



B O A R D O F S T U D I E S
NEW SOUTH WALES

2001

**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, 19, 23, 27 and 31

Total marks – 100

Section I Pages 2–7

10 marks

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

Section II Pages 9–25

70 marks

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

Section III Pages 27–32

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.

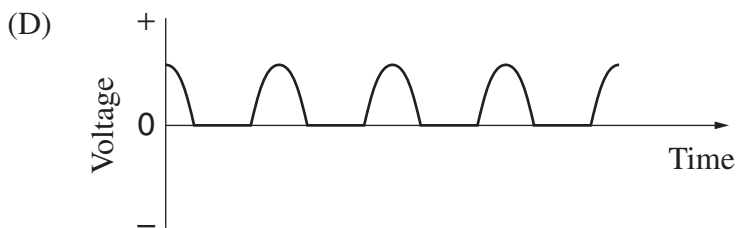
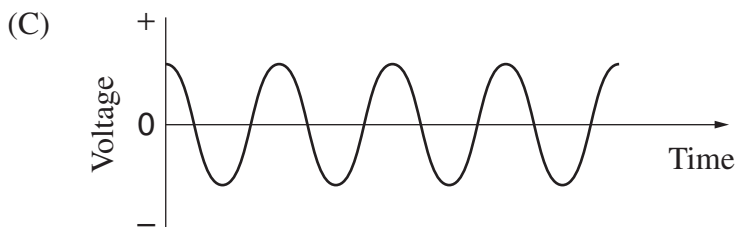
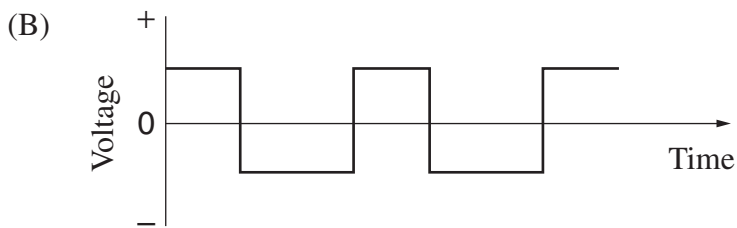
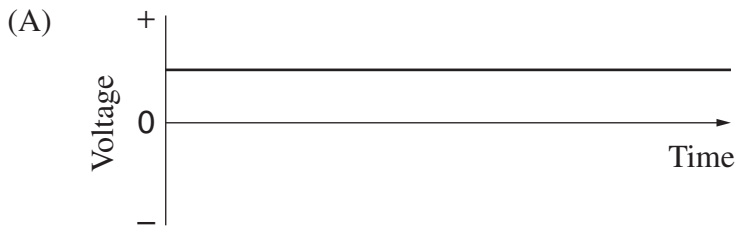
A B C D

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.

A B C D
correct →

- 1 Which list best describes the reasons for the use of concrete in civil structures?
- (A) High compressive and tensile strength, and ease of formation on site
 - (B) High compressive strength, ease of formation on site, and ability to be reinforced
 - (C) High tensile strength, ease of formation on site, and relatively low cost
 - (D) High tensile strength, ease of formation on site, and ability to be reinforced

2 Which of the following represents direct current?



3 Which material is best suited for use as a crane hook because of its tensile strength?

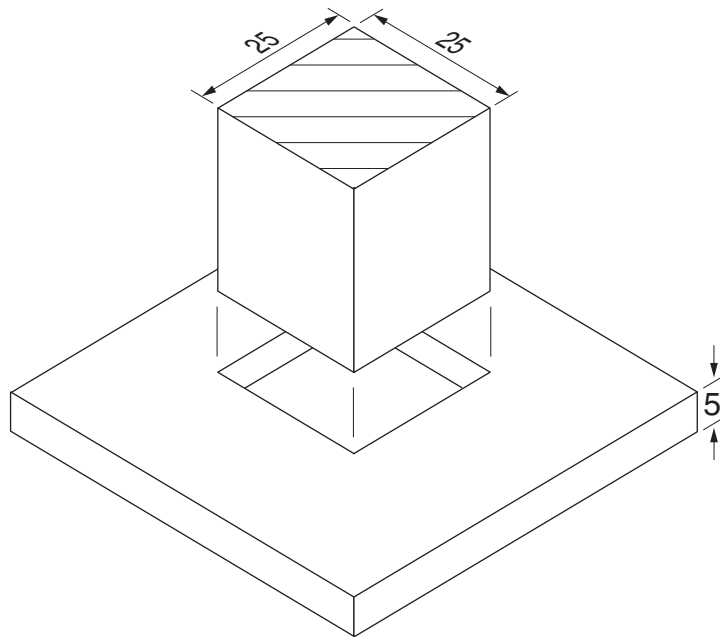
(A) Grey cast iron

(B) Medium-carbon steel

(C) Tungsten carbide

(D) White cast iron

4 A 150 kN load is applied to the square die to punch a hole in the 5 mm thick metal plate shown.



Determine the shear stress in the plate.

(A) 1500 Pa

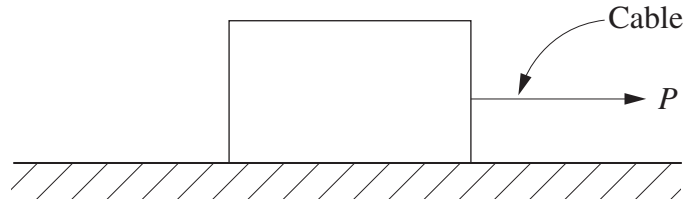
(B) 0.3 MPa

(C) 240 MPa

(D) 300 MPa

Use the information below to answer Questions 5 and 6.

An 800 kg block is at rest on a horizontal surface. A force P is applied to the block by means of a cable. Assume that the acceleration due to gravity is 10 m/s^2 .



5 The cable is horizontal, and the coefficient of static friction $\mu_s = 0.1$. Calculate the force P required to just move the block.

- (A) 8 N
- (B) 80 N
- (C) 800 N
- (D) 8000 N

6 If the cable is now inclined upwards at an angle of 30° to the horizontal, and μ_s remains at 0.1, calculate the least value of force P necessary to just move the block.

- (A) 615 N
- (B) 873 N
- (C) 8.73 kN
- (D) 16 kN

7 Mechanised lifting devices have largely replaced manual lifting in modern society.

Which factors have been most significant in this change?

- (A) The development of hydraulics and improved materials technology
- (B) The increased use of electrical power and the increase in the available workforce
- (C) The improvement in manufacturing methods and the increase in loads to be lifted
- (D) The decrease in the available workforce and the decreased availability of natural resources

- 8 The diagram represents a 12V DC power supply that has four stages of operation.

The copyright owner has refused permission
for this diagram to appear on the Internet.

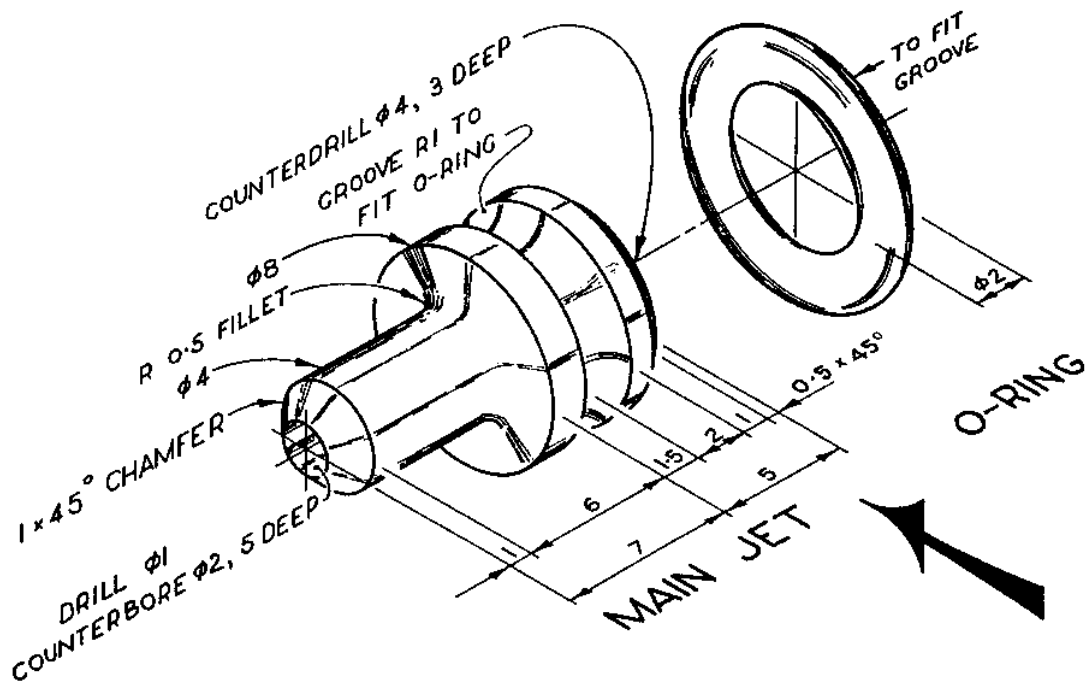
Which of the following correctly lists Stage 1 to Stage 4?

- (A) Regulation, transformation, logic control, rectification
 - (B) Transformation, logic control, rectification, filtering
 - (C) Transformation, rectification, filtering, regulation
 - (D) Regulation, rectification, filtering, transformation
- 9 A piece of annealed medium-carbon steel is reheated and soaked at an appropriate temperature.

Which subsequent cooling process results in ALL of the following property changes?

- increased yield strength
 - increased impact strength
 - increased hardness
 - decreased ductility
- (A) Air cooling
 - (B) Brine quenching
 - (C) Furnace cooling
 - (D) Water quenching

- 10 An exploded pictorial drawing of the main jet and O-ring from a carburettor, used in public transport vehicles, is shown.



A computer-aided drawing (CAD) program is used to produce an orthogonal drawing of the main jet and O-ring.

Which of the following is the most significant advantage of using a CAD program?

- (A) CAD programs produce neater line-work and more accurate drawings.
- (B) Non-skilled operators can produce drawings using CAD programs.
- (C) Use of CAD programs reduces occupational health and safety risks.
- (D) Use of CAD programs can be faster, and changes are more readily made.

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Engineering Studies

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Centre Number

Section II

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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) Select a mode of personal or public transport you have studied.

2

Mode of transport

Materials used in transport systems have changed over the past 100 years.

State a material that was once used extensively in the construction of the mode of transport selected, and state a material that has now replaced it. Explain the reason for this change.

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Question 11 continues on page 10

Question 11 (continued)

- (b) In the post-World War II period, society experienced a vast change in the methods used for long-distance travel. **2**

Identify ONE significant change, and briefly describe its impact on society or the environment.

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- (c) (i) Describe the role of an aeronautical engineer. **2**

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- (ii) Discuss how collaboration between different types of engineers in the aviation industry contributes to maintaining high standards of safety. **4**

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End of Question 11

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Section II (continued)

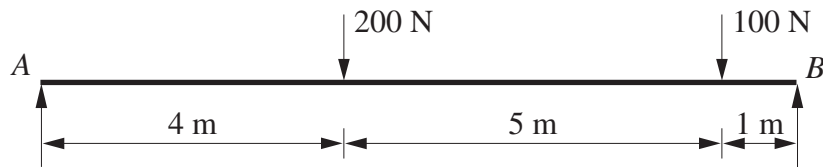
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Marks

Question 12 — Civil Structures (10 marks)

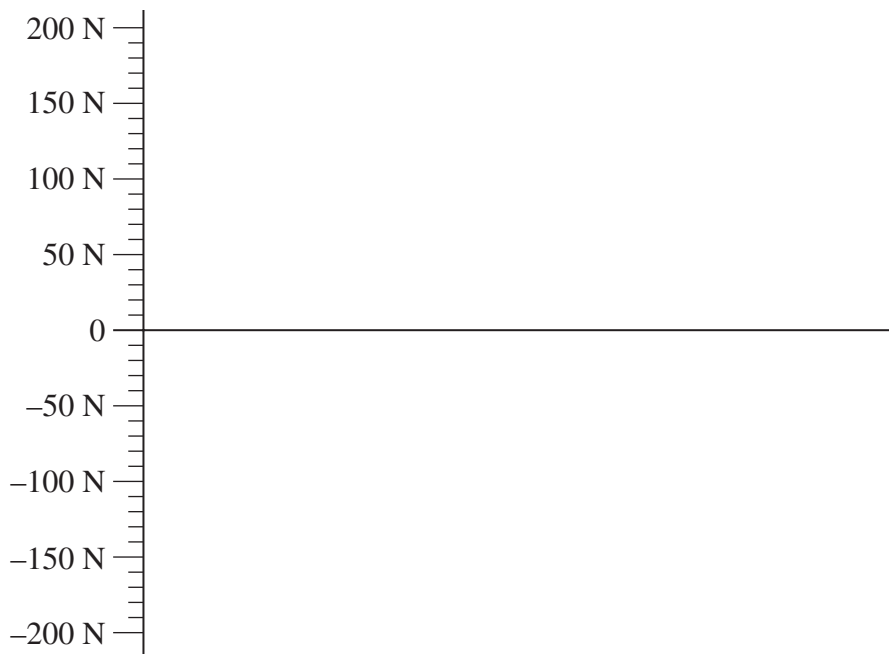
(a) A loaded beam is shown.



(i) Determine the magnitude of the reaction at A. 1

Magnitude of reaction at A = kN

(ii) Draw the shear-force diagram for the loaded beam. 1

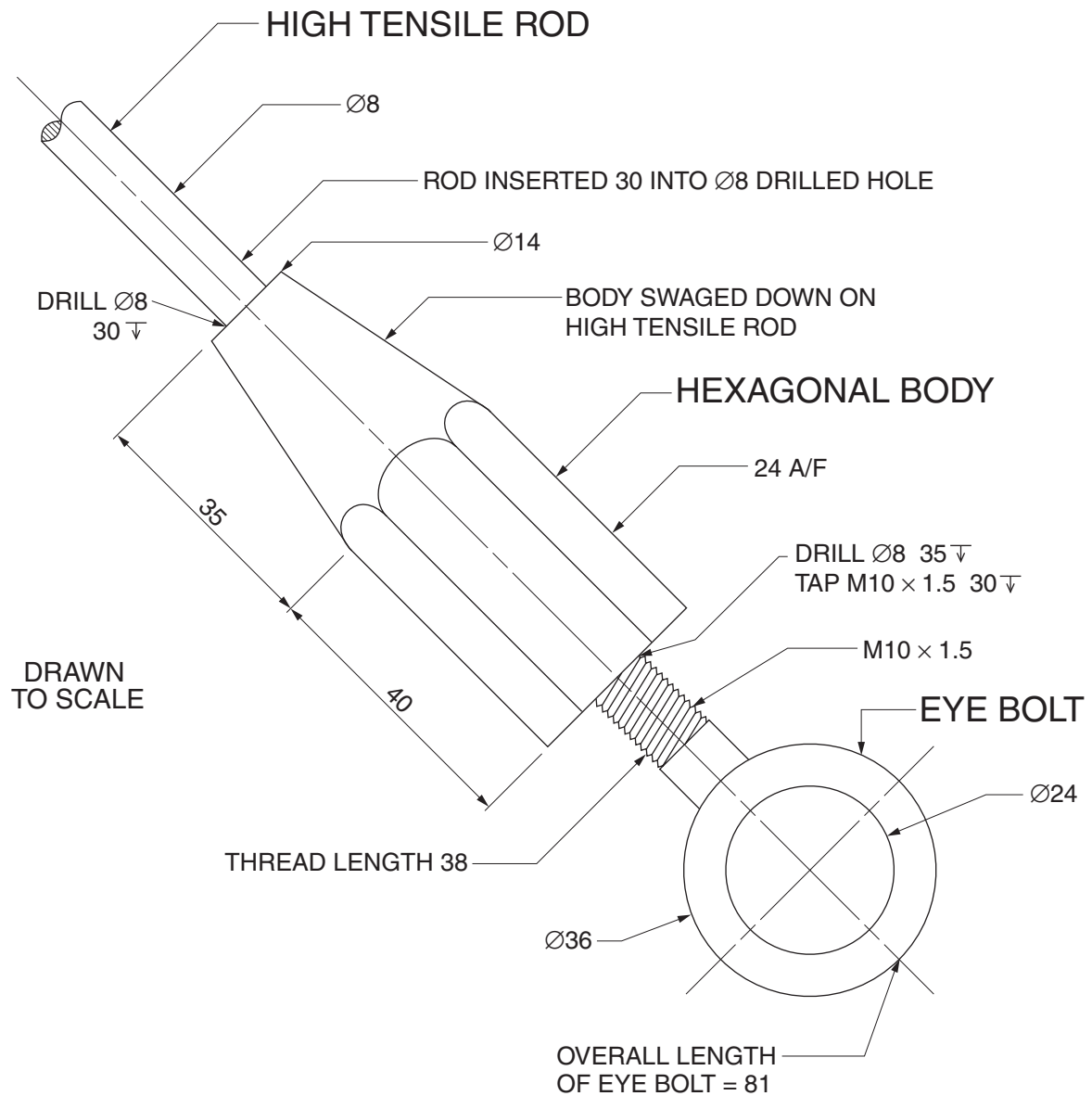


Question 12 continues on page 12

Question 12 (continued)

- (b) A design drawing for a turnbuckle used for tensioning a high tensile rod in a shade shelter construction is shown.

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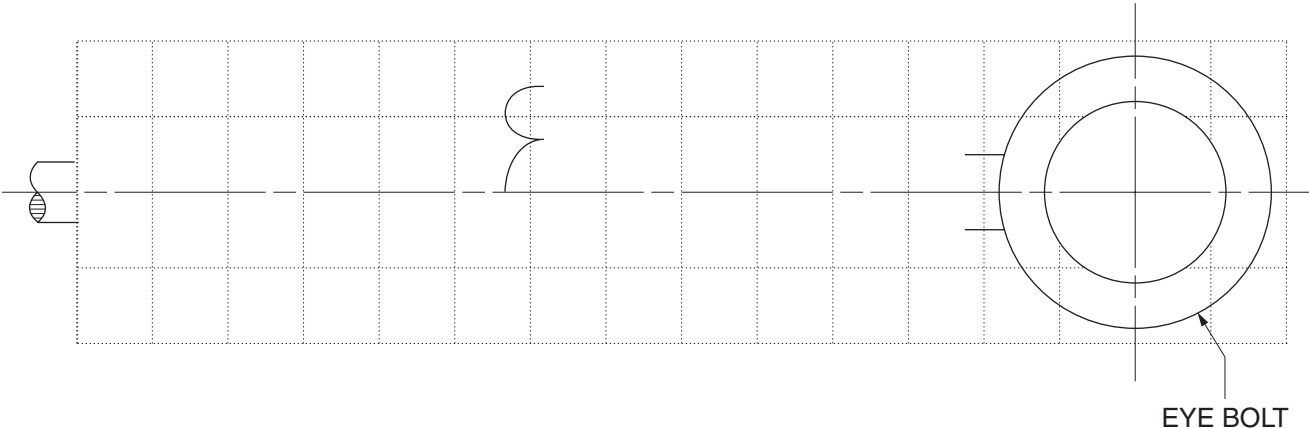


ALL DIMENSIONS IN mm

Question 12 continues on page 13

Question 12 (continued)

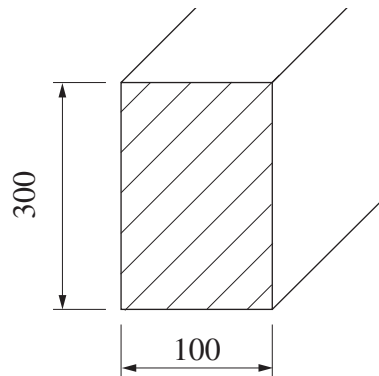
Sketch a half-sectional view of the turnbuckle, applying AS1100 drawing standards. Insert the eye bolt 25 mm into the end of the hexagonal body. Use the centre line shown to position your sketch. Use a scale of 1 : 1 for your sketch.



Question 12 continues on page 14

Question 12 (continued)

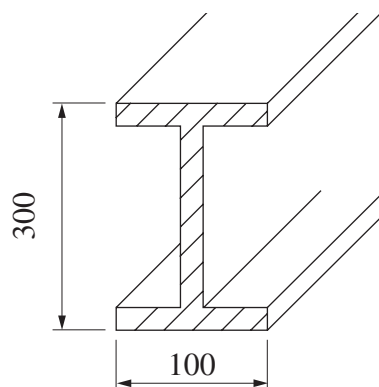
- (c) (i) A beam of rectangular cross-section 300 mm × 100 mm is shown. The beam has a moment of inertia of $225 \times 10^{-6} \text{ m}^4$ and a maximum bending moment of 67.5 kNm. 2



Determine the maximum value of the bending stress in the beam.

Bending stress = MPa

- (ii) Explain why the I-shaped beam is used in preference to the rectangular beam above. 1



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End of Question 12

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Section II (continued)

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Student Number

Marks

Question 13 — Personal and Public Transport (10 marks)

- (a) A powder-formed bearing is used to support an axle shaft in a public transport vehicle. **2**

Identify a suitable metal for use in the bearing, and explain why the properties of the bearing make it suitable when in service.

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- (b) Contrast the manufacture of annealed glass with that of a safety glass. Explain why safety glass is used in preference to annealed glass in the windscreen of a public transport vehicle. **3**

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Question 13 continues on page 16

Question 13 (continued)

- (c) A medium-carbon steel is used for a vehicle axle. Describe the processes that may be used to produce a hardened and tempered structure in the steel. **5**

Explain the changes in structure and properties that result from the hardening process, and discuss why subsequent tempering is necessary.

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Section II (continued)

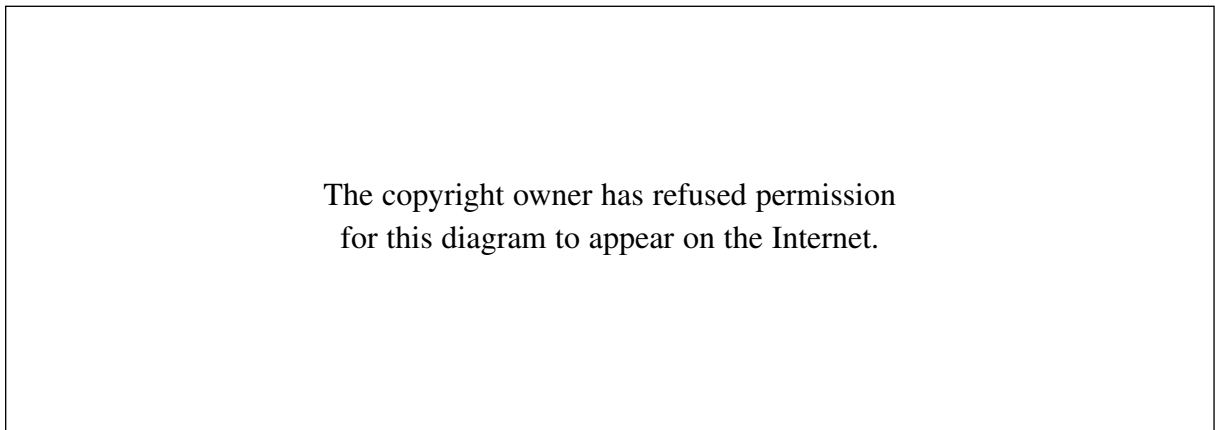
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Marks

Question 14 — Lifting Devices (10 marks)

(a) A hydrostatic lifting device is shown.



Water is delivered from a river into the float chamber, C. This raises the float and, in turn, lowers the load. When water is let out, the float lowers and the load is raised.

- (i) The velocity ratio of the pulleys is 1 : 20, and the friction in the pulleys reduces the efficiency to 85%. Calculate the load that can be lifted if a 40 tonne float is used. 2

Load = tonnes

- (ii) Discuss the use of hydraulic systems in preference to mechanical systems in lifting devices. 2

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Question 14 continues on page 18

Question 14 (continued)

- (b) Describe an important safety feature that would need to be considered when designing a lifting device. **1**

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- (c) Identify TWO properties of a material used in the manufacture of lifting devices, and describe the importance of these properties in this application. **5**

For the properties that you have identified, describe appropriate testing methods used to evaluate the suitability of these materials for this use.

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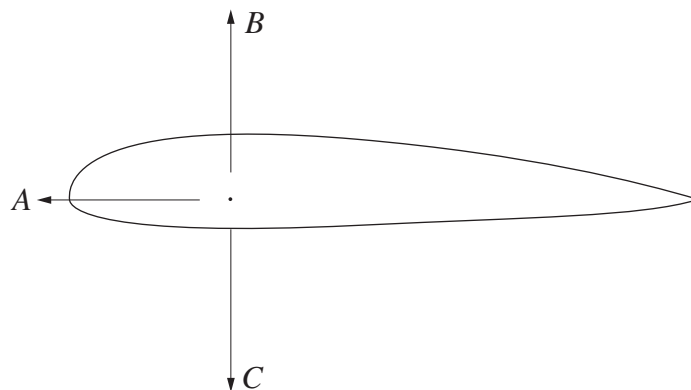
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Marks

Question 15 — Aeronautical Engineering (15 marks)

(a) The forces shown on the aerofoil section are active during flight.



(i) Name the forces indicated. 3

A C

B

(ii) On the diagram, sketch the airflow across the aerofoil section during forward motion. Explain, with reference to forces A, B and C, how this airflow enables flight. 3

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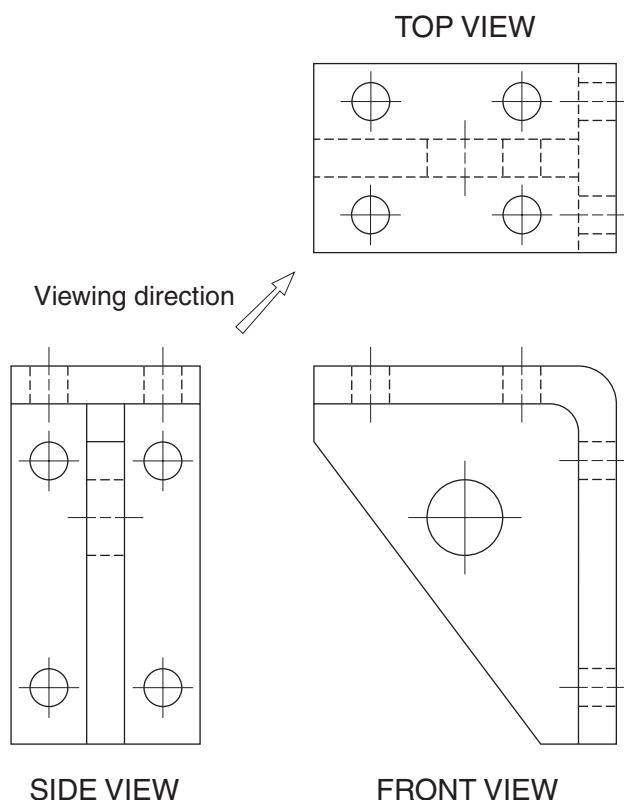
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Question 15 continues on page 20

Question 15 (continued)

- (b) An orthogonal drawing of an aircraft engine mounting bracket is shown in third-angle projection. 4

Using sizes taken directly from the drawing, sketch a pictorial view of the bracket when viewed in the direction indicated. Do NOT indicate centre lines or hidden outlines.



Question 15 continues on page 21

Question 15 (continued)

- (c) Age-hardened aluminium alloys are used in aircraft construction. **5**

Name a specific alloy and discuss the suitability of the alloy for this application. Identify and describe a non-destructive test method that would be appropriate in inspecting for cracks.

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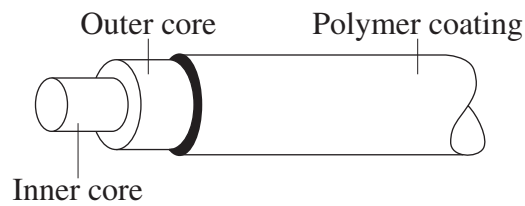
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Student Number

Marks

Question 16 — Telecommunication (15 marks)

- (a) The diagram shows a section of fibre-optical cable which consists of two similar materials forming the inner and outer cores, and a polymer coating. **3**



Explain how fibre-optical cable transmits data, and why fibre-optical cable has replaced copper for this use.

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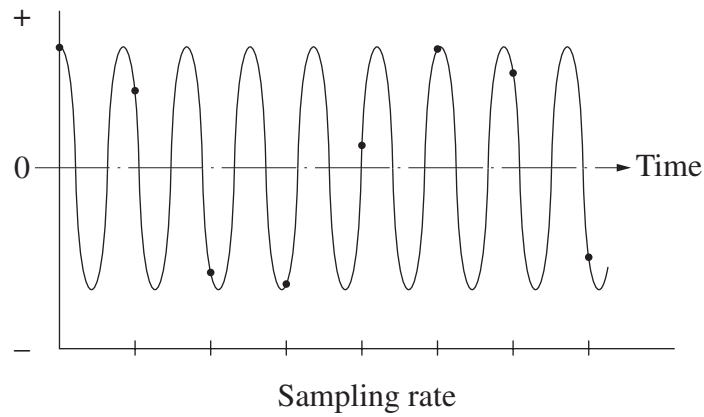
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Question 16 continues on page 24

Question 16 (continued)

- (b) An analogue signal is shown on the diagram. This signal is passed through an analogue-to-digital converter, sampling at the rate indicated. The resulting digital signal is indicated on the diagram as dots on the analogue signal.

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Explain how the analogue signal is converted to a digital signal, and discuss the importance of the sampling rate during this conversion process.

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Question 16 continues on page 25

Question 16 (continued)

- (c) (i) Discuss the health and safety issues associated with the use of a telecommunications device that you have studied, and outline an effective strategy that may be used to overcome these issues. 4

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- (ii) The introduction of modern telecommunications devices has resulted in much debate in our society concerning legal and ethical issues. Discuss TWO such issues. 3

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End of Question 16

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Centre Number

Section III

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Student Number

20 marks

Attempt Questions 17–18

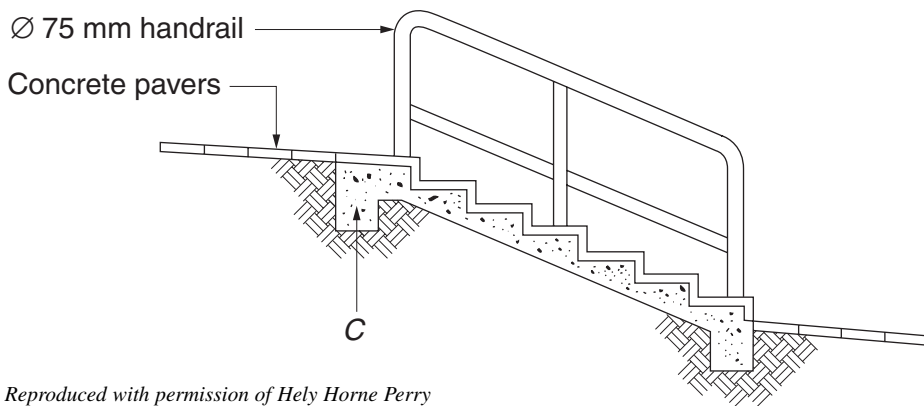
Allow about 40 minutes for this section

Answer the questions in the spaces provided.

Marks

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

As part of an engineering report, a drawing of a step and handrail construction has been prepared.



Reproduced with permission of Hely Horne Perry Medcalf Architects Pty Ltd, Milsons Point, NSW.

- (a) Identify the feature at C, and explain the purpose of its inclusion in the design. 2

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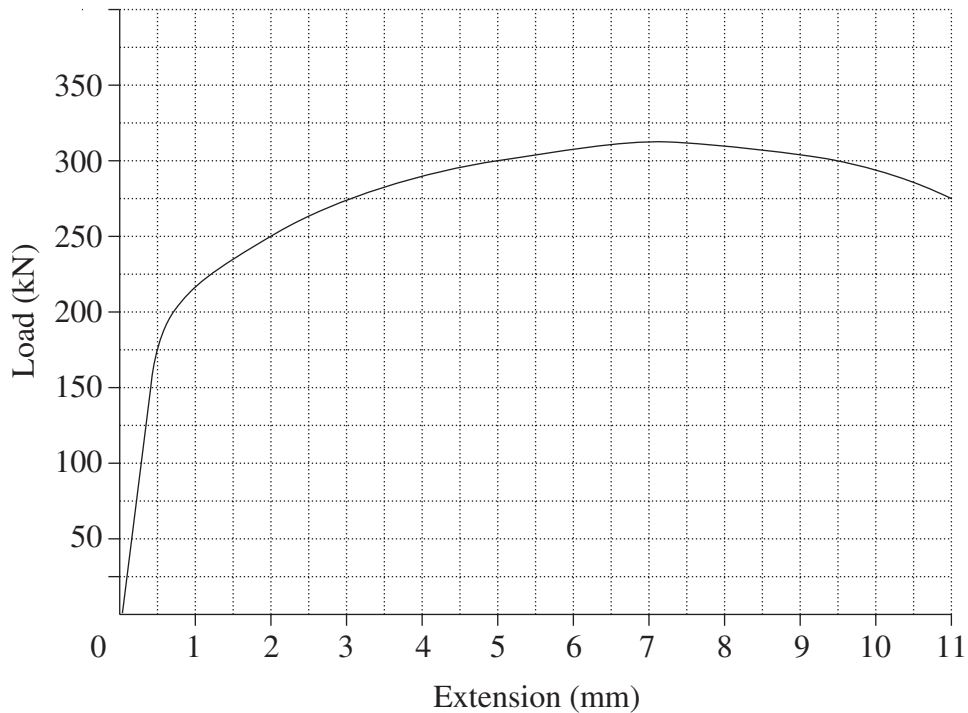
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Question 17 continues on page 28

Question 17 (continued)

- (b) A sample of metal is tested for its suitability as material for the handrail. The $\varnothing 20$ mm sample has a gauge length of 80 mm. The resultant load-extension diagram is shown.



- (i) Determine the ultimate tensile strength of the metal. 1

Ultimate tensile strength = MPa

- (ii) Determine the Young's modulus for the metal $\left(E = \frac{PL}{eA} \right)$. 2

Young's modulus = GPa

- (iii) Describe how ONE other mechanical property of the metal sample can be obtained from the load-extension diagram. 1

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Question 17 continues on page 29

Question 17 (continued)

- (c) Discuss TWO social and/or environmental factors that a civil engineer would consider in writing an engineering report for the design of the step and handrail construction. **4**

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End of Question 17

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Section III (continued)

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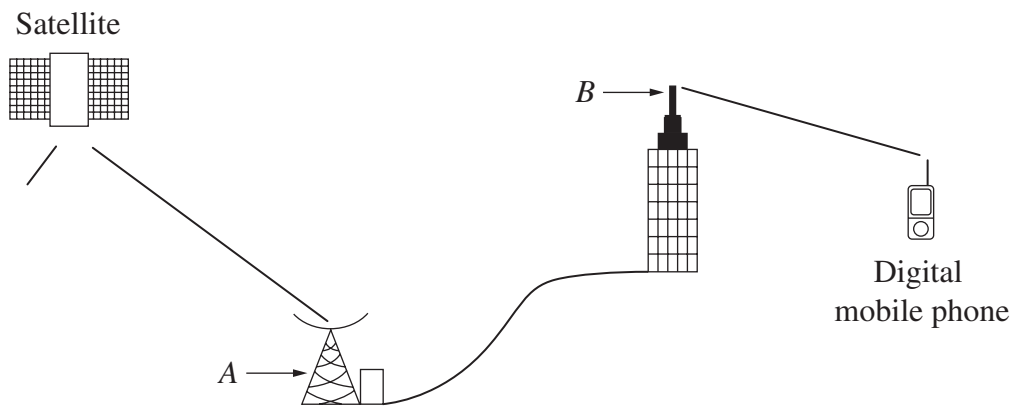
Marks

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

(a) A section of a mobile phone system is shown.

2

Identify Parts *A* and *B*, and outline their functions within the system.



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Question 18 continues on page 32

Question 18 (continued)

- (b) Satellite communication systems have had a profound effect upon some sections of our society. 3

Discuss this statement, using specific examples.

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- (c) Satellite communication systems are a recent innovation in telecommunications engineering. 5

Describe the roles of engineers in the design, construction and operation of satellite communication systems.

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