

Surname						Other Names					
Centre Number						Candidate Number					
Candidate Signature											

Leave blank

General Certificate of Secondary Education
Summer 2003

DESIGN AND TECHNOLOGY
Systems and Control Technology

3546/F



FOUNDATION TIER

F

Thursday 19 June 2003 1.30 pm to 3.30 pm

In addition to this paper you will require:
a pen, pencil, ruler, eraser and pencil sharpener.

For Examiner's Use	
SECTION A MECHANISMS FOCUS	
Number	Mark
A1	
A2	
A3	
A4	
A5	
A6	
A7	
A8	
TOTAL	
SECTION B PNEUMATICS FOCUS	
Number	Mark
B1	
B2	
B3	
B4	
B5	
B6	
B7	
B8	
TOTAL	
Examiner's initials	

Time allowed: 2 hours

Instructions

- Write your name and other details in the spaces provided above.
- Answer **either Section A** – Mechanisms Focus Technology;
or Section B – Pneumatics Focus Technology.
not both
- Write your answers in this question paper/answer book.

Information

- The maximum mark for this paper is 125.
- A list of formulae is given on page 2 which you may need to use when answering certain questions.
- The number of marks is given in brackets at the end of each question or part-question.
- Wherever calculations are needed you should show your working.
- All dimensions are given in millimetres unless otherwise stated.
- You are reminded of the need for good English and clear presentation.

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The following information may be of use to you when answering questions on this paper.

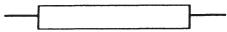
Pneumatics	Force = Pressure \times Area		
Ratio of Simple Gears	Gear Ratio = $\frac{\text{Number of teeth on driven gear}}{\text{Number of teeth on driver gear}}$		
Velocity Ratio	Velocity Ratio = $\frac{\text{Diameter of driven pulley}}{\text{Diameter of driver pulley}}$		
	Output speed = $\frac{\text{Input speed}}{\text{Gear/Velocity ratio}}$		
Forces	Moments = Force \times Distance		
	Sum of clockwise moments = sum of anti-clockwise moments		
Series Resistance	$R_T = R_1 + R_2 + R_3$		
Parallel Resistance	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ OR $R_T = \frac{R_1 \times R_2}{R_1 + R_2}$		
Potential Difference	$V = I \times R$		
Transistors	Current Gain = $\frac{\text{Collector Current}}{\text{Base Current}}$		
Amplifier Gain	$A_v = \frac{\text{Change in output voltage}}{\text{Change in input voltage}}$		
Area of circle = πr^2	$\pi = 3.142$		
Resistor Colour Code	E12 Resistor preferred values		
Colour	Number	Number of Zeros	10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and decades thereafter.
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	

SECTION A – MECHANISMS FOCUS

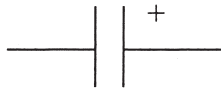
Answer **all** questions in this section.

Do **not** answer these questions if you have answered the questions in **Section B – Pneumatics Focus** (pp. 22–39).

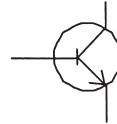
A1 (a) Identify the following components.



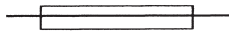
(i) _____



(ii) _____



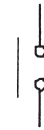
(iii) _____



(iv) _____



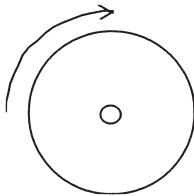
(v) _____



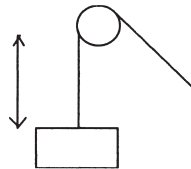
(vi) _____

(6 marks)

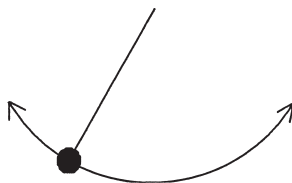
(b) What type of motions do the following drawings show?



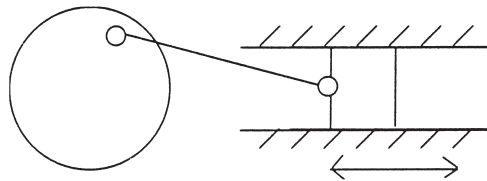
(i) _____



(ii) _____



(iii) _____



(iv) _____

(4 marks)

- (c) Name the **two** parts of the mechanism indicated by the arrows.

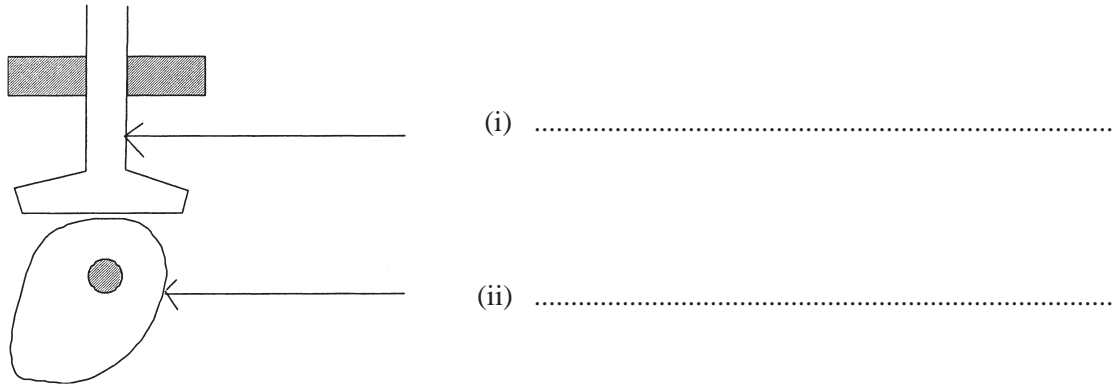


Figure 1

(2 marks)

- (d) In the space below produce a simple design sketch of a microswitch and guard mechanism that could be used on a pillar drill. The switch and mechanism should ensure that the user **could not** operate the machine without the guard in position.

You do not need to draw the pillar drill. Only sketch the idea for how the microswitch and guard will work.

(6 marks)

Turn over ►

A2 A student has decided to use the monostable circuit shown in **Figure 2** as the timing element in a game being designed. The circuit is based around a 555 timer integrated circuit (IC).

- (a) Use the information given on the circuit diagram to help you to complete the table in **Figure 2** which describes the pins used for the connection of the 555 timer Integrated Circuit (IC).

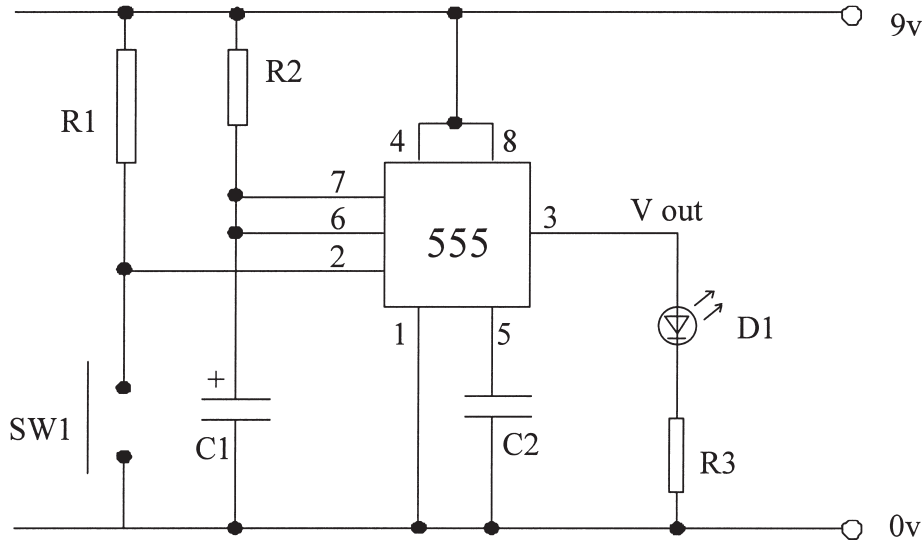


Figure 2

Pin number	Label	Pin number	Label
1		5	Control voltage
2		6	Threshold
3		7	Discharge
4	Reset	8	

Component D1 is a light emitting diode.

It has to be inserted with the correct for it to function correctly.
(5 marks)

- (b) The unlabelled version of the circuit chosen by the student is shown again below in **Figure 3**. Circle the two components that can be best used to control the timing of the pulse in the circuit shown below.

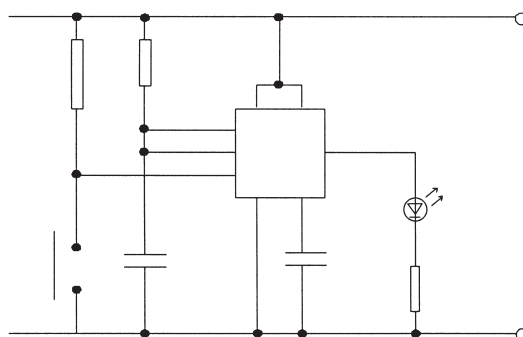
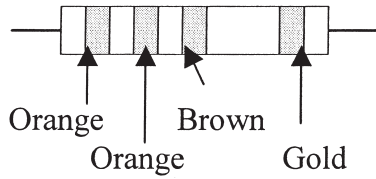


Figure 3

(2 marks)

(c) (i) Resistor 3, (R3), is shown in **Figure 4**.

What is the value of this resistor?



..... Ohms
(1 mark)

Figure 4

(ii) Explain what the Gold band indicates.

.....
(1 mark)

(iii) Explain why the resistor is positioned in series with the LED in **Figure 3**.

.....
.....
(2 marks)

(d) The 555 IC is a DIL integrated circuit. These circuits can easily be damaged when fixing or handling.

Describe **two** precautions that can be taken to safeguard against damage.

1
.....
(1 mark)

2
.....
(1 mark)

QUESTION A2 CONTINUES ON THE NEXT PAGE

Turn over ►

- (e) The circuit is to be assembled on a printed circuit board. The student has manufactured the case for the game out of *Medium Density Fibre Board* (MDF). In the space below show a suitable method of fixing the circuit board to the MDF case.

This question is worth 4 marks.

Marks will be awarded as follows:

Method of fixing the circuit board to the MDF case; (2 marks)
Quality of drawing. (2 marks)

A3 (a) Identify the type of gear mechanism shown in **Figure 5**.

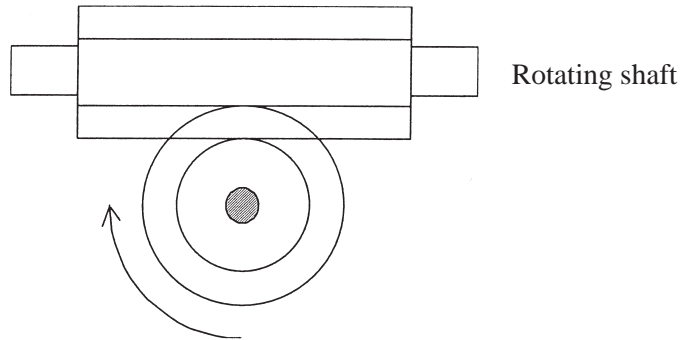


Figure 5

Type of mechanism (1 mark)

(b) Identify the type of gear used in **Figure 6** to turn rotation through 90 degrees.

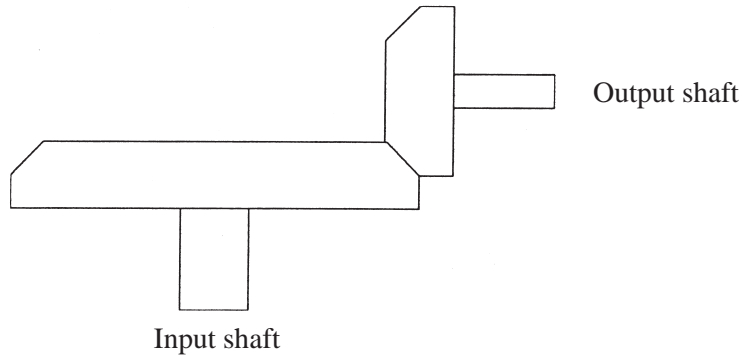


Figure 6

Type of gear (1 mark)

(c) Will the output shaft in **Figure 6** be rotating at the same speed, faster or slower than the input shaft?

..... (1 mark)

- (d) Complete the gear system, shown in **Figure 7**, that would allow the output shaft to rotate at 400rpm and in the same direction as the input shaft.

Indicate on **Figure 7** the number of teeth on each gear used in your solution.

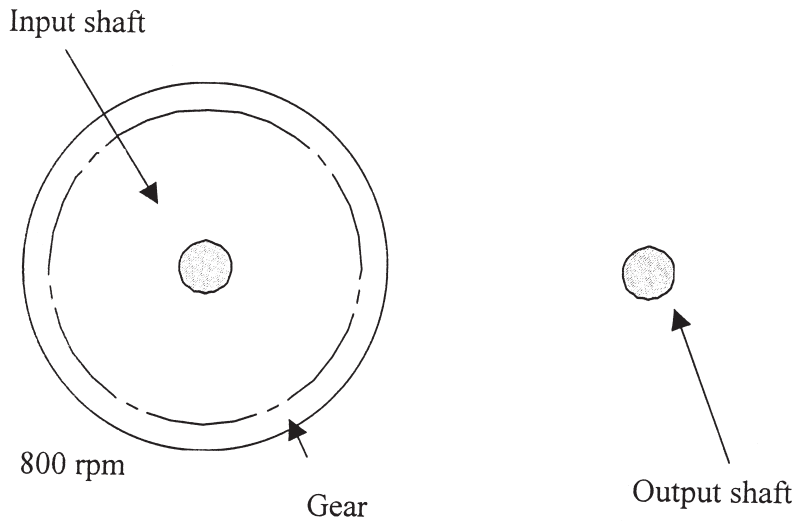


Figure 7

(4 marks)

- (e) Give **two** safety precautions that are used in gear systems commonly found in workshop machinery.

1

.....

2

.....

(2 marks)

Give a disadvantage of gear systems.

.....

.....

(1 mark)

A4 The drawing below, **Figure 8**, shows a toy train that has been manufactured using a variety of different plastic materials.

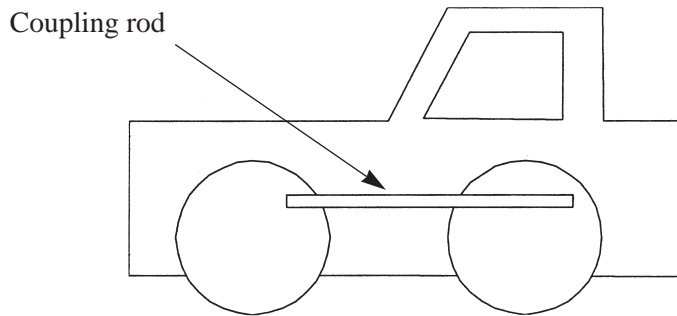


Figure 8

- (a) (i) **Figure 9** shows the coupling rod from the wheel linkage mechanism. It is to be made of plastic (hdp).

What manufacturing process would be best to produce it?

.....
(1 mark)

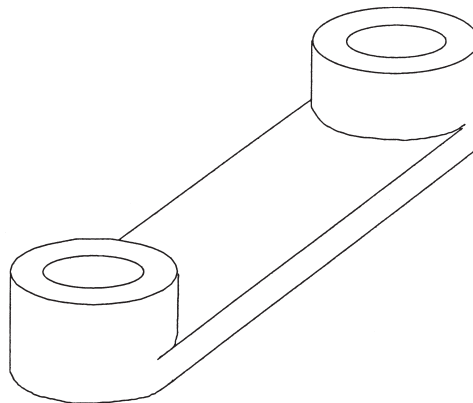
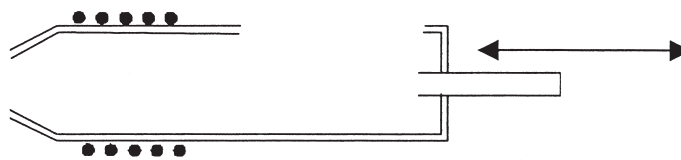


Figure 9

- (ii) The drawing in **Figure 10** is an incomplete drawing of the process used to manufacture the coupling rods.

Complete the drawing by showing the position of the split mould and the hopper in this manufacturing process.



Heater elements

Figure 10

(2 marks)

(b) Modify the drawing of the component shown in **Figure 9** to show how the component could easily be strengthened. ANSWER BY ADDING LINES TO THE DRAWING GIVEN ON THE PREVIOUS PAGE.

(4 marks)

(c) (i) Which type of plastic is most suitable for recycling – thermoplastic or thermosetting plastic?

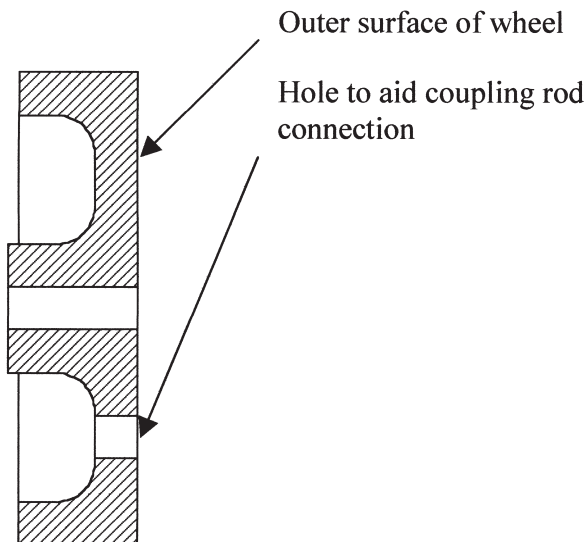
..... (1 mark)

(ii) Describe briefly how a manufacturer would recycle this type of plastic.

.....
.....
..... (2 marks)

(d) On the toy train a coupling rod connects the two wheels. This is shown in **Figure 8** and **Figure 9**.

Sketch a suitable method of fixing this link to the wheel and at the same time allowing it free rotation. You may use the given cross-section of the wheel or re-draw it in the space provided.



Cross section
Through wheel

(4 marks)

Turn over ►

A5 Many toys use cams to impart motions to give interest to the toy. The profile of a cam determines the type of motion.

- (a) Describe what happens to the follower when the cam shown in **Figure 11** completes one full rotation.

.....

.....

.....

(2 marks)

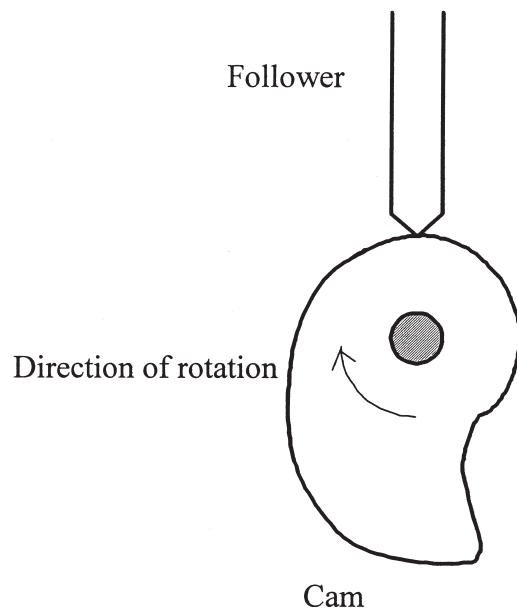


Figure 11

- (b) (i) In the space below design a cam that could be used to make the driver's head and body in **Figure 12** move up and down at the same speed as the toy is pulled along. You may use whatever drawing format you wish.

Add notes to your drawing to explain how it works.

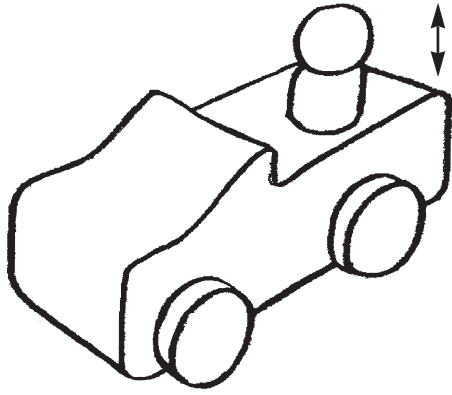


Figure 12

(5 marks)

- (ii) Fill in the spaces below using words from the list below.

spindle	painting	polishing	wood	plastic
dowel	tubing	axle	friction	temperature

In the model shown the axle could be made of as it is a cheap readily available material. The wheels and cam could be made from injection moulded which would be pressed onto the The body of the driver would be made from a similar plastic. The use of plastics would reduce the..... between the cam and the underside of the body. The use of plastics avoids the need for as the granules are already coloured.

(5 marks)

Turn over ►

A6 A heating system has been designed for a sauna. It ensures that:

- the sauna operates within a given temperature range;
- if the temperature falls below the minimum level a heater is activated;
- if the temperature exceeds the maximum level the heat source is turned off.

The heater is turned on when the output voltage is high.

(a) (i) What is the name of a component that senses temperature?

.....
(1 mark)

(ii) In the space below draw the symbol that is used to represent this component.

(2 marks)

(b) The temperature control system flowchart for the process is partially completed in **Figure 13** below.

Complete the flowchart by adding to **Figure 13** as required.

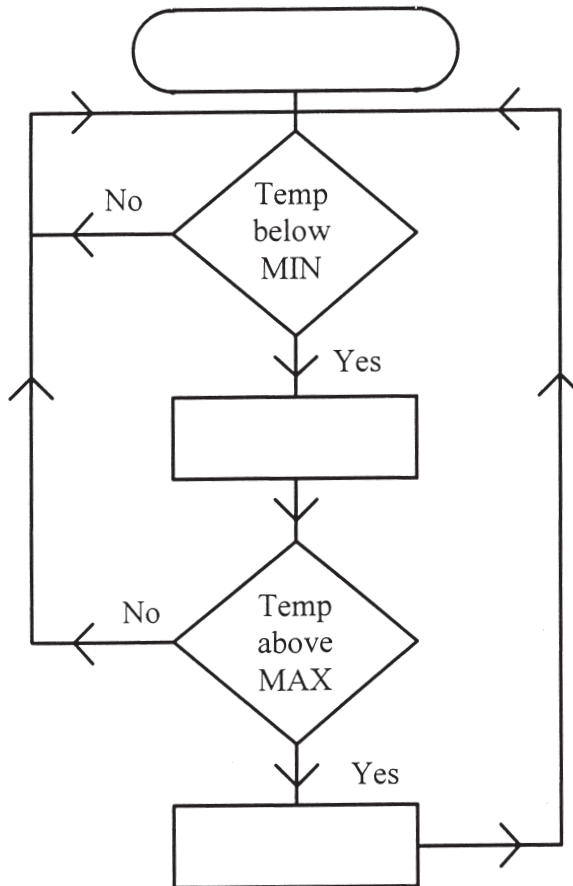
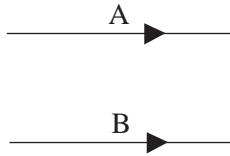


Figure 13

(3 marks)

(c) The heating system uses an AND logic gate.

Complete the logic gate symbol and truth table for an AND logic gate.



A	B	C
0	0	0
1	0	
0	1	
1	1	

(4 marks)

(d) A different way of controlling an electronic heating system is to use an Op Amp.

On the circuit shown in **Figure 14** label the indicated components, using the given numbers or words.

1 – Op Amp
4 – Relay

2 – Transistor
5 – Heater

3 – Diode
6 – Potentiometer

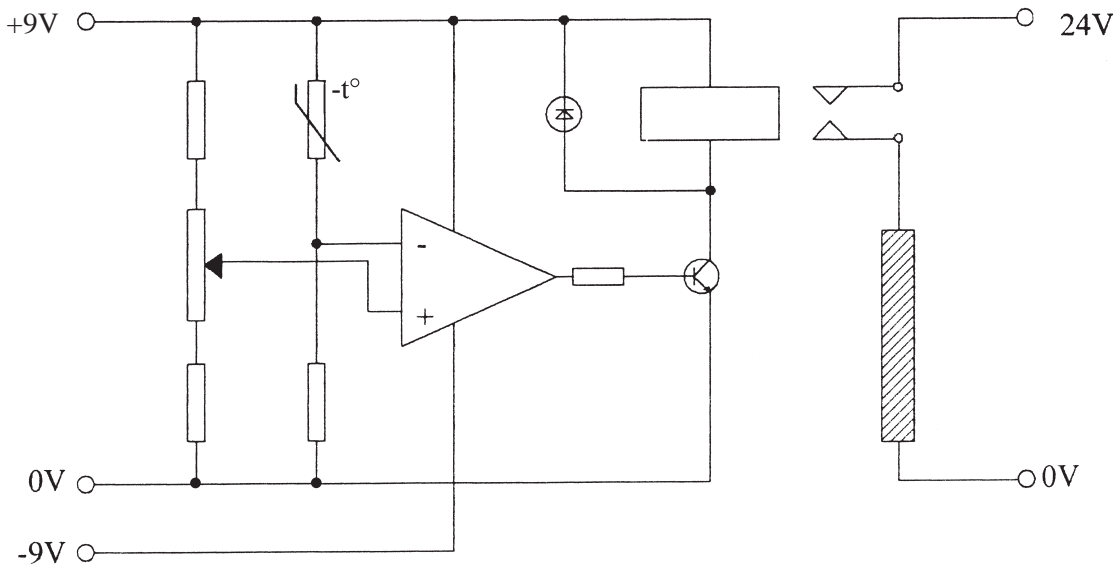


Figure 14

(6 marks)

(e) Explain the function of the diode in the circuit shown in **Figure 14**.

.....

 (2 marks)

(f) Explain why a relay is used in the circuit shown in **Figure 14**.

.....

 (2 marks)

(2 marks)

Turn over ▶

A7 (a) Computer Aided Design (CAD) is often used to design printed circuit boards and for use in electronic circuits.

(i) Give **two** advantages of using CAD.

.....
.....
(2 marks)

(ii) Give **one** disadvantage of using CAD.

.....
(1 mark)

(b) When CAD software is bought for use on a PC system the user purchases the license to use it. The following terms are all related to the purchasing and installation of software.

Briefly explain what the terms mean.

Single user license

Multi-user license

Software piracy

(3 marks)

(c) Printed circuit boards can be made using Computer Aided Milling machines.

Give **two** advantages and **one** disadvantage of producing a printed circuit board in this way.

Advantage 1
(2 marks)

Advantage 2
(2 marks)

Disadvantage
(2 marks)

(d) (i) Give **one** example of a product that is made using an automated production process.

.....
(1 mark)

(ii) Give **two** advantages that arise from the use of automated production machinery for your chosen product.

Advantage 1
.....
(1 mark)

Advantage 2
.....
(1 mark)

(e) You have designed a new product that is quite unique in the market place.

Give **four** methods of marketing this product so that buyers become aware of it.

Method 1
(1 mark)

Method 2
(1 mark)

Method 3
(1 mark)

Method 4
(1 mark)

TURN OVER FOR THE NEXT QUESTION

Turn over ►

A8 A local park has a small gauge railway on which children can have rides. In a number of places the railway track crosses a pedestrian pathway. The railway runs between two hedgerows except where it crosses a pedestrian pathway. A typical crossing is shown in **Figure 15**. The park is only open during daylight hours.

The park owners would like a simple barrier crossing designing which is based upon the same idea as barrier crossings used on full size railways. They do not want their barrier crossing to be as complicated but it does have to meet the following criteria:

- It must close the gap when an electrical signal reaches it.
- An audible (sound) alarm must activate until the barrier is raised.
- The barrier must lift when a second electrical signal reaches it.

Use **these two pages only** to sketch ideas for a design that will satisfy the brief for the barrier.

This question is worth 15 marks.

You will be marked as follows:

Mechanism for raising and lowering barrier;	(5 marks)
Design for audible output;	(5 marks)
Use of suitable materials;	(2 marks)
Quality of drawings.	(3 marks)

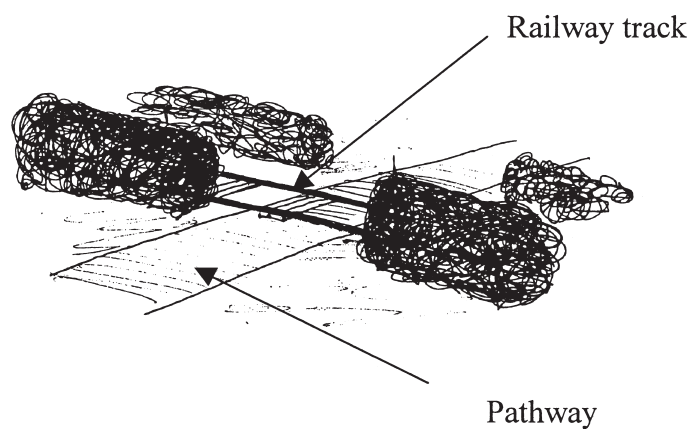


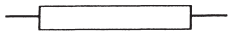
Figure 15

SECTION B – PNEUMATICS FOCUS

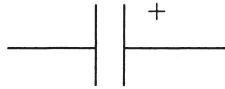
Answer **all** questions in this section.

Do **not** answer these questions if you have answered the questions in **Section A – Mechanisms Focus** (pp. 4–21).

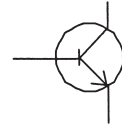
B1 (a) Identify the following components.



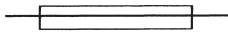
(i) _____



(ii) _____



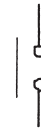
(iii) _____



(iv) _____

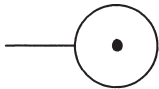


(v) _____



(vi) _____
(6 marks)

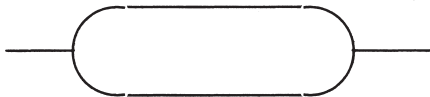
(b) Identify the following components.



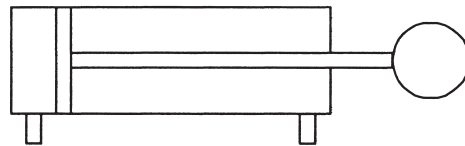
(i) _____



(ii) _____



(iii) _____



(iv) _____

(4 marks)

(c) Name the **two** parts of the mechanism indicated by the arrows in **Figure 1**.

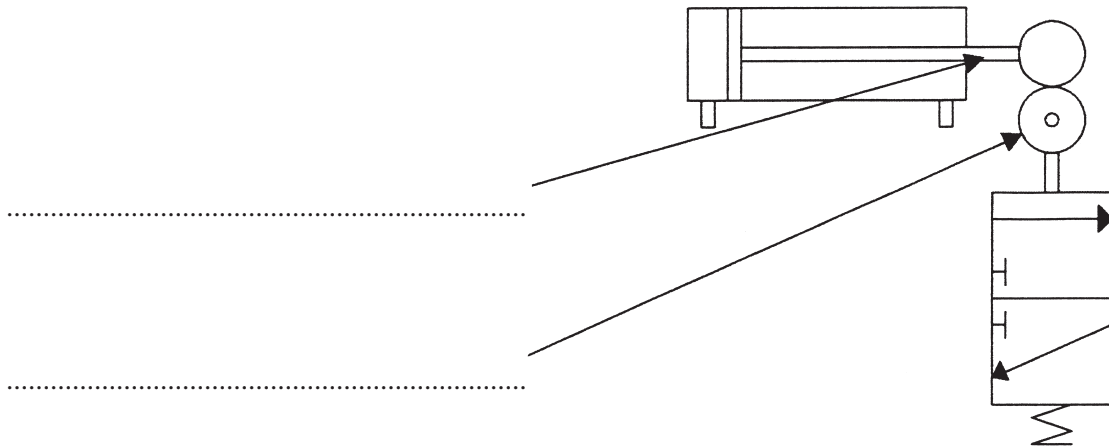


Figure 1

(2 marks)

(d) Two 3 port control valves form part of a powered Guillotine. This is designed so that the guillotine will only operate when both valves are opened. This is a safety feature that ensures both of the operators hands have to be free of the machine before the guillotine can operate.

In the space below produce a pneumatic circuit diagram for a safety mechanism that would perform this function. This function is an AND function. The arrow below is the final output once the two valves have been activated. Use this as part of your answer.



Output to
Guillotine

(6 marks)

Turn over ►

B2 A student has decided to use the monostable circuit shown in **Figure 2** as the timing element in a game being designed. The circuit is based around a 555 timer integrated circuit (IC).

- (a) Use the information given on the circuit diagram to help you to complete the table in **Figure 2** which describes the pins used for the connection of the 555 timer Integrated Circuit (IC).

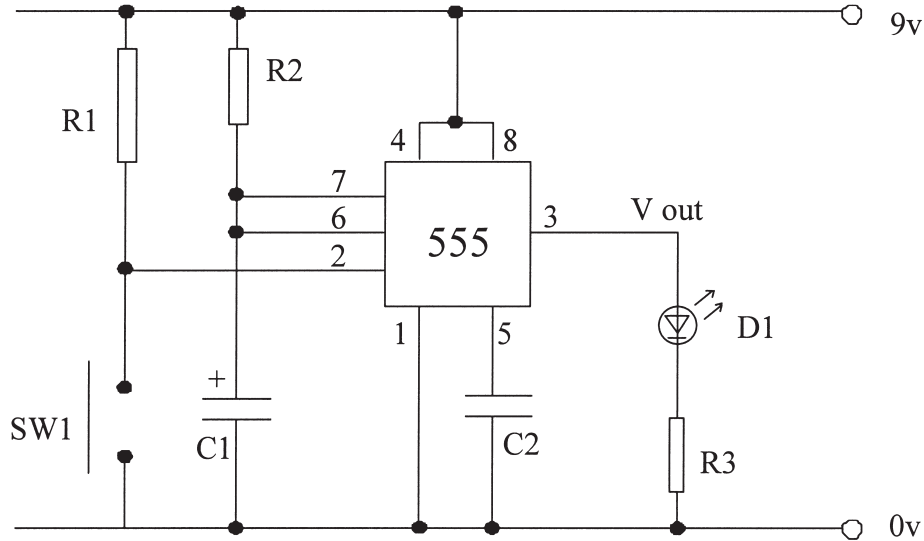


Figure 2

Pin number	Label	Pin number	Label
1		5	Control voltage
2		6	Threshold
3		7	Discharge
4	Reset	8	

Component D1 is a light emitting diode.

It has to be inserted with the correct for it to function correctly.
(5 marks)

- (b) The unlabelled version of the circuit chosen by the student is shown again below in **Figure 3**. Circle the two components that can be best used to control the timing of the pulse in the circuit shown below.

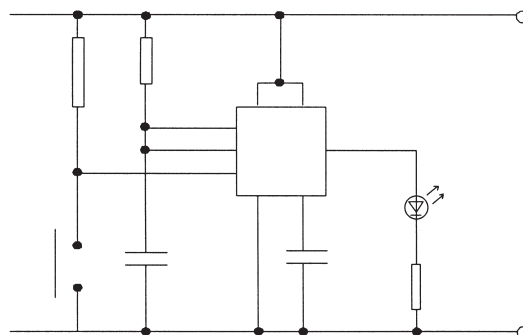
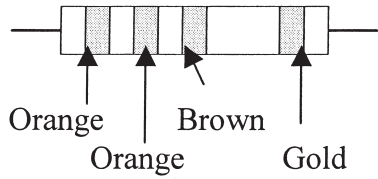


Figure 3

(2 marks)

(c) (i) Resistor 3, (R3), is shown in **Figure 4**.

What is the value of this resistor?



..... Ohms
(1 mark)

Figure 4

(ii) Explain what the Gold band indicates.

.....
(1 mark)

(iii) Explain why the resistor is positioned in series with the LED in **Figure 3**.

.....
.....
(2 marks)

(d) The 555 IC is a DIL chip. These chips can easily be damaged when fixing or handling.

Describe **two** precautions that can be taken to safeguard against damage.

1
.....
(1 mark)

2
.....
(1 mark)

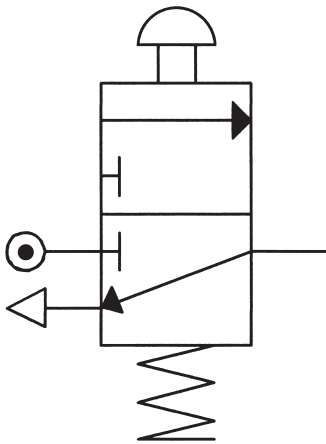
- (e) The circuit is to be assembled on a printed circuit board. The student has manufactured the case for the game out of *Medium Density Fibre Board* (MDF). In the space below show a suitable method of fixing the circuit board to the MDF case.

This question is worth 4 marks.

Marks will be awarded as follows:

Method of fixing the circuit board to the MDF case; (2 marks)
Quality of drawing. (2 marks)

B3 (a) Give the full name for the valve illustrated in **Figure 5**.



.....

.....

.....

.....

.....

(3 marks)

Figure 5

(b) A large toy shop has decided to produce a moving promotional display. The front of the display is moulded in plastic – (abs). The mechanisms, valves and control lines are attached behind it and are accessible from the rear.

Using the components listed below produce a simple pneumatic circuit drawing that will give a time delay to a piston movement.

Components:

single acting cylinder, flow regulator, reservoir, lever operated 3 port valve.

(4 marks)

(c) Air going into a cylinder is at a pressure of 0.5 N/mm^2 and the piston is 100 mm in diameter.

What force does the cylinder exert? Give units where applicable.

Force produced by cylinder = air pressure \times surface area of piston.

Area of piston =

.....

.....

Force =

.....

.....

$\pi = 3.142$

(3 marks)

10

TURN OVER FOR THE NEXT QUESTION

Turn over ►

- B4** The drawing **Figure 6** shows a toy train that has been manufactured using a variety of different plastic materials.

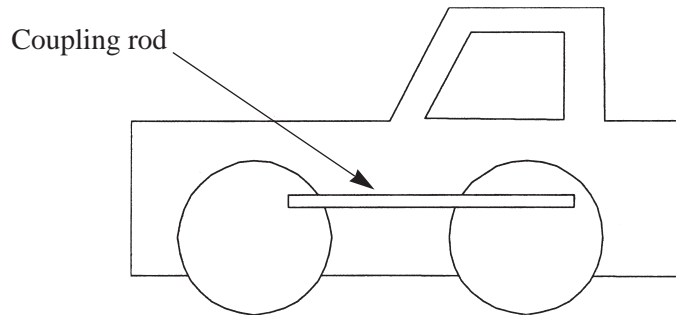


Figure 6

- (a) (i) **Figure 7** shows the coupling rod from the wheel linkage mechanism. It is to be made of plastic (hdp).

Which manufacturing process is best to use?

.....
(1 mark)

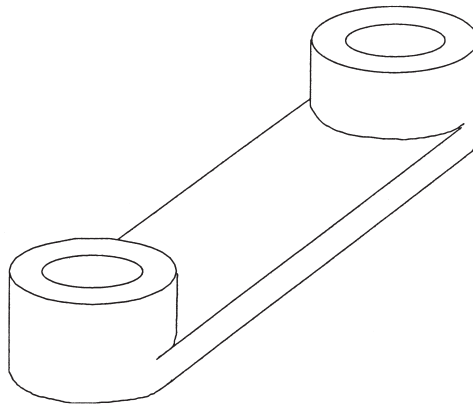
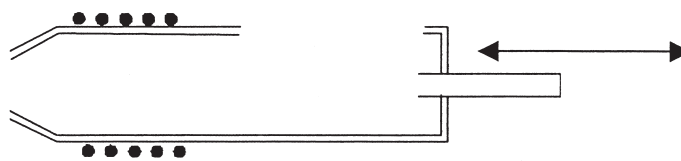


Figure 7

- (ii) The drawing in **Figure 8** is an incomplete drawing of the process used to manufacture the coupling rods.

Complete the drawing by showing the position of the split mould and the hopper in this manufacturing process.



Heater elements

Figure 8

(2 marks)

(b) Modify the drawing of the component shown in **Figure 7** to show how the component could easily be strengthened. ANSWER BY ADDING LINES TO THE DRAWING GIVEN ON THE PREVIOUS PAGE. (4 marks)

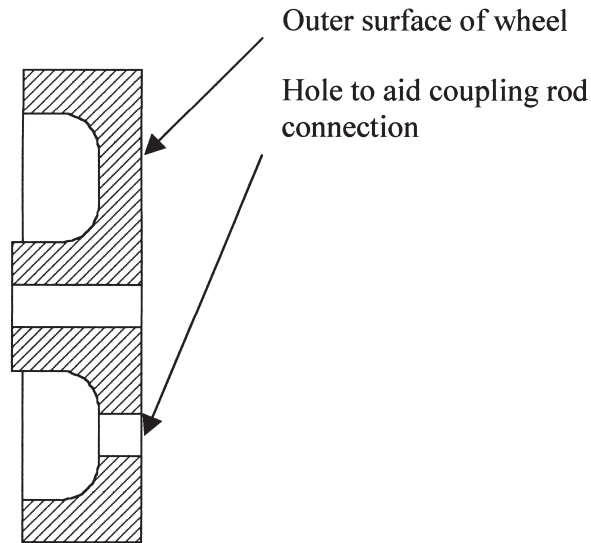
(c) (i) Which type of plastic is most suitable for recycling – thermoplastic or thermosetting plastic.

..... (1 mark)

(ii) Describe briefly how a manufacturer would recycle this type of plastic.

.....
.....
..... (2 marks)

(d) On the toy train a coupling rod connects the two wheels. This is shown in **Figures 6 and 7**. Sketch a suitable method of fixing this link to the wheel yet at the same time allowing it free rotation. You may use the given cross-section of the wheel or re-draw it in the space below.



Cross section
Through wheel

(4 marks)

Turn over ►

B5 A baggage-handling terminal at an airport has pneumatically controlled doors. The circuit diagram shown in **Figure 9** represents the system used.

- (a) Complete the sentences below to describe what happens in the pneumatic door system shown in **Figure 9**.

You are to use the letters when describing what happens. Eg. when valve A is operated cylinder D will

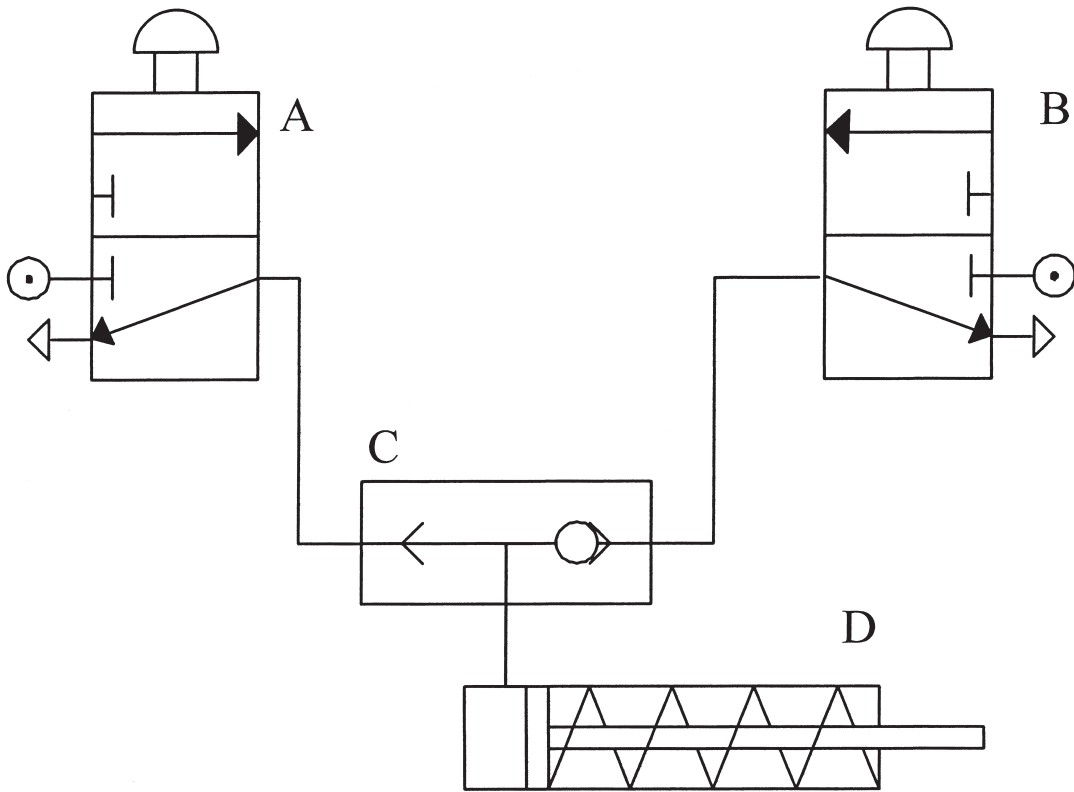


Figure 9

When valve A is activated

.....
.....

When valve B is activated

.....
.....

(2 marks)

- (b) In operation it was found that the door system would be safer if it could open quickly and close slowly.

In the space below, redraw and modify the pneumatic circuit given in **Figure 9** to allow the door to open quickly and close slowly when either valve is operated.

(5 marks)

- (c) Fill in the spaces below using words from the list below.

pneumatics	PICs	DILs	aluminium
electronics	welding	mechanics	steel
environments	risks	materials	fabrication

Many control systems use a combination of and: this is often called mechatronics.

A walking machine is a good example of a mechatronic system. Walking machines can be used in that are hostile to human beings.

Plastic materials and are often used in their construction as they have good strength to weight ratios.

The use of has reduced the need for many circuit components and therefore made the control devices much smaller.

(5 marks)

Turn over ►

B6 A heating system has been designed for a sauna. It ensures the following:

- the sauna operates within a given temperature range;
- if the temperature falls below the minimum level a heater is activated;
- if the temperature exceeds the maximum level the heat source is turned off.

The heater is turned on when the output voltage is high.

(a) (i) What is the name of a component that senses temperature.

.....
(1 mark)

(ii) In the space below draw the symbol that is used to represent this component.

(2 marks)

(b) The temperature control system flowchart for the process is partially completed in **Figure 10** below.

Complete the flowchart by adding to **Figure 10** as required.

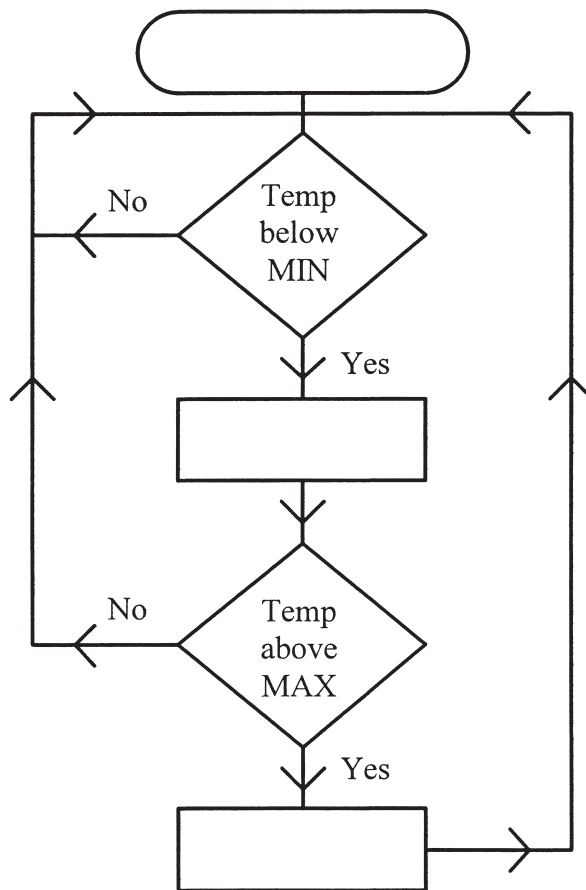


Figure 10

(3 marks)

(c) The heating system uses an AND logic gate.

Complete the logic gate symbol and truth table for an AND logic gate.



A	B	C
0	0	0
1	0	
0	1	
1	1	

(4 marks)

(d) A different way of controlling an electronic heating system is to use an Op Amp.

On the circuit shown in **Figure 11** label the indicated components using the given numbers or words.

- 1 – Op Amp
- 4 – Relay

- 2 – Transistor
- 5 – Heater

- 3 – Diode
- 6 – Potentiometer

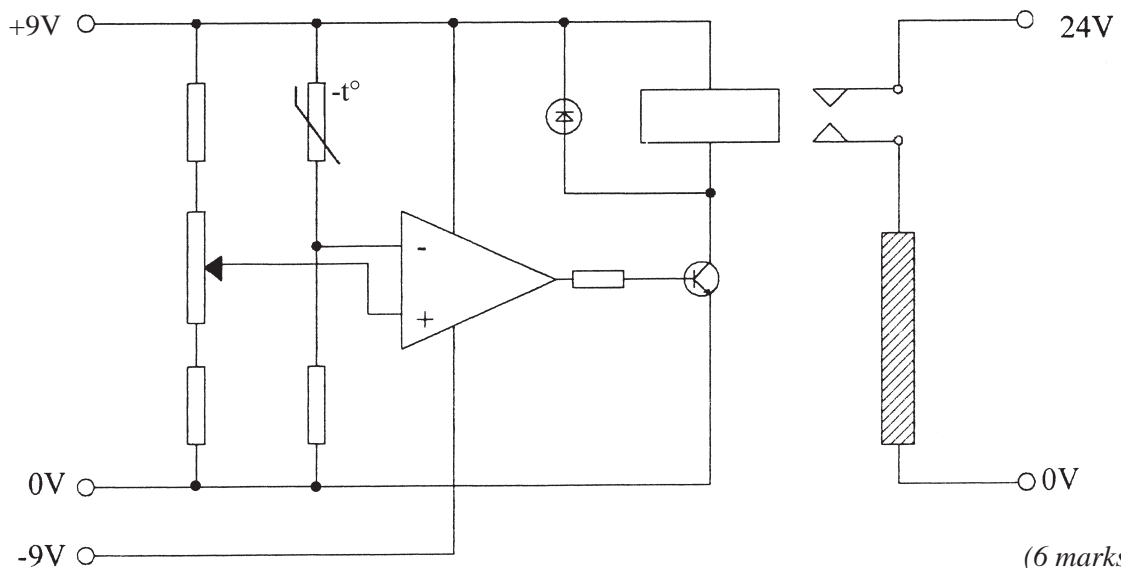


Figure 11

(6 marks)

(e) Explain the function of the diode in the circuit shown in **Figure 11**.

.....

 (2 marks)

(f) Explain why a relay is used in the circuit shown in **Figure 11**.

.....

 (2 marks)

Turn over ►

B7 (a) Computer Aided Design (CAD) is often used to design printed circuit boards and for use in electronic circuits.

(i) Give **two** advantages of using CAD.

.....
.....
(2 marks)

(ii) Give **one** disadvantage of using CAD.

.....
(1 mark)

(b) When CAD software is bought for use on a PC system the user purchases the license to use it. The following terms are all related to the purchasing and installation of software.

Briefly explain what they mean.

Single user license

Multi-user license

Software piracy

(3 marks)

(c) Printed circuit boards can be made using Computer Aided Milling machines.

Give **two** advantages and **one** disadvantage of producing a printed circuit board in this way.

Advantage 1
(2 marks)

Advantage 2
(2 marks)

Disadvantage
(2 marks)

(d) (i) Give **one** example of a product that is made using an automated production process.

.....
(1 mark)

(ii) Give **two** advantages that arise from the use of automated production machinery for your chosen product.

1
(1 mark)

2
(1 mark)

(e) You have designed a new product that is quite unique in the market place. Give **four** methods of marketing this product so that buyers become aware of it.

Method 1
(1 mark)

Method 2
(1 mark)

Method 3
(1 mark)

Method 4
(1 mark)

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TURN OVER FOR THE NEXT QUESTION

Turn over ►

B8 A local car park has an exit gate which is in the form of a barrier that raises when a car is sensed. The barrier is controlled pneumatically.

- The barrier must raise when a signal reaches it.
- It must stay open until a second signal reaches it.
- It will then lower slowly to the closed position.

Use **these two pages only** to sketch ideas for a design that will satisfy the brief for the barrier.

This question is worth 15 marks.

You will be marked as follows:

Pneumatic mechanism for raising and lowering barrier;	(5 marks)
Design for pneumatic circuit;	(5 marks)
Use of suitable components;	(2 marks)
Quality of drawings.	(3 marks)

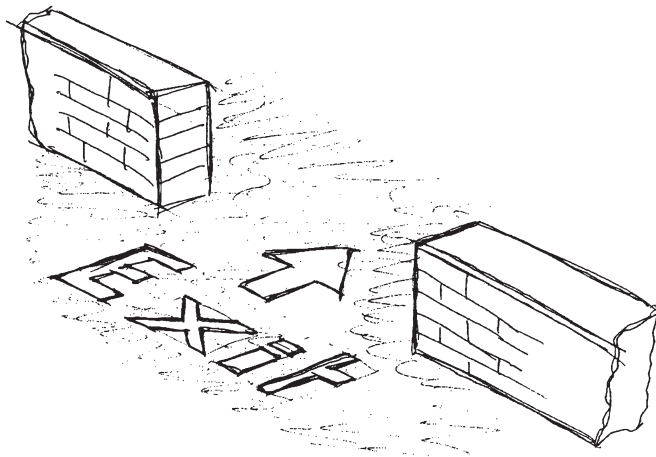


Figure 12

END OF QUESTIONS