



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

2004

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, 13, 17, 19, 23, 27 and 29

Total marks – 100

Section I Pages 2–7

10 marks

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

Section II Pages 9–26

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

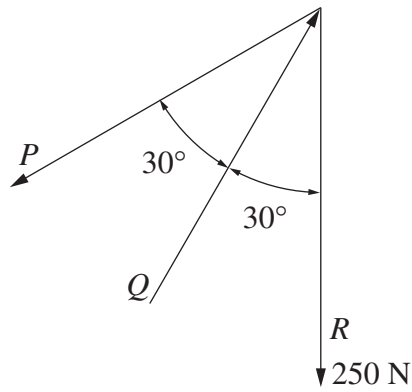
If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

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 ↙

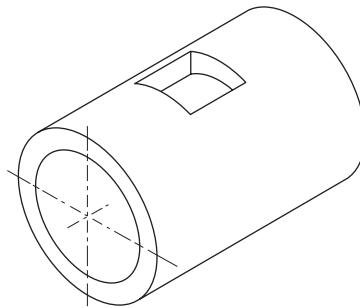
1 Three concurrent forces in a state of equilibrium are shown.



What will be the value of force Q ?

- (A) 250 N
- (B) 289 N
- (C) 433 N
- (D) 577 N

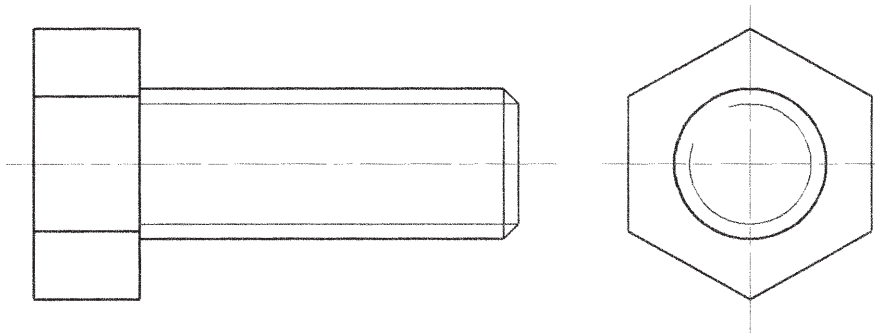
2 A component is shown in the pictorial drawing.



Which of the following drawings represents the half-section front view of the component?

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

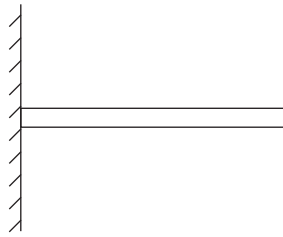
3



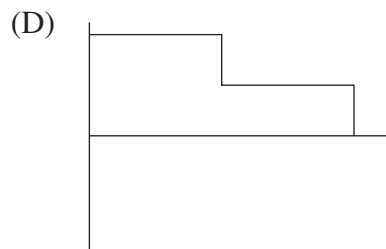
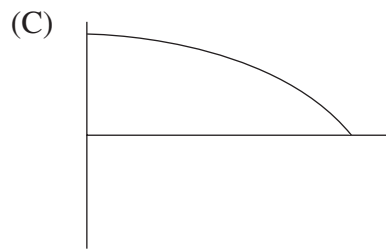
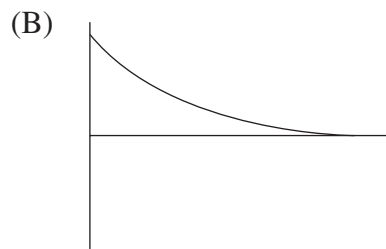
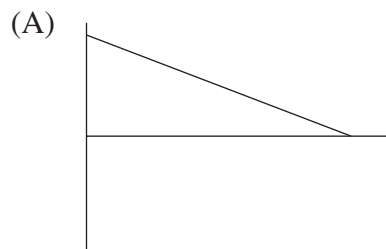
Taking measurements from the orthogonal drawing, which of the following describes the bolt?

- (A) M16 × 4, length 50
 - (B) M20 × 2, length 50
 - (C) M20 × 4, length 50
 - (D) M20 × 4, length 64
- 4 Which forming process involves a low-melting point metal alloy being fed under pressure into a permanent metal mould?
- (A) Die casting
 - (B) Blow moulding
 - (C) Investment casting
 - (D) Injection moulding

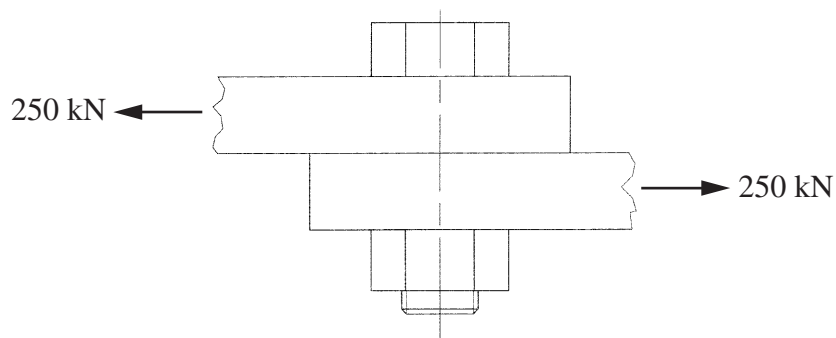
- 5 A steel cantilever beam is shown.



Which sketch best represents the shape of the bending moment diagram for the beam, if the mass of the beam is uniformly distributed?



- 6 A 250 kN force is applied to the plates, as shown.



What is the shear stress in the $\text{Ø}20$ mm bolt?

- (A) 199 MPa
- (B) 398 MPa
- (C) 796 MPa
- (D) 1592 MPa

7 A high-carbon steel punch is to be used to make holes in mild-steel sheet.

What are the final heat-treatment processes required in the manufacture of the punch?

- (A) Normalising then hardening
- (B) Hardening then tempering
- (C) Normalising then tempering
- (D) Hardening then normalising

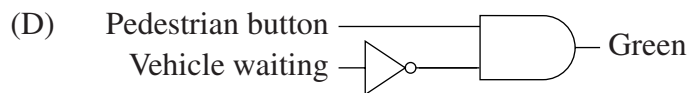
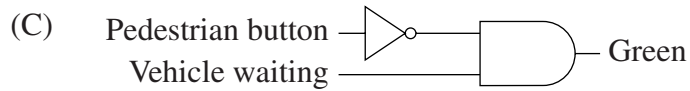
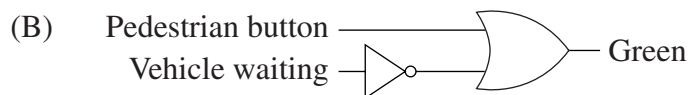
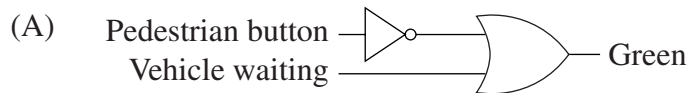
8 What is the major use of geotextiles in civil projects?

- (A) To inhibit weed growth
- (B) To prevent movement of subsoil layers
- (C) To strengthen concrete during pouring
- (D) To produce 'sail-like' structures for shade

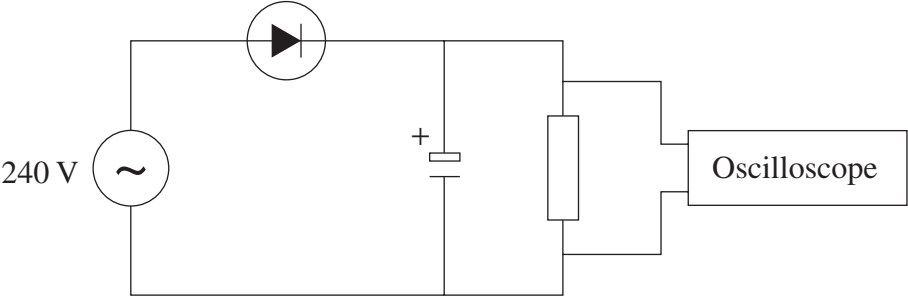
9 A traffic light will change to green for a vehicle if either:

- the pedestrian button is NOT pushed, OR
- the vehicle is waiting.

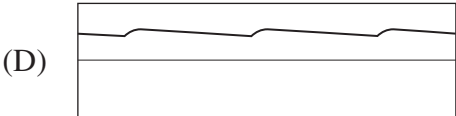
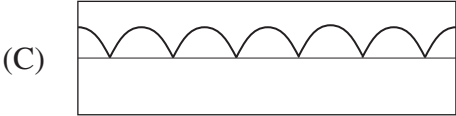
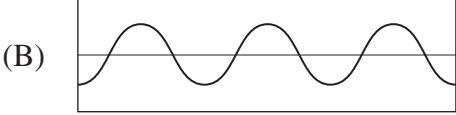
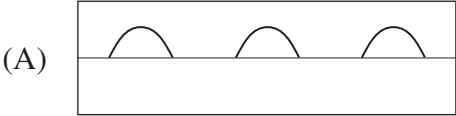
Which simple logic circuit indicates this condition?



10 An AC to DC rectification circuit is shown.



Which wave form would be displayed on the oscilloscope?



BLANK PAGE

--	--	--	--	--

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) Aeronautical engineers may be employed in applications not directly related to aircraft design. **4**

Explain how specific areas of knowledge of the aeronautical engineer may be applied to:

- yacht design, OR
- racing car design.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 11 continues on page 10

Question 11 (continued)

- (b) Explain how the application of electronic control technology has improved EITHER braking efficiency OR engine efficiency in the modern motor vehicle. 3

.....

.....

.....

.....

.....

.....

.....

.....

- (c) Identify a technological change in personal or public transport, and explain the environmental effect of this change. 3

.....

.....

.....

.....

.....

.....

.....

.....

End of Question 11

--	--	--	--	--

Centre Number

Section II (continued)

--	--	--	--	--	--	--	--	--	--

Student Number

Marks

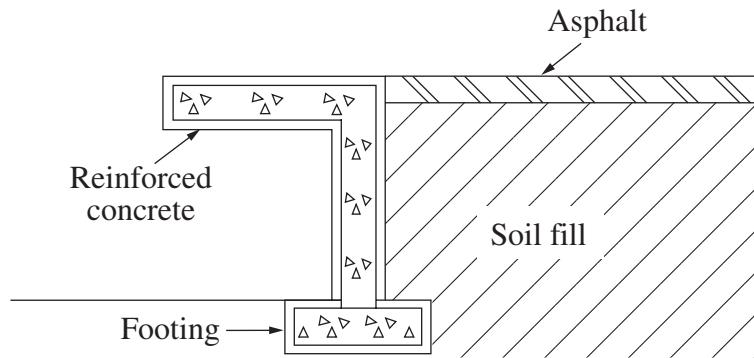
Question 12 — Civil Structures (10 marks)

(a) Typically, a railway station is a combination of a reinforced concrete edging and an asphalt platform.

(i) Identify the constituents of asphalt, and explain their function. 2

.....
.....
.....
.....

(ii) Explain, in terms of their properties, why reinforced concrete and asphalt are used as indicated in the cross-sectional representation of a train platform. 3

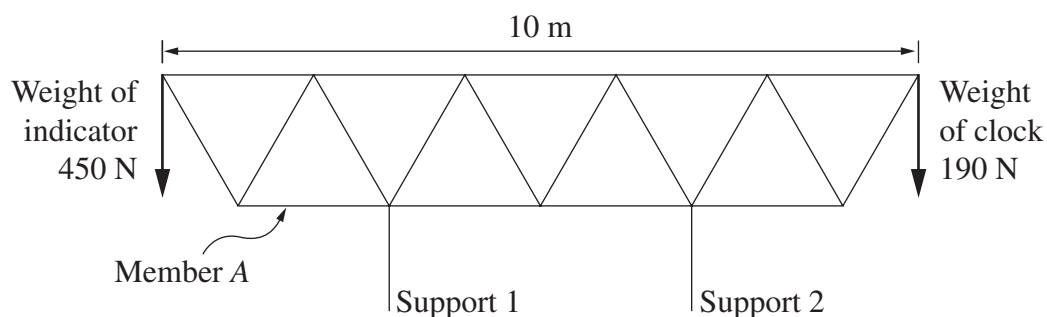


.....
.....
.....
.....
.....
.....
.....
.....

Question 12 continues on page 12

Question 12 (continued)

- (b) The truss shown is used to support the roof of a railway station platform shelter. The truss also supports a train indicator and a clock. The truss has a weight of 4 kN acting through its centre of mass. All members are 2 metres in length.



- (i) Determine the reaction in Support 1. 2

Reaction in Support 1 = N

- (ii) Determine the magnitude and nature of the force in Member A. 3

Magnitude of force in Member A = N

Nature of force in Member A =

End of Question 12

--	--	--	--	--

Centre Number

Section II (continued)

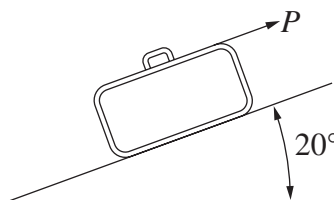
--	--	--	--	--	--	--	--	--	--

Student Number

Marks

Question 13 — Personal and Public Transport (10 marks)

- (a) A suitcase weighing 300 N is to be pulled up an inclined ramp as shown. The coefficient of static friction between the suitcase and ramp is 0.3. Force P acts parallel to the ramp. **2**



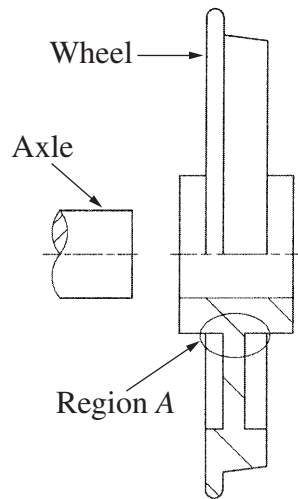
Determine the minimum value of force P required to start the suitcase moving up the ramp.

$P = \dots\dots\dots$ N

Question 13 continues on page 14

Question 13 (continued)

- (b) An exploded drawing of an experimental wheel and axle assembly for a passenger train carriage is shown. During preliminary testing, failure was found to occur in Region A.



- (i) Explain why the failure occurred, and outline how Region A could be redesigned to overcome the tendency to fail. 2

.....

.....

.....

.....

.....

.....

- (ii) Describe a suitable non-destructive test that will detect early signs of possible wheel failure in Region A. 2

.....

.....

.....

.....

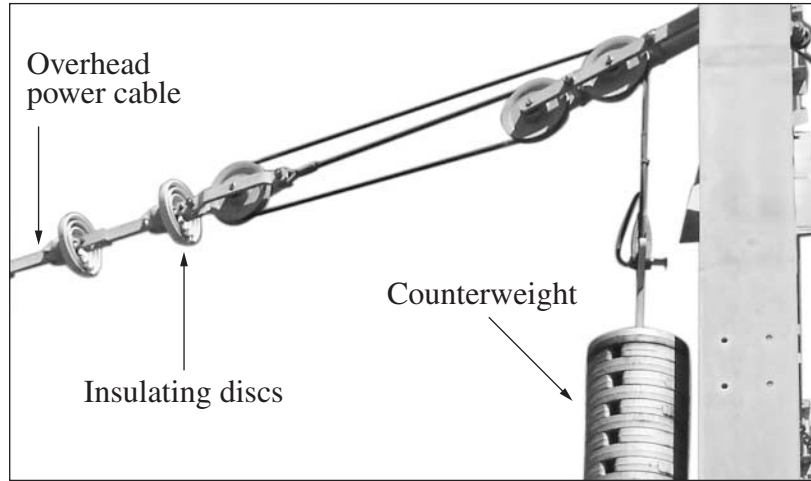
.....

.....

Question 13 continues on page 15

Question 13 (continued)

- (c) The tensioning system for overhead power cables of an electric train network is shown in the photograph.



- (i) Determine the resultant tension in the overhead power cable when the counterweight has a total mass of 1.2 tonnes. 2

Tension = N

- (ii) Name a suitable material for the manufacture of the insulating discs. Explain in terms of the material's structure why it is an insulator. 2

.....

.....

.....

.....

.....

.....

End of Question 13

BLANK PAGE

--	--	--	--	--

Centre Number

Section II (continued)

--	--	--	--	--	--	--	--	--

Student Number

Marks

Question 14 — Lifting Devices (10 marks)

(a) A crane uses a DC electric motor to lift a mass of 250 kg vertically from the ground. After 18 seconds the mass is 20 metres off the ground with an upward velocity of 2 ms⁻¹.

(i) Determine the average power required by the motor to perform this lifting operation. **3**

Power = kW

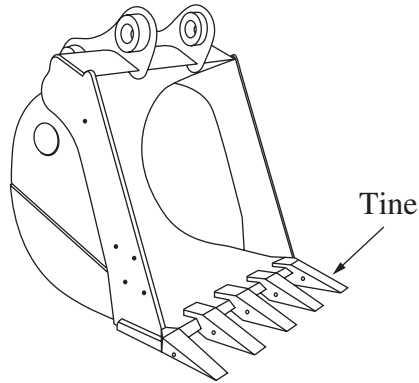
(ii) Explain the function of a commutator in a DC motor. **2**

.....
.....
.....
.....

Question 14 continues on page 18

Question 14 (continued)

- (b) Replaceable tines used on excavation buckets are made from a low-carbon steel by a drop-forging process, followed by heat treatment.



- (i) Describe the drop-forging process. 2

.....

.....

.....

.....

.....

.....

- (ii) The service properties of the tine require it to be abrasion resistant and tough. Describe a suitable heat treatment process and the resultant change in structure in the tine. 3

.....

.....

.....

.....

.....

.....

.....

.....

End of Question 14

--	--	--	--	--

Centre Number

Section II (continued)

--	--	--	--	--	--	--	--	--

Student Number

Marks

Question 15 — Aeronautical Engineering (15 marks)

- (a) (i) Explain the reason for having the replaceable leading edge on the timber propeller shown in the photograph. **2**



.....

.....

.....

.....

.....

.....

.....

- (ii) With reference to Bernoulli's Principle, explain why propeller blades have an aerofoil-shaped cross-section. Diagrams may be used to assist in your answer. **3**

.....

.....

.....

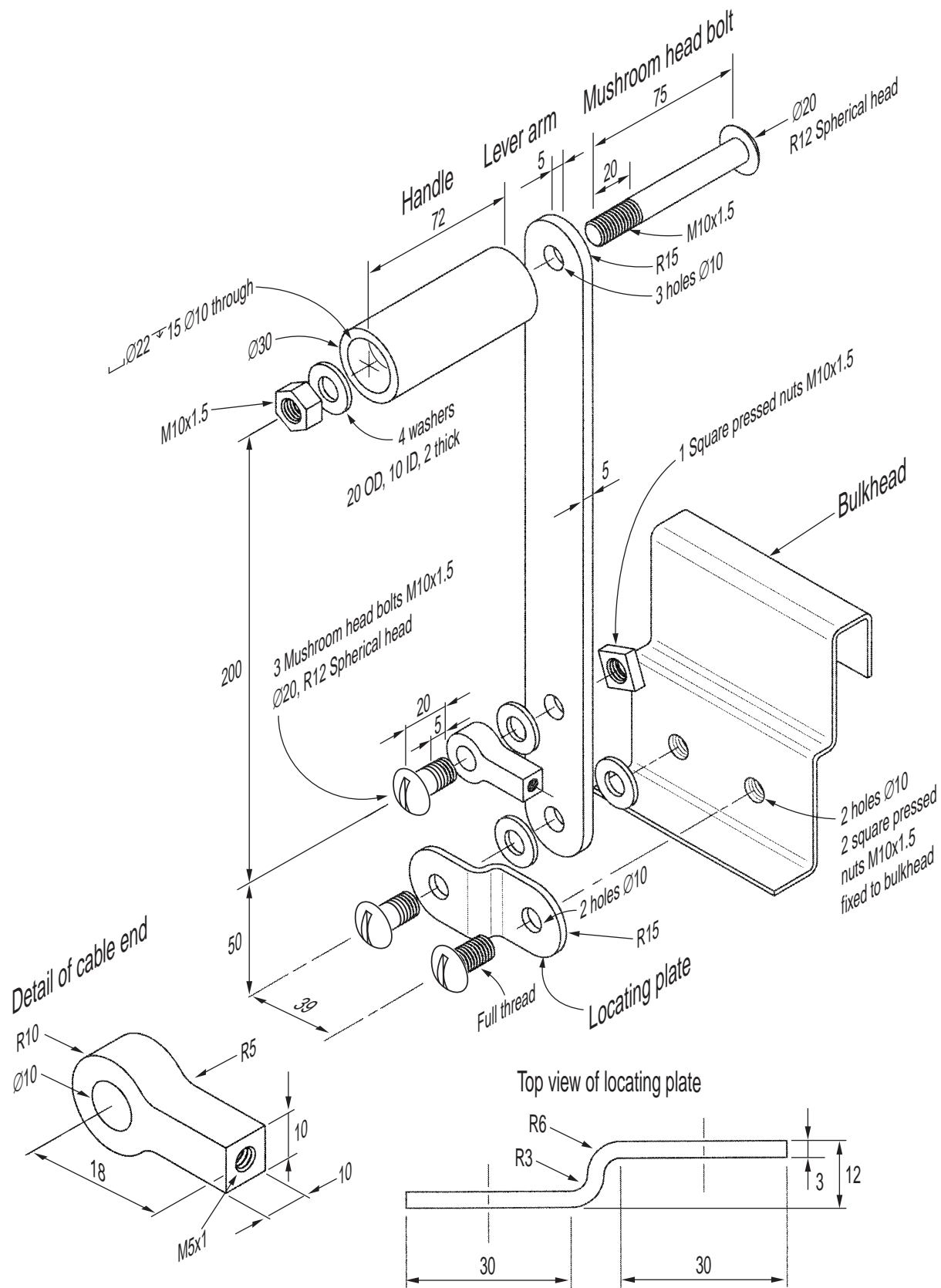
.....

Question 15 continues on page 20

Question 15 (continued)

(b) Details of a flaps control arm for a light aircraft are given.

4

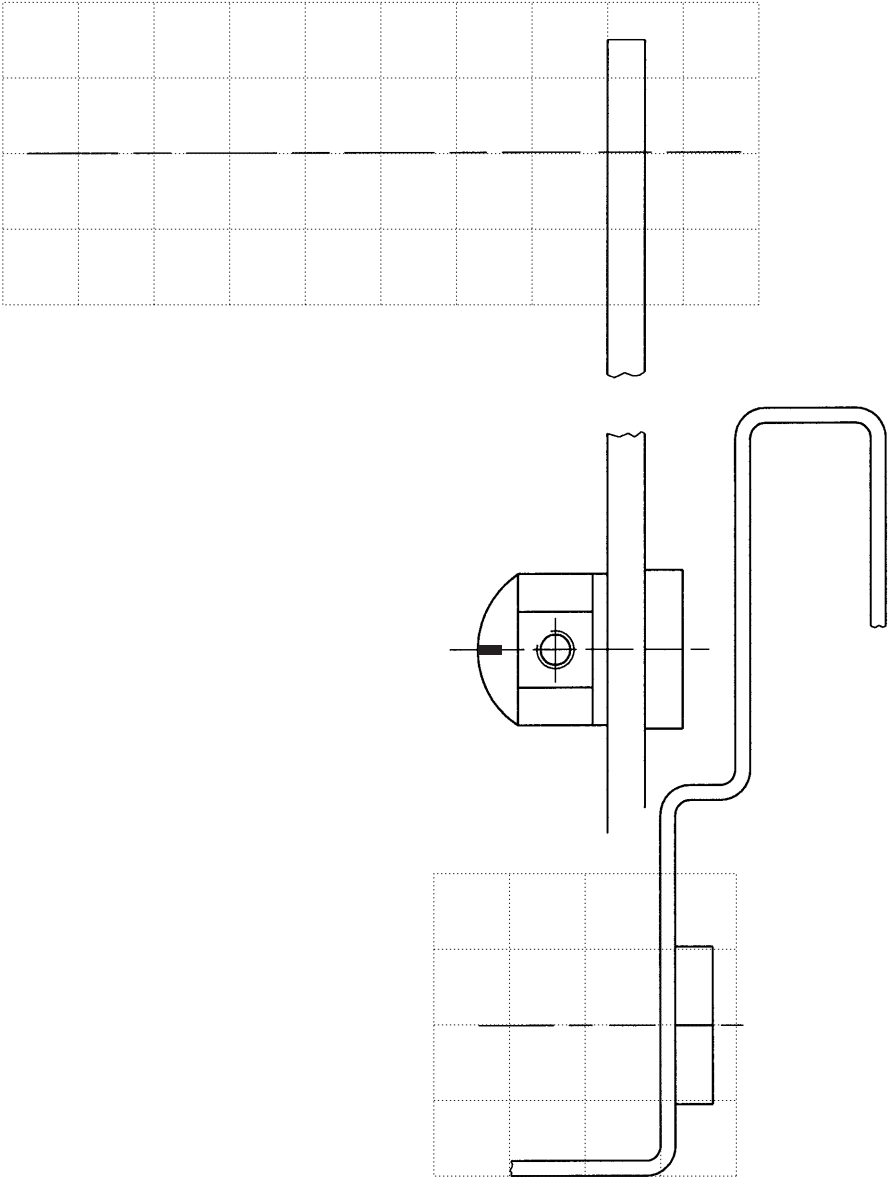


Question 15 continues on page 21

Question 15 (continued)

A partially completed orthogonal sketch of the front view of the assembly is shown, drawn to a scale of 1 : 1.

Complete the assembled orthogonal sketch of the flaps control arm in the space provided. The handle is to be fully sectioned. Apply AS1100 drawing standards where appropriate. Do NOT show hidden outline. Do NOT dimension.



Question 15 continues on page 22

Question 15 (continued)

- (c) (i) Identify TWO innovations in the aeronautics industry, and explain how these have affected society. 4

.....

.....

.....

.....

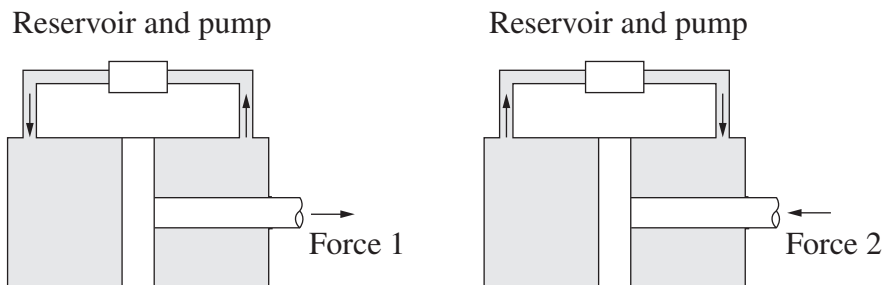
.....

.....

.....

.....

- (ii) Double-acting, or two-way hydraulic rams are used in many aircraft to control moveable components. The diagrams below represent the ram operating in opposite directions. 2



Explain why Force 1 is greater than Force 2 when the same hydraulic pressure is used in the system.

.....

.....

.....

.....

.....

.....

End of Question 15

--	--	--	--	--

Centre Number

Section II (continued)

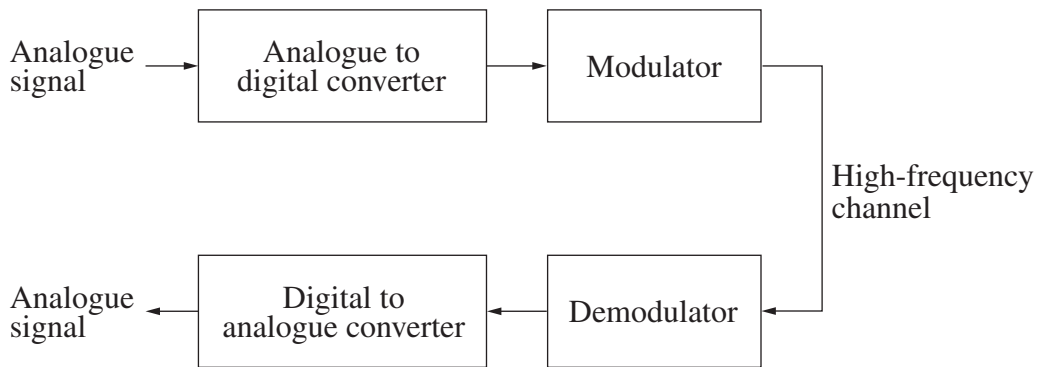
--	--	--	--	--	--	--	--	--

Student Number

Marks

Question 16 — Telecommunication (15 marks)

- (a) The key elements of a digital telecommunication system are shown in the diagram. The modulator and demodulator permit the transmission of digital information over a high-frequency channel.



- (i) Describe the process of frequency modulation. 2

.....

.....

.....

.....

.....

- (ii) Explain why frequency modulation is preferred over amplitude modulation in a modern telecommunication system. 2

.....

.....

.....

.....

.....

Question 16 continues on page 24

Question 16 (continued)

- (b) (i) Satellites can be found in synchronous (geosynchronous) and asynchronous orbits. 3

Explain the difference between the two orbits, and indicate a satellite use for each orbit.

.....

.....

.....

.....

.....

.....

.....

.....

.....

- (ii) A multimedia broadcast (sound and vision) from a remote location via satellite has a limited bandwidth. 2

Describe the effect of the limited bandwidth on reception of the broadcast.

.....

.....

.....

.....

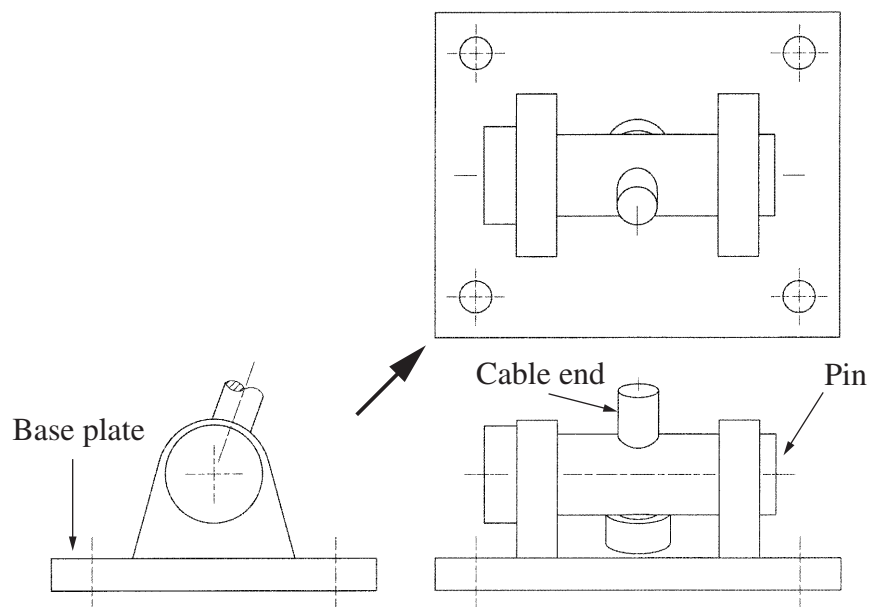
.....

.....

Question 16 continues on page 25

Question 16 (continued)

- (c) The orthogonal assembly drawing gives details of a cable support bracket for a telecommunication tower.



- (i) Taking sizes from the assembled orthogonal drawing, sketch a pictorial view of the pin assembled into the base plate when viewed in the direction of the arrow. Do NOT draw the cable end. 3

Question 16 continues on page 26

Question 16 (continued)

- (ii) The cable has a length of 60 metres and is permitted to undergo a maximum axial extension of 200 mm. The modulus of elasticity for the cable is 210 GPa. 3

Determine the maximum allowable tensile stress for the cable.

Maximum allowable tensile stress = MPa

End of Question 16

--	--	--	--	--

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)

Modern metal-framed bus shelters are replacing the older masonry and timber-framed shelters, similar to the styles shown in the photographs.



Older style bus shelter



Modern style bus shelter

- (a) Outline TWO social factors that have influenced this change of style.

2

.....

.....

.....

.....

.....

.....

Question 17 continues on page 28

Question 17 (continued)

- (b) (i) Timber was used as a construction material in older style shelters. **2**
Outline the reasons for this choice of material.

.....
.....
.....
.....
.....
.....

- (ii) Suggest a suitable material that could be used for the frame of the **2**
modern style shelter. Justify the choice of material.

.....
.....
.....
.....
.....
.....

- (c) Explain TWO different types of corrosion that may occur on the modern **4**
style shelter. Identify where these potential corrosion sites will occur.

.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....

End of Question 17

--	--	--	--	--

Centre Number

Section III (continued)

--	--	--	--	--	--	--	--	--	--

Student Number






Marks

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

- (a) A cantilever beam used in the roof structure of a modern bus shelter may be selected from a variety of cross-sectional shapes. Design specifications require a maximum bending moment of 750 Nm for this beam. **3**

Using the table supplied:

- select the beam that will support the greatest load, and
- calculate the maximum stress for the selected beam.

<i>Beam</i>	<i>Cross-sectional shape</i>	$I_{xx}(\text{m}^4)$	$Y_{\text{max}}(\text{m})$	<i>Cross-sectional area</i> (m^2)	$\frac{Y_{\text{max}}}{I_{xx}} (\text{m}^{-3})$
<i>A</i>		1.688×10^{-6}	0.050	1.492×10^{-3}	29 621
<i>B</i>		1.412×10^{-6}	0.040	1.500×10^{-3}	28 329
<i>C</i>		2.459×10^{-6}	0.065	1.492×10^{-3}	26 433
<i>D</i>		0.916×10^{-6}	0.035	1.492×10^{-3}	38 209
<i>E</i>		1.269×10^{-6}	0.040	1.500×10^{-3}	31 521

Beam selected:

Maximum stress =

Question 18 continues on page 30

Question 18 (continued)

- (b) 'We strive to maintain accuracy in this table. However, errors may occur and the end user assumes all risk and liability from its use.' 2

This statement, or similar ones, are often found attached to commercially provided engineering tables. Discuss the implications of this statement for the engineer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 18 continues on page 31

Question 18 (continued)

(c)



- (i) Tempered glass was chosen as the material to be used for the clear vertical panels in this bus shelter. Laminated glass and polycarbonate sheet were also considered.

3

Justify the selection of tempered glass in preference to laminated glass and polycarbonate sheet.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 18 continues on page 32

Question 18 (continued)

- (ii) The roofing panels are supported by cantilevered beams which are attached to the vertical supports. The cross-sectional areas of these beams taper significantly from the rear to the front. 2

Explain the structural reason for tapering these beams.

.....

.....

.....

.....

.....

.....

End of paper

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

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

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

Machines

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

BLANK PAGE