Rewarding Learning

ADVANCED
General Certificate of Education
January 2012

Technology and Design

Assessment Unit A2 1

assessing

Systems and Control

[AV211]

AV211

TUESDAY 31 JANUARY, MORNING

TIME

2 hours.

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 **either** the two questions in Section A **or** the two questions in Section B.
Answers to Questions **1(d)(ii)**, **2(d)**, **4(c)** and **4(d)** should be made on the A3 pro forma answer pages provided.
At the conclusion of the examination, attach the A3 pro forma answer pages securely to the Answer Booklet with the treasury tag supplied.

INFORMATION FOR CANDIDATES

The total mark for this paper is 80, including a maximum of 4 marks for quality of written communication.
Marks for quality of written communication will be awarded for Questions **2(e)** and **3(d)**.
Figures in brackets printed down the right-hand side of the pages indicate the marks awarded to each question or part question.

Answer **either** the **two** questions in Section A **or** the **two** questions in Section B.

Section A

Electronic/Microelectronic Systems

1 The voltage divider circuit shown in **Fig. 1(a)** is to be used as part of a system for measuring air temperature. The resistance/temperature characteristic for the thermistor Rt is also shown.

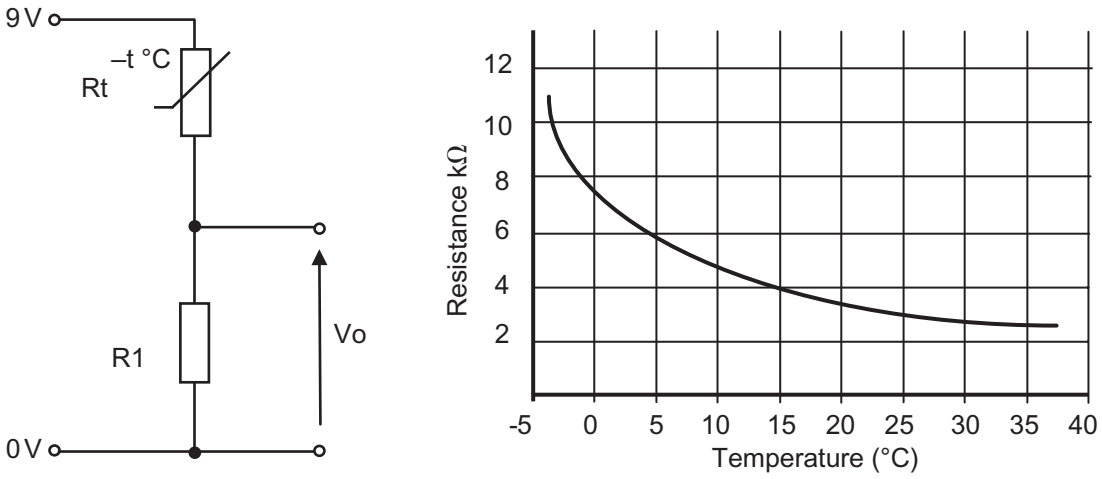

Fig. 1(a)

(a) (i) State the function of the voltage divider circuit shown in **Fig. 1(a)**. [1]

(ii) With reference to the resistance/temperature characteristic in **Fig. 1(a)** where the thermistor Rt is placed above the fixed resistor R1 in the voltage divider arrangement. Explain how the voltage Vo changes as temperature changes. [2]

(iii) Calculate the required value for the resistor R1 to obtain a Vo of 3 volts in **Fig. 1(a)** when the air temperature is 15 °C. [3]

(b) A student is proposing to design a basic weather station to display wind speed, wind direction and air temperature. The front panel for the design is shown in **Fig. 1(b)**.

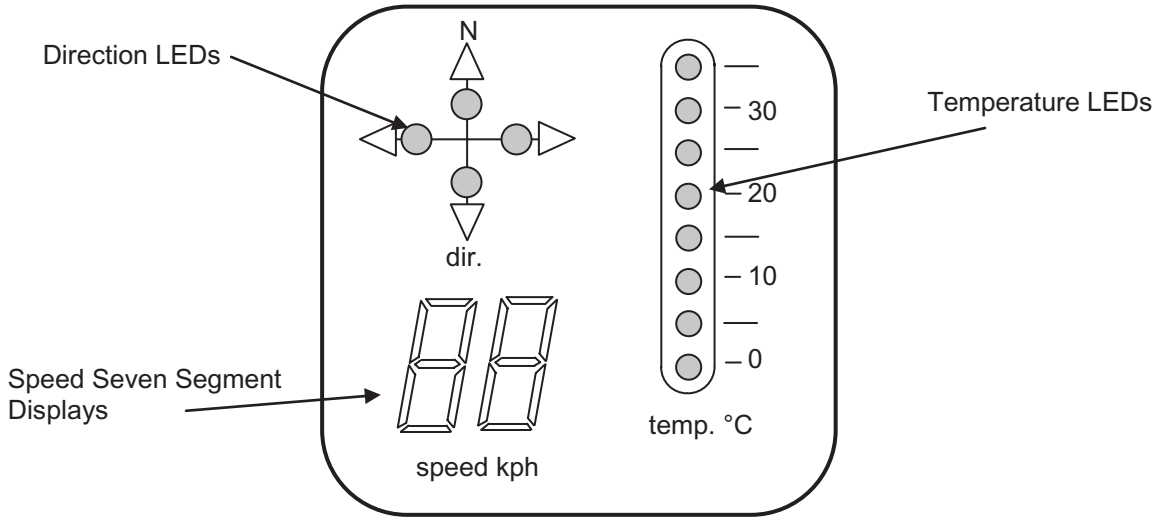

Fig. 1(b)

The output Vo from the voltage divider in **Fig. 1(a)** is to be connected to the temperature LEDs shown in **Fig. 1(b)** using a bar array driver, the LEDs being connected in common cathode arrangement.

(i) Explain with the aid of an annotated diagram what is meant by the term common cathode. [2]

(ii) State **two** advantages and **one** disadvantage, other than cost, of using LED seven segment displays over LCD type displays for the application in **Fig. 1(b)**. [3]

(iii) Draw a labelled circuit diagram showing how the voltage divider in **Fig. 1(a)** would be connected to a bar array driver and temperature LEDs. [3]

(c) The wind direction LEDs on the front panel shown in **Fig. 1(b)** are to be illuminated using a PIC. The input sensors (**A** and **B**) to the PIC are phototransistors with infrared transmitters used in conjunction with a slotted disc.

A logic 1 is produced when an infrared light is blocked by the disc. **Fig. 1(c)** shows 2 views; the slotted disc and the position of the sensors. The disc will be turned by the rotating shaft shown in **Fig. 1(d)**.

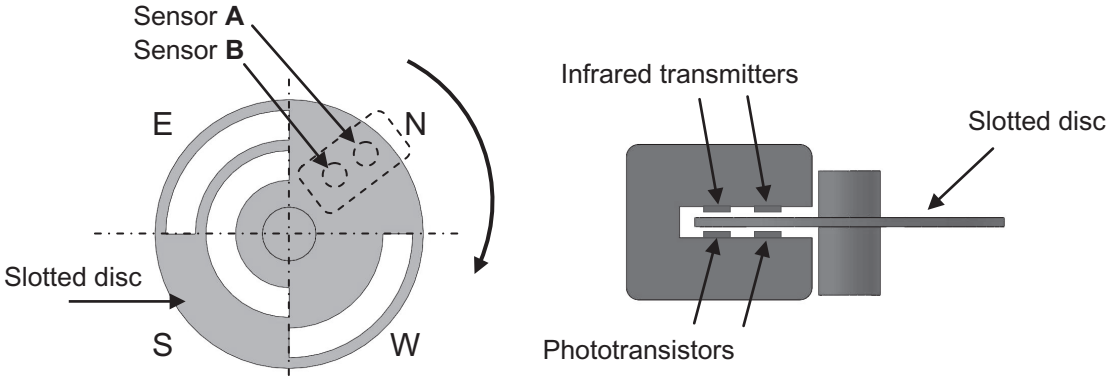

Fig. 1(c)

(i) Draw a circuit diagram showing how the phototransistors could be connected to a PIC to produce logic 1 and logic 0 inputs. Also show how the direction LEDs could be connected to the PIC outputs. [4]

(ii) Draw a truth table showing the logic signals from the sensors for each of the wind directions as the disc in **Fig. 1(c)** rotates in a clockwise direction. [3]

(iii) Write a flowchart program to check the wind direction every 2 seconds and illuminate the appropriate LED. The wind direction LEDs are connected as follows: North is op1 of the PIC, East is op2, South is op3 and West is op4. [6]

(d) The wind speed is to be displayed on the seven segment displays on the front panel shown in **Fig. 1(b)**.

The position of a non contact sensor which is attached to a shaft with wind speed cups is shown in **Fig. 1(d)**. The sensor, in conjunction with other components will enable a 5 volt pulse to be generated each time the shaft rotates.

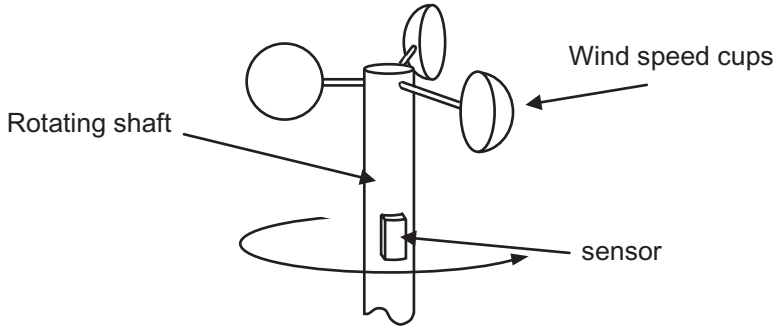

Fig. 1(d)

(i) Draw and describe a suitable sensor that could be used to detect each revolution of the shaft. [3]

(ii) Using annotated electronic circuit diagrams on the blank pro forma provided (answer number **1(d)(ii)**) design a complete circuit that will:

- fulfil a method of connecting the sensor to additional circuitry to provide a voltage or logic signal each time the shaft in **Fig. 1(d)** rotates;
- display the wind speed up to a maximum of 99 kph on the seven segment displays; and
- take the wind speed reading every 2 seconds. [10]

2 A linear variable resistor is arranged as shown in **Fig. 2(a)**. The voltage Vo is measured between terminal **C** (the wiper) and terminal **A**.

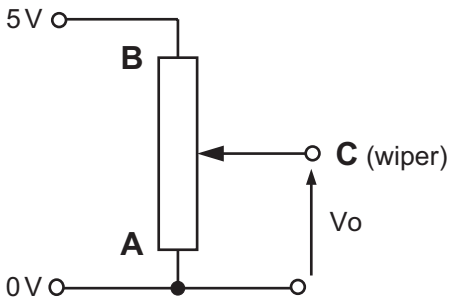

Fig. 2(a)

(a) Sketch and label a graph of how the voltage Vo varies as the wiper is moved from terminal **A** to terminal **B**. [2]

(b) Part of a prototype system for testing the height of components on a production line conveyor is shown in **Fig. 2(b)**. The measuring head which is attached to the wiper of a variable resistor is moved down to rest on a component. The voltage Vo at the wiper (terminal **C**) is to be displayed on a voltmeter. The maximum movement of the measuring head from terminal **A** is 10 mm which produces a change in Vo of 250 mV for every mm moved.

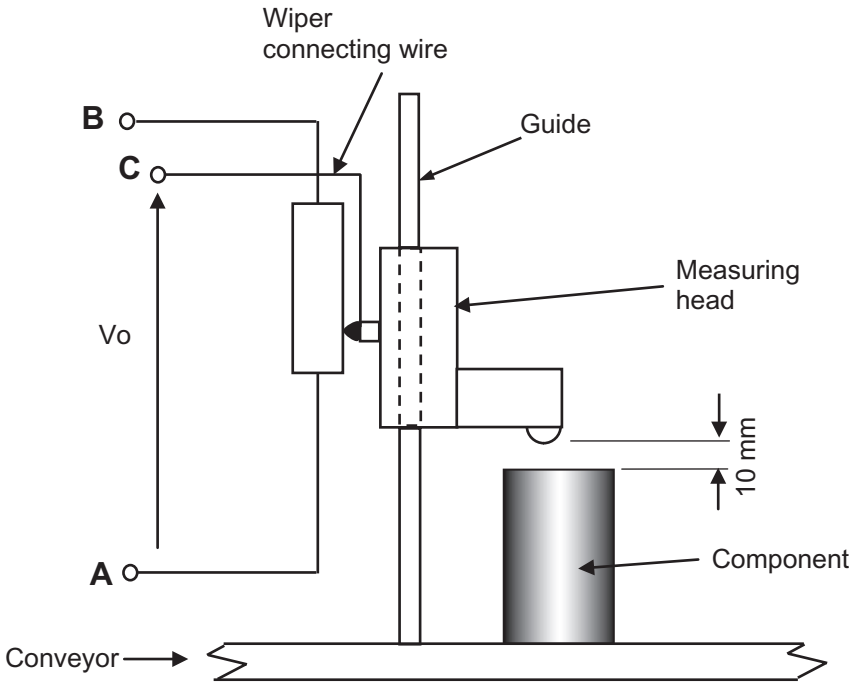

Fig. 2(b)

(i) Explain how the arrangement shown in **Fig. 2(b)** could be used as the basis of a system to measure the distance the moving point of the measuring head has travelled from terminal **A**. [3]

(ii) It is required that the voltage displayed by the voltmeter, in volts, should represent the distance travelled by the measuring head in mm, i.e. the voltmeter should display 10 V when the wiper has moved by 10 mm.

Determine the gain of an amplifier required to be connected between the wiper and the voltmeter to meet this requirement. [2]

(iii) An amplifier based on an opamp is to be used where the gain of an inverting amplifier and a non-inverting amplifier is given by $-R_f/R_1$, and $1 + R_f/R_1$ respectively.

Draw a suitable amplifier and specify suitable values for R_f and R_1 where R_f is the feedback resistor. [5]

(c) An additional circuit is required to indicate if the components being checked by the system shown in **Fig. 2(b)** have passed or failed the height test.

The additional PIC based circuit which is shown in **Fig. 2(c)** utilises Vo from the variable resistor in **Fig. 2(b)**. One of two LEDs will be illuminated, the pass LED indicating a component of the correct height and the fail LED indicating an undersized component.

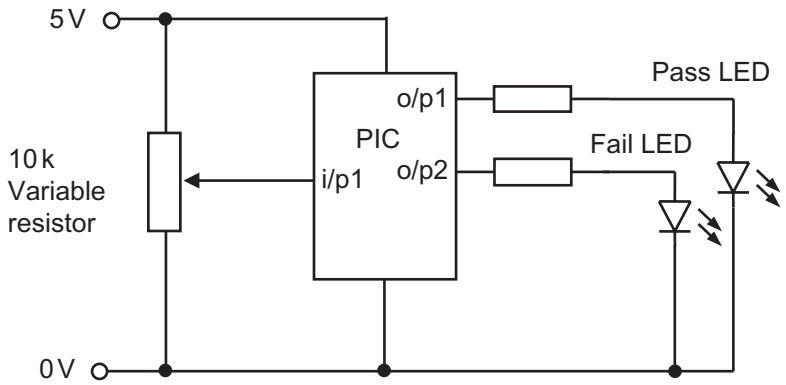

Fig. 2(c)

(i) The PIC shown in **Fig. 2(c)** has an analogue input port (i/p1) with a voltage range from 0V to 2.5 V and a digital equivalent range from 0 to 255. Calculate the digital values that correspond to input port voltages of 750 mV and 1.25 V. [2]

(ii) When selecting the components for the circuit in **Fig. 2(c)** the designer had the option of using either a 10 K variable resistor or a 1 K variable resistor. With reference to the power dissipation of both justify the choice of the 10 K variable resistor. [2]

(iii) Using a flowchart, write a program that will check the analogue port continuously and illuminate the appropriate LED. Assume that components presenting a voltage at the analogue port (i/p1) of 750 mV or less have failed the height test. [5]

(d) The component testing system shown in **Fig. 2(d)** is to be automated so that components are tested and any that fail the test are removed from the conveyor. The proposed layout for the automated system is shown in **Fig. 2(d)** below.

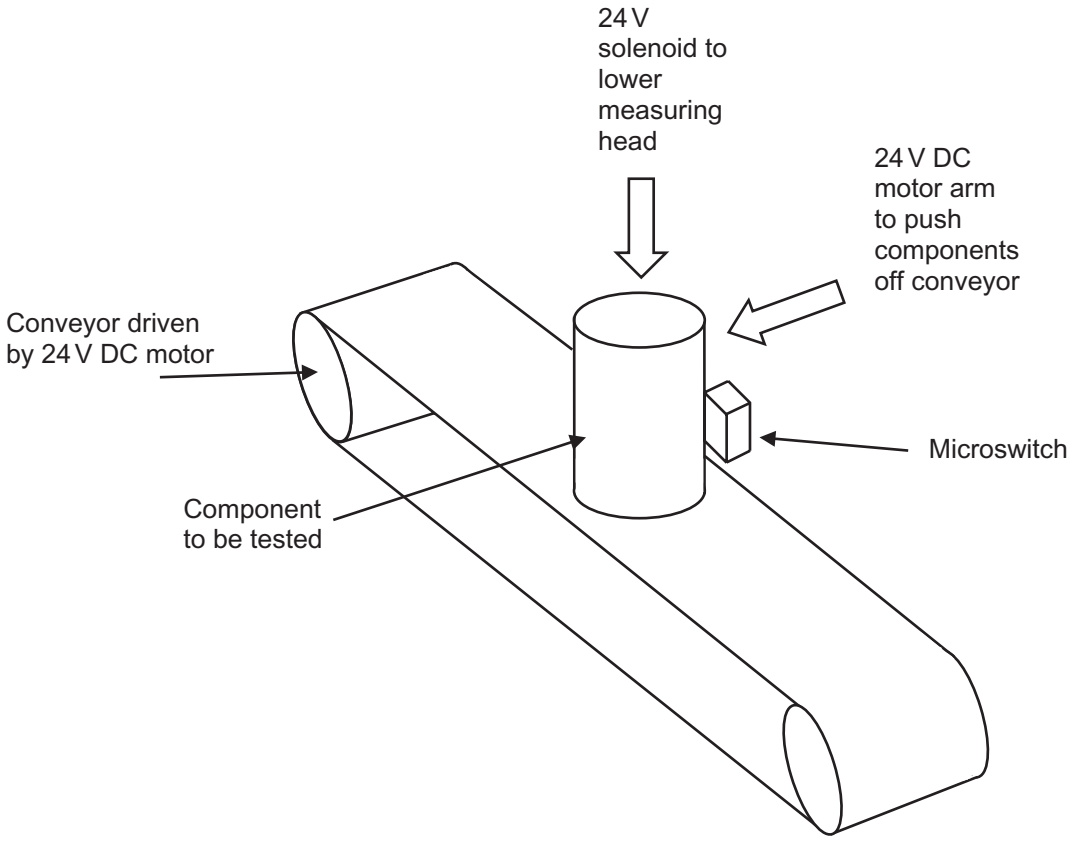

Fig. 2(d)

Using electronic circuit diagrams on the blank pro forma provided (answer number **2(d)**), design a circuit that:

- As the components pass under the measuring head they will contact a microswitch. The signal from the microswitch will be used to stop the conveyor which is moved by a 24 volt DC motor.

- A 24 volt solenoid is then to be activated which will bring the measuring head down on the component. After a time delay of 0.25 seconds to allow the reading to be taken by the circuit in **Fig. 2(c)**, the solenoid should retract.

- At the same time a 24 volt DC motor attached to a mechanical arm will begin to slowly move forward and after 0.5 seconds push the failed components into a crate. The conveyor should then continue to move as the DC motor arm reverses. [10]

(e) Electronic systems can be analysed in terms of on/off or continuous control and can also be categorised as either open loop or closed loop.

Compare the main features of on/off and continuous type control systems and supplement your comparison with practical examples of both types.

Then discuss the main difference between open loop and closed loop systems, describing the main factors that will influence the choice of a particular type of control system. [5]

Quality of written communication [4]

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Answer **either** the **two** questions in Section A **or** the **two** questions in Section B.

Section B

Mechanical and Pneumatic Control systems

3 **(a)** **Fig. 3(a)** shows a prototype rig to be used when filming for part of a car advert to show the effortless exchange of movement and motion within the car.

In the sequence the car is lowered which in turn lifts the platform. As the platform rises it makes contact with a switch which activates the motorised gearbox engaging the clutch.

The output from the clutch drops in height and direction to shaft **C** which drives a cam to activate a switch to pump water to the windscreen jets and a linkage to move the windscreen wiper.

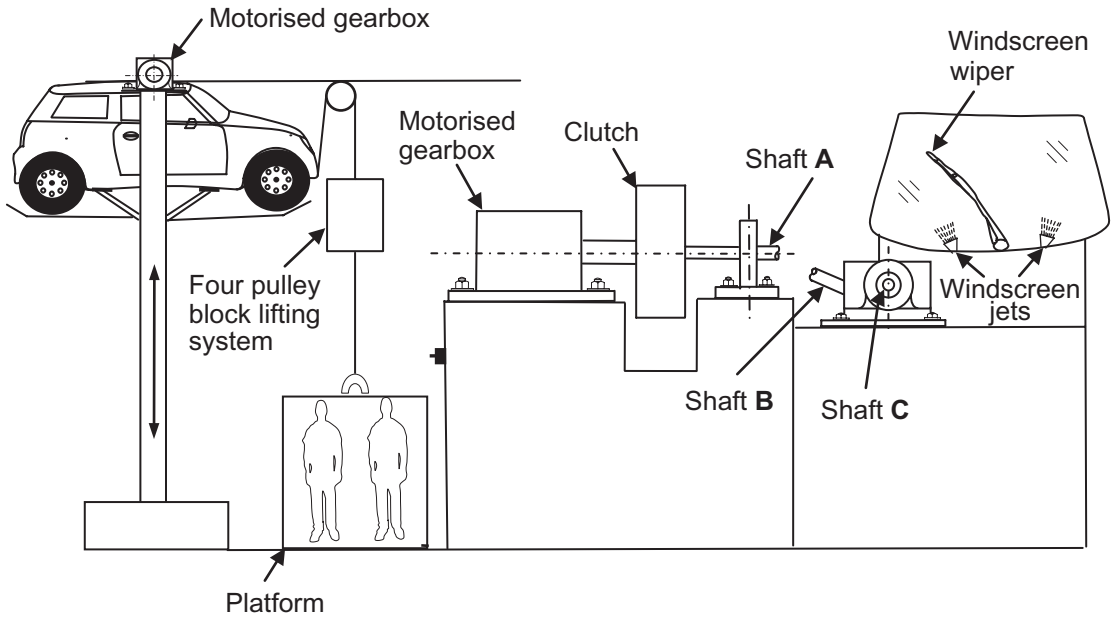

Fig. 3(a)

(i) Briefly explain what is meant by a compound gear train. [2]

(ii) Using an annotated sketch produce a cam profile which will activate the switch to pump water to the windscreen jets for 3 seconds if the camshaft rotates at 10 rpm. [4]

(iii) A linkage is required to move the wiper arm across the windscreen in an oscillating motion from the rotating shaft. With the use of an annotated sketch, name and draw a suitable linkage to convert the rotary motion into an oscillating motion. [3]

(b) **(i)** As the car is lowered it pulls on the cable which is fed through a four pulley block lifting system to eventually lift the platform. With the use of an annotated sketch outline the main features of a four pulley block lifting system. Comment on why the mechanical advantage for this lifting system is 4. [4]

(ii) Calculate the minimum power required from the output shaft to lift the car 1.8 metres in 30 seconds if the gravitational force on the car is 8000 N. Assume a 20% loss of power due to friction. [3]

(c) **Fig. 3(c)** below shows an outline drawing of the shafts and housing which support the single plate clutch.

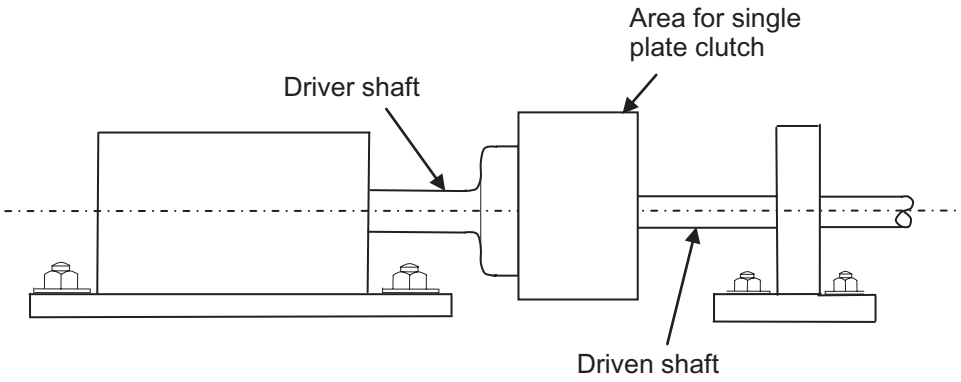

Fig. 3(c)

With the use of an annotated sketch explain the main features of a single plate clutch. Include in your answer the method used to activate this clutch. [5]

(d) The gearbox which provides the drive/motion to raise and lower the car on the lifting ramp uses a lubricant.

Explain the purpose of a lubricant and discuss the mechanics of lubrication and viscosity and the factors to be considered when choosing a lubricant for this application. [5]

Quality of written communication [4]

(e) In your answer booklet design, draw and annotate a mechanical system which will achieve the following requirements:

- A means of providing a positive drive from shaft **A** to shaft **B** while maintaining a constant speed. Show how your design is attached to the shafts (making reference to **Fig. 3(e)(i)** below).

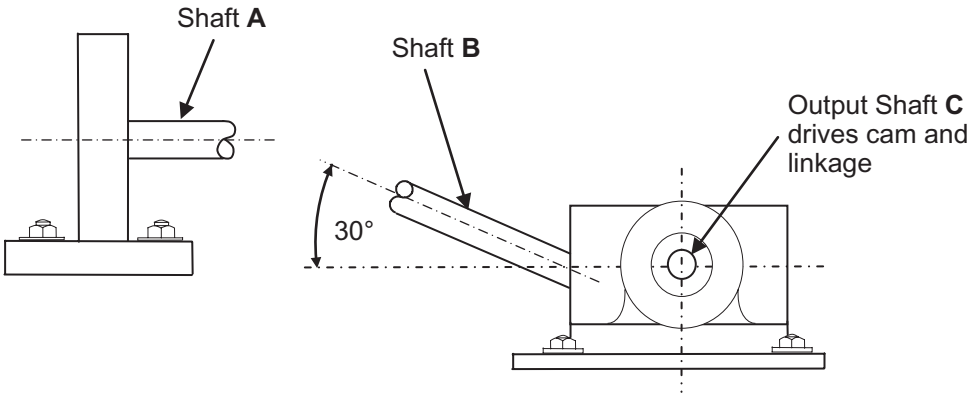

Fig. 3(e)(i)

- A gearbox design (making reference to **Fig. 3(e)(ii)** below), using only gears with teeth between 20 and 100 that will provide a suitable output speed to move the support bracket of the car 1.6 metres in 20 seconds with one rotation per minute of the output shaft moving the bracket 20 mm.

  The input speed of the gearbox is 7680 rpm with both the input and output shafts required to rotate in an anticlockwise direction. **(State clearly the number of teeth for each of the gears on shafts A, B, C, D and E.)** [10]

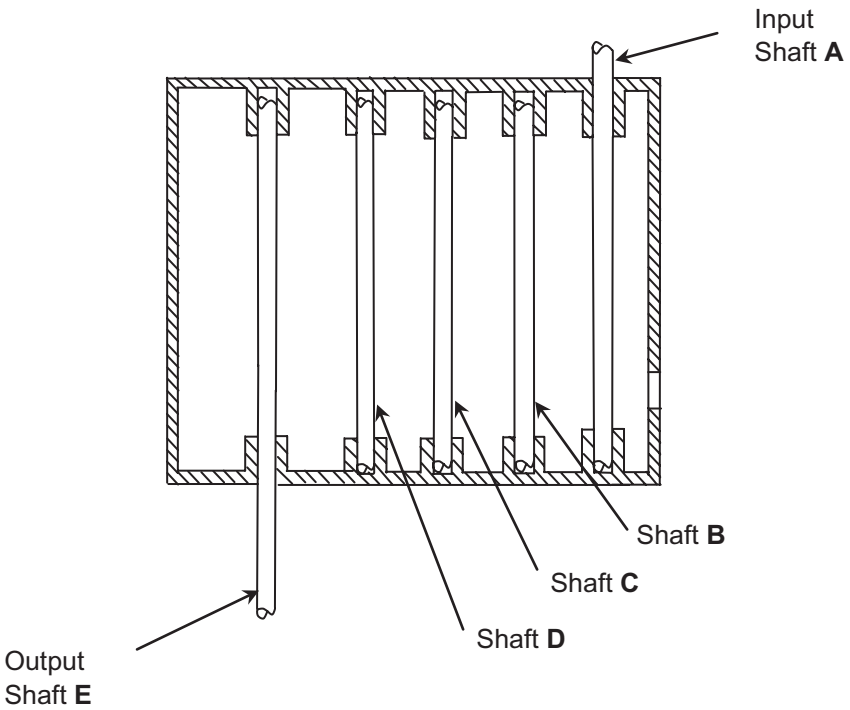

Fig. 3(e)(ii)

4 **(a)** Safety issues need to be considered and procedures followed when using pneumatics. Outline **two** main safety issues which arise when using pneumatics. For each safety issue outline the procedure to be used in order to minimise the risk of injury to the user. [4]

(b) **Fig. 4(a)** below shows a circuit used to control the speed of a double acting cylinder for an industrial process.

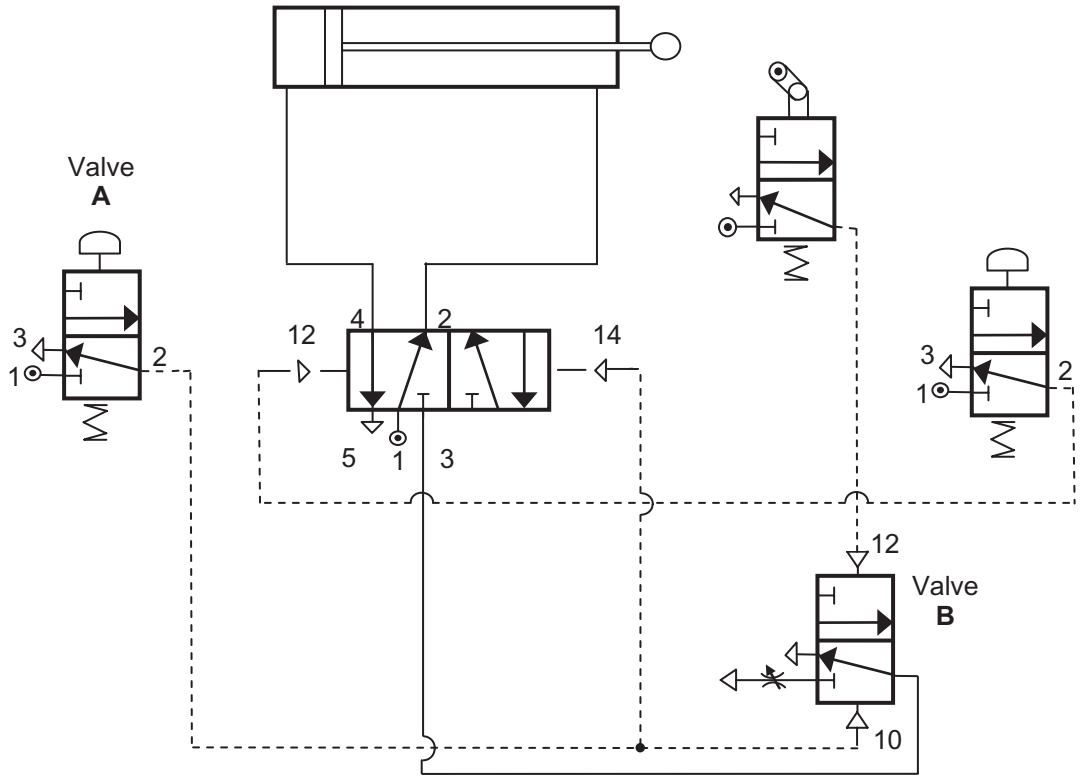

Fig. 4(a)

(i) Explain how the circuit in **Fig. 4(a)** operates starting from when Valve **A** is pressed. (Your answer should include a detailed explanation of the operation of Valve **B**.) [6]

(ii) With reference to **Fig. 4(b)** and the data below, calculate the air consumed by the cylinder as the piston rod moves through one cycle, then calculate the maximum number of complete cycles that could be made by the piston rod per minute if the compressor has a capacity to produce 285 litres per minute.
(In your calculations ignore friction.)

Double Acting cylinder

Piston rod instroked Piston rod outstroked

Fig. 4(b)

Diameter (D) = 100 mm
Piston rod diameter (d) = 20 mm
Stroke (S) = 160 mm
Gauge pressure = 4 bar
Compressor capacity = 285 litres per minute
Atmospheric pressure = 1 bar
Please assume $\pi = 3.14$ [4]

(c) **Fig. 4(c)** shows a pneumatic test unit used to simulate some of the conditions a chair would be subjected to. The sequence is as follows:

- The chair is positioned and only when door 1 and door 2 are closed and the operator presses the lever set/reset 5 PV on the control panel will cylinder **A** outstroke to clamp the chair.

- The test begins by the operator activating the Start 3 PV on the control panel. This sends cylinder **B** positive slowly pressing down on the seat.

- The exhaust air from cylinder **B** as it goes positive creates a time delay before activating the 5 PV which controls cylinder **C** sending it negative to pull on the back rest.

- When cylinder **C** goes negative it will send a signal to the 5 PV which in turn will send cylinder **B** negative.

- When cylinder **B** goes negative it will send a signal to the 5 PV controlling cylinder **D** sending it positive.

- Cylinder **D** in the positive position is detected by an air bleed which is used to send cylinder **D** negative.

- Detection of cylinder **D** in the negative position will then activate cylinder **C** sending it positive.

- Detection of cylinder **C** in the positive position will repeat the sequence.

- When the test has been completed the operator will activate the lever set/reset 5 PV on the control panel which makes cylinder **A** instroke to release the clamp and allow the chair to be removed once the doors have been opened.

On the pro forma provided (answer number **4(c)**) draw a suitable pneumatic circuit to achieve the desired sequence outlined above. [16]

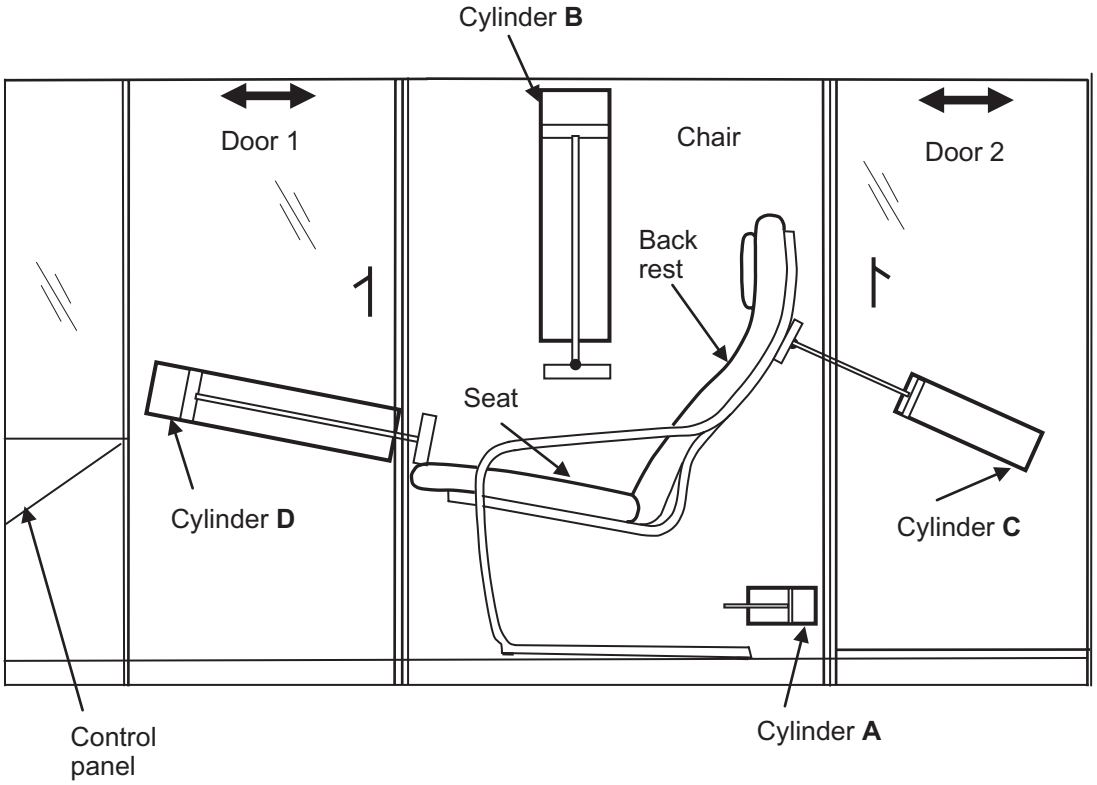

Fig. 4 (c)

(d) On the pro forma provided (answer number **4(d)**) design and draw a system which will:

- send a momentary signal (single air pulse) to the counter on the control panel using the exhaust air from cylinder **D** each time it instrokes; and
- clamp the chair securely by applying a downward force each time cylinder **A** outstrokes. [10]

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Question No. 1(d)(ii)

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Pro forma answer page
(answer number 1(d)(ii))

Question No. 2(d)

ADVANCED LEVEL TECHNOLOGY AND DESIGN
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January 2012

Centre Number

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Candidate Number

Pro forma answer page
(answer number 2(d))

Question No. 4(c)

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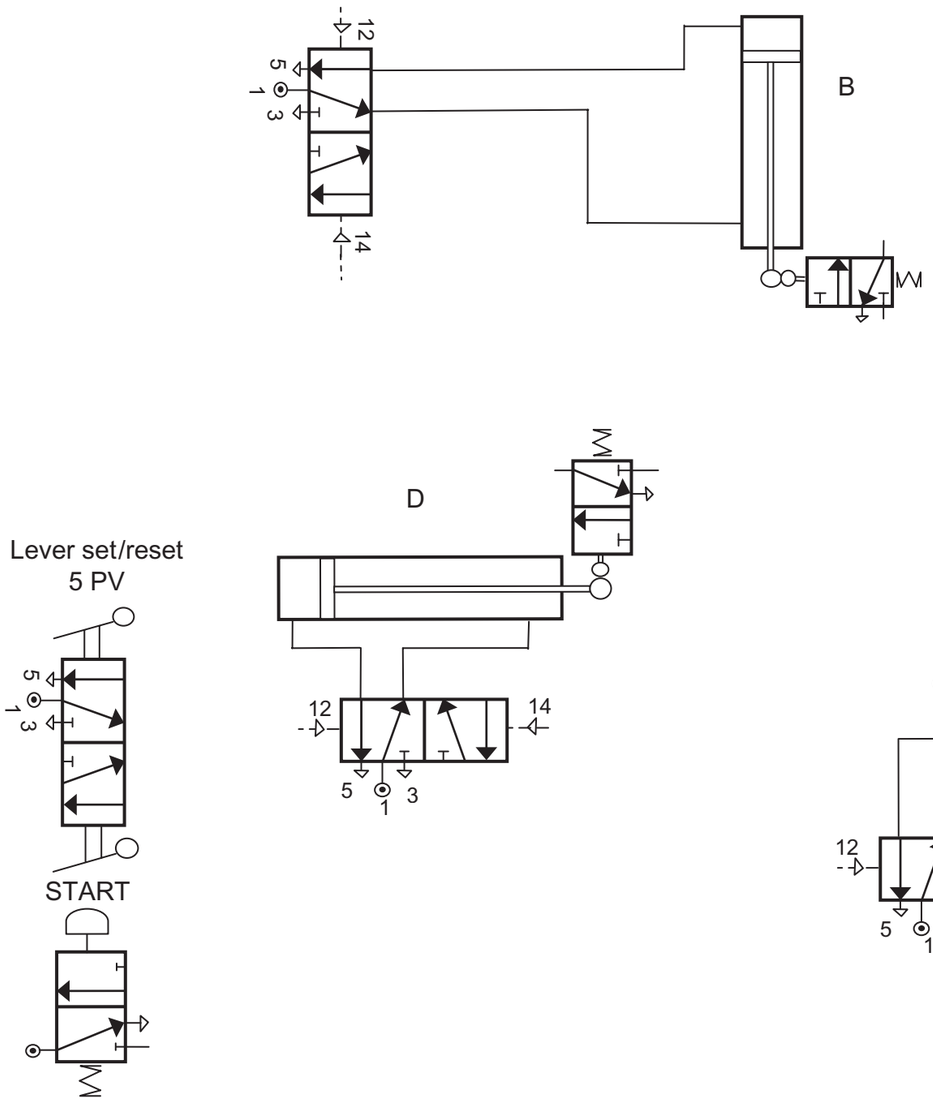

Pro forma answer page
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Question No. 4(d)

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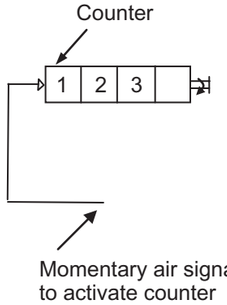

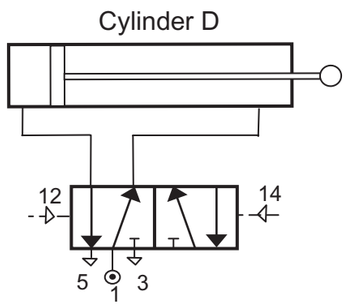

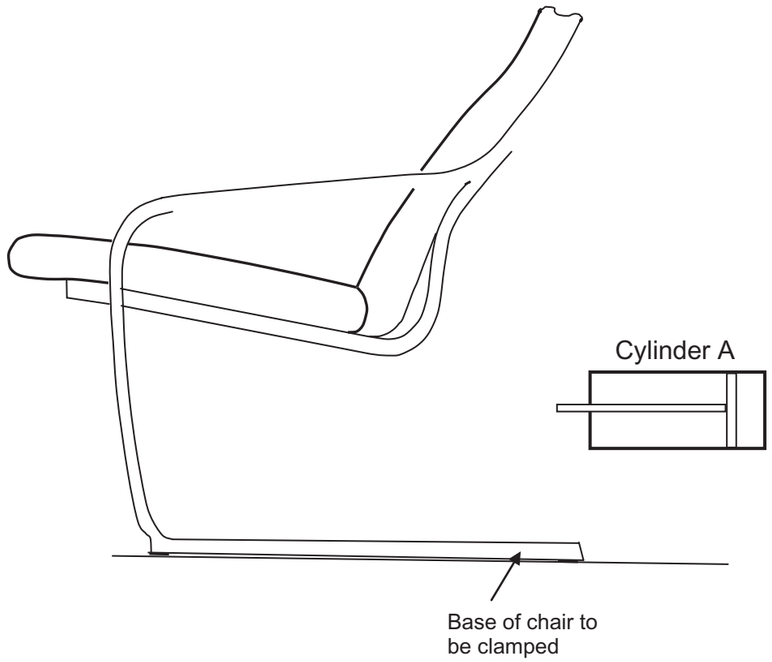

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