

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

2002

**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, 19, 23, 27, 31 and 35

Total marks – 100

Section I Pages 2–6

10 marks

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

Section II Pages 9–30

70 marks

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

Section III Pages 31–36

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.

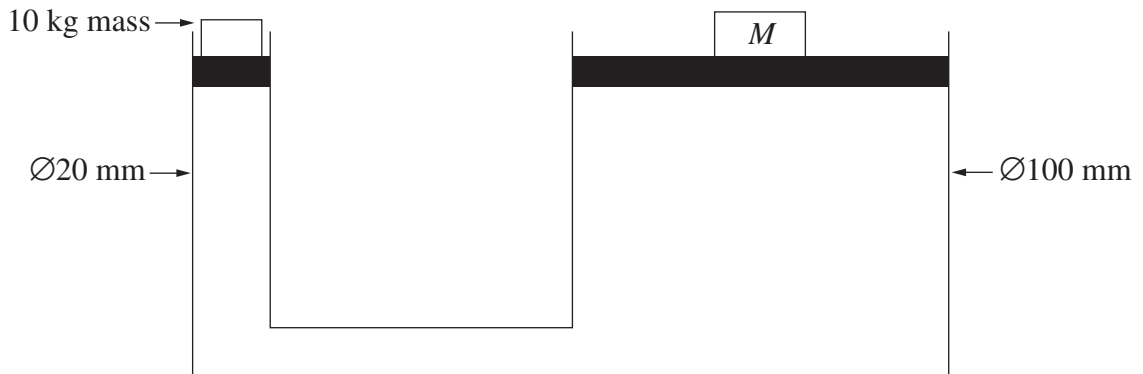
A B C D

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.

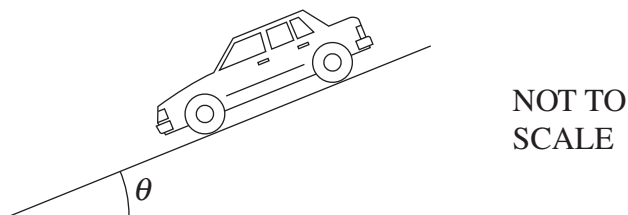
A B C D
correct ↙

- 1 Which of the following is a thermosetting polymer?
- (A) Nylon
 - (B) Acrylic resin
 - (C) Polyvinylchloride
 - (D) Melamine formaldehyde
- 2 A car axle made of steel suddenly fails after several years of use. What is the most likely cause of failure?
- (A) Creep
 - (B) Fatigue
 - (C) Age hardening
 - (D) Work hardening
- 3 Which of the following properties are the most important when choosing steel for the manufacture of a building girder?
- (A) Fatigue limit and modulus of elasticity
 - (B) Fatigue limit and ultimate tensile strength
 - (C) Yield strength and modulus of elasticity
 - (D) Yield strength and ultimate tensile strength
- 4 Why would alloy steel be preferred over plain carbon steel for a hardened and tempered component in a heavy transport vehicle?
- (A) It has greater hardenability.
 - (B) It softens more during tempering.
 - (C) It reduces the cost of the component.
 - (D) It has a better age-hardening response.

- 5 What is the greatest mass, M , that can be lifted by the 10 kg mass using the hydraulic lifting device shown in the diagram?



- (A) 2 kg
(B) 50 kg
(C) 250 kg
(D) 500 kg
- 6 In a tension test, which of the following represents the engineering (nominal) strain?
- (A) The extension of the test piece
(B) The extension divided by the final gauge length
(C) The extension divided by the original gauge length
(D) The force divided by the original cross-section area
- 7 A car is parked on a sloping surface. The coefficient of friction between the car tyres and the surface is 0.25.

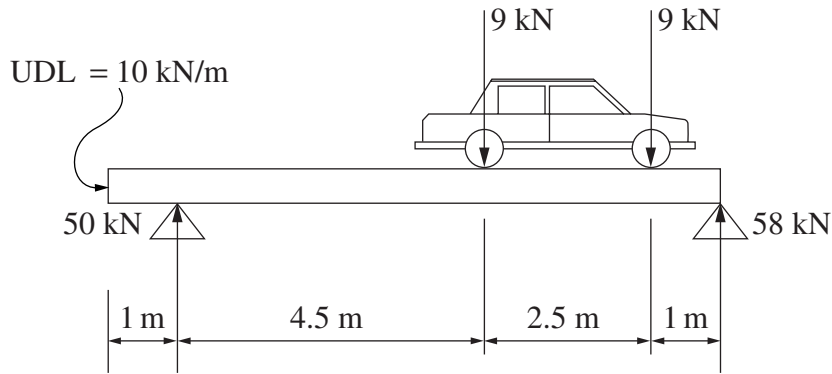


Which of the following angles is the largest possible value of θ before the car starts to slide?

- (A) 10°
(B) 14°
(C) 22°
(D) 27°

- 8 A car is parked on a reinforced concrete beam. The beam has a uniformly distributed load (UDL) as shown.

What is the correct shear force diagram for the beam?



- (A)
- (B)
- (C)
- (D)

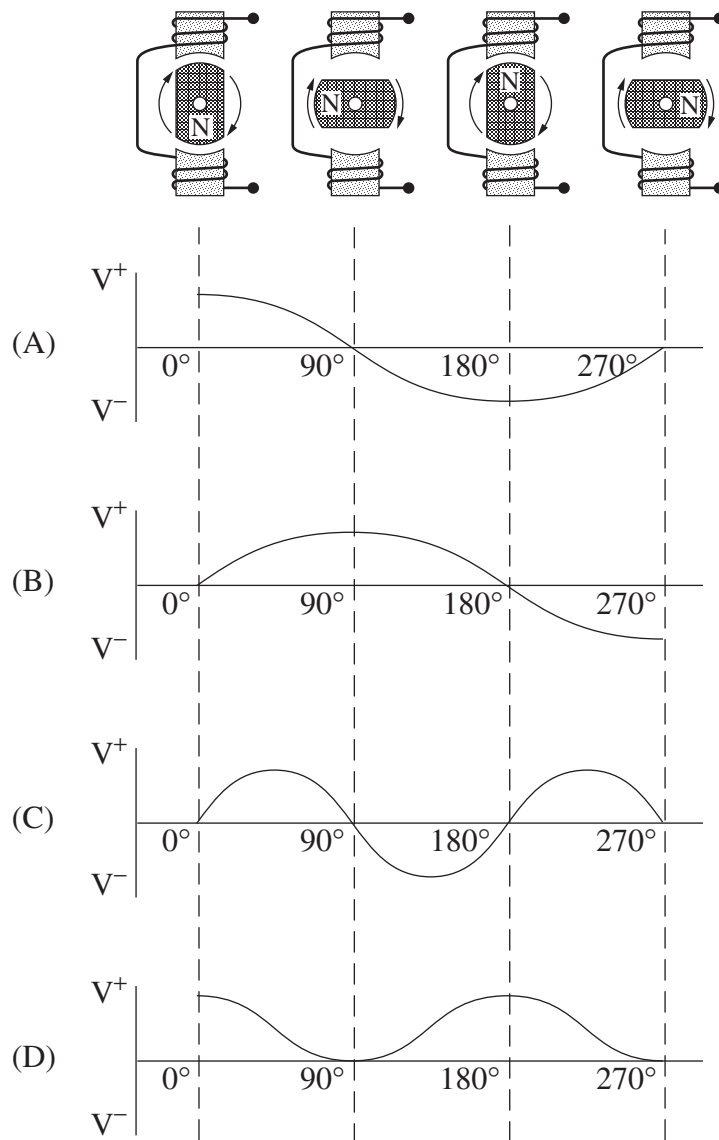
- 9 A $\text{Ø}8$ mm steel cable used in a lifting device has a maximum allowable stress of 800 MPa. A factor of safety of 2 was set by the manufacturer.

Which of the following would be the maximum allowable load for the steel cable?
(Assume $g = 10 \text{ m s}^{-2}$)

- (A) 1000 kg
- (B) 2000 kg
- (C) 10 000 kg
- (D) 20 000 kg

- 10 A magnet rotates in an alternating current generator, as shown.

Which graph best represents the voltage in the generator as the magnet rotates?



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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) An engineer is given a managerial role within a large telecommunications company. Outline TWO specific managerial tasks that would be performed in this role. **3**

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Question 11 continues on page 10

Question 11 (continued)

- (b) Select a telecommunications product that has changed significantly over time. Describe how changes in technology have allowed the ongoing development of this product. **3**

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- (c) A recent innovation in telecommunications is the control of electronic devices from a distance. Describe ONE example of this innovation, and discuss the effects that this innovation has had on both individuals and the wider community. **4**

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End of Question 11

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Section II (continued)

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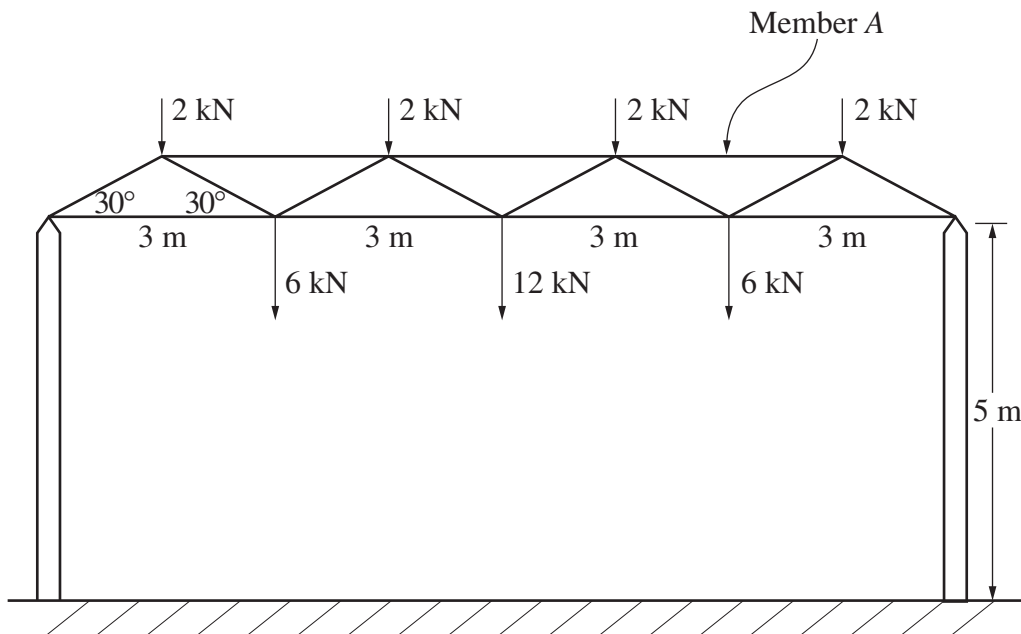
Student Number

Marks

Question 12 — Civil Structures (10 marks)

- (a) The truss shown is used to support overhead wires for an electric rail system. 3

Determine the magnitude and nature of the force in Member A.



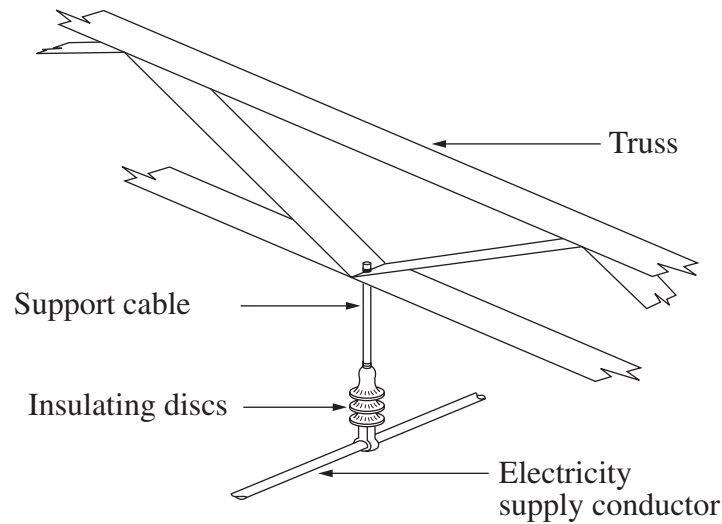
Magnitude of the force in Member A =

Nature of the force in Member A =

Question 12 continues on page 12

Question 12 (continued)

- (b) A $\text{Ø}10$ mm cable is attached to the truss to support the electricity supply conductor as shown. The material currently used for the support cable has a Young's modulus of 180 GPa and must withstand a maximum tensile force of 6 kN.



- (i) The support cable must not extend more than 0.5 mm when placed under the maximum tensile force. Calculate the maximum allowable length of the support cable. 3

(You may use $E = \frac{PL}{eA}$)

Maximum allowable length =

Question 12 continues on page 13

Question 12 (continued)

- (ii) The support cable is to be replaced. Identify an appropriate metal for the new cable and give TWO reasons to justify your choice. 2

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- (iii) Explain why a glazed ceramic material is preferred to either an unglazed ceramic or a polymeric material for the insulating discs. 2

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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) To improve access for people with restricted mobility, a hydraulic lifting device is used to lower and raise the front suspension of a stationary bus by 250 mm. The front of the bus exerts a load of 3 tonnes and the upward movement must be completed in 5 seconds. Calculate the power required by the hydraulic device for the upward movement. (Assume $g = 10 \text{ m s}^{-2}$) **2**

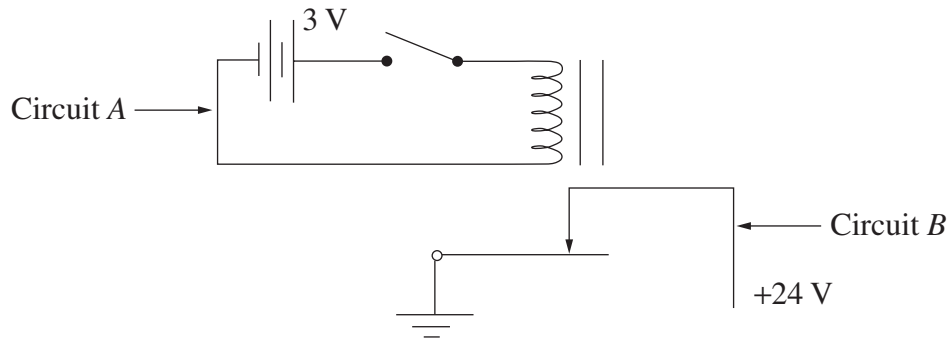
Power required =

Question 13 continues on page 16

Question 13 (continued)

(b) Explain the operation of circuit A to control circuit B.

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Question 13 continues on page 17

Question 13 (continued)

(c) Many people support the continued development of alternative transport solutions to overcome problems in cities.

(i) Discuss an environmental issue and a social issue associated with the ongoing development of electric transport. **3**

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(ii) Explain how technological developments may improve public transport in the future. **3**

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End of Question 13

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Section II (continued)

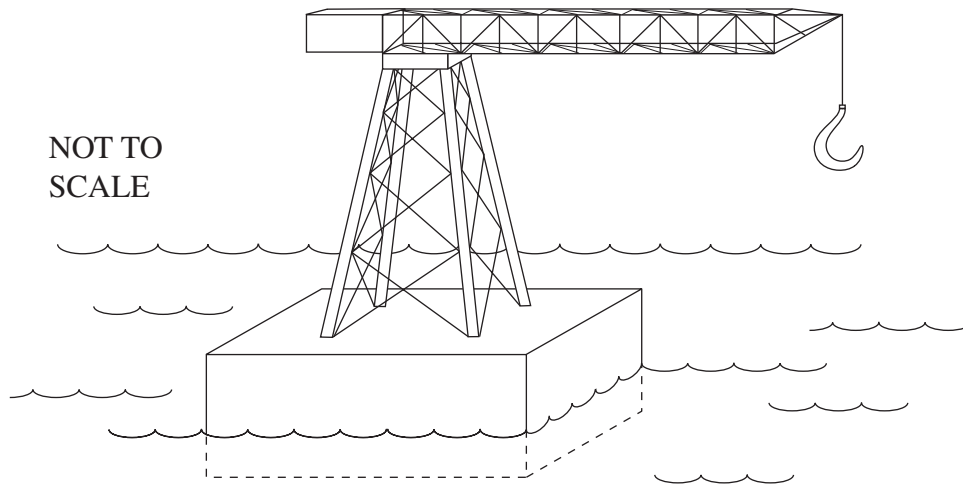
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Student Number

Marks

Question 14 — Lifting Devices (10 marks)

- (a) A crane mounted on a floating pontoon is used in lifting operations. The combined mass of the pontoon and crane is 10 tonnes. The pontoon is 8 m long, 5 m wide and 2 m high. 3
- 5 m wide and 2 m high.



Determine the load on the crane that would submerge 70% of the pontoon below the surface of the water. (Assume that the pontoon remains level.)

Mass of 1 m³ of water = 1 tonne.

Load =

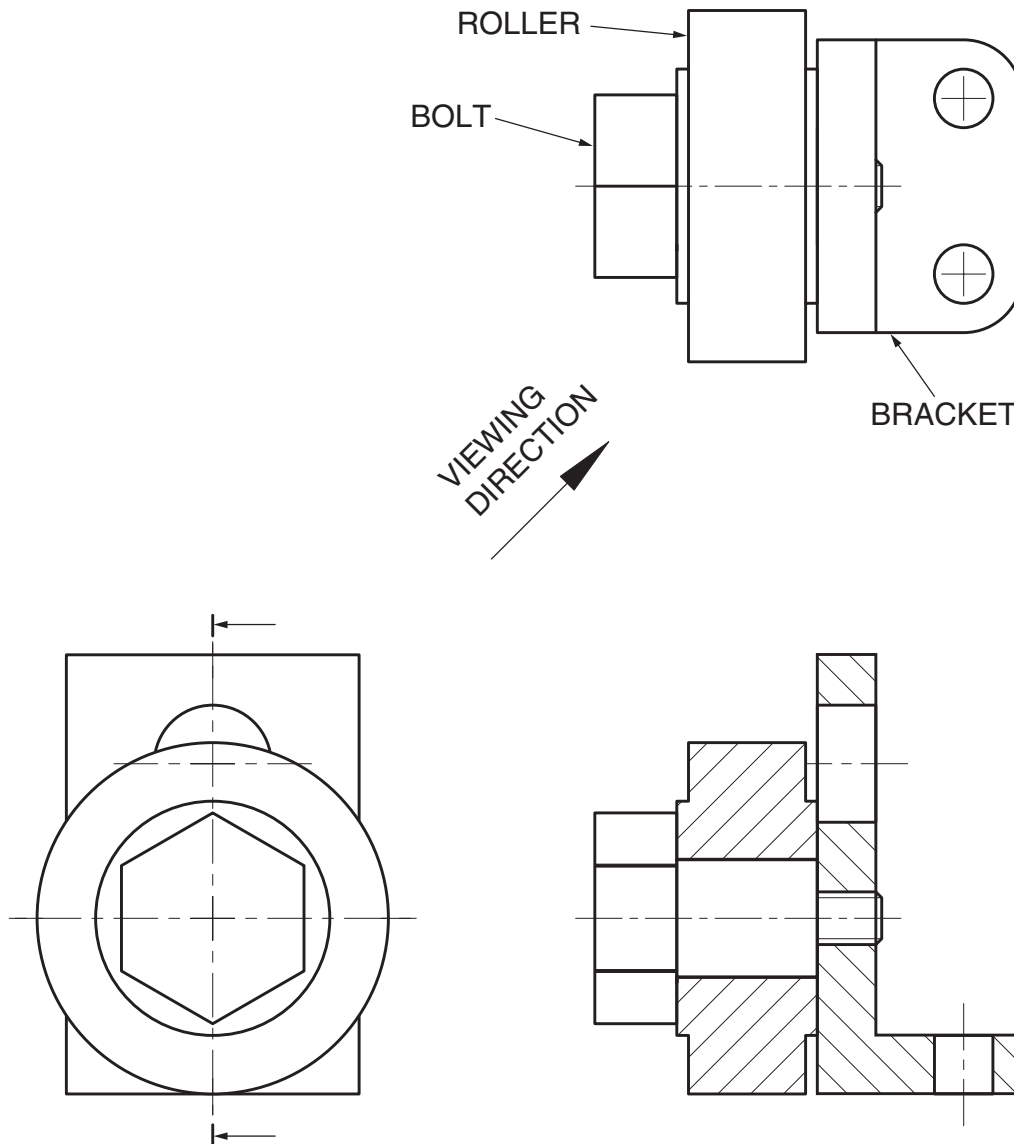
Question 14 continues on page 20

Question 14 (continued)

- (b) The orthogonal assembly drawing below shows the details of the sliding door mechanism of an elevator, drawn to a scale of 1 : 1.

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On page 21, sketch a full-size pictorial view of the bolt, assembled correctly into the bracket, when viewed in the direction of the arrow. Do NOT include the roller or any hidden detail in your sketch.



Question 14 continues on page 21

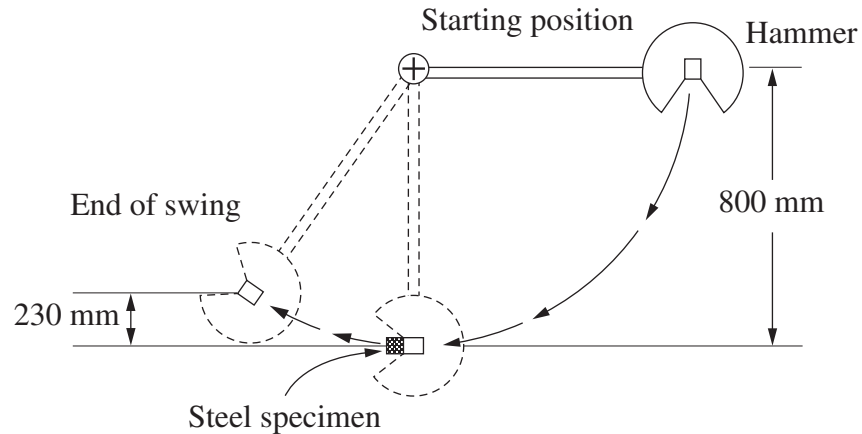
Question 14 (continued)

Question 14 continues on page 22

Question 14 (continued)

(c) The toughness of the steel used in a lifting device is to be evaluated by an impact test.

- (i) In the test, a hammer of mass 12 kg is released from a height of 800 mm. The hammer strikes and fractures the steel specimen at the bottom of the arc, and swings through to a height of 230 mm, as shown. 2



Assuming that there is no friction loss in the test machine, determine the energy lost by the hammer in fracturing the steel specimen.

Energy lost =

- (ii) Outline the effect of increasing carbon content on the structure and toughness of steel. 2

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End of Question 14

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Centre Number

Section II (continued)

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Student Number

Marks

Question 15 — Aeronautical Engineering (15 marks)

- (a) The frame of an aircraft is designed to be light and strong. Identify an appropriate alloy and describe the heat treatment process used to achieve these desired properties. **3**

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- (b) Describe the operation of turboprop and jet propulsion systems. Outline a relative advantage of each system. **4**

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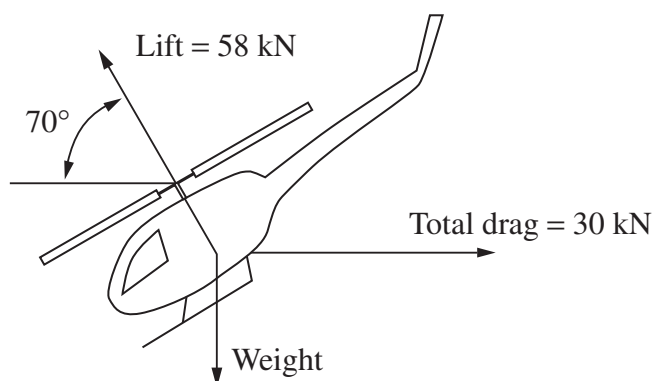
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Question 15 continues on page 24

Question 15 (continued)

(c) A helicopter of mass 5.4 tonnes experiences the forces shown below.

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Using a graphical solution, determine the magnitude and direction of the resultant force acting on the helicopter. All working must be shown. (Assume $g = 10 \text{ m s}^{-2}$)

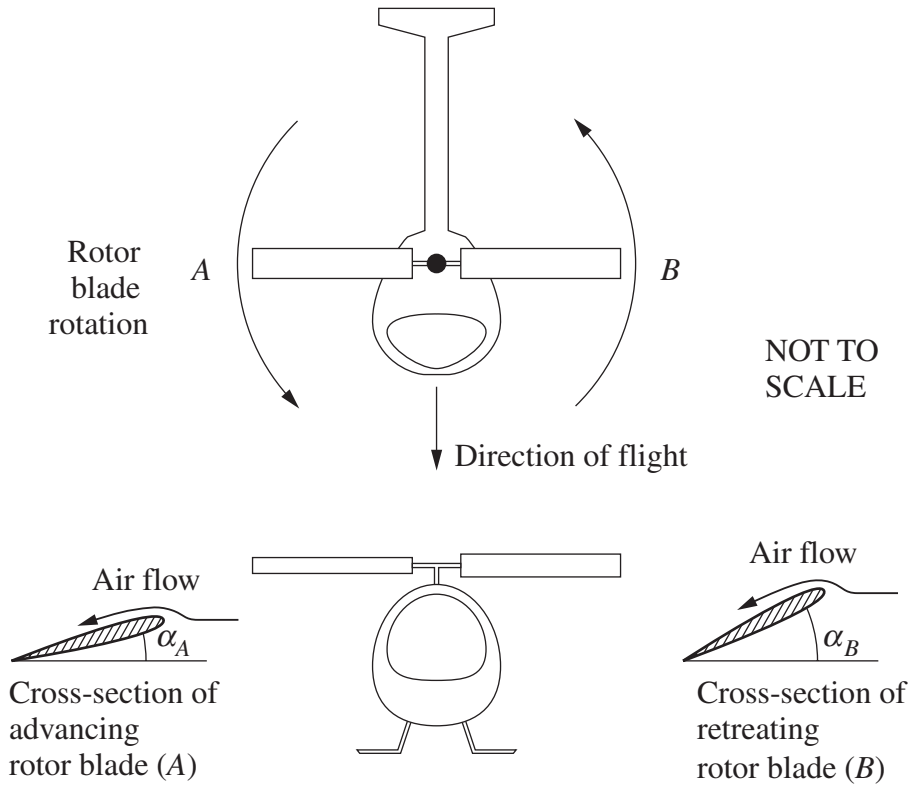
Magnitude of the resultant force =

Direction of the resultant force =

Question 15 continues on page 25

Question 15 (continued)

- (d) The principles of aerodynamics hold true for both fixed and rotary winged aircraft. Helicopters require a method to alter the relative angle of attack, α , of their rotor blades as they move through their rotation cycle. In forward level flight, $\alpha_A < \alpha_B$, as shown below. Without this method, helicopters would roll over to their retreating blade side, B .



Explain why the helicopter would roll if it was not able to alter the angle of attack of its rotor blades through their rotation cycle.

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End of Question 15

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Section II (continued)

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Student Number

Marks

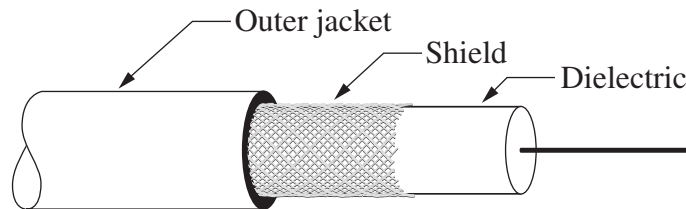
Question 16 — Telecommunication (15 marks)

(a) The type of cable used is important to the quality of data transmission.

(i) Explain why the twisting of the wires in unshielded twisted pairs (UTP) cable improves the performance. 2

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(ii) Three of the components of coaxial cable are indicated on the diagram. 3



Name a specific material for each component, and give a reason for its suitability.

Outer jacket: Material

Reason

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Shield: Material

Reason

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Dielectric: Material

Reason

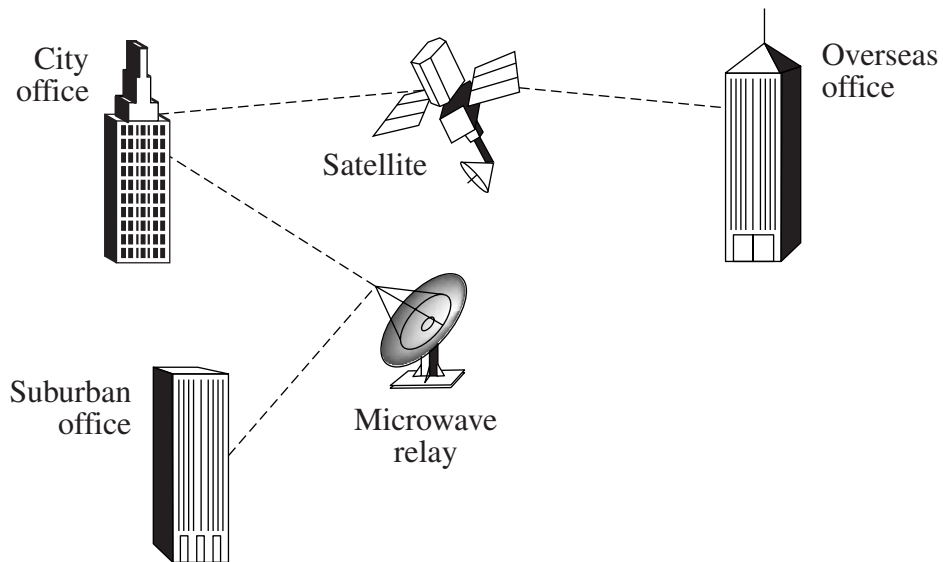
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Question 16 continues on page 28

Question 16 (continued)

- (b) Two methods of transmitting data without using long cables are microwave and satellite transmission, as shown. Discuss microwave and satellite transmission systems. Why are these two systems sometimes linked?

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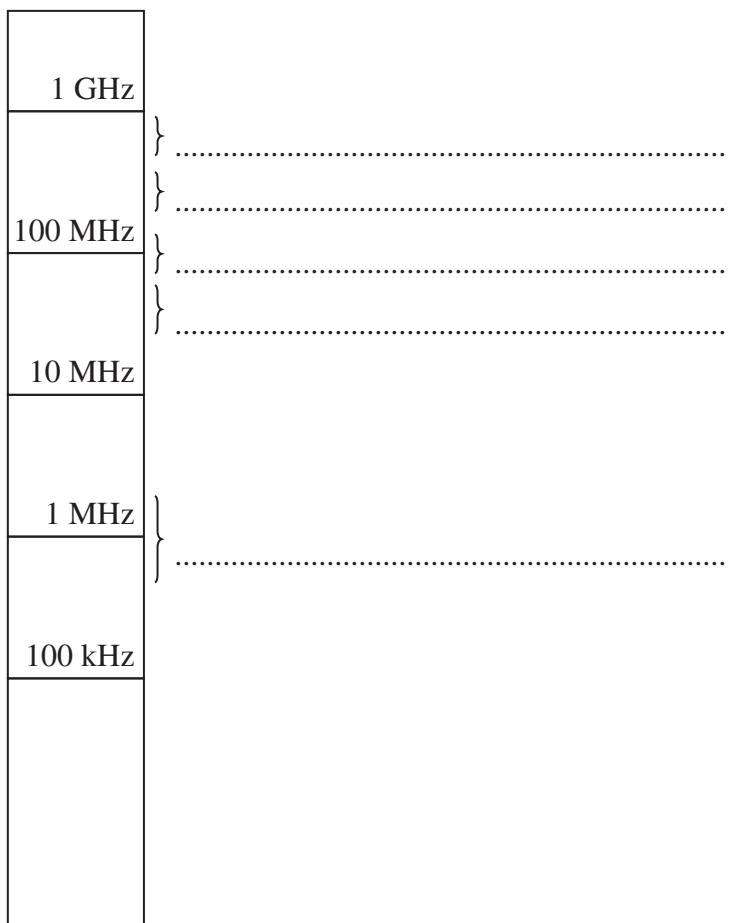
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Question 16 continues on page 29

Question 16 (continued)

(c) Along the electromagnetic spectrum diagram below, identify the approximate locations of the frequency bands for the following: 3

- AM transmissions
- FM transmissions
- TV (VHF) transmissions
- TV (UHF) transmissions
- Mobile (cell) phone transmissions.



Question 16 continues on page 30

Question 16 (continued)

- (d) Explain why amplitude modulated (AM) receivers are sensitive to static noise, while frequency modulated (FM) receivers are less sensitive. **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

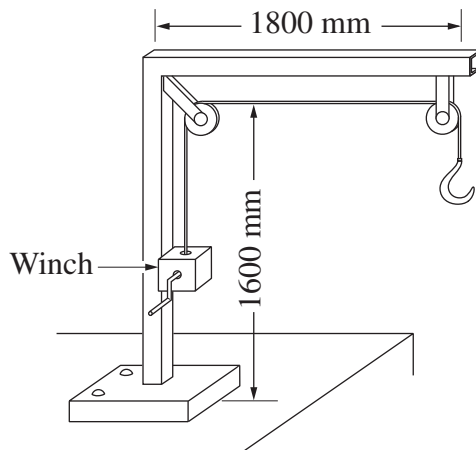
Allow about 40 minutes for this section

Answer the questions in the spaces provided.

Marks

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

A sailing club intends to purchase a simple mechanical hoist system, as shown, to assist disabled sailors into and out of their vessels from the wharf. The hoist system is to be assessed by an engineer for its suitability.



- (a) Discuss THREE considerations an engineer would report on when assessing the suitability of the hoist system.

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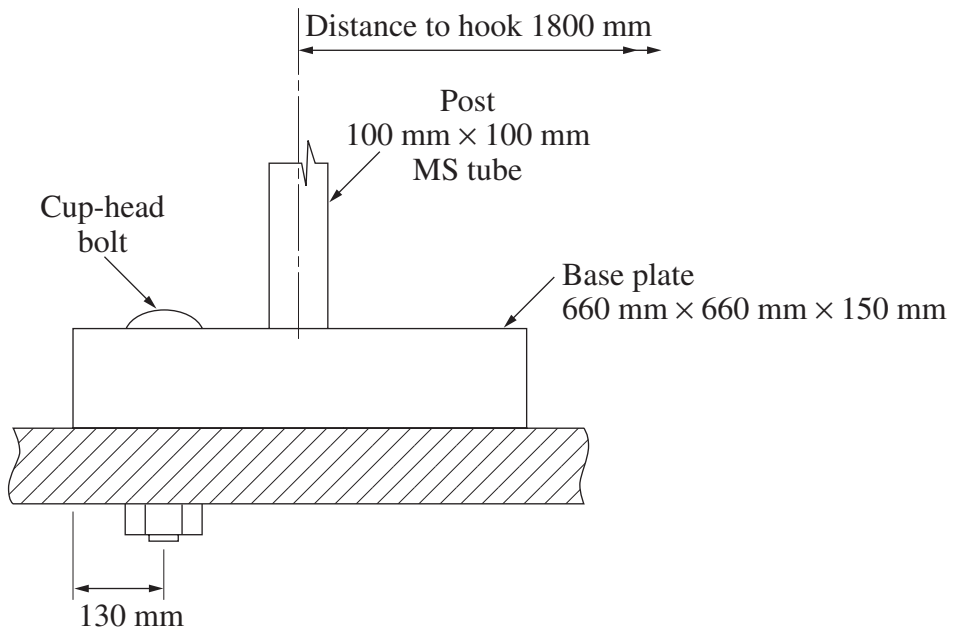
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Question 17 continues on page 32

Question 17 (continued)

(b)

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Determine the force in EACH of the TWO bolts if a 90 kg sailor is lifted with the hoist.

Force =

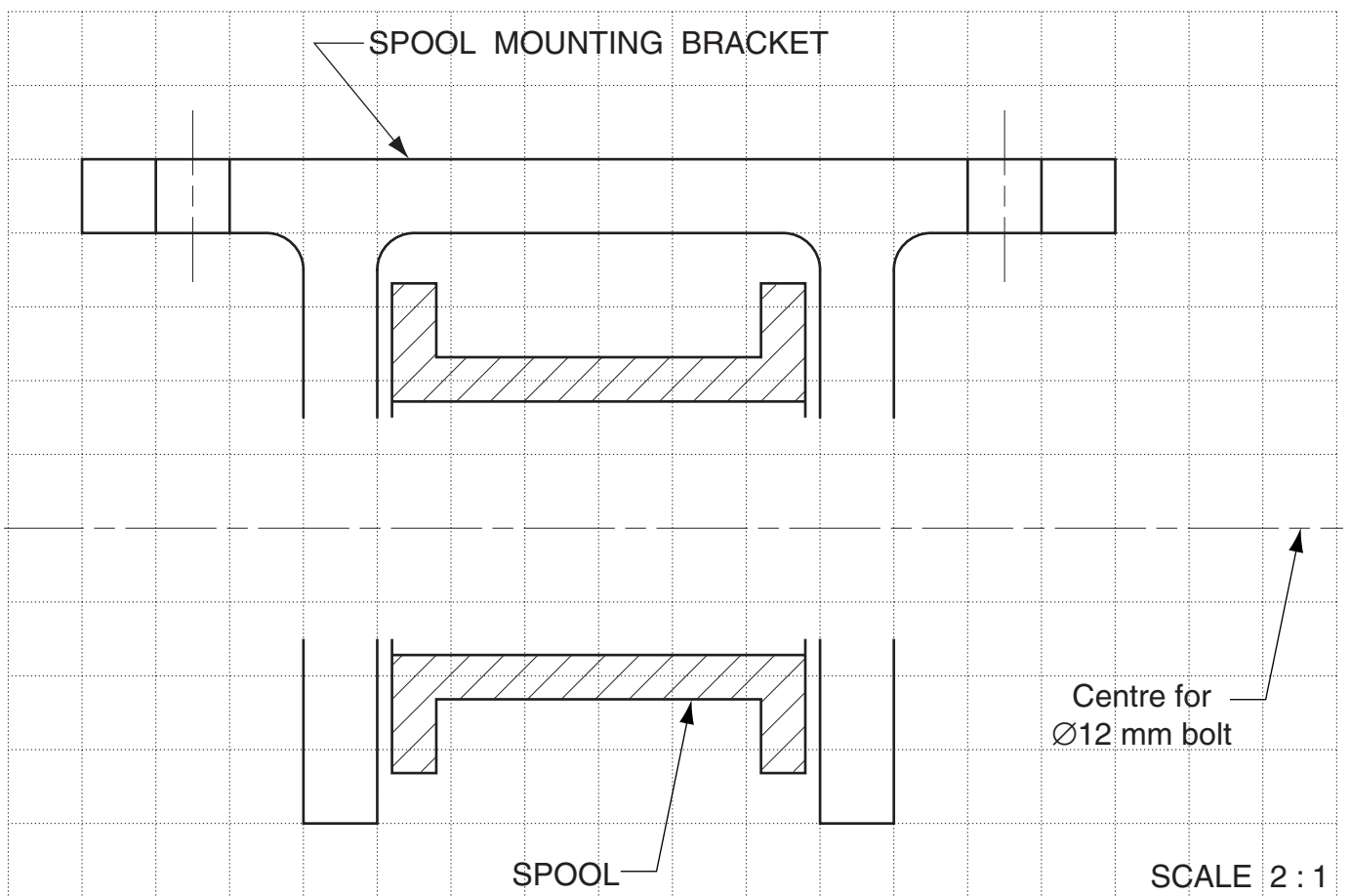
Question 17 continues on page 33

Question 17 (continued)

- (c) Inside the winch for the hoist is a spool mounting bracket. The spool is supported by a $\text{Ø}12$ mm hexagonal-head bolt inside a bush. The bush has an outside diameter of 17 mm and is 28 mm long. A partially completed orthogonal sketch of the top view of this assembly is shown, drawn to a scale of 2 : 1. 4

Complete the assembled orthogonal sketch on the grid below, in full section. Show the bush and an appropriate $\text{Ø}12$ mm bolt with a hexagonal nut and flat washer. Dimension the bolt.

Apply AS1100 drawing standards where appropriate.



End of Question 17

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Centre Number

Section III (continued)

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Student Number

Marks

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

An engineer is required to report on the suitability of alternative materials to make poles for power distribution.

- (a) Steel, hardwoods and reinforced concrete are the materials to be investigated. **3**
Evaluate the suitability of each material for use as a power pole.

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Question 18 continues on page 36

Question 18 (continued)

- (b) Spalling or ‘concrete cancer’ can be a problem with reinforced concrete products. Explain this problem, and identify methods that can be used to prevent spalling. 3

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- (c) Faulty power poles are to be removed and recycled. Identify the advantages of recycling power poles. Discuss methods for recycling untreated hardwoods and reinforced concrete. Identify uses for the recycled by-products. 4

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End of paper

FORMULAE SHEET

Dynamics

$$F = ma$$

$$KE = \frac{1}{2}mv^2$$

$$PE = mgh$$

$$SE = \frac{1}{2}kx^2$$

$$F = kx$$

$$P = \frac{W}{t}$$

$$W = Fs$$

$$\text{Pressure} = \frac{F}{A}$$

Statics

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

$$M = Fd; \quad F = \mu N$$

Machines

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

Strength of materials

$$\sigma = \frac{P}{A}; \quad E = \frac{\sigma}{\varepsilon}; \quad \%RA = \frac{A_0 - A}{A_0} \times 100; \quad FS = \frac{\sigma_{\text{yield}}}{\sigma_{\text{working}}}; \quad I = \frac{bd^3}{12}; \quad \sigma = \frac{My}{I}$$

Area of a circle

$$A = \frac{\pi}{4}d^2$$

Circumference of a circle

$$C = \pi d$$

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