Rewarding Learning

ADVANCED
General Certificate of Education
2012

Technology and Design

Assessment Unit A2 1

assessing

Systems and Control

[AV211]

AV211

TUESDAY 22 MAY, AFTERNOON

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)(iii)**, **2(e)(iii)**, **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 **1(e)** and **3(f)**.
Figures in brackets printed down the right-hand side of 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 An electronic system has been devised to measure the deflection of steel beams under loading. **Fig. 1(a)** shows how the beams are to be loaded using a hydraulic pump/actuator which is switched by an electrical control signal. The placement of strain gauges on the beam is shown along with the pattern of a typical strain gauge.

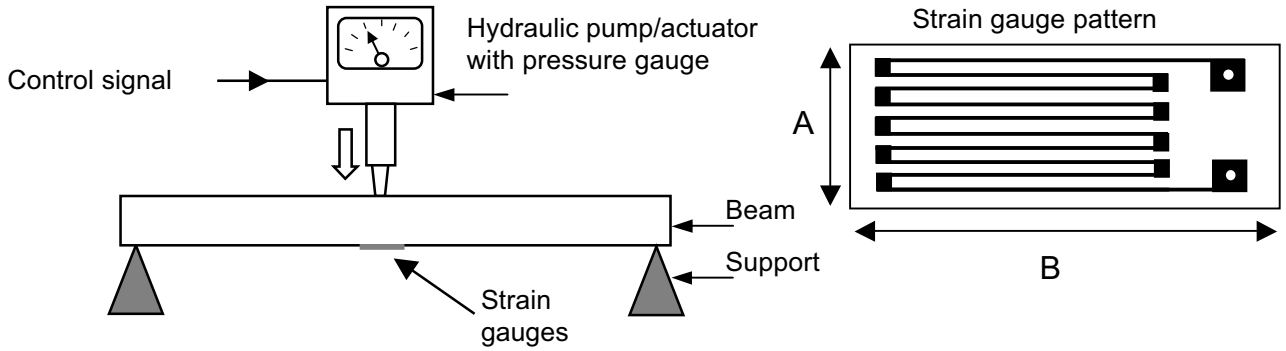


Fig. 1(a)

(a) (i) State the main physical property of a strain gauge that changes when the gauge is deformed. [1]

(ii) With reference to the strain gauge pattern shown in **Fig. 1(a)**, briefly explain the distinction between the active and passive axis on a strain gauge and state if axis A in **Fig. 1(a)** is the active or passive axis. [2]

(iii) Two strain gauges are to be used to eliminate errors due to changes in temperature. With reference to the strain gauge in **Fig. 1(a)** describe with the aid of a sketch how to orientate the two gauges in order to eliminate errors due to temperature changes. [3]

(b) The two strain gauges are to be connected as part of a Wheatstone bridge as shown in **Fig. 1(b)**, where Rg_1 and Rg_2 will represent the resistances of the strain gauges. The resistance values of Rg_1 and Rg_2 are each $120.0\,\Omega$ when the sensors are unstrained. You may assume that $R_2 = R_3 = 120.0\,\Omega$.

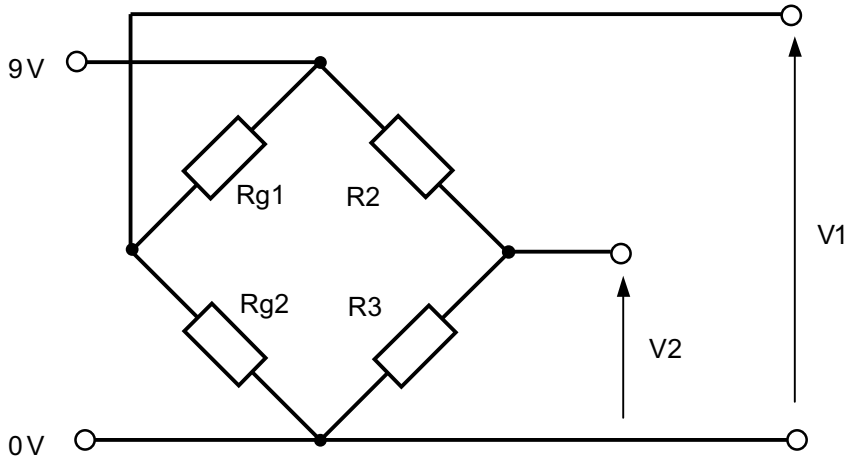


Fig. 1(b)

(i) Briefly describe the principle of operation of a Wheatstone bridge circuit. [2]

(ii) During testing it was found that the resistance values of Rg_1 and Rg_2 were $120.1\,\Omega$ and $120.6\,\Omega$ respectively when the beam was holding the maximum load.

Calculate V1 when the beam is holding the maximum load. [2]

(c) The voltages V1 and V2 from the Wheatstone bridge circuit shown in **Fig. 1(b)** are to be connected to an op amp based circuit in differential mode where $Vo = (R_F/R_1)(V1 - V2)$.

(i) Calculate the required gain of the differential amplifier if the maximum output voltage is 4 V. [2]

(ii) Draw the differential amplifier choosing suitable values for the feedback resistors R_F and R_1 to achieve the gain calculated in **(c)(i)**. Also add labels to show V1, V2 and Vo. [4]

(d) The output from the difference amplifier in question **1(c)(ii)** is connected to the analogue input of a PIC. The voltage range of the analogue input ranges from 0 V to 4 V and the corresponding digital range is 0 to 255. The 8 outputs from the PIC are connected to 6 LEDs, a 12 volt buzzer and 24 volt relay respectively. The buzzer and relay utilise transistors as drivers.

(i) Calculate the digital equivalent values that correspond to analogue inputs of 0.8 volts and 2.4 volts respectively. [2]

(ii) Draw a block diagram to show the various input, control and output blocks for the complete testing system. [3]

(iii) The output panel for the beam testing system is shown in **Fig. 1(d)**. Each green LED represents 0.1 mm of deflection. When the deflection is equal to 0.5 mm the red LED should also flash, the alarm sound and the hydraulic pump (which is switched by 24 volt relay) should stop to allow the beam to be inspected and readings taken from the pressure gauge. The red LED should continue to flash until reset by a switch on the panel.

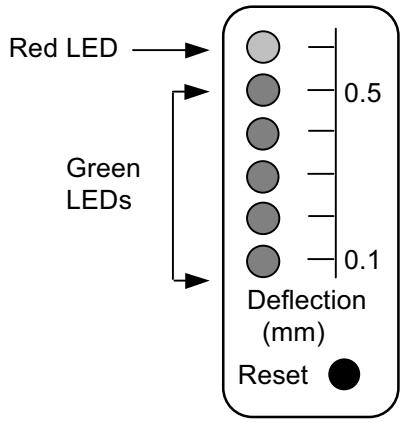


Fig. 1(d)

Using electronic circuit diagrams on the blank pro forma provided (answer number **1(d)(iii)**), design a circuit and associated flow chart program that will fulfil the following:

- Light the green LEDs consecutively for equally divided input voltage levels up to 4 volts corresponding to 0.1 mm deflection up to 0.5 mm.
- When the deflection equals 0.5 mm the red LED should flash on and off 2 times each second.
- At the same time the sounder should be activated and the control relay for the hydraulic pump should stop. [10]

(e) Designers of electronic systems can choose between PIC based or hard wired solutions to meet their requirements. Compare and contrast the main features of both of these types of system. Supplement your answer with a specific application where the use of the PIC can be justified in preference to a hard wired circuit. [5]

Quality of written communication. [4]

2 The display board for a theme park ride consists of 5 coloured 12 volt lamps, A, B, C, D and E, which are arranged in a row as shown in **Fig. 2(a)**. The lamps which flash with an eye-catching sequence are controlled by the outputs from a logic circuit. As the outputs of the counter Qa, Qb and Qc are incremented from 000 the lamps are to be switched on in the following sequence, A, AB, ABC, BCD, CDE, DE, E, all off.

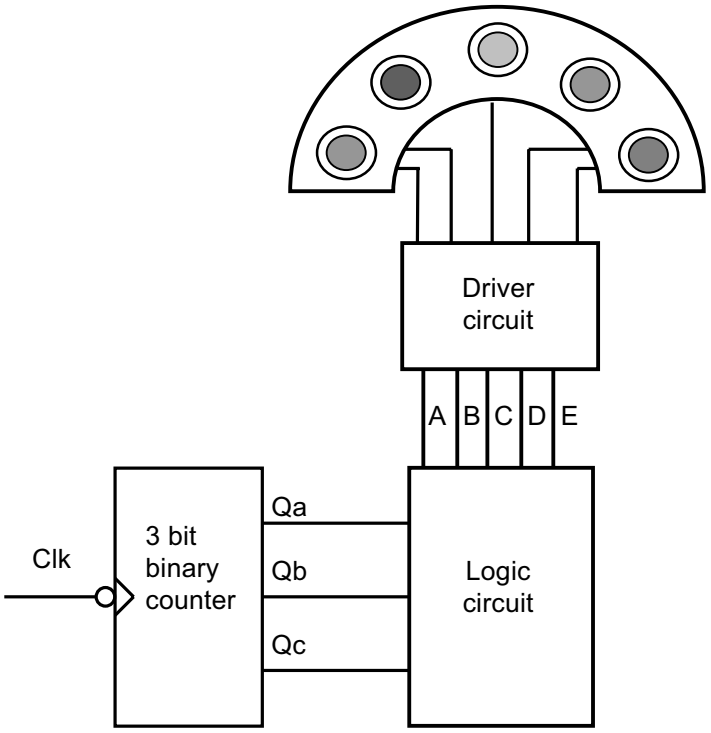


Fig. 2(a)

(a) (i) Draw a truth table for the counter outputs Qa, Qb and Qc as the counter is incremented from 000 to 111 assuming that Qa is the LSB.

The truth table should include columns for A, B, C, D and E showing when the lamps are on. Assume a "1" corresponds to a lamp being lit. [3]

(ii) Deduce minimised logic expressions for the outputs A, B and C using Karnaugh maps. [6]

(iii) Draw logic circuits for the minimised logic expressions for outputs A, B and C. [3]

(b) A system has been devised to inform people waiting in the queue for a theme park train ride about the number of seats available. A turnstile operator is responsible for locking and unlocking the entrance/exit turnstiles. The ride can accommodate 99 people and each time a person passes through one of the turnstiles the display will either count up or count down by 1. **Fig. 2(b)** shows the entrance and exit turnstiles and the large seven segment displays.

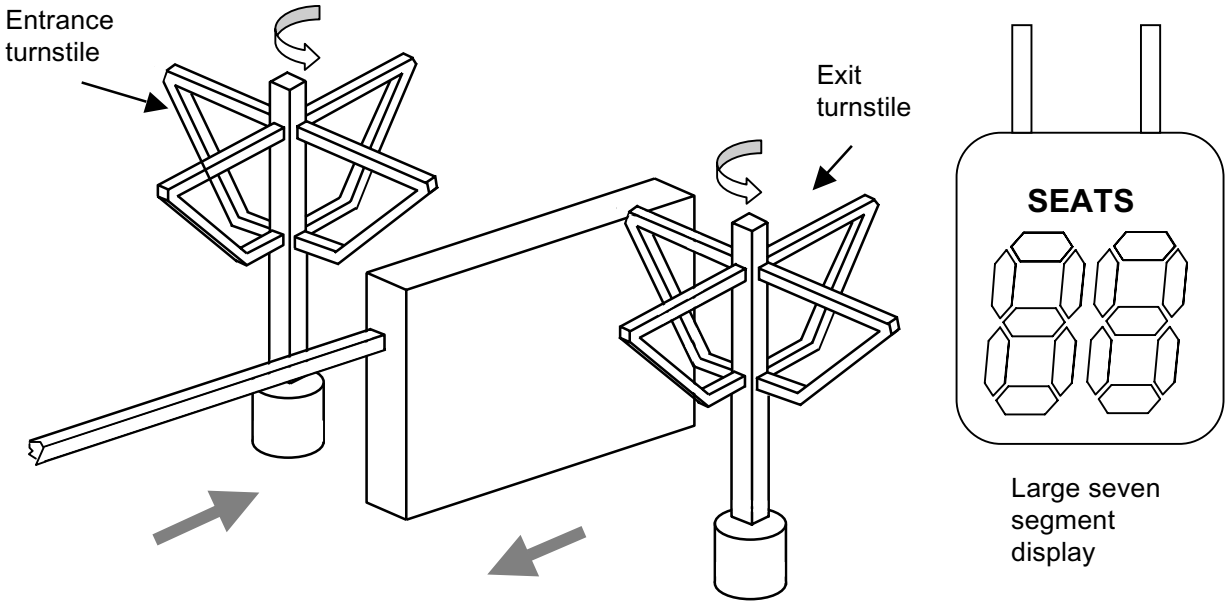


Fig. 2(b)

State **two** advantages, other than cost of using LED type displays over LCD types for the application described above. [2]

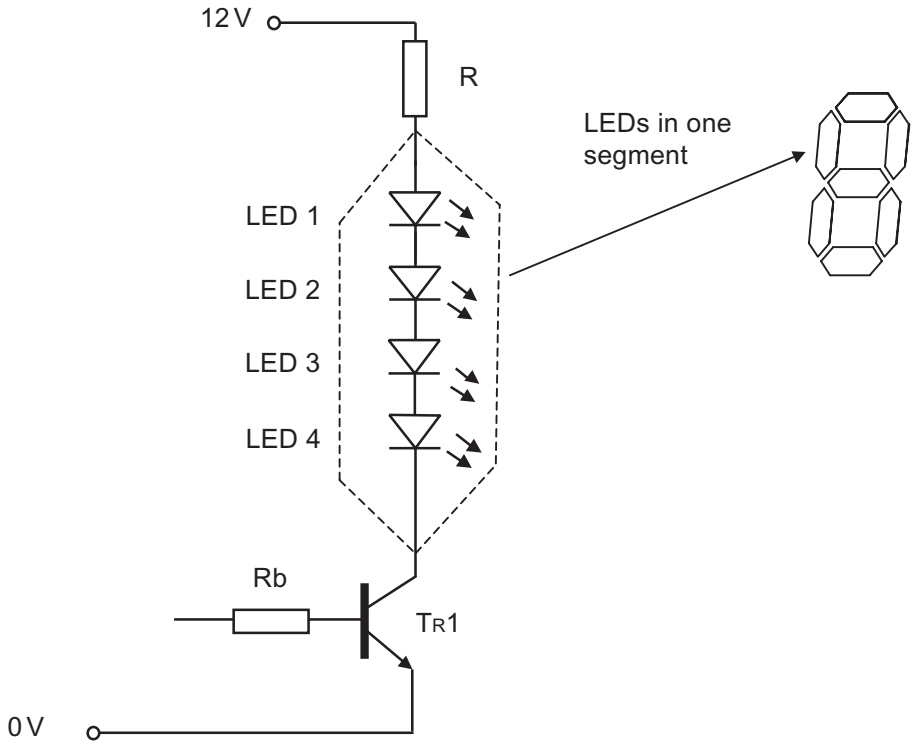


Fig. 2(c)

(c) In the large seven segment displays used to indicate the number of seats available each segment consists of 4 LEDs connected as shown in **Fig. 2(c)** The current in each LED is 20 mA and the forward voltage of each LED is 2.5 volts.

(i) Determine a suitable value and power rating for the resistor R. (Assume that there is no voltage drop across the collector/emitter of the transistor TR1.) [3]

(ii) Calculate the total power dissipated by the LEDs when a segment is illuminated. [2]

(d) The entrance and exit turnstiles can only turn in one direction as shown in **Fig. 2(b)**. Each time a person pushes through a turnstile it will rotate by 90°. A microswitch is to be used to detect the rotation of the turnstile and hence detect each person.

(i) Using an annotated sketch, show how a microswitch could be used to detect the movement of the turnstile. [2]

(ii) A PIC is to be used to detect the activation of the microswitch and produce a short pulse.
With the aid of a circuit diagram explain how a digital input to a PIC can be provided by using a microswitch. [2]

(iii) During initial testing of the PIC circuit, it was evident that more than one pulse was being detected from the microswitch even though only one person was passing through the turnstile. Explain the likely cause of this problem and suggest a method of overcoming it. [3]

(e) A BCD up/down counter is to be used as the basis of a circuit to control the large seven segment displays shown in **Fig. 2(b)**. Additionally a PIC circuit is to be used to read the pulses from each of the turnstiles to control the BCD up/down counter.

(i) Briefly explain why a BCD counter is more appropriate than a binary counter for the application described in **2(b)**. [2]

(ii) The large seven segment displays shown in **Fig. 2(b)** are of the common anode display type. Explain with the aid of a diagram what is meant by the term common anode display. [2]

(iii) Using electronic circuit diagrams on the blank pro forma provided (answer number **2(e)(iii)**), design a circuit using BCD counters and a PIC that will fulfil the following to enable the turnstile operator to establish when to lock and unlock the turnstiles.

- Count down the number of people passing the entrance turnstile from 99 and display it on the common anode seven segment displays.
- Count up the number of people passing the exit turnstile from 0 and display this on the common anode seven segment displays. [10]

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

Section B

Mechanical and Pneumatic Control systems

3 **Fig. 3(a)** shows a chainsaw and sawhorse used to cut up logs for burning on open fires or wood burning stoves.

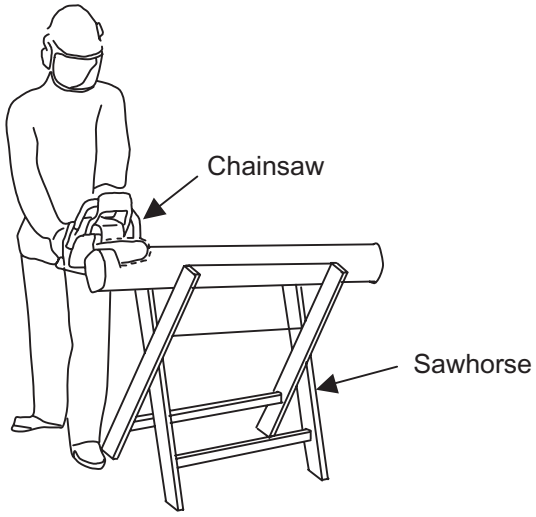


Fig. 3(a)

(a) Outline **one** main safety issue associated with the use of a Mechanical control system. [1]

(b) The engine in the chainsaw contains a cylinder head which is bolted on to the body of the engine and a piston which moves up and down in a crank and slider arrangement. **Fig. 3(b)** shows the bolt used to join the cylinder head to the body of the engine and the piston, connecting rod and pin used in a crank and slider arrangement.

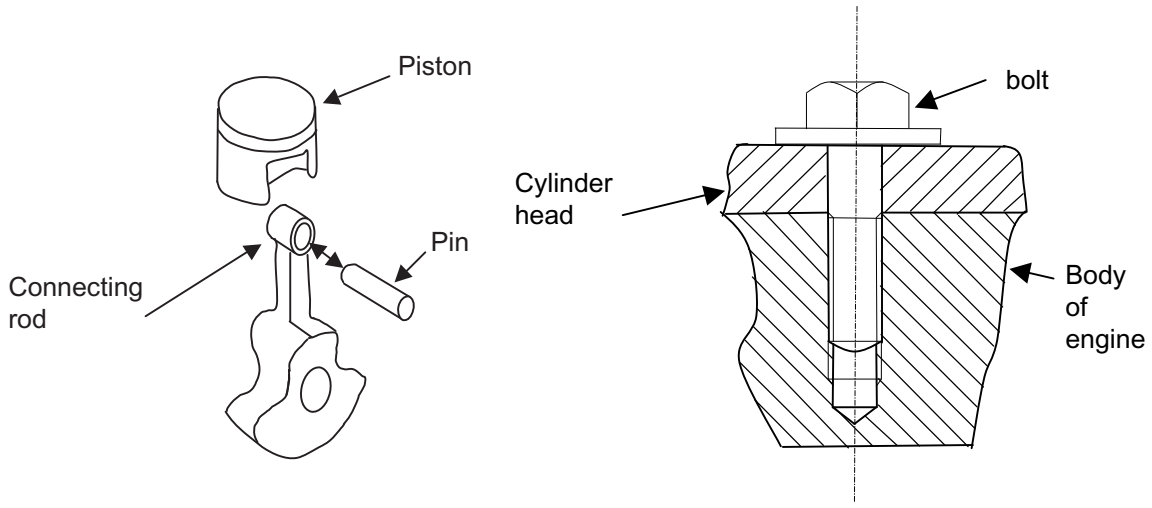


Fig. 3(b)

(i) The bolts which secure the head onto the body of the engine are set to a torque of 80 Nm and the mechanic applies a force 400 mm from the centre turning point. Calculate the minimum force required to slacken the bolt. [2]

(ii) The piston in the chainsaw engine moves 180 mm at a speed of 3000 rpm. If the piston has a mass of 0.3 kg, calculate the kinetic energy for the piston ignoring friction. [4]

(c) Roller element bearings are used to support the pin in the connecting rod as shown in **Fig. 3(b)**. With reference to **Fig. 3(c)** below produce an annotated sketch of an appropriate roller element bearing which would provide suitable support for the pin. [4]

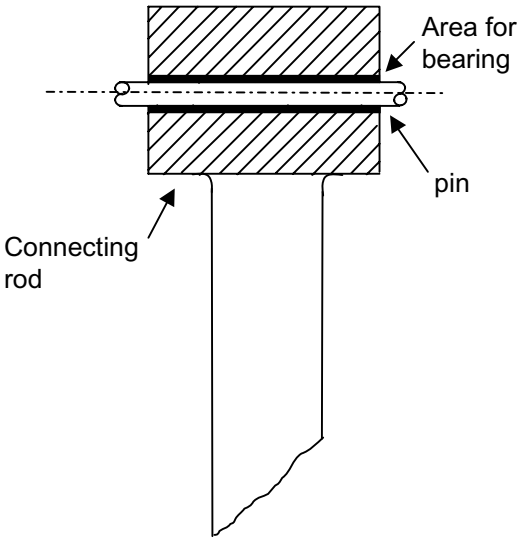


Fig. 3(c)

(d) Gaskets and seals are used on various parts of the chainsaw.

(i) Briefly explain the purpose of a gasket and give **one** main reason why they are used. [2]

(ii) With reference to **Fig. 3(d)** name and produce an annotated sketch of a suitable seal for the petrol cap. This seal will help prevent leaks when the petrol cap is screwed into the threaded hole of the tank. [2]

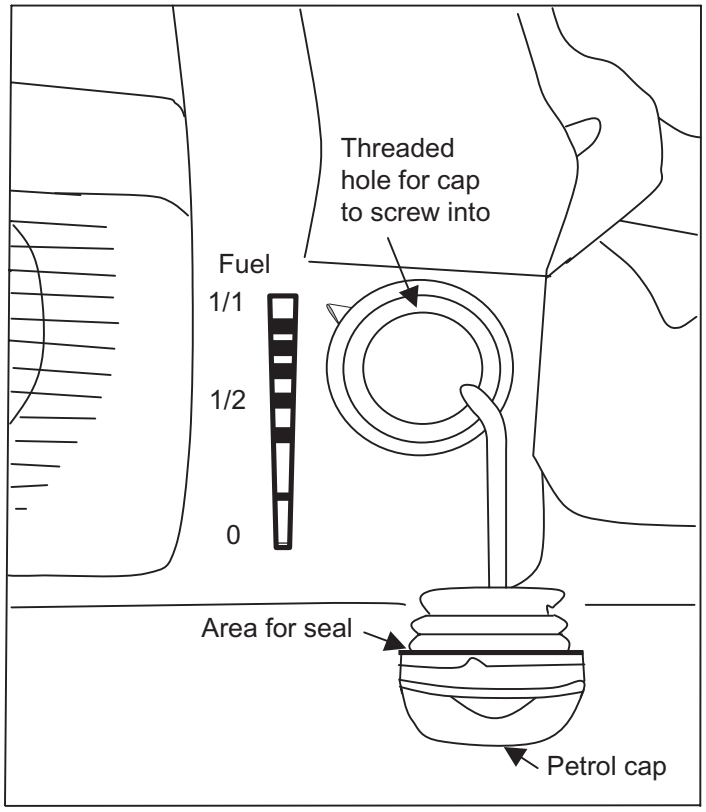


Fig. 3(d)

(e) The chainsaw uses a band brake as a safety device. When activated the brake prevents the sprocket which drives the chain from rotating.
With the use of an annotated sketch draw a band brake. Include in your sketch a method to activate this brake. [3]

(f) The chainsaw uses a clutch to transmit motion from the crankshaft in the engine to the sprocket and chain drive. As the operator increases the engine revs by pressing the throttle the clutch gradually engages.
Discuss the merits of using each of the following clutches; cone, centrifugal or diaphragm. Select an appropriate clutch for the chainsaw and justify your choice. [5]

Quality of written communication. [4]

(g) In **Fig. 3(g)** a transparent safety guard has been fitted to the sawhorse to give protection to the operator from flying debris. This safety guard is connected to the leg of the sawhorse using a ball and socket joint.

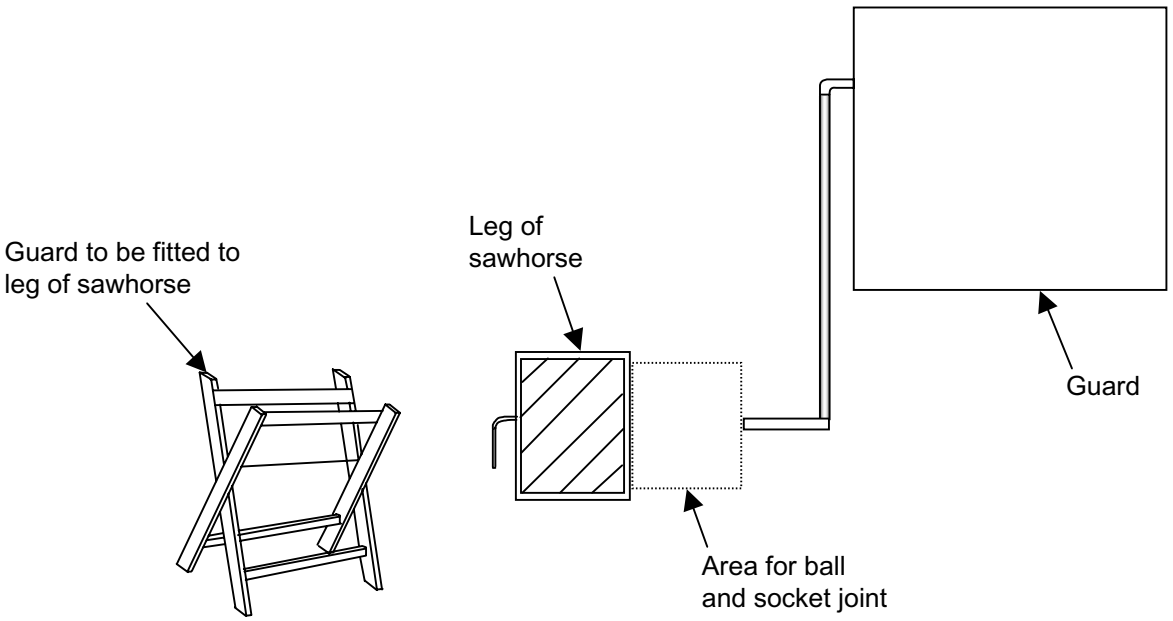


Fig. 3(g)

With the use of an annotated sketch draw a ball and socket joint. Explain how the ball and socket joint enables the guard to remain in a set position. [3]

(h) **Figs. 3(h)(i)** and **(ii)** show drawings of a sawhorse which requires additional features. Design, draw and annotate an appropriate mechanical system which would achieve each of the following requirements:

- A means of enabling the operator to quickly adjust the angle at X. When a handle which is fixed to leg A is rotated by the operator, leg B will move in or out in order to set a comfortable height to work from. (See **Fig. 3(h)(i)** below.)

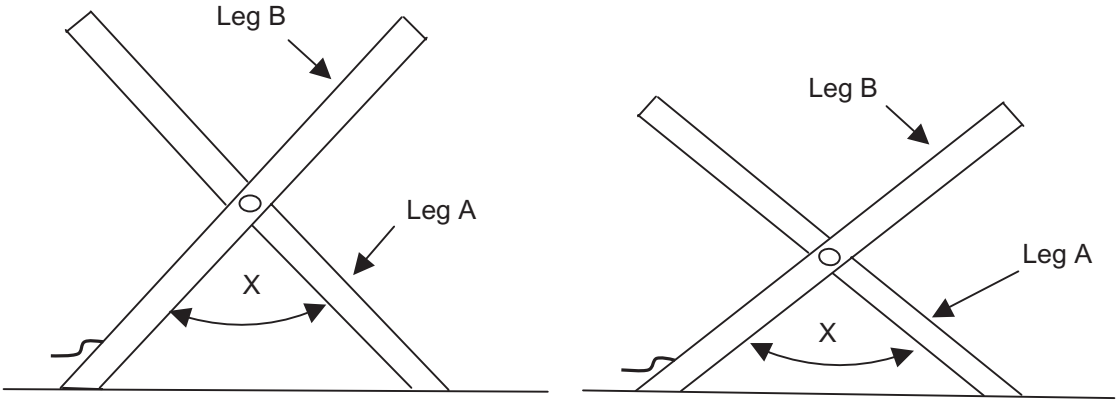


Fig. 3(h)(i)

- A means of enabling the log to be clamped and secured in position for cutting. When the operator presses down on the foot pedal this will make the rubber pads squeeze in to clamp the log (making reference to **Fig. 3(h)(ii)** below). [10]

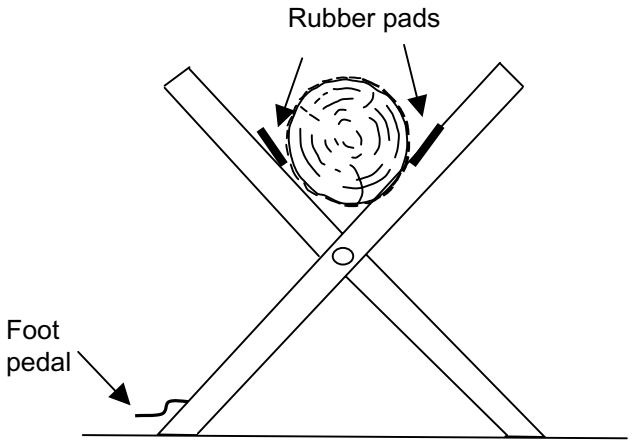


Fig. 3(h)(ii)

4 **(a)** **Fig. 4(a)** below shows a circuit to be used to sand blocks of wood. Name the specific components which are the input, control and output for the circuit. [3]

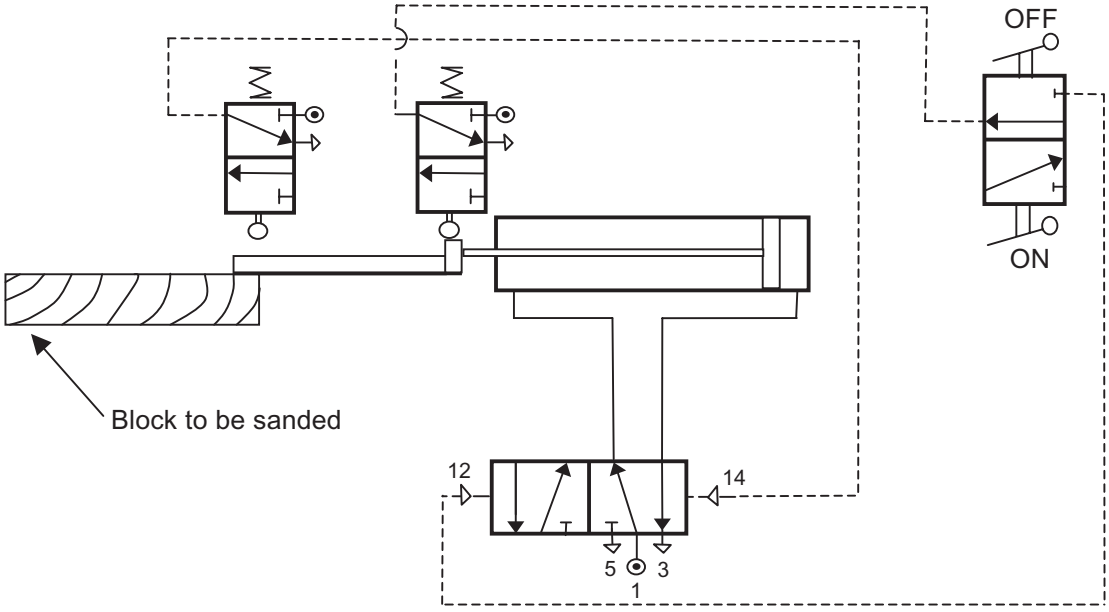


Fig. 4(a)

(b) **(i)** **Fig. 4(b)** shows a circuit designed to control a hopper containing sand. When valves A and B are pressed together the 5 PV should send the cylinder negative to open the base of the hopper. When the bag fills the table would lower to activate an air bleed and send the cylinder positive to close the hopper.

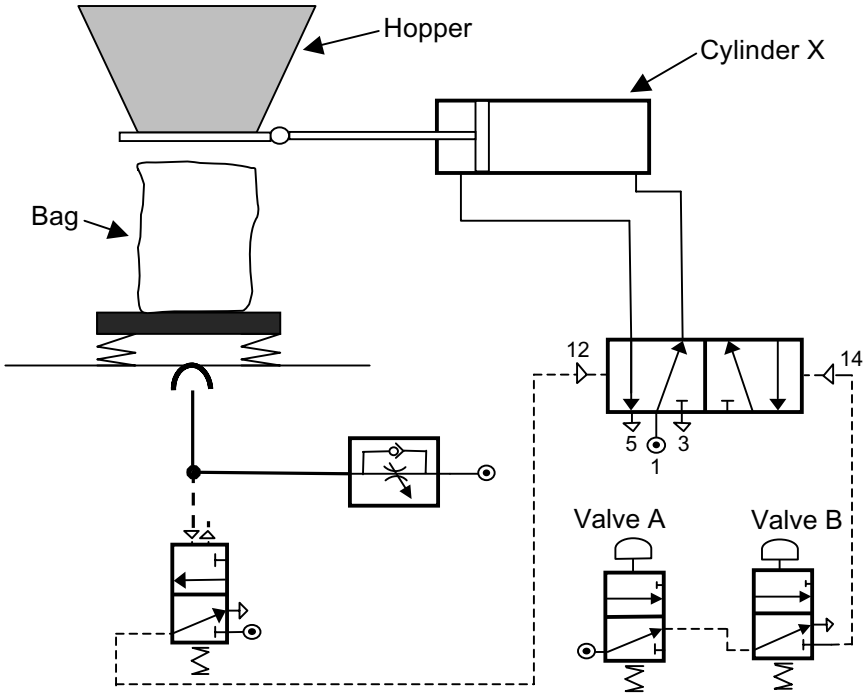


Fig. 4(b)

The operator has discovered **two** mistakes made when piping up the circuit. Identify each of the two mistakes and explain what corrective measures need to be taken in order for the circuit to function. [4]

(ii) With reference to **Fig. 4(b)** calculate the work done by cylinder X if the force required to open the base of the hopper is 1852 N and the distance moved by the force is 400 mm. [2]

(iii) With reference to Table 1 select an appropriate air pressure, piston rod and cylinder size in order to minimise the difference between the outstroke and instroke forces. Having selected from the table calculate the difference. [4]

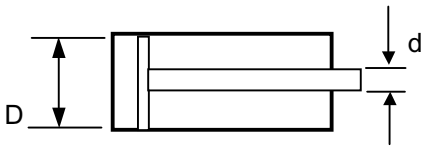


Table 1

Available (d) piston rod sizes	Available (D) cylinder sizes	Available air pressure settings
12 mm	32 mm	3 bar
16 mm	40 mm	4 bar
18 mm	48 mm	6 bar

(c) The pneumatic workstation shown in **Fig. 4(c)** is used to assist in the production of leather belts. On the workstation leather is fed from a roll along a guide rail where it is clamped, then blanked to create belt holes before being cut to a set length. The end of the belt is then fixed to a buckle by a rivet to complete the operation.
The following sequence is managed from the control panel:

- The motor is switched on and the gear wheel rotates to feed the belt along the guide rail.
- When the belt reaches the end of the rail it activates a switch which turns off the motor feeding the belt and sends an electric pulse to a solenoid valve.
- This solenoid starts the pneumatic sequence with Cylinder A1 and A2 outstroking to clamp the belt.
- Then cylinder B outstrokes to lower the blanking pins to create the belt holes.
- Next, cylinder C outstrokes to cut the belt to a predetermined length.
- Cylinder C then instrokes which in turn makes cylinder B instroke.
- Then cylinder A1 and A2 instroke to unclamp the belt.
- The operator takes the end of the belt and positions it with a buckle and a rivet in a jig directly below cylinder D.
- After a long time delay cylinder D outstrokes slowly to clinch the rivet and secure the buckle to the belt.
- Cylinder D then instrokes to complete the sequence.
- Emergency stops need to be piped into the circuit so that the operator can stop the sequence from either emergency stop 1 or emergency stop 2 at any stage.

On the pro forma provided (answer number **4(c)**) draw a suitable sequential pneumatic circuit to achieve the desired sequence outlined above. [17]

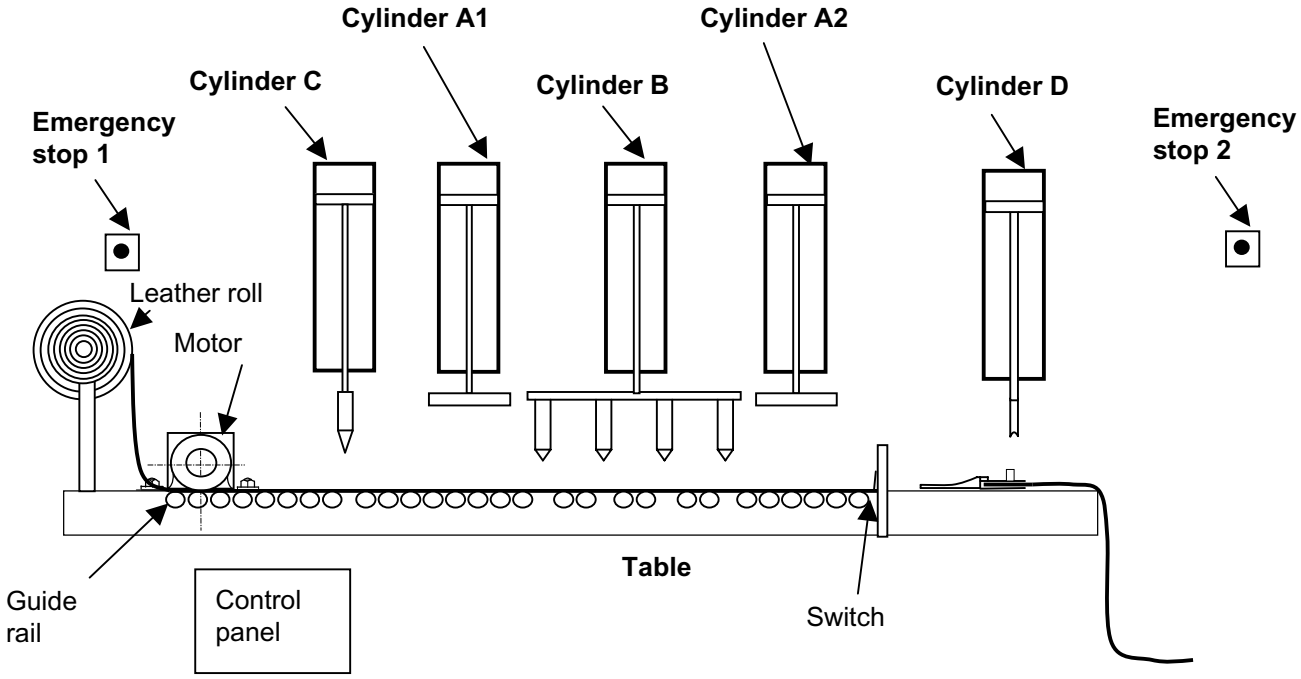


Fig. 4(c)

(d) Testing on the pneumatic workstation found that changes were required to the operation of cylinder D. On the pro forma provided (answer number **4(d)**) design and draw:

- a pneumatic system which will enable cylinder D to outstroke either from the sequence (signal from C +) or after inspection when the buckle is replaced and detected in its original position and a foot operated valve is pressed.
- a pneumatic system which controls the speed of cylinder D and automatically returns the cylinder to the instroke position after a time delay. [10]

THIS IS THE END OF THE QUESTION PAPER

112208

Question No. 1(d)(iii)

ADVANCED LEVEL TECHNOLOGY AND DESIGN
Assessment Unit A2 1
2012

Centre Number

71

Candidate Number

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

Question No. 2(e)(iii)

ADVANCED LEVEL TECHNOLOGY AND DESIGN
Assessment Unit A2 1
2012

Centre Number

71

Candidate Number

Pro forma answer page
(answer number 2(e)(iii))

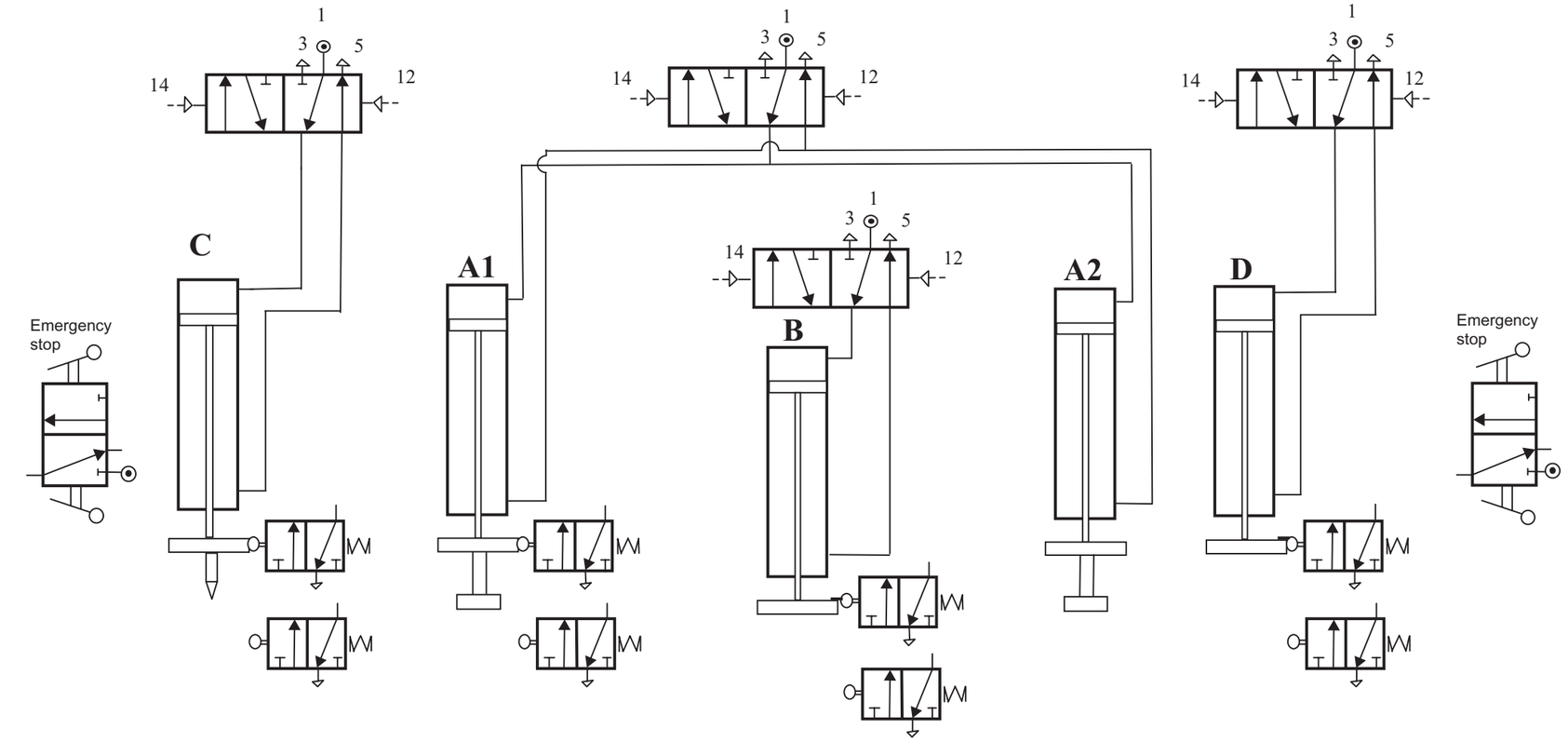
Question No. 4(c)

ADVANCED LEVEL TECHNOLOGY AND DESIGN
Assessment Unit A2 1
2012

Centre Number

71

Candidate Number



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

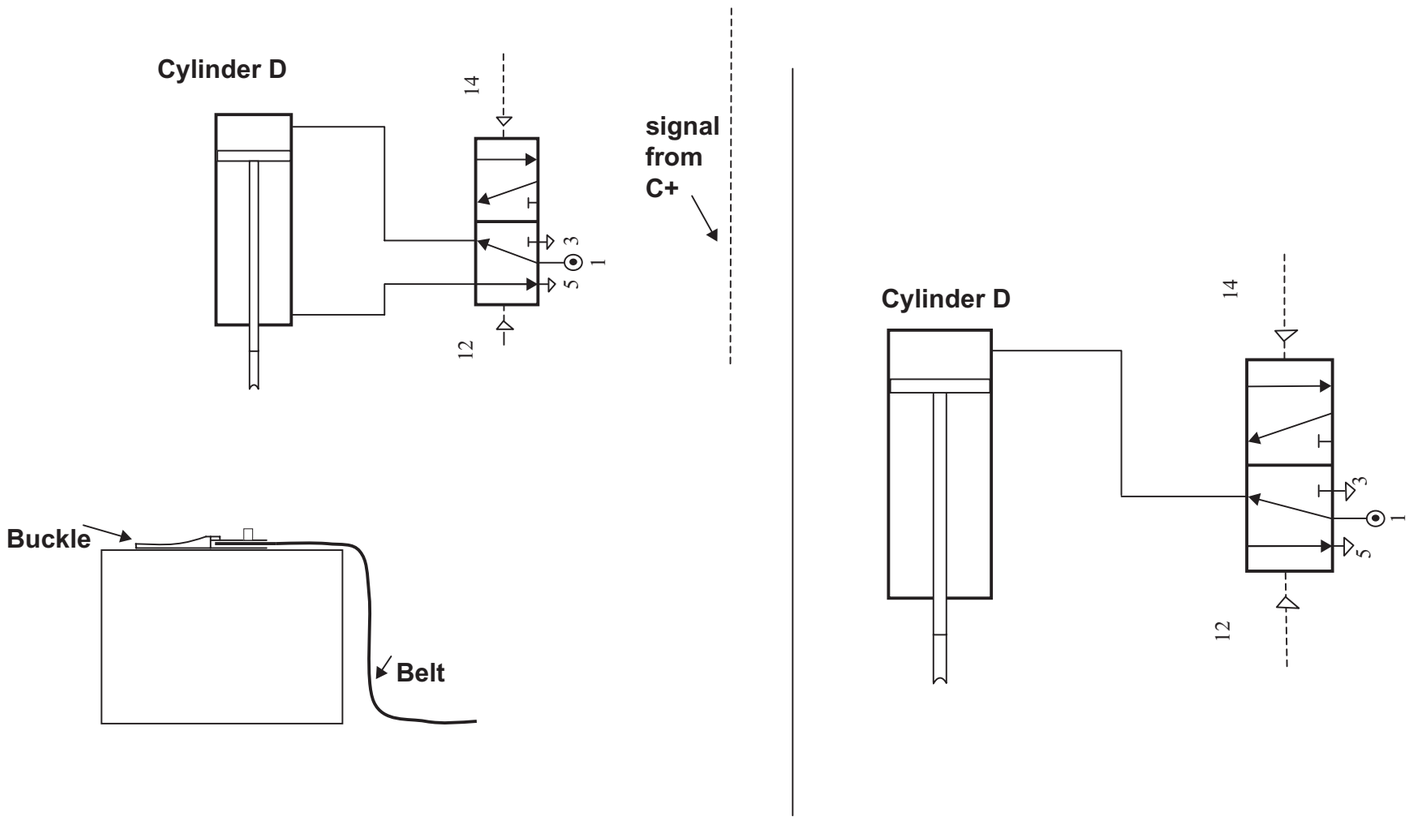
Question No. 4(d)

ADVANCED LEVEL TECHNOLOGY AND DESIGN
Assessment Unit A2 1
2012

Centre Number

71

Candidate Number



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