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General Certificate of Education
January 2009

Technology and Design

Assessment Unit A2 3

assessing

Unit 6 – Systems and Control in Product Design

[A2V31]

A2V31

FRIDAY 16 JANUARY, MORNING

TIME

2 hours 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number on the Answer Booklet provided and on the A3 pro forma answer pages provided.
Answer **three** questions.
Answer the **one** question in Section A and **either** the **two** questions in Section B **or** the **two** questions in Section C.
Answers to Questions **1(a)(v)** or **1(b)(v)**, Question **4(a)(v), 4(b)** and Question **5(c)(ii), (iii) and (iv)** should be made on the A3 pro forma answer pages provided.

INFORMATION FOR CANDIDATES

The total mark for this paper is 80, including a maximum of 4 marks for quality of written communication.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
At the conclusion of the examination, attach the A3 pro forma answer pages securely to the Answer Booklet with the treasury tag supplied.
You are provided with an insert sheet for Question **1**.
Do not write your answers on this insert.
A materials data sheet is provided.

Section A

This question is compulsory.

You are advised to spend 1 hour and 15 minutes on this section.
You are required to answer **either 1(a)** or **1(b)**.

For candidates studying Electronic and Microelectronic control systems answer part (a) using the pro forma (answer 1(a)(v)) and an answer booklet.

1 (a) **Fig. 1(a)** shows a prototype test rig used to test the performance of tennis rackets. The following sequence occurs.

- The tennis racket is secured in position and Door 1 is closed.
- The hopper is filled with a set number of tennis balls and the operator selects at the control panel one of the three speeds for Motorised Gearbox A after closing Door 2.
- From the control panel the operator controls the Stepper Motor to set the distance between the tennis racket and the ball launcher.
- The operator selects at the control panel an angle between position 1 and position 2 at which the ball will hit the racket. This is controlled by Motorised Gearbox B.
- The test can only begin when the two doors are closed and the operator presses the start button on the control panel.
- When this happens, Motorised Gearbox A starts and a signal activates the electromechanical release at the bottom of the hopper to release a ball from the chute every 5 seconds.
- When the hopper and chute are empty Motorised Gearbox A stops allowing the operator to collect the tennis balls and change the settings if required.

(i) With reference to **Fig. 1(a)** suggest a suitable composite for the central panel and briefly outline **two** main reasons why your choice would be suitable. [3]

(ii) With reference to **Fig. 1(a)** suggest a suitable metal for the I profile test bed and briefly describe how it would be manufactured. [2]

(iii) Using annotated sketches briefly outline **two** alternative methods that may be used to detect if the doors have been closed. [4]

(iv) Briefly outline the type of logic function used for **two** distinctly different situations on the test rig. [2]

(v) On the pro forma provided (answer number **1(a)(v)**) use Electronic and Microelectronic circuit diagrams with annotation to produce a viable solution that will fulfil each of the specified points stated below.

(N.B. All brackets, housings, screws, nuts and bolts are not required)

- Design a circuit that will allow the operator to pre-select one of three speeds for Motorised Gearbox A. When the start button is pressed the motor should run at the selected speed (assume the start button is a push to make switch). [4]

- Design a circuit that will allow the operator, from the control panel, to move the Stepper Motor forwards and backwards to adjust the distance between the tennis racket and the ball launcher (**Fig. 1(a)(i)**). [6]

- Design a circuit that will indicate the angle at which the tennis racket holder is being held (**Fig. 1(a)(ii)**). This angle should then be shown on the seven segment displays on the control panel. [12]

- Design a circuit that will provide a 1 second pulse every 5 seconds that could be used to trigger the electromechanical release at the bottom of the hopper. [5]

For candidates studying Pneumatic and Mechanical control systems answer part (b) using the pro forma (answer 1(b)(v)) and an answer booklet.

1 (b) **Fig. 1(b)** shows a test rig used to test the performance of tennis rackets.
The following sequence occurs.

- The tennis racket is secured in position and Door 1 is closed.
- The hopper is filled with a set number of tennis balls and the operator selects one of the three speeds for Motorised Gearbox A after closing Door 2.
- From the control panel the operator controls Motorised Gearbox B to set the distance between the tennis racket and the ball launcher.
- The operator, from the control panel, then sets the angle of the tennis racket holder to either position 1 or position 2.
- The test can only begin when the two doors are closed and the operator presses the start button on the control panel.
- When this happens, Motorised Gearbox A starts and a signal activates the electromechanical release at the bottom of the hopper to release a ball from the chute every 5 seconds.
- When the hopper and chute are empty Motorised Gearbox A stops allowing the operator to collect the tennis balls and change the settings if required.

(i) With reference to **Fig. 1(b)** suggest a suitable composite for the central panel and briefly outline **two** main reasons why your choice would be suitable. [3]

(ii) With reference to **Fig. 1(b)** suggest a suitable metal for the I profile test bed and briefly describe how it would be manufactured. [2]

(iii) Using annotated sketches briefly outline **two** alternative methods that may be used to detect if the doors have been closed. [4]

(iv) Briefly outline the type of logic function used for **two** distinctly different situations on the test rig. [2]

(v) On the pro forma provided (answer number **1(b)(v)**) use Pneumatic and Mechanical circuit diagrams with annotation to produce a viable solution that will fulfil each of the specified points stated below.

(N.B. All brackets, housings, screws, nuts and bolts are not required)

- Design a suitable mechanism driven from the output shaft of Motorised Gearbox B that will move the carriage along the test bed (**Fig. 1(b)(i)**). [4]

- Design a suitable system that will allow the operator to set the angle of the tennis racket holder to either position 1 or position 2 **(Fig. 1(b)(ii)**). [6]

- Design a gearbox using only gears with teeth between 20 and 100 that will provide an output speed of 1920 rpm from an input of 20 rpm. Then with the minimum number of additional gears with teeth between 20 and 100, show how you would achieve the second and third output speeds. **(Show all calculations and state clearly the number of teeth for each of the gears (Fig. 1(b)(iii))**. [12]

- Design a suitable mechanism that will provide a positive drive from the output shaft of Motorised Gearbox A to shaft B in order to launch the tennis ball. Show how the design is attached to the shafts **(Fig. 1(b)(iii)**). [5]

Section B

Electronic and Microelectronic Control Systems

Answer **both** questions in this section.

2 A voltage divider is connected to a power supply as shown in **Fig. 2(a)**.

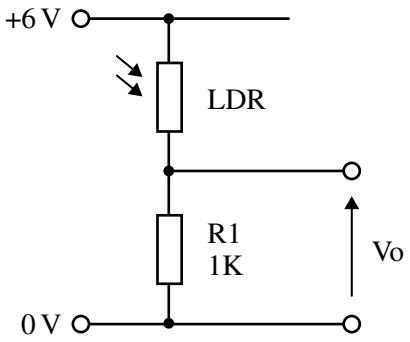

Fig. 2(a)

(a) (i) A light dependent resistor (LDR) can be used as the basis for a sensor to measure light. State the principal physical property of the LDR that is used in the measurement of light. [1]

(ii) Under certain light conditions the resistance of the LDR shown in **Fig. 2(a)** will vary from 2000 Ω to 2500 Ω. Calculate the corresponding values for Vo. [2]

(b) Part of a system for testing the clarity of recycled glass samples is shown in **Fig. 2(b)**. The opaque box contains a light source which is to be placed on one side of the glass sample while the circuit from **Fig. 2(a)** is to be placed on the other side. A digital voltmeter (DVM) is to be used to display the results of the tests.

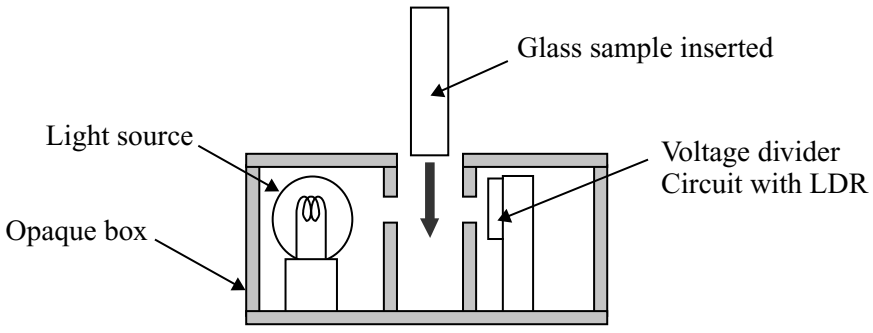

Fig. 2(b)

(i) It is required that the voltage to be displayed by the DVM, in millivolts, should represent the percentage clarity of the glass with the number displayed varying between 0 and 100. The voltage from the voltage divider is found to vary by a maximum of 50 mV. An amplifier is needed to meet this requirement. Determine the gain of the amplifier. [2]

(ii) Design a non inverting amplifier circuit based on an op-amp that will have the required gain from **(b)(i)**. The gain of a non inverting amplifier is given by $1+\frac{R_f}{R}$ where R_f is the feedback resistor. [4]

(iii) Digital Voltmeters are available with either seven segment LED displays or LCD displays. State **one** main advantage and **one** main disadvantage of each type of display. [2]

(c) A simple "pass/fail" quality test for glass samples could be produced by using a PIC as shown in **Fig. 2(c)**. The PIC has an analogue to digital converter (ADC). The voltage range of the ADC port (i/p1) is from 0 V to 6 V with corresponding digital values ranging from 0 to 255.

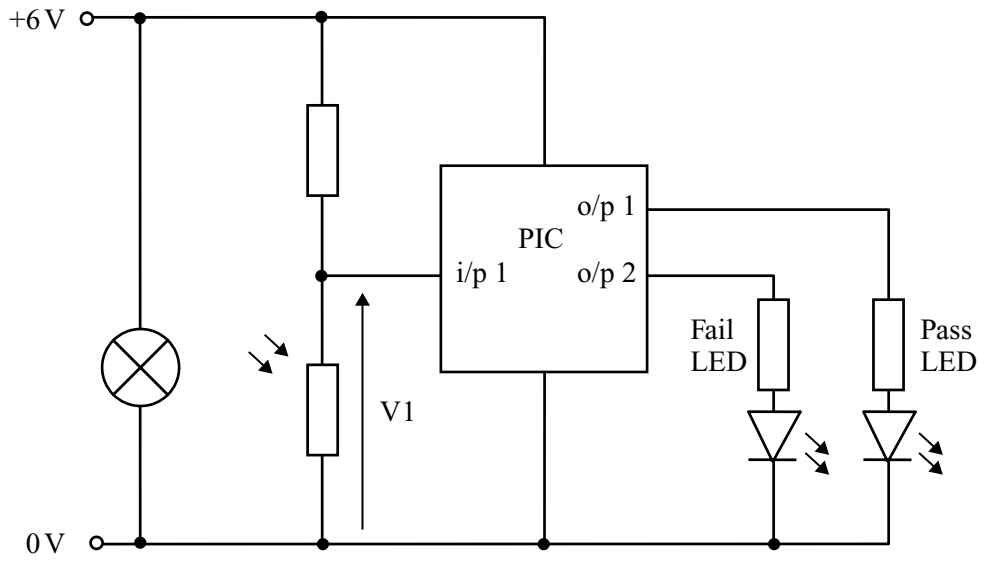

Fig. 2(c)

(i) Briefly outline what is meant by the term **analogue to digital conversion**. [2]

(ii) When the input voltage V1 in **Fig. 2(c)** is greater than 0.8 V the glass sample is considered to have failed the quality test. Determine the digital value that corresponds to 0.8 V provided by the ADC. [2]

(iii) For the PIC circuit shown in **Fig. 2(c)**, write a suitable flowchart program that will continuously check the ADC port (i/p1) and turn on the appropriate LED. [4]

3 A car wash system consists of an eight stage sequence where high pressure water is required at stages 1, 3, 6 and 8. The stages are incremented by the output from a 3-bit binary counter with outputs A, B and C, where A is the least significant bit. The high pressure water supply is switched on and off by a 110 volt solenoid valve which is controlled by a logic circuit.

(a) (i) Draw a truth table for the logic circuit that controls the high pressure water solenoid, assuming that the output of the logic circuit is F. [5]

(ii) Using a Karnaugh Map, deduce a minimised expression for the output F. [4]

(iii) Draw a logic circuit that would produce the required output F. [2]

(iv) The position of a vehicle in a car wash could be determined by using an ultrasonic system. Briefly explain how such a system could be used to achieve this. [1]

Fig. 3(a) shows how a 110 V water solenoid valve is interfaced to the logic circuit from **3(a)(iii)**.

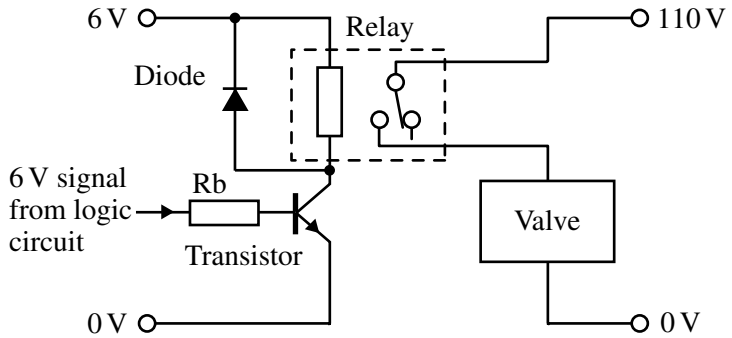

Fig. 3(a)

(b) (i) State the function of each of the following components in the circuit shown in **Fig. 3(a)**.

- transistor
- relay
- diode [3]

(ii) Calculate a suitable value for resistor Rb in **Fig. 3(a)** if the gain of the transistor is 100 and the relay coil is 60 ohms. (Assuming that Vbe is 0.7 volts) [4]

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Section C

Pneumatic and Mechanical Systems

Answer **both** questions in this section.

4 **Fig. 4(a)** shows a cam and follower mechanism used as part of a visual display.

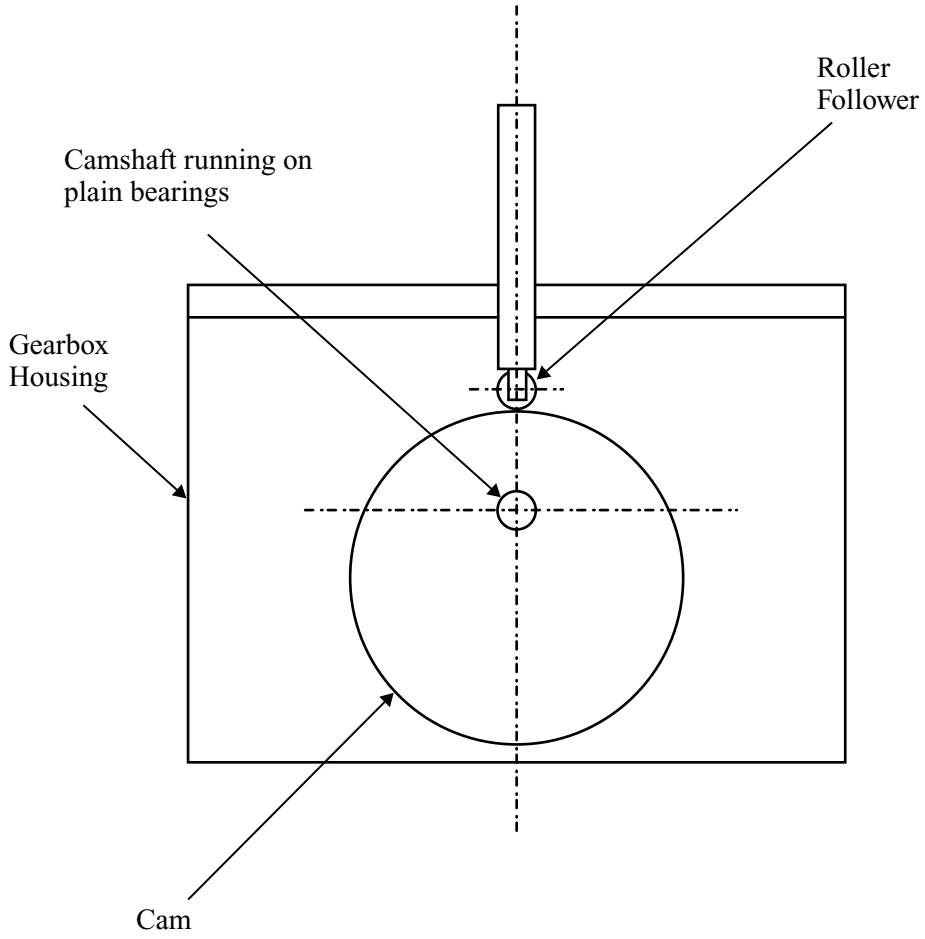

Fig. 4(a)

(a) **(i)** Briefly describe **one** advantage and **one** disadvantage associated with the use of a roller follower. [2]

(ii) The top section of the gearbox housing can be removed to access the gearbox. State a suitable method to prevent oil leakage when the top section is in place. [1]

(iii) The cam is mounted on a horizontal shaft which runs on plain bearings. During operation the cam has a torque of 1.1 Nm. Showing all calculations state how much work is done against friction after 500 revolutions. [3]

(iv) Showing all calculations state the power expended in overcoming friction when the cam rotates at 120 rev/min. [3]

(v) On the pro forma provided (answer number **4(a)(v)**), construct a performance/ displacement diagram which would accurately produce the following motion:

- 0–90 rise 40 mm with uniform velocity
- 90–120 dwell
- 120–180 rise 40 mm with uniform velocity
- 180–360 fall 80 mm with uniform acceleration and retardation. [4]

A scale of 1 mm = 1 mm should be used.

(b) On the pro forma provided (answer number **4(b)**), using appropriate formal drawing techniques, construct a cam profile which would accurately follow the performance/ displacement diagram shown in **Fig. 4(b)**. The diameter of the roller follower is 10 mm and the minimum cam diameter is 30 mm. The roller follower is offset to the right of the cam centre line by 10 mm and the cam rotates in a clockwise rotation.

[6]

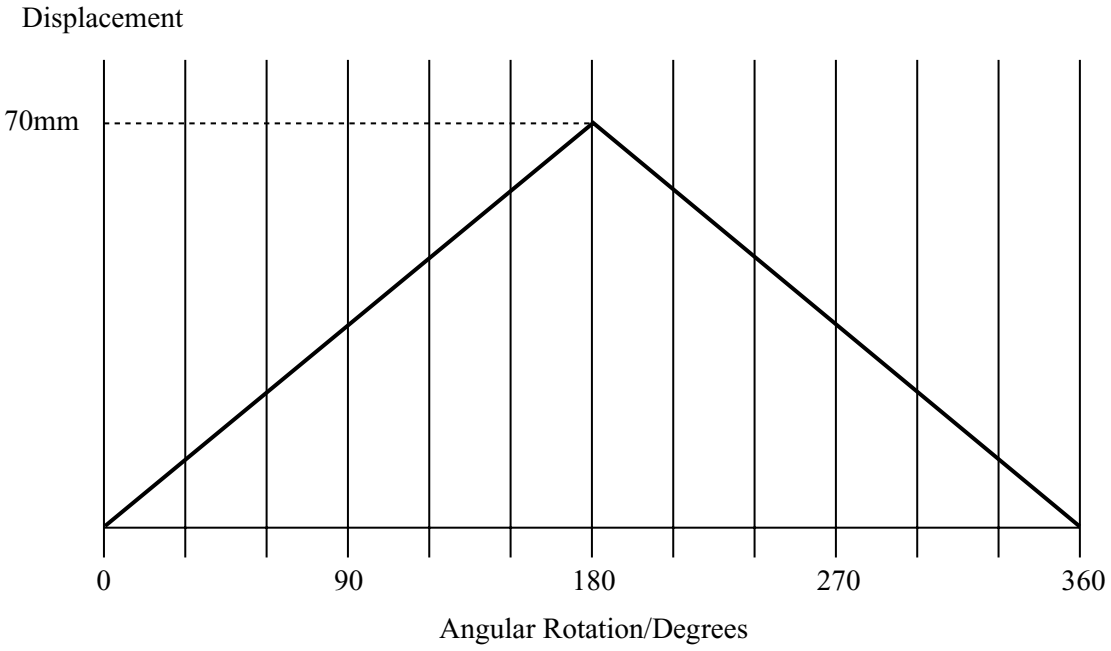

Fig. 4(b)

5 **Fig. 5** shows parts of a prototype pneumatic recycling station. Used cardboard boxes collected in the hopper are squashed by Cylinder D to reduce their storage size.

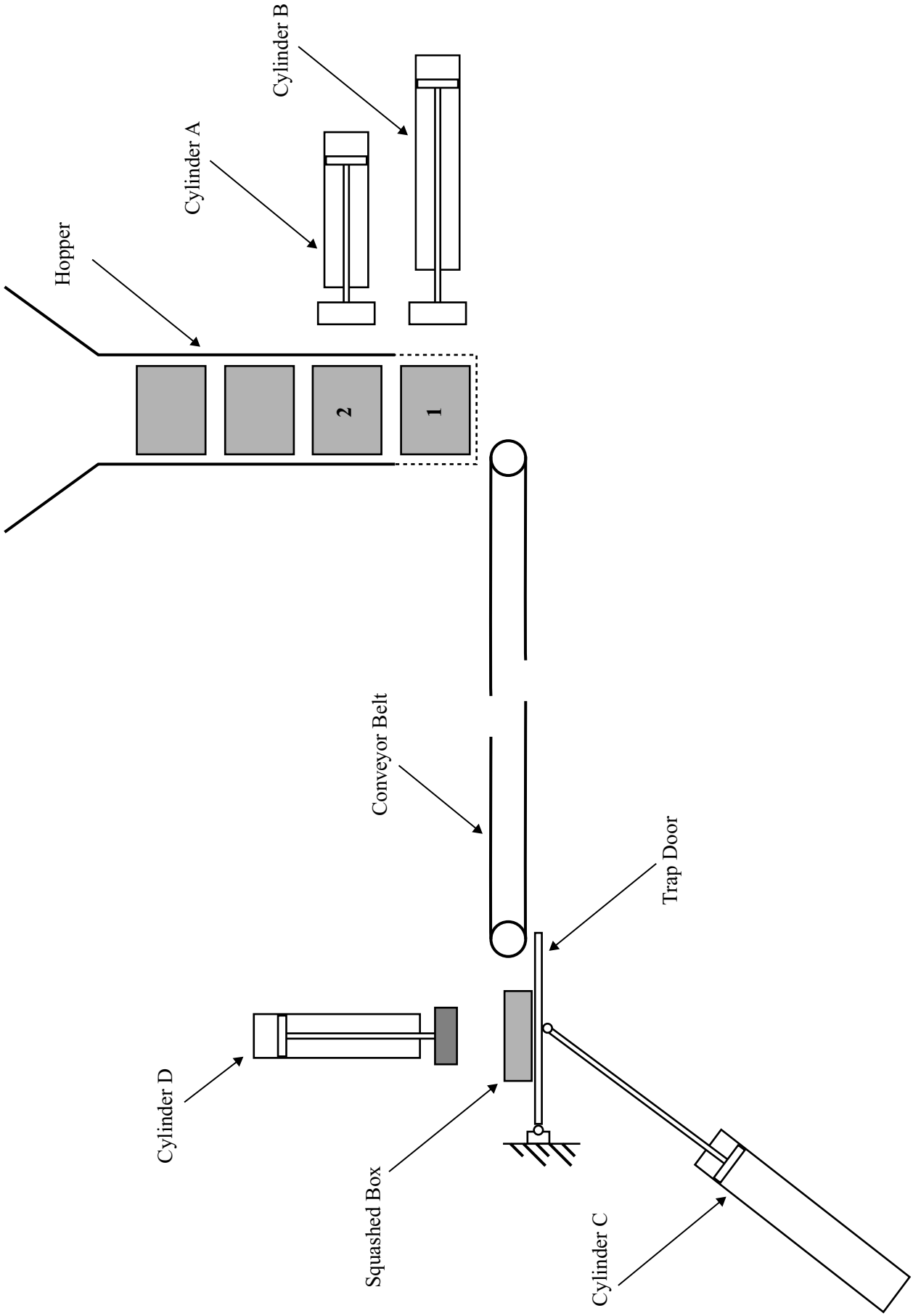

Fig. 5

(a) Briefly state what is meant by the term **positive feedback technique** when applied to pneumatic systems. [1]

(b) **(i)** The rotary motion is transferred from the motor to the conveyor belt using a cone clutch. Using an annotated sketch outline the main features of a cone clutch. [2]

(ii) Briefly describe **two** methods typically employed to activate clutches. [2]

(c) The prototype pneumatic recycling station performs the following sequence once the **Start** valve is switched:

- Cylinder A outstrokes to secure box 2.
- Cylinder B outstrokes pushing box 1 onto the conveyor belt.
- Cylinder C outstrokes to close the trap door.
- Cylinder D outstrokes to squash box 1.
- Cylinder C instrokes.
- Cylinder D instrokes.
- Cylinder B instrokes.
- Cylinder A instrokes.

(i) State the pneumatic sequence. [1]

(ii) On the pro forma provided (answer number **5(c)(ii)**, **(iii) and (iv)**) draw a suitable interlocking/cascade sequential circuit to achieve the desired sequence. [9]

(iii) During testing it was found that there was insufficient force to adequately squash the boxes. On the pro forma provided (answer number **5(c)(ii)**, **(iii) and (iv)**) add an additional double acting cylinder (Cylinder D1) to operate simultaneously with Cylinder D. [2]

(iv) On the pro forma provided (answer number **5(c)(ii)**, **(iii) and (iv)**) add any necessary components to enable Cylinders D and D1 to outstroke slowly. [2]

THIS IS THE END OF THE QUESTION PAPER

GCE Advanced Technology and Design Assessment Unit A2 3 January 2009
(for use with Question 1(a))

Fig. 1(a)

For candidates studying Electronic and Microelectronic control systems.

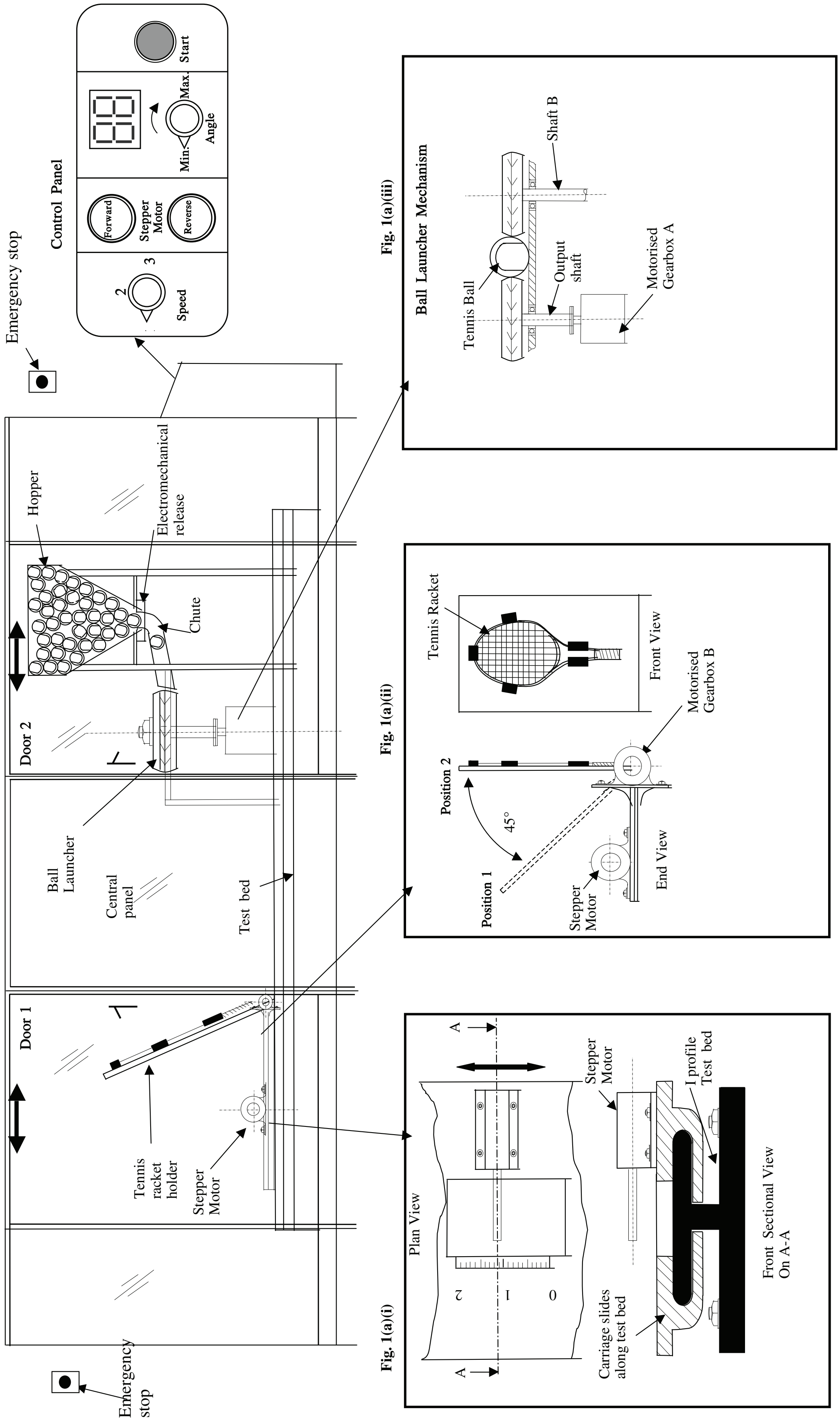

Fig. 1(a) For candidates studying Electronic and Microelectronic control systems.

AMENDED VERSION

Do not write your answers on this insert

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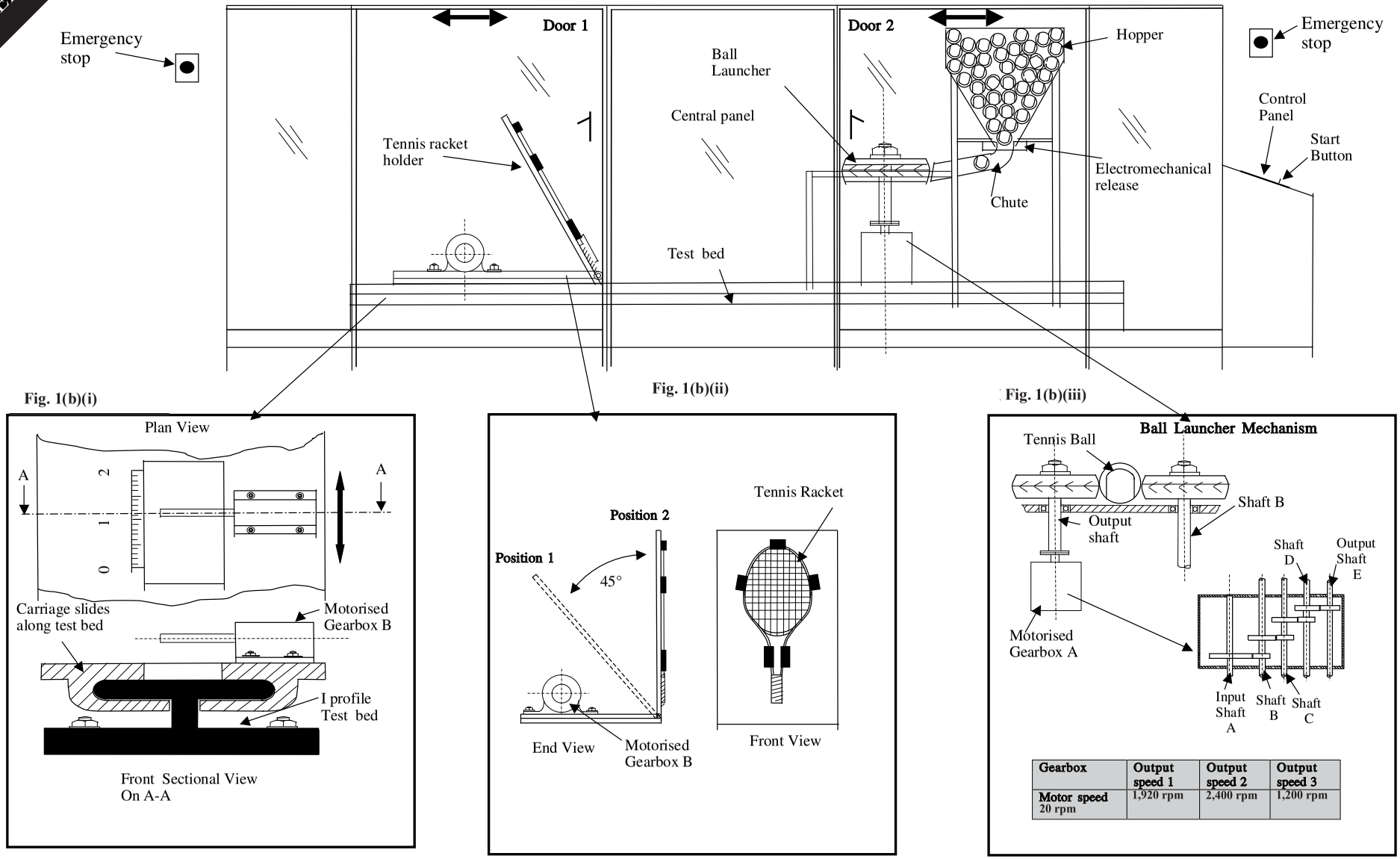
Fig. 1(b)

For candidates studying Pneumatic and Mechanical control systems.

Fig. 1(b) For candidates studying Pneumatic and Mechanical control systems



Gearbox	Output speed 1	Output speed 2	Output speed 3
Motor speed 20 rpm	1,920 rpm	2,400 rpm	1,200 rpm

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Question No. 1(a)(v) or 1(b)(v)

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Candidate Number

Pro forma answer page
(answer number 1(a)(v) or 1(b)(v))

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ADVANCED LEVEL TECHNOLOGY AND DESIGN
Assessment Unit A2 3 Unit 6
January 2009

Centre Number

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Candidate Number

Pro forma answer page
(answer number 4(a)(v))

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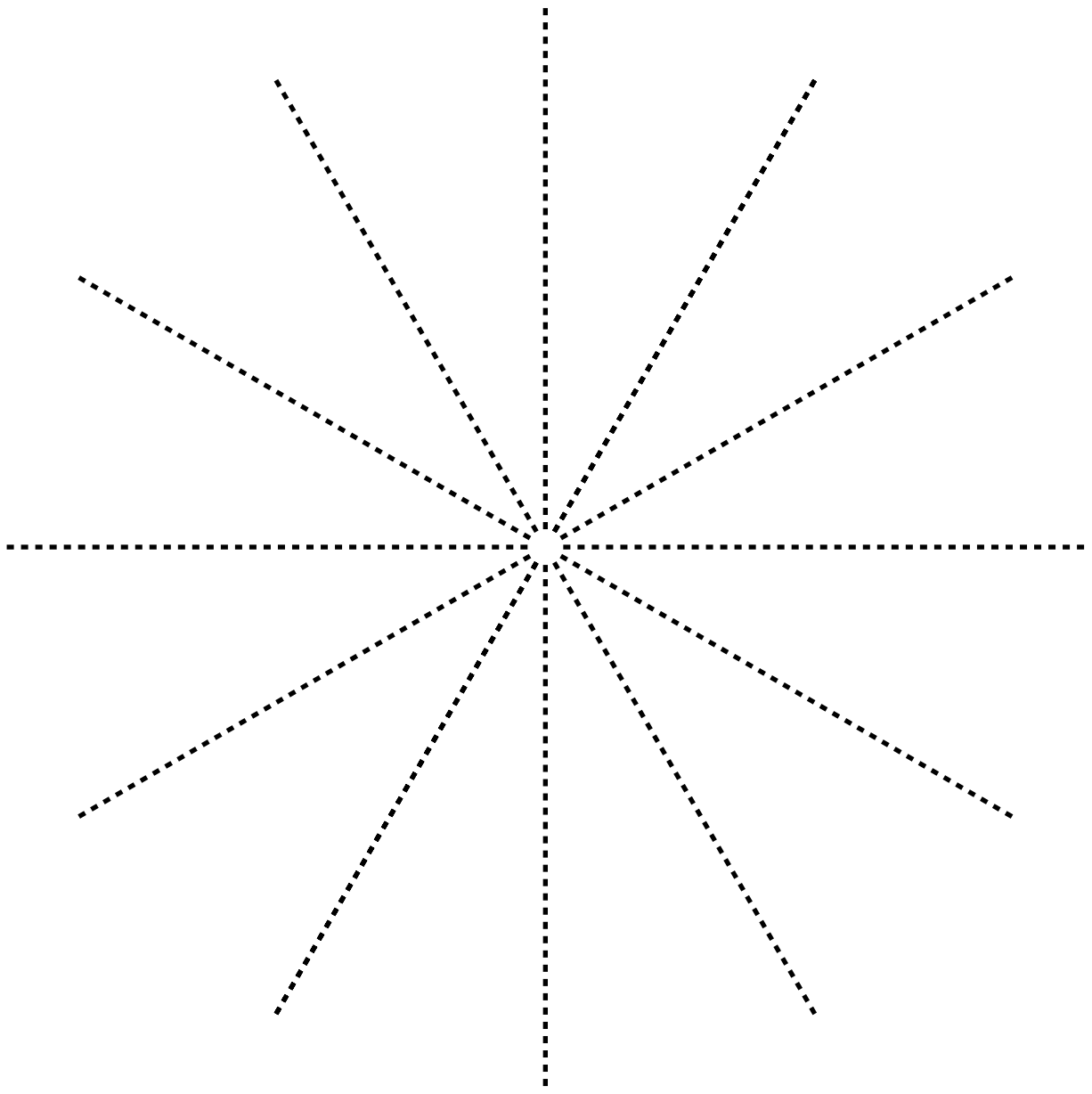
Question No. 4(b)

ADVANCED LEVEL TECHNOLOGY AND DESIGN
Assessment Unit A2 3 Unit 6
January 2009

Centre Number: 71

Candidate Number:



Pro forma answer page
(answer number 4(b))

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Question No. 5(c)(ii), (iii) and (iv)

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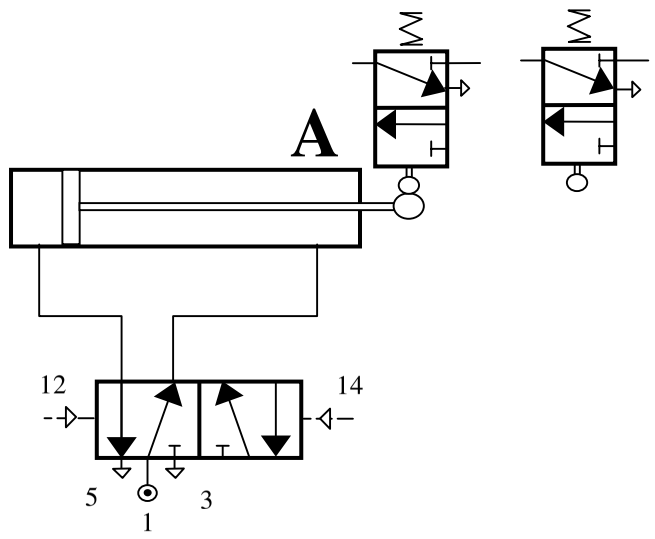

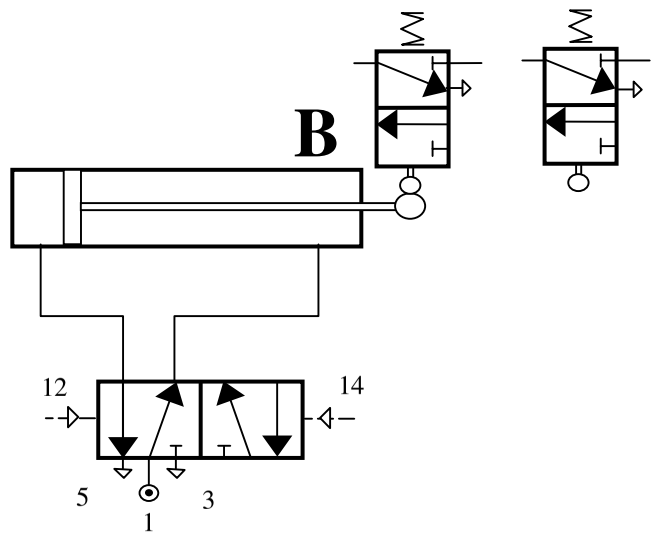

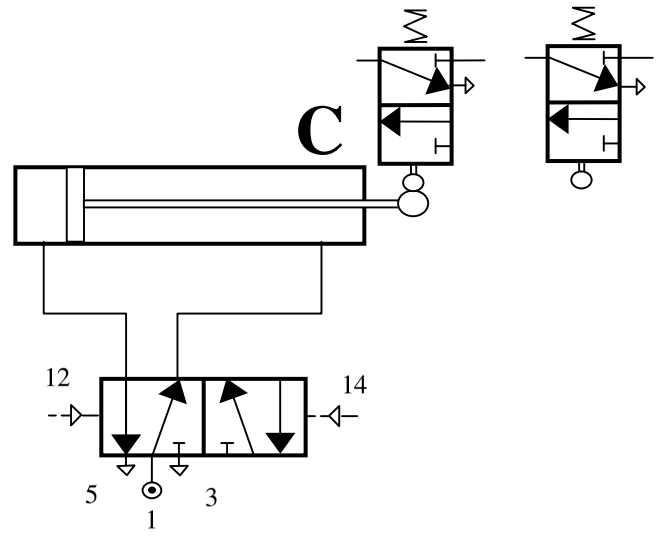

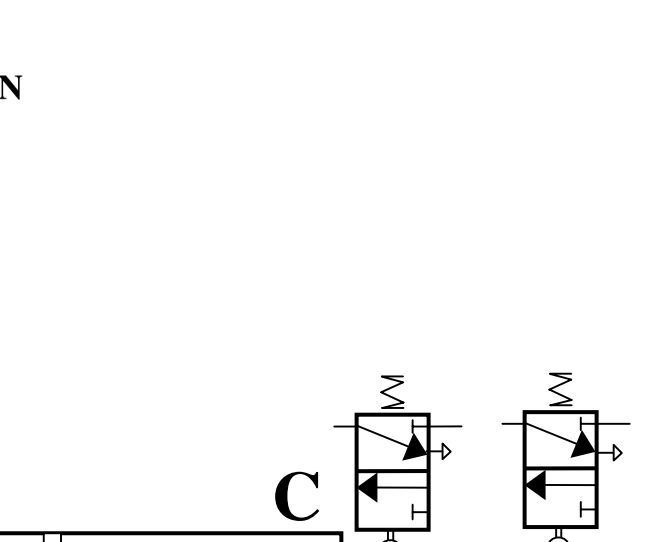

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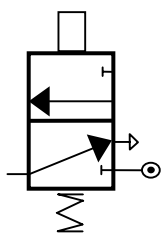

Pro forma answer page
(answer number 5(c)(ii), (iii) and (iv))

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