

Surname					Other Names				
Centre Number					Candidate Number				
Candidate Signature									

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General Certificate of Secondary Education
Summer 2003

DESIGN AND TECHNOLOGY
Systems and Control Technology

HIGHER TIER

Thursday 19 June 2003 1.30 pm to 3.30 pm

3546/H

H



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

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

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. 22–42).

A1 (a) A fish tank environment is controlled by a number of control systems.

The monostable circuit in **Figure 1** is used to control the timing of the feeding of the fish. Use the information given 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).

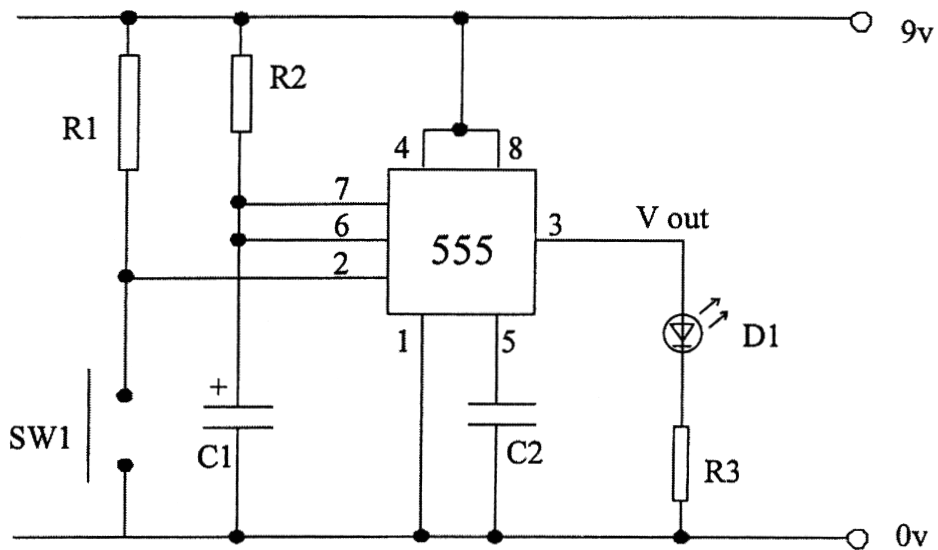


Figure 1

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

Figure 2

(4 marks)

Component D1 is a light emitting diode.

It has to be inserted with the correct for it to function correctly.
(1 mark)

QUESTION A1 CONTINUES ON THE NEXT PAGE

Turn over ►

- (b) The 555 IC used in the circuit is a DIL integrated circuit.

What does DIL mean?

.....
(1 mark)

What method is best used for locating a DIL integrated circuit?

.....
(1 mark)

- (c) Add a light dependant resistor and a variable resistor to the circuit shown in **Figure 3** that will enable the circuit to be activated when the light level drops. The variable resistor controls the sensitivity of the circuit.

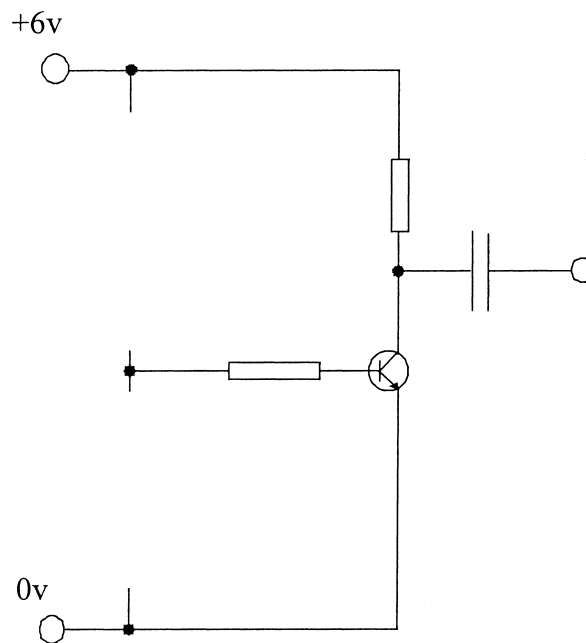


Figure 3

Correct components = 2

Quality of drawing = 1

(3 marks)

- (d) The circuit in **Figure 4** is used for the thermostatic control of the fish tank heating system. It is partially completed. Complete the diagram by inserting a relay and protection diode in the correct positions.

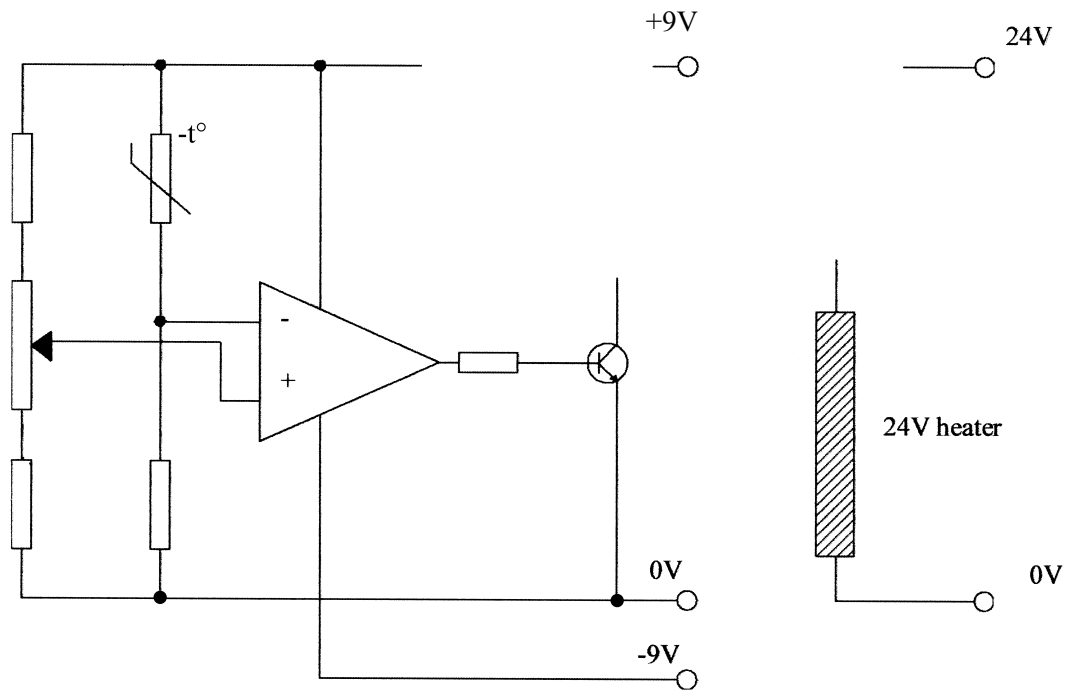


Figure 4

(4 marks)

14

TURN OVER FOR THE NEXT QUESTION

Turn over ►

A2 (a) A radio controlled racing car contains many mechanisms to transmit power and to change the directions of movement.

- (i) Identify the type of gear mechanism shown in **Figure 5** that is used in the steering mechanism.

.....
(1 mark)

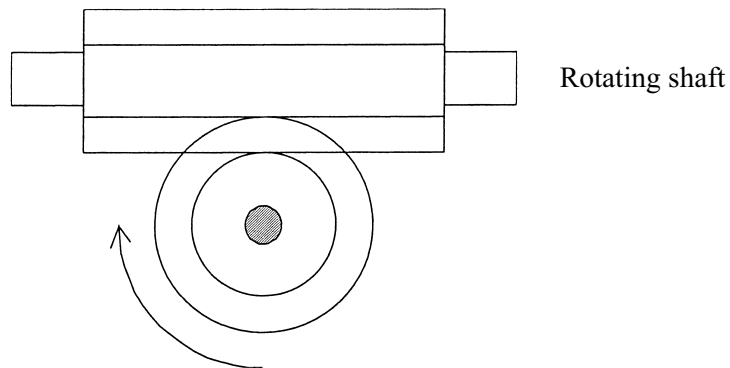


Figure 5

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

.....
(1 mark)

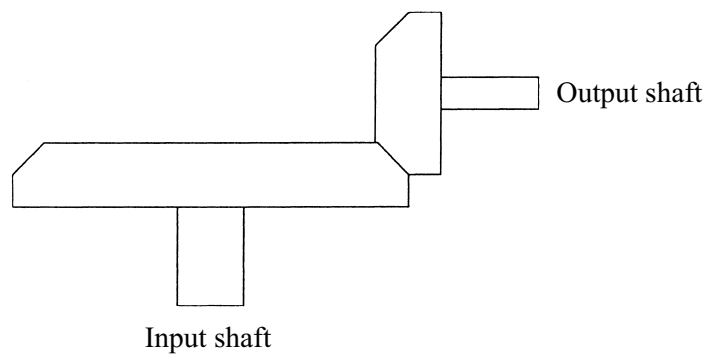


Figure 6

- (iii) Will the output shaft in the system above be rotating at the same speed, faster or slower?

.....
(1 mark)

- (b) Within the drive mechanism of the car it is necessary to change the speed of rotation of an output shaft whilst having it rotate in the same direction as the input shaft.

The diagram **Figure 7** shows the relative positions of the input and output shafts.

Draw a system that will work for heavy loads and **reduce** the speed of the output shaft whilst keeping the direction of rotation the same as that of the input shaft.



Figure 7

(4 marks)

- (c) Gears of the type in **Figure 8** are often used in confined spaces. What is the name given to this type of gear arrangement.

.....
(1 mark)

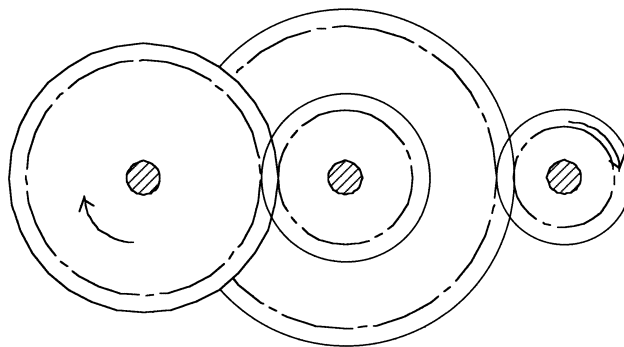


Figure 8

QUESTION A2 CONTINUES ON THE NEXT PAGE

Turn over ►

- (d) If the input shaft in the system in **Figure 9** is rotating at 200 rpm what speed will the output shaft be rotating at?

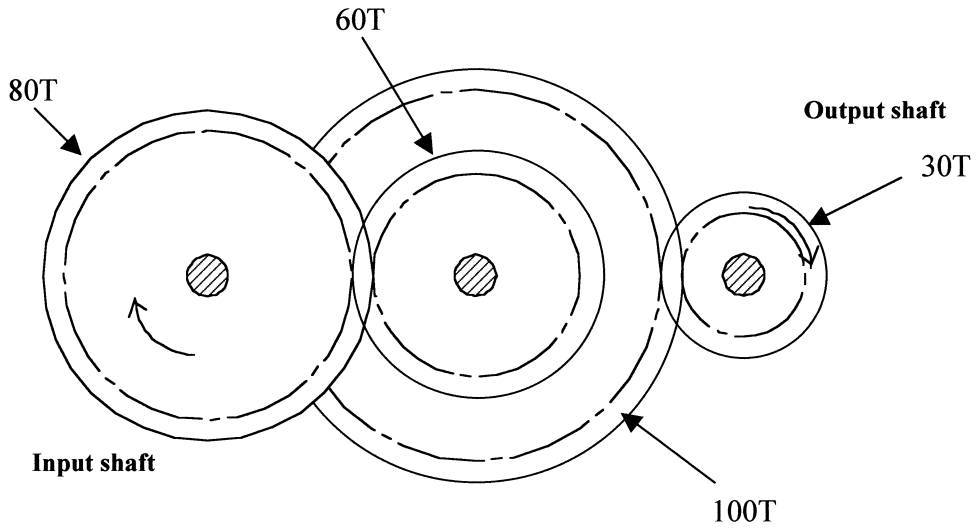


Figure 9

.....

.....

.....

.....

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.....

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.....

.....

.....

.....

(6 marks)

- (e) Drive belts are sometimes used to transmit rotational movement between shafts.

Give **two** advantages of using drive belts rather than gears.

.....

.....

(2 marks)

Give **two** disadvantages of using drive belts rather than gears.

.....

.....

(2 marks)

- A3** The drawing below shows a toy train that has been manufactured using a variety of different plastic materials.

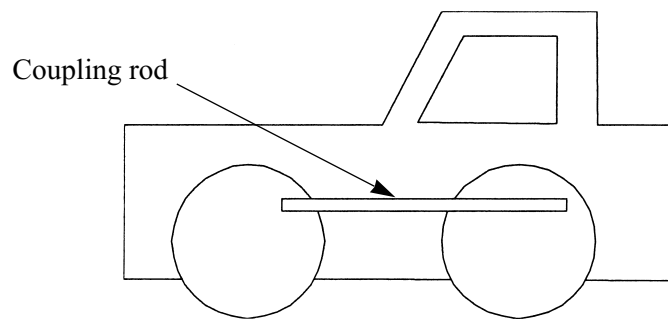


Figure 10

- (a) The drawings below show the coupling rod from the wheel linkage mechanism. It is to be made of plastic (hdp). The manufacturing process to be used is injection moulding.

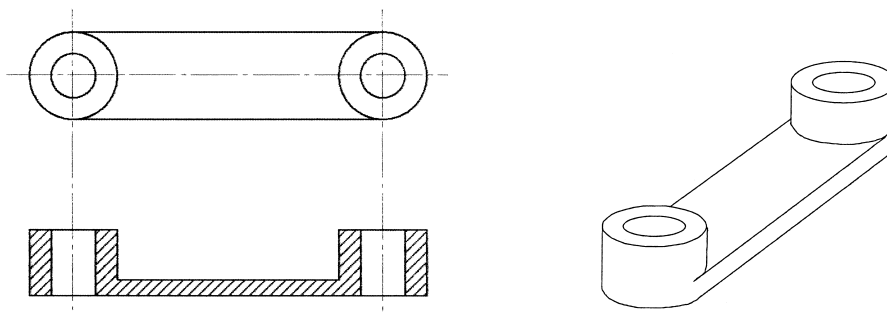


Figure 11

In the space below produce a labelled sketch showing the injection moulding process.

(6 marks)

- (b) The orthographic drawing of a coupling rod used in the drive mechanism of the train is shown in **Figure 12**. Modify this drawing to show a simple way of strengthening the rod.

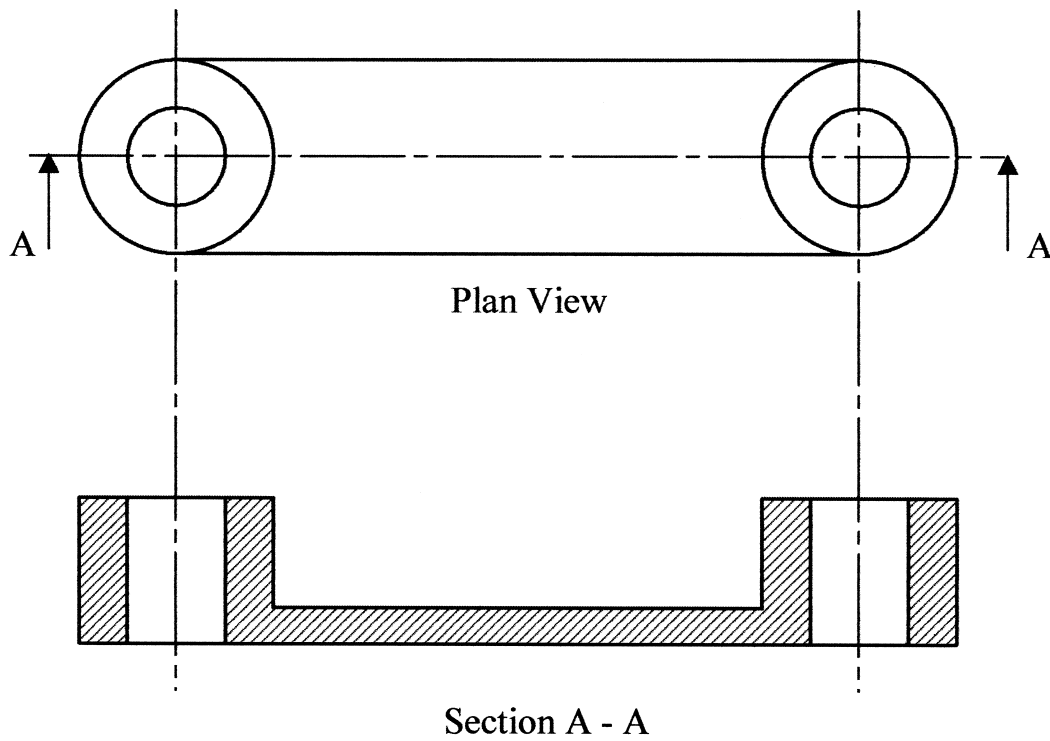


Figure 12

(4 marks)

- (c) Moving parts often require bearings to reduce friction. In the space below sketch a roller bearing.

(3 marks)

Turn over ►

A4 Many toys use cam mechanisms to impart motion. The rotating cam imparts a motion to the follower that in turn will cause another component to move. The first part of this question asks some general questions about cams and followers and the final part requires you to use your knowledge of cams to design a solution to a specific toy maker's problem.

- (a) On **Figure 13** draw a cam profile that will ensure a gradual rise followed by a fast fall. Indicate the direction of rotation.

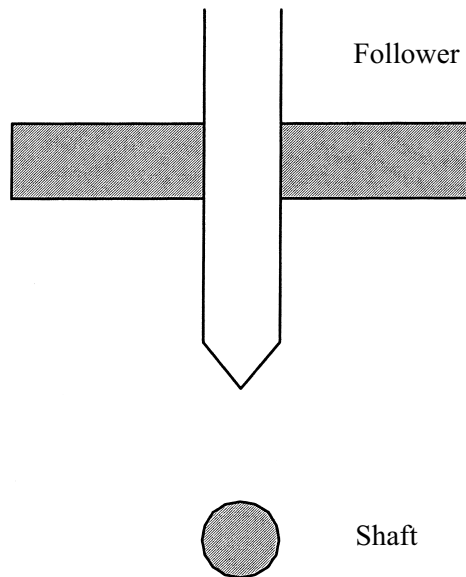


Figure 13

(4 marks)

- (b) To reduce friction in cam systems roller ended followers are often used.

In the space below sketch a roller ended follower.

(4 marks)

- (c) The diagram **Figure 14** shows a simple pull along toy that a toy maker wishes to produce. He wants the head and body of the driver to go **up** and **down** and **rotate** as the toy is pulled along. In the space below show how a mechanism including a cam may be used to satisfy this design requirement. You may use whatever drawing format you wish. Add notes to your drawing to explain how it works.

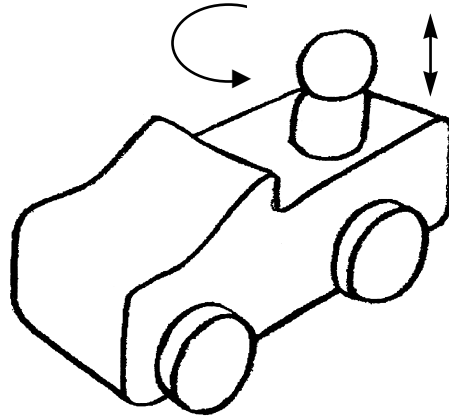


Figure 14

This question is worth 13 marks.

Marks will be awarded as follows:

Quality of sketching;	<i>(3 marks)</i>
Cam suitability for up/down motion;	<i>(4 marks)</i>
Suitability for rotational motion;	<i>(2 marks)</i>
Annotation.	<i>(4 marks)</i>

Turn over ►

A5 The design and production of printed circuit boards for use in electronic devices has changed in many ways to ensure a greater degree of operator safety and improved quality control. CAD and CAM are two of the areas that have helped to ensure high quality design and manufacturing processes to be developed. Increasingly these are being used in the school situation.

Using examples from school or industry answer the following questions.

(a) Computer aided design (CAD) is often used to design printed circuit boards 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 also 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** quality control 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)

TURN OVER FOR THE NEXT QUESTION

Turn over ►

- A6 (a)** A small cruise ship company uses two gang-planks on each of its ships. One of the gang-planks is for passengers getting on to the ship and the other is for passengers getting off.

For safety reasons the company requires a device that will give an audible alarm if a passenger attempts to board the ship by opening the exit gate and using the exit gang-plank. **Figure 15a** shows the layout of the exit gate when seen from above. If a person attempts to enter in the direction of arrow A the alarm is to sound.

If a person approaches in the opposite direction to arrow A the alarm is not to sound.

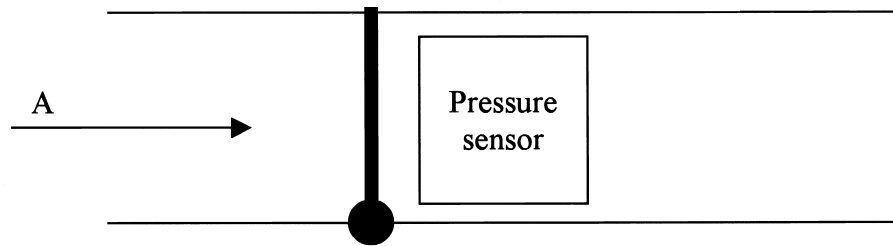
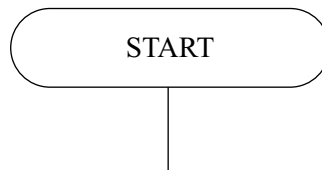


Figure 15a

In the space below develop a suitable flowchart that will show the logic to be used in the alarm system.



(10 marks)

- (b) **Figure 15b** below shows a seven-segment display for recording the numbers of people boarding a ship correctly. Each of the segments can be thought of as an LED which illuminates when it has a value of 1.

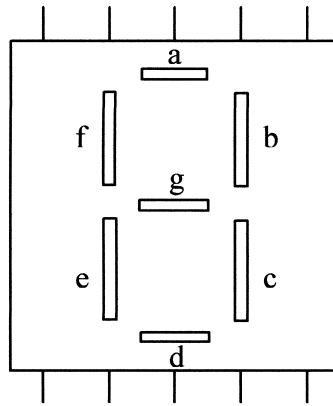


Figure 15b

Complete the grid below to show the combinations required to produce the number shown. A sample row has been completed for you.

Number	a	b	c	d	e	f	g
1	0	1	1	0	0	0	0
2							
5							
8							
9							

(1 mark)

(1 mark)

(1 mark)

(1 mark)

- (c) The audible alarm used to warn of passengers attempting to board the wrong gang-plank has to be very loud. For this reason it has been decided that it has to be a mains powered (240 volt) alarm siren.

Describe how a 9 volt control circuit could be used to trigger the high voltage circuit used in the alarm siren.

.....

.....

(2 marks)

QUESTION A6 CONTINUES ON THE NEXT PAGE

Turn over ►

- (d) The entry gang-plank has a counting circuit that is connected to the seven segment display. The counting circuit is triggered by a mechanical mechanism that is activated when the passenger leaves the gang plank to get onto the cruise ship.

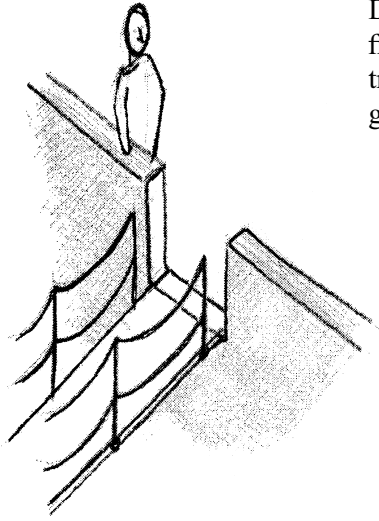


Figure 16

Design an activating mechanism which will fit onto the ship side rails or deck and will trigger when someone walks through the gap in the rails, as shown in **Figure 16**.

Add brief notes to your designs to explain how your mechanism works.

Use the space below and on page 19 to design your mechanism.

This question is worth 10 marks.

Marks will be awarded as follows:

Quality of idea;	(4 marks)
Notes;	(3 marks)
Quality of drawing.	(3 marks)

Turn over ►

A7 Many electronic devices contain PICs: (Programmable Interface Controllers). These components allow the circuit designer to incorporate many logic functions onto one customised integrated circuit.

A wagon designer has designed a wagon with a powered tailgate that allows items to be lowered and raised to and from the ground. The main stages in the operation are outlined in **Figures 17a and 17b**.

- The first operation of the tailgate is to tilt from the vertical to the horizontal position.

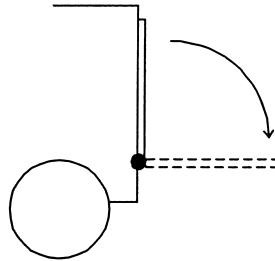


Figure 17a

- The second stage is when the tailgate lowers to the ground whilst remaining in the horizontal position.

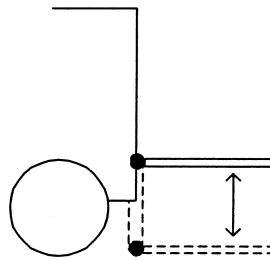


Figure 17b

The wagon designer has decided that the tailgate needs to have safety features that function during the operating process.

- Check 1: is there sufficient distance behind the wagon to allow the tailgate to tilt from the vertical to the horizontal position?
- Check 2: ensure that nothing is below the gate during the second stage of the lowering process. If an obstruction is detected the tailgate must stop and give an audible alarm. The operator must remove the obstruction before the process can continue.

Both of the sensors used in the checks transmit an electrical signal to the control chip when something is in a position of obstruction. The control chip is able to bring the system to a fail-safe state.

Using any presentations style for PIC design that you are familiar with show a program algorithm, logic diagram or process flowchart that would work for the situation described.

This question is worth 14 marks.

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. 3–21).

B1 (a) A fish tank environment is controlled by a number of control systems.

The monostable circuit in **Figure 1** is used to control the timing circuit used to feed the fish. Use the information given 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).

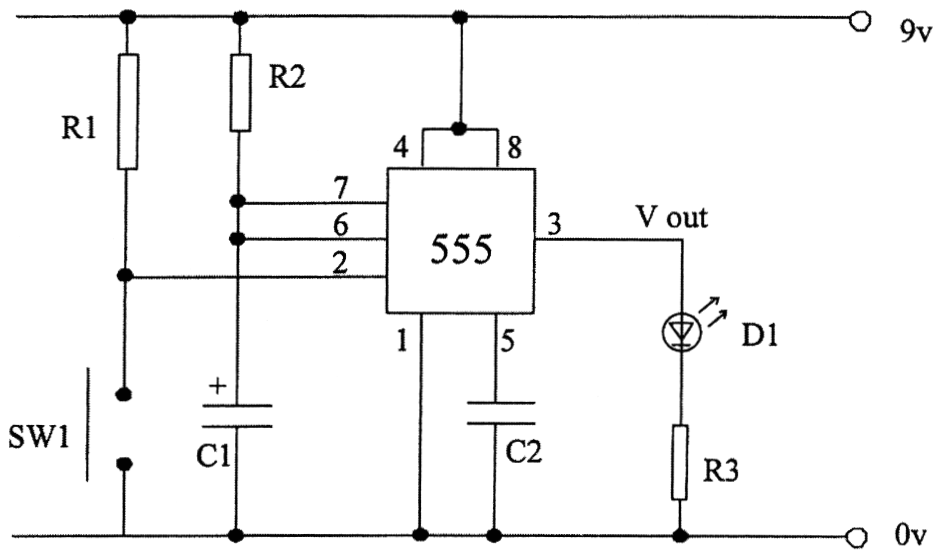


Figure 1

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

Figure 2

(4 marks)

Component D1 is a light emitting diode.

It has to be inserted with the correct for it to function correctly.
(1 mark)

- (b) The 555 IC used in the circuit is a DIL integrated circuit.

What does DIL mean?

.....
(1 mark)

What method is best used for locating a DIL integrated circuit?

.....
(1 mark)

- (c) Add a light dependant resistor and a variable resistor to the circuit shown in **Figure 3** that will enable the circuit to be activated when the light level drops. The variable resistor controls the sensitivity of the circuit.

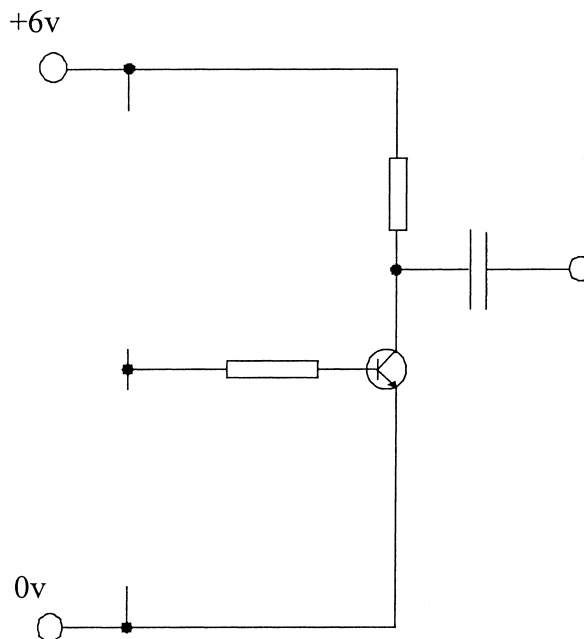


Figure 3

Correct components = 2

Quality of drawing = 1

(3 marks)

QUESTION B1 CONTINUES ON THE NEXT PAGE

Turn over ►

- (d) The circuit in **Figure 4** is used for the thermostatic control of the fish tank heating system. It is partially completed. Complete the diagram by inserting a relay and protection diode in the correct positions.

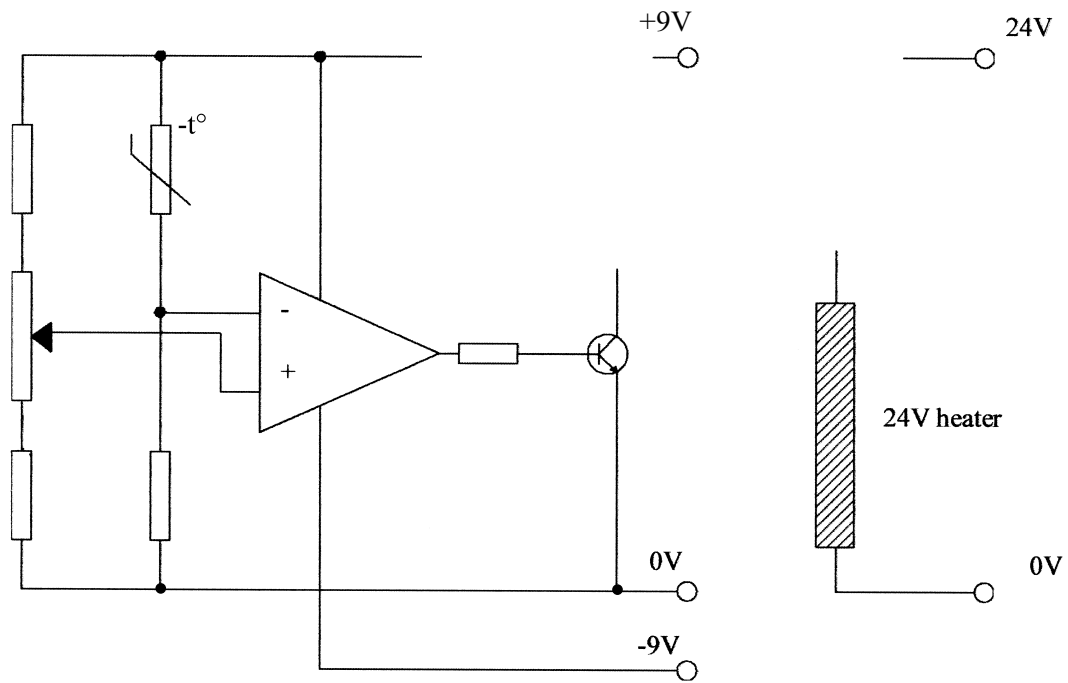
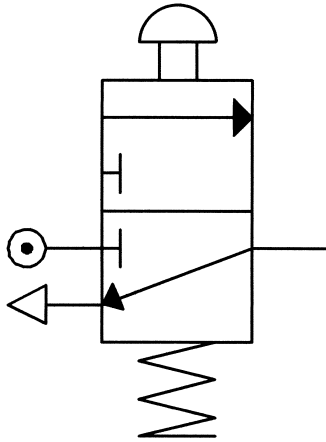


Figure 4

(4 marks)

- B2** (a) When designing and making pneumatic circuits off the shelf components are frequently used. A common component used in pneumatic circuits is shown in **Figure 5**.

Give the full name of the valve illustrated.



.....

.....

.....

.....

(4 marks)

Figure 5

- (b) A large toy shop has decided to produce an automated 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 show a simple assembly 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) An activating cylinder on the shop display has air going into a cylinder 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.

.....

.....

.....

.....

.....

.....

.....

$\pi = 3.142$ (6 marks)

- (d) Many commercial pneumatic systems utilise a fail-safe circuit.

What does the term fail-safe mean?

.....

.....

(1 mark)

Why is it necessary for a fail-safe circuit to have a separate air supply?

.....

.....

(1 mark)

Give an example of where a fail-safe circuit would be used.

.....

.....

(1 mark)

Why is the fail-safe circuit necessary in the situation described above?

.....

.....

(1 mark)

Turn over ►

- B3** The drawing **Figure 6** shows a toy train that has been manufactured using a variety of different plastic materials.

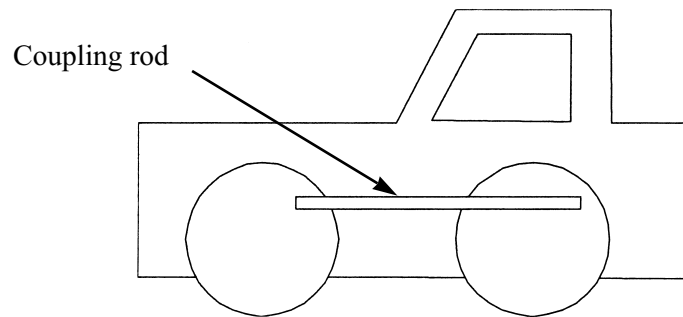


Figure 6

- (a) The drawings in **Figure 7** show the coupling rod from the wheel linkage mechanism. It is to be made of plastic (hdp). The manufacturing process to be used is injection moulding.

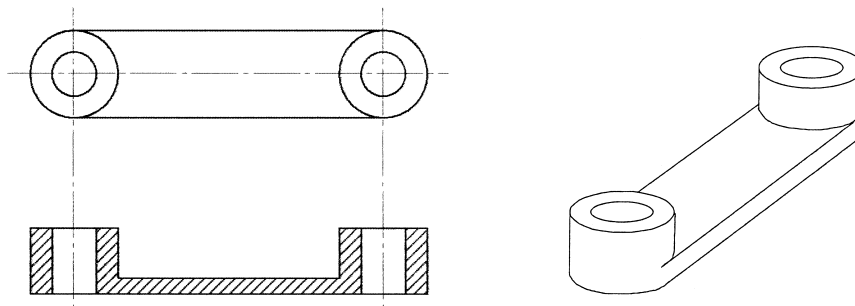


Figure 7

In the space below produce a labelled sketch showing the injection moulding process.

(6 marks)

- (b) The orthographic drawing of a coupling rod used in the drive mechanism of the train is shown in **Figure 8**. Modify this drawing to show a simple way of strengthening the rod.

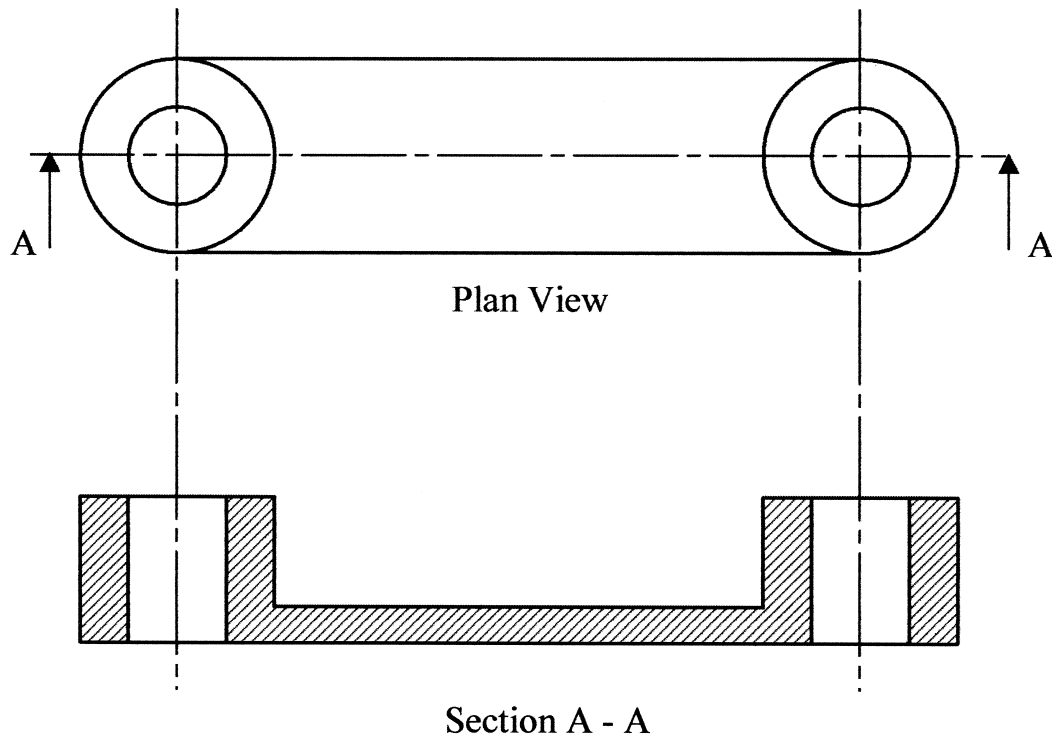


Figure 8

(4 marks)

- (c) Moving parts often require bearings to reduce friction. In the space below sketch a roller bearing.

(3 marks)

Turn over ►

B4 Many automated production lines use pneumatic systems.

- (a) The diagram **Figure 9** shows part of a production line. The item shown in dotted lines travels from left to right. When it hits the stop at the right hand side a clamp is activated to hold the work as shown.

Two valves and control mechanisms are used to sense the following before it is clamped:

- the presence of the item at A;
- the presence of the item at B.

Complete the drawing below to show the most suitable activating mechanism, valve symbol and connections for each of the valves shown.

Ensure that the activating mechanism is shown in the position it would be BEFORE the item slid into position.

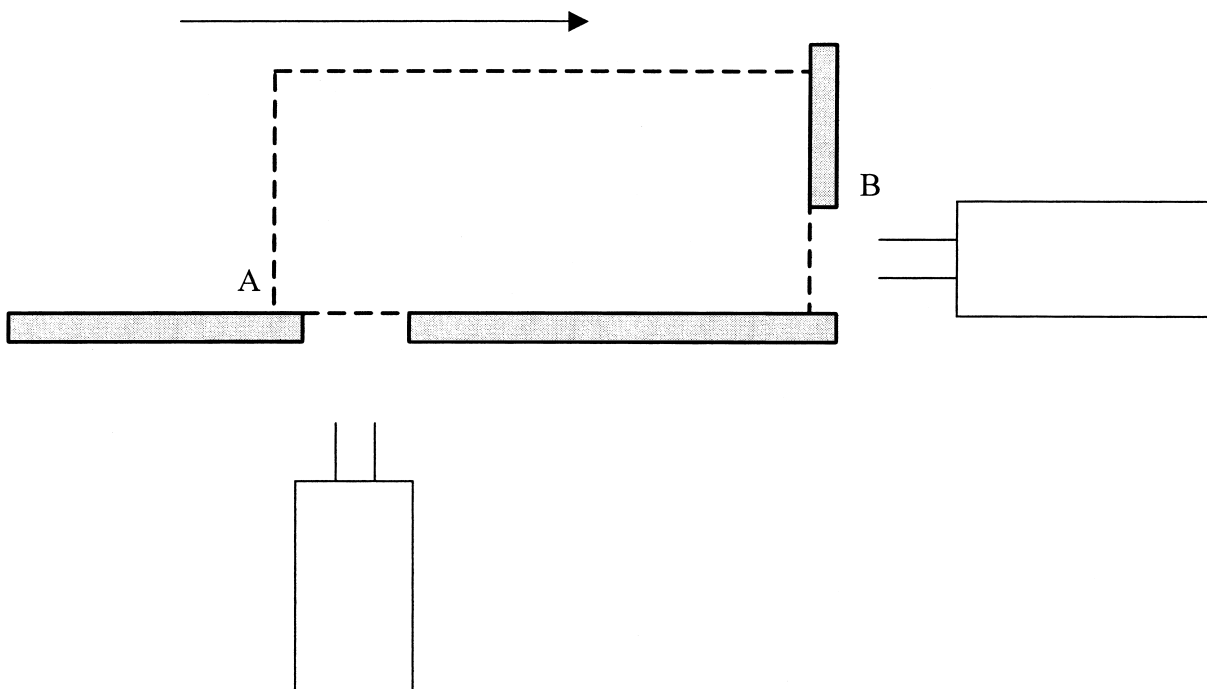


Figure 9

(4 marks)

- (b) The two control valves on the production line are used to sense the presence of the item. Only when both valves are opened will the next process begin. This is a safety feature that ensures that the machine cannot operate unless the item is correctly positioned.

Complete the circuit diagram **Figure 10** showing how the two valves would be connected to perform this function.

You need to complete the drawings of the valves and the necessary control lines. The arrow below is the final output line once the two valves have been activated. Use this as part of your answer.

This question is worth 10 marks.

Marks will be awarded as follows:

Quality of sketching;	(2 marks)
Completion of valves;	(6 marks)
Correct connection of valves.	(2 marks)

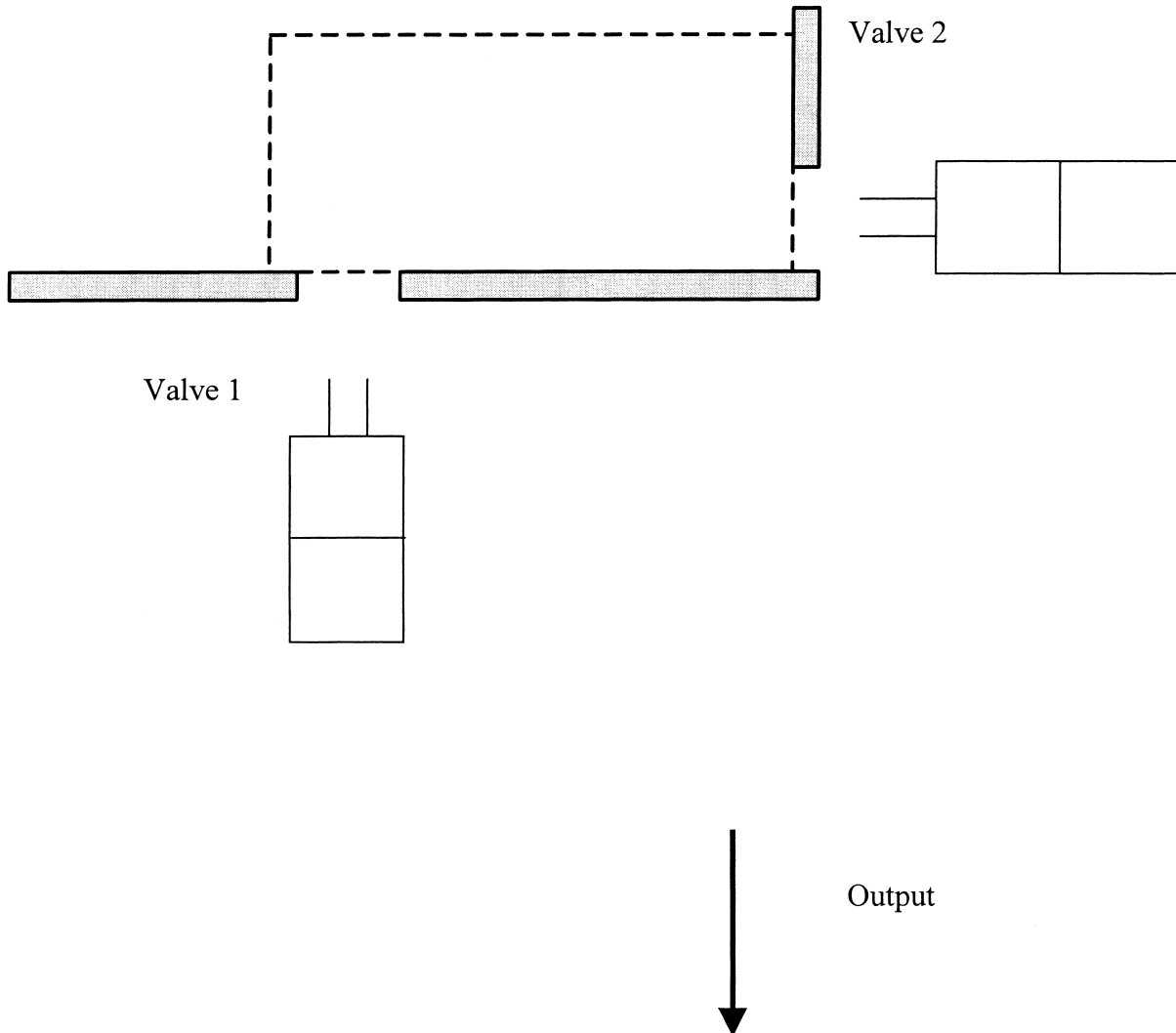


Figure 10

QUESTION B4 CONTINUES ON THE NEXT PAGE

Turn over ►

- (c) The manufacturer has decided that the output from the sensing valves should activate a single acting cylinder that will clamp the item to the table ready for a machining process to commence.

In **Figure 11** modify the drawing to show where the cylinder would be positioned and the necessary lines that would connect to it. It is spring loaded to return to the unclamped position.

This question is worth 7 marks.

Marks will be awarded as follows:

Quality of sketching;	(2 marks)
Completion of cylinder & activating rod;	(4 marks)
Correct connection of cylinder to output.	(1 mark)

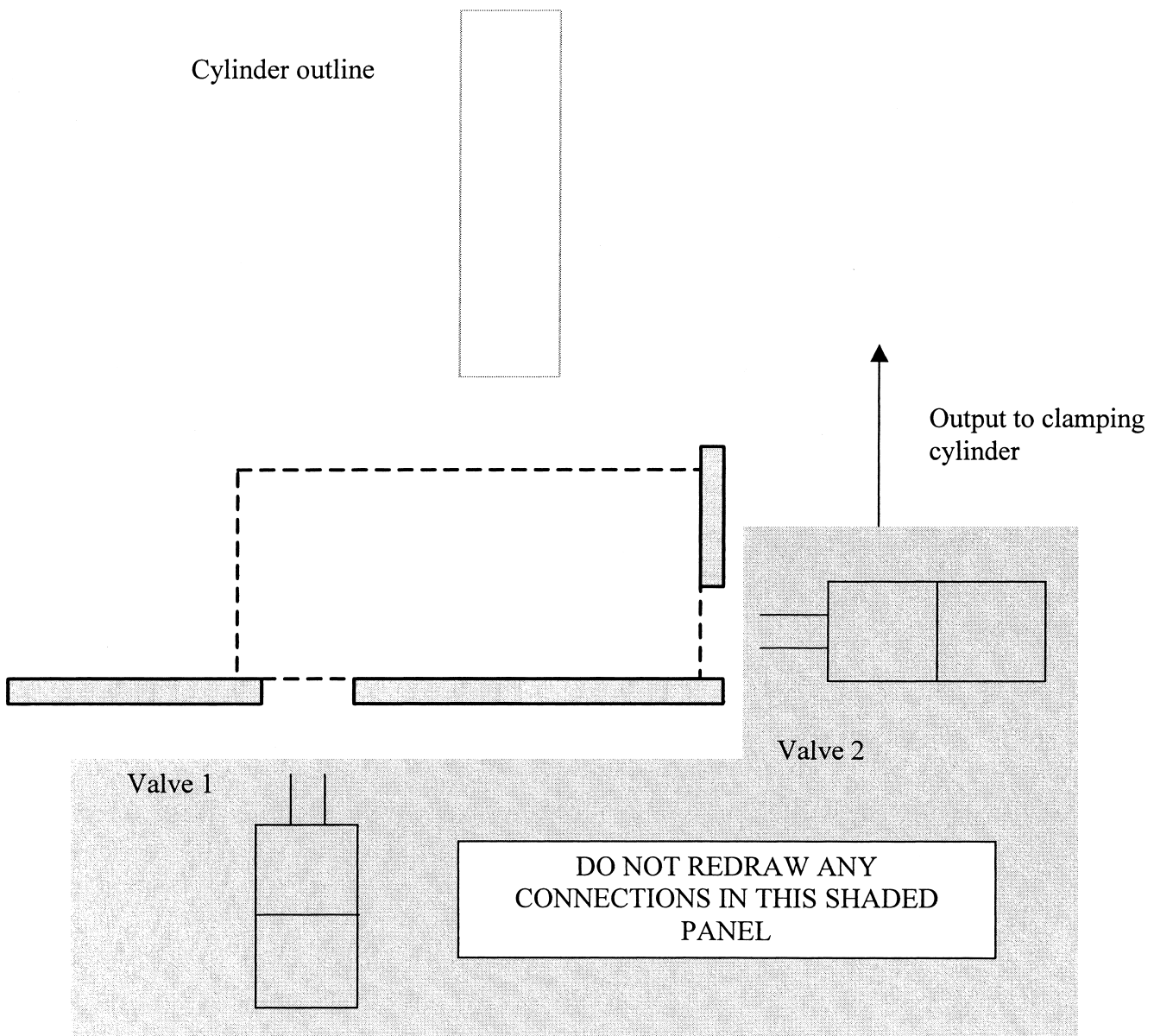


Figure 11

B5 The design and production of printed circuit boards for use in electronic devices has changed in many ways to ensure a greater degree of operator safety and improved quality control. CAD and CAM are two of the areas that have helped to ensure high quality design and manufacturing processes to be developed. Increasingly these are being used in the school situation.

Using examples from school or industry answer the following questions.

(a) Computer aided design (CAD) is often used to design printed circuit boards 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 following terms mean.

Single user license

Multi-user license

Software piracy

(3 marks)

(c) Printed circuit boards can also 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** quality control advantages that arise from the use of automated production machinery for your chosen product.

.....
(1 mark)

.....
(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 ►

- B6** (a) A small cruise ship company uses two gang-planks on each of its ships. One of the gang-planks is for passengers getting onto the ship and the other is for passengers getting off.

For safety reasons the company requires a device that will give an audible alarm if a passenger attempts to board the ship by opening the exit gate and using the exit gang-plank. **Figure 12a** shows the layout of the exit gate when seen from above. If a person attempts to enter in the direction of arrow A the alarm is to sound.

If a person approaches in the opposite direction to arrow A the alarm is not to sound.

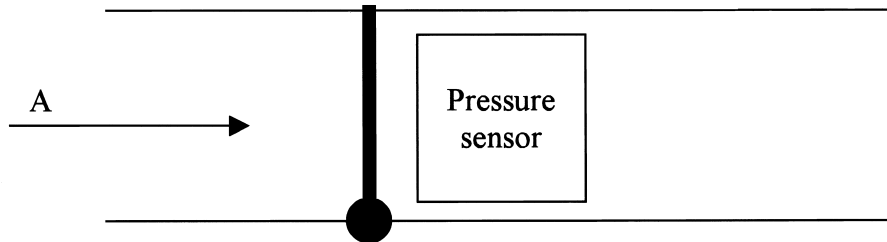
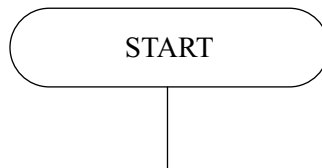


Figure 12a

In the space below develop a suitable flowchart that will show the logic to be used in the alarm system.



(10 marks)

- (b) **Figure 12b** below shows a seven-segment display for recording the numbers of people boarding the ship correctly. Each of the segments can be thought of as an LED which illuminates when it has a value of 1.

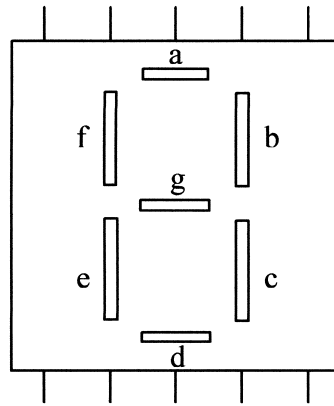


Figure 12b

Complete the grid below to show the combinations required to produce the numbers shown. A sample row has been completed for you.

Number	a	b	c	d	e	f	g
1	0	1	1	0	0	0	0
2							
5							
8							
9							

(1 mark)
(1 mark)
(1 mark)
(1 mark)

- (c) The audible alarm used to warn of passengers attempting to board the wrong gang-plank has to be very loud. For this reason it has been decided that it has to be a mains powered, (240 volt), alarm siren.

Describe how a 9 volt control circuit could be used to trigger the high voltage circuit used in the alarm siren.

.....
.....

(2 marks)

- (d) In the space below and on page 39, design a pneumatically controlled barrier that will close the space once the final passenger has boarded. The barrier will be located in the opening in the side walls as shown in **Figure 13**.

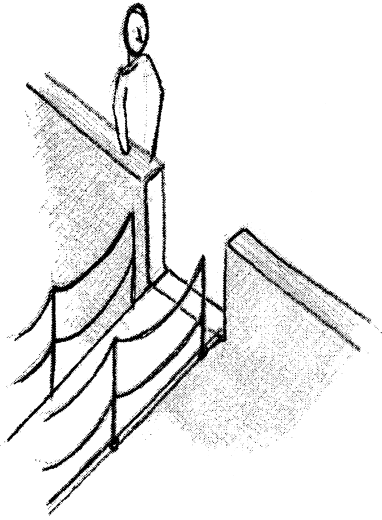


Figure 13

Add brief notes to your designs to explain how your barrier works.

This question is worth 10 marks.

Marks will be awarded as follows:

Quality of idea;	<i>(4 marks)</i>
Notes;	<i>(3 marks)</i>
Quality of drawing.	<i>(3 marks)</i>

Turn over ►

B7 Many electronic devices contain PICs: (Programmable Interface Controllers). These components allow the circuit designer to incorporate many logic functions onto one customised integrated circuit.

A wagon designer has designed a wagon with a pneumatically powered tailgate that allows items to be lowered and raised to and from the ground. The main stages in the operation are outlined in **Figures 14a and 14b**.

- The first operation of the tailgate is to tilt from the vertical to the horizontal position.

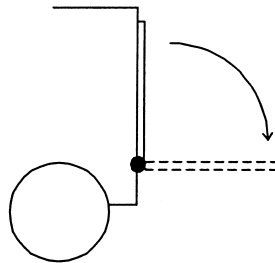


Figure 14a

- The second stage is when the tailgate lowers to the ground whilst remaining in the horizontal position.

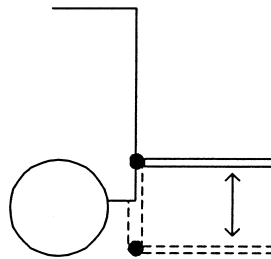


Figure 14b

The wagon designer has decided that the tailgate needs to have some electronic safety features that function during the operation process.

- Check 1: is there sufficient distance behind the wagon to allow the tailgate to tilt from the vertical to the horizontal position?
- Check 2: ensure that nothing is below the gate during the second stage of the lowering process. If an obstruction is detected the tailgate must stop and given an audible alarm. The operator must remove the obstruction before the process can continue.

Both of the sensors used in the checks transmit an electrical signal to the control chip when something is in a position of obstruction. The control chip is able to bring the system to a fail-safe state.

Using any presentations style for PIC design that you are familiar with show a program algorithm, logic diagram or process flowchart that would work for the situation described.

This question is worth 14 marks.

END OF QUESTIONS