BOARD OF STUDIES
NEW SOUTH WALES

2010

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, 31 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 9–27

70 marks

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

Section III Pages 31–35

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 What property of a material does the area under the stress–strain curve measure?

(A) Toughness

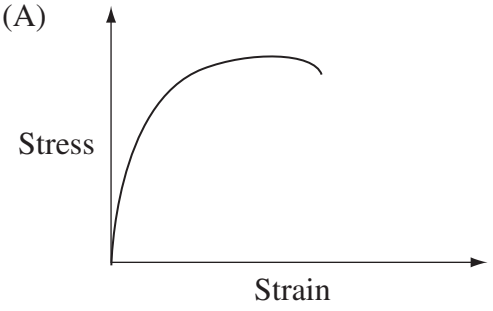
(B) Shear strength

(C) Ultimate tensile strength

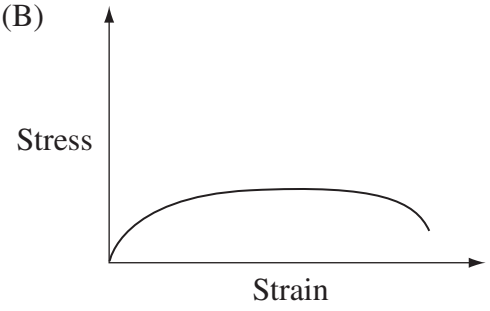
(D) Percentage elongation at failure

2 Which of the following stress–strain curves is typical of glass under tensile load?

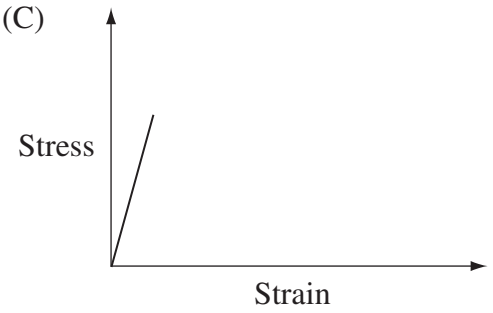
(A)



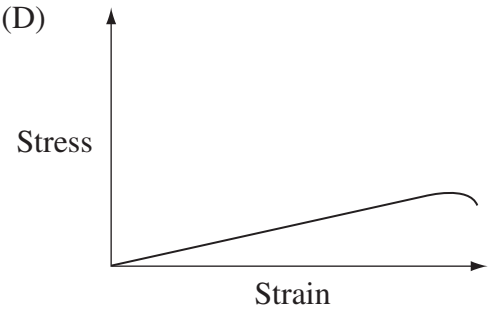
(B)



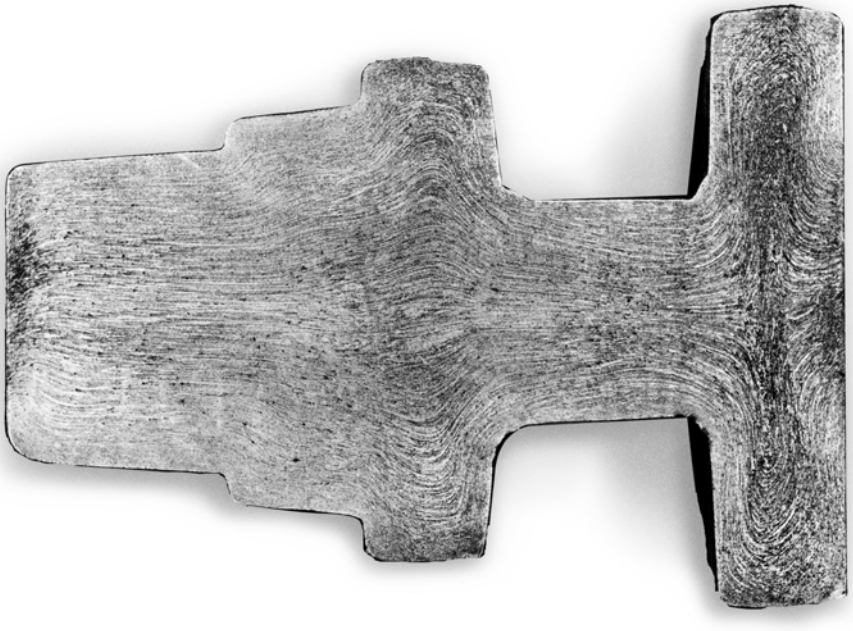
(C)



(D)



3 The grain structure can be seen on a gear blank that has been sectioned and etched.



Which manufacturing process would produce the grain structure shown?

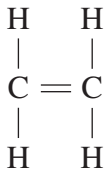
(A) Casting

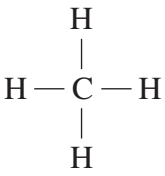
(B) Rolling

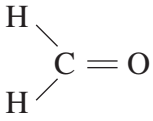
(C) Forging

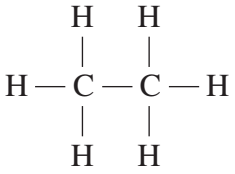
(D) Machining

4 Which molecule would form polyethylene by addition polymerisation?

(A) 

(B) 

(C) 

(D) 

5 Which statement best describes pre-stressed concrete?

(A) A concrete structure is loaded before it is fully cured.

(B) Mild steel rods are cast into concrete to resist tensile forces.

(C) Tensile forces are applied to embedded cables after concrete has cured.

(D) Concrete is cast around high strength cables previously placed in tension.

6 When considering static friction, the normal force

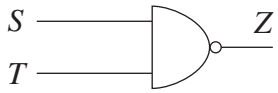
(A) is always vertical.

(B) is always horizontal.

(C) equals the friction force.

(D) is always perpendicular to the friction surface.

7 A NAND gate is a common digital logic element with the following truth table.



NAND gate

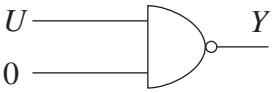
S	*T*	*Z*
0	0	1
0	1	1
1	0	1
1	1	0

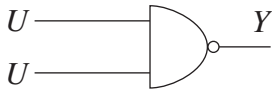
The truth table for a NOT gate is shown.

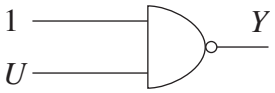
NOT gate

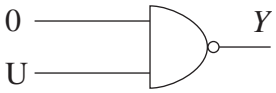
U	*Y*
0	1
1	0

Which of the following circuits represents a NOT gate created using a NAND gate?

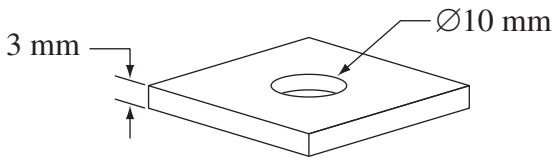
(A) 

(B) 

(C) 

(D) 

8 The ultimate shear stress of the steel plate shown is 450 MPa.



What is the force required to punch the hole?

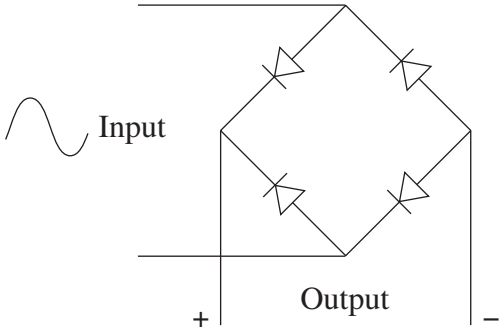
(A) 14.1 kN

(B) 35.3 kN

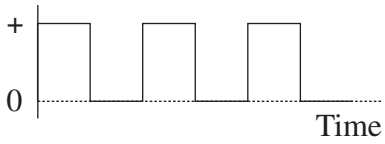
(C) 42.4 kN

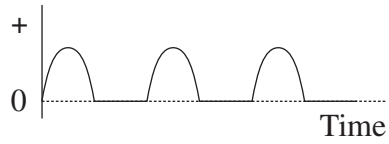
(D) 114.0 kN

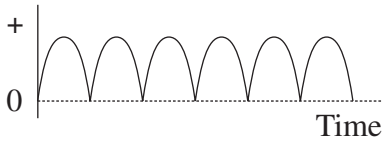
9 A full wave bridge rectifier with an AC input is shown.

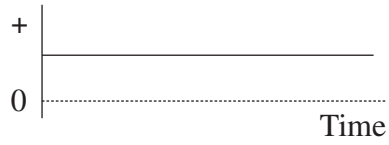


Which voltage–time graph best represents the output?

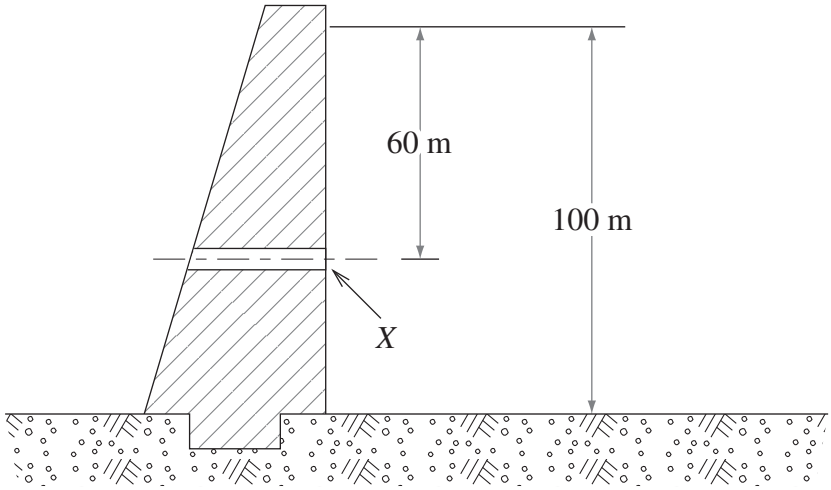
(A)


(B)


(C)


(D)


10 The dam shown holds 80 megalitres of water.



What is the approximate pressure at the centre of the outlet pipe indicated at *X*?

(A) 400 kPa

(B) 600 kPa

(C) 1 MPa

(D) 8 MPa

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2010 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

Centre Number

Section II

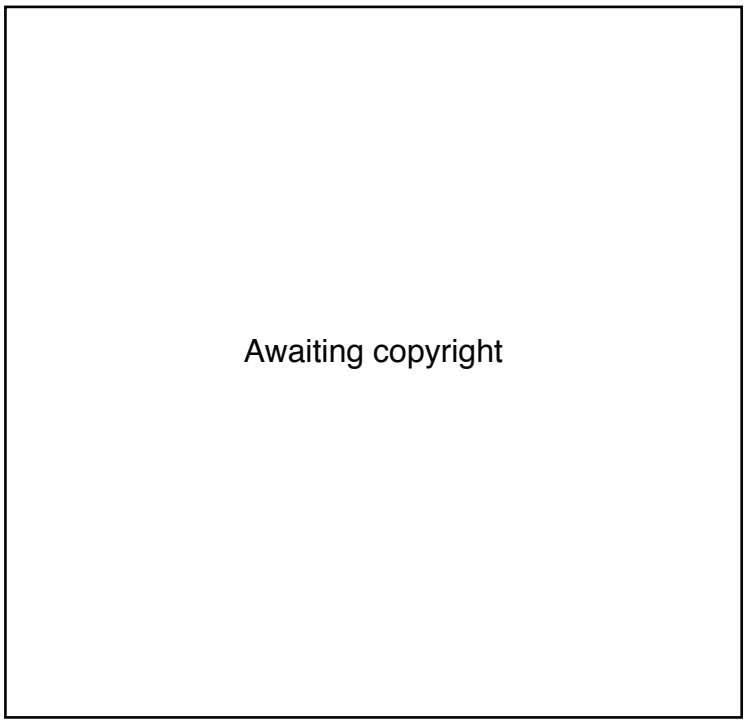
Student Number

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 image shows a hydraulically operated passenger lift from the early 1900s.



(a) Explain the use in lift construction of ONE modern engineering material that was not available in the 1900s. **2**

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Question 11 continues on page 10

Question 11 (continued)

(b) Outline the roles of an engineer in the design and safe operation of modern passenger lifts. **3**

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(c) Outline the impacts of passenger lifts on society and the built environment. **3**

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(d) Describe how a total lift travel of 8 m could be achieved with a hydraulic ram having only 2.5 m of installation height. **2**

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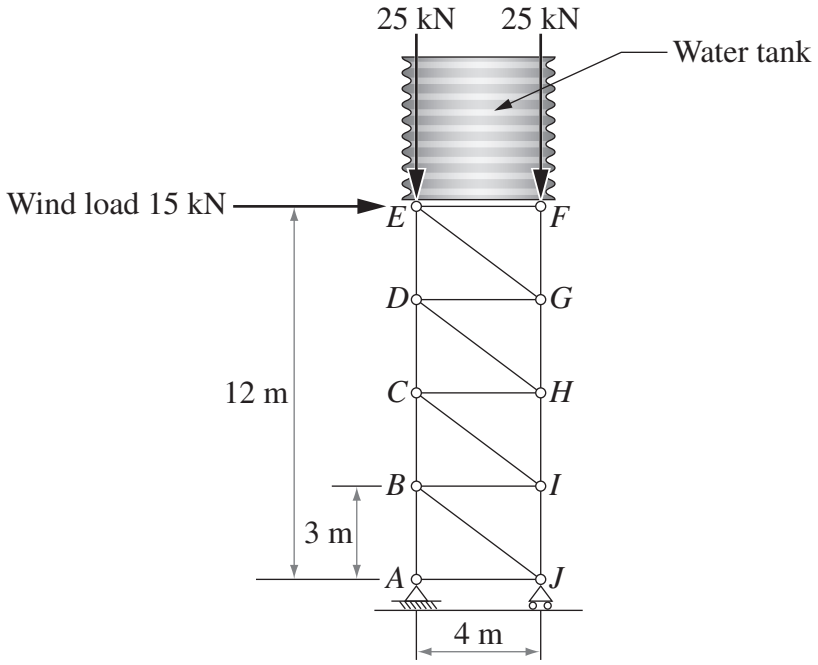
End of Question 11

Question 12 — Civil Structures (10 marks)

Please turn over

Question 12 — Civil Structures (10 marks)

A pin-jointed truss is loaded as shown.



(a) (i) Calculate the magnitude of the vertical reactions at *A* and *J*, and the horizontal reaction at *A*. **2**

	Horizontal	Vertical
A	kN	kN
J		kN

Question 12 continues on page 13

(ii) Calculate the magnitude of the force in member *BJ*. **2**

Force *BJ* = ... kN

(iii) How could this truss be redesigned to make it more rigid against varying wind direction without changing the types of materials used? Use a sketch in your answer. **2**

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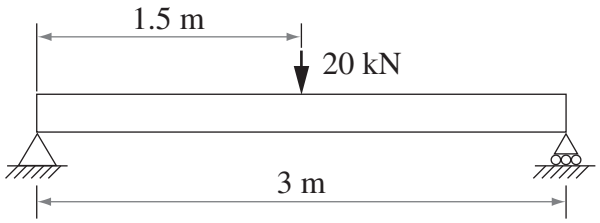
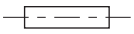
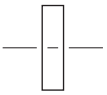
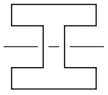
Question 12 continues on page 14

Question 12 (continued)

(b) A beam is to be constructed using one of the cross-sectional shapes in the table below. The beam is to be loaded as shown.



Beam	*Cross-sectional shape*	I_{xx} (mm^4)	y_{max} (mm)	A (mm^2)
A		0.8×10^6	16	350
B		72.0×10^6	150	350
C		94.3×10^6	150	350
D		120.7×10^6	150	350

(i) Select the most suitable cross-sectional shape for the beam. Give a reason for your selection. **1**

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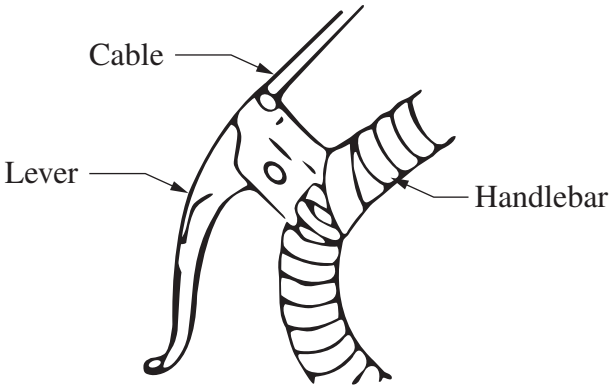
(ii) Calculate the maximum bending stress in the chosen beam. **3**

..... MPa

End of Question 12

Question 13 — Personal and Public Transport (10 marks)

(a) (i) Pressure die-casting is used to manufacture the lever for a brake assembly. Identify a suitable material for this product. **1**



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(ii) Describe the process of pressure die-casting this brake lever. **3**

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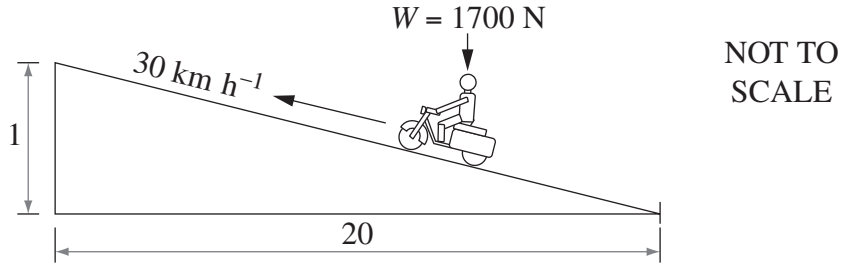
Question 13 continues on page 16

Question 13 (continued)

(b) An electric motor scooter is ridden up a slope of 1 in 20 as shown.



(i) Calculate the power required to maintain a constant velocity of 30 km h^{-1}. **2**

Power = ... kW

(ii) In another situation the power required is 600 W. Calculate the current drawn from the scooter's 12-volt battery to maintain a constant uphill velocity. **2**

$P = VI$ P = Power
V = Voltage
I = Current

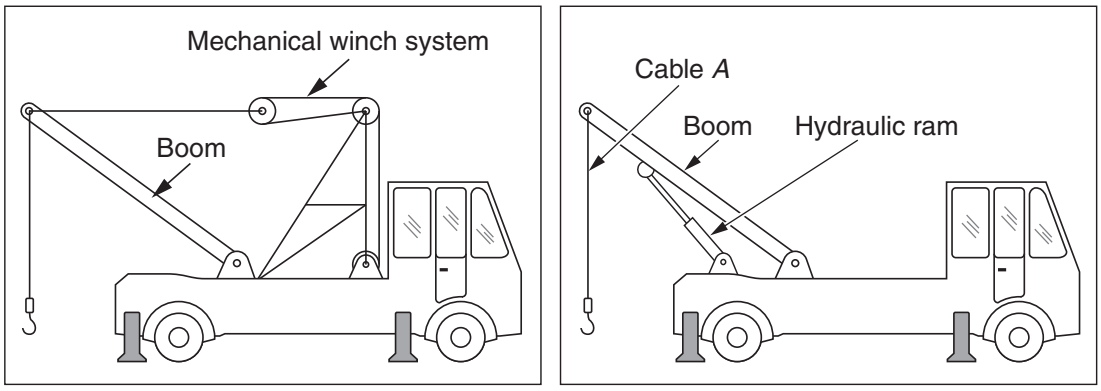
Current = ... A

(iii) A different electric motor scooter has a 12-volt battery rated at 20 ampere hours. Calculate the maximum distance it can travel if it draws 45 Amperes when travelling at a constant speed of 25 km h^{-1}. **2**

Distance = ... km

Question 14 — Lifting Devices (10 marks)

(a) Two different crane types are shown.



(i) What are the advantages of the hydraulic system compared with the mechanical system for operating the boom? **2**

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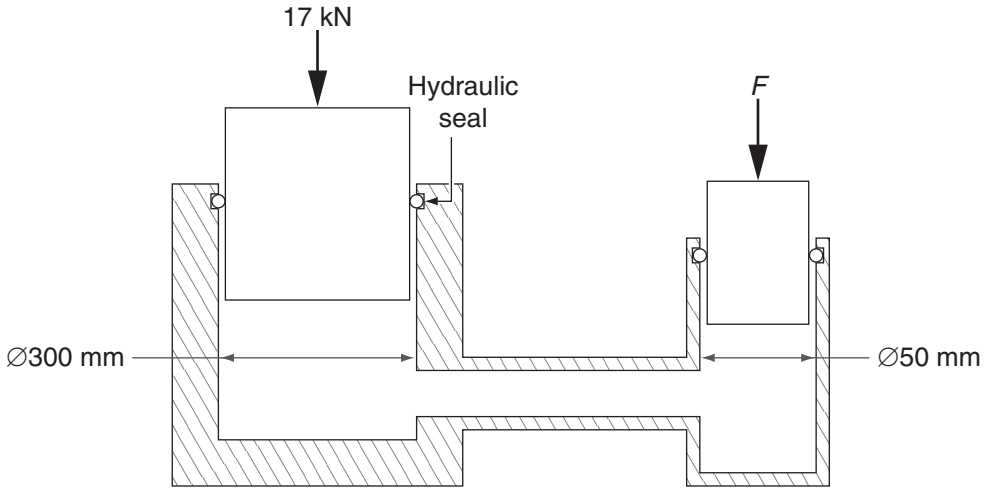
(ii) If a 2 tonne mass at the end of cable *A* is accelerated upwards at 0.4 m s^{-2}, what is the tension in cable *A*? (Assume the cable mass to be negligible.) **2**

Tension in cable *A* = ... N

Question 14 continues on page 18

Question 14 (continued)

(b) A sectioned diagram of a hydraulic system is shown.



(i) Calculate the force (F) that must be applied at the small cylinder to lift a 17 kN load. **2**

Force = ... kN

(ii) Justify your choice of a suitable material for the hydraulic seals. **2**

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(c) Describe ONE destructive test that could be used to ensure quality control of steel crane hooks during manufacture. **2**

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Question 15 — Aeronautical Engineering (15 marks)

(a) Commonly, recreational aircraft are powered by piston driven internal combustion engines. **2**

Apart from cost, why is this type of engine suitable for these aircraft?

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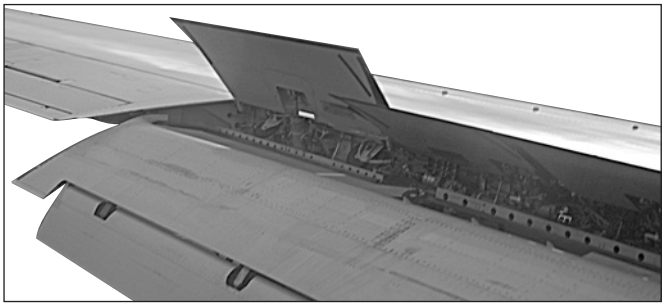
(b) The photo shows airbrakes in place as an aircraft lands. **2**



Explain how an airbrake operates to slow an aircraft during landing.

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Question 15 continues on page 20

Question 15 (continued)

(c) Composites, such as reinforced carbon and aramid fibre (Kevlar®) are increasingly being used in modern aircraft production. **2**

Excluding cost, compare the use of these composites over the use of traditional materials such as aluminium alloys.

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(d) An aircraft has an age-hardened duralumin skin. During operation 250°C exhaust gases are inadvertently directed onto the skin of the aircraft. **2**

Describe how this would affect the mechanical properties of the skin.

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(e) The outer skin on modern aircraft frames is generally made from sheet Alclad – a high strength aluminium alloy coated with a thin layer of pure aluminium. Explain the advantage of this material over the use of sheet aluminium alloy. **2**

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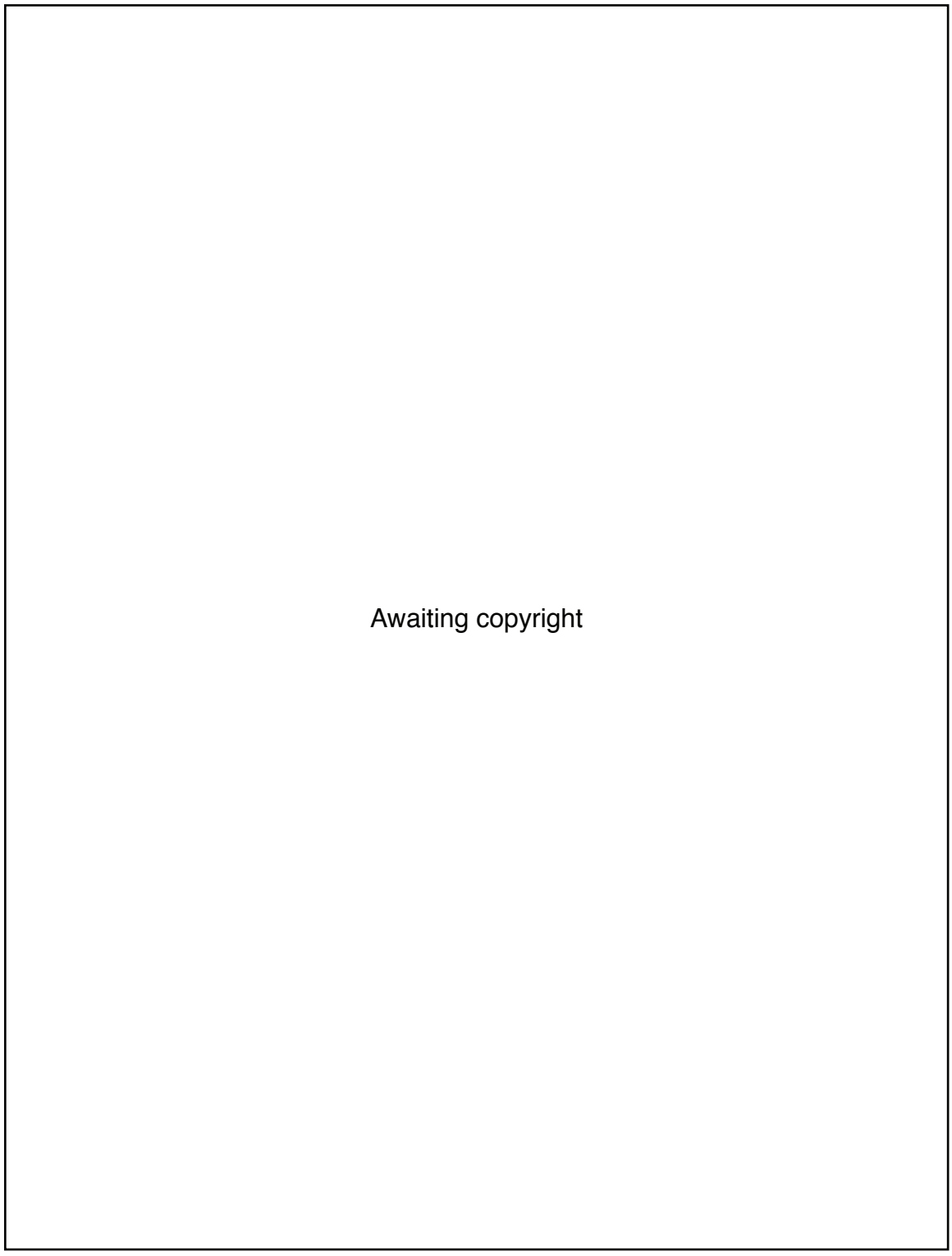
Question 15 continues on page 21

Question 15 (continued)

(f) A partially-sectioned, exploded isometric drawing of a propeller assembly is shown. **5**

Sketch a full-sectioned orthogonal view of the assembled parts on the centre line given. Use a scale of 1 : 2. Show one nut, bolt and washer in place only. View from the direction of the arrow A.

Part of the outline of the shaft is given as a starting point.



End of Question 15

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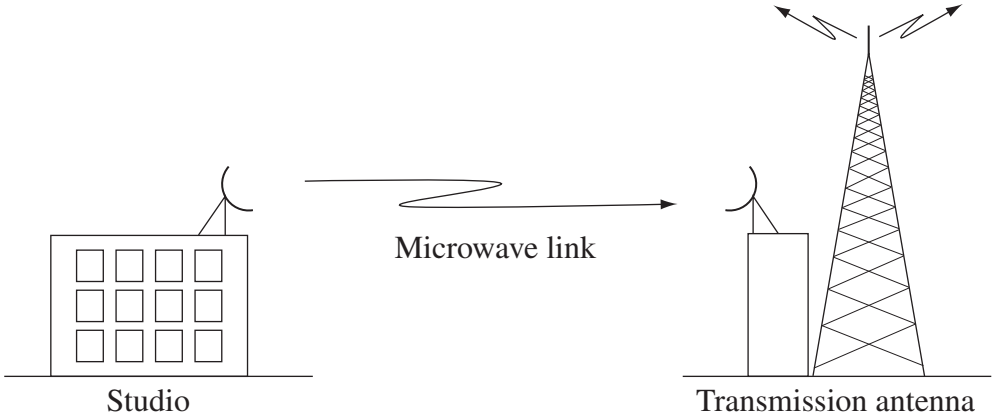
Question 16 — Telecommunication (15 marks)

(a) A microwave communication link exists between a particular television studio and a transmission antenna as shown.



(i) Name the transmission medium used in the microwave link. **1**

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(ii) What are the characteristics of the microwave communication link between the studio and the antenna? **2**

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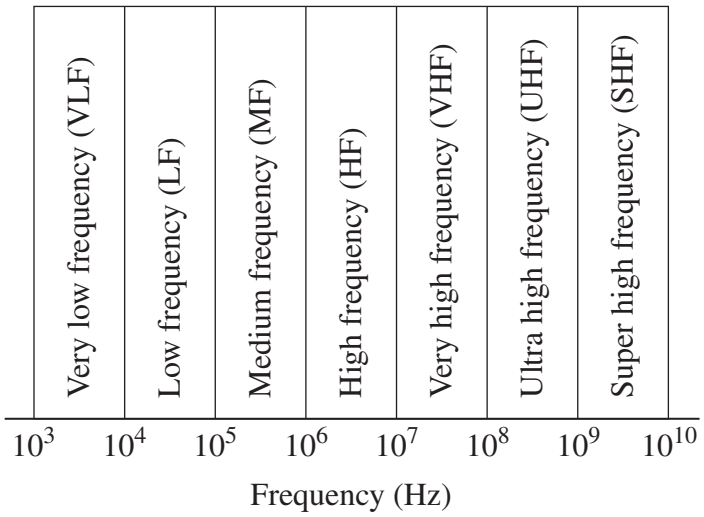
Question 16 continues on page 24

Question 16 (continued)

(iii) Which frequency band would typically represent that used in a microwave communication link? **1**



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Question 16 continues on page 25

Question 16 (continued)

(b) An analogue signal must be sampled and quantised before it can be used in a digital communication system.

(i) Describe the sampling process. **2**

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(ii) Describe the quantisation process. **2**

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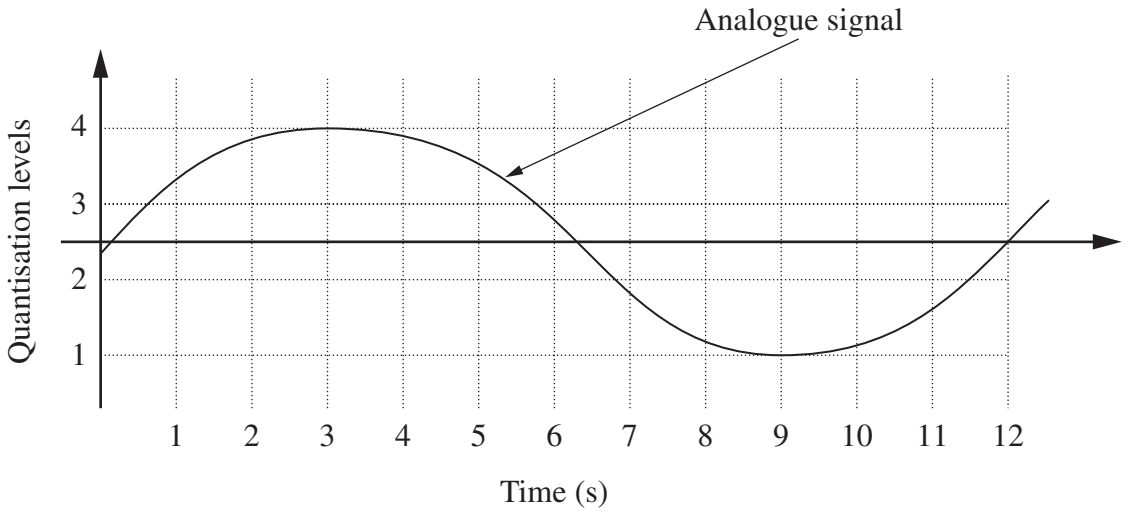
(iii) Sketch the resultant waveform on the graph after sampling the analogue signal every one second with four levels of quantisation. **2**

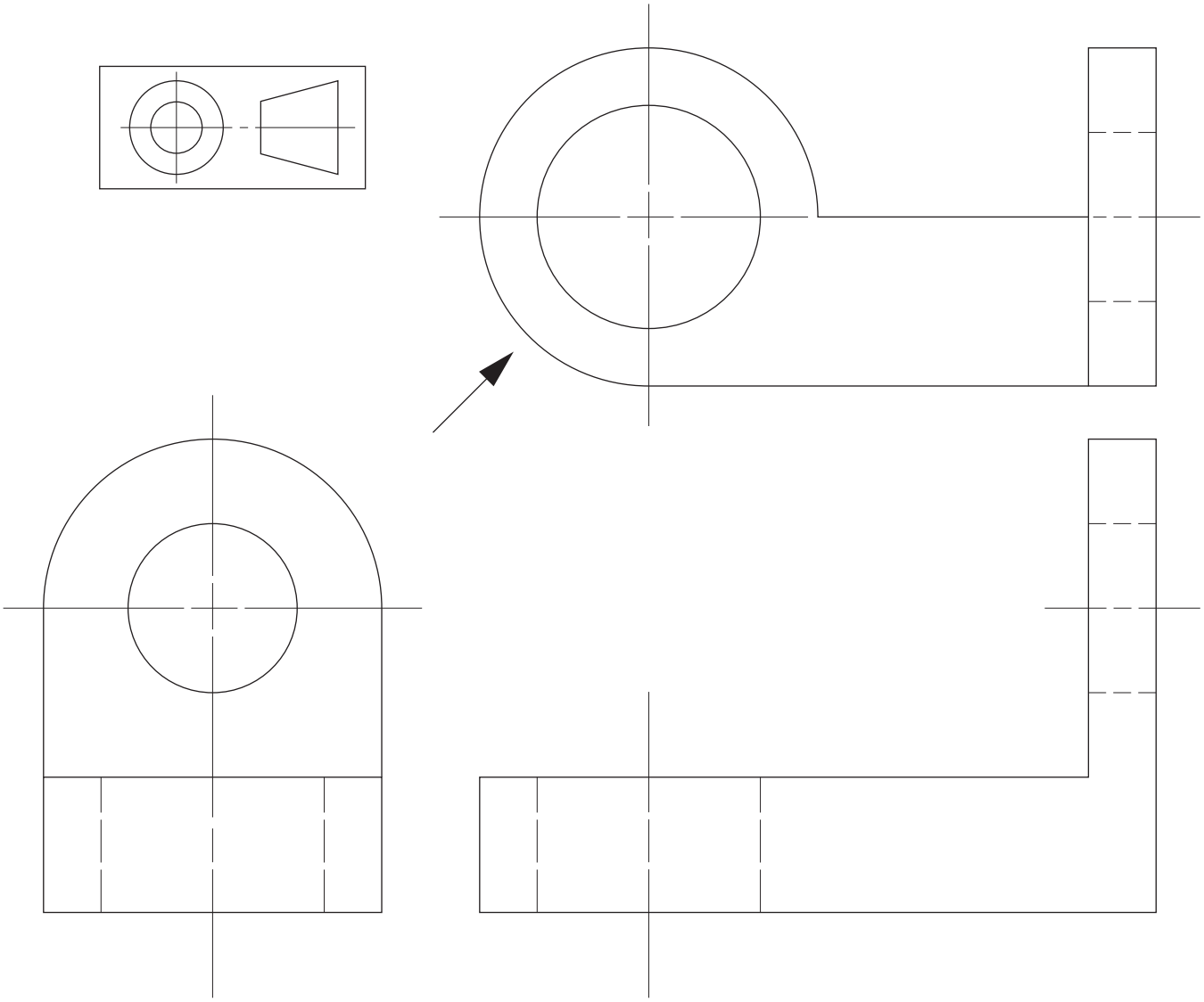


Question 16 continues on page 26

Question 16 (continued)

(c) Orthogonal views of an antenna bracket are given. **5**

Draw a full size pictorial sketch of the bracket viewed from the direction of the arrow. Take measurements from the orthogonal drawing.



Answer this question on page 27

End of Question 16

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2010 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

Centre Number

Section III

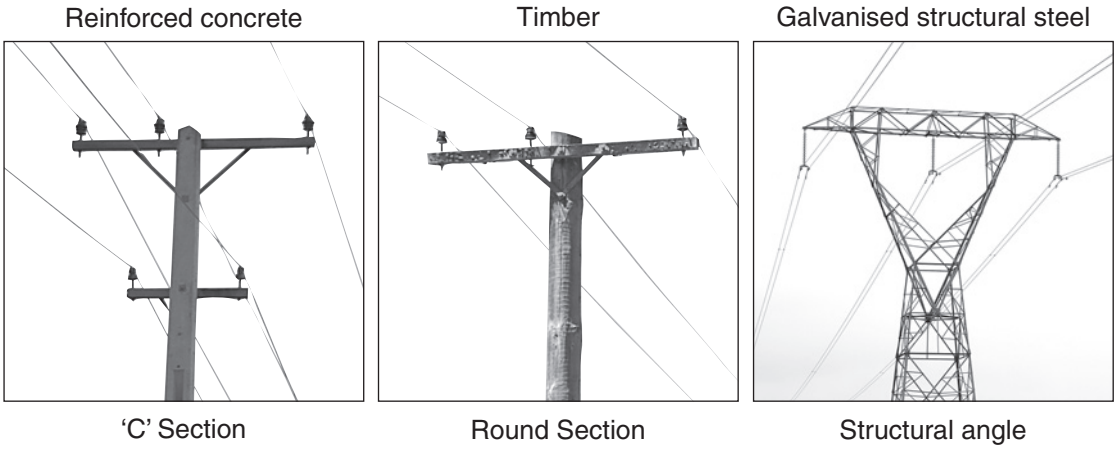
Student Number

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

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

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

(a) Power poles are made from different materials and structural sections as shown.



(i) Which selection criteria should be used to determine the most suitable pole for a particular installation? **2**

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Question 17 continues on page 32

(ii) Compare the properties of reinforced concrete and timber in terms of their use in power poles. **2**

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(iii) Identify ONE social and ONE environmental impact that power poles could have. **2**

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(b) (i) Explain the differences that might be found in engineering reports prepared for different stakeholders. **2**

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(ii) Explain the advantages of transmitting electrical power at high voltages. **2**

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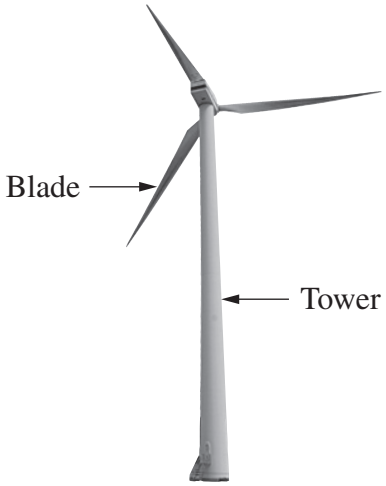
End of Question 17

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

(a) Wind turbines generate electricity as wind passes over the blades, causing them to rotate and transfer mechanical energy to a generator.



(i) Which factors would an engineer consider when selecting an appropriate site for installing several wind turbines? **2**

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(ii) Name and justify the use of TWO engineering materials which could be used in large modern wind turbine blades. **3**

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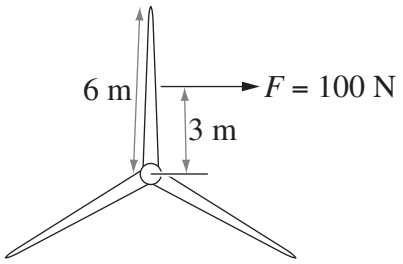
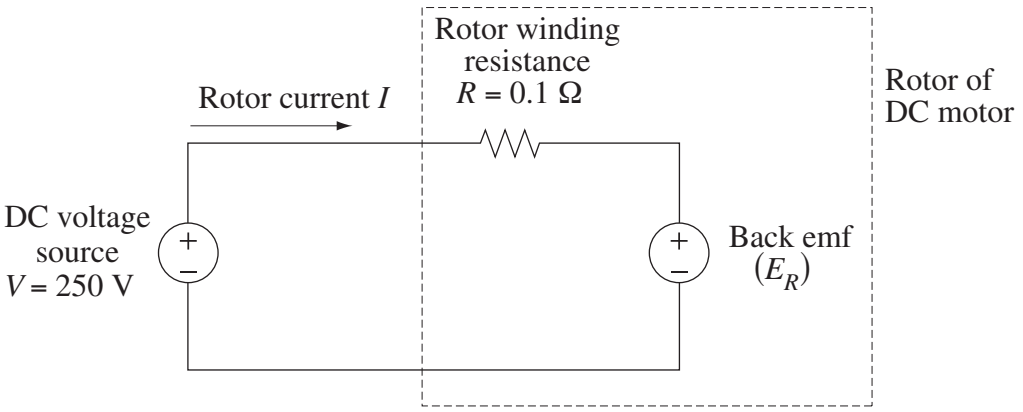
Question 18 continues on page 34

(iii) A wind turbine produces an equivalent rotational force of 100 N per turbine blade acting 3 m from the centre of the turbine. Calculate the total torque to be transmitted to the generator. **1**



Torque = ... N m

(b) A separately excited DC motor is used to raise and lower an elevator. The stator is supplied with a constant current.



(i) Explain, in terms of rotor current and back emf, the effect of increasing the mechanical load on the motor. **2**

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Question 18 continues on page 35

Question 18 (continued)

(ii) To raise an unloaded elevator, a rotor current of 75.9 amperes is required. Using Ohm's law $(V = IR)$, calculate the back emf (E_R). **2**

Back emf (E_R) = ... V

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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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