
2023 HSC Engineering Studies Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates an understanding of how computer graphics are used in aeronautical engineering 	2
<ul style="list-style-type: none"> • Provides some relevant information 	1

Sample answer:

Computer graphics such as 3D visualisations can create a detailed and accurate visual model or simulation of aircraft components being designed in order to convey information and ideas.

Answer could include:

- To create interactive user interfaces
- Providing a means of artistic expression for engineers
- Visualisation, simulation and analysis
- Present data in the analysis of flight dynamics and servicing of aircraft
- Manufacturing and prototyping.

Question 21 (b)

Criteria	Marks
<ul style="list-style-type: none"> • Explains the benefits of collaboration when completing the engineering report 	3
<ul style="list-style-type: none"> • Provides some explanation of the benefits of collaboration when completing the engineering report 	2
<ul style="list-style-type: none"> • Provides some relevant information 	1

Sample answer:

A collaborative approach allows for the pooling of expert knowledge of aircraft industry professionals and their expertise resulting in a more comprehensive report and reducing the risk of errors.

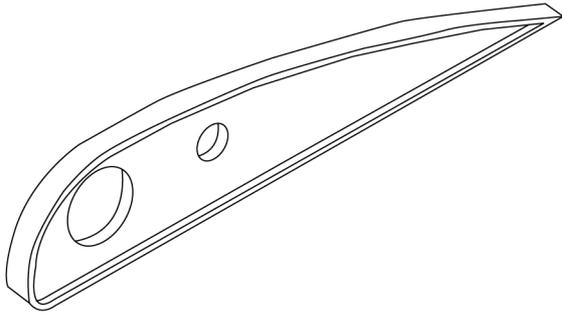
Answers could include:

- Promotes teamwork and ownership of the report where inventive design concepts, new angles, ideas and insights foster a culture of innovation
- Time efficiency – dividing tasks among multiple team contributors can expedite the completion of the report
- Cross-validation – multiple team members can independently verify and validate design calculations and recommendations
- Professional development – team members learn from each other, build professional relationships and enhance their own skill sets.

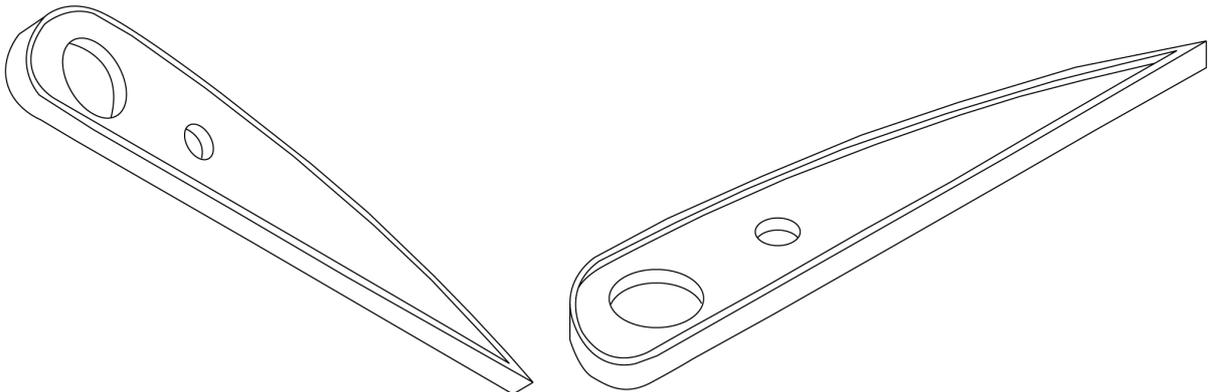
Question 21 (c)

Criteria	Marks
<ul style="list-style-type: none"> Constructs a proportioned freehand isometric sketch of the wing rib 	3
<ul style="list-style-type: none"> Demonstrates substantial progress towards producing an appropriate isometric sketch of the wing rib 	2
<ul style="list-style-type: none"> Provides some aspects of a pictorial sketch 	1

Sample answer:



Answers could include:

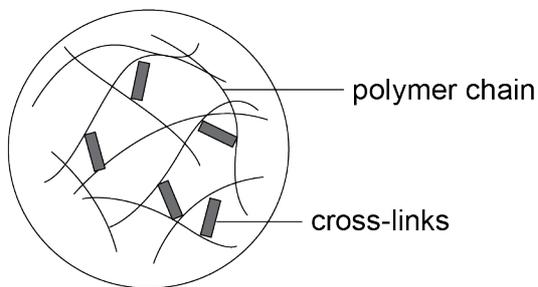


Question 21 (d)

Criteria	Marks
<ul style="list-style-type: none"> Describes the microstructure and provides an appropriately labelled drawing of the microstructure 	3
<ul style="list-style-type: none"> Describes the microstructure and provides a partially correct drawing OR <ul style="list-style-type: none"> Outlines the microstructure and provides an appropriately labelled drawing 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

Thermosetting polymers have a three-dimensional network structure, where polymer chains are cross-linked by covalent bonds in a network of polymer chains.



Question 22 (a) (i)

Criteria	Marks
• Outlines why new materials have been used	2
• Provides some relevant information	1

Sample answer:

CCA materials contain arsenic and are not considered suitable for use in children’s playground structures.

Answers could include:

- Manufactured timbers incorporating recycled plastics have better resistance to insect attack. CCA being toxic/carcinogenic, harmful, hazardous to health, safety hazard, entering the bloodstream
- Environmental concerns.

Question 22 (a) (ii)

Criteria	Marks
• Justifies the choice of a suitable material to use if a structure will be exposed to the weather at all times	3
• Describes an appropriate material to use if a structure will be exposed to the weather at all times	2
• Provides some relevant information	1

Sample answer:

A suitable material could be untreated finished hardwood, which is resistant to corrosion and degradation in bright sunlight. It is also very tough and wear resistant.

Answers could include:

- UV stabilised High Density Polyethylene is a suitable material to use, which offers bright colours, formability of complex shapes and low maintenance
- Stainless Steel or Galvanised Steel, which offers good corrosion resistance, strength and wear resistance
- Compact Laminate is another suitable material made of softwood and phenolic binder gives high dimensional stability over time and good abrasion resistance
- Creosote-treated pine and hardwood, both of which are weather resistant; precast reinforced concrete with smooth finish again being weather resistant and strong in tension
- Another suitable material is UV Stabilised ABS. This polymer is strong, light weight, impact resistant and has good resistance to water swell.

Question 22 (b) (i)

Criteria	Marks
<ul style="list-style-type: none"> Shows relevant working in the correct calculation of the left and right reactions (magnitude and direction) 	3
<ul style="list-style-type: none"> Makes progress towards the calculation of the left and/or right reactions 	2
<ul style="list-style-type: none"> Provides some relevant calculations 	1

Sample answer:

$$\overset{+}{\curvearrowright} \Sigma M_L: 0 = (2 \times 450) + (4 \times 850) - (R_R \times 5)$$

$$= 900 + 3400 - (R_R \times 5)$$

$$R_R = 4300 \div 5$$

$$R_R = 860 \text{ N}\uparrow$$

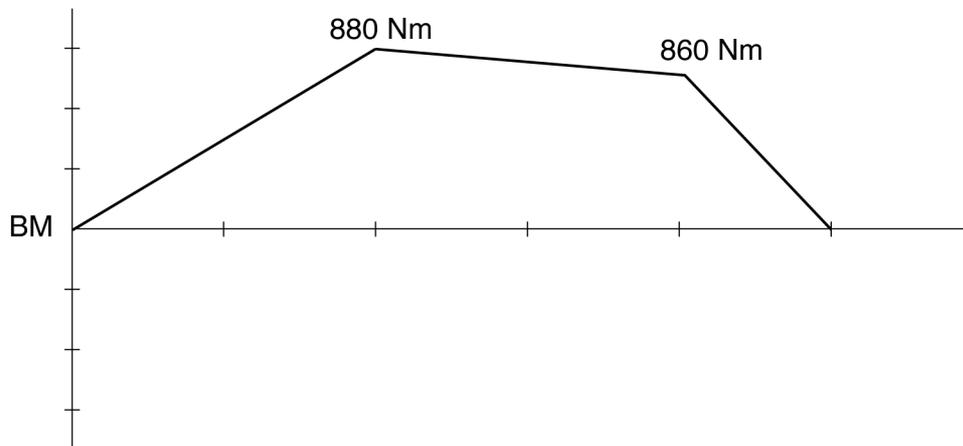
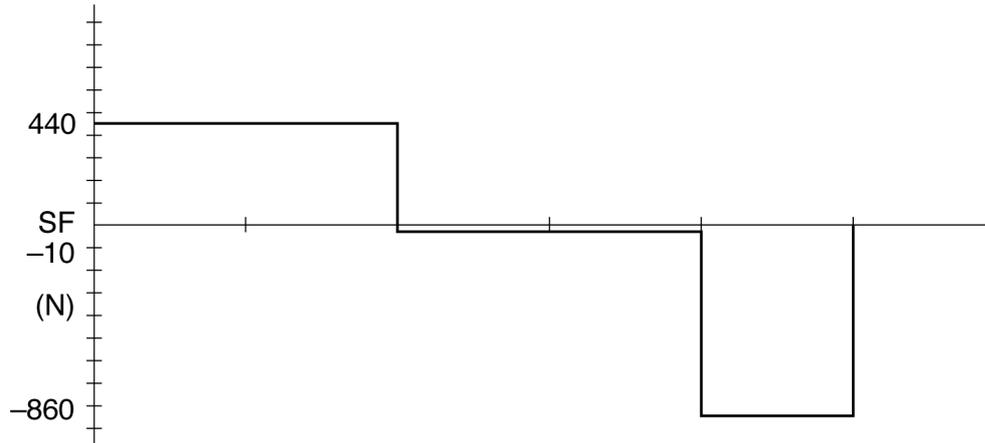
$$\Sigma F_V\uparrow: 0 = -450 - 850 + 860 + R_L$$

$$R_L = 440 \text{ N}\uparrow$$

Question 22 (b) (ii)

Criteria	Marks
<ul style="list-style-type: none"> • Produces correct diagrams using appropriate scale 	3
<ul style="list-style-type: none"> • Produces partially correct diagrams OR <ul style="list-style-type: none"> • Produces one correct diagram 	2
<ul style="list-style-type: none"> • Provides some relevant information 	1

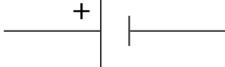
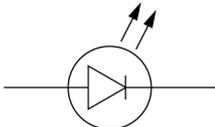
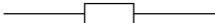
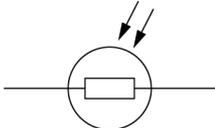
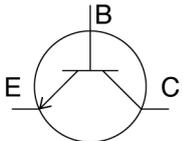
Sample answer:



Question 23 (a)

Criteria	Marks
• Demonstrates a thorough understanding of symbols used for electronic components	3
• Demonstrates some understanding of symbols used for electronic components	2
• Provides some relevant information	1

Sample answer:

Component	Symbol
Open switch	
Power cell	
Light emitting diode	
Resistor	
Light dependent resistor	
NPN transistor	
Capacitor	

Question 23 (b)

Criteria	Marks
<ul style="list-style-type: none"> Describes the responsibilities of the engineer regarding security issues of telecommunications devices 	3
<ul style="list-style-type: none"> Demonstrates some understanding of the responsibilities of the engineer regarding security issues of telecommunications devices 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

The engineer's responsibilities include ensuring the ongoing integrity of telecommunications networks and integration of service devices. They need to ensure that the data of the consumer is protected and cannot be intercepted by others.

Answers could include:

- Conducting threat analysis
- Keeping devices up to date so that they are protected from potential threat
- Design and implement protocols into the devices to protect the consumer. Eg encryption, password protection
- Identifying service impacts and difficulties.

Question 23 (c)

Criteria	Marks
<ul style="list-style-type: none"> Provides how insulating materials are used in the telecommunications industry, with an example 	3
<ul style="list-style-type: none"> Describes insulating materials, with an example <p>OR</p> <ul style="list-style-type: none"> Provides how an insulating material is used 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

In the telecommunications industry, insulating materials are necessary to reduce or eliminate accidental electrocution and unwanted current loss. For example, Polyethylene is a polymer that is used as a cable insulation, commonly as a wrap around copper wires. Polymers have the necessary properties to prevent or reduce the current flow.

Answer could include:

- Epoxy resin on printed circuit board
- Polymer casing for telecommunication devices.

Question 23 (d)

Criteria	Marks
<ul style="list-style-type: none"> Explains why 5G networks need more cellular antennae, positioned closer than 4G networks, with reference to the diagram 	3
<ul style="list-style-type: none"> Describes the difference between the 5G and 4G networks with reference to the diagram 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

As seen in the diagram, 5G networks employ shorter wavelengths and are a higher frequency band than 4G networks. The short wavelength means that the signal cannot travel as far as the signal in the 4G Network. Given that there is shorter signal range and the signal cannot travel as far there needs to be antennae positioned closer together. As the antennae are closer together, they require more antennae to cover the same distances.

Question 24 (a)

Criteria	Marks
<ul style="list-style-type: none"> Provides a comparison of the properties of timber and steel in roller coaster support structures 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

Unlike steel, timber has the ability to flex and bend, which can absorb some of the forces exerted by the roller coaster. However, timber has less mechanical strength than steel and is more susceptible to rot and insect damage over time.

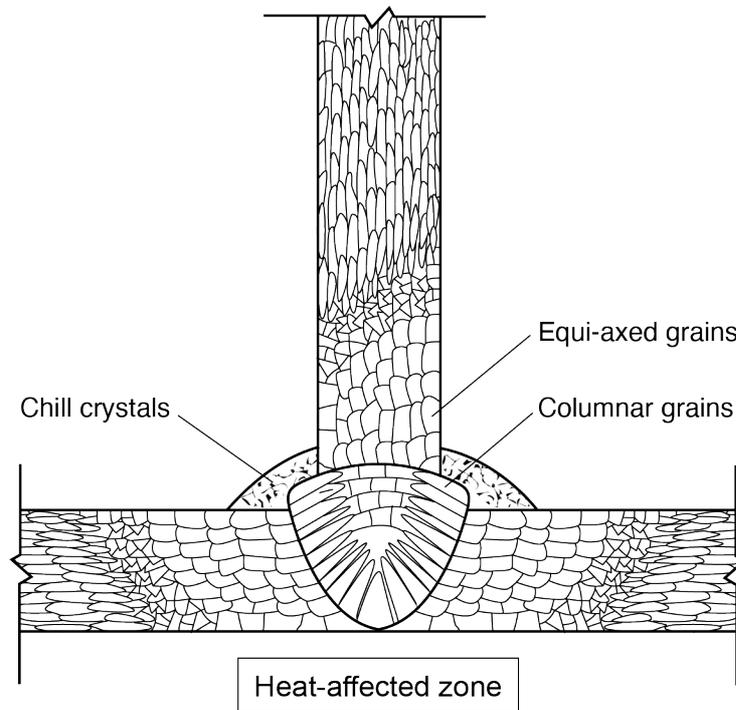
Answers could include:

- Steel frames are much more easily fabricated and assembled than timber frames, which can save time and costs in the construction process.
- Steel is much more resistant to fire than timber, which makes it a safer material to use in roller coasters.
- Steel is a more suitable material for roller coaster support structures due to its strength, durability, fire resistance, and ease of fabrication. Timber is not as strong as steel and has less durability, but it does have some advantages such as low cost, and ability to flex and bend.
- Steel has greater mechanical strength and is a more durable material than timber. It is able to withstand the higher stresses and forces exerted on a roller coaster.

Question 24 (b)

Criteria	Marks
<ul style="list-style-type: none"> Draws and labels the resulting microstructure of the parent and weld metal 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:



Question 24 (c)

Criteria	Marks
• Shows relevant working in calculating the height of the roller coaster car at point <i>B</i>	3
• Makes progress towards calculating the height of the roller coaster car at point <i>B</i>	2
• Provides some relevant information	1

Sample answer:

Conservation of energy

$$mgh_A + \frac{1}{2}mv_A^2 = mgh_B + \frac{1}{2}mv_B^2$$

$$550 + \frac{1}{2}0^2 = 10h_B + \frac{1}{2}.30^2$$

$$550 = 10h_B + 450$$

$$h_B = (550 - 450) \div 10$$

$$h_B = 10 \text{ metres}$$

Question 24 (d) (i)

Criteria	Marks
• Provides the purpose of the NAND gate in the schematic given	2
• Provides some relevant information	1

Sample answer:

The NAND gate ensures that if any or all of the inputs are zero the output will result in a 1 and thus turn on the warning light.

Answers could include:

The NAND gate ensures that the warning light will remain ON until all conditions for safe operation are met.

Question 24 (d) (ii)

Criteria	Marks
• Completes the truth table	3
• Partially completes the truth table	2
• Provides some relevant information	1

Sample answer:

<i>Safety harnesses secure</i>	<i>Track is clear</i>	<i>Ride gates are locked</i>	<i>Operator warning light</i>
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

Question 25 (a)

Criteria	Marks
• Describes the process of compression moulding	3
• Outlines some steps in the process of compression moulding	2
• Provides some relevant information	1

Sample answer:

Compression moulding of aircraft components is a process that begins by feeding a polymer into an open, heated mould cavity. The polymer is softened and the mould is then closed and compressed. Compression allows the material to make contact with all areas of the mould. The charge cures within the heated mould. When the piece is cured it is removed. The mould can be reused.

Answers could include:

Moulds can be used in the manufacture of composites.

Question 25 (b)

Criteria	Marks
<ul style="list-style-type: none"> Explains the functions of a transistor in an electrical circuit 	3
<ul style="list-style-type: none"> Describes the functions of a transistor in an electrical circuit OR <ul style="list-style-type: none"> Explains one function of a transistor in an electrical circuit 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

A transistor can operate as an amplifier. It magnifies the signal by allowing a current to flow from the emitter to the collector when a small current passes through the base. It also operates as a switch by allowing current to flow if conditions are met.

Question 25 (c)

Criteria	Marks
<ul style="list-style-type: none"> Outlines how GPS satellites determine a position on the planet 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

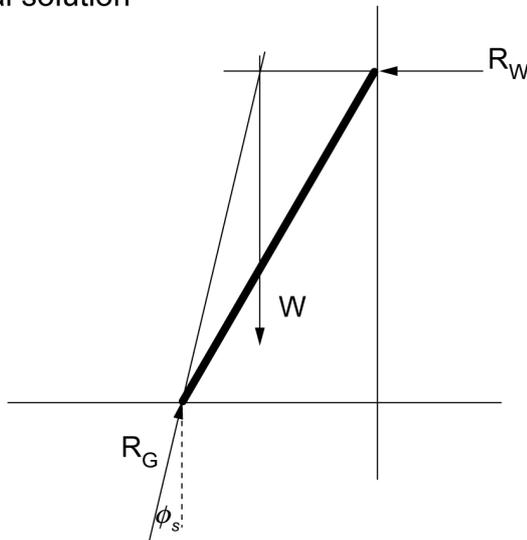
Position is determined when a GPS triangulates signals, measuring the time it takes signals to travel from satellites to the GPS receiver and calculating the difference.

Question 25 (d)

Criteria	Marks
<ul style="list-style-type: none"> Shows relevant working in the correct calculation of the minimum coefficient of friction between the ground and ladder 	4
<ul style="list-style-type: none"> Makes progress towards calculating the minimum coefficient of friction using a substantially correct method 	3
<ul style="list-style-type: none"> Makes some progress towards calculating the minimum coefficient of friction 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

Graphical solution



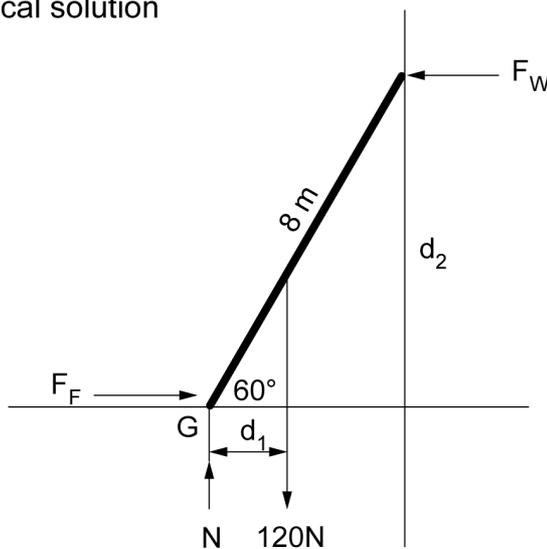
$$\phi = 16^\circ \text{ (as measured)}$$

$$\mu = \tan \phi_s$$

$$\mu = \tan 16^\circ$$

$$\mu = 0.289$$

Analytical solution



$$\cos 60 = \frac{d_1}{4} \qquad \sin 60 = \frac{d_2}{8}$$

$$d_1 = 2 \text{ m} \qquad d_2 = 6.928 \text{ m}$$

$$\Sigma M_G = 0$$

$$0 = (120 \times 2) - (F_W \times 6.928)$$

$$F_W = \frac{240}{6.928}$$

$$F_W = 34.6 \text{ N} \qquad \therefore F_F = 34.64 \text{ N}$$

$$N = 120 \text{ N} \uparrow$$

$$F_F = \mu N$$

$$\mu = \frac{34.64}{120}$$

$$\mu = 0.28$$

Question 26 (a)

Criteria	Marks
• Calculates the shear force of the punching die	3
• Makes progress towards calculating the shear force using an appropriate method	2
• Provides some relevant information	1

Sample answer:

$$\sigma_s = \frac{F}{A_s}$$

Shear Area A_s = perimeter of punch-out shape x thickness of plate

$$\begin{aligned}\text{Perimeter} &= (112 \times 2) + (15 \times 4) + (\pi \times 60) \\ &= 472.4 \text{ mm}\end{aligned}$$

$$\begin{aligned}\text{Shear Area } A_s &= 472.4 \text{ mm} \times 10 \text{ mm} \\ &= 4\,725 \text{ mm}^2 \\ &= 4\,725 \times 10^{-6} \text{ m}^2\end{aligned}$$

$$\begin{aligned}\text{Shear force} &= \text{shear stress} \times \text{shear area} \\ &= 345 \times 10^6 \text{ Pa} \times 4\,725 \times 10^{-6} \text{ m}^2 \\ &= 1\,630\,125 \text{ N}\end{aligned}$$

$$\text{Shear force} = 1\,630 \text{ kN}$$

Question 26 (b)

Criteria	Marks
• Describes the implications for the individual engineer and the company	3
• Outlines the implications for the individual engineer and/or the company	2
• Provides some relevant information	1

Sample answer:

The engineer has not worked ethically, the design is the intellectual property of the company and the engineer has stolen the property of the team and the company. This could also have legal implications for the individual as the engineer has not sought permission to produce the device.

The financial implications for the company if the device is produced is that they are not able to recoup the costs of development and unable to receive the economic benefit of the product on the market.

Answers could include:

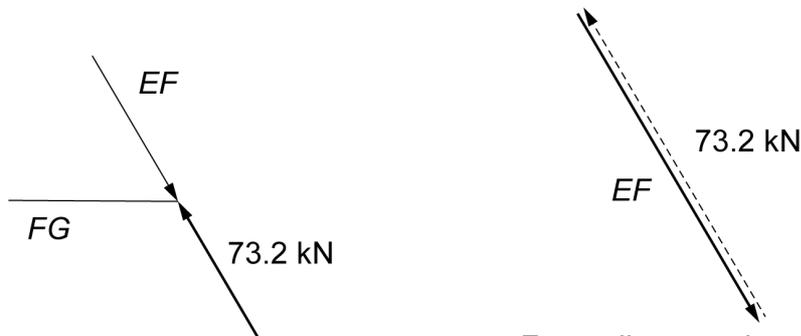
- Legal and ethical implications
- Health and safety factors
- Financial ramifications
- Logistical considerations
- Profits for the individual rather than the company
- Employment ramifications.

Question 26 (c)

Criteria	Marks
<ul style="list-style-type: none"> Shows relevant working in the correct calculation of the two internal reactions States their nature 	6
<ul style="list-style-type: none"> Makes substantial progress towards the calculation of the two internal reactions using a correct method States their nature 	4–5
<ul style="list-style-type: none"> Makes progress towards calculating the two internal reactions 	3
<ul style="list-style-type: none"> Makes progress towards calculating a reaction 	2
<ul style="list-style-type: none"> Provides some relevant information 	1

Sample answer:

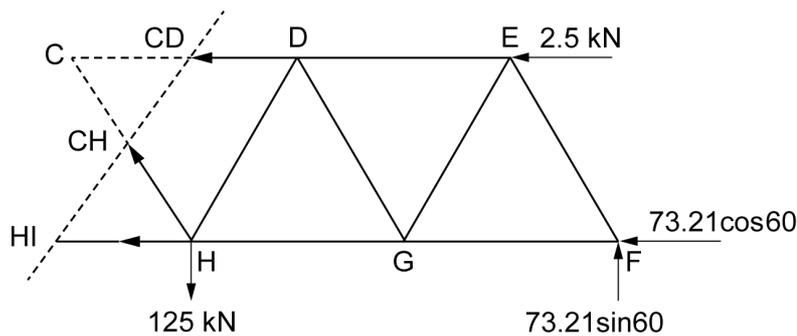
EF:



$EF = 73.2 \text{ kN (compression)}$

Force diagram closes with the two collinear forces, FG is redundant (zero force member).
So, $EF = 73.2 \text{ kN}$

CH:



$$\begin{aligned}
 + \uparrow \Sigma F_v &= 0 \\
 0 &= -125 + 73.2 \sin 60^\circ + CH \sin 60^\circ \\
 CH \sin 60^\circ &= 61.607 \\
 CH &= \frac{61.607}{\sin 60^\circ} \\
 CH &= 71.138 \text{ kN (tension)}
 \end{aligned}$$

Question 27 (a)

Criteria	Marks
• Discusses the use of composite materials in aircraft construction, with specific examples	4
• Describes how composite materials are used in aircraft construction	3
• Identifies composites used in aircraft construction	2
• Provides some relevant information	1

Sample answer:

Fiber-Reinforced Polymer (FRP) composites are used in the aeronautical industry due to their high strength-to-weight ratio. This is important as reducing weight leads to lower fuel consumption and increased payload capabilities.

Composites are used for aircraft structural components due to their energy absorption properties in order to avoid failure of components.

However, composite materials can suffer brittle failure. In aircraft, the failed composite component cannot be repaired and it would need to be replaced.

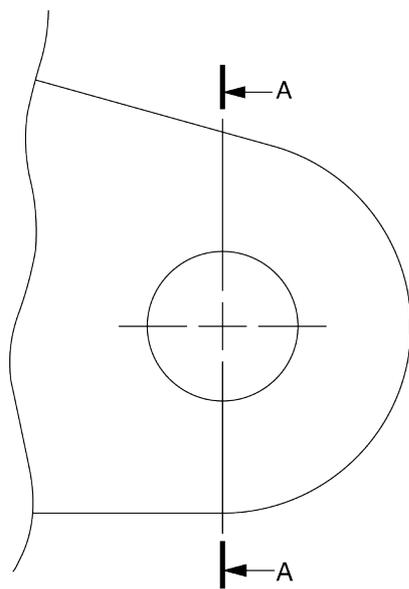
Answers could include:

- Composites used to:
 - improve fatigue resistance
 - increase corrosion resistance
- Composite materials have high strength-to-weight ratios, which means they can withstand large loads while being lightweight. An example of a sandwich composite material is a honeycomb core sandwich panel made of two thin, stiff facing sheets (such as fibreglass or aluminium) and a lightweight, honeycomb core material (such as Nomex, paper). This type of composite material is used in many aero applications due to its high strength-to-weight ratio and improved stiffness
- Composite materials components can be time consuming to manufacture.

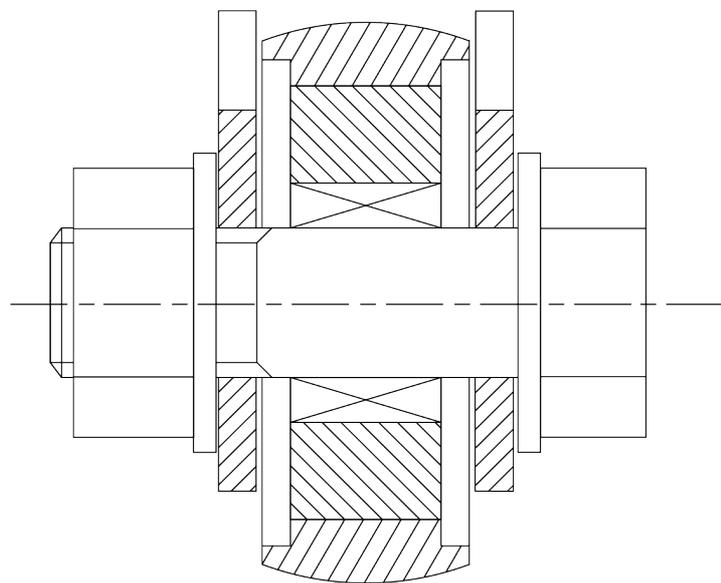
Question 27 (b)

Criteria	Marks
<ul style="list-style-type: none"> • Demonstrates detailed application of knowledge and understanding when sectioning the assembled front view to AS 1100 standards 	6
<ul style="list-style-type: none"> • Demonstrates substantial application of knowledge and understanding when sectioning the assembled front view to AS 1100 standards 	5
<ul style="list-style-type: none"> • Demonstrates adequate application of knowledge and understanding of the front view to AS 1100 standards 	3–4
<ul style="list-style-type: none"> • Makes some progress towards producing a front view drawing 	2
<ul style="list-style-type: none"> • Provides some relevant information 	1

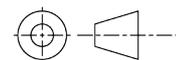
Sample answer:



PARTIAL LEFT VIEW



SECTION A-A



Scale 1:2

2023 HSC Engineering Studies Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Personal and public transport — engineering materials, testing of materials – p28	H2.1
2	1	Civil structures — historical and societal influences – p24	H1.2, H4.2
3	1	Telecommunications engineering — copper and its alloys – p36	H1.2
4	1	Aeronautical engineering — communication, AS1100 – p33	H3.3
5	1	Telecommunications engineering — materials, fibre optics – p37	H1.2
6	1	Aeronautical engineering — engineering mechanics; fluid mechanics – p32	H3.1
7	1	Civil structures — materials – p25	H1.2
8	1	Personal and public transport — historical and societal influences	H4.2
9	1	Civil structures — materials, composites – p26	H2.1
10	1	Civil structures — materials, stress and strain – p25	H3.1
11	1	Personal and public transport — materials, thermosetting polymers – p29	H1.2
12	1	Personal and public transport — engineering mechanics, simple machines – p28	H3.1
13	1	Civil structures — engineering materials, stress and strain – p25	H1.2
14	1	Personal and public transport — materials, heat treatment of ferrous metals – p28	H2.1
15	1	Telecommunications engineering — electricity/electronics, satellite communication systems – p37	H1.2
16	1	Aeronautical engineering — engineering mechanics and hydraulics, fundamentals of flight mechanics – p32	H3.1
17	1	Aeronautical engineering — communication, AS1100 – p33	H3.3
18	1	Personal and public transport — engineering mechanics, static friction – p28	H3.1
19	1	Civil structures — engineering mechanics, truss analysis – p25	H3.1
20	1	Aeronautical engineering — communication, developments – p33	H3.3

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Aeronautical engineering — communication, computer graphics CAD – p34	H3.3
21 (b)	3	Aeronautical engineering — communication: collaborative work practices – p34	H3.2
21 (c)	3	Aeronautical engineering — communication, freehand and technical drawing – p33	H3.3
21 (d)	3	Aeronautical engineering — materials, thermosetting polymers – p33	H1.2

Question	Marks	Content	Syllabus outcomes
22 (a) (i)	2	Civil structures — materials, composites – p26	H1.2
22 (a) (ii)	3	Civil structures — materials: corrosion – p26	H1.2
22 (b) (i)	3	Civil structures — mechanics, truss analysis – p25	H3.1
22 (b) (ii)	3	Civil structures — mechanics, bending stress – p25	H3.1
23 (a)	3	Personal and public transport — electronics/electricity, power generation – p29	H1.2
23 (b)	3	Telecommunications engineering — scope of the profession, legal and ethical implication – p36	H1.1
23 (c)	3	Telecommunications engineering — insulation materials – p37	H1.2
23 (d)	3	Telecommunications engineering — electronics/electricity, transmission media – p37	H1.2
24 (a)	2	Transport — historical developments – p27	H4.2
24 (b)	2	Transport — materials, manufacturing processes – p28	H1.2
24 (c)	3	Transport — mechanics, basic calculations for work energy and power – p28	H3.1
24 (d) (i)	2	Telecommunications — digital technologies – p37	H2.1
24 (d) (ii)	3	Transport — electricity/electronics, digital technologies – p37	H2.1
25 (a)	3	Aeronautical engineering — materials, thermosetting polymers – p33	H2.1
25 (b)	3	Telecommunications engineering — electronics, electricity, semiconductors – p36	H2.1
25 (c)	2	Telecommunications engineering — electricity/electronics, GPS	H2.1
25 (d)	4	Transport — mechanics, static friction – p28	H3.1
26 (a)	3	Civil structures — mechanics stress and strain – p25	H3.1
26 (b)	3	Aeronautical engineering — scope of the profession, legal and ethical implications – p31	H1.1
26 (c)	6	Civil structures — mechanics, truss analysis – p25	H3.1
27 (a)	4	Aeronautical engineering — materials, composites – p33	H1.2
27 (b)	6	Transport — communications, sectional views – p29	H3.3