BOARD OF STUDIES
NEW SOUTH WALES

2009

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 29

Total marks – 100

Section I Pages 2–6

10 marks

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

Section II Pages 9–25

70 marks

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

Section III Pages 27–31

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 Which property is measured by an Izod impact test?

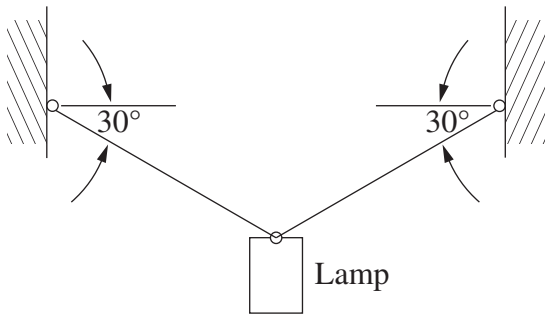
(A) Hardness

(B) Malleability

(C) Notch toughness

(D) Compression strength

2 A 4 kg lamp is suspended at the centre of a wire as shown.



What is the tension in the wire?

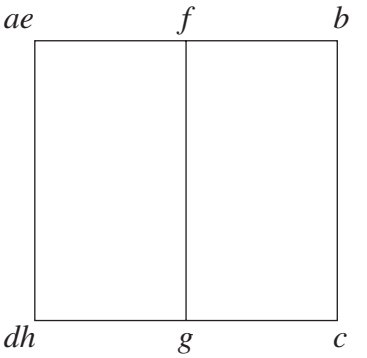
(A) 20.0 N

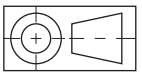
(B) 34.4 N

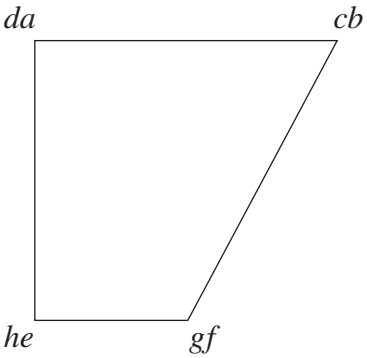
(C) 40.0 N

(D) 68.8 N

3 The orthogonal views represent a hollow transition piece from square tube to rectangular tube.

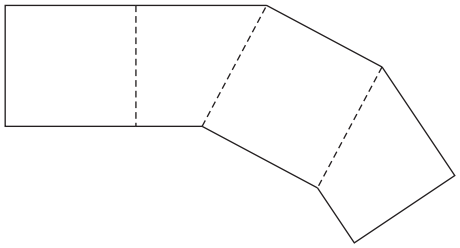




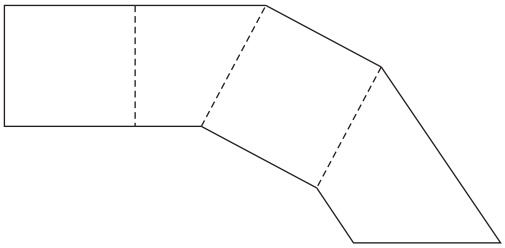


Which of the following diagrams represents the development of the transition piece?

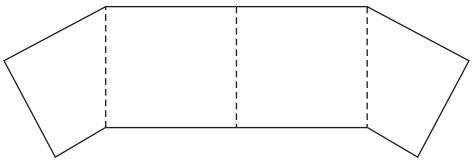
(A)



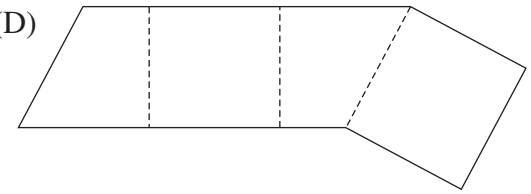
(B)



(C)



(D)



4 In a permanent magnet DC motor, the direction of rotation can be changed by

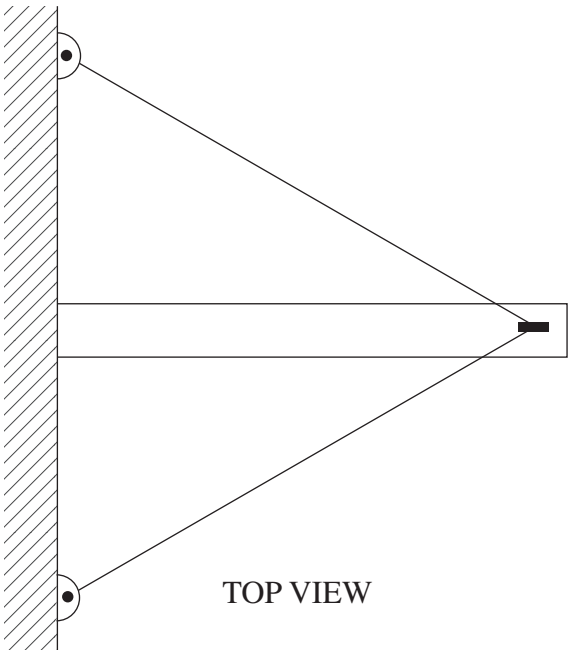
(A) reducing the supply voltage.

(B) reducing the armature current.

(C) reversing the polarity of the stator current.

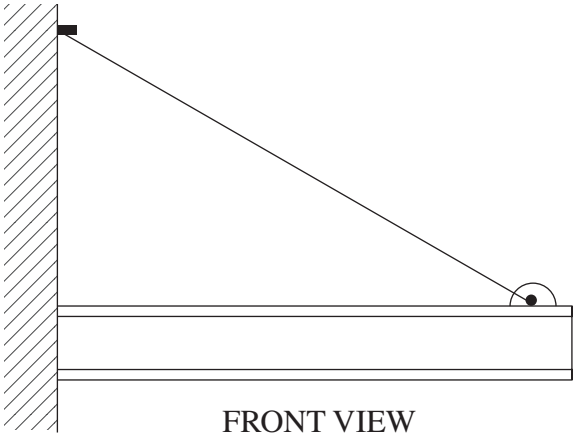
(D) reversing the polarity of the supply voltage.

5 A cantilevered beam is supported by two wire stays.



TOP VIEW

Scale 1 : 100



FRONT VIEW

What is the true length of each of the stays?

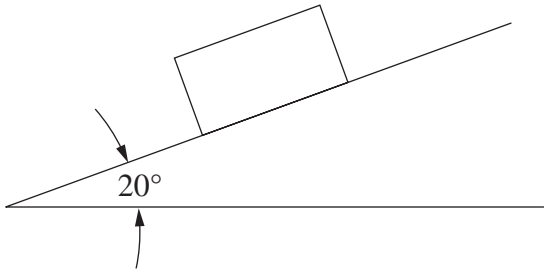
(A) 70 mm

(B) 80 mm

(C) 7.0 m

(D) 8.0 m

6 A box is placed on an inclined plane as shown. The coefficient of friction, μ, is equal to 0.33.



Which statement is true?

(A) The box will remain stationary.

(B) The box will accelerate down the plane.

(C) The box will move down the plane at a constant rate.

(D) The box will move down the plane at a decreasing rate.

7 Which two mechanical properties would be most desirable in a steel trailer suspension spring?

(A) Hardness and toughness

(B) Toughness and weldability

(C) Weldability and resilience

(D) Resilience and high yield strength

8 The equivalent DC voltage of an AC voltage is

(A) 0.500 times the peak AC voltage.

(B) 0.707 times the peak AC voltage.

(C) 1.412 times the peak AC voltage.

(D) 3.000 times the peak AC voltage.

9 A copper water pipe is attached to a wooden fence with a pressed mild steel saddle. The pipe and saddle are frequently wet.

In this situation the copper pipe will

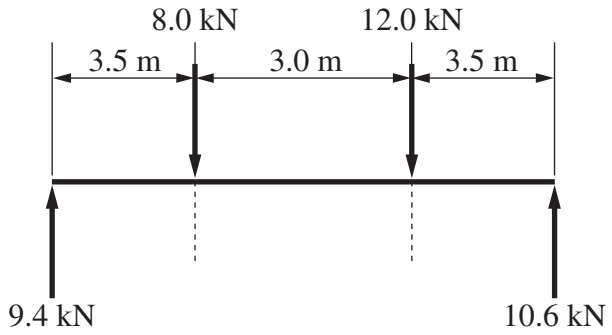
(A) have the higher positive potential and corrode.

(B) cathodically protect the saddle from corroding.

(C) form a sacrificial anode and protect the saddle from corroding.

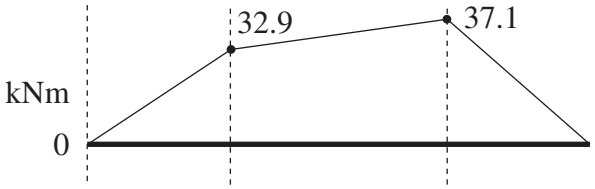
(D) form a galvanic cell with the saddle causing the saddle to corrode.

10 A beam is loaded as shown.

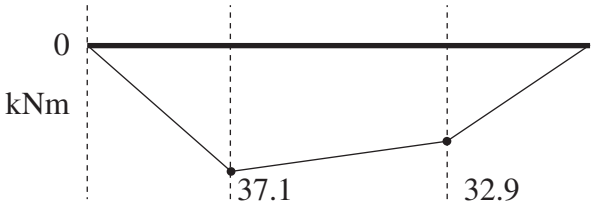


Which of the following diagrams correctly represents the bending moment?

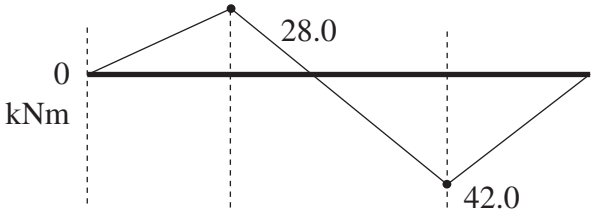
(A)



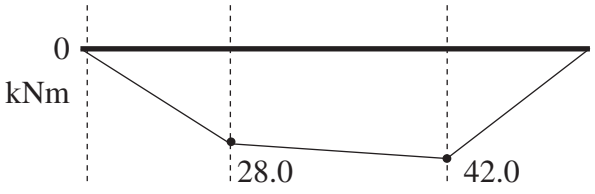
(B)



(C)



(D)



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Engineering Studies

Centre Number

Section II

Student Number

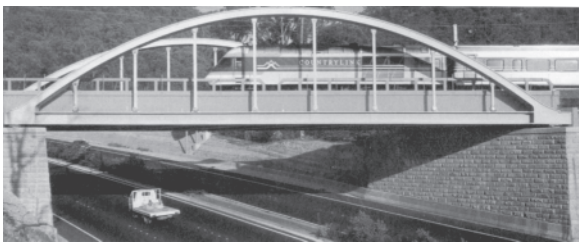
70 marks
Attempt Questions 11–16
Allow about 2 hours for this section

Answer the questions in the spaces provided.

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

The images show two bridges built about a century apart.

Bridge *X* (c 1890)



Bridge *Y* (c 1990)

(a) List the responsibilities of the site engineer during construction of Bridge *Y*. **2**

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(b) Outline an innovation in engineering materials and an innovation in construction methods that were available for Bridge *Y* that were not available for Bridge *X*. **3**

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Question 11 continues on page 10

Question 11 (continued)

(c) (i) Bridge *X* is an item of engineering heritage. **2**

Describe issues that engineers would need to consider to ensure the preservation of this structure.

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(ii) Explain why engineers, from different fields, worked in teams during the construction of Bridge *Y*. **3**

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End of Question 11

Question 12 — Civil Structures (10 marks)

(a) A steel section for a truss bridge has been cold rolled. **2**

Outline the changes in the mechanical properties of the steel section due to cold rolling.

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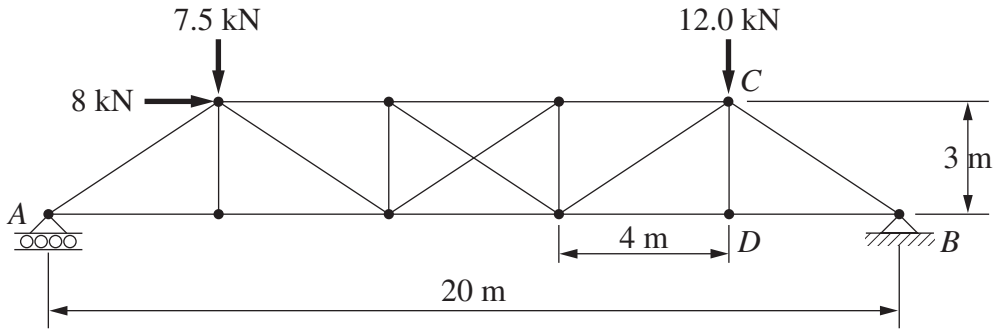
Question 12 continues on page 12

Question 12 (continued)

(b) The pin-jointed truss shown is used to span a creek. Each panel is 4 m long by 3 m high.



(i) Calculate the magnitude of horizontal and vertical reactions at support *B*. **2**

Horizontal reaction at *B* ..... kN

Vertical reaction at *B* ..... kN

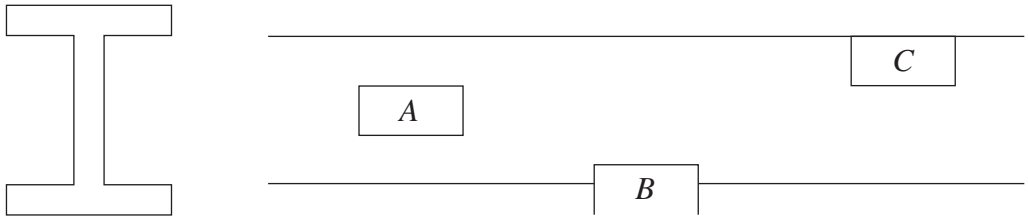
(ii) Determine the magnitude of the compression force in member *BC*. **2**

Magnitude of force ..... kN

Question 12 continues on page 13

Question 12 (continued)

(c) A hole or recess has to be cut in a structural beam for service pipes to pass through. Possible locations for the hole or recess are shown below.



(i) Explain which location *A*, *B* or *C* would have least effect on the bending strength of the beam. **2**

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(ii) Explain why rounded corners would be used in preference to square corners for the hole or recess in this situation. **2**

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End of Question 12

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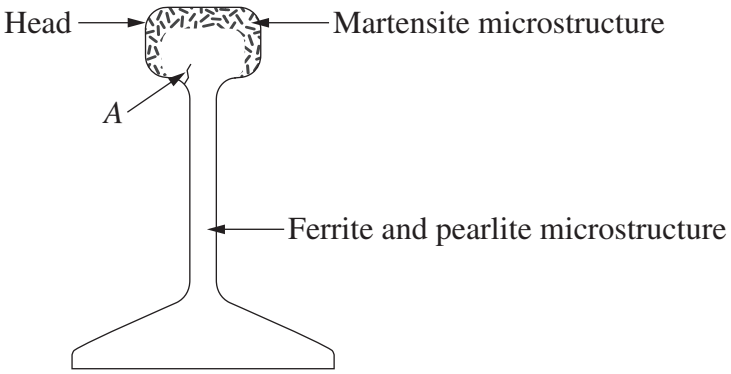
Question 13 — Personal and Public Transport (10 marks)

(a) The cross-section of a piece of 0.7% carbon steel railway track is shown.



(i) A small surface crack is suspected at *A*. **2**

Name and describe a test that could be used to detect the crack.

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(ii) Name and describe a heat treatment process that could have been used to produce the martensite microstructure in the head. **3**

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Question 13 continues on page 16

Question 13 (continued)

(b) Windows in modern trains are made from laminated glass. **3**

Explain how the structure of a laminated glass train window protects people in case of an accident.

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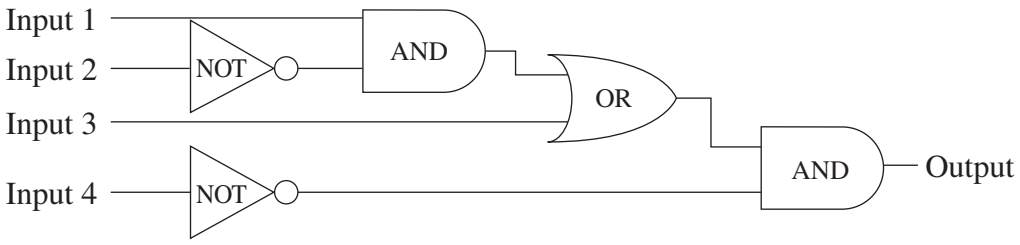
(c) Digital logic is used to control the operation of doors on a train. The doors will open only when the train is not moving and either an emergency occurs, or when requested by the driver if the brakes are on. **2**

Inputs		
Emergency	No Yes	0 1
Driver request	No Yes	0 1
Train moving	No Yes	0 1
Brakes off	No Yes	0 1

Output		
Doors open	No Yes	0 1



Using the information above, identify inputs 1, 2 and 3 to ensure the correct operation of the train doors. Input 4 has been identified.

Input 1: .....

Input 2: .....

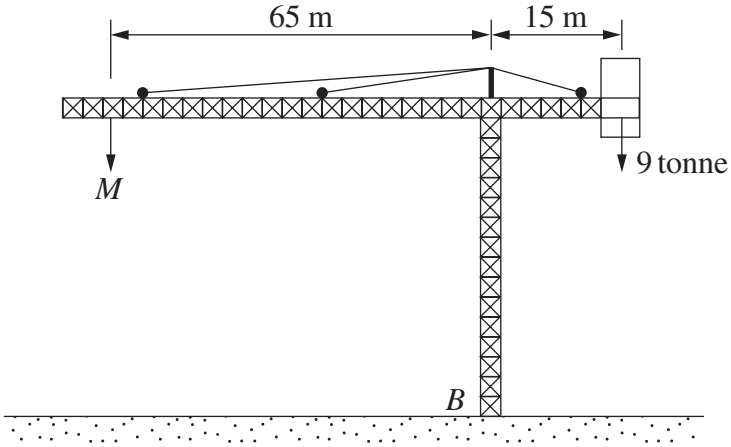
Input 3: .....

Input 4: Train moving.....

End of Question 13

Question 14 — Lifting Devices (10 marks)

(a) A tower crane is used on a building site.



(i) Calculate the mass, M, that can be balanced by the 9 tonne counterweight. Neglect the mass of the jib. **1**

Mass ..... tonne

(ii) Assume the jib and tower trusses have a total mass of 4 tonne acting down the axis of the tower. **3**

Calculate the magnitude of the reactions at B with the 9 tonne counterweight in place and with no mass at M.

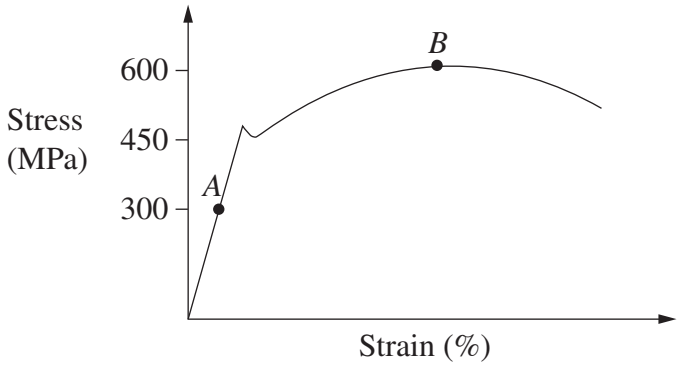
Vertical reaction ..... kN

Moment reaction ..... MNm

Question 14 continues on page 18

Question 14 (continued)

(b) A bolt used in the crane structure shown in part (a) is subjected to a tensile test which produces a stress/strain graph as shown.



The maximum allowable stress in service for the bolt is marked as Point *A*.

(i) Explain why the stress value at *A* is used for calculations instead of the stress value at *B*. **2**

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(ii) Calculate the minimum diameter of the bolt that will support a tensile load of 76.35 kN with a maximum allowable stress of 300 MPa. **2**

Diameter ..... mm

(c) A permanent magnet DC motor is connected to a constant mechanical load. **2**

Describe how pulse width modulation (PWM) is used to vary the speed of the motor.

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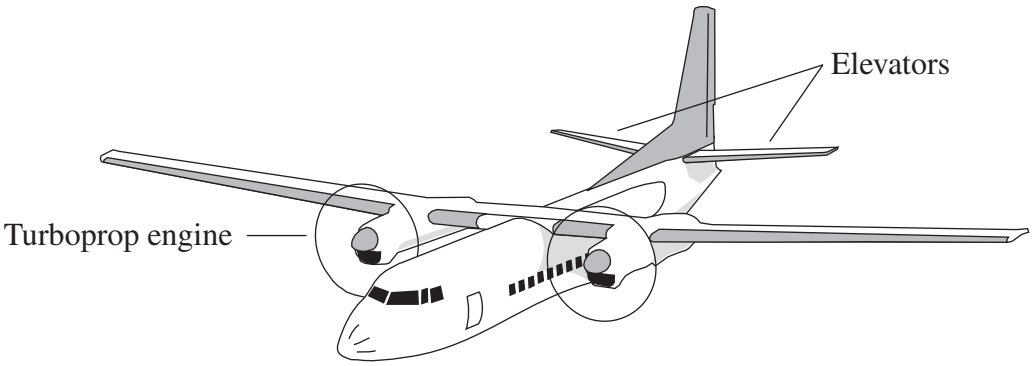
End of Question 14

Question 15 — Aeronautical Engineering (15 marks)

(a) The diagram shows features of a turboprop aircraft.



(i) Describe the operation of a turboprop engine to produce thrust. **2**

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(ii) In terms of airflow, how do elevators control the pitch of an aircraft? **2**

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Question 15 continues on page 20

Question 15 (continued)

(b) Polymer adhesives are widely used in structural applications in modern aircraft in place of metal rivets. **3**

Describe the advantages and disadvantages of the use of polymer adhesives in aircraft.

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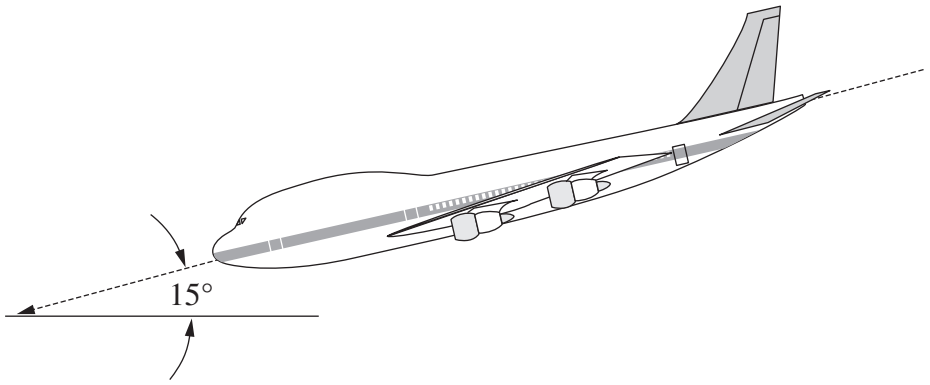
(c) An aircraft of mass 300 tonnes is in a steep descent. The aircraft has a lift to drag ratio (L:D) of 8:1. **2**



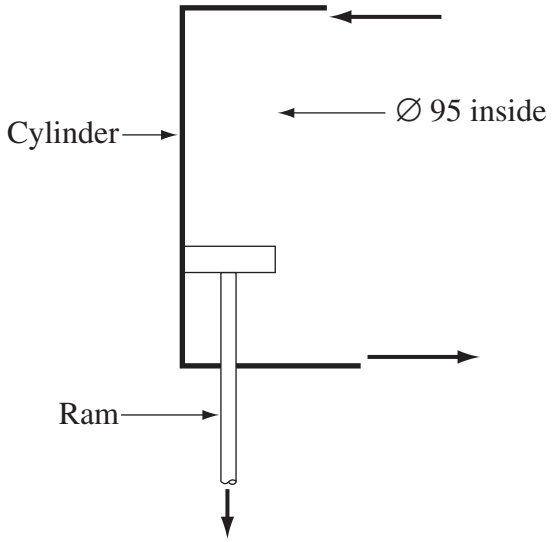
Calculate the drag while maintaining constant velocity.

Drag ..... kN

Question 15 continues on page 21

Question 15 (continued)

(d) A double-acting hydraulic ram operates a control surface on an aircraft. A hydraulic pressure of 10.3 MPa is applied to the fluid inside the cylinder. **2**



Calculate the force produced on the ram.

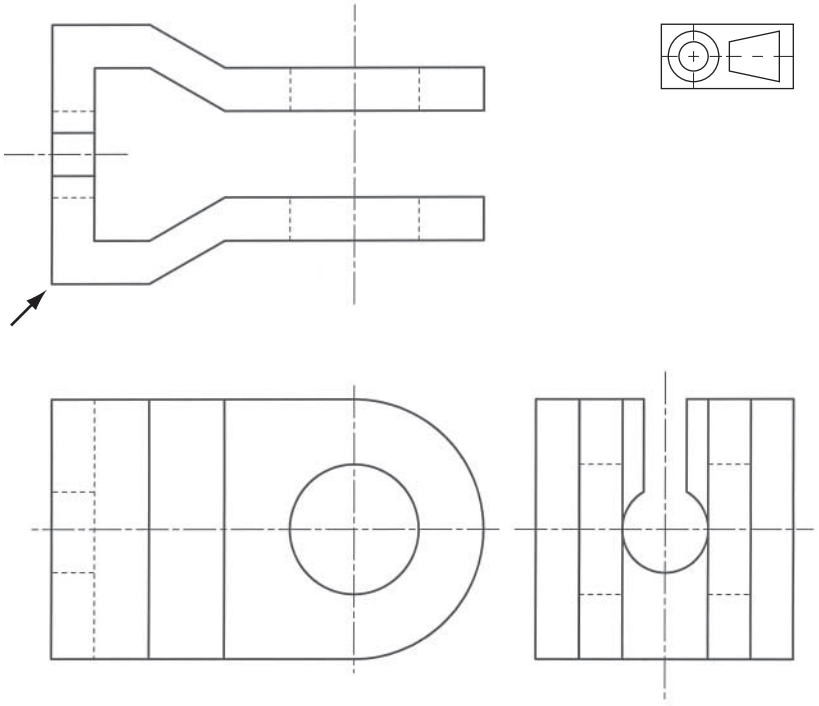
Force ..... kN

Question 15 continues on page 22

Question 15 (continued)

(e) Orthogonal views of an aircraft cable mount are provided. **4**

Draw a pictorial sketch of the mount from the direction of the arrow. Transfer sizes directly from the orthogonal views.



End of Question 15

Centre Number

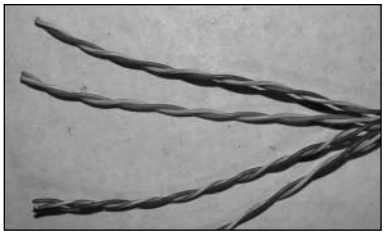
Section II (continued)

Student Number

Question 16 — Telecommunication (15 marks)

(a) Various cable types are used in telecommunications systems. **3**

List ONE advantage and ONE disadvantage of each of the following cable types.



Unshielded twisted pair

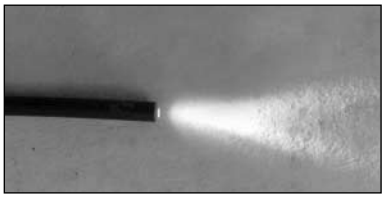
Advantage: .....

Disadvantage: .....

Coaxial

Advantage: .....

Disadvantage: .....



Optical fibre

Advantage: .....

Disadvantage: .....

Question 16 continues on page 24

Question 16 (continued)

(b) Describe the term *multiplexing* in the context of a telecommunications system. **2**

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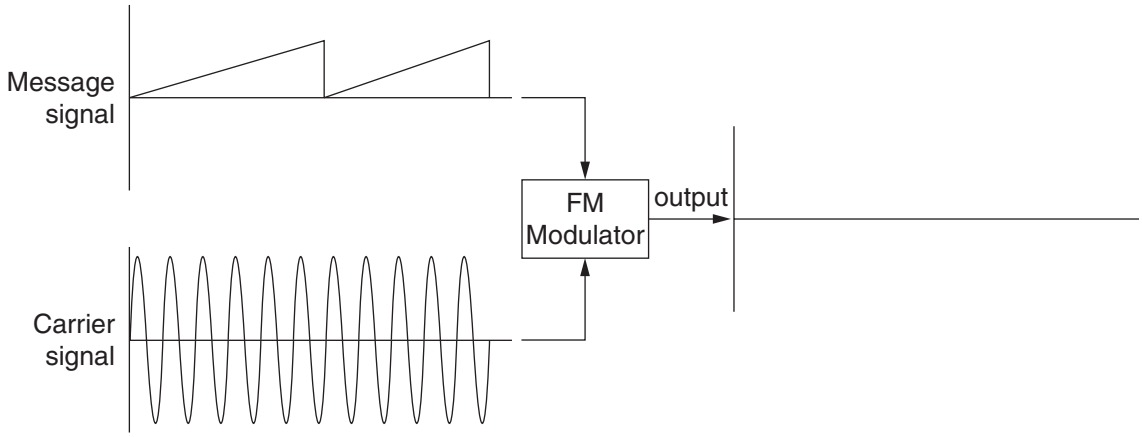
(c) Given the message and carrier signals below, sketch the output of the FM modulator. **2**



(d) Compare the modulation techniques used to transmit analogue television signals. **3**

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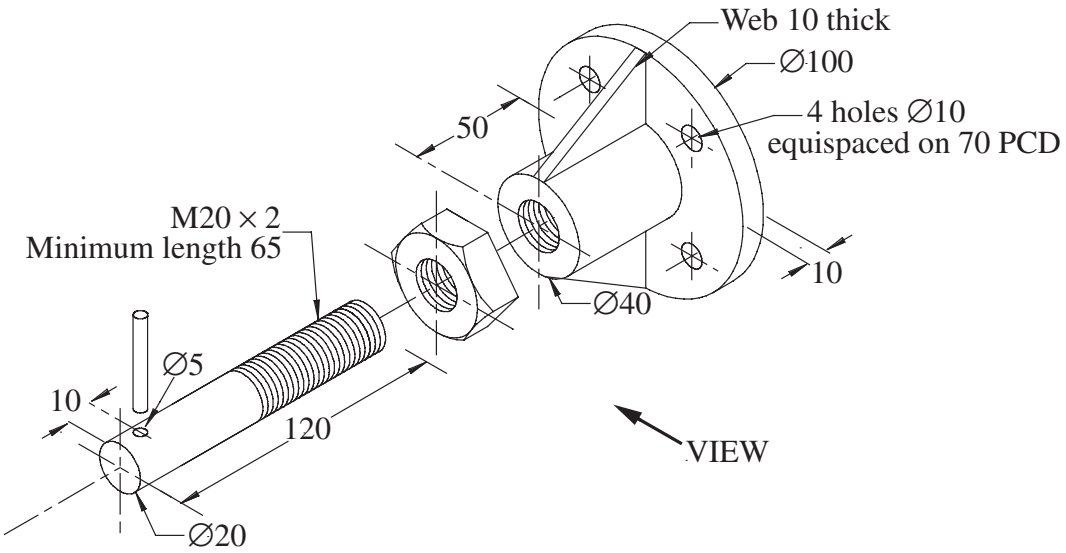
Question 16 continues on page 25

Question 16 (continued)

(e) An isometric view of an antenna anchor for a guy wire is given. **5**



Sketch a full sectional front view of the assembled antenna anchor from the direction of the arrow.

Scale: Full size

End of Question 16

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Engineering Studies

Centre Number

Section III

Student Number

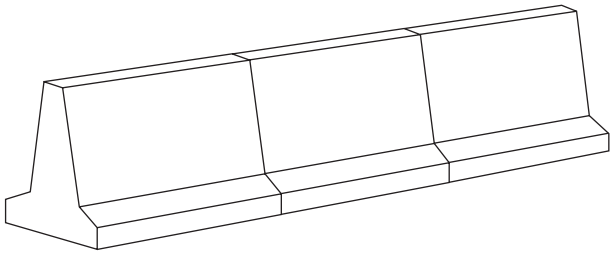
20 marks
Attempt Questions 17–18
Allow about 40 minutes for this section

Answer the questions in the spaces provided.

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

Two different types of roadside crash barriers are shown.

Cable barrier



Concrete barrier

(a) (i) Outline the social benefits of using crash barriers on roads. **2**

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(ii) Explain how barriers such as these function to reduce the severity of road accidents. **2**

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Question 17 continues on page 28

Question 17 (continued)

(b) (i) In an engineering report, what criteria would an engineer use to compare the performance of the cable and concrete barriers? **2**

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(ii) Explain why an engineer would recommend using steel for the cable and polypropylene for the posts in the cable barrier system. **2**

Steel cable

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Polypropylene posts

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(c) If the maximum strain in a cable is 0.02, calculate the maximum force that can be applied to the cable, where Young's modulus, E, is 195 GPa and Area, A, is 180 mm^2. **2**

Maximum force ..... kN

End of Question 17

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

The use of the *Smart Pole* enhances the display of traffic management, street signage, ambient lighting and other visual elements of an intersection.

Traditional intersection with street and traffic lights

Smart Pole intersection

(a) What criteria, other than installation cost, would an engineer use to determine the feasibility of installing a *Smart Pole* system in a city? **2**

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Question 18 continues on page 30

(b) Polycarbonate and aluminium alloy are being considered as alternative materials for a traffic light housing. **3**

Compare the use of these materials for this application.

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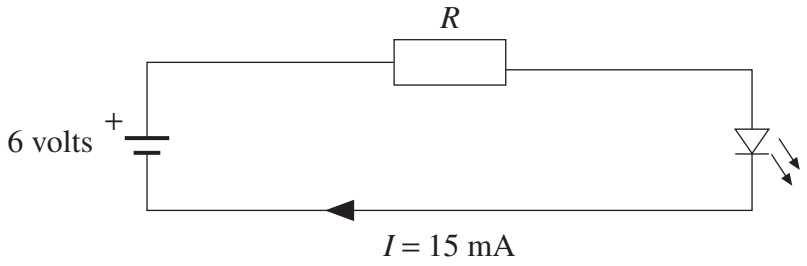
(c) Incandescent lamps are being replaced with solid state LED devices in traffic lights.

(i) Shown below is a simple circuit to drive a single LED. **2**



For correct operation the required voltage drop across the LED is 1.5 V.

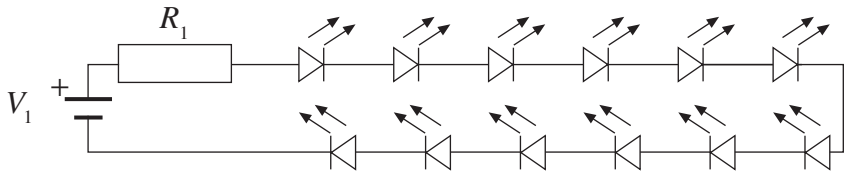
Using Ohm's law ($V = IR$), determine the value of the resistance R for correct operation, when the desired current I is 15 mA.

Resistance ..... Ω

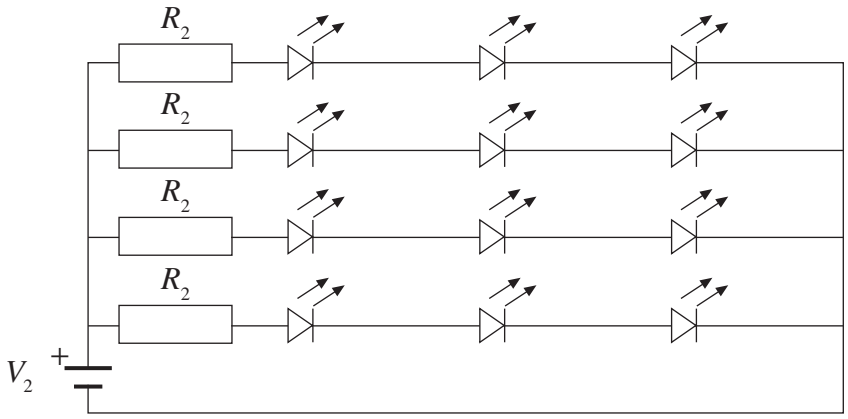
Question 18 continues on page 31

(ii) Two possible circuits used to drive a cluster of 12 LEDs for a traffic light are shown. **3**

Circuit 1



Circuit 2



Choose ONE of these circuits and justify the choice for use in traffic lights.

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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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