NSW Education Standards Authority

2024 HSC Engineering Studies Marking Guidelines

Section I

Multiple-choice Answer Key

Question	Answer
1	B
2	D
3	C
4	B
5	C
6	D
7	A
8	B
9	D
10	B
11	C
12	D
13	C
14	B
15	B
16	D
17	C
18	A
19	C
20	A

Section II

Question 21 (a)

Criteria	Marks
• Outlines how innovations in engineering materials have improved the inservice properties of piers	2
• Provides some relevant information	1

Sample answer:

The concrete pier better resists insect attack and is less susceptible to environmental conditions.

Answers could include:

- Treated timbers are more durable and resistant due to the application of chemicals
- Enhanced service properties: increased strength and durability; less maintenance with ceramic blocks
- Lightweight, high-strength materials simplify construction and reduce load stresses.

Question 21 (b)

Criteria	Marks
• Explains why geotextiles are used in the construction of retaining walls	3
• Demonstrates some understanding of why geotextiles are used in the construction of retaining walls	2
• Provides some relevant information	1

Sample answer:

Geotextiles are used to provide and/or improve drainage where water flow might occur. They distribute the load and improve the overall performance of the structure. It can distribute the load more evenly. It helps to prevent soil erosion by providing a stable base to prevent soil from being washed away.

Answers could include:

- Help improve drainage by allowing water to pass through while preventing soil erosion and therefore, pressure behind the wall
- Geotextiles enhance soil stability, by preventing mixing of different soil layers and improving load-bearing capacity
- They reinforce the soil mass, by increasing the overall strength and longevity of the retaining wall system.

Question 21 (c)

Criteria	Marks
• Shows relevant working in calculating the maximum thickness of the strap bracing	3
• Makes progress towards calculating the maximum thickness of the strap bracing	2
• Provides some relevant information	1

Sample answer:

$$\text{Shear stress} = \frac{\text{Shear force}}{\text{Shear area}}$$

$$380 \times 10^6 \text{ Pa} = \frac{5730 \text{ N}}{\text{Shear area}}$$

$$\text{Shear area} = \frac{5730}{380 \times 10^6}$$

$$= 0.00001508 \text{ m}^2$$

$$\text{Shear area} = \pi \times \text{diameter} \times \text{thickness}$$

$$\text{Thickness} = \frac{\text{Shear area}}{\pi \times \text{diameter}}$$

$$= \frac{0.00001508}{\pi \times 0.006}$$

$$= 0.0008 \text{ m}$$

$$= 0.8 \text{ mm}$$

Question 21 (d)

Criteria	Marks
• Completes the table using correct terminology	3
• Completes most of the table using some correct terminology	2
• Provides some relevant information	1

Sample answer:

What does 'M' stand for in M5 × 0.8? **Metric**	What is the allowable range for the R2.5 ±0.5 dimension? **From 2 mm to 3 mm (or 1 mm)**
Which dimension is not to AS1100? **2.5 mm**	What does the 0.8 refer to in the expression M5 × 0.8? **Pitch of thread**
Name the tensioner material **(GALVANISED Steel) GALZ275**	What is the unit of measurement used in this drawing? **Millimetres (mm)**
What is the name of the curve indicated by letter A? **Fillet**	State ONE radial dimension **R18** or **R2.5**
What is the angle of projection? **3rd**	Which line type is missing from the SIDE VIEW? **Hidden detail**

Question 22 (a)

Criteria	Marks
• Outlines the environmental responsibilities of an aeronautical engineer	2
• Provides some relevant information	1

Sample answer:

Engineers must comply with environmental regulations and legislation that may impact on aspects of their work.

Answers could include:

- Ensure that waste is disposed of correctly to ensure that the environmental impact is minimised
- Design, test and ensure environmental compliance of regulations of aircraft components (eg noise levels).

Question 22 (b)

Criteria	Marks
• Shows relevant working in calculating the allowable maximum total mass of the pilot and passengers	3
• Makes progress towards calculating the allowable maximum total mass of the pilot and passengers	2
• Provides some relevant information	1

Sample answer:

Mass of empty plane = 906 kg

∴ *mg* of empty plane = 9060 N

Required thrust for full plane: 1050 N

Max Lift to Drag ratio: 10.5

When the plane is cruising, the force system is in equilibrium. ∴ thrust = drag = 1050 N

$$\frac{\text{Lift}}{\text{Drag}} = 10.5$$

Max Lift = Drag × 10.5

Max Lift = 1050 N × 10.5

Max Lift = 11 025 N

Max mg of pilot and passengers = 11 025 N – 9060 N = 1965 N

∴ Max total allowable mass of pilot and passengers = 196.5 kg

Question 22 (c)

Criteria	Marks
• Provides a discussion on the use of CAD in aeronautical engineering	3
• Demonstrates some understanding of the use of CAD in aeronautical engineering	2
• Provides some relevant information	1

Sample answer:

CAD models form the basis for physical prototypes, using techniques like 3D printing or traditional manufacturing. Digital models provide precise geometry for CNC machining and other processes, ensuring final product accuracy.

However, CAD requires training and time to become proficient, and CAD can be expensive to implement.

Answers could include:

Simulation and analysis: CAD can be used to analyse aircraft component performance under various conditions, including bending stress of airframes. Simulation results refine CAD designs, ensuring compliance with safety and performance standards.

Question 22 (d)

Criteria	Marks
• Demonstrates a sound understanding of how fibre metal laminate (FML) contributes to enhanced structural performance	3
• Demonstrates some understanding of how fibre metal laminate (FML) is used in aircraft	2
• Provides some relevant information	1

Sample answer:

FML is used in the manufacture of aircraft to improve the structural performance due to the improved impact resistance, better fatigue and corrosion resistance, and weight advantages in comparison to aluminium alloys traditionally used in aircraft construction. FML is a robust material that can resist higher degrees of cyclic loading because it is manufactured with directionality that can be tailored to the specific area of the aircraft. FML can be manufactured to tailor the inservice properties of the material suitable to a variety of applications.

Question 23 (a)

Criteria	Marks
• Outlines a use of semiconductors in the telecommunications industry with an example	3
• Outlines a use of semiconductors	2
• Provides some relevant information	1

Sample answer:

Semiconductor amplifiers can be used to enhance signal processing in wireless communication. In smart phones they facilitate the amplification and improvement in signal strength resulting in clear and reliable mobile transmission. In ICs they are used for modulating and demodulating signals, allowing efficient wireless communication.

Question 23 (b)

Criteria	Marks
• Describes strategies to reduce the risk for the engineer with reference to an issue	3
• Describes a strategy or outlines strategies to reduce the risk for the engineer with reference to an issue	2
• Provides some relevant information	1

Sample answer:

Telecommunications engineers work on satellite dishes and other structures at height. To minimise the risk, they must ensure that they wear safety harnesses that prevent injuries from falling from heights. The engineer should have completed relevant safety training before undertaking the task so that they are aware of the possible risks and how to avoid them.
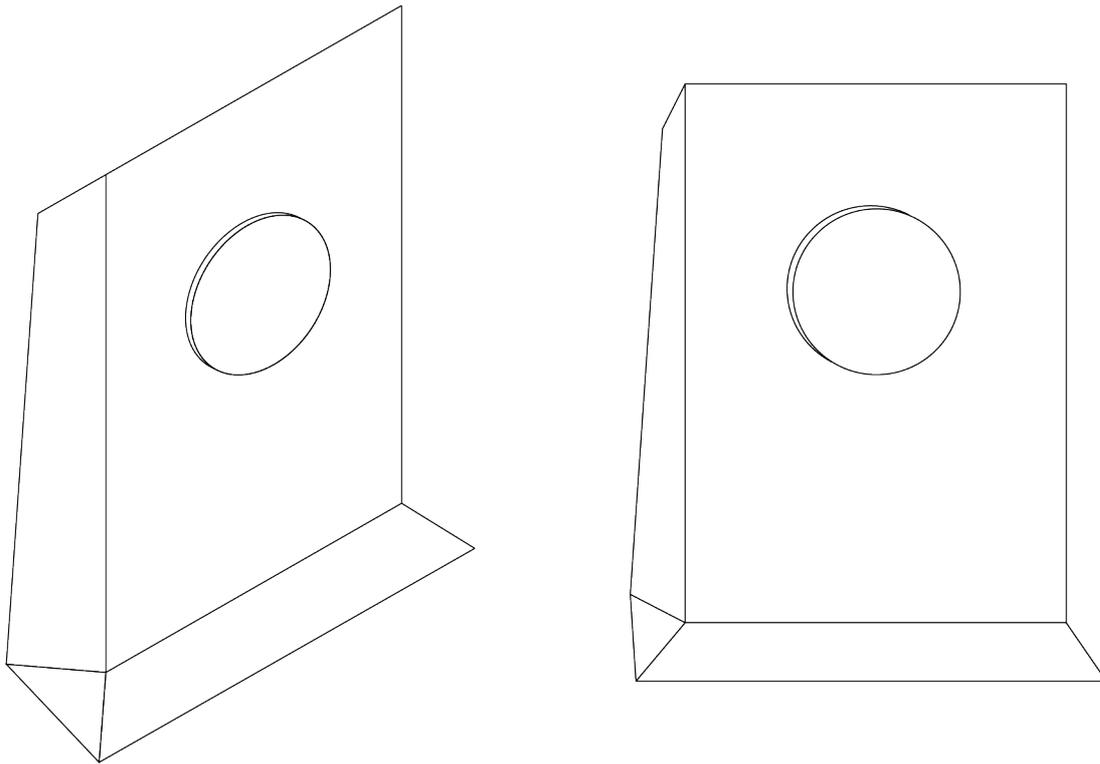
Answers could include:

- UV/EMR exposure during installation and maintenance of equipment; PPE training, warning signage and barriers
- Electrocution; training and safe work practices, work site inspections, SWMSs, emergency management plans/drills
- Operating equipment within guidance specifications.

Question 23 (c)

Criteria	Marks
• Provides an appropriate freehand pictorial sketch of the wi-fi router	3
• Demonstrates substantial progress towards a pictorial sketch of the wi-fi router	2
• Provides some aspects of a pictorial sketch	1

Sample answer:

Answers could include:

- Oblique view in the direction of the arrow
- Perspective view in the direction of the arrow
- Planometric view in the direction of the arrow.

Question 23 (d)

Criteria	Marks
• Completes the table with appropriate entries	4
• Completes the table with appropriate entries and some minor errors	3
• Completes the table with some appropriate entries	2
• Provides some relevant information	1

Sample answer:

Part	Material	Justification of material	Manufacturing method
Screen	**Acrylic**	Needs to be impact resistant	**Cast**
Hand receiver	ABS	**Complex shaped, easily moulded**	**Injection moulded**
Shelf	**Stainless steel**	**Corrosion resistance, hardness, cleanability**	Cold rolled and pressed

Question 24 (a)

Criteria	Marks
• Demonstrates how impact testing would be used during the design and development of a motorcycle helmet	2
• Provides some relevant information	1

Sample answer:

Impact tests simulate real-world crash conditions. These tests can help to determine a helmet's energy absorption, its structural integrity as well as compliance with relevant safety standards or regulations.

Question 24 (b)

Criteria	Marks
• Explains how brushless DC motors are suitable for electric powered bicycles	3
• Describes brushless DC motors	2
• Provides some relevant information	1

Sample answer:

Brushless DC motors are easy to control because they use electronic commutation which means more efficient motor operation. This is crucial for applications like electric powered bicycles where precise speed and torque control are important. The absence of brushes means that the motor has less wear over time. Brushless DC motors can provide high torque at low speeds, which is beneficial for starting and climbing hills.

Answers may include:

- Regenerative braking
- Efficiency
- Compact size and lightweight.

Question 24 (c)

Criteria	Marks
• Shows relevant working in the correct calculation of the power requirement of the escalator, including correct units	3
• Makes some progress towards calculating the power requirement of the escalator	2
• Provides some relevant information	1

Sample answer:

$W_{1 \text{ passenger}} = mgh$

$W_{1 \text{ passenger}} = (64.8 \text{ kg} \times 10 \text{ m/s}^2) \times 5.2 \text{ m} = 3369.6 \text{ J}$

$W_{10 \text{ passengers}} = 33696 \text{ J (rounded)}$

$P = \dfrac{W_{10 \text{ passengers}}}{\text{Time}} = \dfrac{33696 \text{ J}}{60 \text{ s}}$

$P = 561.6 \text{ W}$

Question 24 (d)

Criteria	Marks
• Explains with a labelled sketch why tempering is necessary	4
• Explains why tempering is necessary OR • Describes tempering and provides a labelled sketch that represents the resulting microstructure	3
• Describes tempering	2
• Identifies an appropriate reason OR • Provides a sketch that represents the resulting microstructure	1

Sample answer:

Fully hardened steel tends to be very brittle. This brittleness can make it prone to cracking or breaking under certain conditions, particularly when subjected to sudden impacts or stresses. Tempering is crucial to achieving the desired balance of hardness, toughness, and other mechanical properties necessary for specific applications, ensuring that the material can perform reliably under various operating conditions.
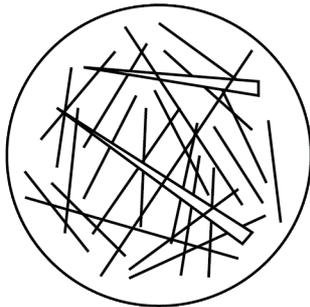

Martensite by hardening
  (Acicular martensite)

Answer could include:

Tempering is a subsequent heat treatment process often employed after quenching to address the issue of brittleness. During tempering, the fully hardened steel is reheated to a lower temperature (below its critical temperature) and then cooled again. This controlled heating and cooling process helps to relieve some of the internal stresses induced during quenching and allows for the adjustment of the steel's hardness and toughness properties.

- Reducing brittleness
- Improving toughness
- Reducing internal stresses
- Enhancing machinability.
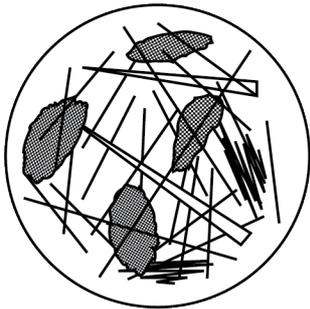
Ferrite and finely
dispersed cementite
(Tempered martensite)

Question 25 (a)

Criteria	Marks
• Outlines how flight data recorders have improved aviation safety	2
• Provides some relevant information	1

Sample answer:

After an incident the aeronautical engineer is able to review the data and determine possible causes of the incident and make improvements based on findings.

Question 25 (b)

Criteria	Marks
• Calculates the required current value with relevant working	3
• Demonstrates some understanding of the steps required to calculate the required current value	2
• Provides some relevant information	1

Sample answer:

$$I = \frac{E}{R}$$

$$R_{total} = 10\ \Omega + \frac{1}{\dfrac{1}{20\ \Omega} + \dfrac{1}{25\ \Omega}}$$

$$R_{total} = 21.11\ \Omega$$

$$\therefore\ \text{Current } (I) = \frac{12\ V}{21.11\ \Omega}$$

$$I = 0.57\ \text{Amps}$$

Question 25 (c)

Criteria	Marks
• Uses the specified method in the correct calculation of the external reaction and internal reactions • States their magnitude and direction/nature	6
• Uses the specified method to make substantial progress towards the calculation of the external reaction and/or internal reactions OR • States their magnitude and direction/nature	4–5
• Makes progress towards calculating the reactions	3
• Makes progress towards calculating a reaction	2
• Provides some relevant information	1

Sample answer:

Determine	*Method to solve*	
External reaction at *E*	Mathematical	$\Sigma M_A{)^+} = 0 = (200 \times 2) + (75 \times 10) - (129.9 \times 3.46) - (R_E \times 12)$ $\qquad 0 = 400 + 750 - 450 - R_E 12$ $\qquad R_E = \dfrac{700}{12} = 58.33 \text{ N}\uparrow$ **58.33** N Direction: $\uparrow$
Internal reaction of member *CF*	Method of sections	$\Sigma F_V{\uparrow^+} = 0 = (\text{Sin } 60° \times CF) - 75 + 58.33$ $\qquad - \text{Sin } 60° \times CF = -75 + 58.33$ $\qquad \therefore CF = \dfrac{16.67}{\text{Sin } 60°}$ $\qquad CF = 19.25 \text{ N(T)}$ **19.25** N Nature of force (T or C): **T**

Internal reaction of member *BG*	Graphical	

In the diagram: *BC* (horizontal), *BG*, 200 N (vertical), 250 N.

$\therefore BG \approx 19$ N

Nature of force (T or C): **T**

Question 26 (a)

Criteria	Marks
• Outlines ways in which satellite services have benefited people in rural areas	2
• Provides some relevant information	1

Sample answer:

Satellites allow for communication to occur even if people in rural areas are out of the cellular telecommunications network area. Satellite services are provided over an expansive geographical area as they are not dependent on proximity from an exchange or node.

Answer could include:

- Portability
- Relatively cost effective
- Uses existing infrastructure.

Question 26 (b)

Criteria	Marks
• Correctly completes the truth table and identifies the logic gate	3
• Completes the truth table and identifies the logic gate with error	2
• Provides some relevant information	1

Sample answer:

Truth table:

Acceptable signal strength	*Acceptable traffic flow*	*Activate booster*
1	1	0
1	0	0
0	1	0
0	0	1

Logic gate: NOR

Question 26 (c) (i)

Criteria	Marks
• Draws an appropriate free body diagram	1

Sample answer:
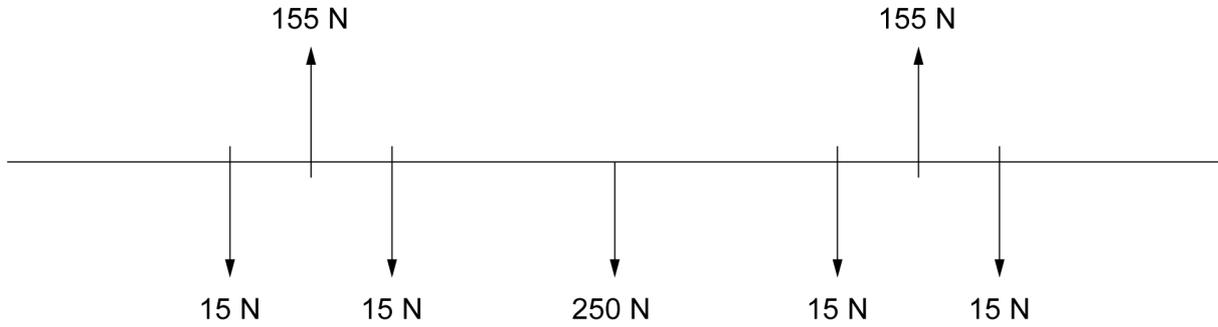
Question 26 (c) (i)

Question 26 (c) (ii)

Criteria	Marks
• Produces correct and labelled shear force and bending moment diagrams	5
• Produces a labelled shear force diagram and bending moment diagram	4
• Produces a substantially correct shear force diagram OR bending moment diagram	3
• Applies an appropriate method that shows some understanding of shear force diagram or bending moment diagram	2
• Demonstrates an understanding of shear force diagrams or bending moment diagrams	1

Sample answer:
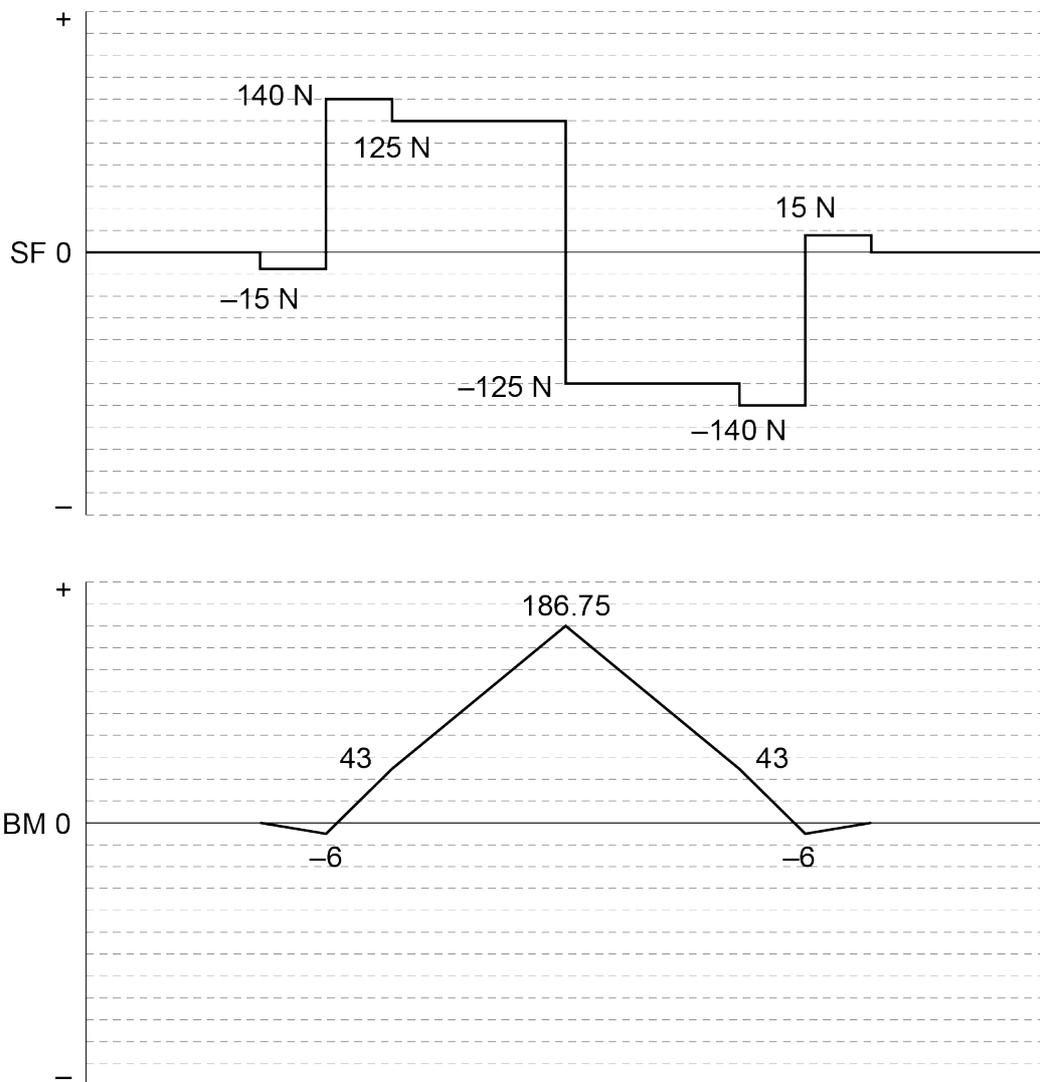
Question 27 (a)

Criteria	Marks
• Outlines a method of corrosion protection	2
• Provides some relevant information	1

Sample answer:

The use of protective coatings such as painting or powder coating would give this component protection from corrosion, sealing it from the effects of oxygen, water or pollutants.

Question 27 (b)

| Criteria	Marks
• Explains why hot forging would be used to manufacture the shear pin	3
• Makes progress towards explaining why hot forging would be used to manufacture the shear pin	2
• Provides some relevant information	1

Sample answer:

Hot forging results in a material that is stronger than cast or machined parts. Hot forging is also able to produce parts that are more complex in shape. Produces optimal yield strength, low hardness and high ductility.

Question 27 (c)

Criteria	Marks
• Demonstrates detailed application of knowledge and understanding when sectioning the assembled front view to AS1100	6
• Demonstrates substantial application of knowledge and understanding when sectioning the assembled front view to AS1100	5
• Demonstrates adequate application of knowledge and understanding of the front view to AS1100 standards	3–4
• Makes progress towards a front view drawing	2
• Provides some relevant information	1

Sample answer:

SCALE 1 : 1
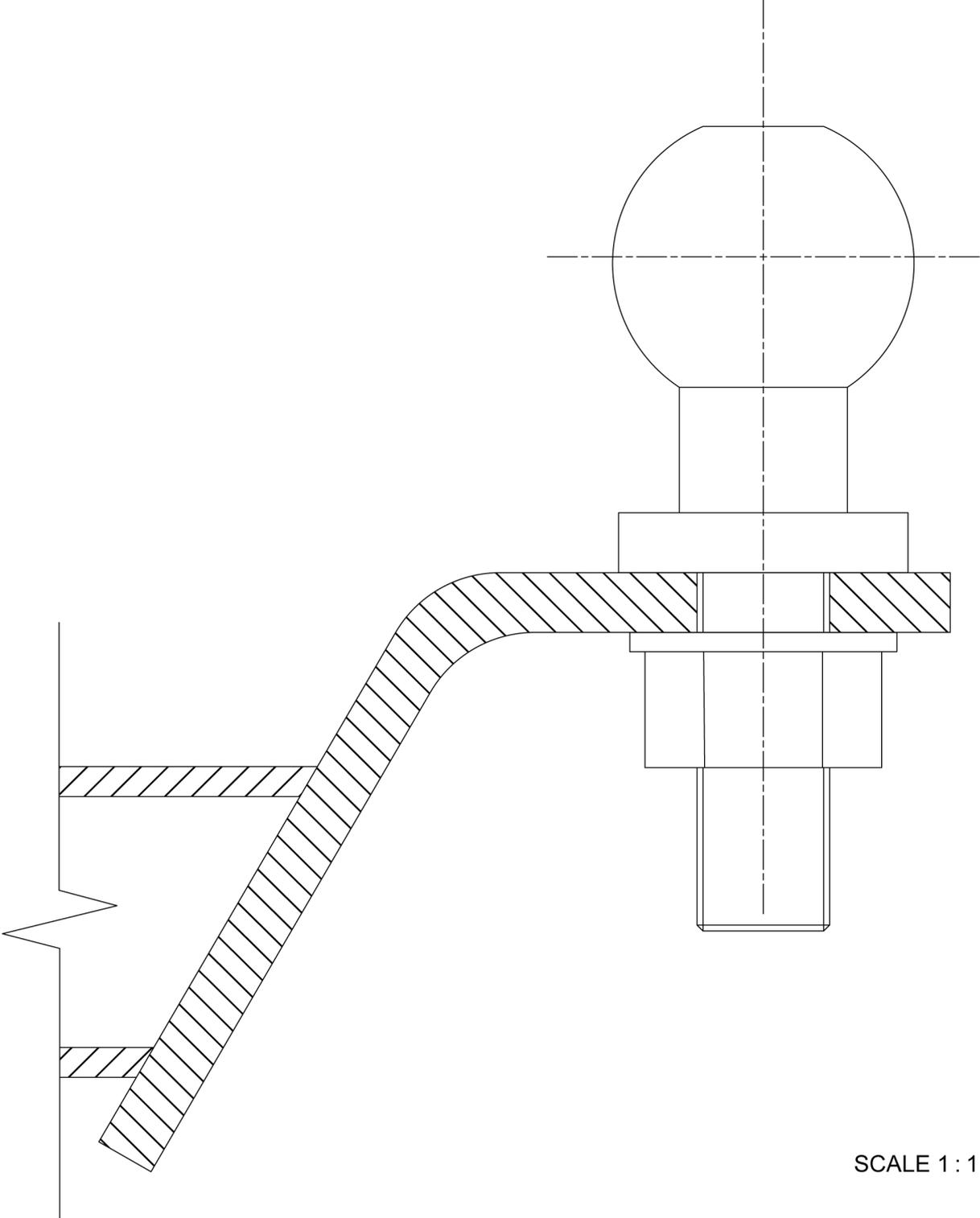
2024 HSC Engineering Studies
Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Civil structures — materials, ceramics – p25	H1.2
2	1	Civil structures — mechanics, stress/strain diagram – p25	H1.2
3	1	Personal and public transport — mechanics, simple machines – p28	H3.1
4	1	Telecommunications engineering — electricity/electronics, analogue and digital systems – p37	H1.2
5	1	Telecommunications engineering — electricity/electronics, radio transmission – p37	H1.2
6	1	Civil structures — mechanics, shear force and bending moment diagrams – p25	H3.1
7	1	Telecommunications engineering — electricity/electronics – p37	H1.2, H2.2
8	1	Aeronautical engineering — mechanics and hydraulics, Bernoulli's principle – p32	H3.1
9	1	Personal and public transport — materials, ceramics and glasses – p29	H1.2
10	1	Personal and public transport — mechanics, static friction – p28	H3.1
11	1	Civil structures — materials, crack theory – p25	H2.1
12	1	Aeronautical engineering — mechanics and hydraulics, fundamental flight mechanics – p32	H3.1
13	1	Telecommunications engineering — electricity/electronics, satellite communication systems – p37	H2.2
14	1	Aeronautical engineering — mechanics and hydraulics, propulsion systems – p32	H3.1
15	1	Personal and public transport — materials, manufacturing processes – p28	H2.1
16	1	Civil structures — mechanics, bending stress calculation – p25	H3.1
17	1	Telecommunications engineering — electricity/electronics, transmission media – p37	H1.2
18	1	Aeronautical engineering — communication, developments – p33	H3.3
19	1	Personal and public transport — mechanics, static friction – p28	H3.1
20	1	Civil structures — mechanics, bending stress calculation – p25	H3.1

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Civil structures — historical and societal influences – p24	H4.2
21 (b)	3	Civil structures — materials, composites – p26	H1.2, H2.1
21 (c)	3	Civil structures — mechanics, stress and strain – p25	H3.1
21 (d)	3	Civil structures — communication, Australian Standard (AS 1100) – p26	H3.3
22 (a)	2	Aeronautical engineering — scope of the profession – p31	H1.1

Question	Marks	Content	Syllabus outcomes
22 (b)	3	Aeronautical engineering — mechanics and hydraulics, fundamental flight mechanics – p32	H3.1
22 (c)	3	Aeronautical engineering — communication, computer graphics, computer aided drawing (CAD) – p33	H2.2
22 (d)	3	Aeronautical engineering — materials, composites – p33	H1.2
23 (a)	3	Telecommunications engineering — materials, semiconductors – p36	H1.2
23 (b)	3	Telecommunications engineering — scope of the profession – p36	H1.1
23 (c)	3	Telecommunications engineering — communication, freehand and technical pictorial drawing – p37	H3.3
23 (d)	4	Telecommunications engineering — materials – p36	H1.2
24 (a)	2	Personal and public transport — materials, testing of materials – p28	H1.2
24 (b)	3	Personal and public transport — electricity/electronics, electric motors used in transport systems – p29	H2.1
24 (c)	3	Personal and public transport — mechanics, basic calculations for work, energy and power – p28	H3.1
24 (d)	4	Personal and public transport — materials, heat treatment of ferrous alloys – p28	H1.2
25 (a)	2	Aeronautical engineering — historical and societal influences – p32	H4.3
25 (b)	3	Personal and public transport — electricity/electronics, simple circuits – p29	H3.1
25 (c)	6	Civil structures — mechanics, truss analysis – p25	H3.1, H3.3
26 (a)	2	Telecommunications engineering — historical and societal influences – p36	H4.3
26 (b)	3	Telecommunications engineering — electricity/electronics, digital technology – p37	H3.1, H3.3
26 (c) (i)	1	Aeronautical engineering — mechanics and hydraulics, bending stress – p32	H3.1, H3.3
26 (c) (ii)	5	Aeronautical engineering — mechanics and hydraulics, bending stress – p32	H3.1, H3.3
27 (a)	2	Civil structures — materials, corrosion – p26	H2.1
27 (b)	3	Personal and public transport — materials, manufacturing process for non-ferrous metals – p29	H1.2, H2.1
27 (c)	6	Personal and public transport — communication, sectional views – p29	H3.3