



NSW Education Standards Authority

2022 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

**General
Instructions**

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A formulae sheet is provided at the back of this paper

**Total marks:
100**

Section I – 20 marks (pages 2–8)

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

Section II – 80 marks (pages 9–35)

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

Section I

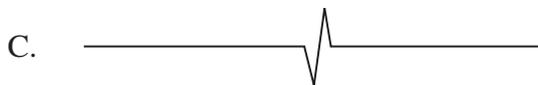
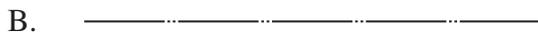
20 marks

Attempt Questions 1–20

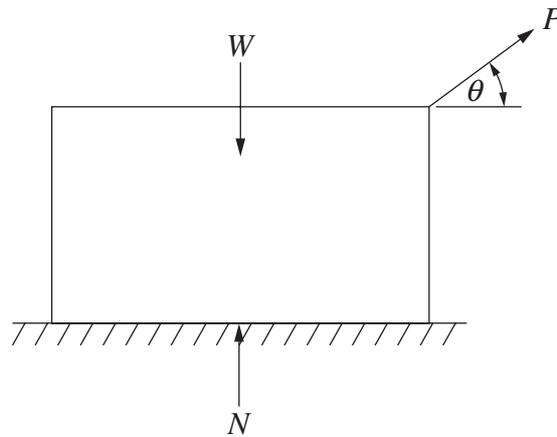
Allow about 30 minutes for this section

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

- 1 What property of a material can be measured by testing its resistance to scratching?
- A. Hardness
 - B. Stiffness
 - C. Strength
 - D. Toughness
- 2 Which of the following best describes the change in battery-powered telecommunications products since the introduction of semiconductors?
- A. Larger and use less power
 - B. Smaller and use less power
 - C. Larger and use more power
 - D. Smaller and use more power
- 3 Which of the following is the AS 1100 standard for drawing a break line?



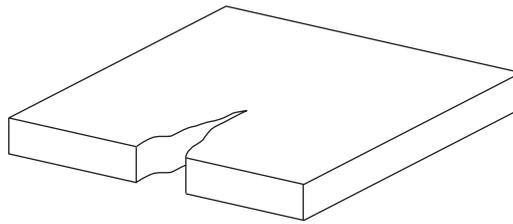
- 4 The diagram shows a box being pulled along a horizontal surface at angle θ to the horizontal.



Which equation is correct for N ?

- A. $N = W - P \cos \theta$
 - B. $N = W + P \cos \theta$
 - C. $N = W - P \sin \theta$
 - D. $N = W + P \sin \theta$
- 5 Contemporary aircraft construction includes the use of alloys and composite materials.
- Which of the following statements is NOT true for composite materials used in aircraft?
- A. They are generally corrosion resistant.
 - B. They can be made into complex shapes.
 - C. They have a high strength-to-weight ratio.
 - D. They generally cost less than other materials.

- 6 The diagram shows a steel plate with a crack developing.



- Which of the following would best prevent the crack from growing?
- A. Welding the crack
 - B. Riveting a plate over the crack
 - C. Drilling a hole at the end of the crack
 - D. Filling the crack with an industrial adhesive
- 7 What is the thickness of a standard nut that fits a M20 × 2 bolt?
- A. 10 mm
 - B. 16 mm
 - C. 18 mm
 - D. 20 mm
- 8 It is appropriate to produce a half development of a transition piece when the piece
- A. is very large.
 - B. is symmetrical.
 - C. is very complex.
 - D. needs to be produced quickly.
- 9 Which of the following is an advantage of modelling in 3D computer aided drawing (CAD)?
- A. It allows for rapid prototyping.
 - B. The design process is automated.
 - C. The models can be intricate and complicated.
 - D. It allows for finer tolerances than instrument drawing.

- 10** Which of the following identifies two causes of parasitic drag?
- A. Aircraft lift, angle of attack
 - B. Aircraft lift, material of aircraft skin
 - C. The movement of air over the wing, angle of attack
 - D. The movement of air over the wing, material of aircraft skin

- 11** A diode bridge is used to convert AC to DC current.

What type of conversion is this known as?

- A. Partial rectification
 - B. Inverse rectification
 - C. Full wave rectification
 - D. Half wave rectification
- 12** A geotextile is to be used in a retaining wall for a public green space project.

When selecting a suitable geotextile, which set of material properties should be considered?

- A. Colour, opacity and filtration
 - B. Colour, permeability and rigidity
 - C. Tensile strength, opacity and rigidity
 - D. Tensile strength, permeability and filtration
- 13** Four students (A, B, C, D) completed a table regarding the orbit of a GPS satellite.

Which student is correct?

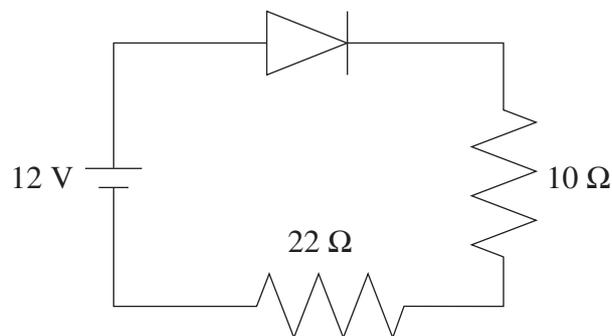
THE ORBIT OF A GPS SATELLITE	
<i>Matches Earth's rotation?</i>	<i>Is above the equator?</i>
A. Yes	Yes
B. Yes	No
C. No	No
D. No	Yes

- 14 What feature of fibre optic cables has made them a suitable replacement for traditional copper-based cables?
- A. Lower bandwidth
 - B. Higher attenuation
 - C. Do not need repeaters over long distances
 - D. Not susceptible to electromagnetic interference
- 15 The terms *roll*, *yaw* and *pitch* describe an aircraft's movements. Each movement is controlled by a specific component of the aircraft.

In which row of the table is each movement correctly matched to the component which controls it?

	<i>Roll</i>	<i>Yaw</i>	<i>Pitch</i>
A.	Ailerons	Rudder	Elevators
B.	Rudder	Ailerons	Elevators
C.	Ailerons	Rudder	Flaps
D.	Rudder	Ailerons	Flaps

- 16 The diagram shows a circuit. The diode causes a voltage drop of 0.7 volts.



What is the current flowing in this circuit?

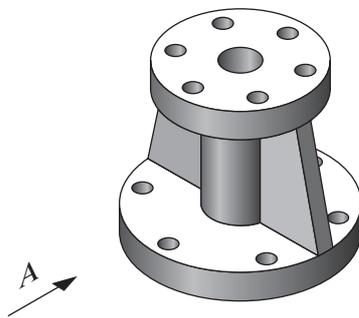
- A. 0.35 A
- B. 0.38 A
- C. 0.40 A
- D. 0.51 A

- 17 During routine maintenance, ultrasonic testing is performed on some aircraft components such as aircraft landing gear.

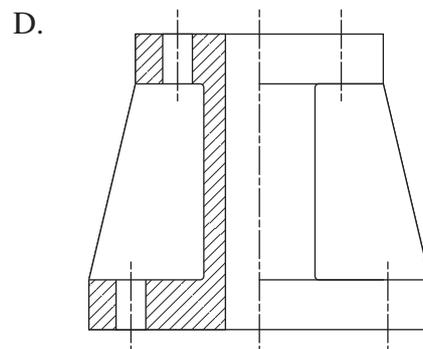
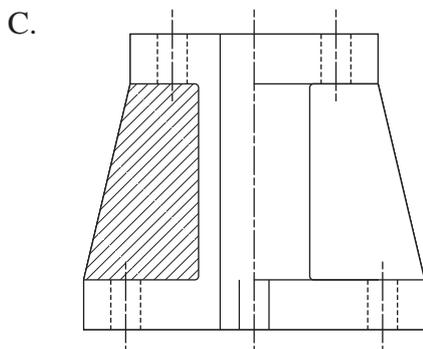
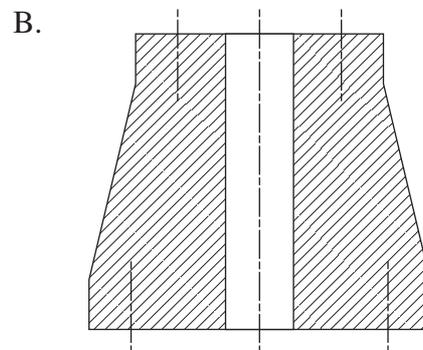
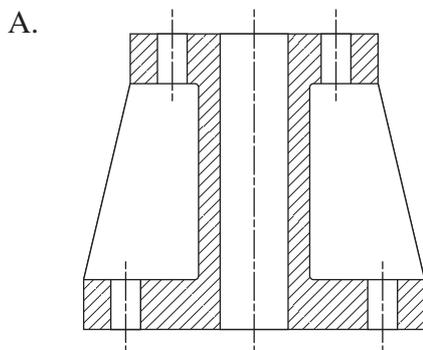
What is the reason for performing this test?

- A. It can be performed quickly.
- B. It reveals any surface defects.
- C. It reveals any hidden internal faults.
- D. It can be carried out using simple techniques.

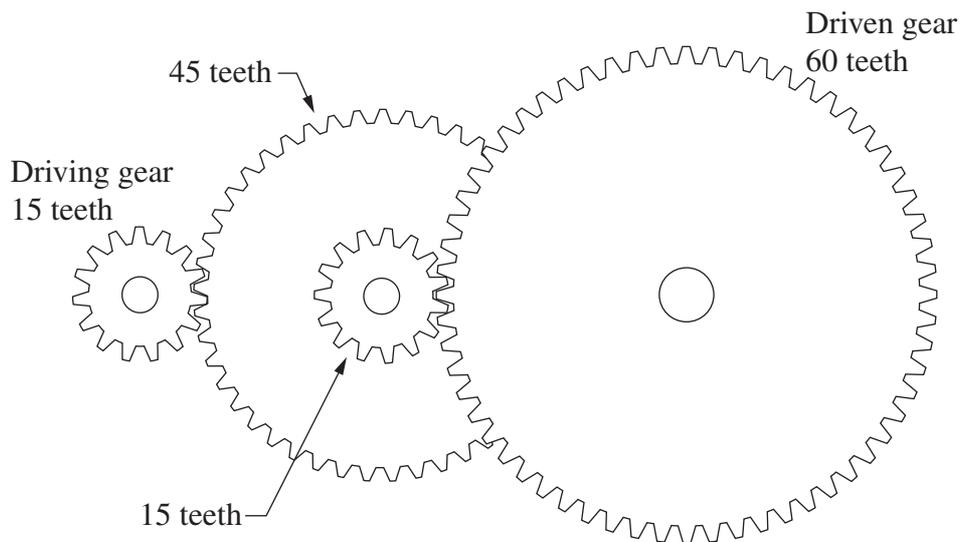
- 18 A pictorial view of a machine component is shown.



When viewed from the direction of arrow A, which drawing correctly shows the half-sectional view?



- 19 A gear system for a machine is shown.



What is the speed, in revolutions per minute (rpm), of the driven gear when the driving gear rotates at 1800 rpm?

- A. 150 rpm
 - B. 450 rpm
 - C. 600 rpm
 - D. 1800 rpm
- 20 For a particular material, specimens of different sizes were tested. A load–extension diagram and a stress–strain diagram are to be drawn for each specimen.

The shape of which diagram(s) will be affected by the size of the specimen tested?

- A. Both diagrams
- B. Neither diagram
- C. The stress–strain diagram only
- D. The load–extension diagram only

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Centre Number

Engineering Studies

Section II Answer Booklet

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Student Number

80 marks

Attempt Questions 21–27

Allow about 2 hours and 30 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page.
 - 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.
 - Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.
-

Please turn over

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Do NOT write in this area.

Question 21 (11 marks)

(a) The following images show an older bus and a contemporary bus.



Courtesy of Sydney Bus Museum



(i) Older buses had flat, toughened glass windscreen panels. 2

How is toughened glass manufactured?

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(ii) Contemporary buses have windscreens which curve around the front of the bus. 3

Describe the manufacturing process used to make these windscreens.

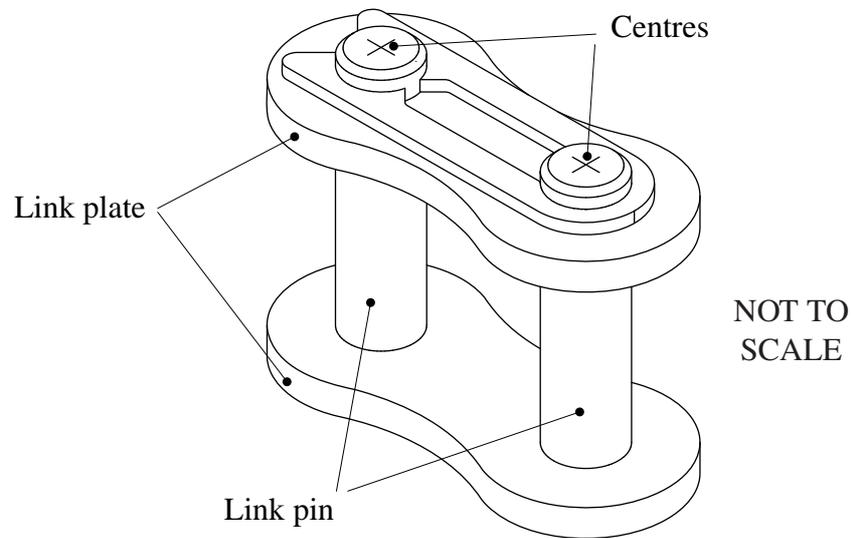
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Question 21 continues on page 12

Question 21 (continued)

(b) A pictorial drawing of an assembled chain master link is shown.

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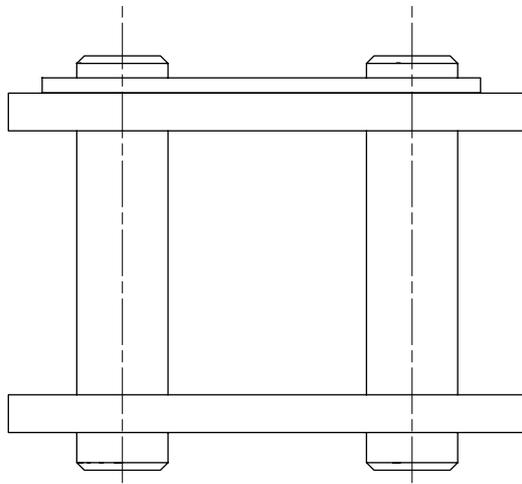
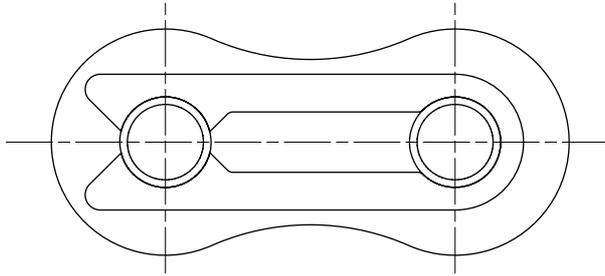
Complete the orthogonal views provided on page 13, to AS 1100 standards, by adding the following dimensions.

- The overall height of the assembly — 55 mm
- The thickness of one link plate — 5 mm
- The radius of the link plate — 15 mm
- The diameter of the link pin — 12 mm
- The chamfer of the pin — 1 mm
- Distance between centres of pins — 38 mm

Question 21 continues on page 13

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Question 21 (continued)



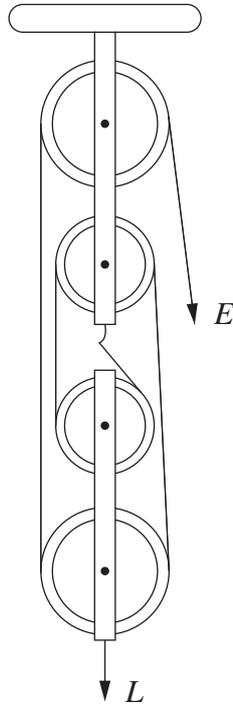
Question 21 continues on page 14

Do NOT write in this area.

Question 21 (continued)

- (c) To change a tyre on a bus, a system of pulleys, as shown, is used to lift the wheel and tyre to re-fit them back on the bus. The wheel and tyre have a combined mass of 95 kg.

3



What effort is required to lift the wheel and tyre if the efficiency of the pulley system is 80%?

Effort: N

End of Question 21

Question 22 (12 marks)

A smart watch is shown.



Many smart watches have in-built functions that provide useful health and safety features for the wearer, such as heart rate monitoring, location tracking and fall detection.

- (a) Discuss ONE legal or ethical implication that the telecommunications engineer would need to consider in the design, function or manufacture of such a device.

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Question 22 continues on page 16

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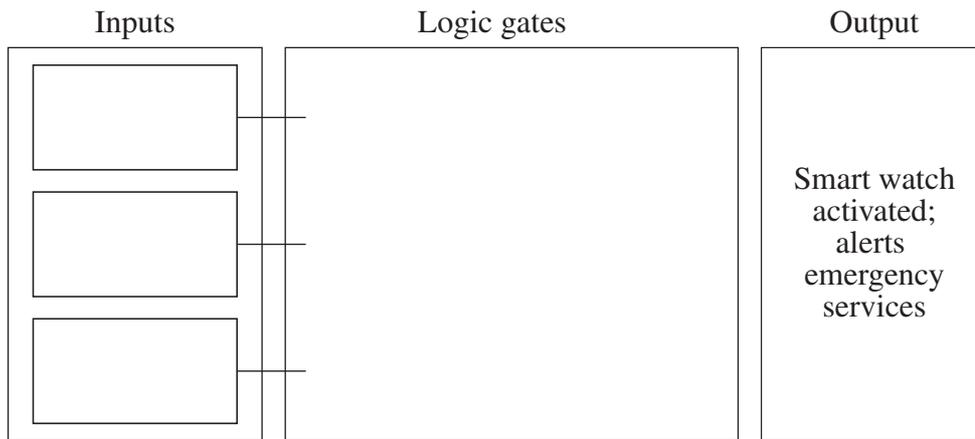
Question 22 (continued)

- (b) In the event of a fall or a medical emergency, smart watches are designed to alert emergency services when either of the following conditions is met. 3

Condition 1: the smart watch emergency alert is manually activated

Condition 2: the smart watch detects a sudden fall and no movement for 1 minute

An incomplete logic diagram showing the activation of the smart watch is given.



Complete the diagram by identifying the inputs and drawing the appropriate logic gates.

- (c) An engineer is selecting a suitable material for the exterior housing of a telecommunications device such as the smart watch. Justify material properties that should be considered. 3

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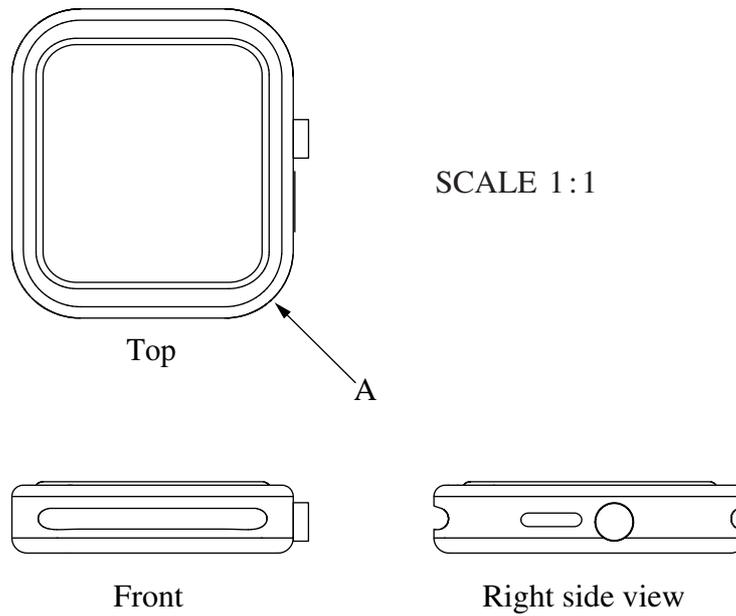
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Question 22 continues on page 17

Question 22 (continued)

(d) An orthogonal view of a smart watch is shown.

3



Construct a freehand pictorial sketch of the smart watch as viewed in the direction of the arrow.

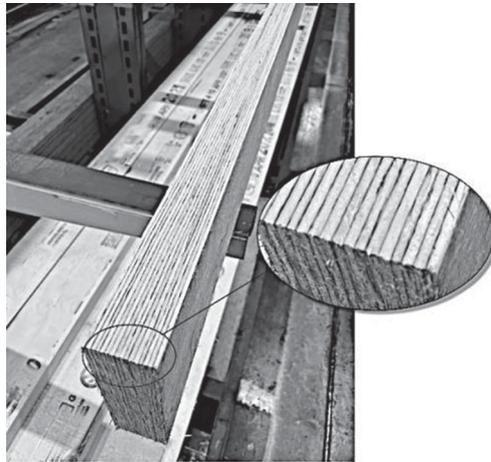
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End of Question 22

Question 23 (13 marks)

- (a) The image shows a laminated veneer lumber (LVL) beam that is used to span long distances in buildings.

2



Give reasons for using LVL instead of a steel beam as the supporting member in a building.

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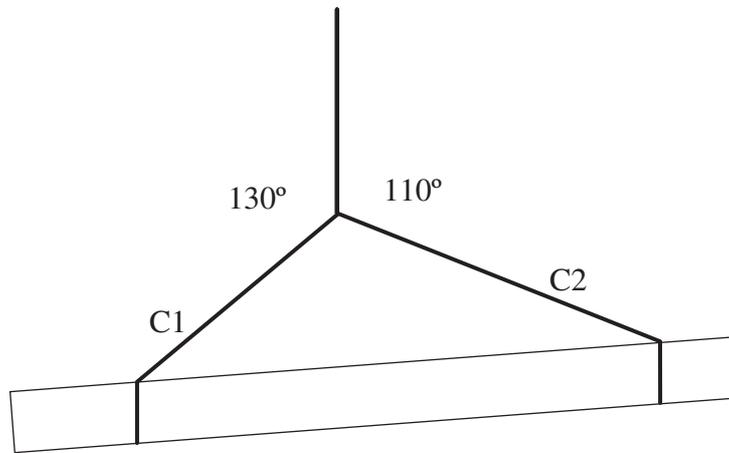
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Question 23 continues on page 19

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Question 23 (continued)

(b) The diagram represents a 120 kg beam that is being guided into place by a crane. 3



Use a scale drawing to graphically determine the tension in the two cables attached to the beam.

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Tension in C1 = kN

Tension in C2 = kN

Question 23 continues on page 20

Question 23 (continued)

- (c) Steel I-beams have been used when large, open spans need to be created inside buildings.

4

Explain how microstructural changes take place in steel when an I-beam is formed using the process of hot rolling. You may use a drawing to support your answer.

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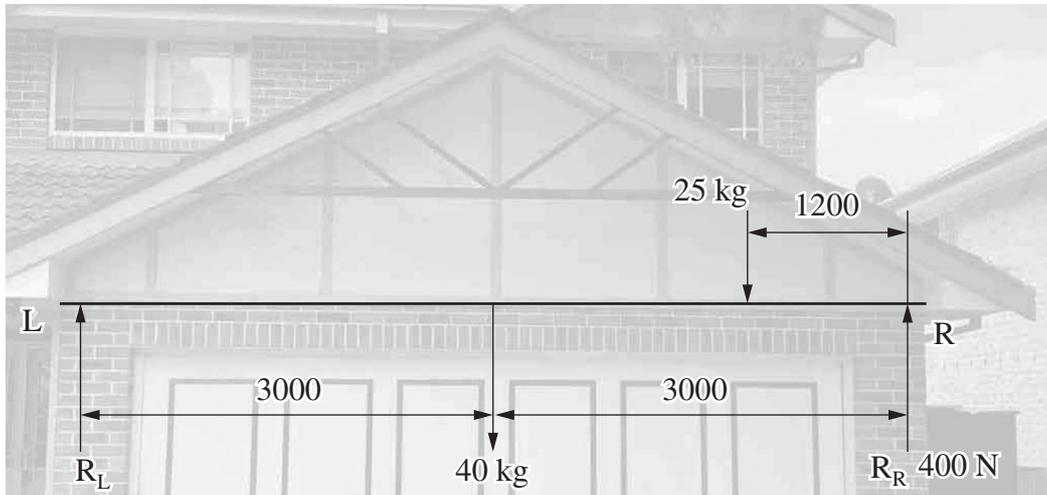
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Question 23 continues on page 21

Question 23 (continued)

- (d) A solar panel is to be attached to the roof of a residential garage. A beam of mass 40 kg is shown. The solar panel generates a 25 kg point load as shown.

4



Complete the shear force and bending moment diagrams for the beam, using an appropriate scale.



End of Question 23

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Question 24 (12 marks)

- (a) An aeronautical engineer is developing a prototype for a new propeller design.

3

Identify a suitable method of developing the prototype and outline the benefits of using this method.

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Question 24 continues on page 23

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Question 24 (continued)

(b) The image shows corroded screws on the body of an aircraft.

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Identify this type of corrosion and explain how it can occur.

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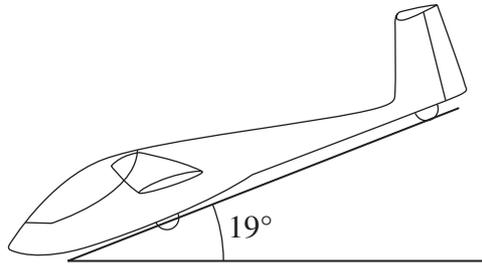
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Question 24 continues on page 24

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Question 24 (continued)

(c) An image of a glider is shown.



The glider is currently on a descent at an angle of 19 degrees. The total lift force is 6250 N.

(i) Draw a free-body diagram, indicating all forces acting on the glider. 1

(ii) If the mass of the pilot is 95 kg, calculate the mass of the glider. 3

Mass of glider: kg

(iii) Calculate the lift-to-drag ratio. 2

Lift-to-drag ratio:

End of Question 24

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Question 25 (11 marks)

(a) Describe how an insulation test is performed on electrical cabling.

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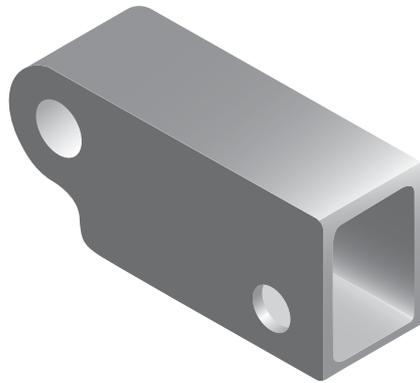
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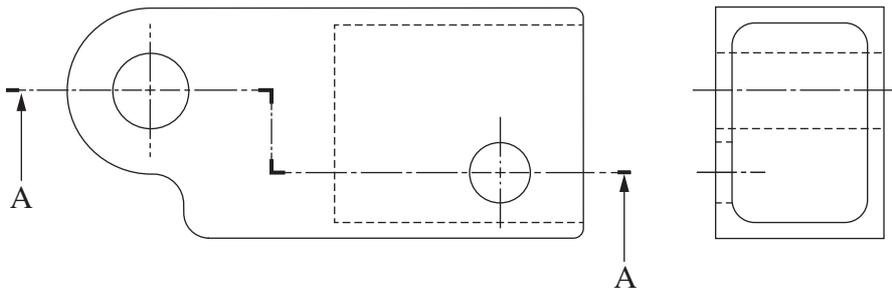
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(b) A pictorial view of a machine part is shown.

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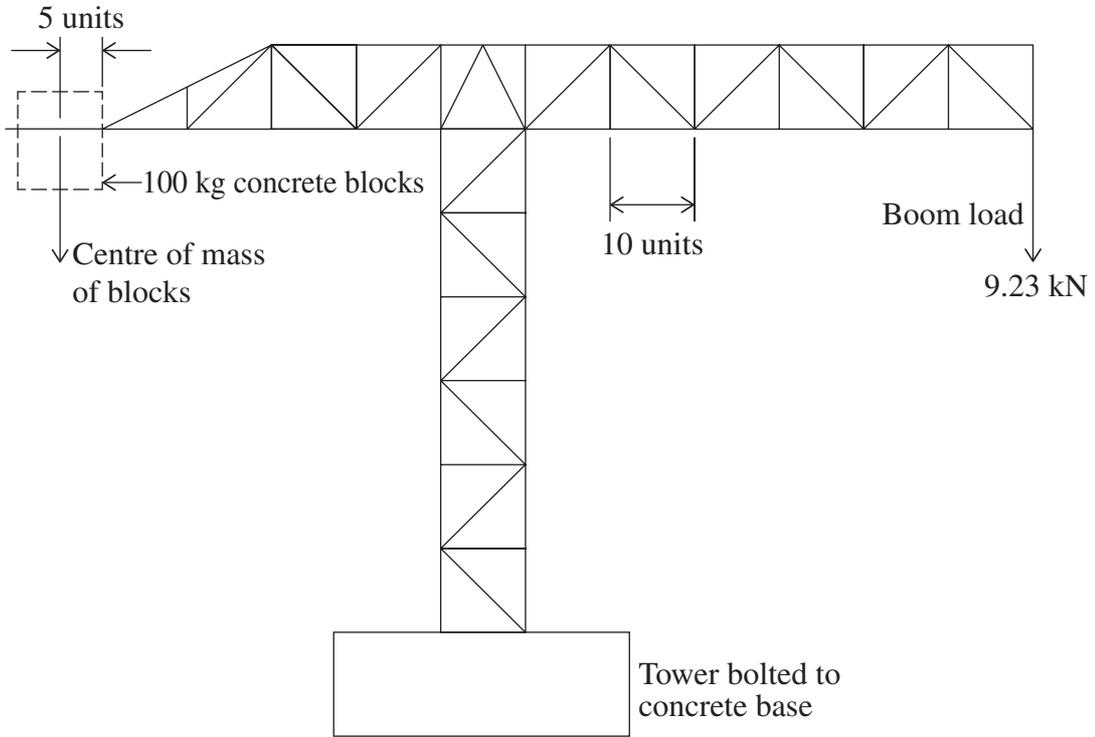
Use the front view and side view provided to complete a sketch of an offset section of the part in the top view.



Question 25 continued on page 26

Question 26 (11 marks)

- (a) (i) The diagram shows a tower crane being used in the construction of a building. 2



Determine the number of 100 kg concrete blocks required to place the boom arm in equilibrium.

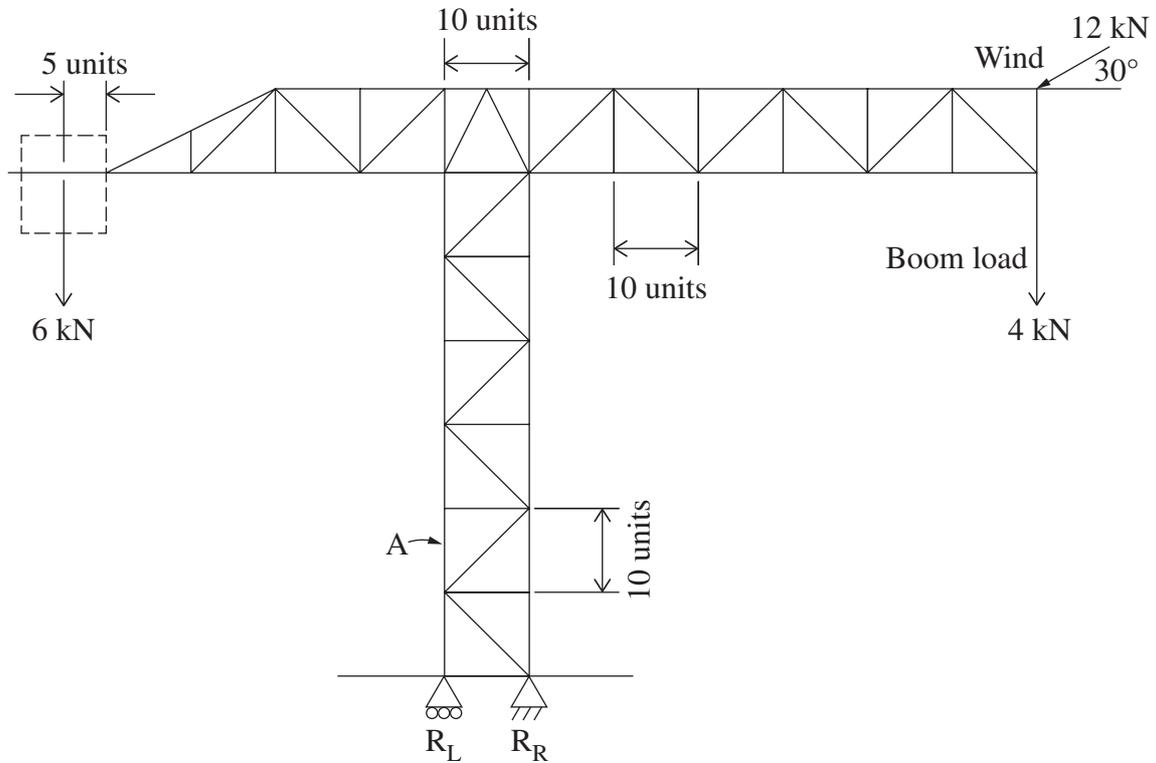
Number of blocks:

Question 26 continues on page 28

Question 26 (continued)

- (ii) Under a different set of conditions, a wind force is applied, as shown in the diagram.

6



Question 26 continues on page 29

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Question 26 (continued)

Determine the magnitude and nature of the internal reaction in member A.

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Magnitude of internal reaction in member A: kN

Nature of reaction:

Question 26 continues on page 30

Question 26 (continued)

- (b) Different modes of transport emit different amounts of carbon dioxide (CO₂). For example, petrol cars emit more CO₂ than electric cars while in motion.

3

Describe engineering innovations that have led to lower carbon dioxide emissions from electric transportation.

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End of Question 26

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Question 27 (10 marks)

(a) Describe TWO different uses of polymers in telecommunications.

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Question 27 continues on page 32

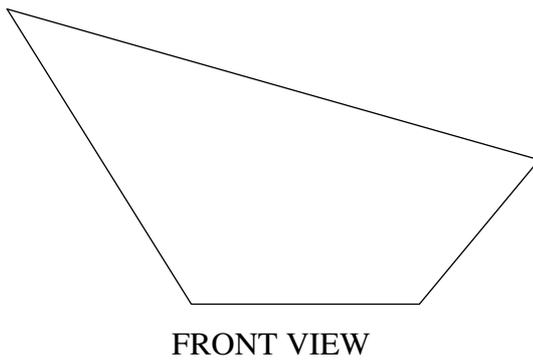
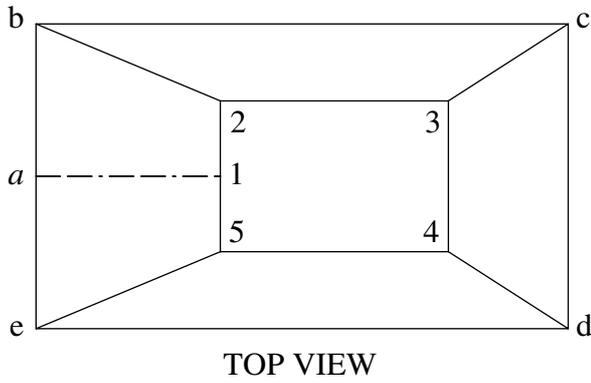
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Question 27 (continued)

- (b) The top and front views of a transition piece in an aircraft air conditioning duct are shown.

6

Complete a half-pattern development of the transition piece, starting from the line $a-1$ given below.



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Section II extra writing space

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Section II extra writing space

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Engineering Studies

FORMULAE SHEET

Force, Moments

$$F = ma; \quad M = Fd$$

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

Friction

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

Energy, Work, Power

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

Pressure

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

Stress and Strain

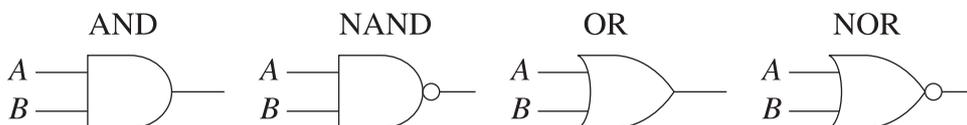
$$\sigma = \frac{F}{A}; \quad \epsilon = \frac{e}{L}; \quad E = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{My}{I}$$

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

Machines

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

Digital Electronics



Electricity, Electronics

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

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

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

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