BOSTES BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2016 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A formulae sheet is provided at the back of this paper
- Write your Centre Number and Student Number at the top of pages 13, 17, 19, 23, 27, 31 and 35

Total marks – 100

Section I Pages 2–10

20 marks

- Attempt Questions 1–20
- Allow about 30 minutes for this section

Section II Pages 13–37

80 marks

- Attempt Questions 21–27
- Allow about 2 hours and 30 minutes for this section

Section I

20 marks
Attempt Questions 1–20
Allow about 30 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

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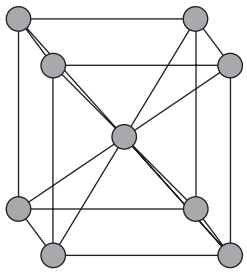
1 What is the name of the crystal structure represented in the sketch?



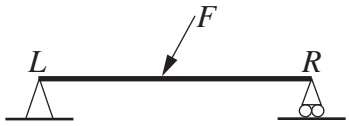
(A) Body close packed

(B) Face centred cubic

(C) Body centred cubic

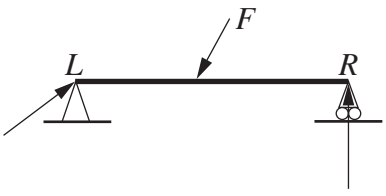
(D) Cubic close packed

2 A simply supported beam is loaded with a force F as shown.

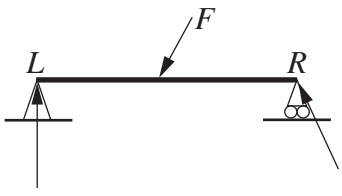


Which diagram represents the reaction forces at supports L and R?

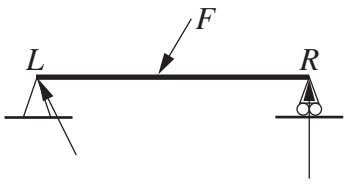
(A)



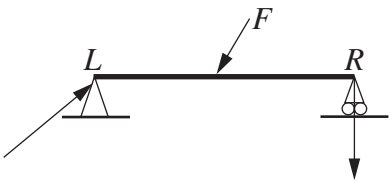
(B)



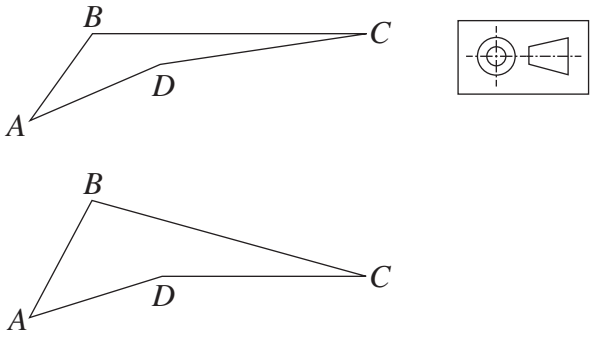
(C)



(D)



3 Four points *A*, *B*, *C* and *D* are plotted in orthogonal projection.



How many lines are shown as true length?

(A) 1

(B) 2

(C) 3

(D) 4

4 In which of the following pairs are both electronic components semi-conductors?

(A) Diode and resistor

(B) Diode and transistor

(C) Capacitor and resistor

(D) Capacitor and transistor

5 In which of the following pairs do the forces oppose each other during level flight?

(A) Lift and drag

(B) Thrust and lift

(C) Drag and thrust

(D) Weight and drag

6 A mild steel test piece is placed under an increasing tensile load.

When will this test piece start to permanently deform?

(A) At failure

(B) At the elastic limit

(C) At the plastic limit

(D) At the ultimate tensile strength

7 Which aeronautical engineering innovation was investigated in Australia by experimenting with box kites?

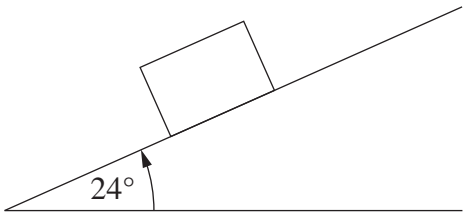
(A) Aerofoils

(B) Air brakes

(C) Wing flaps

(D) Wing warping

8 A block begins to slide when a ramp is inclined to 24°.



What is the coefficient of friction between the block and the ramp?

(A) 0.24

(B) 0.41

(C) 0.45

(D) 0.91

9 Which type of satellite is commonly used to broadcast TV signals?

(A) Low Earth-orbit satellite that orbits over the poles

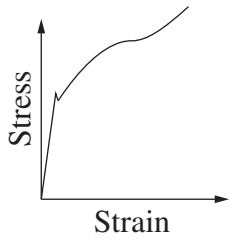
(B) High Earth-orbit satellite that orbits over the poles

(C) Geostationary satellite that orbits above the equator

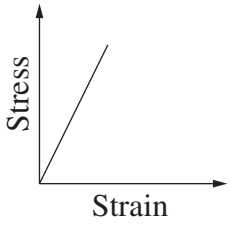
(D) Geosynchronous satellite that orbits above the Tropic of Capricorn

10 Which of the following stress–strain curves best represents a test result showing true stress and true strain of a thermosoftening polymer?

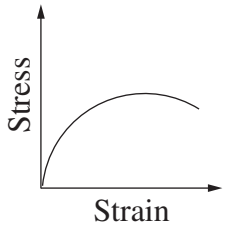
(A)



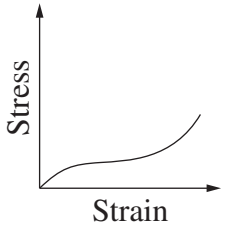
(B)



(C)



(D)



11 Which aircraft engine incorporates bypass air to create thrust?

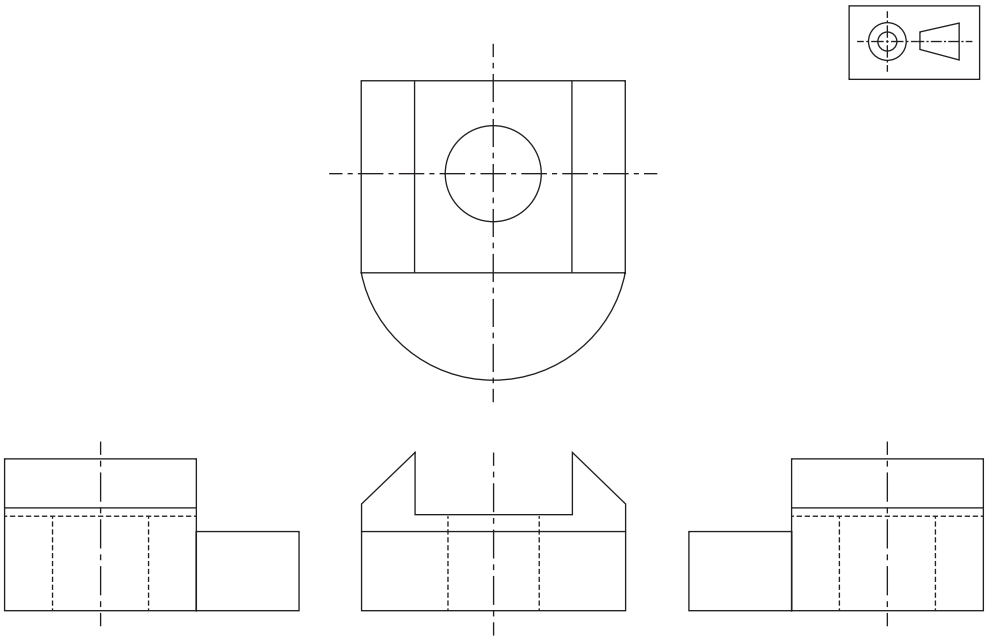
(A) Scramjet

(B) Turbojet

(C) Turbofan

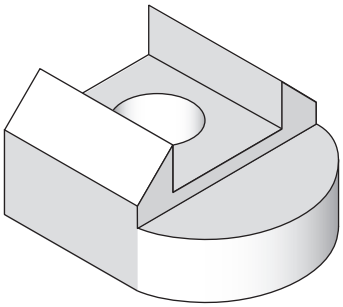
(D) Turboprop

12 Orthogonal views of an object are shown.

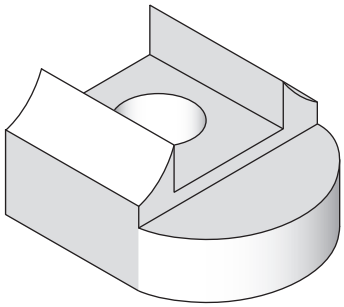


Which of the pictorial drawings best represents the object?

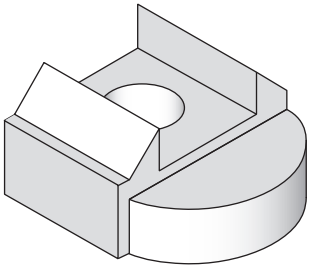
(A)



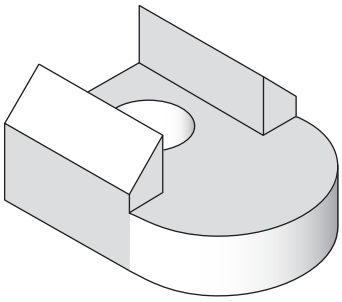
(B)



(C)



(D)



13 A 240 V, 75 W light globe is replaced with a 240 V, 12 W LED globe of equivalent brightness.

What is the theoretical power saving?

(A) 12 W

(B) 63 W

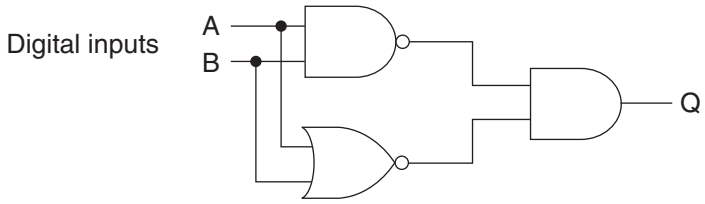
(C) 87 W

(D) 240 W

14 As the applied load is increased during a compression test, what changes occur to the cross-sectional area and gauge length of a copper specimen?

	Cross-sectional area	*Gauge length*
(A)	Increases	Decreases
(B)	Decreases	Increases
(C)	Increases	Increases
(D)	Decreases	Decreases

15 Consider the logic circuit shown.



Which table shows the correct output values at Q for the given input values A and B?

(A)

A	B	Q
0	1	1
1	0	0

(B)

A	B	Q
0	1	0
1	0	0

(C)

A	B	Q
0	1	0
1	0	1

(D)

A	B	Q
0	1	1
1	0	1

16 Which row of the table correctly identifies the project responsibilities of a civil engineer when planning a new highway?

	Project responsibilities			
	Stormwater drainage	*Pavement alignment*	*Project management*	*Traffic management*
(A)	✗	✗	✓	✓
(B)	✓	✓	✗	✓
(C)	✓	✗	✗	✗
(D)	✓	✓	✓	✗

17 What process is applied to dried clay for it to obtain the required compressive strength for use as a common brick?

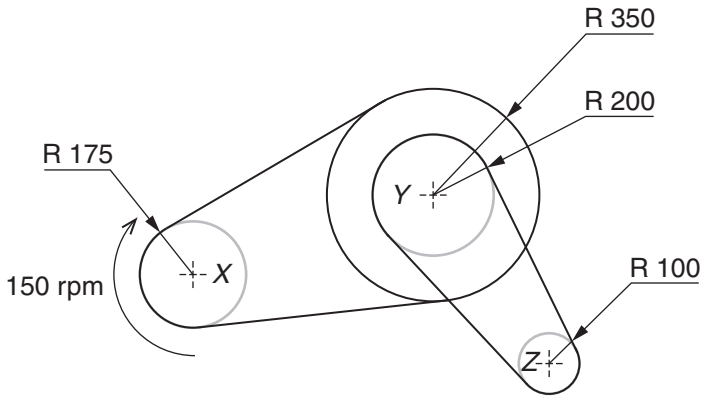
(A) Annealing

(B) Extrusion

(C) Glazing

(D) Vitrification

18 The diagram shows three pulleys *X*, *Y* and *Z*.



If pulley *X* rotates at 150 rpm clockwise, what will be the speed and direction of rotation of pulley *Z*?

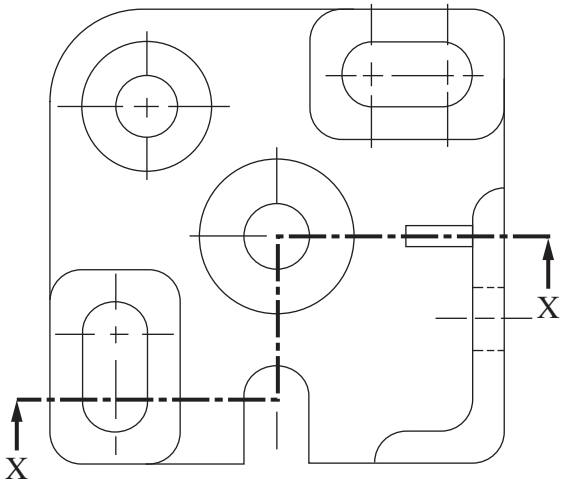
(A) 150 rpm clockwise

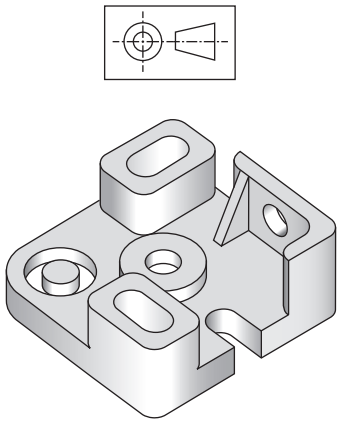
(B) 300 rpm clockwise

(C) 75 rpm anticlockwise

(D) 150 rpm anticlockwise

19 A locating block is sectioned by an offset cutting plane labelled X–X.

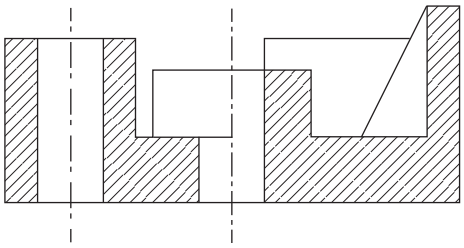




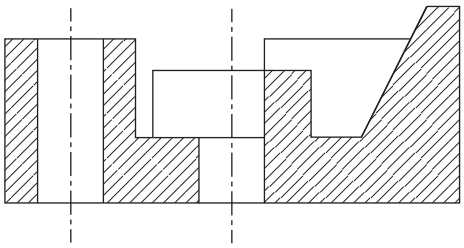
Locating block

Which front view is sectioned to AS 1100 standards?

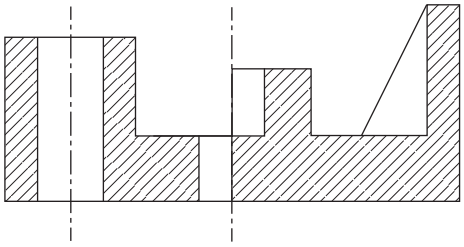
(A)



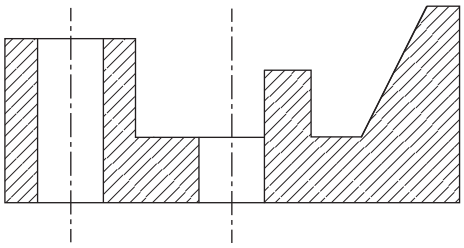
(B)



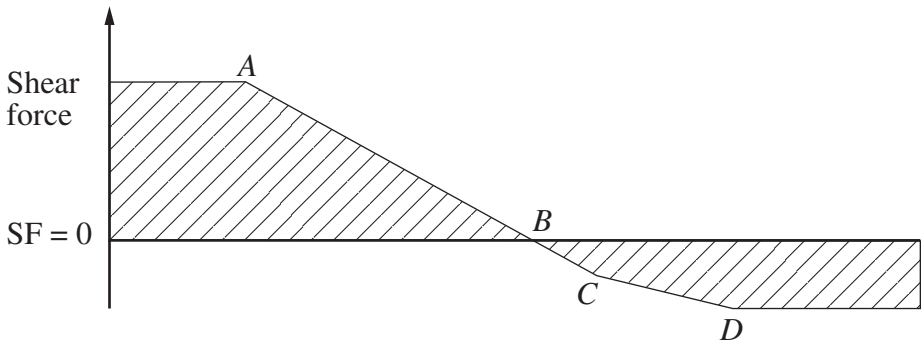
(C)



(D)



20 A shear force diagram for a loaded beam is shown.



What is the position of the maximum bending moment?

(A) *A*

(B) *B*

(C) *C*

(D) *D*

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Engineering Studies

Centre Number

Student Number

Section II

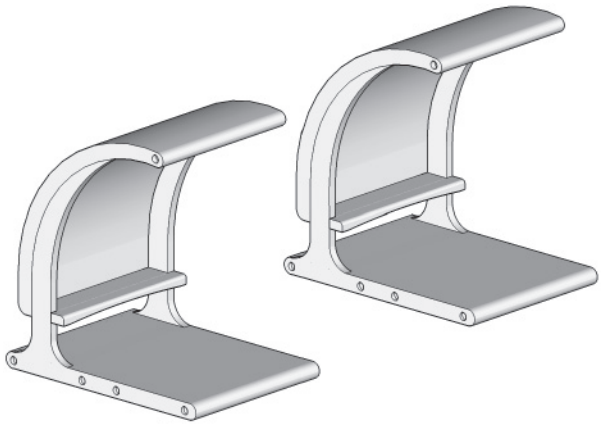
80 marks
Attempt Questions 21–27
Allow about 2 hours and 30 minutes for this section

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (12 marks)

(a) The reinforced concrete modules shown are designed for public seating. A typical use would be as a bus shelter.



(i) Outline benefits of using this type of modular seating system. **3**

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Question 21 continues on page 14

Question 21 (continued)

(ii) Steel-reinforced concrete is used in the seating module. **3**

Explain why steel is suitable for reinforcing concrete.

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(iii) A 12 mm diameter steel reinforcing bar was used in this seating module. During a proof test, a load of 26 kN extended a 0.9 m length of this reinforcing bar by 1 mm. **3**

Calculate the value of Young's Modulus (E) for this bar.

Young's Modulus ..... GPa

Question 21 continues on page 15

Question 21 (continued)

(b) Manufacturers of student travel cards use a PVC based polymer. **3**

Justify why a PVC based polymer is a suitable material for this application.

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End of Question 21

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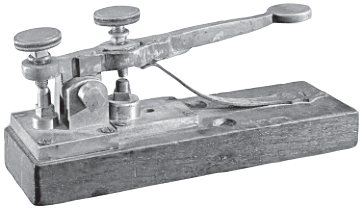
Centre Number

Section II (continued)

Student Number

Question 22 (12 marks)

(a) Three examples of communication devices are shown. **3**



Morse code key

Bakelite phone

Smartphone

How has each of these devices contributed to the advancement of telecommunications?

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(b) Describe TWO methods of generating electricity. **3**

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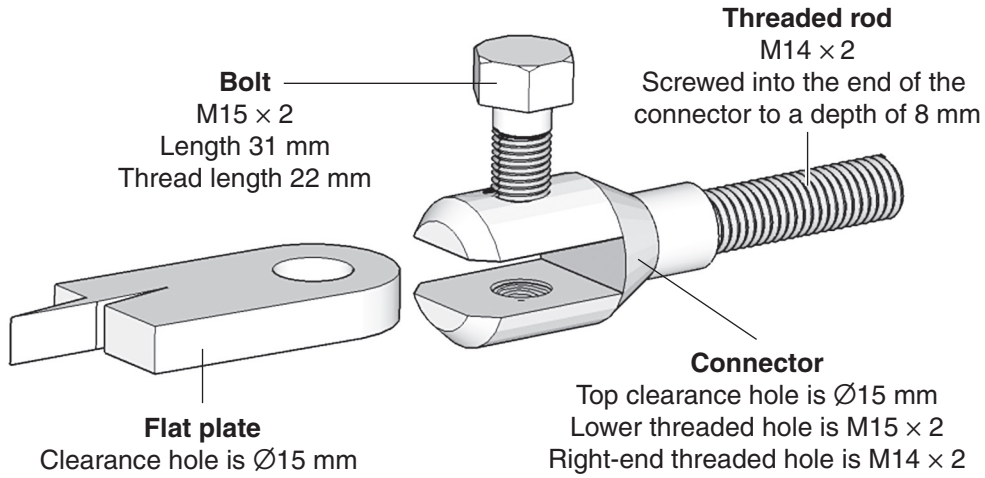
Question 22 continues on page 18

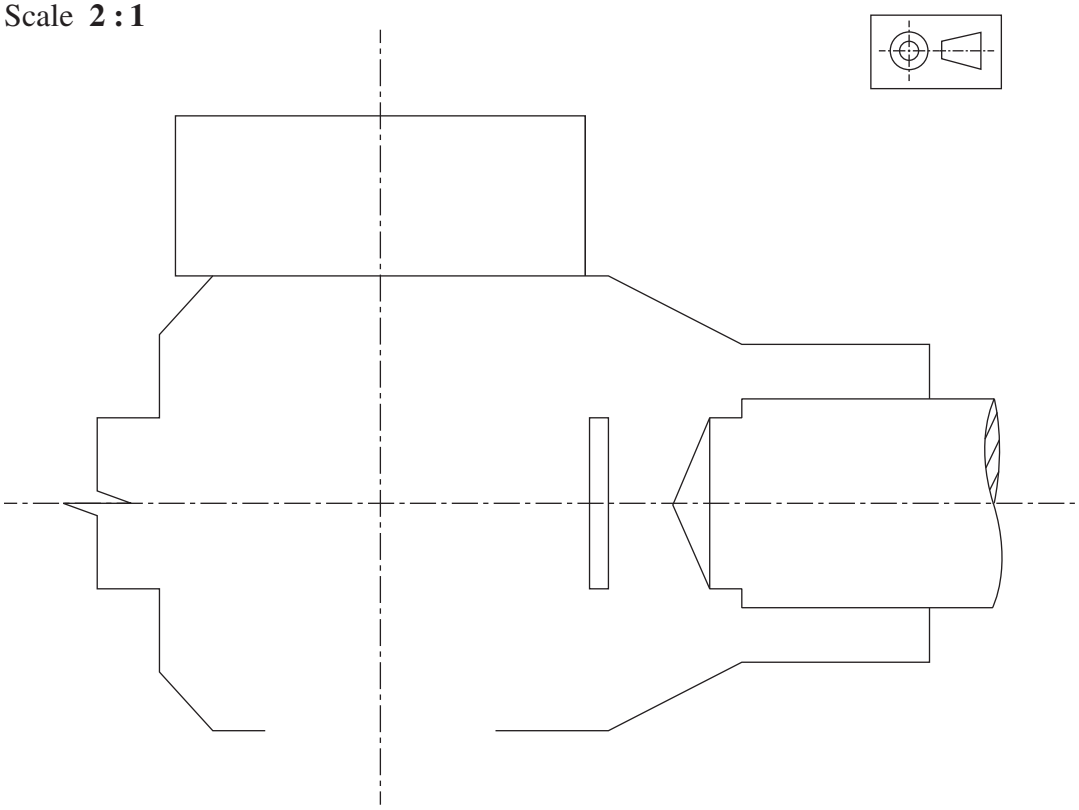
Question 22 (continued)

(c) An electrical connector is screwed onto a threaded rod. A flat plate is then secured to the connector by a bolt screwed into a threaded hole. **6**



Complete the scaled sectioned front view with the parts assembled.

Scale **2 : 1**



End of Question 22

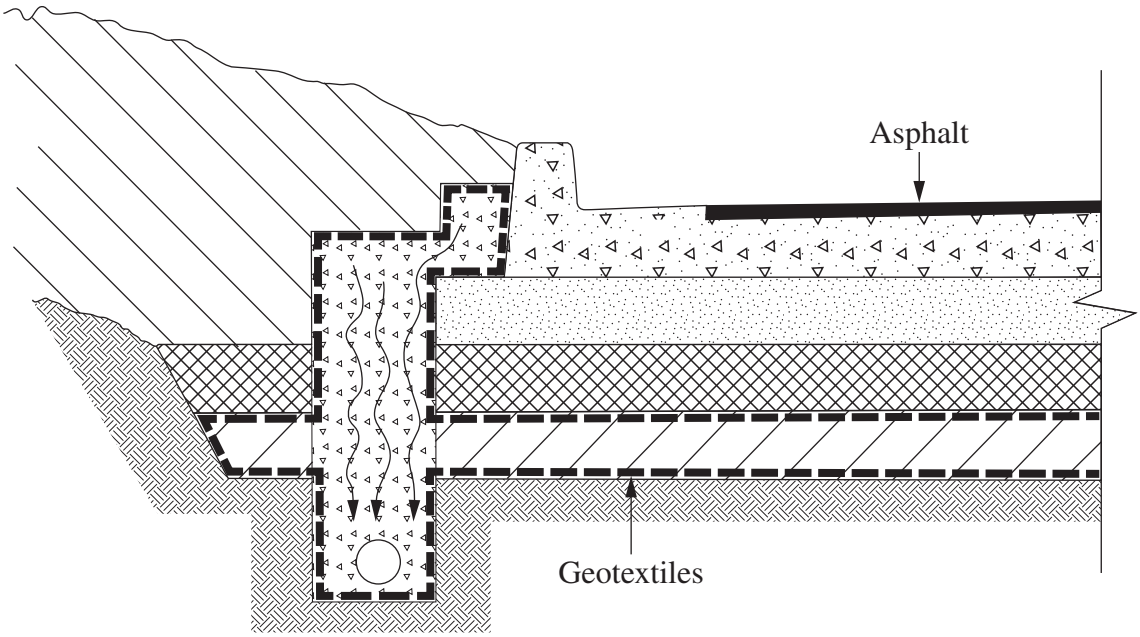
Centre Number

Section II (continued)

Student Number

Question 23 (12 marks)

This diagram shows the cross-section of a highway pavement drawn using AS 1100 drawing standards.



(a) Explain the benefits of using AS 1100 drawing standards in the preparation of engineering drawings such as the one above. **3**

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Question 23 continues on page 20

Question 23 (continued)

(b) (i) Outline the properties of asphalt that make it suitable for highway pavement surfaces. **3**

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(ii) Why are geotextiles used in the construction of highway pavements? **3**

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Question 23 continues on page 21

Question 23 (continued)

(c) A heavy vehicle is travelling on a level section of the highway at a constant velocity of 90 km/h while experiencing a resistance to motion of 18 kN. **3**

Calculate the power required to maintain this velocity.

Power = ... kW

End of Question 23

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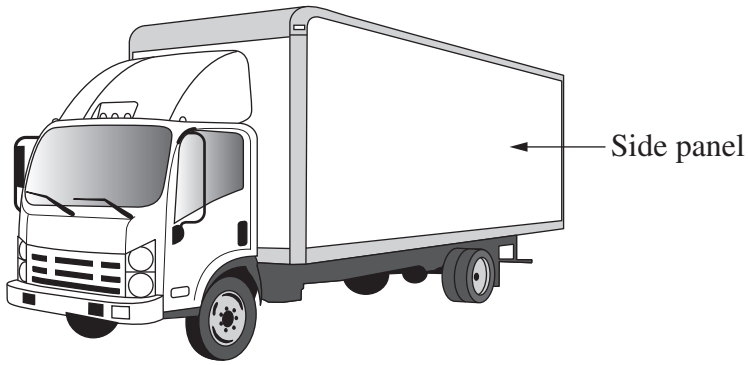
Centre Number

Section II (continued)

Student Number

Question 24 (11 marks)

An image of a truck is shown.



(a) Compare the selection of laminated glass with toughened glass as a windscreen for this vehicle. **3**

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Question 24 continues on page 24

(b) Give reasons for selecting an aluminium alloy for the side panel of the truck. **2**

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(c) Truck tyres are made using vulcanised synthetic rubber combined with high tensile steel wire. **3**

Explain why this combination of materials has been chosen.

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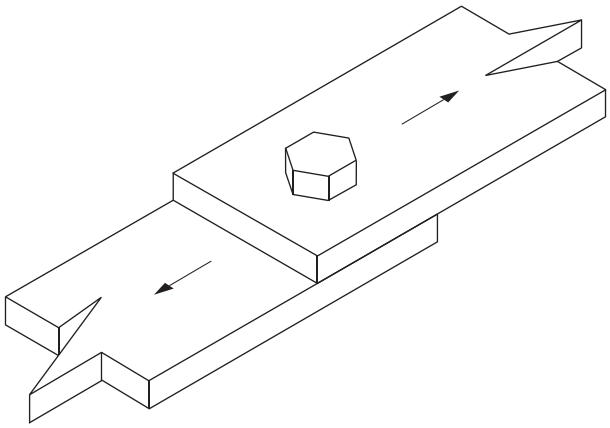
Question 24 continues on page 25

Question 24 (continued)

(d) A mild steel nut and bolt is used to hold a bumper bar onto the chassis of the truck. The bolt needs to withstand a maximum shear load of 2 kN. **3**



If the maximum shear stress of the material is 56 MPa and the factor of safety is 2, calculate the minimum bolt diameter.

Minimum diameter = ... mm

End of Question 24

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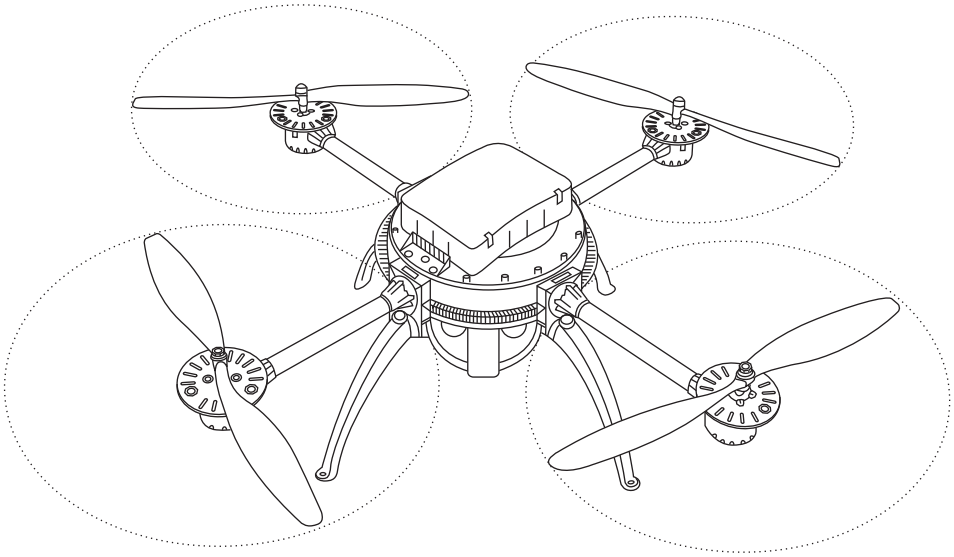
Question 25 (12 marks)

(a) An image of a small drone is shown.



(i) Explain how this drone achieves flight. **3**

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Question 25 continues on page 28

Question 25 (continued)

(ii) Nylon propellers are used on drones whereas carbon fibre composite propellers are used on commercial aircraft. **3**

Describe a suitable manufacturing method for each type of propeller.

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(b) Aircraft flight control systems use either cables or 'fly-by-wire' systems. **3**

Contrast these flight control systems.

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Question 25 continues on page 29

Question 25 (continued)

(c) A taut cable and aerofoil of similar thickness are tested in a wind tunnel. The results show that the aerofoil produces significantly less drag than the cable. **3**

Explain how the aerofoil produces less drag than the taut cable. Use the diagram to assist your response.

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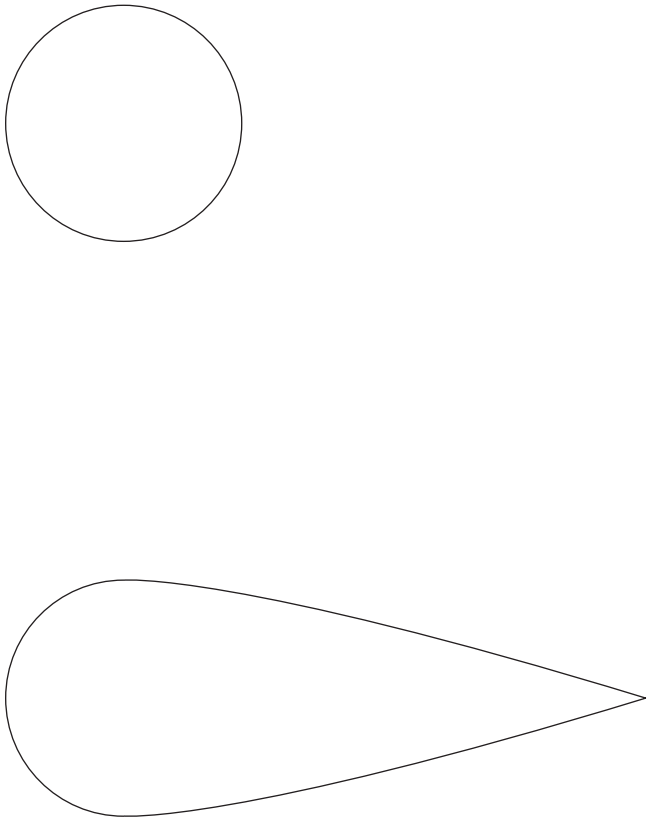

End of Question 25

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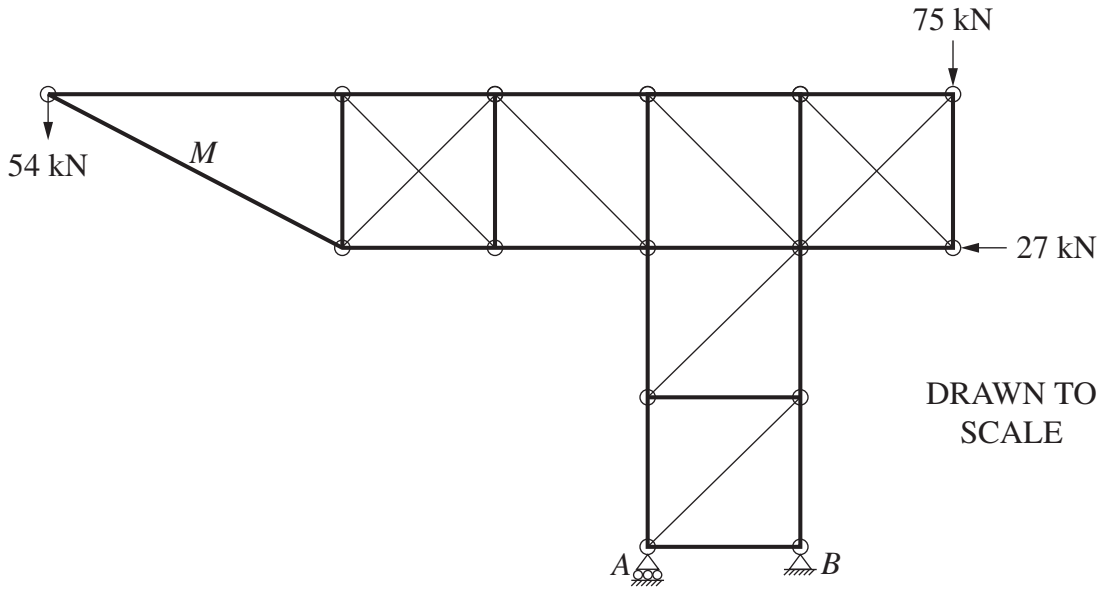
Question 26 (12 marks)

Please turn over

Question 26 (12 marks)

A simplified diagram of a pin jointed truss of a hammerhead crane is shown. It is lifting a load of 54 kN.



(a) (i) Calculate the reactions at supports *A* and *B*. **4**

Reaction at *A* = ... kN at .....°

Reaction at *B* = ... kN at .....°

Question 26 continues on page 33

Question 26 (continued)

(ii) Determine the magnitude and nature of the force in member *M*. **2**

Magnitude = ... kN

Nature = ...

(b) What are redundant truss members? **2**

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Question 26 continues on page 34

Question 26 (continued)

(c) The structural steel I-beams used to make the crane were hot-rolled then normalised. **4**

Explain why normalising was chosen as the heat treatment process. Support your answer with a labelled sketch of the resulting microstructure.

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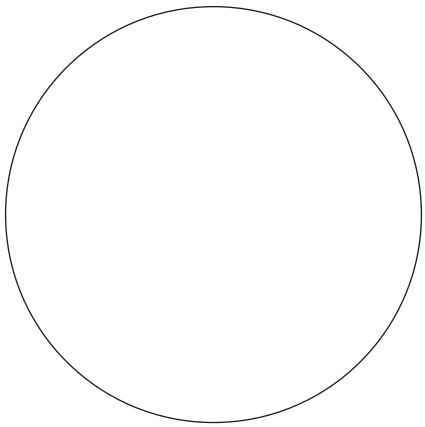

Microstructure

End of Question 26

Question 27 (9 marks)

Please turn over

Question 27 (9 marks)

The table compares the CO_2 emissions of three transport systems – car, train and aircraft.

CO_2 Emissions		
Transport system	*Number of passengers*	*Kilograms of CO_2 emission per passenger per hour*
Car	2	7
Train	200	3
Aircraft	40	120

(a) The table shows that these transport systems produce different amounts of CO_2 emissions per passenger. **2**

Why are these different transport systems still required?

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Question 27 continues on page 37

Question 27 (continued)

(b) For each transport system shown in the CO_2 emissions table, explain how an engineering innovation in that transport system has affected the environment. **7**

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Engineering Studies

FORMULAE SHEET

Force, Moments

$F = ma$; $M = Fd$

If a body is in equilibrium, then $\sum F_x = 0$; $\sum F_y = 0$; $\sum M = 0$

Friction

$F = \mu N$; $\mu = \tan\phi$

Energy, Work, Power

$KE = \frac{1}{2}mv^2$; $PE = mgh$; $W = Fs = \Delta PE + \Delta KE$; $P = \frac{W}{t}$; $P = \frac{Fs}{t}$; $P = Fv$

Pressure

$P = \frac{F}{A}$; $P = P_o + \rho gh$

Stress and Strain

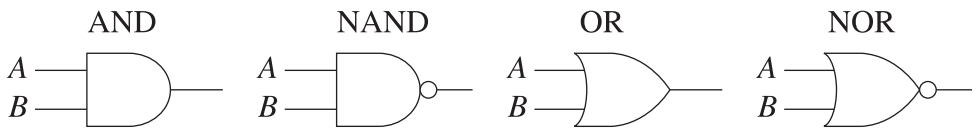
$\sigma = \frac{F}{A}$; $\varepsilon = \frac{e}{L}$; $E = \frac{\sigma}{\varepsilon}$; $\sigma = \frac{My}{I}$

$\sigma_{\text{allowable}} = \frac{\sigma_{yield}}{F \text{ of } S}$ (Ductile); $\sigma_{\text{allowable}} = \frac{\sigma_{UTS}}{F \text{ of } S}$ (Brittle)

Machines

$MA = \frac{L}{E}$; $VR = \frac{d_E}{d_L}$; $\eta = \frac{MA}{VR}$

Digital Electronics



Electricity, Electronics

$E = IR$ $P = I^2R$

Series $R_t = R_1 + R_2 + R_3 + R_4 + \cdots + R_n$

Parallel $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \cdots + \frac{1}{R_n}$

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