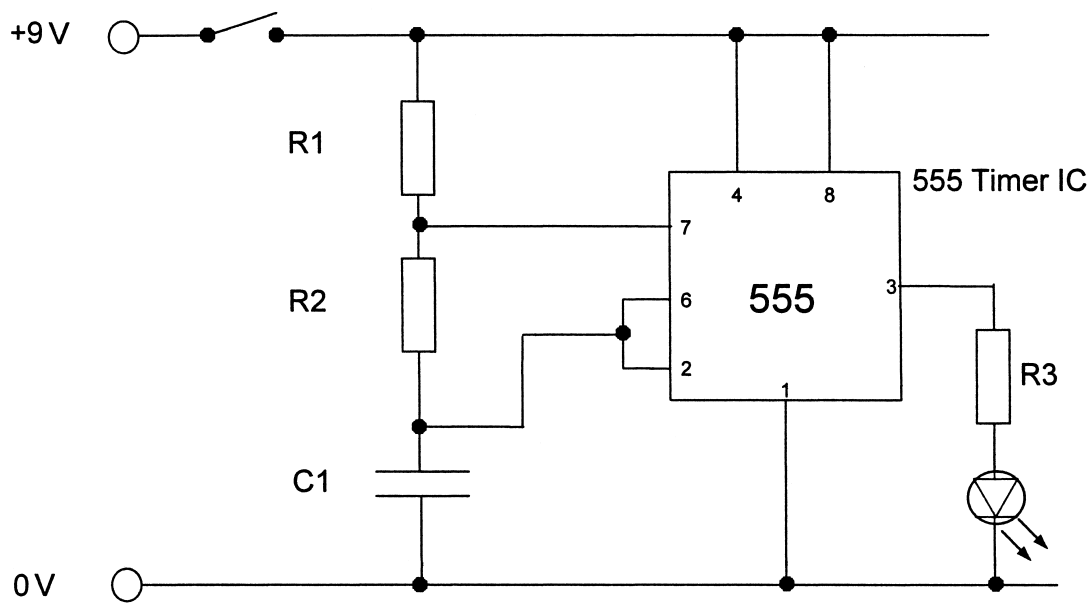
1 (b) (i) Circle **one** of the words below to show how the 555 timer is being used.

astable   monostable   counter

(1 mark)

1 (b) (ii) Explain the purpose of the component labelled R3.

....

....

....

(2 marks)

1 (b) (iii) Explain **two** changes that could be made that would change the flash rate of the output.

....

....

....

(2 marks)

11

Turn over ▶

2 This question is about switches and switching.

The operator of a theme park requires a system that counts people going through a rotating turnstile, which turns through a quarter of a revolution, as each person passes through it.

The input to the system is to be a switch.

2 (a) In the box below show how a switch could be added to the turnstile so that it operates once for each quarter of a revolution of the turnstile.

Marks will be awarded for:

- the fixing of the switch to the turnstile *(1 mark)*
- the switch operating once for each quarter revolution of the turnstile *(3 marks)*
- drawing and labelling. *(2 marks)*

2 (b) (i) Name the type of switch that you have chosen to use.

....
(1 mark)

2 (b) (ii) State why this switch is suitable for this application.

....
(1 mark)

2 (b) (iii) Circle **one** of the words below to show whether your switch is a digital or analogue sensor.

Digital   Analogue

(1 mark)

Turn over for the next question

9

3 This question is about the design process.

The owner of the theme park has asked you to design an Automated Mascot to welcome visitors to the theme park.

(Automate – control or operate automatically)

3 (a) **Analysis**

List **two** factors that you should think about when designing the Automated Mascot and give a reason why each is important. An example has been given.

Example:

Factor – *The likely cost of the whole project.*

Reason – *So that it can be built at a reasonable price.*

Factor 1 ....

....

....

Reason 1 ....

....

....

Factor 2 ....

....

....

Reason 2 ....

....

....
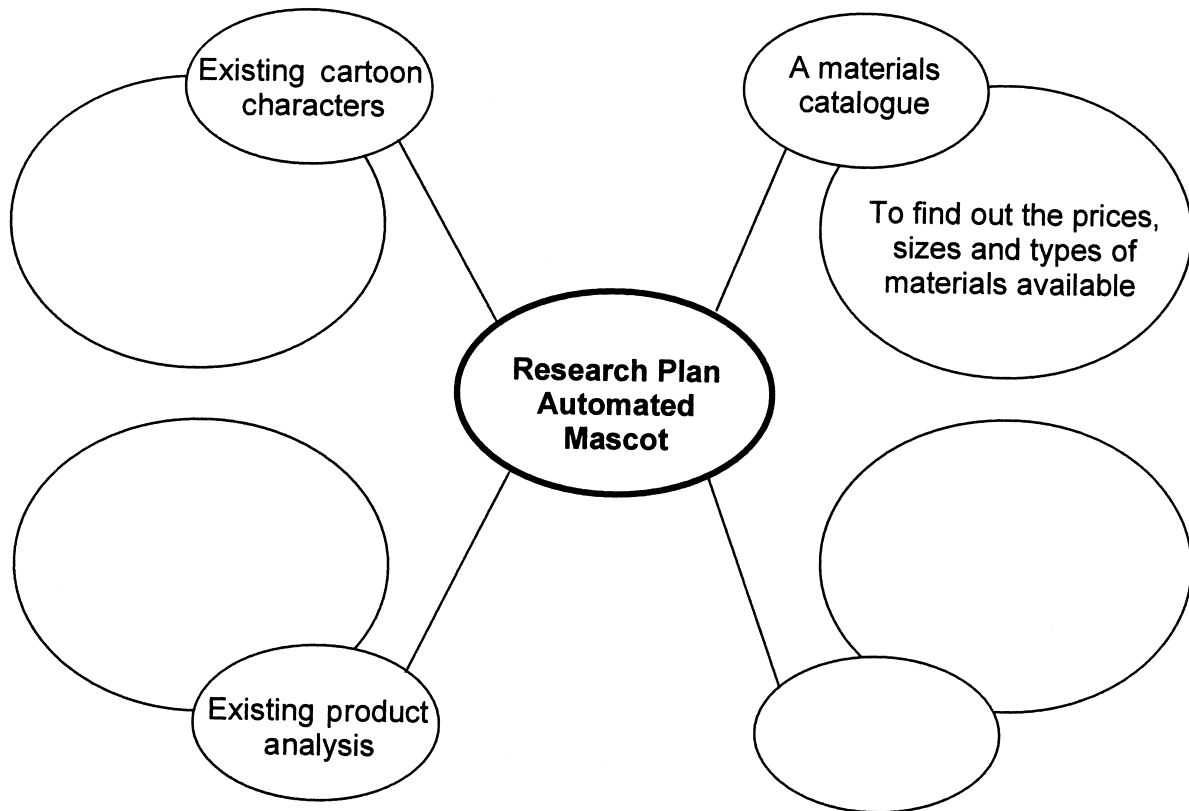
(4 marks)

3 (b) **Research**

The layout of a research plan for the Automated Mascot is shown below.

Complete the research plan by adding suitable research sources and stating the information that you would hope to find. The materials section has been completed for you.

```
        ( Existing cartoon )              ( A materials )
        (   characters    )              (  catalogue  )

  (                  )          ( To find out the prices, )
  (                  )          ( sizes and types of      )
  (                  )          ( materials available     )

              ( Research Plan )
              (   Automated   )
              (    Mascot     )

  (                  )          (                  )
  (                  )          (                  )
        ( Existing product )            (          )
        (    analysis      )
```

(7 marks)

3 (c) Describe how the information from the analysis and research may affect the final design.

....

....

(2 marks)

Question 3 continues on the next page

3 (d) **Design Specification**

Give **four** design requirements for your Automated Mascot.

Example

Function

Requirement ..... *The Mascot must welcome visitors.* ....

Explanation ..... *By waving.* ....

Appearance

Requirement ....

Explanation ....

Materials

Requirement ....

Explanation ....

Safety

Requirement ....

Explanation ....

Durability

Requirement ....

Explanation ....

(8 marks)

21

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Turn over ▶

4 This question is about design ideas for the system that makes the mascot move.

Study the information given in your **Design Specification** from Question 3.

Use this information to sketch **two** different design ideas for an Automated Mascot for the theme park.
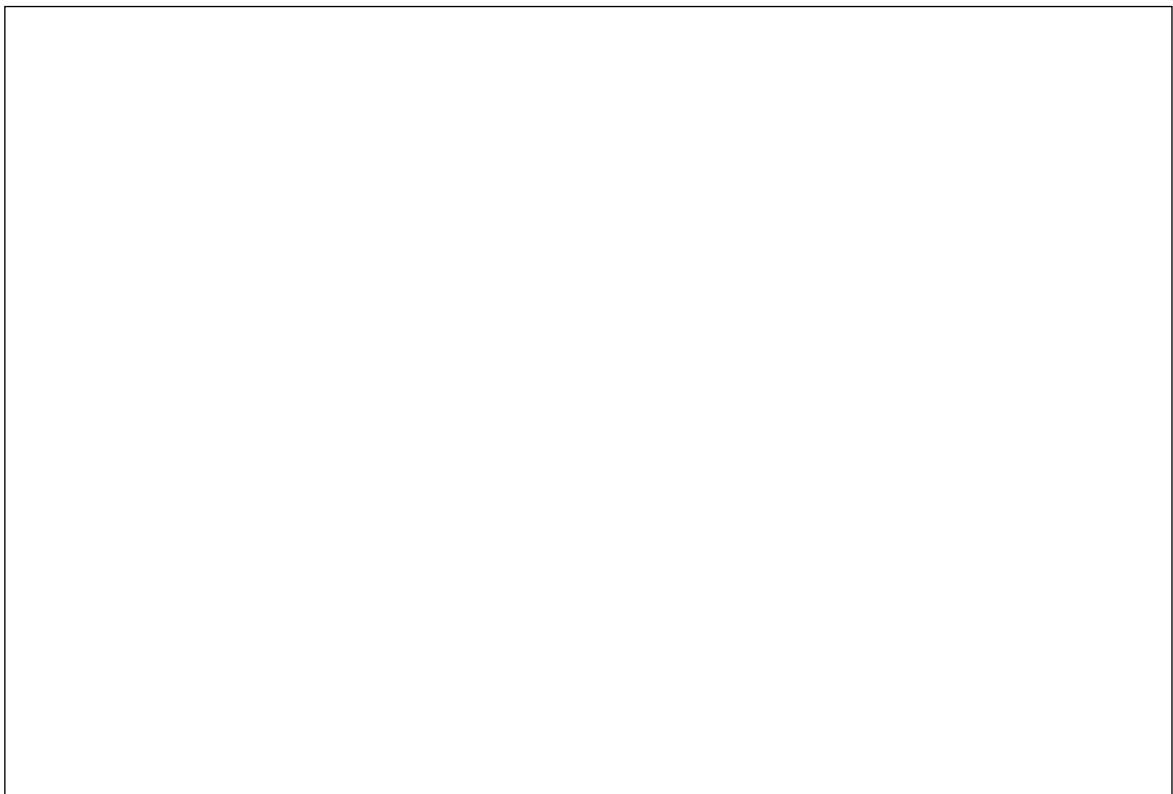
You must show:

- function
- appearance
- materials
- safety
- durability
- which parts move.

Marks will also be awarded for:

- quality of sketches *(2 marks)*
- quality of notes. *(2 marks)*

Idea 1

(6 marks)

Evaluation of **Idea 1**

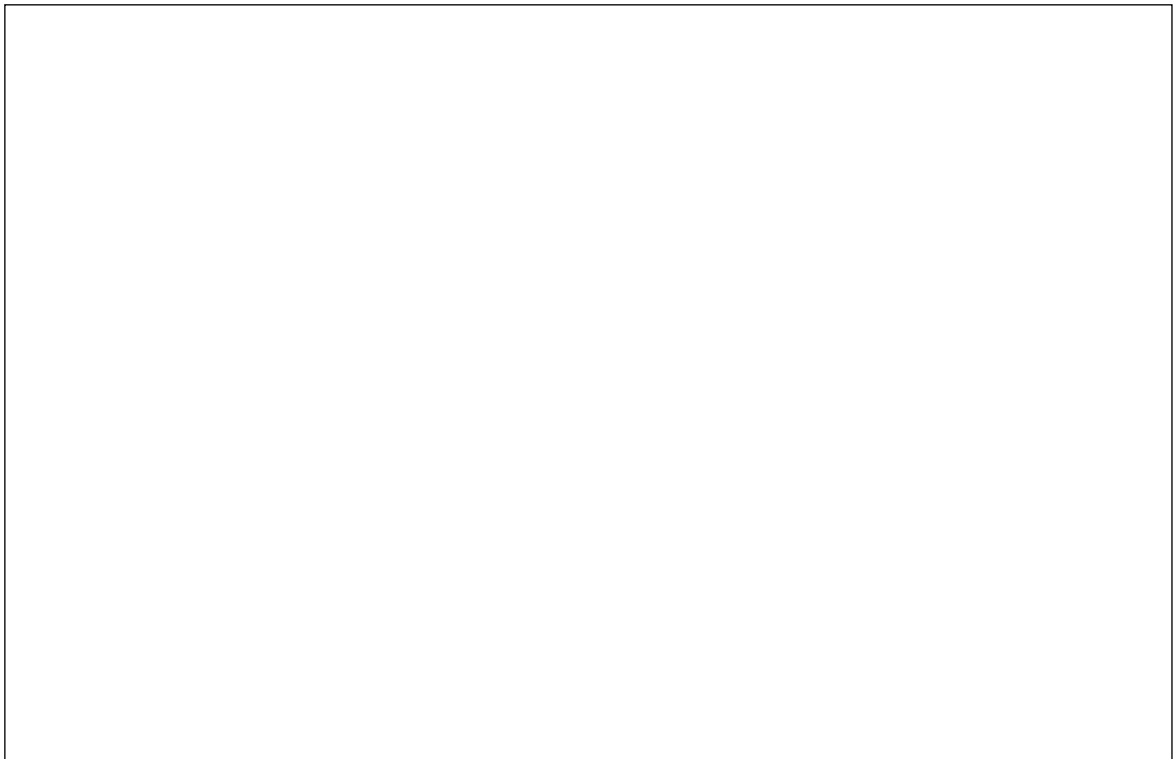Explain how your design meets the requirements of the specification.

Function ....

Appearance ....

Materials ....

Safety ....

Durability ....

(5 marks)

Idea 2

(6 marks)

Evaluation of **Idea 2**

Explain how your design meets the requirements of the specification.

Function ....

Appearance ....

Materials ....

Safety ....

Durability ....

(5 marks)

Turn over ▶

5 This question is about developing the system using mechanisms **or** pneumatics.

Choose **one** of your ideas for development.

Tick the box to show which idea you would choose.

Idea 1 ☐   **Idea 2** ☐

5 (a) It was decided that the Automated Mascot should have an electronic sensor to start the movement when a visitor approached it.

Using notes and sketches, show clearly how an electronic sensing device could detect a visitor.

Only show the 'sensing input' system for detecting the visitor.

Marks will be awarded for:

- a suitable electronic system to detect a visitor *(4 marks)*
- quality of sketches and notes describing the operation. *(4 marks)*

Visitor

5 (b) Using notes and sketches, show clearly details of the system that moves the Automated Mascot.

Note:

- the mascot should move continuously
- you should show details of the mechanism and motor **or** pneumatic cylinder and valve(s)
- show only the moving part of the mascot
- show the paths of all movement.

Marks will be awarded for:

- suitable system to move part of the mascot   *(10 marks)*
- quality of notes and sketches describing the operation.   *(2 marks)*

Note – if using pneumatic valves, do **not** draw pneumatic symbols. Use labelled boxes for the valves.

Turn over ▶

6 This question is about a safety mechanism for a roller-coaster loading station.

When the operator presses the button, Car 1 rolls onto the ride and, once it is clear, Car 2 rolls into Position A.

Operator button

To ride →

Car 2

Car 1

Position B

Position A
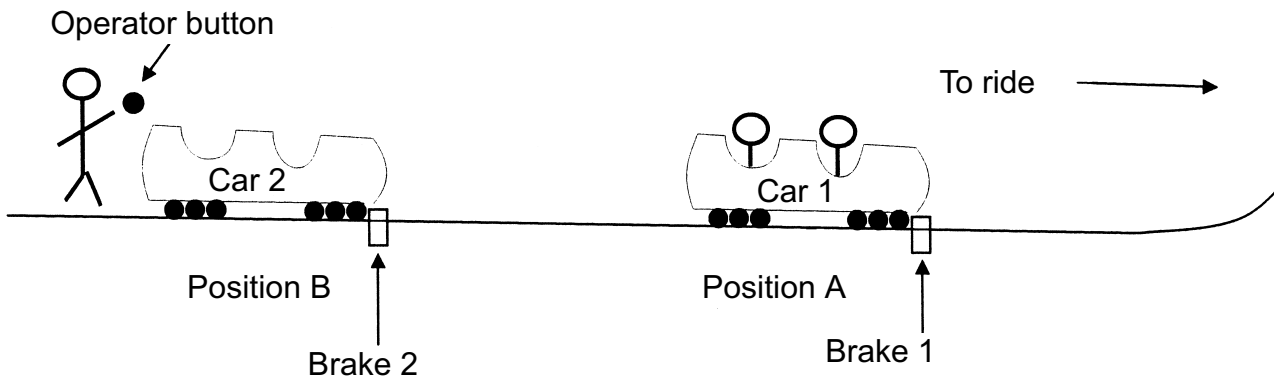
Brake 2

Brake 1

The whole process is controlled using a Peripheral Interface Controller (PIC) chip.
The loading track is on a slight slope so that the car rolls forward when the brake is lowered.
A delay is required to allow Car 1 to move away before Car 2 rolls forward.
The process is a Repeatable/Continuous Operation.

The flowchart on the opposite page shows a sequence of operational instructions that would act as the control program for the above roller-coaster loading system.

Operational instructions to be used.

Brake 1	ON	(UP)
	OFF	(DOWN)
Brake 2	ON	(UP)
	OFF	(DOWN)
Operator Button	ON	
	OFF	

Note:

• assume that the cars are in the position in the diagram above and both Brakes are ON (UP) at the start.
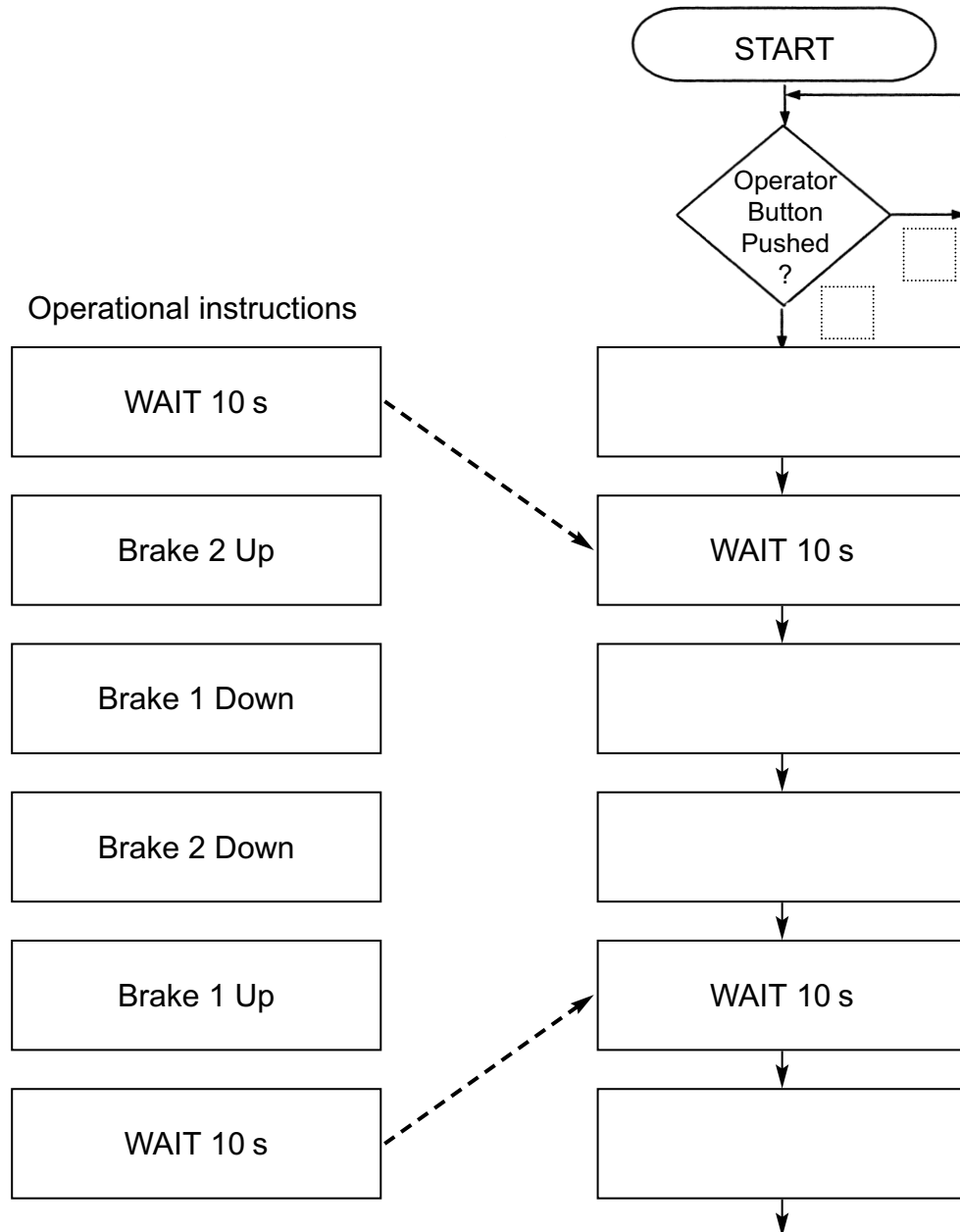
6 (a) Complete the flowchart below for the roller-coaster control process.

- one operational instruction has been completed for you
- use Y = YES, N = NO

Marks will be awarded for:

- each correct output state of the decision box (Y = YES, N = NO)   *(2 marks)*
- each operational instruction in the correct box   *(4 marks)*
- continuous operation.   *(1 mark)*

Operational instructions

| WAIT 10 s |

| Brake 2 Up |

| Brake 1 Down |

| Brake 2 Down |

| Brake 1 Up |

| WAIT 10 s |

Flowchart:

START → Operator Button Pushed ? (decision box, with two empty output state boxes)

→ [ ] → WAIT 10 s → [ ] → [ ] → WAIT 10 s → [ ]

6 (b) Why is the time delay required?

....

....
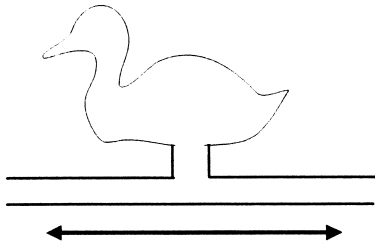
(2 marks)

9

Turn over ▶

7 This question is about a moving target game.

The targets need to be moved from left to right continuously.

The picture that appeared here cannot be reproduced due to third-party copyright constraints.

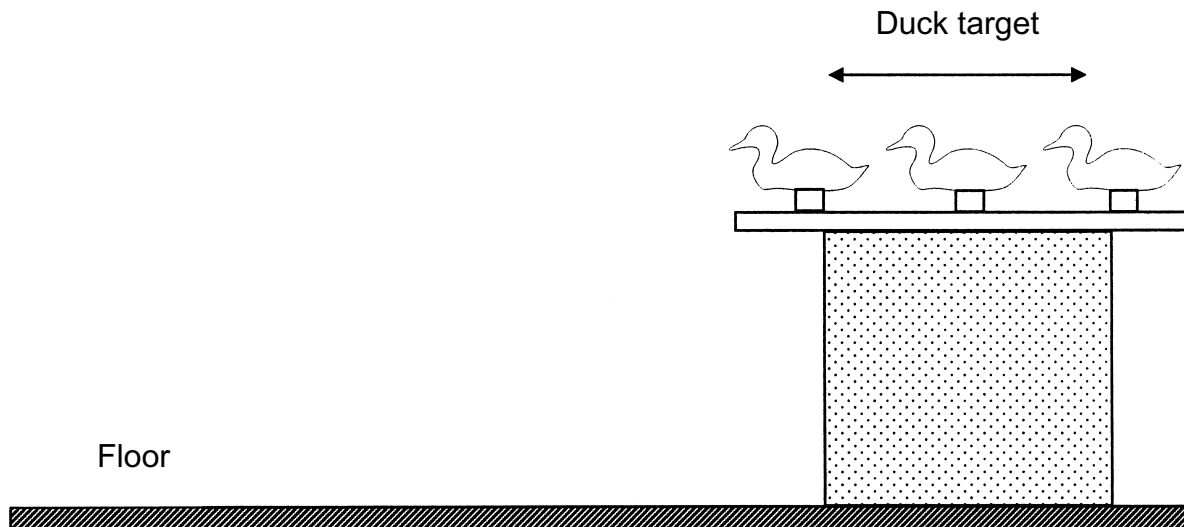**7** (a) (i) Name a suitable material from which the duck targets could be made.

....
(1 mark)

7 (a) (ii) Explain why this material is suitable for a target.

....
(1 mark)

7 (b) The simplified diagram below shows a target.

**Space A**

Duck target

Floor

Add a suitable pneumatic **or** mechanical system to the drawing above in **Space A**, that will move the target left and then right continuously.

Your design must show:

- a system that can move the target left and then right continuously *(3 marks)*
- suitable mounting of the system to the floor and the target *(2 marks)*
- how the system is powered *(1 mark)*
- a drawing that is labelled and describes **all** components and mountings. *(2 marks)*

10

8 This question is about health and safety issues for a roller-coaster system.
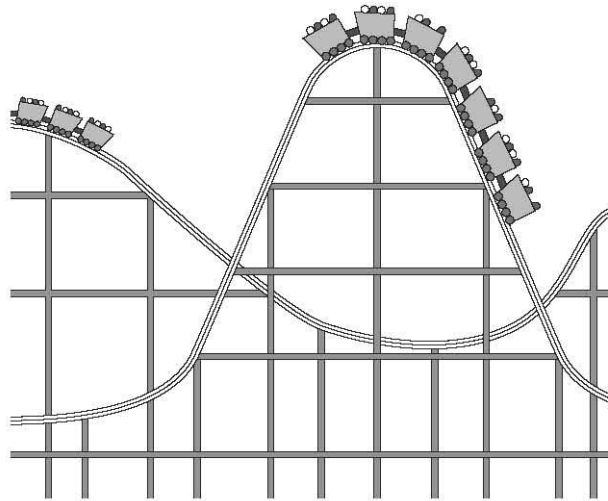
8 (a) List **three** risks that an error in the roller-coaster system could cause.

....

....

....
(3 marks)

8 (b) List **two** safety checks the operator should do every morning before the public use the ride.

....

....
(2 marks)

8 (c) Suggest how passengers could escape safely from the carriage if the ride stops at the top.

....

....
(2 marks)

8 (d) State **two** regular maintenance operations for the roller-coaster.

1 ....

2 ....
(2 marks)

END OF SECTION A QUESTION
Turn over for Section B questions

9

Turn over ▶

SECTION B

Answer **either** Question 9 (below) about mechanisms

or Question 10 (page 23) about pneumatics.

Do **not** answer both questions.

EITHER

9 This question is about a mechanism for a bat in a ghost train.

9 (a) Draw a cam mechanism in **Box A** opposite that will make the bat move up and down continuously.

Note:

- the bat should move up and down smoothly once in a revolution
- the bat is drawn at its lowest position
- use the rotary motion of the motor shaft to turn the cam.

Fixed bearing blocks

Follower

Box A

Motor shaft
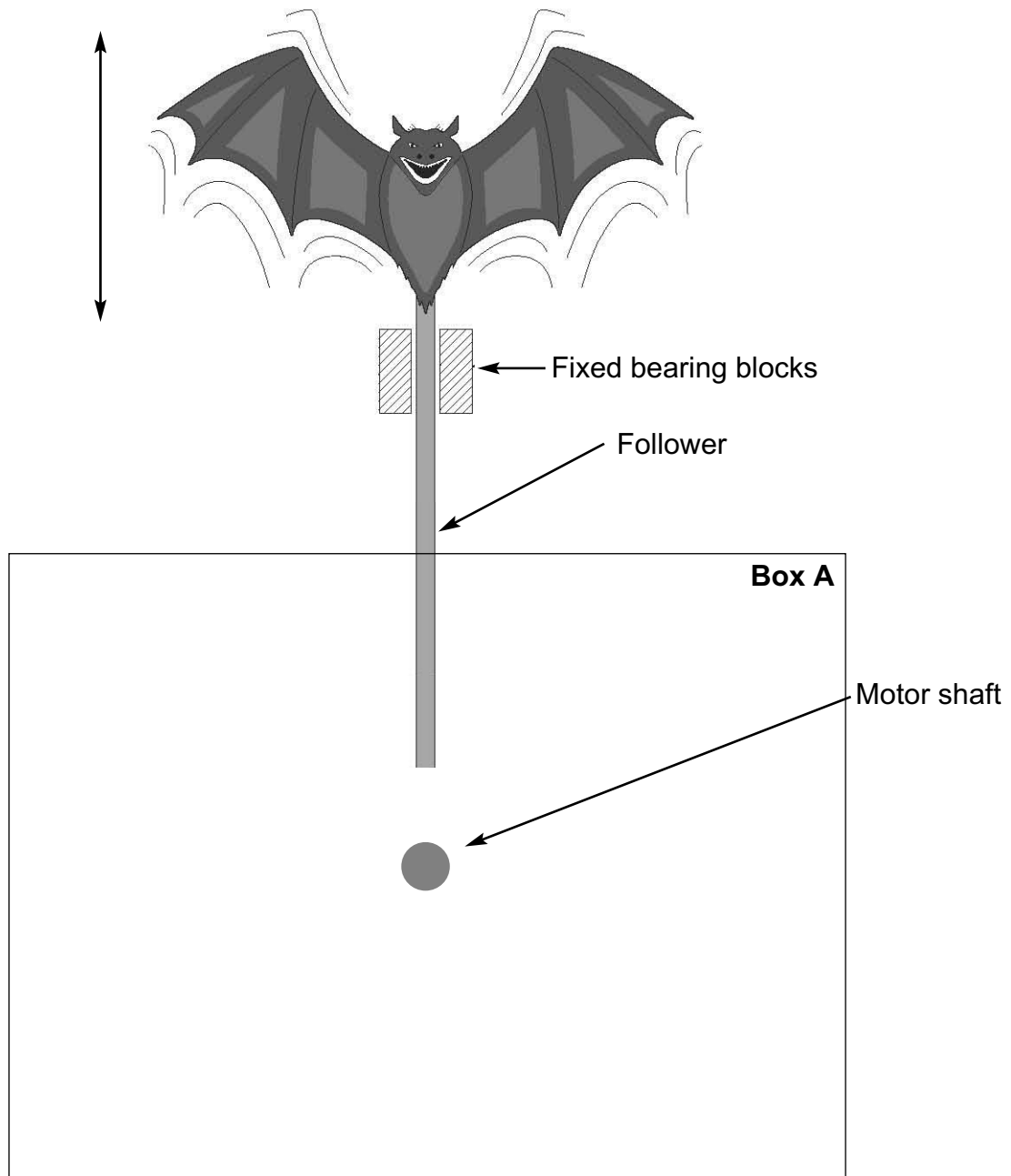
(4 marks)

9 (b) In use the follower was found to stick in the bearing blocks.
Modify the end of the follower to prevent it sticking during use.

(1 mark)

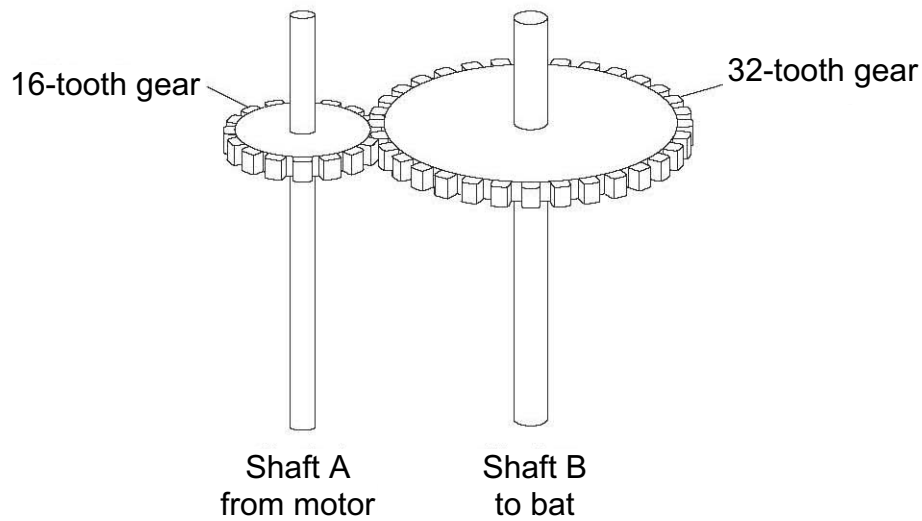**Question 9 continues on the next page**

Turn over ▶

When in use, the bat moved up and down too quickly.

The diagram below shows two gears arranged to slow down the movement of the bat.

16-tooth gear   32-tooth gear

Shaft A
from motor

Shaft B
to bat

9 (c) State the type of gear system shown above.

....

(1 mark)

9 (d) The motor spins at 100 revolutions per minute (rpm).

Calculate the speed of the Shaft B in the gear system above.

Formula ....

Calculation ....

Answer with units ....
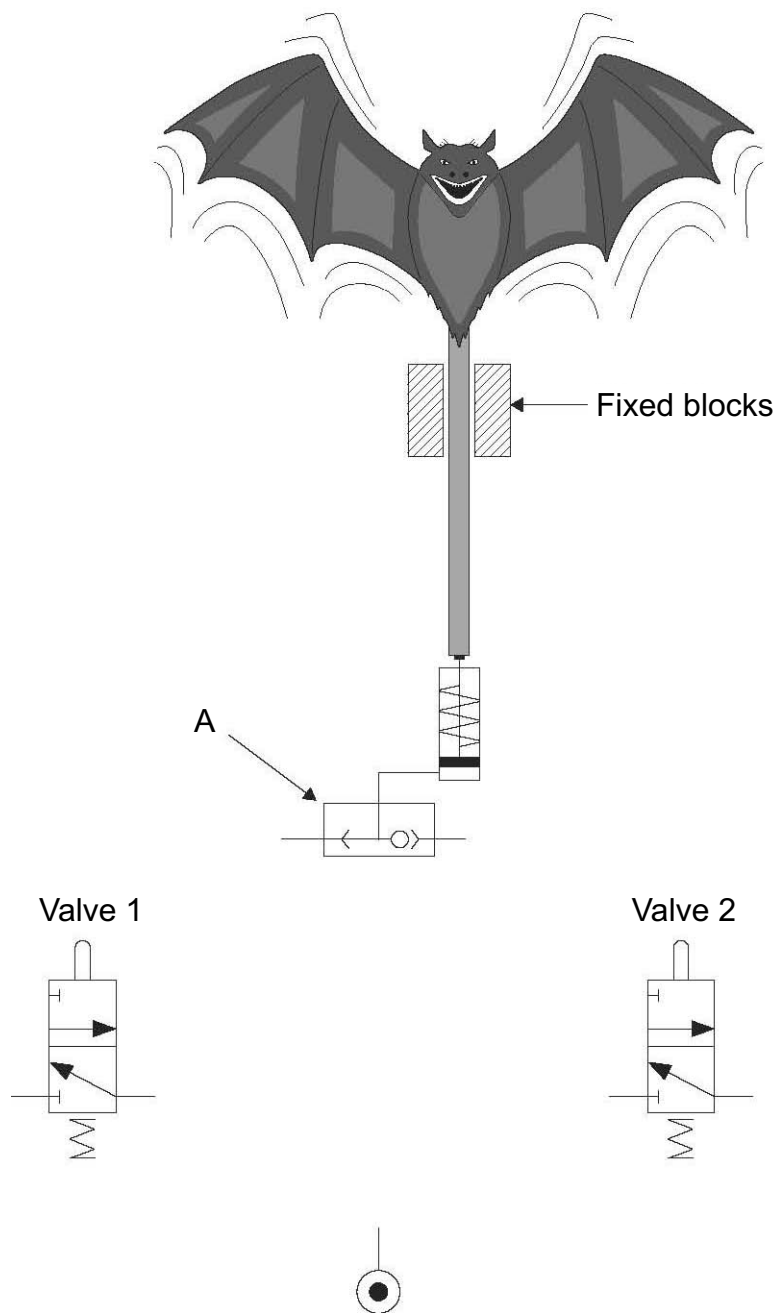
(4 marks)

10

Do **not** answer Question 10 if you have answered Question 9.

OR

10 This question is about a pneumatic system for a bat in a ghost train.

The valves are operated by the ghost train car going over them.

10 (a) Connect the components below so that the bat goes up if **either** valve 1 or 2 is pressed.

Fixed blocks

A

Valve 1   Valve 2

(4 marks)

Question 10 continues on the next page

Turn over ▶

10 (b) Name the component marked A in question 10 (a).

....

(1 mark)

10 (c) A pneumatic cylinder is shown below.
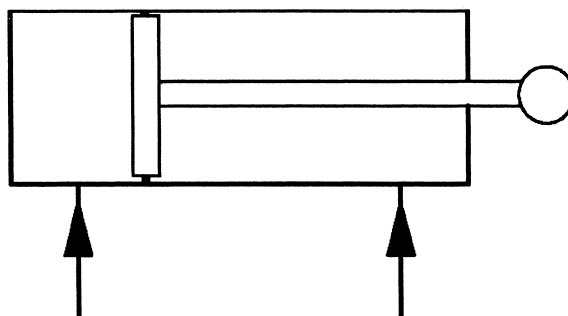
The input air pressure to the cylinder is 10 N/mm^2 and the area of the piston is 100 mm^2.

Calculate the force of the output.

Formula ....

Calculation ....

Output force and units ....

(4 marks)

10 (d) Circle the type of cylinder shown above.

Single   Double   Gas

(1 mark)

10

END OF QUESTIONS