BOARD OF STUDIES
NEW SOUTH WALES

2012

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, 17, 21, 25, 29 and 33

Total marks – 100

Section I Pages 2–7

10 marks

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

Section II Pages 9–28

70 marks

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

Section III Pages 29–35

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 material resists abrasion, surface penetration and scratching.

What property does this material demonstrate?

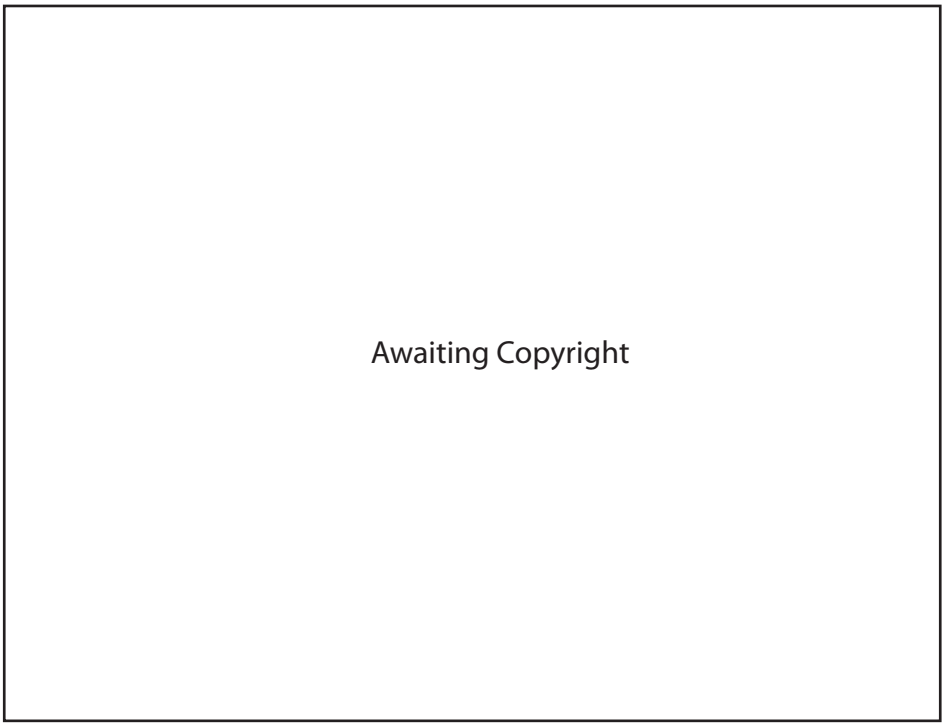
(A) Hardness

(B) Malleability

(C) Strength

(D) Toughness

2 A stress-strain graph for four materials is shown.



Which line on the graph best represents a tough and ductile material?

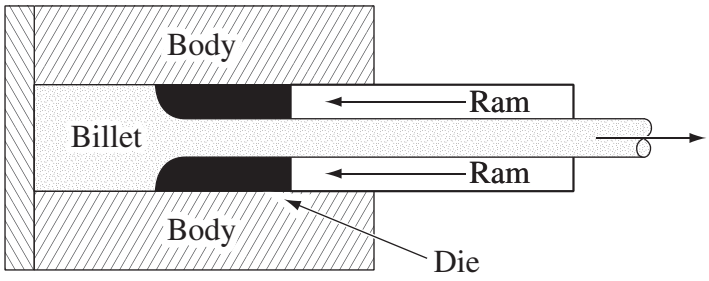
(A) A

(B) B

(C) C

(D) D

3 A working process is shown.



What is this process?

(A) Wire drawing

(B) Direct extrusion

(C) Indirect extrusion

(D) Injection moulding

4 Which of the following would be the most suitable sacrificial anode for a steel structure?

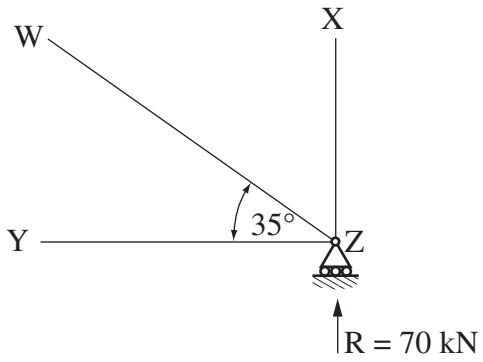
(A) Copper

(B) Graphite

(C) Tin

(D) Zinc

5 When analysing roller joint Z, the reaction at Z is 70 kN vertically upwards and the force in member YZ is 15 kN in tension.



What is the force in member XZ?

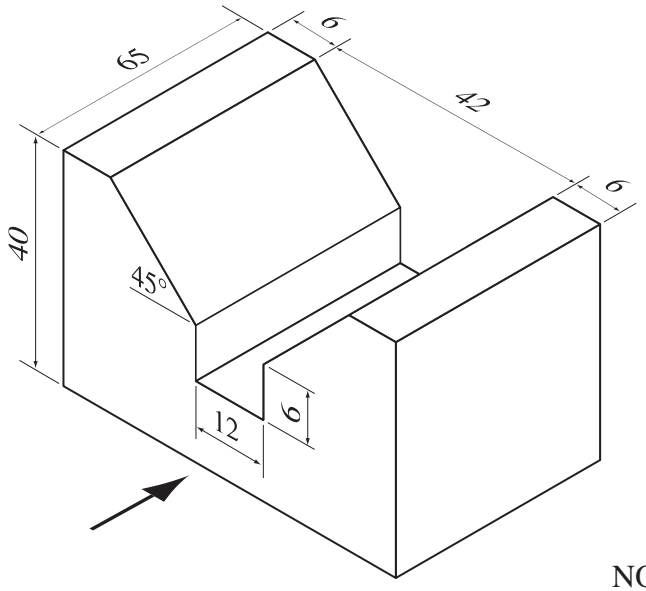
(A) 59.5 kN

(B) 70.0 kN

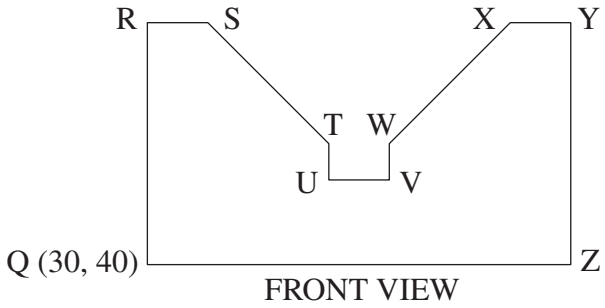
(C) 80.5 kN

(D) 85.0 kN

6 The shape and dimensions of a vee block are shown in the pictorial drawing.



NOT TO SCALE



FRONT VIEW

The coordinates table has been started with the points Q, R and S given.

Drawing point	*Absolute coordinate*	*Relative coordinate*
Q	30, 40	@ 0, 0
R	30, 80	@ 0, 40
S	36, 80	@ 6, 0
T		

What are the absolute and relative coordinates of point T that would be used in a CAD drawing?

(A) 51, 65 @ 15, 15

(B) 51, 65 @ 15, –15

(C) 61, 65 @ 21, –15

(D) 61, 65 @ 31, 25

7 A pipe is suspended by two ropes as shown. Each rope is attached to the pipe and to a central hook.

If both of the support ropes are made shorter and attached at the same points on the pipe, the tension in each rope will

(A) increase.

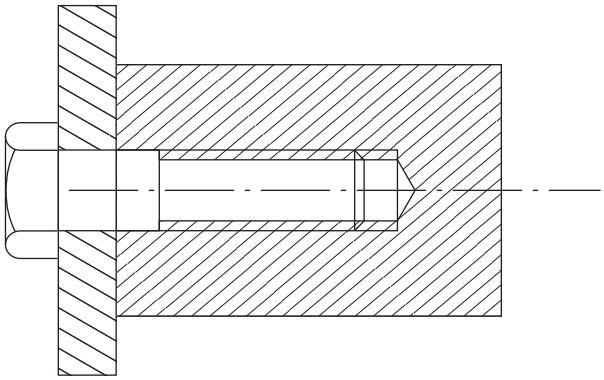
(B) decrease.

(C) equal the weight of the pipe.

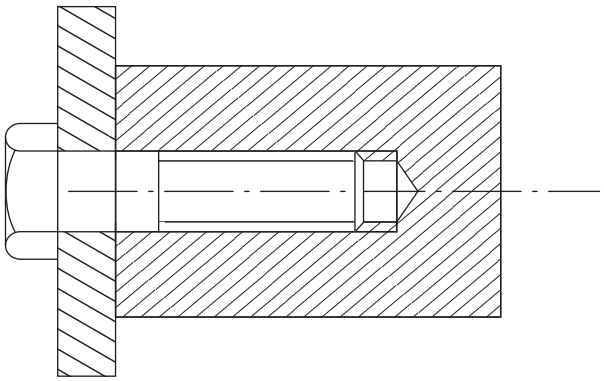
(D) equal half the weight of the pipe.

8 Which of the following drawings shows a bolt in a threaded blind hole drawn to AS 1100 standard?

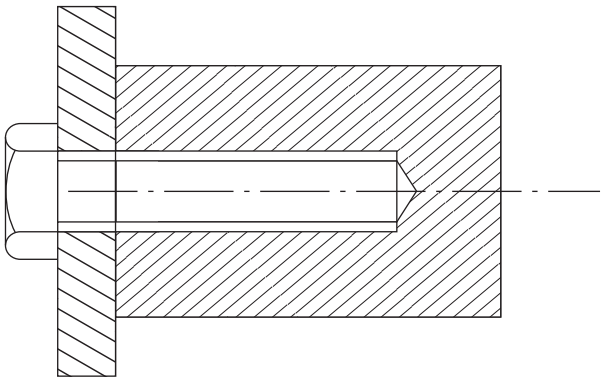
(A)



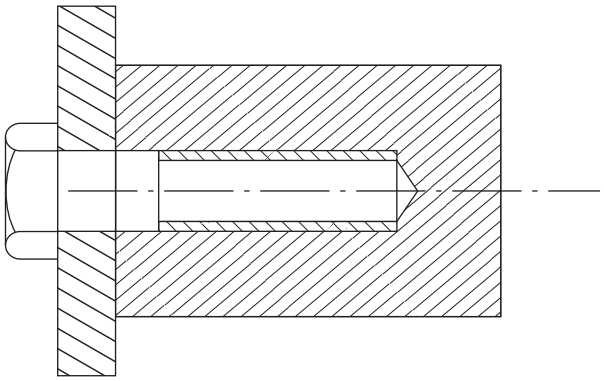
(B)



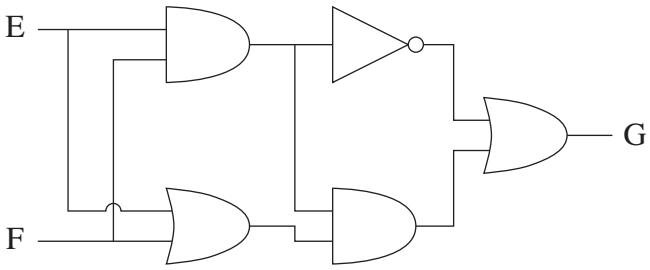
(C)



(D)



9 A logic diagram is shown.



Which truth table best represents the logic diagram?

(A)

E	F	G
0	0	0
1	1	0

(B)

E	F	G
0	0	0
1	1	1

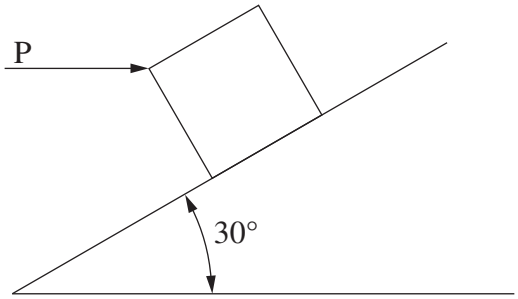
(C)

E	F	G
0	0	1
1	1	0

(D)

E	F	G
0	0	1
1	1	1

10 A 40 kg block is prevented from sliding down a slope by a horizontal force P, as shown. The coefficient of friction between the block and the slope is 0.2.



What is the minimum horizontal force necessary to just start the block moving UP the slope?

(A) 69.3 N

(B) 130.7 N

(C) 269.3 N

(D) 351.4 N

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2012 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)

The images show an early aircraft and a modern aircraft.

(a) How were turning and banking achieved in the early aircraft shown, given that they had no ailerons? **2**

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Question 11 continues on page 10

Question 11 (continued)

(b) Discuss how changes in engineering materials and propulsion systems in the period 1902 to the present day have led to improved aircraft performance. **3**

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(c) A small non-structural crack has been discovered in the wing of a large commercial aircraft. **2**

Outline the primary responsibilities of an aeronautical engineer in regard to the continued operation of this aircraft.

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(d) A town council has directed engineers to provide recommendations for the expansion of a local airport. **3**

Identify THREE possible problems that could concern the local community if the airport is expanded, and recommend engineering solutions for each.

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End of Question 11

Question 12 — Civil Structures (10 marks)

(a) The following data were determined from tensile tests of a sample of structural steel used in a bridge.

Original cross-sectional area = 40 mm^2
Gauge length = 120 mm
Load at proportional limit = 13 kN
Extension at proportional limit = 0.19 mm
Maximum load = 18 kN
Extension at maximum load = 4.9 mm

(i) Determine Young's Modulus for the structural steel. **1**

Young's Modulus = ... GPa

(ii) Determine the ultimate tensile strength (UTS) for the structural steel. **1**

UTS = ... MPa

(b) Name a material that could be used as a structural member in a new road bridge and justify your choice. **2**

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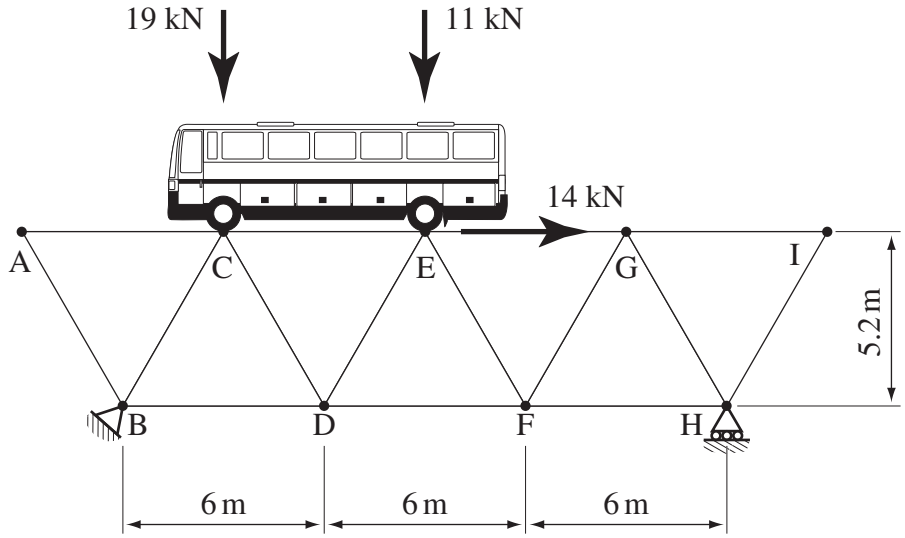
Question 12 continues on page 12

Question 12 (continued)

(c) The forces created by a 3 tonne bus on a pin-jointed truss bridge are shown.



(i) Determine the reaction the bus will create at the pin support B. **2**

Ignore the weight of the bridge.

Magnitude = ... kN

Direction = ...

Question 12 continues on page 13

(ii) Determine the magnitude and nature of the force in member CE. **2**

Magnitude of force in CE = ... N

Nature of force in CE = ...

(d) State TWO different composites that may be used for sealed road surfaces and identify TWO components of each of the composites. **2**

Composite	*Components*

End of Question 12

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Question 13 — Personal and Public Transport (10 marks)

(a) A 4 tonne bus is stationary at the top of a 40° slope.

(i) The handbrake is released and the bus rolls 700 metres to the bottom of the slope. **2**

Calculate the velocity of the bus in km/h at the bottom of the slope. Ignore frictional forces.

Velocity = ... km/h

(ii) The bus then accelerates along the horizontal road to achieve a constant velocity of 60 km/h.

1. Calculate the power required by the brakes to stop the bus from 60 km/h in 45 seconds. **1**

Power = ... kW

2. If the total resistance force supplied by the brakes is 12 kN, calculate the distance taken for the bus to stop. **1**

Distance = ... m

Question 13 continues on page 16

(b) The windscreens of two different buses are shown.

Figure 1

Figure 2

(i) Identify the type of glass that would be most suitable for windscreens in buses and give ONE reason for the window being curved. **2**

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(ii) Why is this type of glass preferred for bus windscreens over other types of window glass? **2**

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(c) Give TWO reasons why a DC motor is used for the starter motor in a bus. **2**

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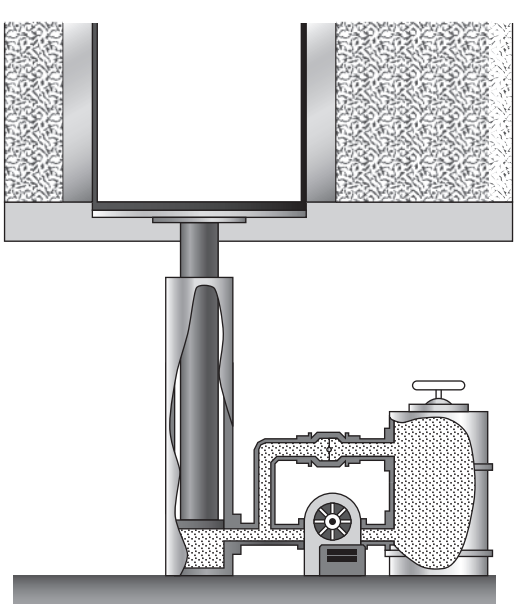
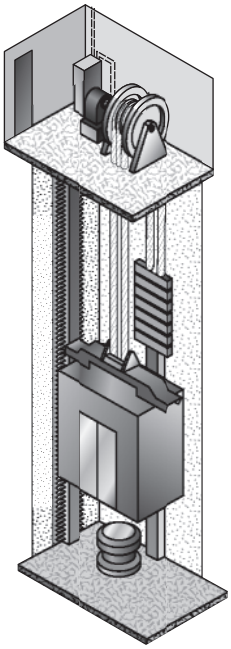
End of Question 13

Question 14 — Lifting Devices (10 marks)

(a) The diagram shows a hydraulic elevator and a cable elevator. **3**



Hydraulic elevator



Cable elevator

Contrast the operation of a hydraulic elevator with that of a cable elevator.

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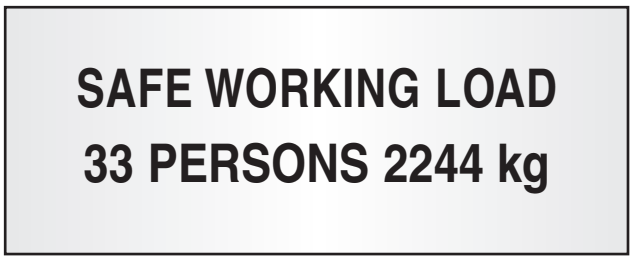
Question 14 continues on page 18

Question 14 (continued)

(b) Three 30 mm diameter cables support the car in a cable elevator. Inside the car is a safety notice.



(i) The yield stress of the cables is 200 MPa. **3**

What factor of safety has been applied at the safe working load?

Factor of safety = ...

(ii) Determine the elongation of the cable if the free length of each cable is 19 metres. **2**

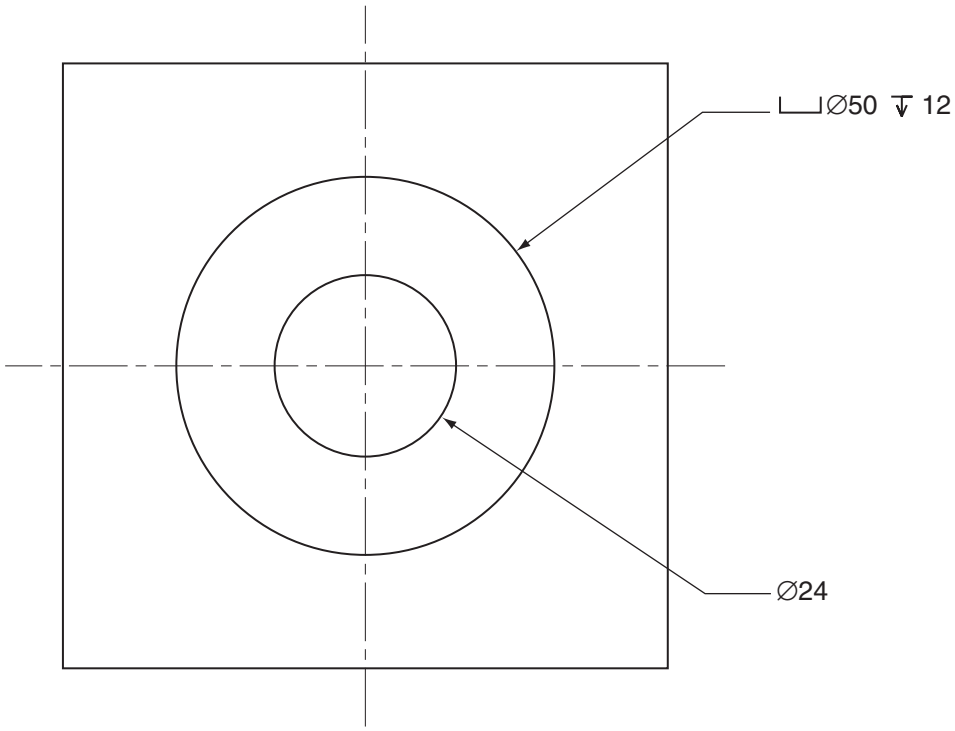
Use E_{Steel} = 210 GPa

Elongation = ... mm

Question 14 continues on page 19

Question 14 (continued)

(c) The support shown has a height of 50 mm. Project a half section front view. **2**



End of Question 14

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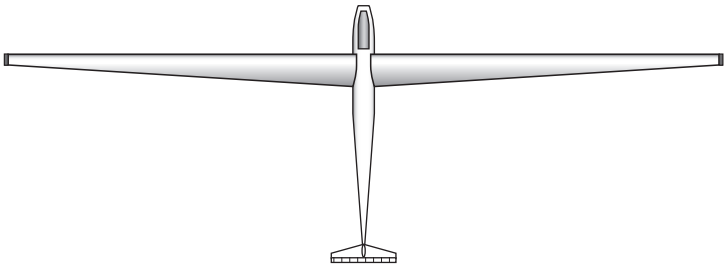
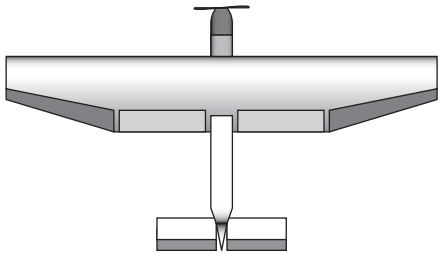
Question 15 — Aeronautical Engineering (15 marks)

(a) A glider and a powered aircraft have significantly different wings. **2**



Glider



Powered aircraft

How does the aspect ratio of the wing (length of wing span : depth of chord) affect the lift and drag of the glider, compared to the lift and drag of the powered aircraft?

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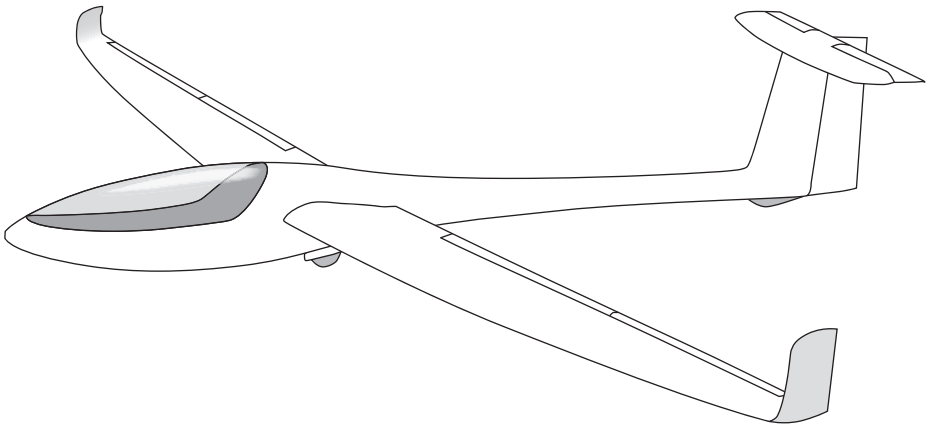
Question 15 continues on page 22

Question 15 (continued)

(b) Gliders use the same control surfaces to control flight as those found on powered aircraft. **3**



On the diagram, indicate each of the following control surfaces using the letters A, E and R. State how each controls flight.

Aileron (A) .....

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Elevator (E) .....

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Rudder (R) .....

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(c) Fibreglass construction is used to achieve sleek, smooth surfaces for gliders. **2**

Describe the process of forming a fibreglass fuselage for a glider.

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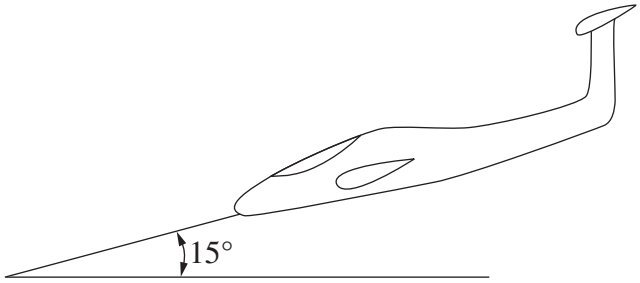
Question 15 continues on page 23

Question 15 (continued)

(d) A glider is maintaining constant velocity in a descent at 15° to the horizontal. The pilot has a mass of 83 kg. **3**

If the glider experiences drag equal to 1600 N, calculate the mass of the glider and the Lift to Drag ratio (L : D).



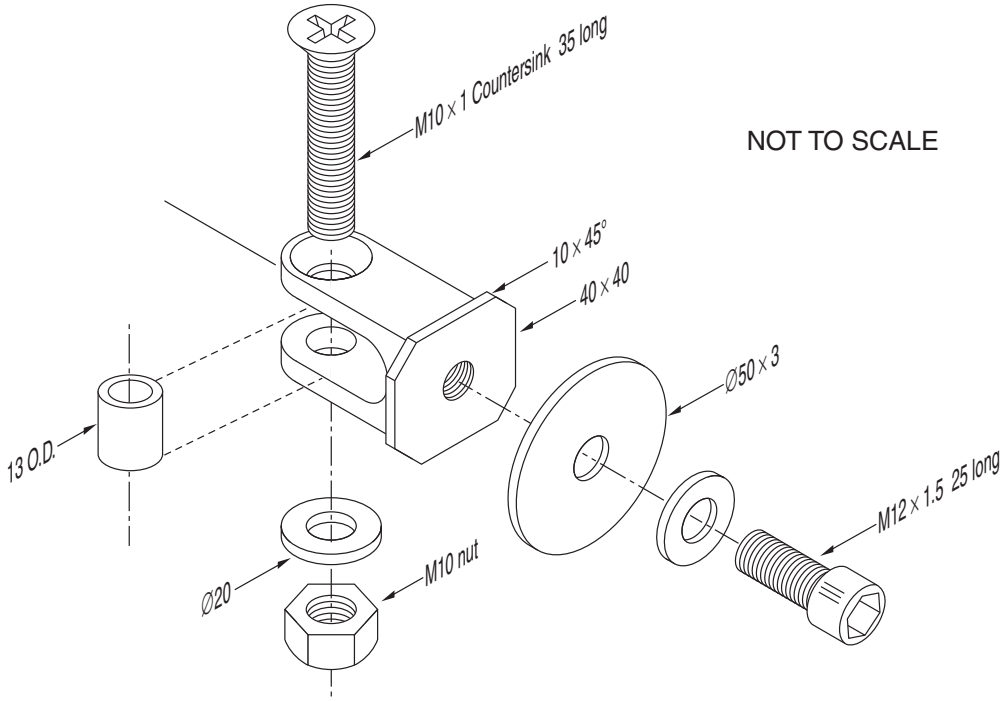
Mass = ... kg

L : D ratio = ...

Question 15 continues on page 24

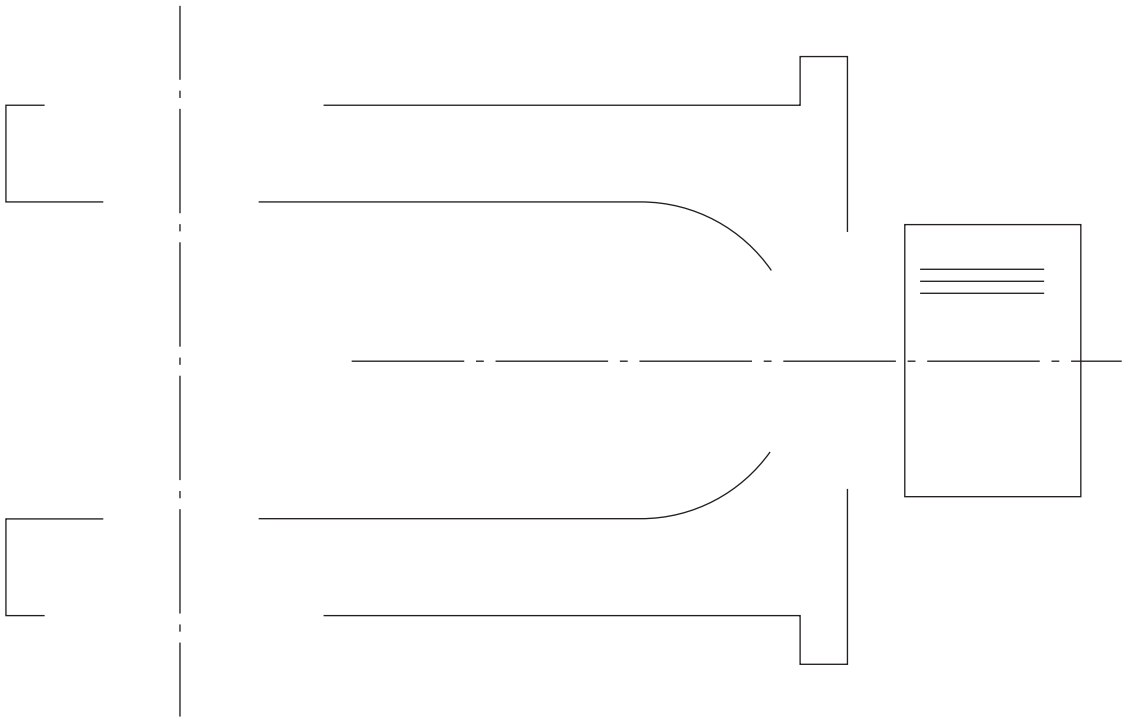
Question 15 (continued)

(e) The exploded isometric drawing of an aircraft door hinge assembly is shown. **5**



Complete the assembled orthogonal sketch of the door hinge assembly in the space below. The door hinge block is to be fully sectioned. Apply AS 1100 drawing standards. Do NOT show hidden detail. Do NOT add dimensions.

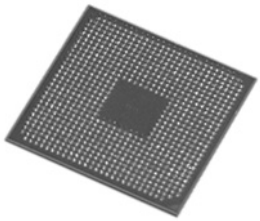
Scale 2 : 1



End of Question 15

Question 16 — Telecommunication (15 marks)

The images show the evolution of components used in electronic circuits.

			
Experimental transistor 1950s	Transistor 1960s	Early integrated circuit 1970s	Very large scale integrated circuit 1990s

(a) What advantages have been gained in telecommunications by this evolution? **2**

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(b) Name a polymer suited to coating copper wire, and describe a process used to produce the coating. **2**

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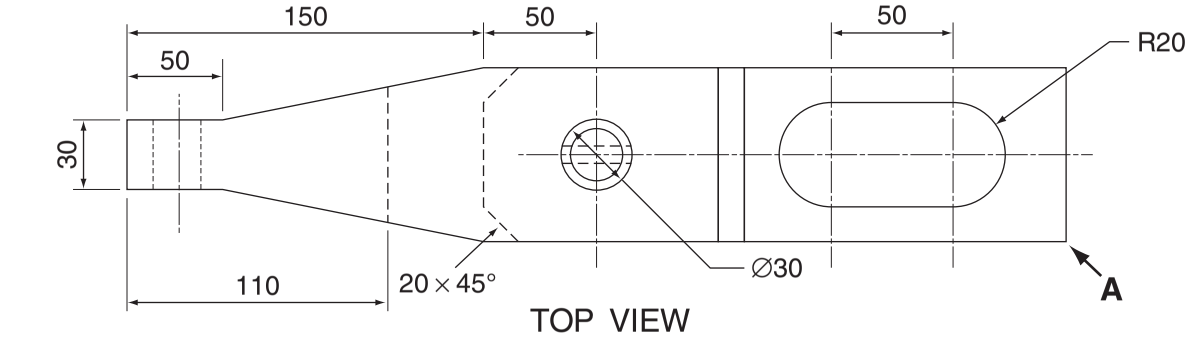
Question 16 continues on page 26

Question 16 (continued)

(c) An orthogonal projection of an aerial support yoke is shown. **5**



TOP VIEW

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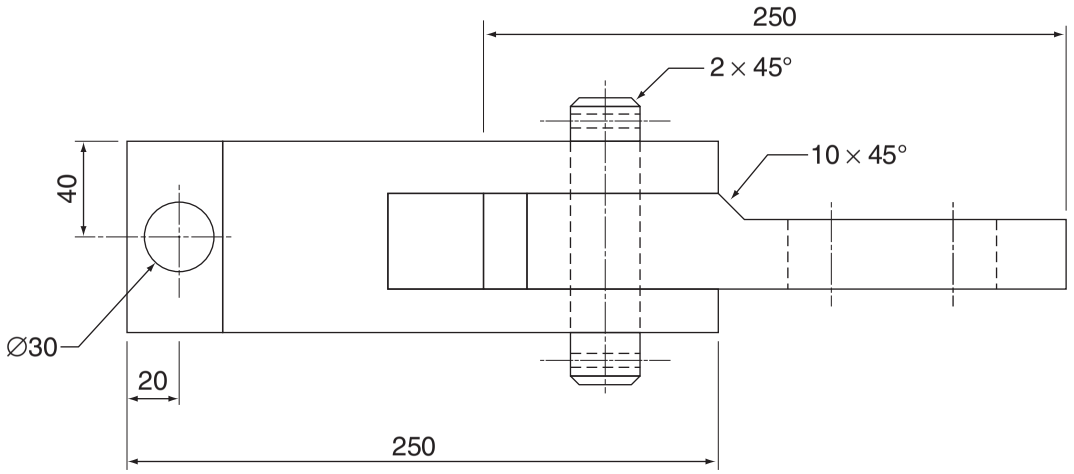
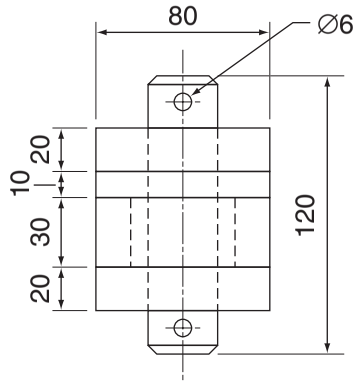


FRONT VIEW



SIDE VIEW

Question 16 continues on page 27

Question 16 (continued)

Sketch a pictorial drawing of the assembled yoke viewed in the direction of arrow **A**.

Question 16 continues on page 28

Question 16 (continued)

(d) (i) Describe the purpose of demodulation in a radio system. **2**

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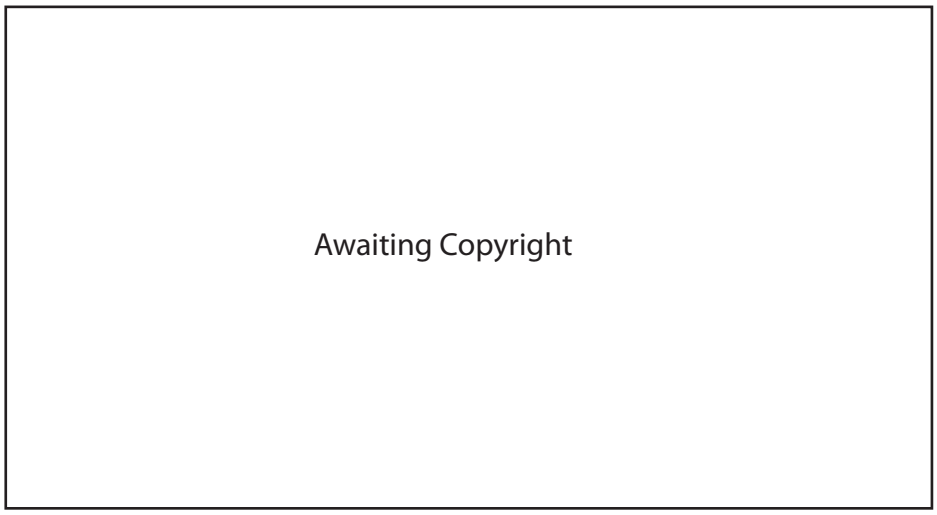
(ii) The circuit represents a simple radio receiver. **2**



How does this circuit demodulate the signal?

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(iii) What is the function of the coil and the variable capacitor in this circuit? **2**

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End of Question 16

2012 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

Centre Number

Student Number

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)

Part of an elevated treetop walkway is shown.

(a) What factors regarding the location of the treetop walkway would be included in an engineering report? **2**

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Question 17 continues on page 30

Question 17 (continued)

(b) What is the purpose of the flanges shown in the circular members? **1**

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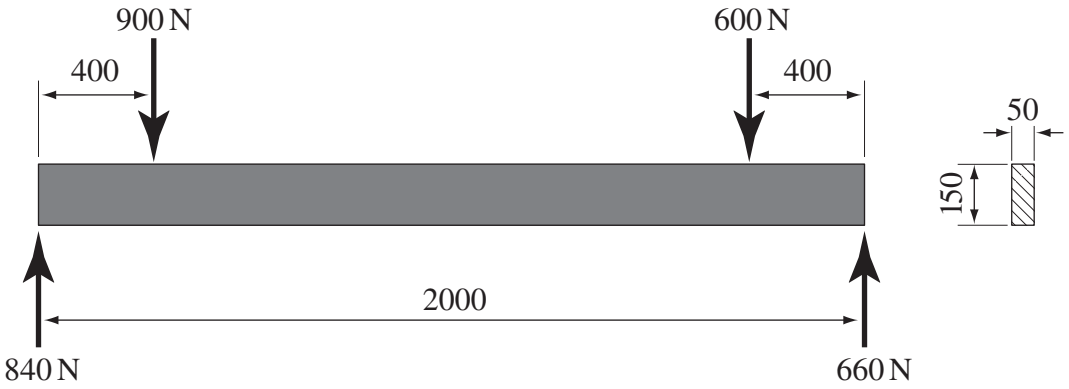
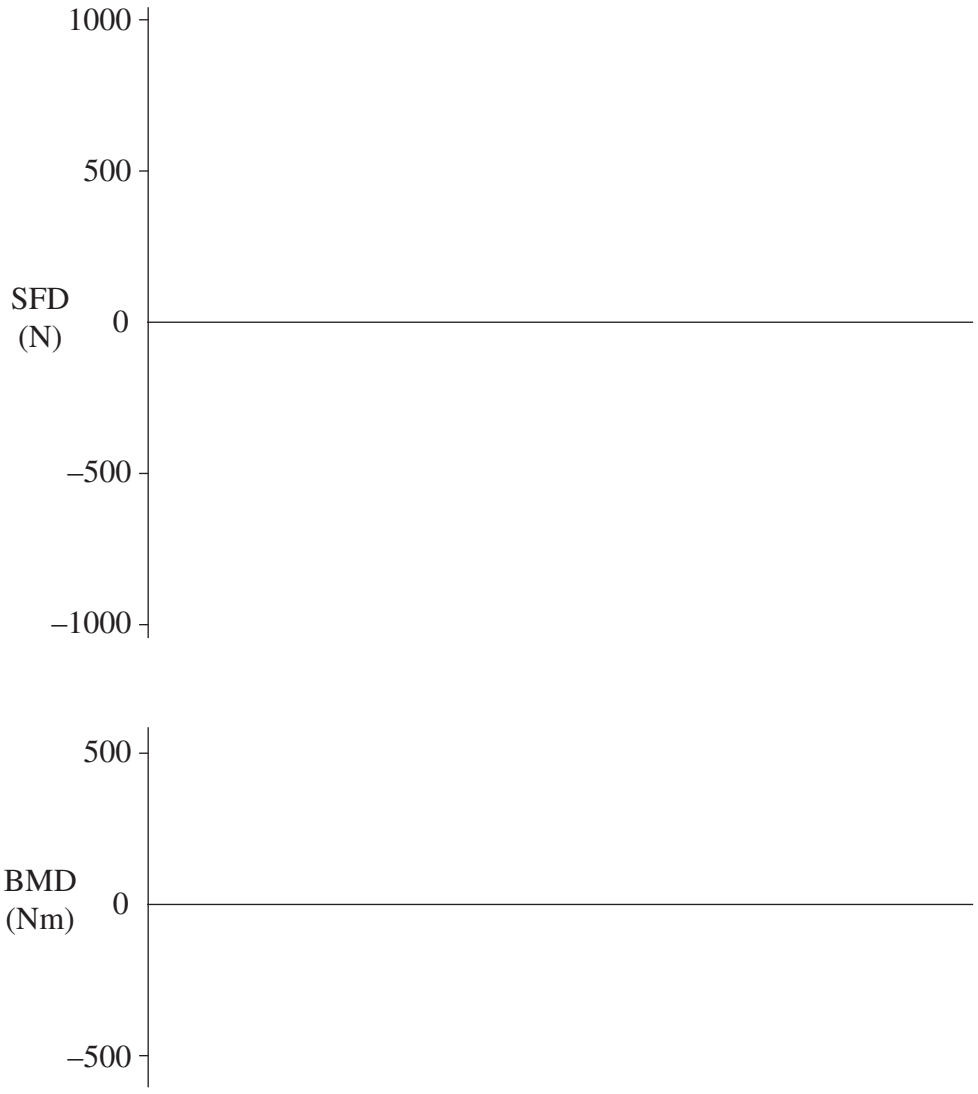
Question 17 continues on page 31

(c) The 2 metre cross beam of the walkway is a 50 mm × 150 mm rectangular beam supported on the edge at both ends with loads acting as shown.



(i) Construct shear force and bending moment diagrams, ignoring the uniformly distributed self weight (UDL) of the beam. **2**



Question 17 continues on page 32

(ii) Describe the change in shape of the BMD if the uniformly distributed self weight (UDL) of the beam is considered. **1**

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(iii) Calculate the maximum bending stress in the cross beam of the walkway given that the second moment of area (I) for the beam is 14×10^6 mm^4. Ignore the self weight of the beam. **2**

Maximum bending stress = ... MPa

(d) An engineer has recommended that the steel walkway be protected from corrosion by hot dip galvanising. **2**

Why is hot dip galvanising an effective method of protecting the walkway?

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End of Question 17

Engineering Studies

Centre Number

Section III (continued)

Student Number

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

(a) How can engineering reports contribute to effective decision-making? **2**

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(b) Engineers produce innovations and inventions which change the way we work, live and communicate. **3**

Explain how such intellectual property can be protected from illegal use.

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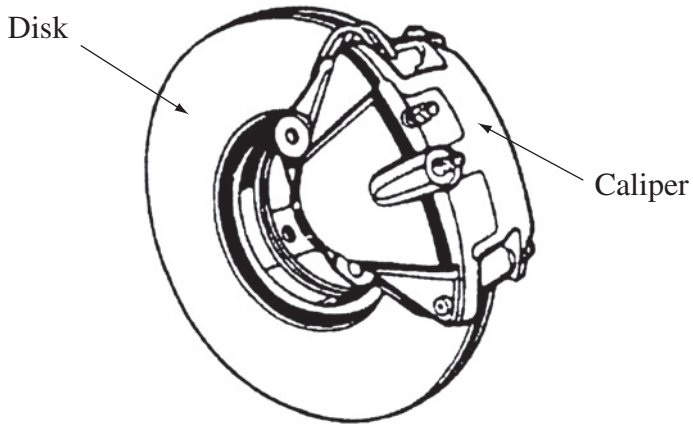
Question 18 continues on page 34

Question 18 (continued)

(c) Brake calipers, such as that shown, could be used in a braking system. They can be made from heat treated aluminium alloy.



(i) Name the principal alloying element that would be used with aluminium in this application. **1**

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(ii) Why would an engineer choose this aluminium alloy to manufacture calipers? **2**

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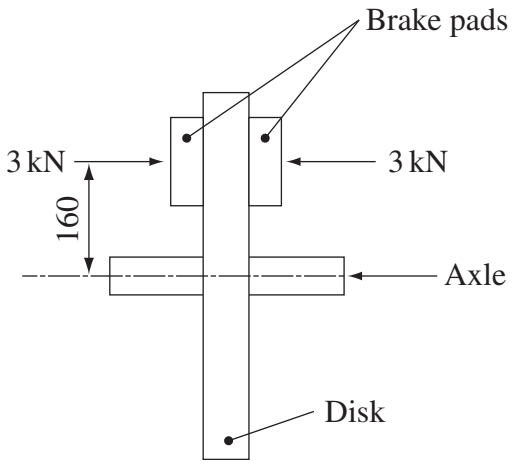
Question 18 continues on page 35

Question 18 (continued)

(d) The braking force applied to each brake pad from the caliper is 3 kN as shown. **2**



The coefficient of friction is 0.4.

What torque (moment) is required to overcome the braking force and allow a stationary vehicle to start moving?

Torque = ... Nm

End of paper

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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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