BOARD OF STUDIES
NEW SOUTH WALES

2011

HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- 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 2–5

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 31–37

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 for Questions 1–10.

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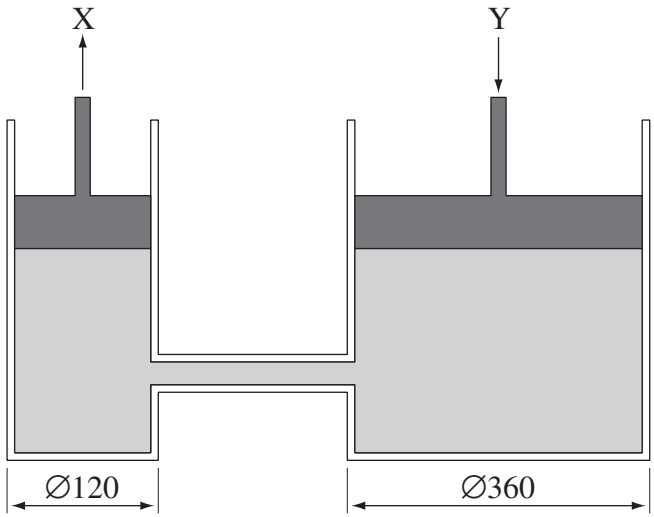
1 A sectional diagram of a hydraulic system is shown.



NOT TO SCALE

If ram Y moves one millimetre how many millimetres will ram X move?

(A) 0.3 mm

(B) 0.9 mm

(C) 3 mm

(D) 9 mm

2 A piece of cold-rolled brass is placed in salt water.

Corrosion of the brass would be due to

(A) electrolytic reaction.

(B) stress corrosion cracking.

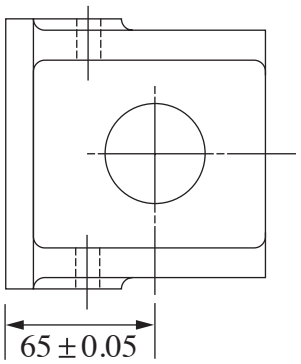
(C) sacrificial cathode formation.

(D) exposure of internal impurities.

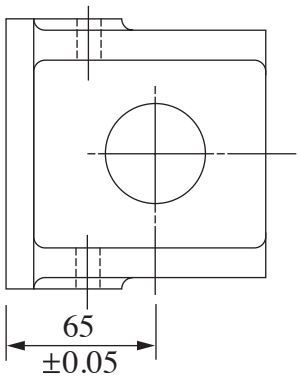
3 A drawing is to be dimensioned to show the 65 mm distance of the hole from the left face. The tolerance on the dimension is ± 0.05 mm.

Which drawing represents the correct method of showing the dimension to AS 1100?

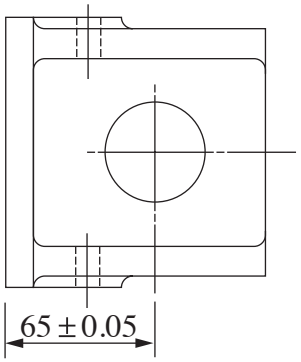
(A)



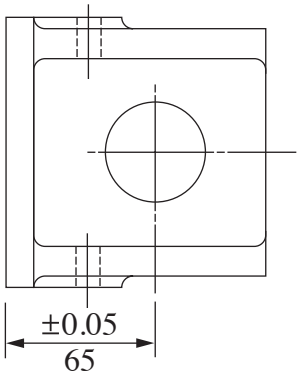
(B)



(C)



(D)



4 Why would a small hole be drilled at the end of a crack in a piece of stressed steel plate?

(A) To weaken the steel

(B) To make the crack oversize

(C) To reduce the length of the crack

(D) To prevent the crack from propagating

5 A bicycle and rider moving at 26 km/h have a kinetic energy of 1.5 kJ.

What is the approximate combined mass of the bicycle and rider?

(A) 28.8 kg

(B) 44.3 kg

(C) 57.5 kg

(D) 115.4 kg

6 The torque of a DC motor is proportional to the rotor circuit

(A) current.

(B) polarity.

(C) frequency.

(D) capacitance.

7 A metal has been sectioned and etched to show its grain structure.

Which manufacturing process would produce this grain structure?

(A) Casting

(B) Forging

(C) Extrusion

(D) Powder forming

8 The magnitude of back emf in a DC motor will

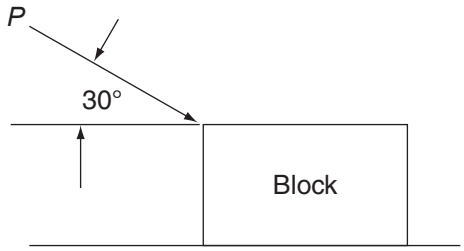
(A) increase with a change in polarity.

(B) increase with an increase in rotor speed.

(C) decrease with an increase in rotor speed.

(D) remain constant with a change in rotor speed.

9 A block of mass 19 kg rests on a surface with a coefficient of friction of 0.3.



What is the magnitude of the force, *P*, when the block is on the point of sliding?

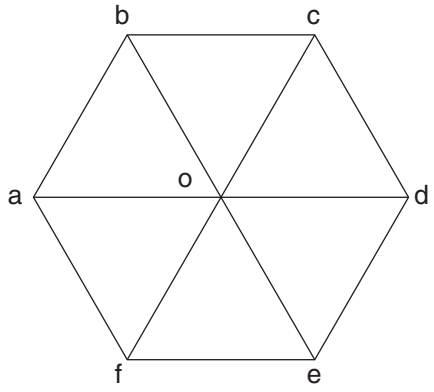
(A) 57 N

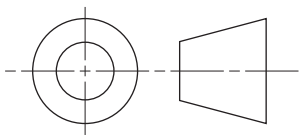
(B) 65.8 N

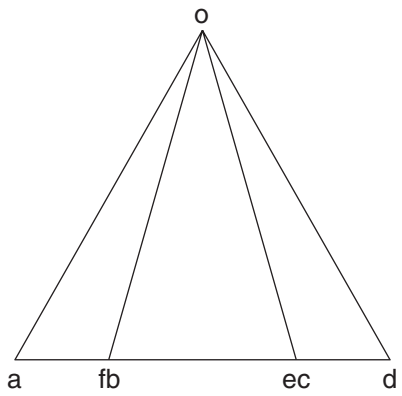
(C) 79.6 N

(D) 190 N

10 How many VISIBLE true lengths appear in the front view of the hexagonal pyramid?







(A) 1

(B) 2

(C) 3

(D) 6

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2011 HIGHER SCHOOL CERTIFICATE EXAMINATION

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. These spaces provide guidance for the expected length of response.

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

Images of a historic penny farthing bicycle and a modern bicycle are shown.

Penny farthing

Modern bicycle

(a) (i) Identify innovations in engineering materials used in the modern bicycle that would not have been available for the penny farthing. **1**

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(ii) What developments in mechanical systems have improved bicycle efficiency? **2**

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Question 11 continues on page 10

Question 11 (continued)

(iii) Name a field of engineering and outline how developments in this field have contributed to the manufacture of the modern bicycle. **2**

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(b) Discuss the use of bicycles as a transport system to address environmental issues. **3**

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(c) For an engineering project that you have studied, outline ONE ethical issue that could affect the project's viability. **2**

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End of Question 11

Question 12 — Civil Structures (10 marks)

(a) Prefabricated concrete is commonly used for walls in industrial and commercial buildings, such as the one shown.

(i) Identify an advantage, other than cost, of prefabricating concrete walls off-site. **1**

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(ii) Name and describe a quality control test used to determine the strength of a concrete sample. **2**

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Question 12 continues on page 12

(b) Explain how the process of toughening glass makes this material suitable for use as cladding for multistorey buildings. **2**

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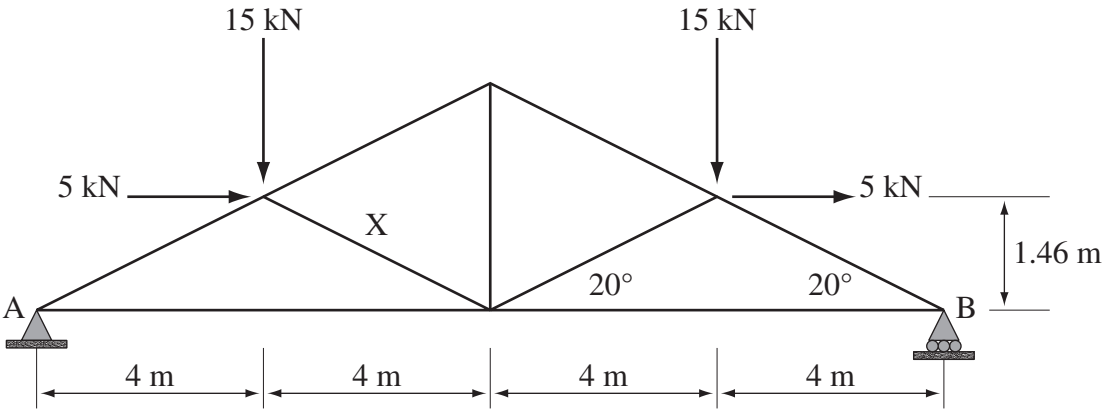
Question 12 continues on page 13

Question 12 (continued)

(c) A symmetrical pin-jointed roof truss for a warehouse is shown.

The wind load exerts a high pressure on the left side and a low pressure on the right side.



(i) Calculate the magnitude and direction of the reaction at A. **3**

Reaction at A .....kN Direction .....

(ii) Calculate the magnitude of the force in member X, and state whether it is in tension or compression. **2**

Force in member X ..... kN

Tension or compression: .....

End of Question 12

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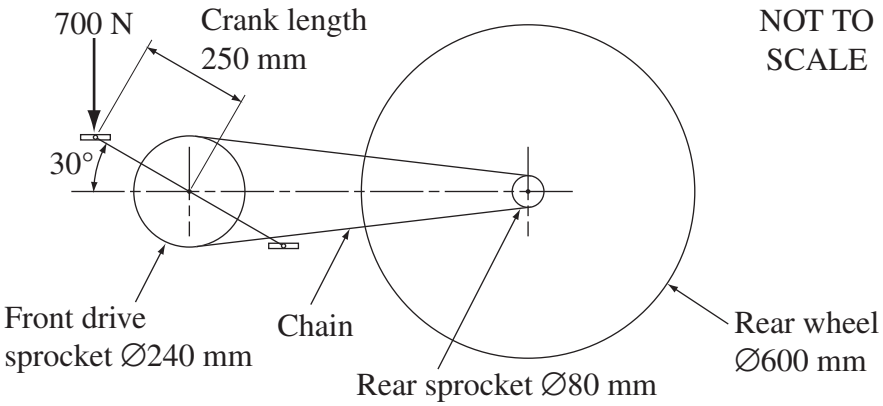
Question 13 — Personal and Public Transport (10 marks)

(a) The drive mechanism of a bicycle is shown.



At a given instant, the pedals are at an angle of 30° to the horizontal, with a vertical force of 700 N applied, as shown. Assume 100% efficiency.

(i) Calculate the force applied to the chain. **2**

Force.....N

(ii) Calculate the velocity ratio of the drive mechanism from the pedal to the rear wheel. **2**

Velocity ratio.....

Question 13 continues on page 16

(b) Identify and describe a manufacturing process that could be used to construct aluminium alloy pedal cranks such as those shown. **2**

Reproduced with kind permission of Daniel Kastner.
http://www.1977mopeds.com/product/805/Pedal-Cran-Arms

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(c) Recommend a type of electric motor for an electrically assisted bicycle. **2**

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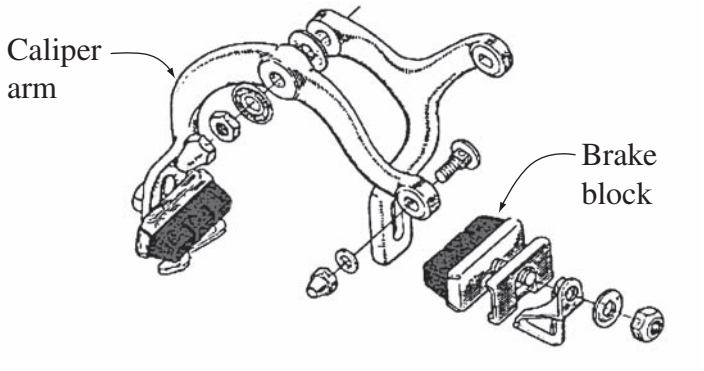
Question 13 continues on page 17

Question 13 (continued)

(d) The drawing shows parts of a bicycle brake caliper. The brake block is composed of vulcanised rubber, glass fibre and carbon black. **2**



Explain the process of vulcanisation and how this enhances the mechanical properties of the brake block.

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End of Question 13

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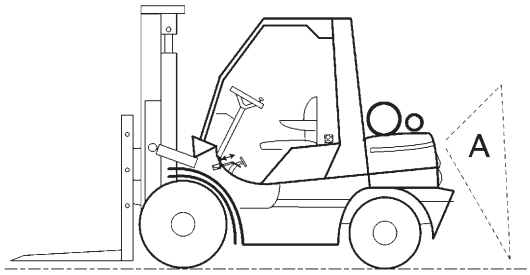
Question 14 — Lifting Devices (10 marks)

(a) The forklift shown has two safety sensors (sensor 1 and sensor 2) to detect objects in zone A when reversing. **2**

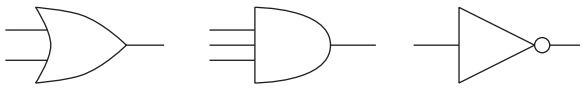


Using all three logic gates shown, design the logic controls to ensure that the brake is applied when the forklift is in reverse gear, and either sensor 1 or sensor 2 is activated, and the engine is running.

Inputs	
Reverse gear selected	0
Sensor 1 activated	1
Sensor 2 activated	1
Engine running	1

Output	
Brake applied	1

Logic Gates

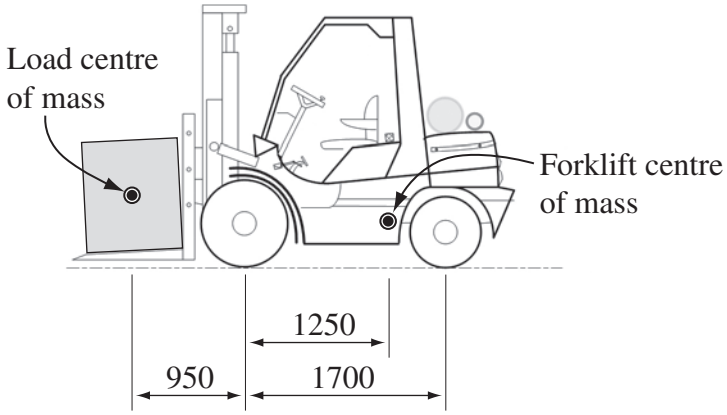


OR Gate AND Gate NOT Gate

Question 14 continues on page 20

Question 14 (continued)

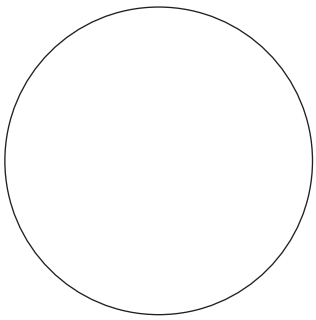
(b) The mass of the forklift is 900 kg. Calculate the maximum load that can be lifted by the forklift without it tipping forward, using a factor of safety of 1.3. **2**



Load = ... kg

(c) (i) The forks of a forklift are made from a normalised 0.4% carbon steel. **2**

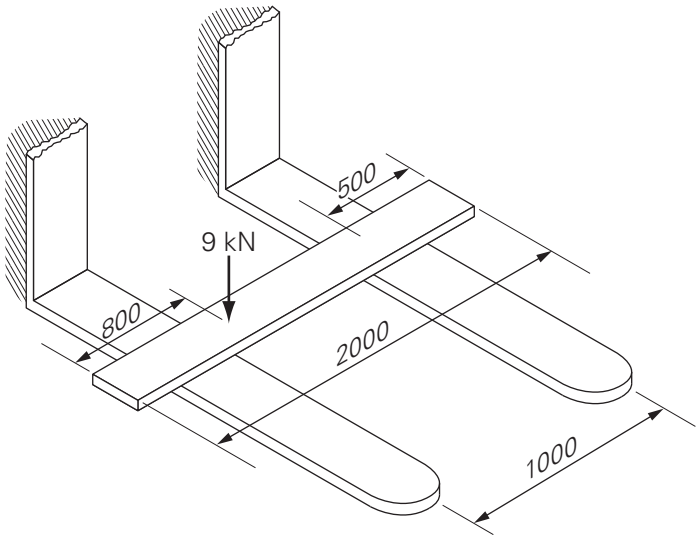
In the circle provided, sketch and label a representative microstructure for this steel.



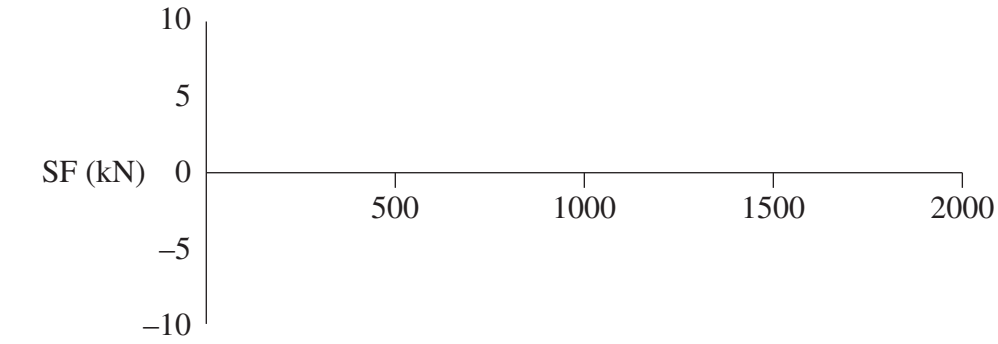
Question 14 continues on page 21

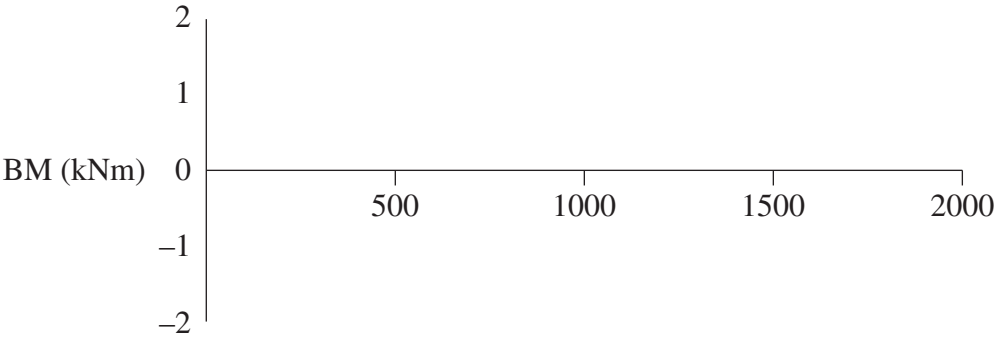
Question 14 (continued)

(ii) The forklift is required to lift a 9 kN load acting on a 2 metre beam as shown. **3**



On the axes provided, sketch the shear force and bending moment diagrams for the loaded beam.





Question 14 continues on page 22

(d) A self-lubricating bearing is mass-produced by powder metallurgy. **1**

What makes this process suitable for this product?

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End of Question 14

Engineering Studies

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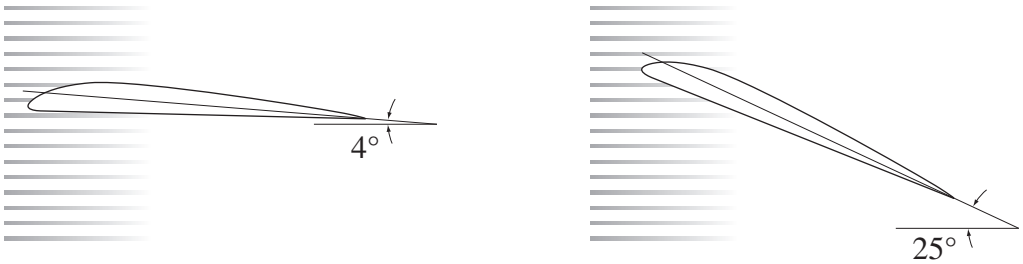
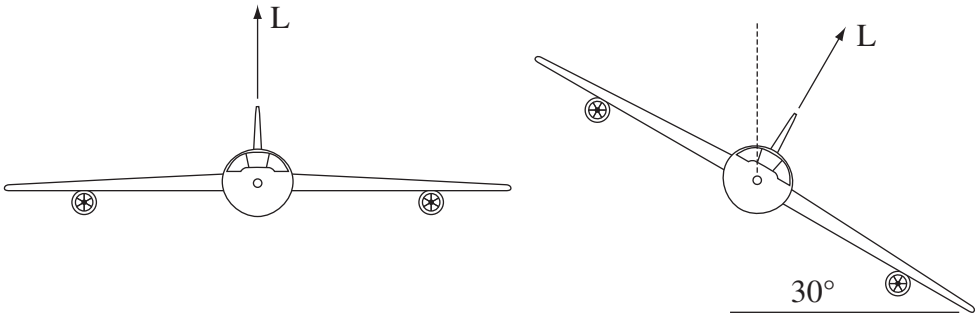
Section II (continued)

Question 15 — Aeronautical Engineering (15 marks)

(a) (i) Two aerofoils in an airstream are shown. Complete the diagrams by indicating typical airflows over each aerofoil. **1**



(ii) The diagrams show a small aircraft in level flight, and banking at an angle of 30°. **2**



Explain why the banking aircraft will lose altitude if the lift vector (L) is the same in each case.

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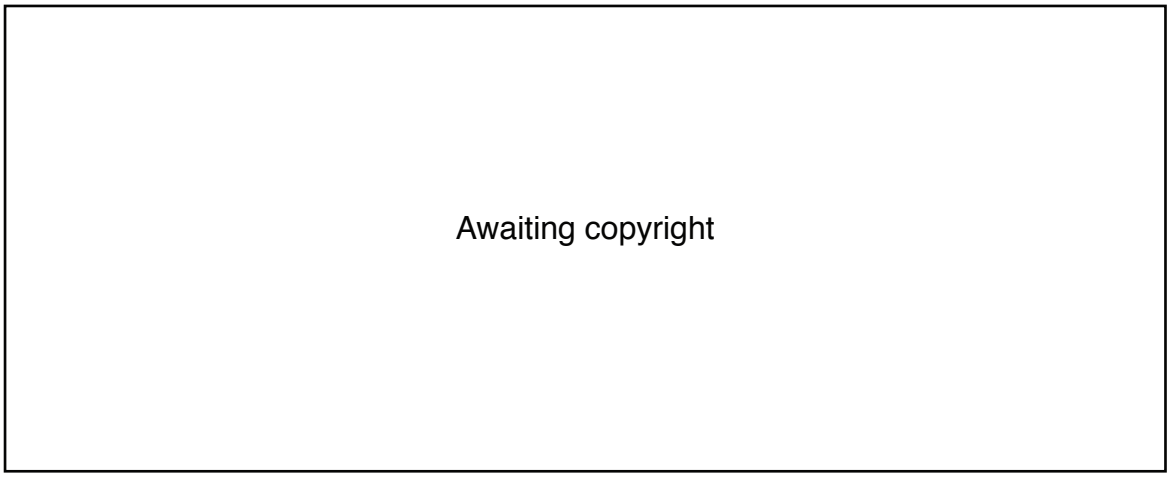
Question 15 continues on page 24

Question 15 (continued)

(b) The front view and the mechanism of an aircraft altitude indicator are shown. **2**



Outline how this instrument operates.

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(c) (i) Laminate materials are used in aircraft construction. **2**

Sketch and label the macrostructure of an aircraft laminate material.

Question 15 continues on page 25

Question 15 (continued)

(ii) Describe TWO properties of laminate materials that are enhanced through the laminating process. **2**

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(d) A steel shaft from an aircraft engine has failed through fatigue. **2**

Its macrostructure is shown.

Describe a non-destructive test that could have identified this problem before failure.

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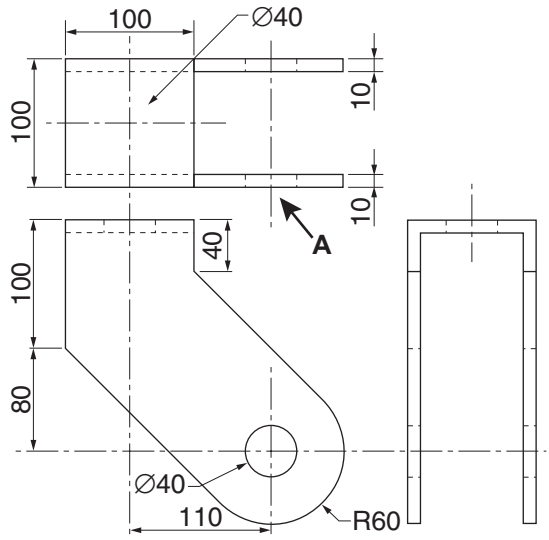
Question 15 continues on page 26

Question 15 (continued)

(e) The top, front and end views of an aircraft mounting bracket are shown. **4**



Sketch a freehand pictorial drawing of this bracket, at a scale of 1:2, when viewed in the direction of arrow **A**.

End of Question 15

Centre Number

Student Number

Section II (continued)

Question 16 — Telecommunication (15 marks)

(a) Compare TWO types of orbit in which satellites can be positioned around Earth. **2**

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(b) Outline TWO forms of multiplexing used in modern telecommunications systems. **2**

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Question 16 continues on page 28

Question 16 (continued)

(c) The bakelite case for the radio shown was produced by hot compression moulding. **2**

Discuss the suitability of this material for this application.

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Question 16 continues on page 29

Question 16 (continued)

(d) (i) Describe an advantage of frequency modulation (FM) over amplitude modulation (AM) for radio transmission. **2**

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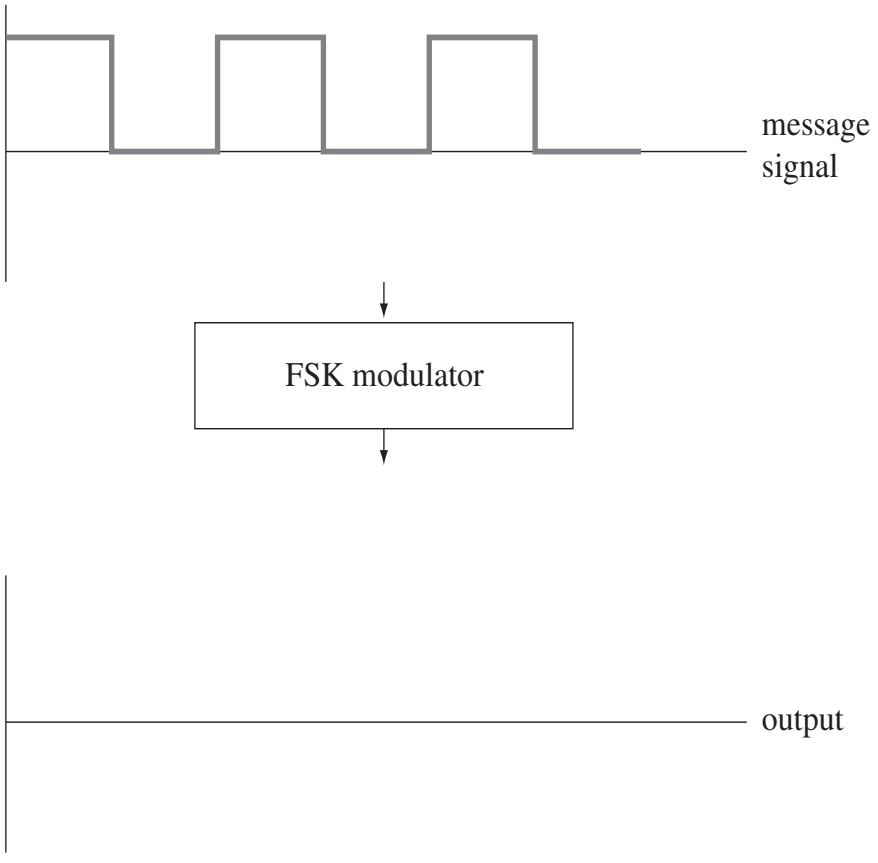
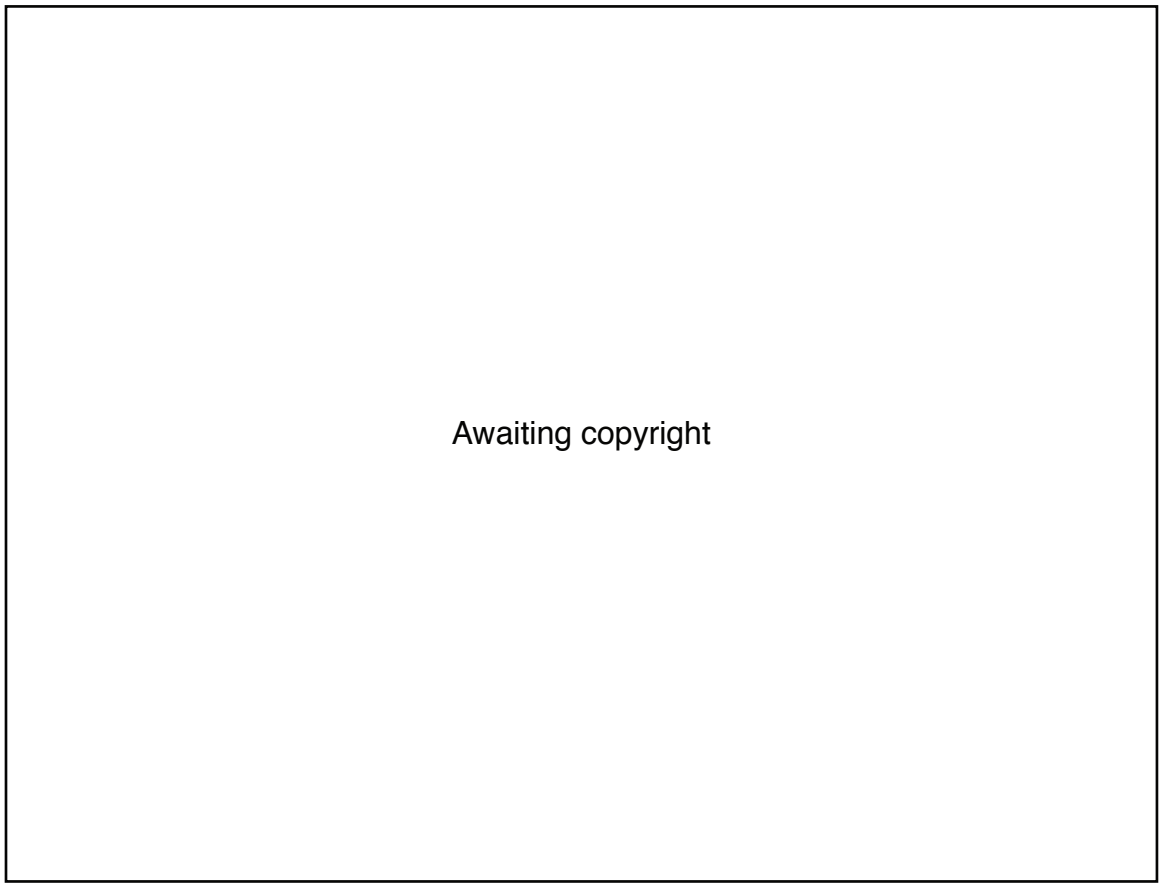
(ii) A frequency shift key (FSK) is a frequency modulation scheme used to modulate a carrier with digital information. For the message signal shown, sketch the output of a frequency shift key (FSK) modulator. **2**



Question 16 continues on page 30

Question 16 (continued)

(e) The exploded isometric drawing shows parts of an antenna mount. **5**



Using a scale of 2:1, sketch a half sectional front view of the assembled mount when viewed in the direction of the arrow. Do not show hidden detail.

End of Question 16

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Section III

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

Answer the questions in the spaces provided.

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

Please turn over

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

(a) (i) Why is it important that engineering reports are referenced? **1**

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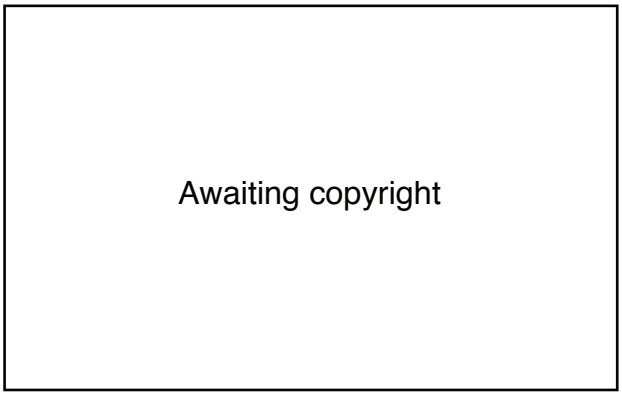
(ii) A consulting engineer is asked to determine whether a replacement design for a fleet of shopping trolleys is viable. The replacement design is shown. **2**



List criteria that would need to be considered in a report on this replacement design.

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(iii) Describe and justify one test that could be conducted to evaluate the trolley against one of the criteria identified in part (a) (ii). **3**

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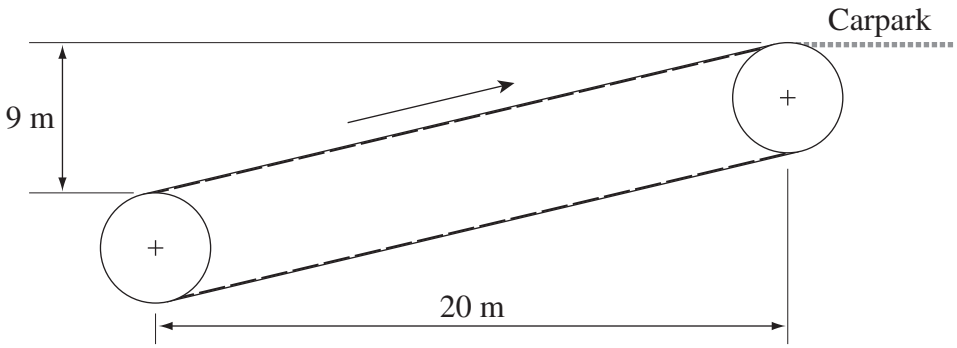
Question 17 continues on page 33

Question 17 (continued)

(b) (i) A shopping centre uses a conveyor system to transport shoppers to its carpark. **2**



A shopper and a trolley have a combined mass of 115 kg on the conveyor. How much power is required to deliver the shopper and trolley to the carpark in 25 seconds?

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(ii) At another installation the conveyor motor operates at 240 volts DC, draws 3 amps and produces 620 watts output. **2**

Using the formula P = VI, determine the percentage power loss of the electric motor.

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End of Question 17

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Centre Number

Section III (continued)

Student Number

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

(a) Outline ONE advantage and ONE disadvantage to society of increased access to telecommunications. **2**

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(b) (i) Describe the advantages of using optical fibre rather than copper wire for telecommunications. **2**

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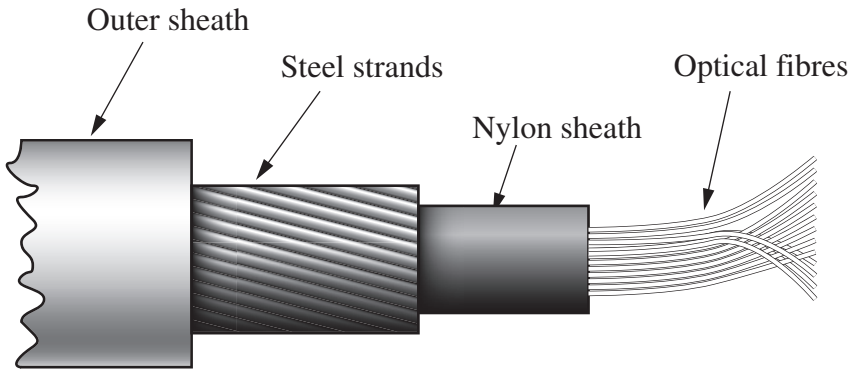
Question 18 continues on page 36

(ii) The sketch of a submarine fibre optic cable shows several components. **2**



Outline the purpose of the following components.

Steel strands: .....

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Outer sheath: .....

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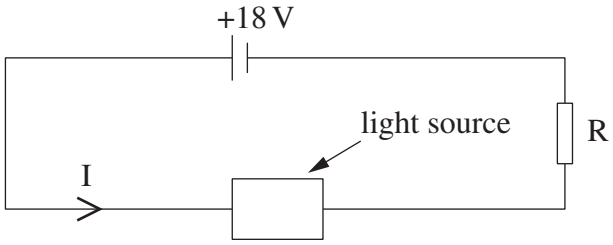
(iii) An engineer performs a test on a light source for an optical fibre cable. A simplified circuit for the test is shown. **2**



For a resistance R = 800 Ω, determine the current I in the circuit using Ohm's law (V = IR), if the voltage across the light source is 2 V.

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Question 18 continues on page 37

Question 18 (continued)

(c) A copper wire is 8 metres in length and has a cross-sectional area of 0.5 mm^2. Given that Young's modulus for copper is 111 GPa, calculate the extension in the wire if it experiences a tensile force of 300 N. **2**

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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

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

Pressure

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

Stress and Strain

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

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

Machines

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

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