



**ADVANCED**  
**General Certificate of Education**  
**2018**

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# **Technology and Design**

**Assessment Unit A2 1**

*assessing*

**Systems and Control  
and  
Product Design**

**[AV211]**

**FRIDAY 8 JUNE, MORNING**

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**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 **two** questions from either Section A, Section B or Section C.

Answers to Question **1(e)**, Question **2(e)**, Question **3(e)(i) and (ii)**, Question **4(c)**, Question **4(d)(i) and (ii)**, Question **5(g)(i) and (ii)** and Question **6(i)(i) and (ii)** 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.

Marks for quality of written communication will be awarded for questions **1(f)**, **3(a)(iv)** and **5(f)**. Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

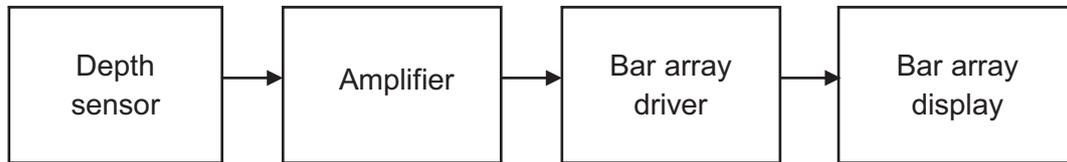
At the conclusion of the examination, attach the A3 pro forma answer pages securely to the Answer Booklet with the treasury tag supplied.

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

## Section A

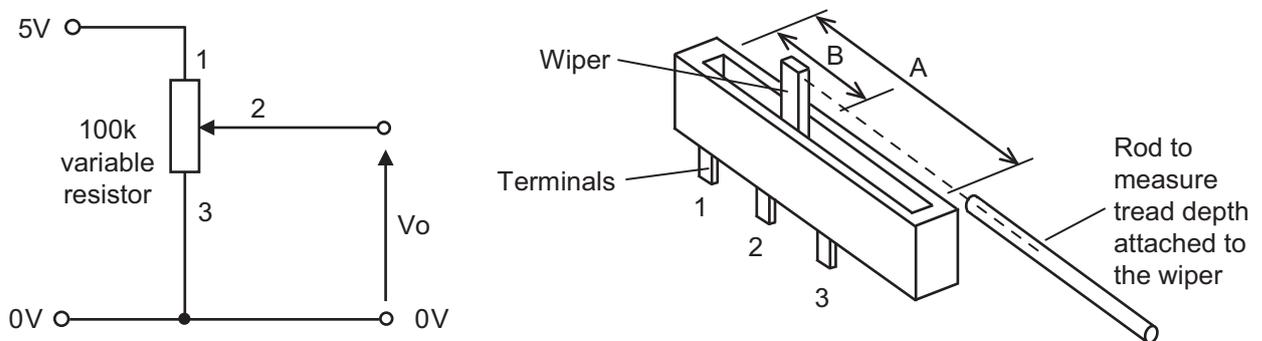
### Electronic/Microelectronic Systems

- 1 A block diagram for a proposed system to measure tyre tread depth is shown in **Fig. 1**. The voltage from a depth sensor is amplified and displayed on a bar array display using a bar array driver.



**Fig. 1**

- (a) State if the system shown in **Fig. 1** can be considered an on/off or a continuous system and justify your answer. [3]
- (b) Part of the circuit used to measure the depth of tyre treads is shown in **Fig. 2**. The circuit is based on a 100k linear variable resistor where the voltage  $V_o$  changes as the wiper of the variable resistor is moved. The variable resistor with labelled terminals is also shown where the wiper can move through a maximum distance of  $A$ . The rod which is pushed into the tyre tread to determine the depth is attached to the wiper.



**Fig. 2**

- (i) Sketch a graph with labelled axes showing how the value of resistance as measured between terminal 2 and terminal 3 in **Fig. 2** varies as the wiper is moved from terminal 3 towards terminal 1. [3]
- (ii) Determine the voltage  $V_o$  in **Fig. 2** if the wiper of the variable resistor is moved to a position where  $B = 6 \text{ mm}$  and  $A = 20 \text{ mm}$ . [2]

- (c) During testing the voltage  $V_o$  in **Fig. 2** ranges from 0–2 volts while the bar array driver which is shown in **Fig. 3** requires a 0–5 volt input range in order to drive a bar array. An amplifier is therefore required.

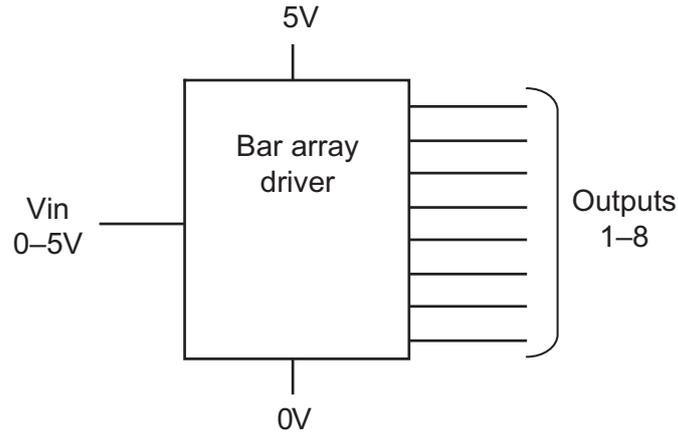


Fig. 3

- (i) Calculate the required gain for the amplifier. [2]
- (ii) Draw a suitable amplifier (based on an op amp) with the required gain to drive the bar array. Assume that the gain of an inverting and non inverting amplifier is given by  $-R_f/R_i$  and  $1+R_f/R_i$  respectively. Specify suitable values for  $R_f$  and  $R_i$  where  $R_f$  is the feedback resistor. [4]
- (d) The bar array display to be used in the tyre tread depth system is shown in **Fig. 4**. It has eight bars which are connected within the display in common cathode configuration. Each bar consists of two LEDs in series as shown.

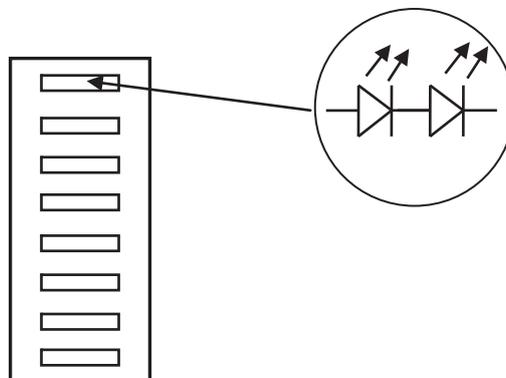
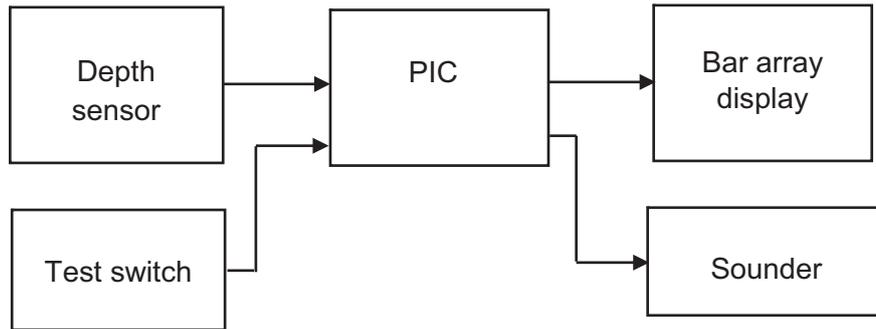


Fig. 4

- (i) Show with the aid of a circuit diagram how the LEDs in the bar array shown in **Fig. 4** are connected within the display to form the common cathode configuration. [2]
- (ii) The bar array driver shown in **Fig. 3** which is to be used with the LED bar array shown in **Fig. 4**, has eight outputs with each output providing 5 volts. Each LED in the bar array operates at 10mA and has a forward working voltage of 2V. Show how you would determine if a protective resistor is required for each bar in the array and then calculate the value of the required protective resistor. [3]
- (iii) Calculate the total power dissipated by the bar array display (excluding protective resistors) in **Fig. 4** when all bars are illuminated. [2]

- (e) The system for measuring tyre tread depth shown in **Fig. 1** is to be modified as shown in **Fig. 5**.



**Fig. 5**

The modifications will allow the system to function as follows:

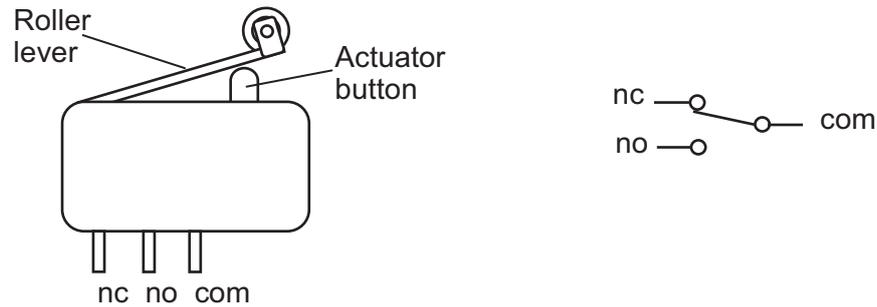
- When the depth sensor has been pushed against the tyre tread a test switch is pressed.
- When the switch is pressed the number of bars illuminated will represent the tread depth in mm up to a maximum of 8 mm. (One bar for each mm)
- The tread depth should be checked every 0.5 seconds.
- If the tyre tread depth is between 0 and 3 mm inclusive the sounder should operate and the appropriate bars should flash at a frequency of 2 Hertz.
- When the test switch is released the sounder should stop and all the bars switch off.
- A hard wired 'power on' LED should indicate that the system is operational.

Using electronic circuit diagrams on the blank A3 pro forma provided (**answer number 1(e)**) design a PIC based circuit and associated flow chart that will control the LED bar array and sounder. Assume that the PIC has a digital input (i/p1) and up to nine digital outputs (o/p0–o/p8). It also has an analogue input (i/p2) with a voltage range of 0V to 2V and a corresponding digital range of 0 to 127. [10]

- (f) Students are often required to produce an electronic control system as part of their coursework submission. Describe **three** main safety issues to be considered when producing or working with electronic control systems. Outline **two** main safety procedures that can be implemented when producing or working with electronic control systems. [5]

Quality of written communication [4]

- 2 (a) A microswitch is to be used to detect the position of a component on a production line. The microswitch is operated by means of a roller lever pressing on the actuator button. The microswitch, its corresponding circuit symbol and terminal labels are shown in **Fig. 6**.



**Fig. 6**

- (i) State how the contact is typically maintained between the common (com) terminal and the normally closed terminal (nc) in a microswitch when the actuator is not pressed. [1]
- (ii) Show with the aid of a circuit diagram how the microswitch shown in **Fig. 6** could be used to produce a 5 volt logic 'high' when the roller lever is operated and a 0 volt logic 'low' when not operated. [3]
- (iii) Microswitch contacts tend to 'bounce' when the actuator button is pressed which can cause unwanted signals when used to provide logic signals. Explain with the aid of a circuit diagram **one** method of effectively overcoming this problem. [5]

(b) Fig. 7 shows a production conveyor and part of the circuit which controls an eight stage paint process that is carried out on a component before it is ejected off the conveyor onto a chute.

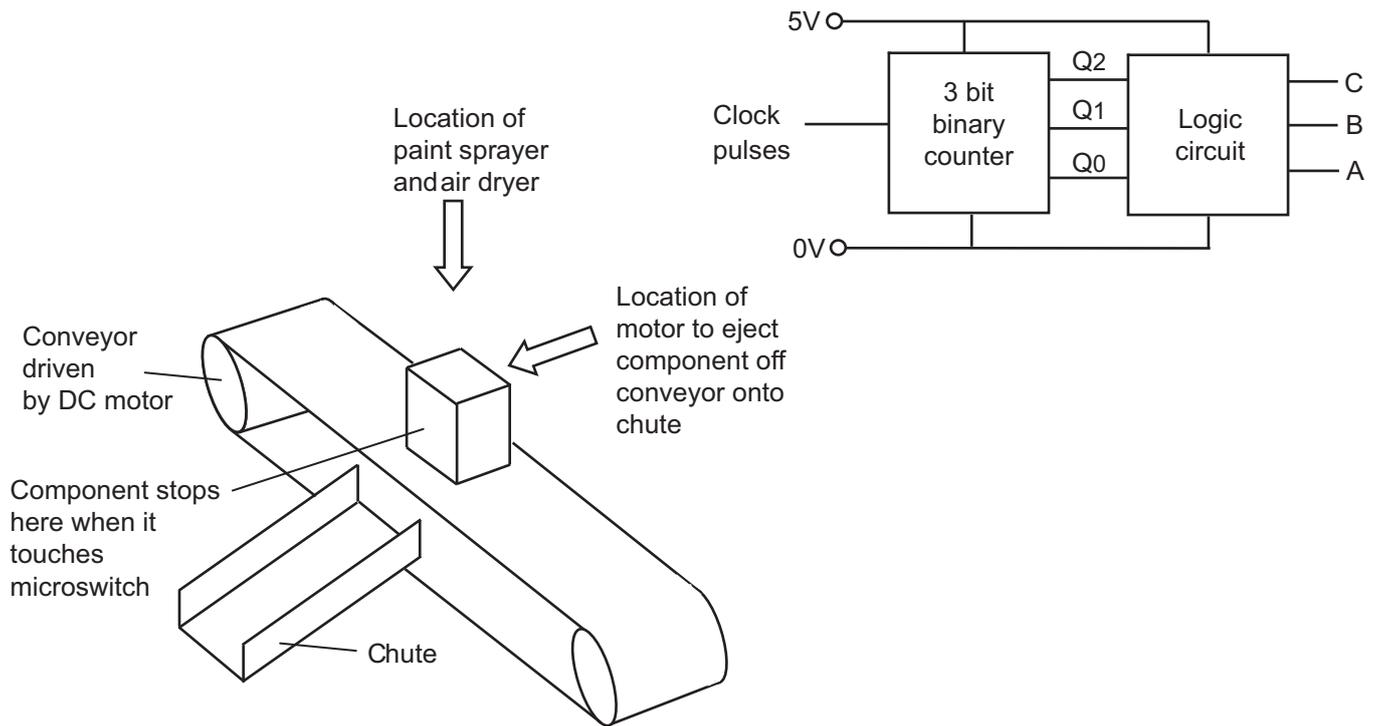


Fig. 7

Each stage of the paint process takes 3 seconds. The timing is determined by the input clock pulses to a 3 bit binary counter (with outputs Q<sub>0</sub>, Q<sub>1</sub> and Q<sub>2</sub>) which in turn drives a logic circuit that generates three control signals A(eject motor), B(air dryer) and C(spray pump). The painting process sequence is as follows:

For stages 1, 4 and 6, spray is applied via a spray pump. For stages 2, 3, 5 and 7 an air dryer is on and the spray pump is off. For stage 8 the sprayer and air dryer are off and a motor ejects the component.

- (i) Sketch a graph with labelled axes showing a suitable clock pulse (with a labelled time period marked in seconds), that could be used for the 3 bit binary counter in Fig. 7. [3]
- (ii) Draw a truth table showing all combinations for the counter outputs Q<sub>0</sub>, Q<sub>1</sub> and Q<sub>2</sub>, and the corresponding logic circuit outputs A, B and C. [4]
- (iii) From the truth table write logic expressions for outputs A, B and C minimising where appropriate using Karnaugh maps. [5]
- (iv) Draw the logic circuit that could be used for the two control signals A(eject motor) and B(air dryer). [3]

- (c) **Fig. 8** shows a seven segment LED display which is to be used to count the number of components that have been pushed onto the chute after painting. A 4 bit binary counter and 7 segment decoder are connected to the display as shown.

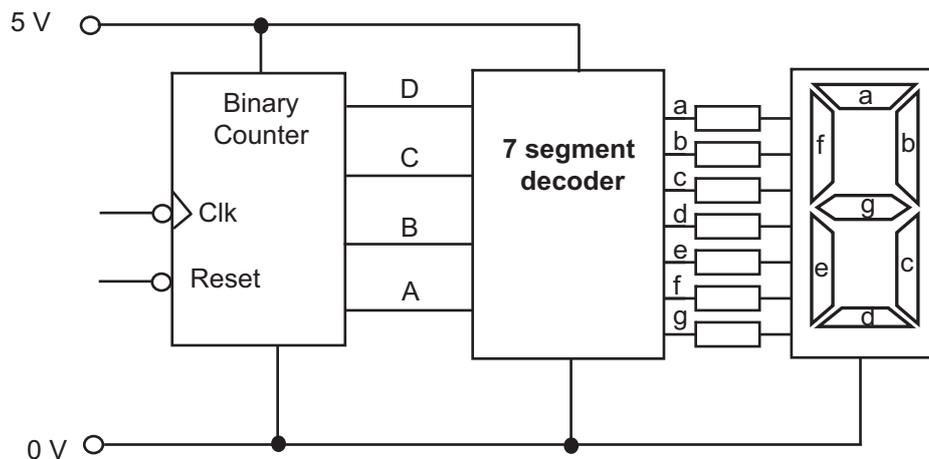


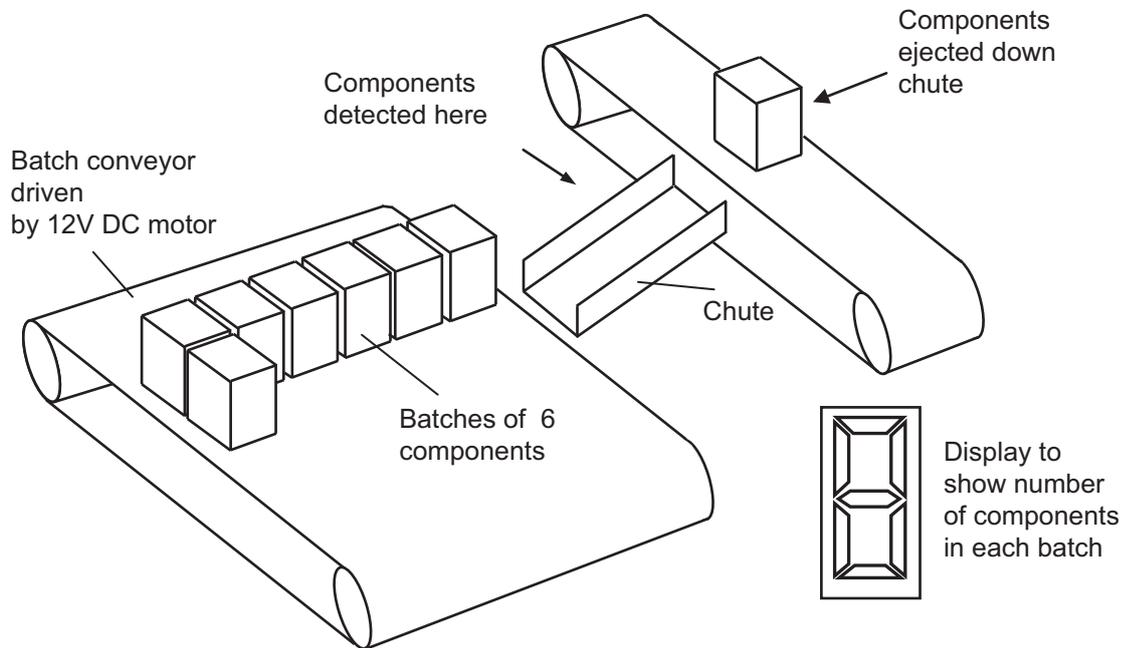
Fig. 8

- (i) State **one** main disadvantage of using an LED seven segment display compared to an LCD type display. [1]
- (ii) The counter shown in **Fig. 8** is a 4 bit binary counter where D is the most significant bit (MSB). Explain what is meant by the term MSB when referring to binary counters. [2]
- (iii) State the decimal equivalent for the maximum 4 bit binary number that the counter in **Fig. 8** can count up to. [1]
- (d) Part of an incomplete logic truth table for the seven segment decoder in **Fig. 8** is shown in **Fig. 9** below. It shows inputs A, B, C, and D (where A is the least significant bit) with the corresponding outputs a to g for two displayed numbers. Determine the missing logic values. (Do not provide your answer on **Fig. 9**). [2]

number	A	B	C	D	a	b	c	d	e	f	g
1	1	0	0	0							
3					1	1	1	1	0	0	1

Fig. 9

- (e) The counter circuit shown in **Fig. 8** is to be used as part of a system to count and display up to 6 components as they are pushed down a chute onto a batch conveyor as shown in **Fig. 10**. The components are detected as they pass down the chute by a non-contact sensor. After 6 components have been counted the DC motor moves the batch conveyor for 5 seconds in preparation for the next batch.



**Fig. 10**

Using electronic circuit diagrams on the pro forma provided (**answer number 2(e)**), complete and annotate a circuit that will fulfil the following:

- Detect each component as it passes down the chute and generate a pulse to operate the counter clock.
- Count and display up to 6 components.
- Supply power to the 12 volt DC motor driving the batch conveyor for 5 seconds to move the conveyor forward when a batch of 6 components has been completed.
- Stop the batch conveyor motor and reset the counter to zero in preparation for the next batch of components.

[10]

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

## Section B

### Mechanical and Pneumatic Control Systems

3 Fig. 11 shows a photograph of a go-kart that contains a range of mechanical systems.



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Fig. 11

- (a) (i) Outline **two** main methods used to minimise the safety issues associated with a mechanical system. [2]
- (ii) Gaskets are used in go-kart engines. Outline **two** main reasons why they are used. [2]
- (iii) With the use of an annotated sketch select and justify a suitable seal between the gearbox and the rotating shaft in Fig. 12 to provide a clamping support. [4]

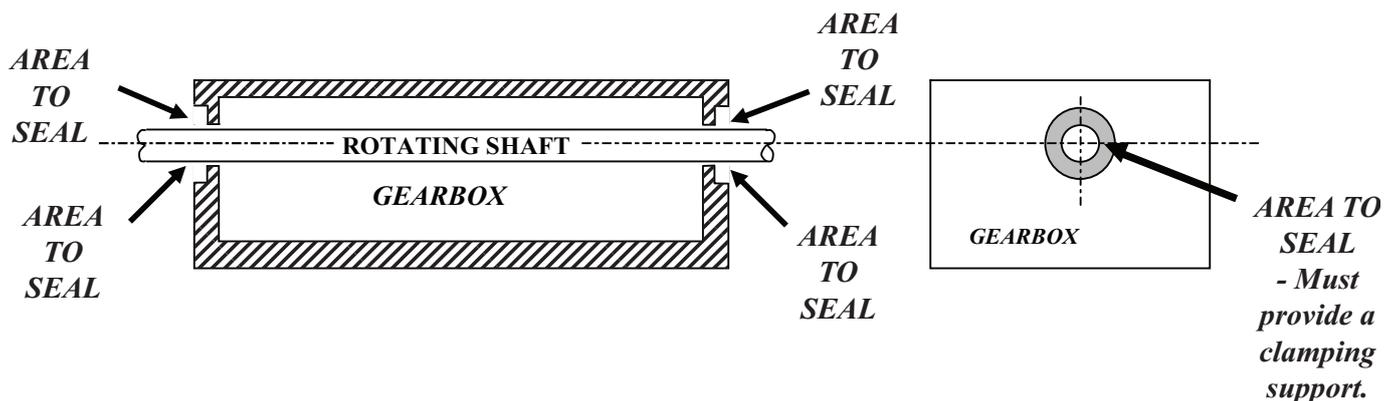


Fig. 12

- (iv) Lubricants in the form of oil are widely used in a range of moving parts on the go-kart. Outline **three** relevant factors when selecting an oil for the go-kart gearbox. Justify why SAE 30 would be a suitable choice for the go-kart gearbox. [5]

Quality of written communication [4]

- (b) **Fig. 13** shows a side and front view of the go-kart wheel and axle. Using an annotated sketch suggest a suitable bearing and housing to support the axle when subjected to radial loads. Also, draw a suitable method to secure the bearing in the housing while making provision for lubrication. [4]

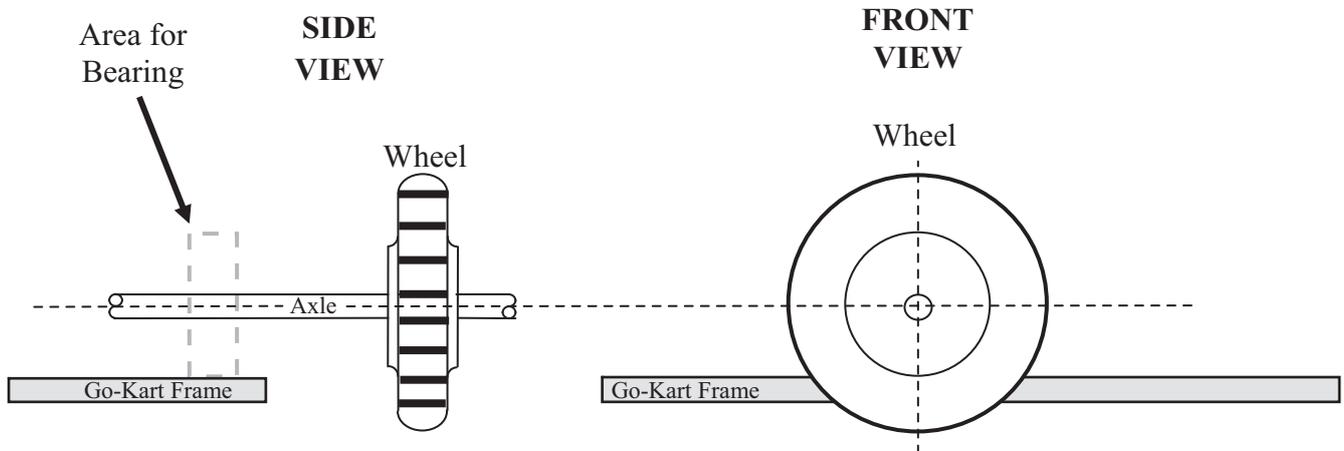


Fig. 13

- (c) **Fig. 14** below shows a compound gear train to be used for initial testing of the go-kart gearbox.

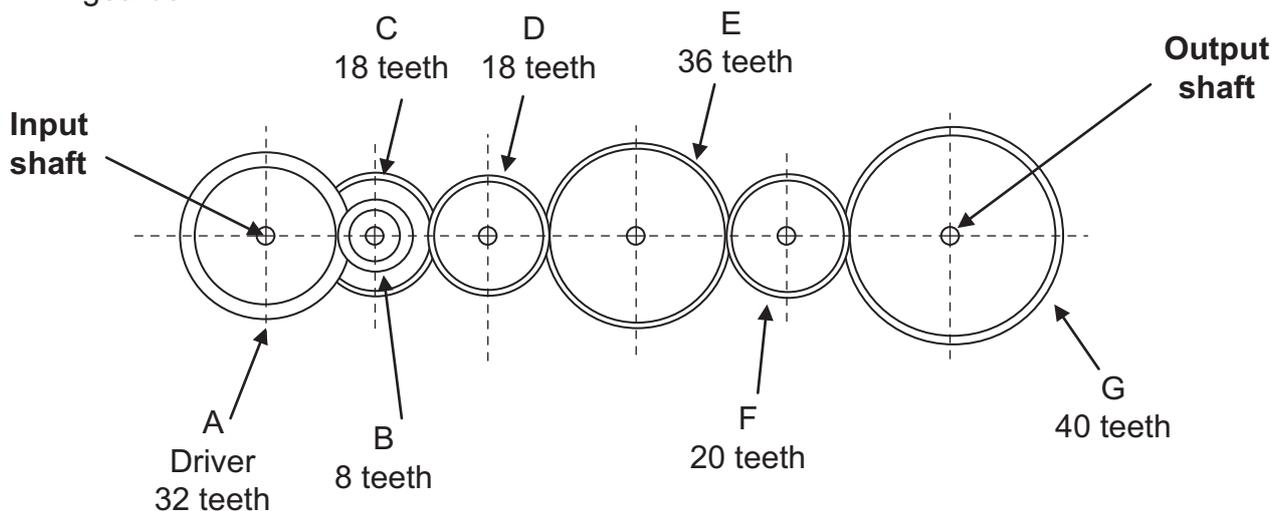


Fig. 14

- (i) Calculate the velocity ratio from gear **A** to gear **G**. [2]
- (ii) Calculate the output torque for the compound gear train shown in **Fig. 14** if the input torque is 300 N/m. [2]
- (iii) The gearbox output shaft and rear axle in the go-kart are attached by a chain and sprocket. Outline **one** advantage and **one** disadvantage of using this system. [2]
- (d) When lifting the go-karts off the race track a wire rope is fed through a three pulley block lifting system via an indoor crane. With the use of a sketch outline the main features of a three pulley block lifting system. [3]

- (e) On the pro forma provided (answer number **3(e)(i)** and **(ii)**) design, draw and annotate an appropriate mechanical system which would achieve the following requirements:
- (i) Enable the go-kart seat to be moved forwards and backwards on the rail using the handle shown. Your solution must allow the user to lock the seat in a set position. [4]
  - (ii) Enable a user to move the go-kart onto the trolley for maintenance purposes. A linkage based mechanism should attach onto the lifting bar located at the back of the go-kart and move the go-kart up to the position indicated using the motor. Please note the before and after positions. [6]

- 4 (a) (i) Explain what is meant by the term interlocking when applied to pneumatic systems. [2]
- (ii) Explain how the circuit in **Fig. 15** operates starting with activation of Valve A (your answer should include a detailed explanation of the operation of valve B). [4]

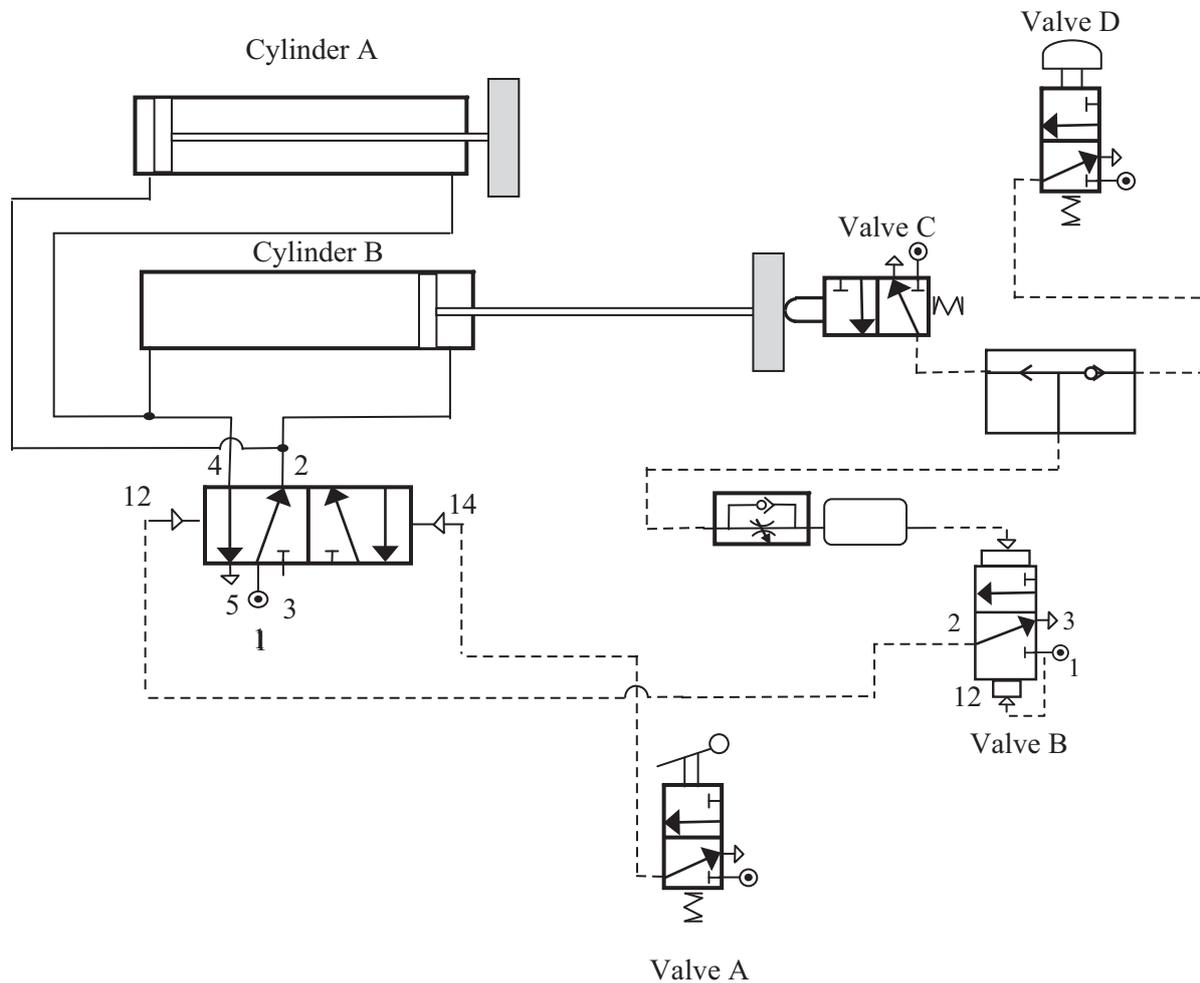


Fig. 15

- (b) (i) Calculate the work done by the cylinder in **Fig. 16** if the force required to outstroke the cylinder is 2000 N and the distance moved is 600 mm. [2]

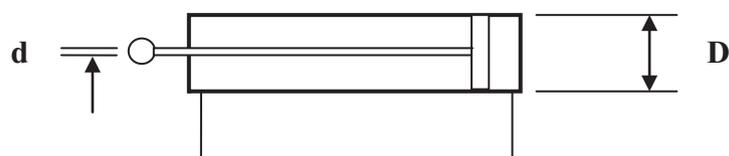


Fig. 16

- (ii) With reference to **Fig. 16** and **Table 1** calculate the difference between the minimum and maximum force achievable during instroke if 20% is lost through inefficiency. (Please assume  $\pi = 3.14$ ) [6]

Available (d) piston rod sizes	Available (D) cylinder sizes	Available air pressure settings
44 mm	140 mm	3 bar
60 mm	160 mm	4 bar
76 mm	180 mm	5 bar

**Table 1**

- (c) The pro forma (**answer number 4(c)**) shows a pneumatic system used for the production of aluminium cans. Complete the following sequence using the minimum number of groups. The sequence follows these stages:
- Aluminium is fed into the production line using a motor. The sequence begins by closing the Guard to activate the START 3PV.
  - Cylinders A1 and A2 go positive slowly to clamp and punch the aluminium at the same time on the production line. When Cylinder A2 is in the positive position it is detected by the roller trip 3/2 valve.
  - Cylinder B then goes positive activating Mill 1. It is detected by a 3/2 valve which sends Cylinder B negative following a delay in time.
  - Following detection by the 3/2 valve Cylinder C then goes positive activating Mill 2. When Cylinder C is in the positive position it is detected by the plunger 3/2 valve which in turn enables Cylinders A1, A2 to go negative. Following detection by the 3/2 valve at A1 Cylinder C goes negative.
  - Following detection of Cylinder C in the negative position Cylinder D goes positive to cut the aluminium to the pre-determined length.
  - Following detection by the 3/2 valve Cylinder D then goes negative activating Cylinder E which is used to lift the aluminium sheet.
  - Following activation of the air bleed Cylinder E resets the sequence and returns to the negative position. [16]
- (d) Reject cans are processed at another area of the factory. On the pro forma provided (**answer number 4(d)(i)** and **(ii)**) design and draw a system which will:
- (i) Act as can crusher through the activation of the pneumatic cylinder. The air bleed shown on pro forma **4(d)(i)** will activate the can crusher cylinder to reciprocate automatically with speed control. This will allow the cans to be crushed when a can is present. [4]
- (ii) Sense the bale of crushed cans on the rollers via the proximity sensor and rotate the bale through 90 degrees by adding an appropriate mechanism to the end of the piston rod on the double acting cylinder. Your solution on the pro forma **4(d)(ii)** must return the double acting cylinder to the negative position automatically. [6]

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

### Section C

#### Product Design

- 5 The foot pump like the one shown in **Fig. 17** below is designed and manufactured by companies in a range of models to suit different markets.



**Fig. 17**

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- (a) For companies developing new products for the bicycle tyre inflation market it is important that the information gained from market research is reliable.

Briefly outline why market research needs to be reliable.

[1]

- (b) When conducting market research for bicycle foot pumps consideration needs to be given to the use of probability and non-probability sampling in order to determine an appropriate client base.

(i) Explain what is meant by non-probability sampling.

[2]

(ii) Briefly outline **one** main reason why companies designing and manufacturing bicycle foot pumps may prefer to use non-probability sampling.

[1]

Once a suitable sample has been generated the use of postal questionnaires is one method that may be used to record and collect information.

(iii) Briefly outline **two** main advantages associated with the use of postal questionnaires as a means of recording and collecting information.

[2]

(iv) Briefly outline **two** main disadvantages associated with the use of postal questionnaires as a means of recording and collecting information.

[2]

- (c) Information and Communication Technology (ICT) is to be used to implement market research for the foot pumps and to analyse the outcome from this research.

(i) Briefly outline **two** ways in which ICT could be used to implement market research for the foot pumps.

[2]

(ii) Briefly outline **two** different ways in which ICT could be used to analyse the outcome from the research on the foot pumps.

[2]

- (d) The company designing and manufacturing the foot pumps has completed a life-cycle assessment and an environmental audit.
- (i) Explain what is meant by a life-cycle assessment. [2]
- (ii) Explain what is meant by an environmental audit and give **one** main potential benefit to the company that may arise through this audit. [3]
- (e) When considering a suitable pricing method for the foot pump the company considered perceived value pricing, cost-plus pricing and contribution pricing.
- (i) Explain what is meant by perceived value pricing, [2]
- (ii) Distinguish between cost-plus and contribution pricing. [2]
- (f) Designers such as Dyson have had a great influence on product design.
- Describe with reference to **five** main discussion points the influence that Dyson has had on product design. [5]
- Quality of written communication [4]
- (g) With reference to **Fig. 18** and **Fig. 19** below and using the blank A3 pro forma provided (**answer number 5(g)(i)** and **(ii)**) produce **one** suitable solution for each of the following:
- (i) Annotated sketches of a low cost design which will provide an additional set of support legs which can extend out to provide a wider base and therefore improve stability when inflating a bicycle tyre. To assist the user the additional support legs need to be quickly released, moved out and secured in position without the use of tools, ready for use. Show how your design is attached to the support legs. [5]

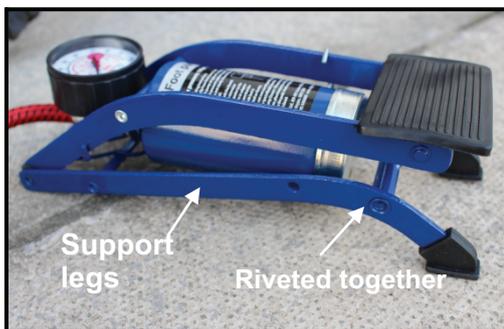


Fig. 18 © CCEA



Fig. 19 © CCEA

- (ii) Using the blank A3 pro forma provided (**answer number 5(g)(i)** and **(ii)**) produce annotated sketches of a design which could be fitted to the support legs of the foot pump. This should allow the three valve accessories shown in **Fig. 20** and **Fig. 21** to be housed safely and be quickly removed or replaced as required by the user. Show how your design could be attached without the use of tools. [5]



Fig. 20

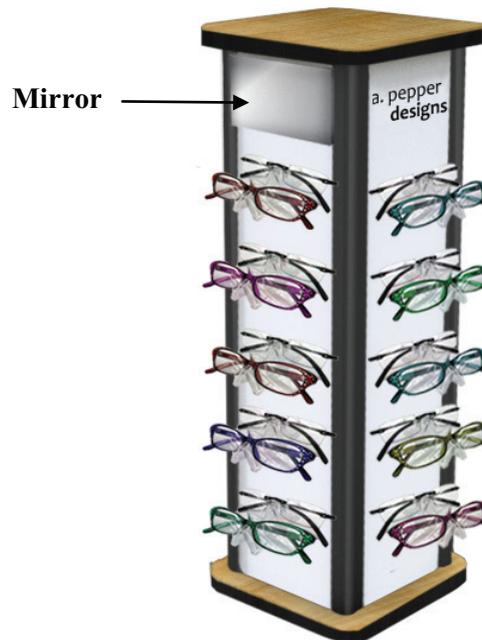
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Fig. 21

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- 6 **Fig. 22** below shows a shop counter display unit used for a new brand of glasses. The unit displays the product range and allows the user to remove the glasses, try them on and see how they look using a mirror which is fitted at the top of one of the sides.



© A. Pepper Designs Inc

**Fig. 22**

Glasses are constantly evolving and developing as technology changes. Some glasses may be categorised as fulfilling a need while others may be said to satisfy a demand.

- (a) Distinguish between needs and demands with regards to the creation of products. [2]
- (b) The introduction of new products to the market may be as a result of innovation in the market or through market pull.
- (i) Explain why it is so important to have innovation in the market. [2]
- (ii) Briefly outline **two** main factors associated with market pull. [2]
- (c) Valuable information can be obtained by researching government legislation. This information can then be used to shape future decisions for a company.
- (i) With reference to a product of your choice, explain the type of information gained by researching government legislation. [2]
- (ii) Explain how this information might influence future decisions for a company producing the product you have chosen. [2]

(d) The company was given advice on market research which suggested they could make use of retail audits and omnibus surveys.

(i) Briefly outline **two** main characteristics associated with retail audits. [2]

(ii) Briefly outline **two** main characteristics associated with omnibus surveys. [2]

(e) Fashion innovators, opinion leaders and the masses are types of consumers who emerge during the life cycle of products.

(i) Distinguish between fashion innovators and opinion leaders. [2]

(ii) Outline **two** main characteristics associated with the masses. [2]

(f) The challenge for many companies is to reduce material use in their products whilst not compromising on the functional and performance characteristics of the product.

With reference to **two** different suitable products of your choice explain specifically how reduction in material use has been achieved. [4]

(g) Moral and social factors are incorporated in the design of everyday products.

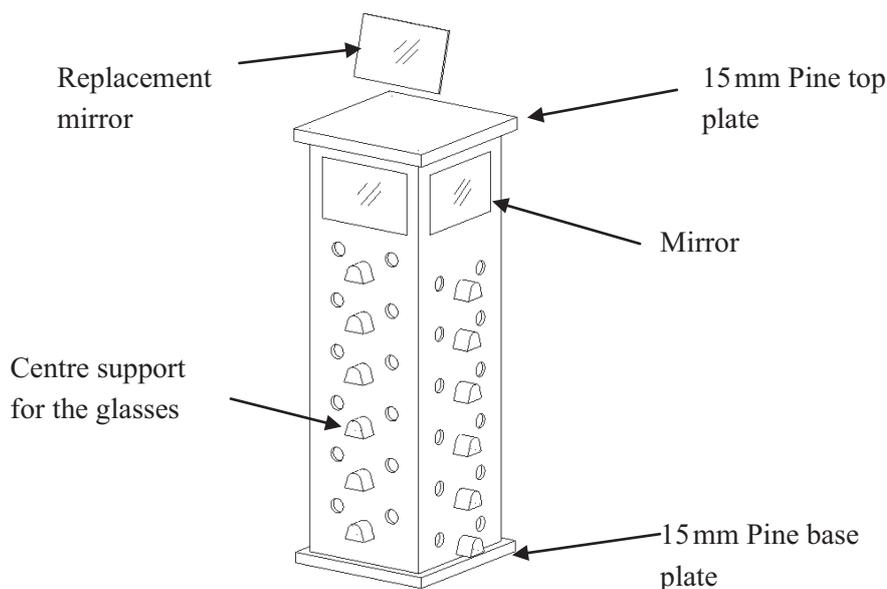
(i) With reference to a suitable product of your choice explain how moral factors have been considered in its design. [2]

(ii) With reference to a suitable product of your choice explain how social factors have been considered in its design. [2]

(h) Some companies can experience specific barriers or difficulties when trying to trade on the international market.

Explain **two** main specific barriers or difficulties associated with international trading. [4]

- (i) **Fig. 23** below shows a drawing and information of a student's design for a shop counter display unit for glasses. The unit is very similar to the design shown in **Fig. 22** with a mirror and a number of glasses displayed on each of the four sides.



**Fig. 23**

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With reference to **Fig. 23** and using the blank A3 pro forma provided (**answer number 6(i)(i)** and **(ii)**) produce **one** suitable solution for each of the following:

- (i) Annotated sketches of a suitable low cost rotating platform to enable the user to move the unit in either a clockwise or anti-clockwise direction in order to view the range of glasses on display. (Your solution must consider minimum use of materials.) [5]
- (ii) Using a different design concept from that used in part (i) provide annotated sketches of a bracket design which will securely hold the replacement mirror in the position shown in **Fig. 23** and will be attached to the surface of the top plate of the display unit. This will remove the need for the four mirrors on the side of the display unit. The bracket design should allow the user to rotate the mirror through 360 degrees to facilitate viewing. Show how your bracket design is securely attached to the mirror and to the top plate of the display unit. [5]

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**THIS IS THE END OF THE QUESTION PAPER**

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