BOARD OF STUDIES
NEW SOUTH WALES

2003

HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue 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 9, 11, 15, 17, 21, 25, 27 and 31

Total marks – 100

(**Section I**) Pages 2–6

10 marks

- Attempt Questions 1–10
- Allow about 20 minutes for this section

(**Section II**) Pages 9–26

70 marks

- Attempt Questions 11–16
- Allow about 2 hours for this section

(**Section III**) Pages 27–33

20 marks

- Attempt Questions 17–18
- Allow about 40 minutes for this section

Section I

10 marks
Attempt Questions 1–10
Allow about 20 minutes for this section

Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: $2 + 4 =$ (A) 2   (B) 6   (C) 8   (D) 9

A ◯   B ●   C ◯   D ◯

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ●   B ✖   C ◯   D ◯

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.

correct

A ✖   B ✖   C ◯   D ◯

1   Which is the most likely effect of increasing the amount of the cross-linking of the polymer chains in rubber?

    (A)   The stiffness of the rubber increases.

    (B)   The brittleness of the rubber reduces.

    (C)   The rubber can be formed more easily.

    (D)   The rubber can be stretched more easily.

2   Which of the following graphs represents a digital signal for a control circuit?

(A)

(B)

(C)

(D)
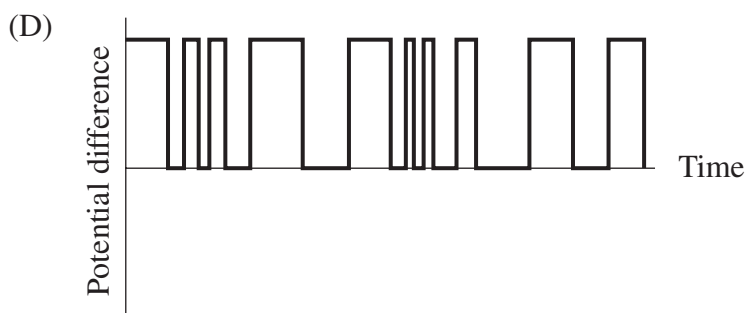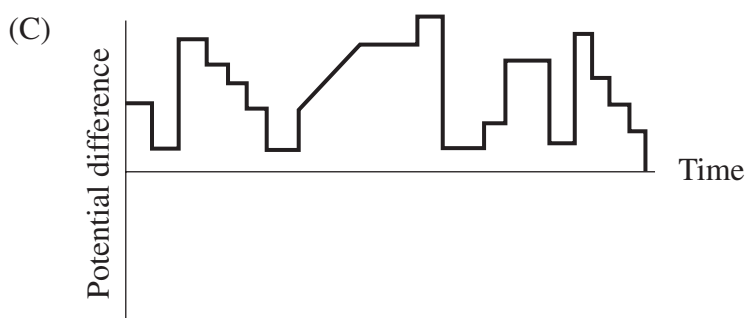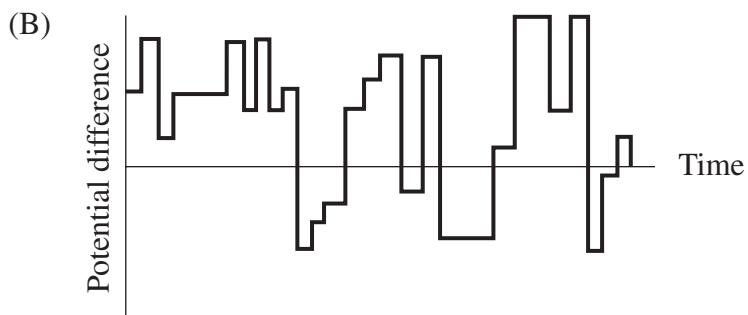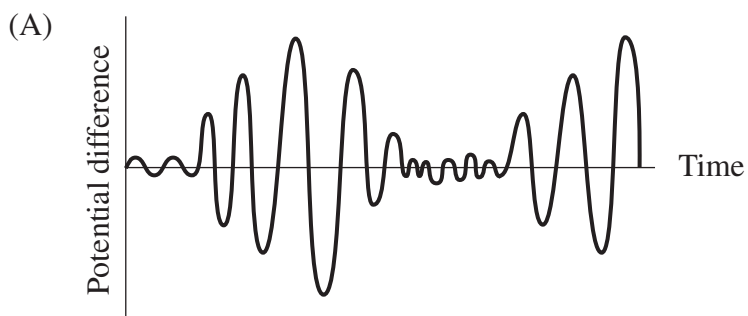
Refer to the following diagram of a steel structure to answer Questions 3 and 4.

The steel used for the structure has a yield stress of 210 MPa.
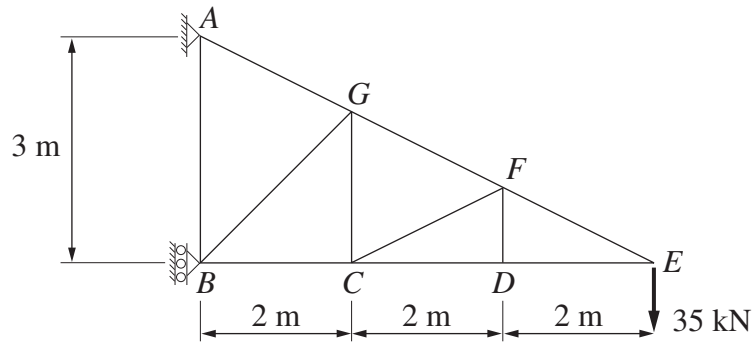
3   The maximum force allowed in member *GF* is 100 kN.

If a factor of safety of 2.5 is applied to calculations, what is the minimum cross-sectional area of member *GF*?

(A)   191 mm^2

(B)   477 mm^2

(C)   1190 mm^2

(D)   2976 mm^2

4   What is the magnitude of the compressive force in member *CD*?

(A)   0 kN

(B)   35 kN

(C)   70 kN

(D)   78 kN

5   Which of the following electronic devices is a semiconductor?

(A)   A capacitor

(B)   An NPN transistor

(C)   A potentiometer

(D)   A resistor

6 Which crane hook has been cold forged and then normalised?

| (A) | (B) | (C) | (D) |
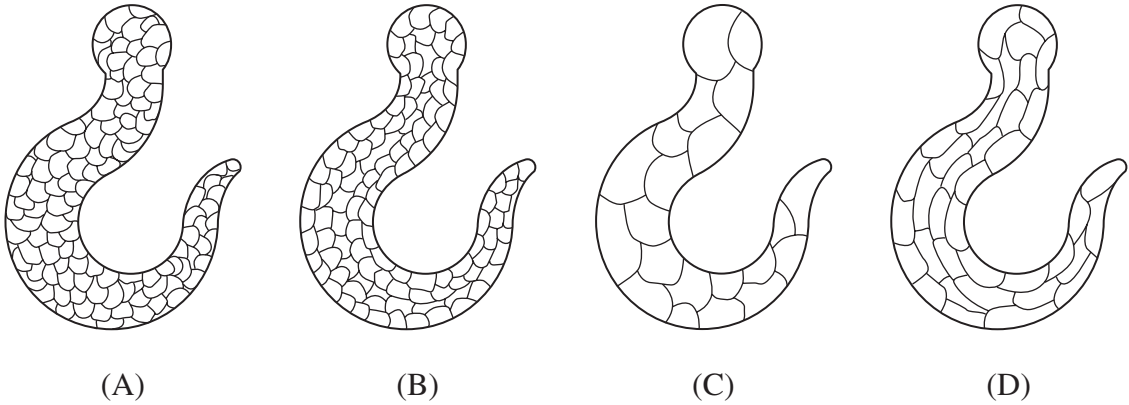
7 To prevent corrosion in the steel hull of a boat, a variety of methods involving cathodic protection may be used.

Which of the following would be an appropriate method?

(A) The use of a lead-based, anti-corrosive paint

(B) The use of a low-voltage impressed alternating current

(C) The use of a less active metal in the galvanic series as an anode

(D) The use of a more active metal in the galvanic series as a sacrificial anode

8 The first stage in the age-hardening process is to heat the alloy to, and hold it at, a temperature just below its melting range.

What is the purpose of this stage?

(A) To fully harden the material

(B) To ensure a large grain size

(C) To evenly distribute second phases

(D) To produce a single-phase solid solution

Refer to the information below to answer Questions 9 and 10.

The orthogonal drawing and pictorial drawing of a transition piece are shown.
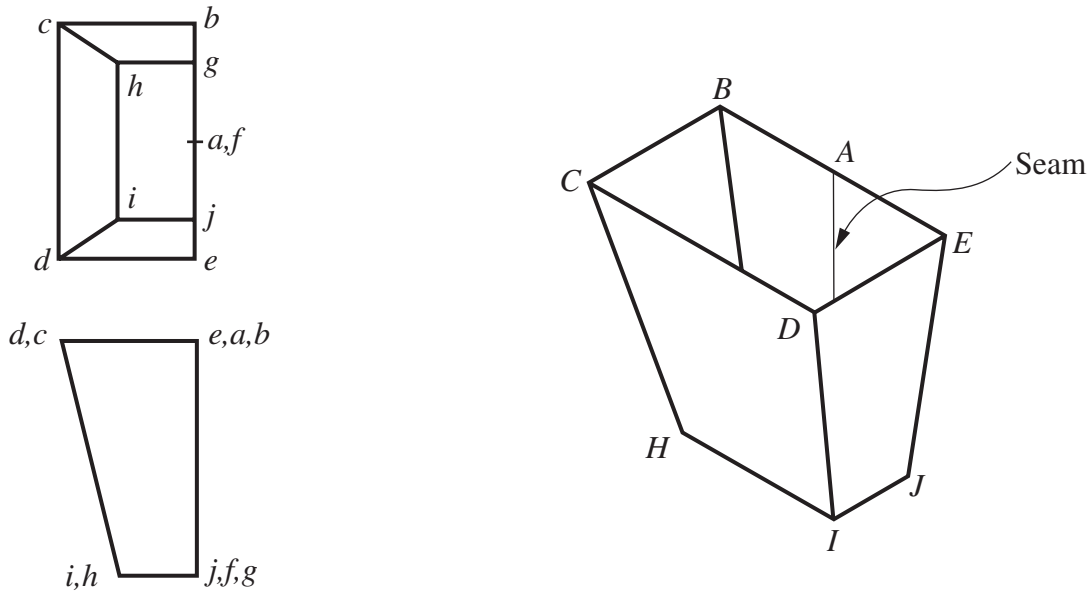
9   Which of the following lines does NOT appear as a true length in either view of the orthogonal drawing?

(A)   *ab*
(B)   *af*
(C)   *bc*
(D)   *ch*

10   Which drawing best represents the shape of a half-pattern surface development?

(A)

(B)

(C)

(D)

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Engineering Studies

Centre Number

Section II

Student Number

70 marks
Attempt Questions 11–16
Allow about 2 hours for this section

Answer the questions in the spaces provided.

Marks

Question 11 — Historical and Societal Influences, and the Scope of the
                  Profession (10 marks)

(a)   The range of knowledge in which an aeronautical engineer is trained includes: **4**

- aerodynamics
- fluid mechanics
- engineering materials
- legal and ethical implications.

Demonstrate how each of these four knowledge areas may be appropriately applied to the design or construction of an aircraft or its components.

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Question 11 continues on page 10

– 9 –

Question 11 (continued)

(b)   Improvements to materials over the past 200 years have changed the significant design features of civil structures. These features include:

- the height of the structures
- the length of unsupported spans
- the load carried by structures
- the stiffness of structures
- the expected lifespan of structures.

    (i)   Outline how the improvements to materials have affected any TWO of these features.   **3**

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    (ii)   Discuss how society has been affected by the changes to any TWO of these features.   **3**

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End of Question 11

Section II (continued)

Centre Number

Student Number

Marks

Question 12 — Civil Structures (10 marks)

(a)   A pre-stressed concrete beam is to be used in the construction of a ferry wharf.

The steel tendons used to pre-stress the beam are 18 mm in diameter and 6 metres in length. A force of 30 kN is to be applied to each tendon.

    (i)   If the Young's modulus for the steel used in the tendons is 210 GPa, calculate the extension of each tendon.

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Extension = ...

    (ii)   Explain TWO benefits of using pre-stressed concrete beams in preference to reinforced concrete beams.

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Question 12 continues on page 12

Question 12 (continued)

(iii) A timber-laminate beam is an alternative to the pre-stressed concrete **3**
beam. Discuss TWO factors, other than strength and cost, an engineer
would consider in choosing the best option.

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(b) The following orthogonal assembly drawing gives details of a pipe support **3**
bracket attached to a steel frame, drawn to a scale of 1 : 1.

FRONT VIEW   SECTIONAL RIGHT
SIDE VIEW
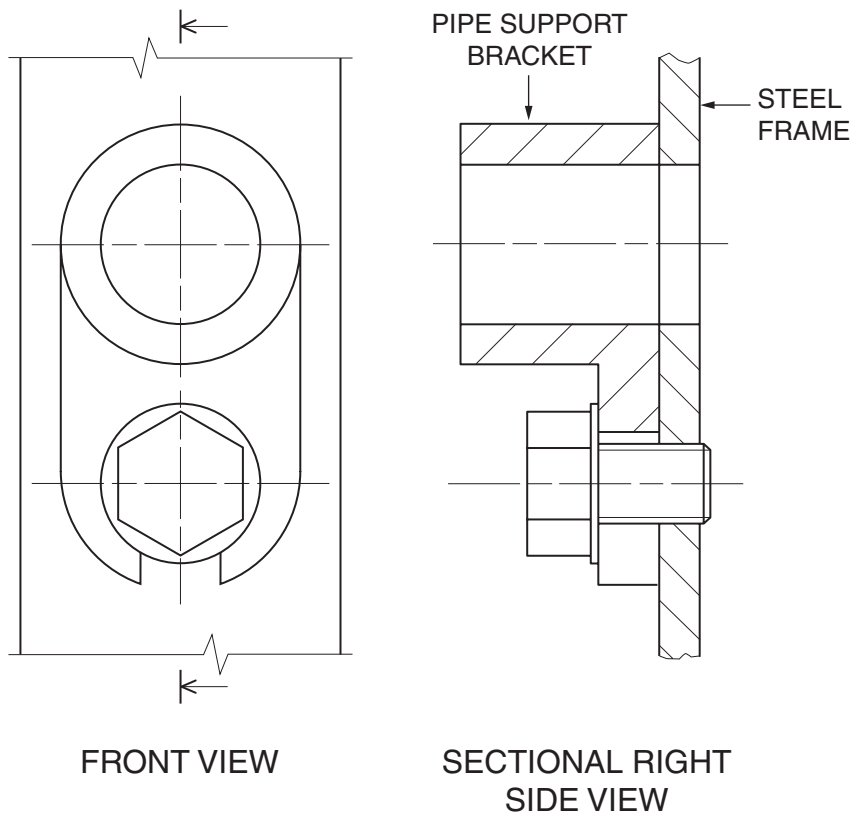
On page 13, sketch a full-size pictorial view of the bracket and frame when
viewed from the front. Do NOT include hidden outline. Do NOT section the
sketch.

Question 12 continues on page 13

Question 12 (continued)

End of Question 12

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Section II (continued)

Marks

Question 13 — Personal and Public Transport (10 marks)

A railway track has rails made of 0.8% carbon steel.

(a)   The surface of the rails has been induction heated and water quenched. Describe **3**
       the final structure and properties of the rail.

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(b)   A suburban train weighing 400 tonnes has to climb a gradient of 1 in 50 at a **3**
       constant velocity of 60 km per hour.

       If the power required to overcome rolling resistance at this velocity is 450 kW,
       calculate the overall power needed to climb the gradient.

Power = ...

– 15 –

Question 13 (continued)

(c)   (i)   Describe how an electric motor is used to convert electricity into rotary   **2**
              motion.

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       (ii)   Describe TWO different applications of electrical motors that are used in   **2**
              transport systems.

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End of Question 13

Centre Number

Student Number

Question 14 — Lifting Devices (10 marks)

Please turn over

Question 14 — Lifting Devices (10 marks)

The diagram shows a lifting device. Arm *RP* is raised or lowered by a hydraulic system comprising a master cylinder and a slave cylinder.
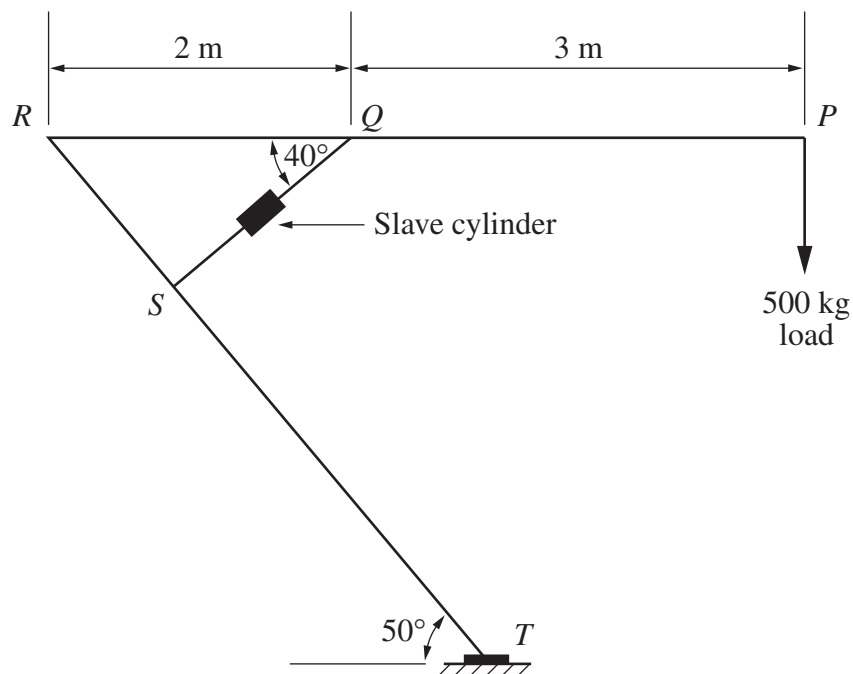
(a) The lifting device is required to hold a load of 500 kg. Determine the minimum force required in member *QS* to keep arm *RP* horizontal. **2**

Minimum force = ...

Question 14 (continued)

(b)   For another set of conditions, the force in member *QS* was found to be 21.35 kN.

   (i)   Draw the shear-force diagram for the arm *RP*. Label the values on the diagram. The mass of the arm should not be considered.   **2**

Shear force   0

   (ii)   Determine the diameter of the master cylinder if the mechanical advantage of the hydraulic system is 3. The slave cylinder has a cross-sectional area of 2800 mm^2.   **3**

Diameter = ...

Question 14 continues on page 20

Question 14 (continued)

(c) Gears used in lifting devices can be manufactured by powder-forming or by a variety of other processes.

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Identify an alternative manufacturing process, and contrast the properties of gears formed by this process with the properties of the powder-formed gears.

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End of Question 14

Engineering Studies

Centre Number

Section II (continued)

Student Number

Marks

Question 15 — Aeronautical Engineering (15 marks)

In common aircraft instruments a pitot tube is connected to both the altimeter and airspeed indicator.
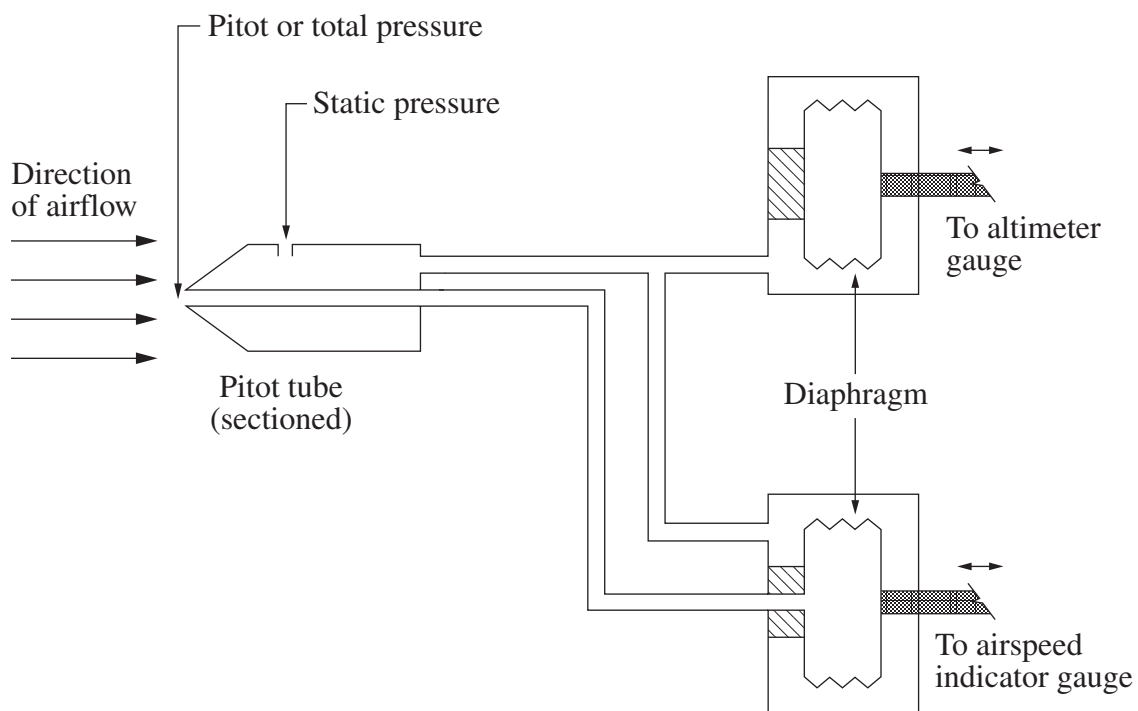
(a) Explain how the airspeed indicator determines airspeed from the pressures sensed by the pitot tube.

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Question 15 (continued)

(b)　(i)　Aluminium and its alloys are generally more active than irons and steels in the galvanic series. Explain why aluminium alloys are more corrosion-resistant than steels.

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　　　(ii)　Identify ONE advantage and ONE disadvantage of the use of composite materials to replace aluminium alloys in aircraft components.

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Question 15 (continued)

(c) In the diagram of an aircraft, the wing has been shown as hidden outline to reveal the wing strut, which has uniform section along its length.

400 mm

200 mm

Detail of cross-section
of wing strut

15 kN

5 m
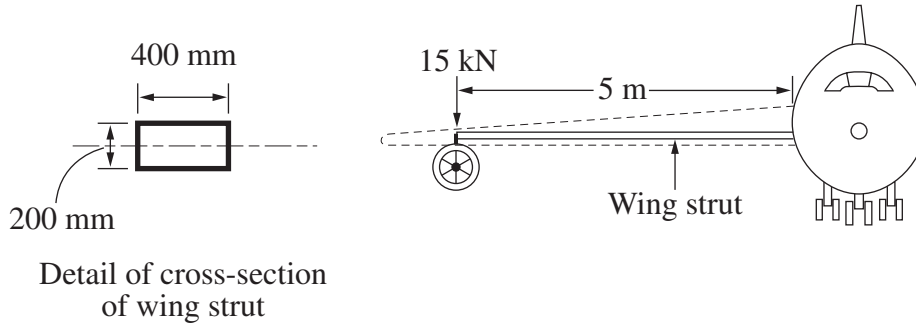
Wing strut

(i) Compare the nature of the stresses experienced by the surfaces of the wing strut when the aircraft is stationary on the ground and when the aircraft is in flight.

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(ii) Determine the maximum value of the bending stress when the strut experiences a force of 15 kN at its end.

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Use $I = 267 \times 10^6 \, \text{mm}^4$.

Bending stress = ...

Question 15 (continued)

(d)   Outline TWO conditions that may cause an aircraft to stall during flight.   **2**

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End of Question 15

Engineering Studies

Section II (continued)

Marks

Question 16 — Telecommunication (15 marks)

(a)   (i)   The telecommunications industry uses copper and fibre optics for transmission of data. State a different application for each of these materials, and explain, in terms of their properties, why they are used for this application.

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(ii)   Cold drawing is used to form copper into electrical wire. Describe TWO problems associated with the use of the process. Describe a subsequent process that will reduce these problems.

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Question 16 continues on page 26

353

Question 16 (continued)

(b) Identify TWO technological changes in the telecommunications industry. Discuss the effects that these changes have had on society.

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(c) (i) Describe the transmission of data from a mobile phone to another mobile phone.

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(ii) Explain the effect that mobile phone communications may have on other electronic systems. State TWO situations where this effect could endanger lives.

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End of Question 16

Engineering Studies

Centre Number

Section III

Student Number

20 marks
Attempt Questions 17–18
Allow about 40 minutes for this section

Answer the questions in the spaces provided.

Marks

Question 17 — Engineering and the Engineering Report (10 marks)

Shade areas are to be added to a major harbourside transport interchange. The interchange is also a popular tourist destination.

(a)   An engineering report is to be produced for the development of shade areas near   **2**
the interchange. Outline a technical issue and a social issue that would need to
be considered in such a report.

Technical:

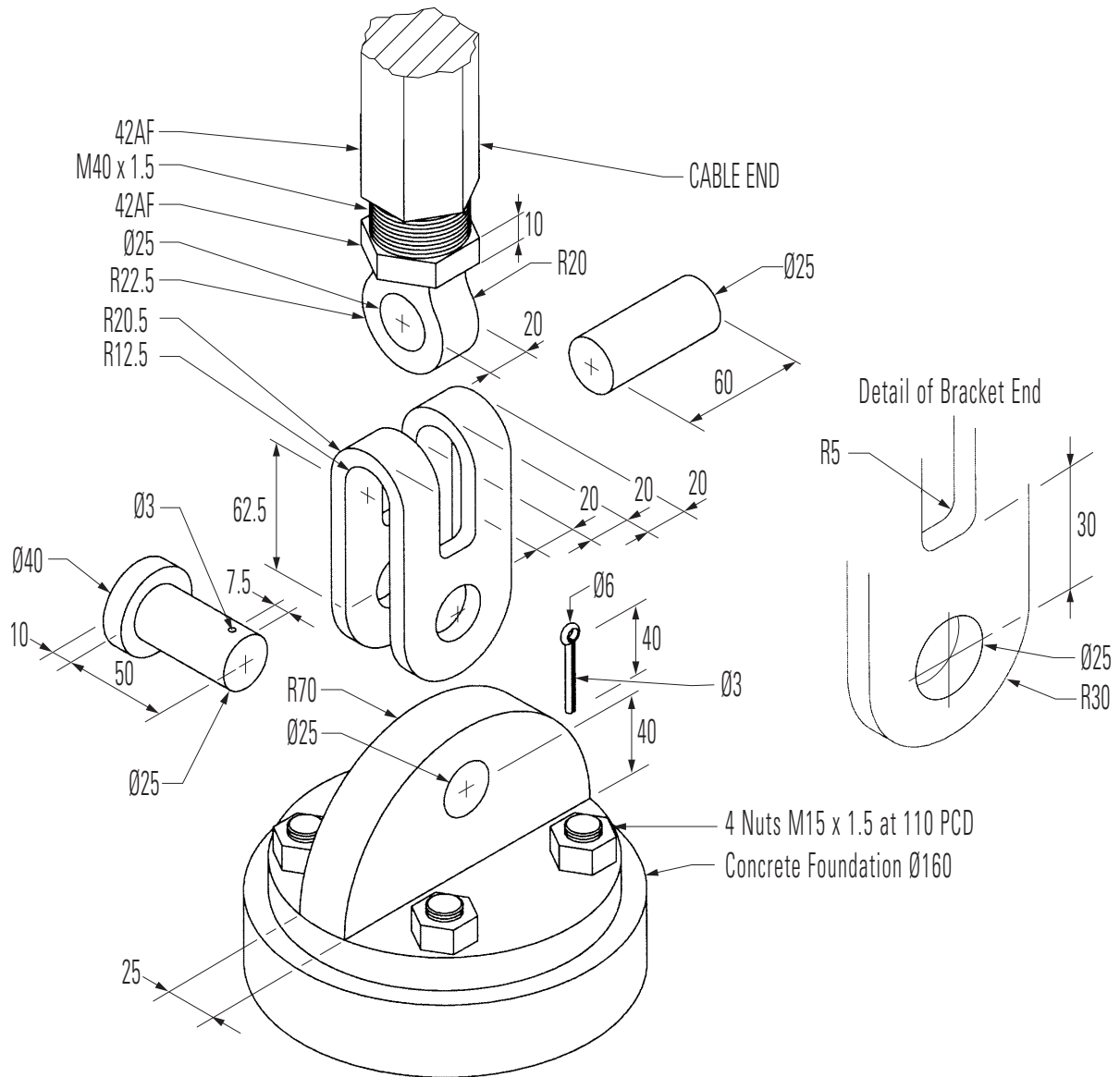...

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Social:

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Question 17 (continued)

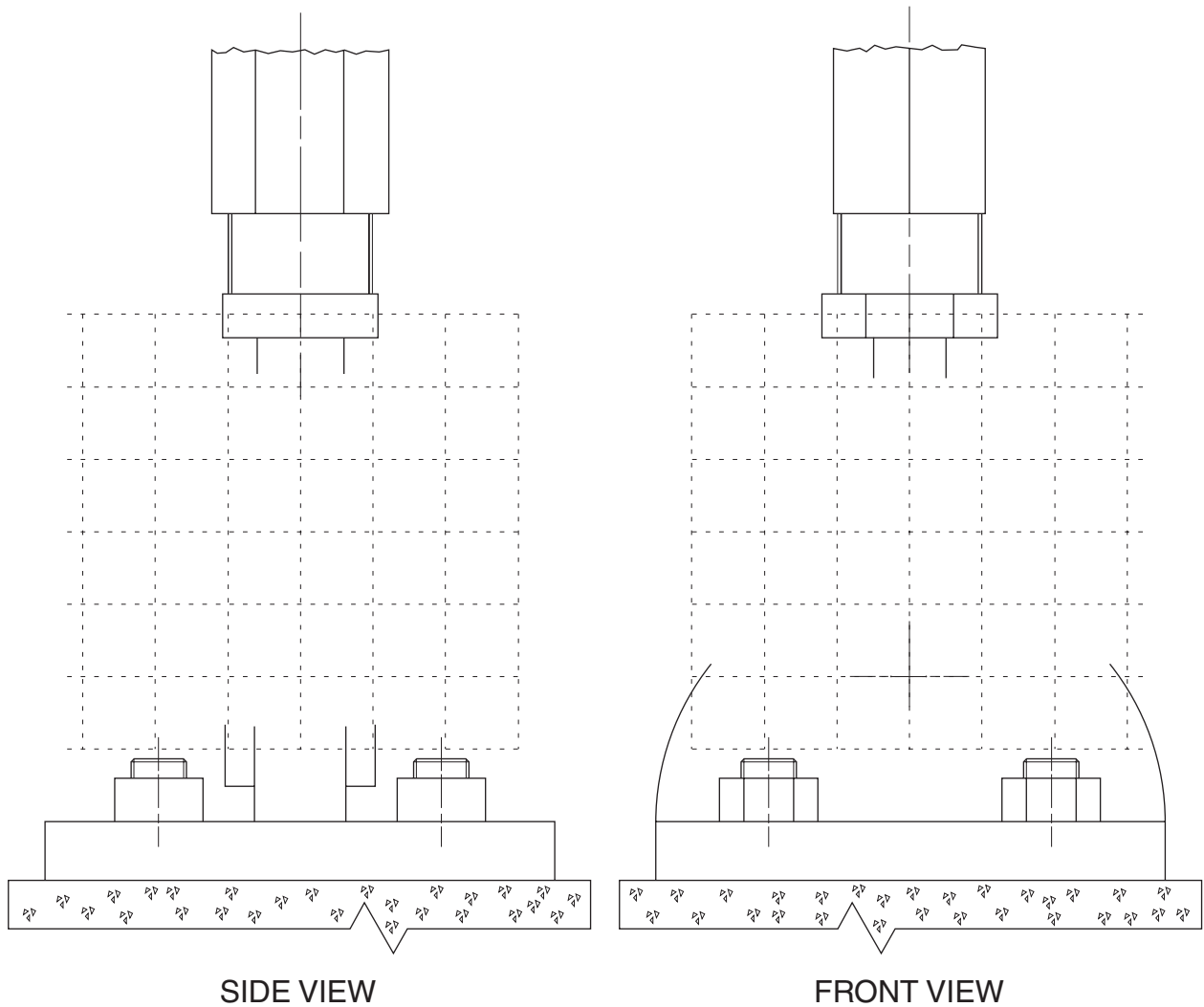(b)   Details of a domestic shade area cable tensioning system are given.   **4**

Question 17 continues on page 29

Question 17 (continued)

A partially completed orthogonal sketch of the front and side views of the assembly is shown, drawn to a scale of $1:2$.

Complete the assembled orthogonal sketch on the grid. Apply AS1100 drawing standards where appropriate. DO NOT show hidden outline. DO NOT dimension.

SIDE VIEW   FRONT VIEW

Question 17 (continued)

(c)

(i) A support for a public shaded area is shown in the photograph. Two types of members, *A* and *B*, are used to distribute the forces created by the weight of the fabric. **2**

Explain the structural reasons for the difference in the shape and size of the members.

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(ii) PVC coated polyester fabric is widely used as the cover for shade areas. Discuss how developments in engineering textiles have influenced the design of public shade structures. **2**

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End of Question 17

Engineering Studies

Section III (continued)

Centre Number

Student Number

Marks

Question 18 — Engineering and the Engineering Report (10 marks)

(a)   Discuss the use of CAD systems as an alternative to traditional drawing methods.   **3**

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Question 18 (continued)

(b)

(i) In many public areas, polymer containers similar to those shown are provided for rubbish and recyclable materials. Describe a forming process to produce the main body of these large containers.

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(ii) The lids used for the containers are moulded from polyethylene. Outline the reasons for this being a suitable choice of material in service.

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Question 18 (continued)

(c)   A loading ramp between a ferry and a wharf is shown. The ramp has a weight   **3**
of 2 kN and a coefficient of static friction with the wharf of 0.2. There is no
friction at the roller support.

7 m

Roller

25°

Wharf

2 kN

Ferry
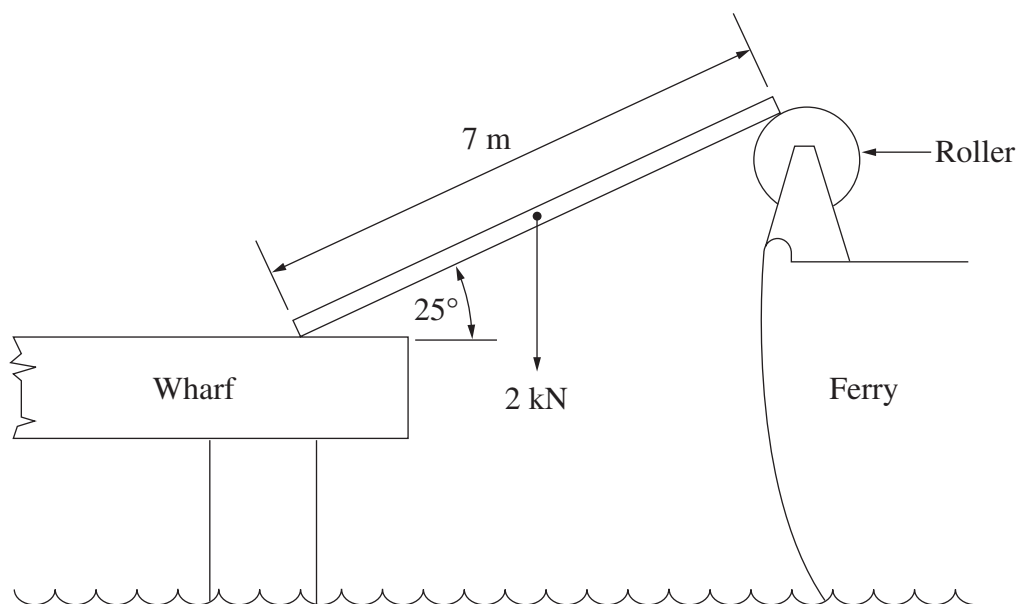
Sketch a free-body diagram of the ramp. Show whether the ramp will slip or
remain static for these conditions.

End of paper

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<div style="text-align:center">**FORMULAE SHEET**</div>

Force, Moments

$F = ma; \quad M = Fd$

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

Friction

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

Energy, Work, Power

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

Pressure

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

Stress and Strain

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

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

Machines

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

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