NSW Education Standards Authority

2024 HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

General Instructions
- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA 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 this page

Total marks: 100

Section I – 20 marks (pages 2–11)
- Attempt Questions 1–20
- Allow about 30 minutes for this section

Section II – 80 marks (pages 13–42)
- Attempt Questions 21–27
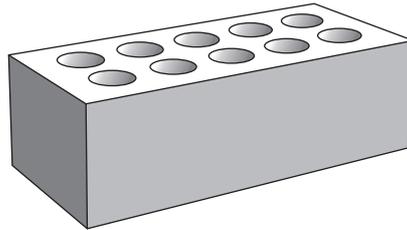- Allow about 2 hours and 30 minutes for this section

Section I

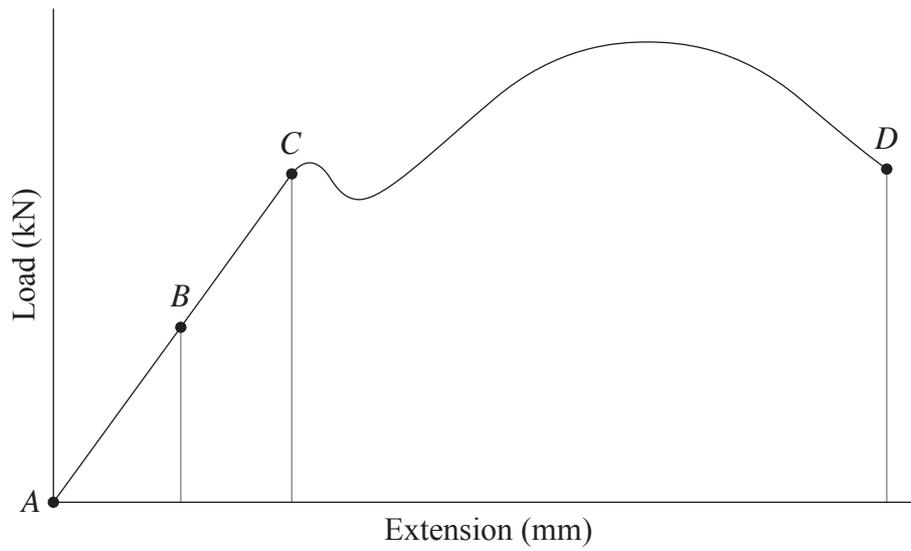**1** A common house brick is shown.

Which forming process was used to manufacture the brick?

A. Forging

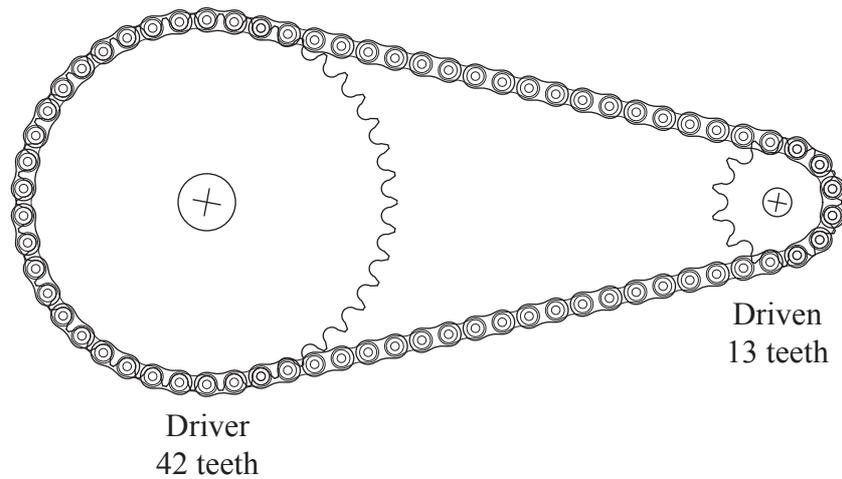B. Extrusion

C. Slip casting

D. Shell moulding

2 A load-extension diagram for a mild steel specimen is shown.

Which letters indicate the area under the curve in which the specimen will permanently change its size and shape?

A. *AB*

B. *AC*

C. *BD*

D. *CD*

3   A simplified image of a bicycle chain drive is shown.

Driven
13 teeth

Driver
42 teeth

If a cyclist is pedalling at 70 revolutions per minute (RPM), what is the RPM of the driven wheel?

A.   3.2

B.   21.7

C.   226.2

D.   546.0

4   Which row of the table correctly identifies characteristics of analogue and digital communications?

	Analogue	*Digital*
A.	Continuous (varying) signal Less susceptible to signal degradation	Discrete (binary) signal More susceptible to signal degradation
B.	Continuous (varying) signal More susceptible to signal degradation	Discrete (binary) signal Less susceptible to signal degradation
C.	Discrete (binary) signal Less susceptible to signal degradation	Continuous (varying) signal More susceptible to signal degradation
D.	Discrete (binary) signal More susceptible to signal degradation	Continuous (varying) signal Less susceptible to signal degradation

5   Which waveform diagram depicts an AM radio signal?

A.

B.

C.

D.
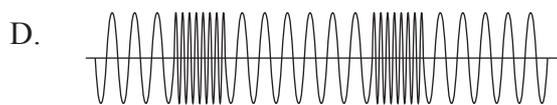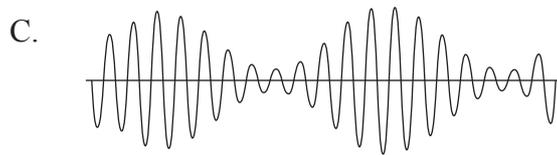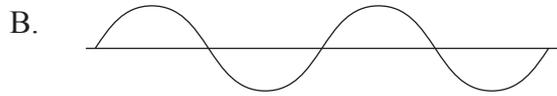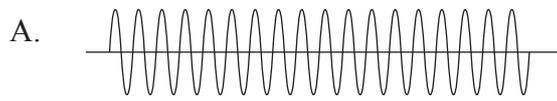
6   A shear force diagram is shown.
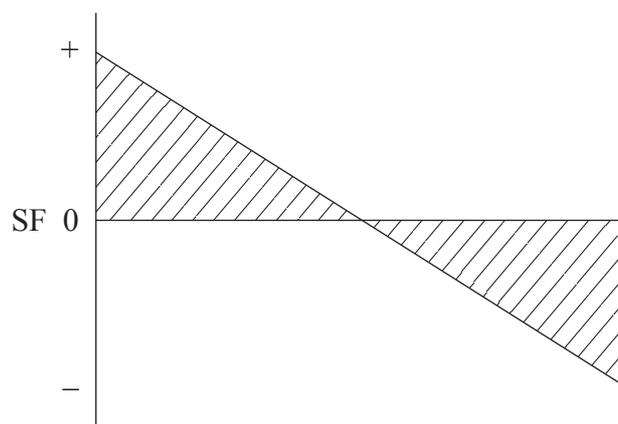
Which of the following beams is represented in the shear force diagram?

A.   A cantilevered beam with a point load

B.   A simply supported beam with a point load

C.   A cantilevered beam with a uniformly distributed load

D.   A simply supported beam with a uniformly distributed load

7   Which row of the table correctly identifies the types of cables?

A.	Coaxial	Fibre optic	High voltage transmission	Twisted pair
B.	High voltage transmission	Twisted pair	Fibre optic	Coaxial
C.	Coaxial	Twisted pair	High voltage transmission	Fibre optic
D.	High voltage transmission	Fibre optic	Coaxial	Twisted pair

8   The cross-section of a tapered tube is shown.
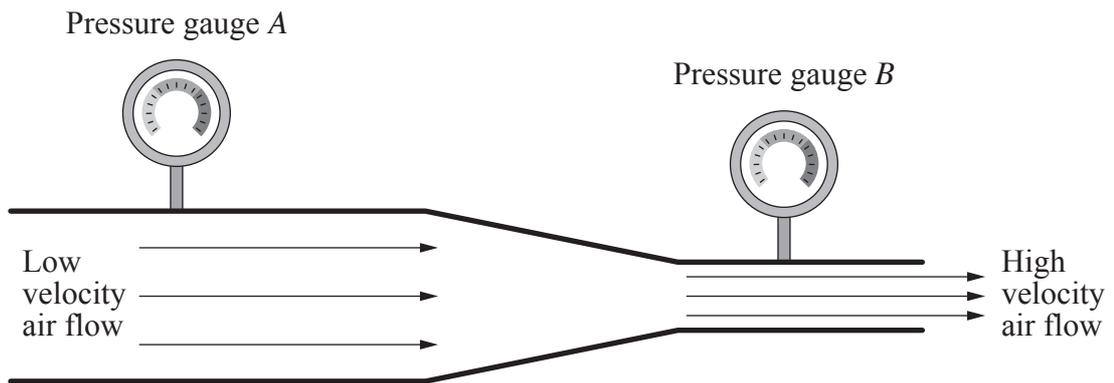
What are the pressure readings at both gauge *A* and at gauge *B* as the air flows through the tube?

	Pressure at gauge A	Pressure at gauge B
A.	High	High
B.	High	Low
C.	Low	Low
D.	Low	High

9 When producing glass, what molten material is the glass floated on in order to obtain a smooth surface?

    A.   Aluminium

    B.   Bronze

    C.   Steel

    D.   Tin

10 An inclined plane is 5 metres long and 2 metres high. A force of 50 N is required to push a box up along the length of the slope.
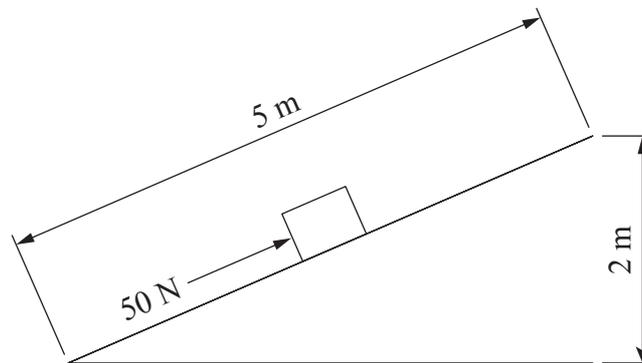
Assuming no friction and 100% efficiency, what is the mass of the box to the nearest kilogram?

    A.   5

    B.   13

    C.   20

    D.   125

11 Why are gap joints strategically placed in pedestrian footpaths?

    A.   To improve visual appeal

    B.   To improve wheelchair access

    C.   To allow for contraction and movement

    D.   To allow for movement of debris and water

12 What is the effect of increasing the angle of attack on the lift and induced drag of an aircraft?

	Lift	Induced drag
A.	Decreases	Decreases
B.	Decreases	Increases
C.	Increases	Decreases
D.	Increases	Increases

13 What is the primary function of GPS satellites?

A. Receiving magnetic field data for accuracy of location

B. Receiving signals from GPS devices to determine distance

C. Transmitting signals that provide accurate timing and positioning data

D. Transmitting weather system data to ground-based stations for tracking

14 Which propulsion system requires fuel and an oxidiser such as liquid oxygen to be carried on board?

A. Ramjet

B. Rocket

C. Turbofan

D. Turboprop

15 Which property is necessary in the manufacture of a sheet steel car door panel?

A. Fatigue

B. Ductility

C. Elasticity

D. Corrosion resistance

16 An I-beam is loaded as shown.
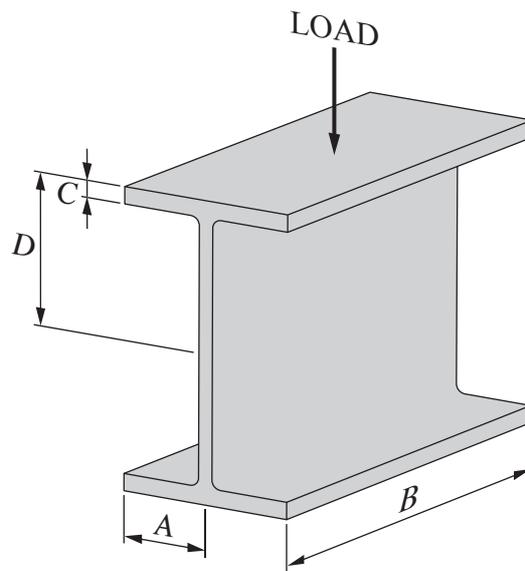
The load is then increased.

Which increase in dimension would provide the most resistance to bending?

A. *A*

B. *B*

C. *C*

D. *D*

17 Why is single-mode cable used for long distance telecommunications rather than other fibre optic cables?

A. It has lower power consumption.

B. It has greater attenuation over distance.

C It has a higher transmission rate and bandwidth.

D. It has a greater change to the index of refraction.

18   A transition duct in an aircraft air conditioning system is shown.
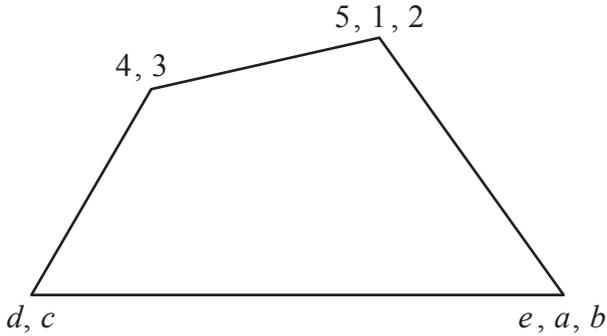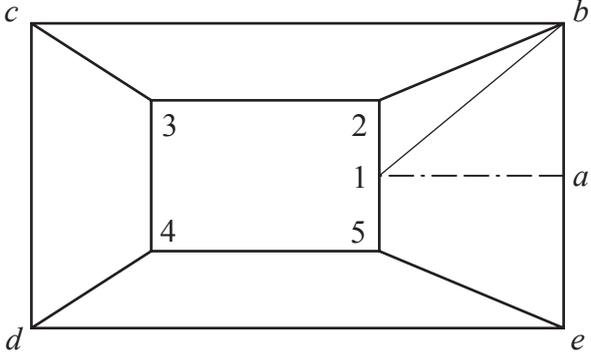
Which is the correct shape and size for side 1, *a, b,* 2 of the transition piece?

A.

B.

C.

D.
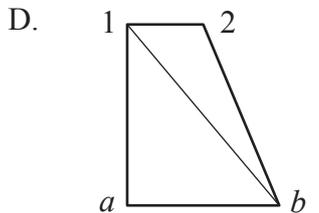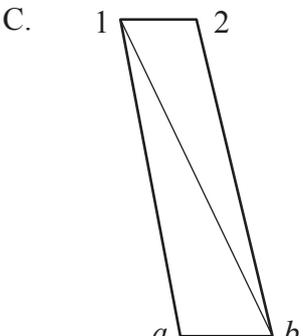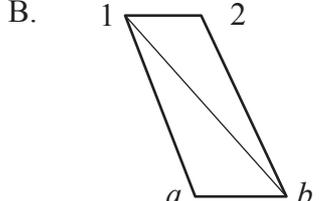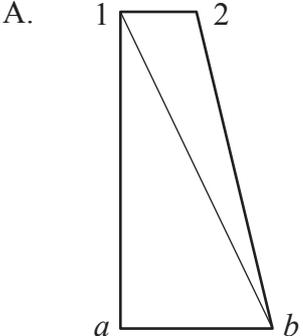
19 Which is the correct angle of repose for rock fill, used on a highway construction, that has a coefficient of friction of 0.84?

A. 20°

B. 30°

C. 40°

D. 50°

20 A cross-section of a beam is shown.
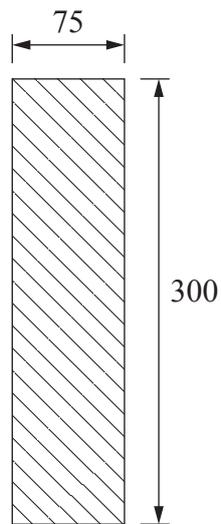
Which of the following is the maximum stress in the beam if the maximum bending moment is 200 kN m and I_{xx} is 168.75×10^{-6} m^4?

A. 177.8 MPa

B. 177.8 GPa

C. 355.6 MPa

D. 355.6 GPa

BLANK PAGE

Centre Number

Student Number

Engineering Studies

Section II Answer Booklet

80 marks
Attempt Questions 21–27
Allow about 2 hours and 30 minutes for this section

Instructions	• Write your Centre Number and Student Number at the top of this page.
	• Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
	• Show all relevant working in questions involving calculations.
	• Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

BLANK PAGE

5348310431

Question 21 (11 marks)

(a) Two piers from different eras, used to support civil structures, are shown. **2**

Outline how innovations in engineering materials have improved the inservice properties of piers.

....

....

....

....

....

7450310437

(b)   A geotextile used in the construction of a retaining wall is shown.   **3**

Why are geotextiles used in the construction of retaining walls?

....

....

....

....

....

....

....

Office Use Only – Do NOT write anything, or make any marks below this line.

4619310431

Question 21 (continued)

(c) Strap bracing is used in the construction of many residential structures. It has holes punched along its length to allow tensioners to be applied as shown.

3
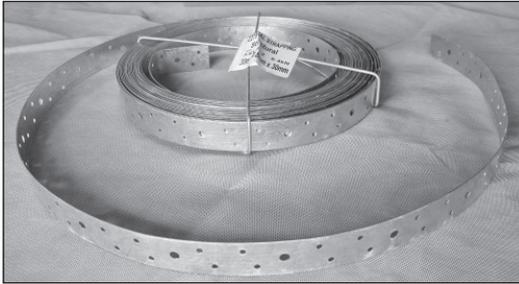
A 6 mm diameter hole is to be punched into mild steel strap bracing.

If the shear strength of the bracing is 380 MPa and the shear force required to punch the hole is 5.73 kN, what is the maximum allowable thickness of the strap bracing?

Maximum allowable thickness: .... mm

Question 21 continues on page 18

(d)   An orthogonal drawing of a strap brace tensioner is shown.   **3**

TOP VIEW

Hex serrated
flange captive nut
M5 × 0.8

R2.5 ±0.5

R18

60°

28

A

FRONT VIEW

2.5
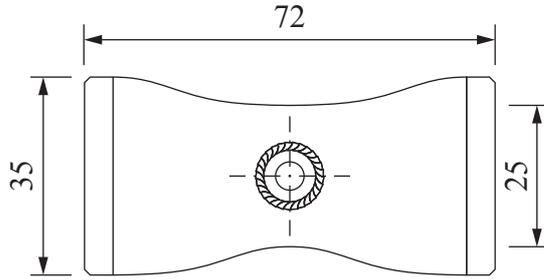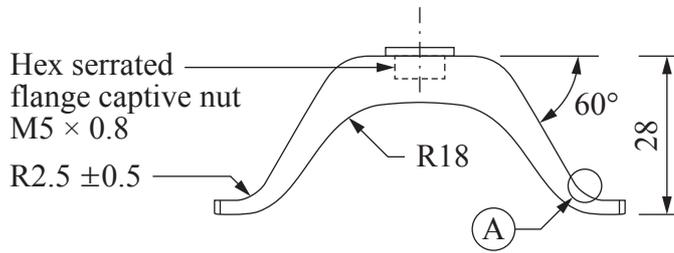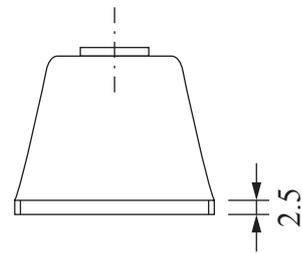
SIDE VIEW

TURBO ENCABULATOR SERVICES	**STRAP BRACE TENSIONER**	
ALL DIMENSIONS IN MM UNLESS OTHERWISE STATED	DRAWN:	
	CHECKED:	
MAT: GALZ275	SIZE: A4	DWG NO: 2 of 3
AS1100 ⊕◁	SCALE: NTS	SHEET 1 of 1

Office Use Only – Do NOT write anything, or make any marks below this line.

8840310431

Question 21 (continued)

With reference to the orthogonal drawing and modified title block, complete the table.

What does 'M' stand for in M5 × 0.8?	What is the allowable range for the R2.5 ±0.5 dimension?
....	....
Which dimension is not to AS1100?	What does the 0.8 refer to in the expression M5 × 0.8?
....	....
Name the tensioner material.	What is the unit of measurement used in this drawing?
....	....
What is the name of the curve indicated by letter A?	State ONE radial dimension.
....	....
What is the angle of projection?	Which line type is missing from the SIDE VIEW?
....	....

End of Question 21

7717310433

Question 22 (11 marks)

(a) Outline the environmental responsibilities of an aeronautical engineer. **2**

....

....

....

....

....

(b) The mass of a single-engine propeller aeroplane, without pilot or passengers, **3**
is 906 kg. It has a maximum lift to drag ratio of 10.5. When fully loaded, the
plane needs to produce 1050 N of thrust to maintain cruising speed and altitude.

What is the maximum total allowable mass for the pilot and passengers in
kilograms?

Maximum total allowable mass of pilot and passengers: .... kg

Question 22 (continued)

(c) Discuss the use of computer-aided drawing (CAD) in aeronautical engineering. **3**

....

....

....

....

....

....

....

(d) How does fibre metal laminate (FML) contribute to enhanced structural performance in aircraft? **3**

....

....

....

....

....

....

....

End of Question 22

8973310438

Question 23 (13 marks)

(a) Outline a use of semiconductors in the telecommunications industry. Include an example in your response.

3

....

....

....

....

....

(b) Telecommunications engineers face many work health and safety risks while carrying out their duties.

3

With reference to ONE issue, describe strategies that can be implemented to reduce the risk for the engineer.

....

....

....

....

....

....

....

Question 23 continues on page 23

7413310436

Do NOT write in this area.

(c)   An orthogonal drawing of a wi-fi router is shown.   **3**

TOP VIEW

FRONT VIEW   SIDE VIEW
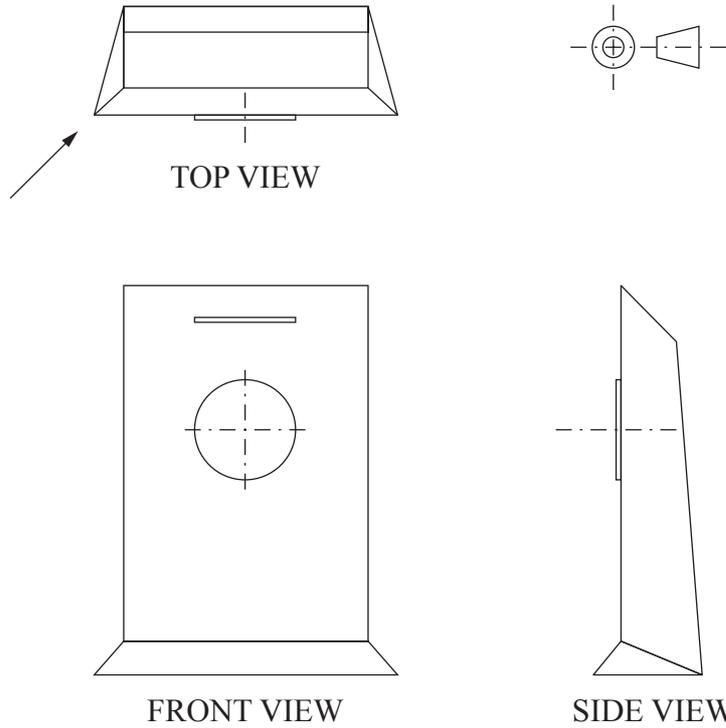
Construct a freehand pictorial sketch of the wi-fi router as viewed in the direction of the arrow.

– 23 –

Office Use Only – Do NOT write anything, or make any marks below this line.

9635310434

Question 23 (continued)

(d)   A public telephone booth is assembled using a variety of parts.   **4**

Screen

Hand receiver

Shelf

Question 23 continues on page 25

Office Use Only – Do NOT write anything, or make any marks below this line.

9643310433
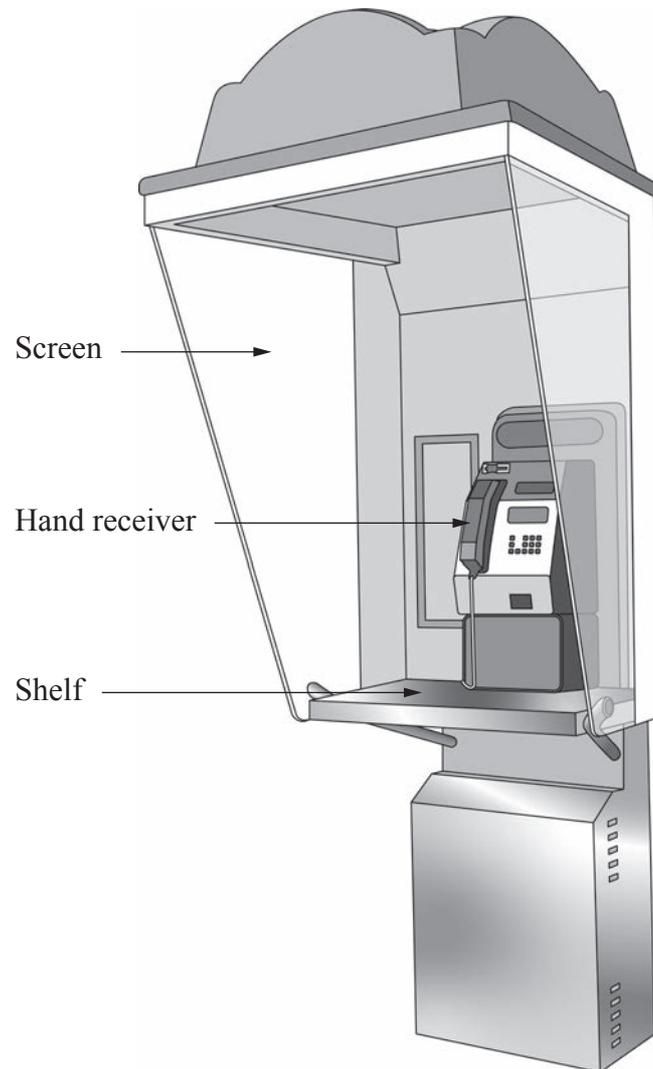
Question 23 (continued)

Complete the table.

Part	Material	Justification of material	Manufacturing method
Screen	....	Needs to be impact resistant	....
Hand receiver	ABS	....	....
Shelf	....	....	Cold rolled and pressed

End of Question 23

8534310431

Question 24 (12 marks)

(a) How would impact testing be used during the design and development of a motorcycle helmet?

2

....

....

....

....

....

(b) Brushless DC motors are used to power electric-powered bicycles.

3

Why are these types of motors so well suited to this application?

....

....

....

....

....

....

....

1724310435

(c)   An escalator is used to move people from the first floor to the second floor. The **3** second floor is located 5.2 metres above the first floor. The average person's mass is 64.8 kg.

Determine the power requirement of the escalator in order to move 10 people from the first floor to the second floor in one minute.

Power required: .... W

Question 24 continues on page 28

4664310431

Question 24 (continued)

(d)   Explain why a fully hardened steel would need to be tempered. **4**

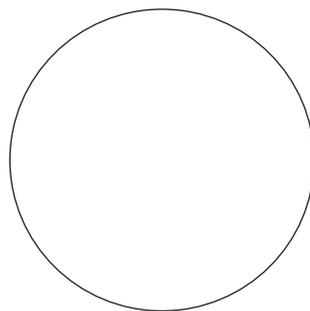Support your answer with a labelled sketch of the resulting tempered microstructure.

....

....

....

....

....

....

....

End of Question 24

Question 25 (11 marks)

(a) Outline how 'Black Box' flight data recorders have led to improved aviation safety.   **2**

....

....

....

(b) A circuit diagram is shown.   **3**
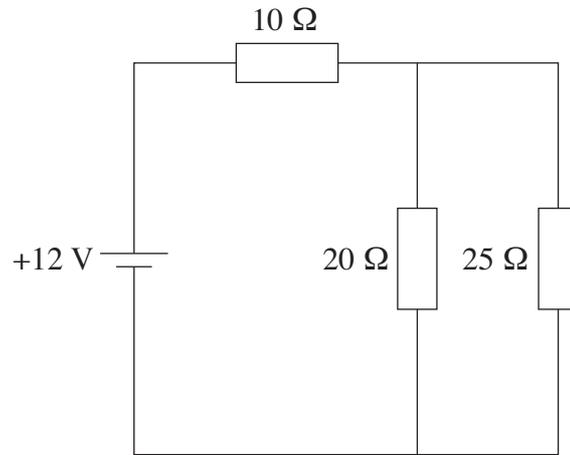
Use Ohm's Law to determine the current in the circuit.

Current in circuit: .... Amps

Question 25 continues on page 30

Office Use Only – Do NOT write anything, or make any marks below this line.

2191310434

(c) A pin-jointed truss is shown. Member *AB* has been determined to be 250 N in   **6**
compression.
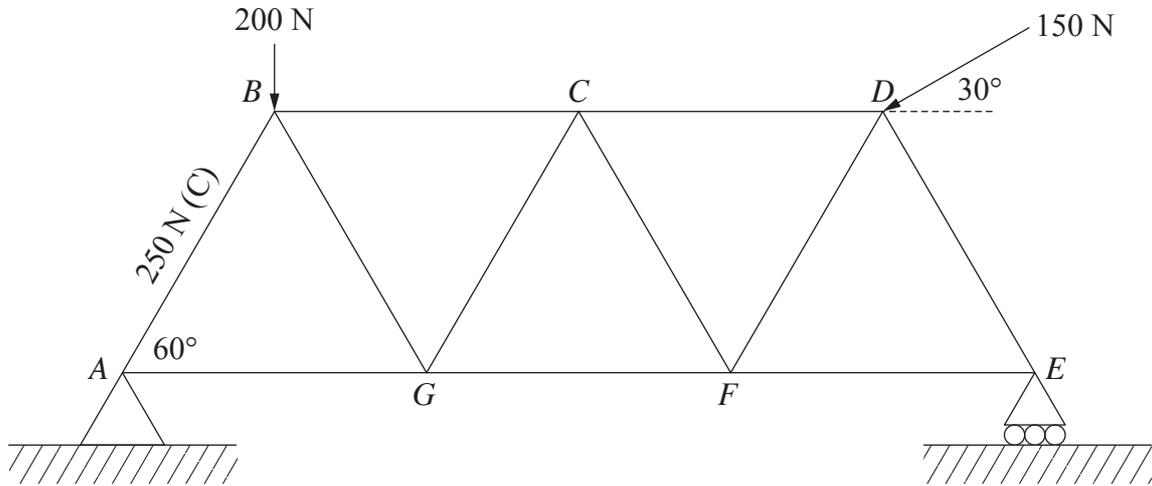
DRAWN TO SCALE

Complete the table. You must use the method specified to solve each component.

Determine	Method to use	Working
External reaction at *E*	Mathematical	.... N Direction: ....

Question 25 continues on page 31

Office Use Only – Do NOT write anything, or make any marks below this line.

6559310436

Question 25 (continued)

Determine	Method to use	Working
Internal reaction of member *CF*	Methods of section	.... N Nature of force (T or C): ....
Internal reaction of member *BG*	Graphical	.... N Nature of force (T or C): ....

End of Question 25

BLANK PAGE

8699310433

Do NOT write in this area.

Question 26 (11 marks)

(a) Outline ways in which satellite services have benefited people living and working in rural areas.

2

....

....

....

....

....

(b) To avoid overloading a cellular network, a logic gate is used to control the activation of a signal booster.

3

The signal booster will only activate when both of the following conditions are met:

• the signal strength falls below an acceptable level
• the network traffic flow falls below an acceptable level.

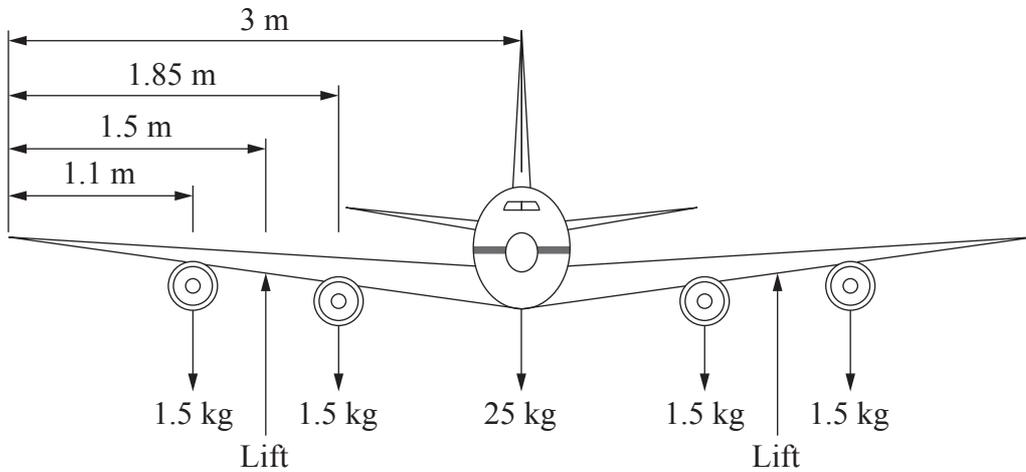Complete a truth table for this scenario and identify a suitable logic gate.

Truth table:

Acceptable signal strength	Acceptable traffic flow	Activate booster

Logic gate: ....

5892310435

Question 26 (continued)

(c)   A drawing of a scale model aircraft flying at constant velocity in level flight is shown.

Assume that the lift acts as a point load only on each wing and is located as shown in the drawing.
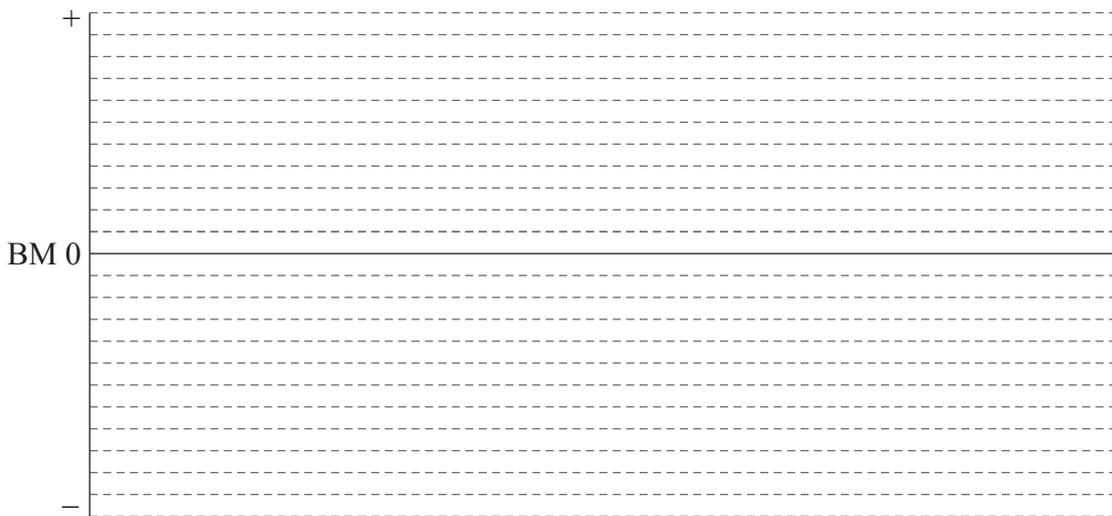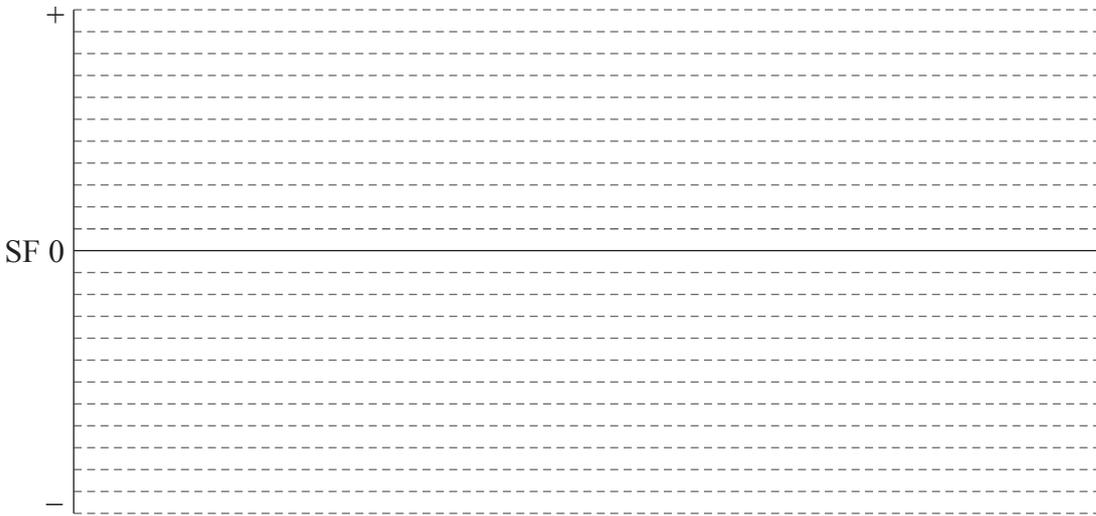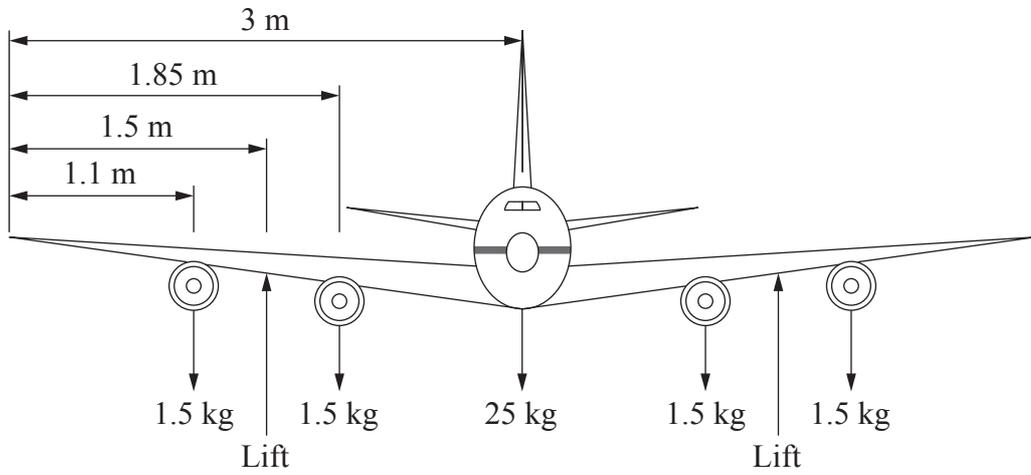
(i)   In the box below, draw the free body diagram of the forces acting on the aircraft.   **1**

– 34 –

Office Use Only – Do NOT write anything, or make any marks below this line.

1902310433

Question 26 (continued)

(ii) Draw both a shear force diagram and a bending moment diagram of the aircraft as the forces act across the wingspan of the aircraft. **5**

3 m

1.85 m

1.5 m

1.1 m

1.5 kg   1.5 kg   25 kg   1.5 kg   1.5 kg

Lift   Lift

+

SF 0

−

+

BM 0

−

End of Question 26

– 35 –

Office Use Only – Do NOT write anything, or make any marks below this line.

6068310431

BLANK PAGE

4194310439

Question 27 (11 marks)

A towbar hitch and shear pin is shown.
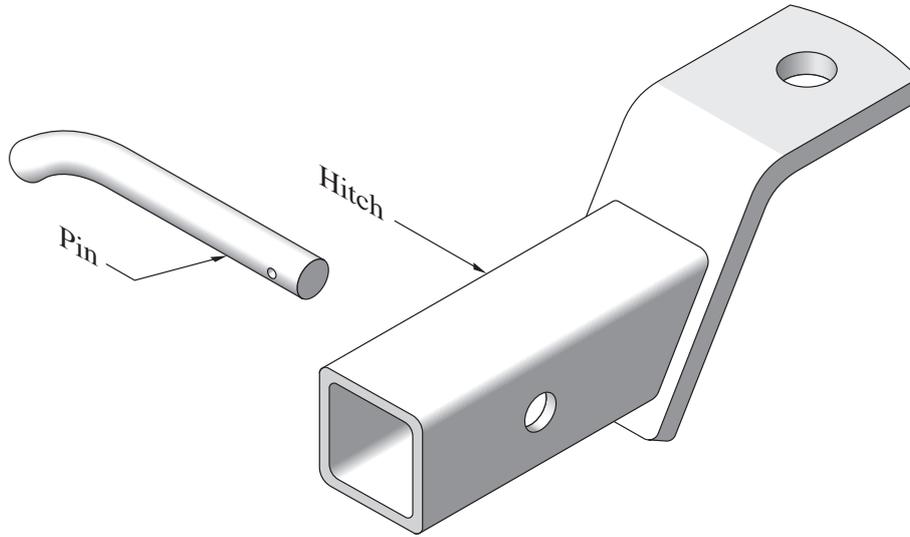
(a)   The hitch is exposed to various environmental conditions.   **2**

Outline a method to protect against corrosion.

....

....

....

....

....

(b)   Explain why hot forging would be used to manufacture the shear pin.   **3**

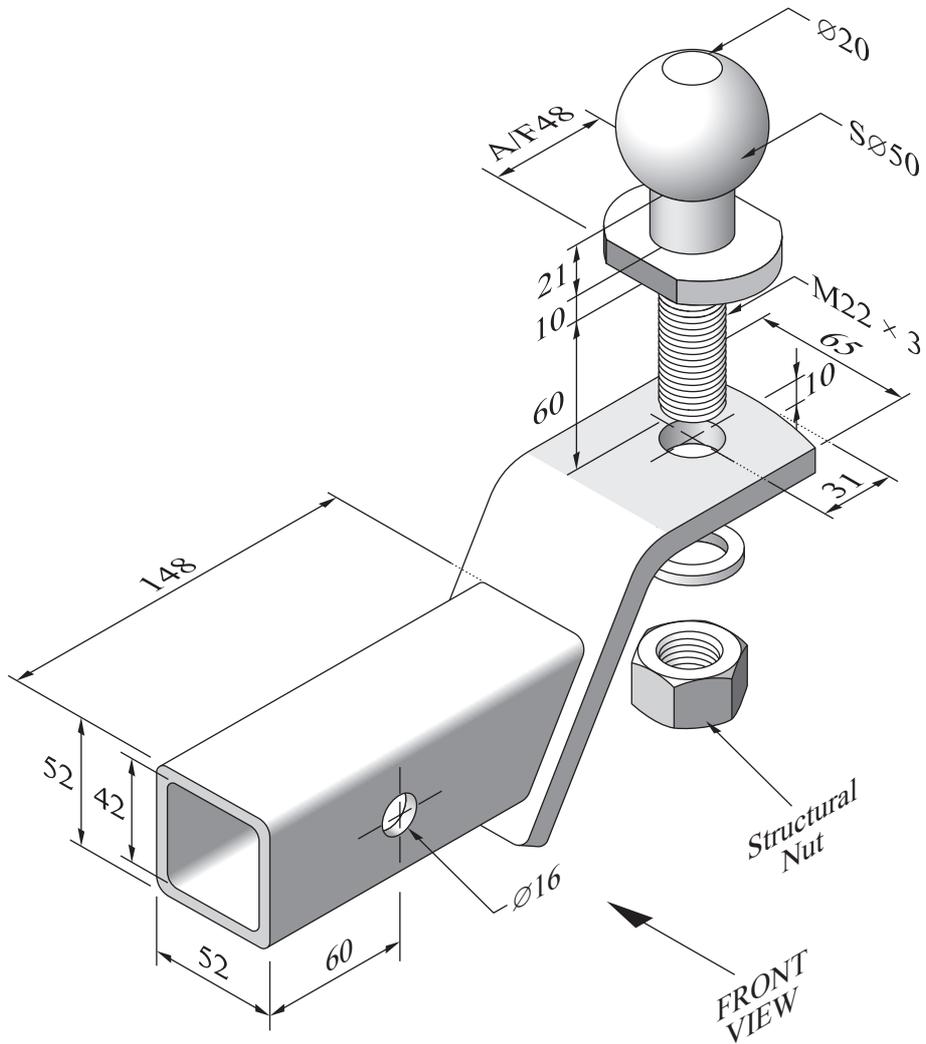...

....

....

....

....

....

....

9911310431

Question 27 (continued)

(c)   An exploded pictorial drawing of a towbar hitch assembly is shown.   **6**

Ø20

A/F48

SØ50

21

10

M22 × 3

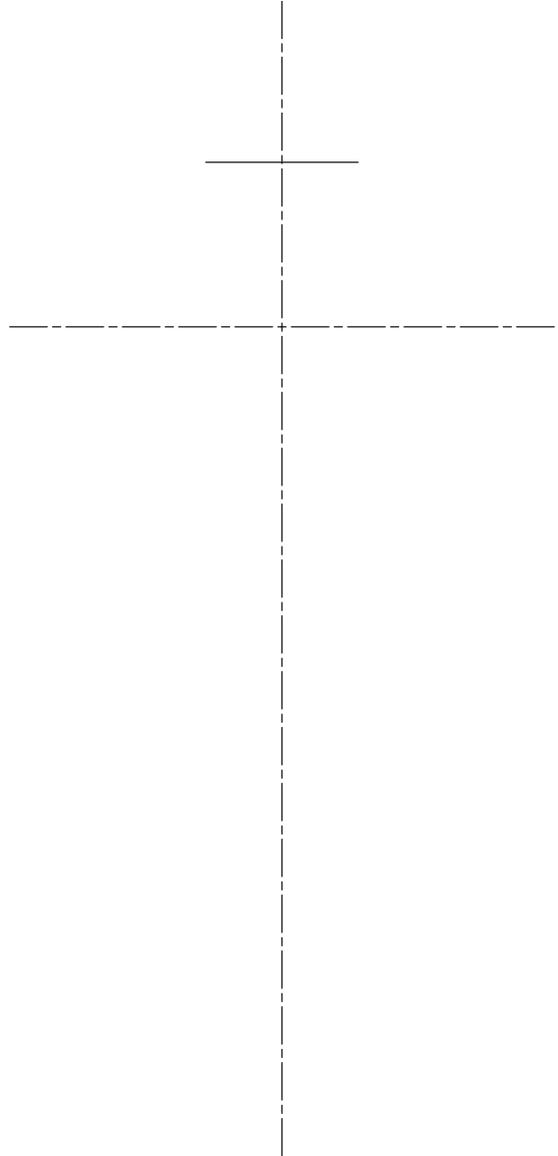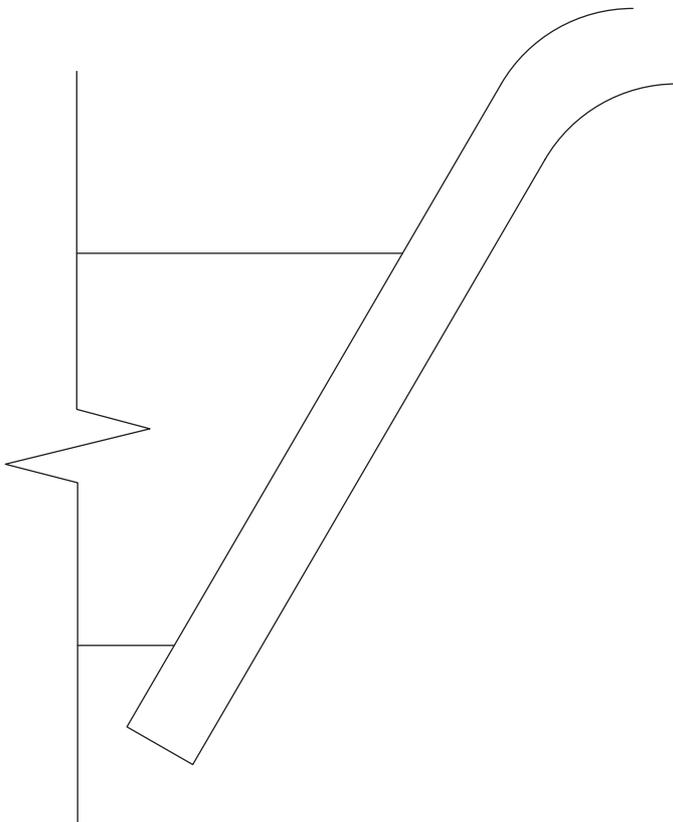65

10

60

31

148

52

42

Structural
Nut

52

60

Ø16

FRONT
VIEW

– 38 –

0014310436

Question 27 (continued)

Complete an assembled front sectional view of the towbar hitch assembly.

Do NOT dimension.

SCALE 1 : 1

End of paper

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

7561310430

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

6393310432

Do NOT write in this area.

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

6907310433

BLANK PAGE

5155310437

BLANK PAGE

Office Use Only – Do NOT write anything, or make any marks below this line.

6054310436

Do NOT write in this area.

Engineering Studies

FORMULAE SHEET

Force, Moments

$F = ma$; $M = Fd$

If a body is in equilibrium, then $\sum F_x = 0$; $\sum F_y = 0$; $\sum M = 0$

Friction

$F = \mu N$; $\mu = \tan\phi$

Energy, Work, Power

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

Pressure

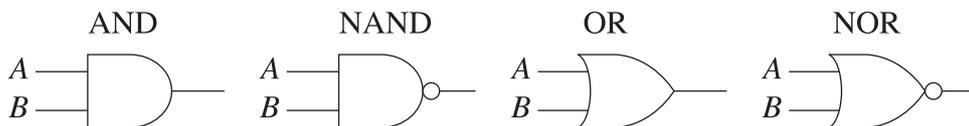$P = \dfrac{F}{A}$; $P = P_o + \rho gh$

Stress and Strain

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

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

Machines

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

Digital Electronics

Electricity, Electronics

$E = IR$ $P = I^2 R$

Series $R_t = R_1 + R_2 + R_3 + R_4 + \cdots + R_n$

Parallel $\dfrac{1}{R_t} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + \dfrac{1}{R_4} + \cdots + \dfrac{1}{R_n}$

BLANK PAGE