BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

2014 HSC Engineering Studies
Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
• Clearly shows how a single hull ferry and a twin hull ferry are used differently to provide public transport	3
• Shows some understanding of how a single hull ferry and/or a twin hull ferry is used to provide public transport	2
• Identifies a feature of either ferry	1

Sample answer:

The single hull ferry is a much larger craft making it more suitable in deeper water because of its draft. It is capable of carrying large numbers of passengers between two wharves.

The twin hull ferry has a shallower draft making it more suitable for shallower water and river travel with less wash in speed-restricted areas. It is more manoeuvrable and manageable for many wharves along the foreshore. It is also able to pass freely under road and rail bridges due to its lower height.

Answers could include:

Speed and/or stability of the catamaran.

Question 21 (b)

Criteria	Marks
• Provides the characteristics and features of the operation of a hydrofoil	3
• Shows some understanding of how a hydrofoil operates	2
• Provides some relevant information	1

Sample answer:

At low speeds the hull sits in the water and the hydrofoils are totally submerged in the water. As the boat's speed increases, the hydrofoils create lift. At a certain speed, the lift produced by the hydrofoils lifts the hull out of the water reducing drag.

Answers could include:

Decreasing the drag contributes to the better use of the power needed for the movement of the boat.

Question 21 (c)

Criteria	Marks
• Correctly outlines factors to be considered by an engineer for ferry wharf design	3
• Identifies factors or outlines a factor to be considered for wharf design	2
• Identifies a factor to be considered for wharf design	1

Sample answer

Factors may include customer's requests for improved amenity (including protection from the weather and more seating) and improved accessibility, detailed marine studies of the site (including depth of water, high and low tide levels) and use of appropriate materials, surfaces and design that discourage vandalism or inappropriate use of the wharf.

Answers could include:

- Ferry master's knowledge and experience of maritime conditions prevailing at the wharf
- Creating a shape and form that visually complements the harbour
- Maintenance of the wharf
- Building and access to wharf when building

Question 21 (d)

Criteria	Marks
• Provides a detailed description of a suitable method of protection	3
• Shows some understanding of a suitable method of protection	2
• Provides some relevant information	1

Sample answer:

Impressed Current Cathodic Protection is used to supply the steel with electrons forcing it to become the cathode thus protecting the steel from corrosion. This method is generally used on larger structures where a sacrificial anode cannot supply enough current to provide complete protection.

Answers could include:

Cathodic protection: A sacrificial anode can be used to protect the steel by joining a more reactive metal (zinc or magnesium) to the steel. The more reactive metal, zinc, corrodes (and is therefore sacrificed) and needs to be replaced periodically.

Question 22 (a) (i)

Criteria	Marks
• Determines reaction with correct magnitude and direction	3
• Shows substantial understanding to determine magnitude and direction	2
• Shows some understanding of application of moments or graphical solution	1

Sample answer:

$\sum M_A = \left(R_e \times 15\right) - \left(20 \times 4.33\right) = 0$

$R_e = \dfrac{(86.6)}{15} = 5.77 \text{ kN} \uparrow$

$\sum V = R_{AV} + 5.77 - 20\sin 60° = 0 \qquad R_{AV} = 17.32 - 5.77 = 11.55 \text{ kN} \uparrow$

$\sum H = R_{AH} + 20\cos 60° = 0 \qquad R_{AH} = -10 = 10 \text{ kN} \leftarrow$

$R_A = \sqrt{\left(R_{AH^2} + R_{AV^2}\right)} = \sqrt{(133.4 + 100)} = 15.28 \text{ kN}$

$\phi = \tan^{-1}\left(\dfrac{11.55}{10}\right) = 49°$

Force 15.28 kN Direction 49° ↖

Question 22 (a) (ii)

Criteria	Marks
• Correctly determines magnitude and nature of the forces in the members BC and DF	3
• Shows substantial understanding to determine forces in members	2
• Uses appropriate method to achieve answer	1

Sample answer:

$\sum M_F = 0 \quad -(BC\sin 30 \times 7.5) - (22.5 \times 7.5) + (30 \times 3.75) = 0$

BC = – 56.25 / 3.75 = 15 kN Nature: Compression

DF = 0 by inspection Joint D Nature: Zero force member

Answers could include:

Method of joints, method of sections, graphical joint analysis

Question 22 (a) (iii)

Criteria	Marks
• Correctly calculates diameter of member	2
• Demonstrates some knowledge of stress calculation or factor of safety	1

Sample answer:

$$\text{F of S} = Ó_{\text{YIELD}} / Ó_{\text{WORKING}}$$

$$Ó_{\text{WORKING}} = 272 / 1.6 = 170 \text{ MPa}$$

$$Ó = F / A \qquad A = F / Ó$$

$$A = \pi d^2 / 4 = 29 \times 10^3 / 170 = 170.6 \text{ mm}^2$$

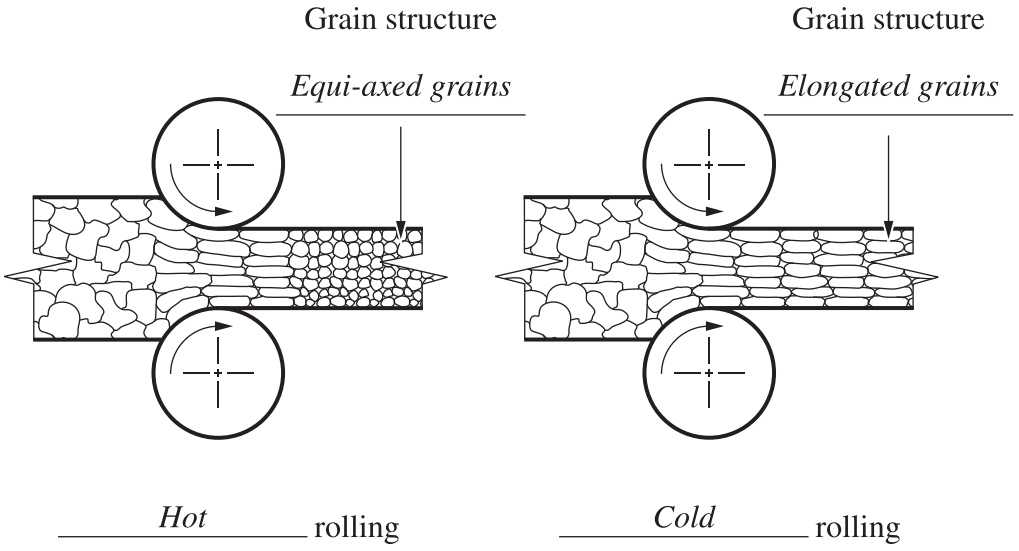
$$d^2 = 4 \times 170.6 / \pi$$

$$d = \sqrt{217.2} = 14.7 \text{ mm}$$

Question 22 (b) (i)

Criteria	Marks
• Correctly labels rolling processes with matching grain structure	2
• Correctly labels a rolling process OR • Correctly labels a grain structure	1

Sample answer:



Question 22 (b) (ii)

Criteria	Marks
• Recognises two different mechanical properties that have been affected • Relates these to the change in grain structure caused by one of the processes	2
• Recognises a mechanical property that has been affected by one of the processes	1

Sample answer:

Name of process: Cold rolling

Mechanical property 1:
Elongation of grains in cold rolling increases ultimate tensile strength.
Mechanical property 2:
Elongation of grains in cold rolling increases hardness of the material.

OR

Name of process: Hot rolling

Mechanical property 1:
Equi-axed grains increase ductility of the material.
Mechanical property 2:
Equi-axed grains increase the toughness of the material.

Question 23 (a)

Criteria	Marks
• Outlines advantages of polymer roof guttering compared to metal roof guttering	3
• Identifies advantages of polymer roof guttering OR • Outlines an advantage of polymer roof guttering	2
• Identifies a feature of polymer/metal roof guttering	1

Sample answer:

Polymer gutters are corrosion resistant therefore they do not need painting like metal gutters. Polymer guttering is less likely to dent due to impact which assists installation.

Answers could include:

Polymer gutters are more flexible than metal gutters which assists installation.

Question 23 (b)

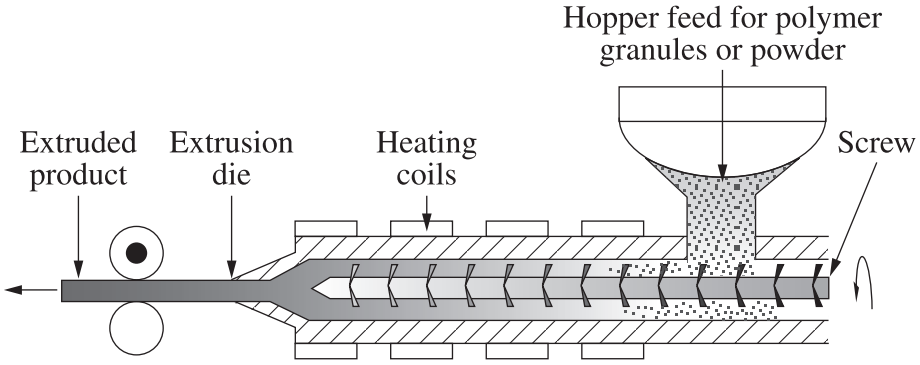
Criteria	Marks
• Names a suitable polymer and gives a description of the extrusion process	3
• Names a suitable polymer and identifies some features of the extrusion process OR • Gives a brief description of the extrusion process	2
• Names a suitable polymer OR • Identifies a feature of the extrusion process	1

Sample answer:

A suitable polymer is PVC.

The plastic in the form of granules is fed from a hopper onto a steel screw which feeds the polymer through a heated chamber and forces it through a die of the shape required.

Answers could include:

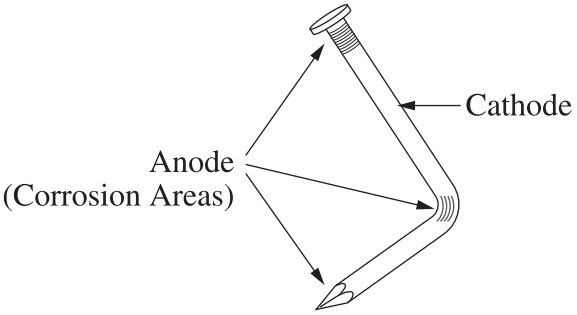


Question 23 (c)

Criteria	Marks
• Identifies the type of corrosion and correctly labels the sketch	2
• Names the type of corrosion OR • Identifies anode/cathode (1 stressed area)	1

Sample answer:

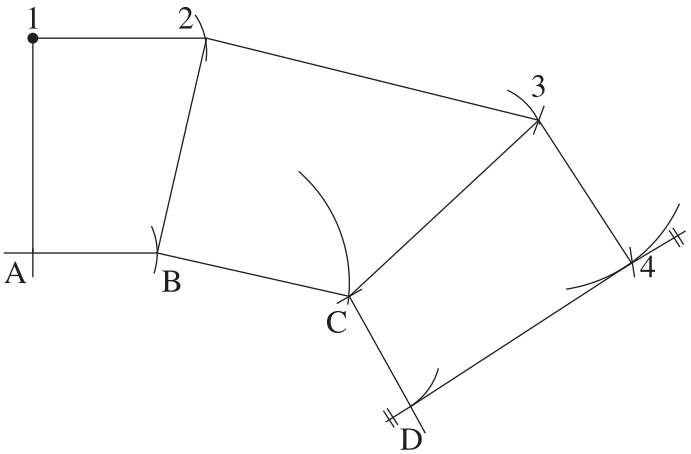
Stress corrosion



Question 23 (d)

Criteria	Marks
• Constructs a correct half development of the transition piece	4
• Constructs a partially correct half development of the transition piece	2–3
• Shows some understanding of constructing a half development	1

Sample answer:



Question 24 (a)

Criteria	Marks
• Correctly calculates the distance (d)	2
• Shows some understanding of how to calculate the distance (d) using moments	1

Sample answer:

Total mass = 550 + 1400 + 1400 = 3350 kg

$3350 \times d = (550 \times 3) + 2(1400 \times 12)$

d = (35250 / 3350)

= 10.5 m

Question 24 (b)

Criteria	Marks
• Gives an outline of the operation of a pitot tube in flight	2
• Identifies a feature of a pitot tube	1

Sample answer:

The pitot tube compares dynamic pressure with static pressure. The difference is then determined using a diaphragm and the deflection determines the indicated airspeed of the aircraft.

Question 24 (c)

Criteria	Marks
• Gives a description of the function of winglets on modern aircraft	2
• Identifies a feature of winglets	1

Sample answer:

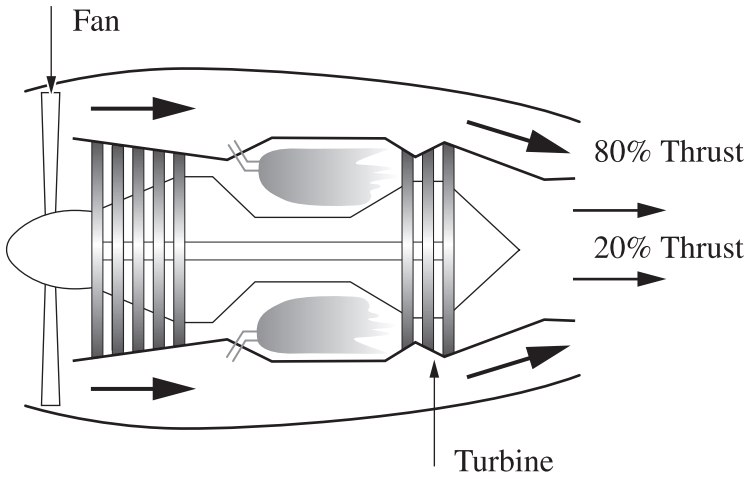
Winglets are placed on the end of the main wings to reduce bleeding of air across the wings. They effectively increase the length of the wing by creating increased lift and reduced drag. They increase stability and fuel efficiency.

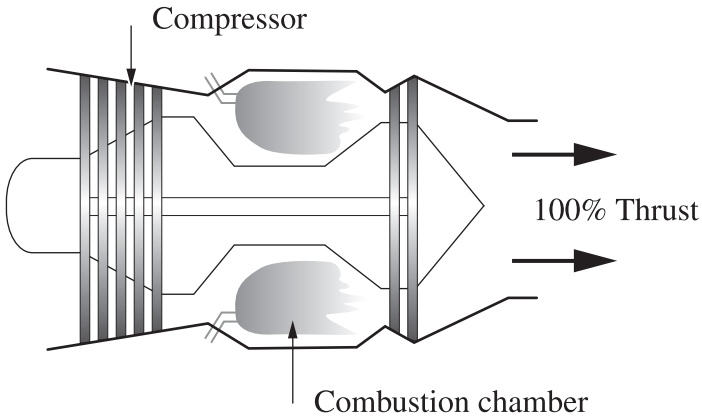
Question 24 (d)

Criteria	Marks
• Clearly explains how thrust created by airflow affects the main operations of the turbofan and turbojet engines	6
• Identifies the effects of thrust created by airflow on the operations of the turbofan and turbojet engines • Provides an explanation in relation to the turbofan and/or turbojet engine	4–5
• Identifies the effects of thrust created by airflow on the operations of the turbofan and turbojet engines OR • Explains how thrust created by airflow affects the operation of a turbofan/turbojet engine	3
• Outlines some features of a turbofan and/or turbojet engine	2
• Identifies a feature of a turbofan or turbojet engine	1

Sample answer:

A turbofan engine creates most of its thrust in the cowling around the engine. The fan which creates 80% of the thrust is powered by the turbine at the rear of the engine. The turbojet creates its thrust by compressing the air which is ignited with a fuel mixture in the combustion chamber with the turbine driving the compressor.





Question 25 (a)

Criteria	Marks
• Outlines two suitable control technologies	3
• Outlines one suitable control technology	2
• Names two control technologies OR • Shows some understanding about making modern cars safer	1

Sample answer:

ABS brakes prevent lock up of the brakes and prevent the car from skidding.
Cruise control allows the driver to maintain a constant speed to suit the speed limit and road conditions.

Answers could include:

- Airbags
- Reversing sensors
- Reversing cameras
- ESP (Electronic Stability Program)

Question 25 (b)

Criteria	Marks
• Shows good understanding of how electricity is generated, stored and changed	3
• Shows some understanding of how electricity is generated and/or stored and/or changed	2
• Provides some relevant information	1

Sample answer:

Electricity is created by a generator or alternator and stored in a battery.

It can be converted to a high voltage system by a transformer or coil.

Question 25 (c)

Criteria	Marks
• Outlines the advantages of using fibre optics in telecommunications	3
• Outlines an advantage of using fibre optics in telecommunications	2
• Identifies features of fibre optics	1

Sample answer:

Fibre optics are thinner than copper wires, allowing more to be bundled into a cable and achieving higher carrying capacity. Fibre optics cable is cheaper than equivalent lengths of copper wire while offering less signal degradation.

Answers could include:

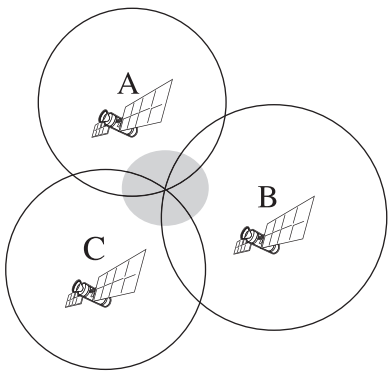
- Band width increases
- Faster
- Less attenuation
- Increased efficiency for data transfer

Question 25 (d)

Criteria	Marks
• Clearly explains how a GPS uses multiple satellites for navigation	3
• Shows some understanding of how a GPS works	2
• Identifies a feature of a GPS OR • Shows some understanding of navigation	1

Sample answer:

A Global Positioning System uses triangulation to determine position. It requires at least three satellites that transmit signals to a receiver. GPS receivers receive satellite signals; they do not transmit. Each GPS satellite transmits data that indicates its location and the current time. A fourth satellite improves the accuracy of its position.



Question 26 (a) (i)

Criteria	Marks
• Correctly calculates the energy loss	2
• Shows some understanding of potential energy calculation	1

Sample answer:

$E_{Lost} = \Delta PE$

$E_{Lost} = mgh_1 - mgh_2$

$E_{Lost} = mg(h_1 - h_2)$

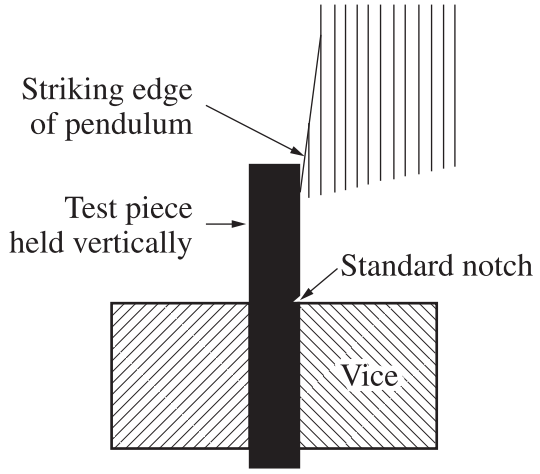
$E_{Lost} = 110(0.8 - 0.23)$

$E_{Lost} = 62.7 \text{ J}$

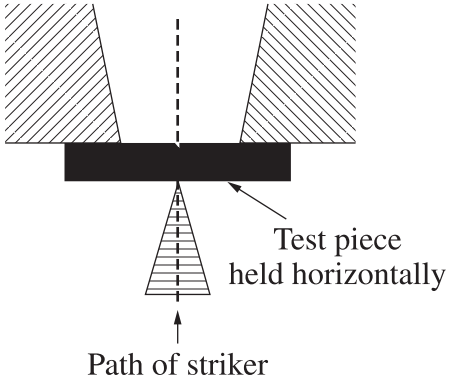
Question 26 (a) (ii)

Criteria	Marks
• Identifies an appropriate test • Sketches how the specimen is held • Indicates the position of the notch relative to the striker • Identifies the mechanical property determined	4
• Identifies an appropriate test and/or mechanical property • Provides a relevant sketch showing how the specimen is held and/or the position of the notch relative to the striker	3
• Identifies features of an appropriate test	2
• Identifies an appropriate test or property being tested	1

Sample answer:

Notched bar Impact Test	
Name of test	IZOD
 Front View	
Mechanical property determined	Toughness

Answers could include:

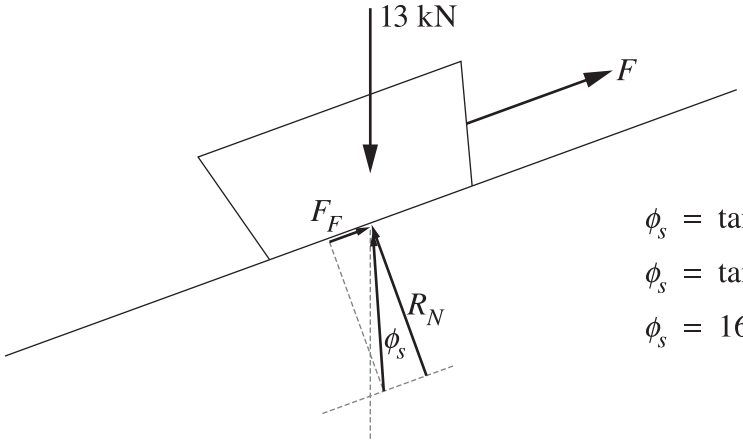
<table>
<tr><th colspan="2">Notched bar Impact Test</th></tr>
<tr><td>Name of test</td><td>CHARPY</td></tr>
<tr><td colspan="2"> 

Top View</td></tr>
<tr><td>Mechanical property determined</td><td>Toughness</td></tr>
</table>

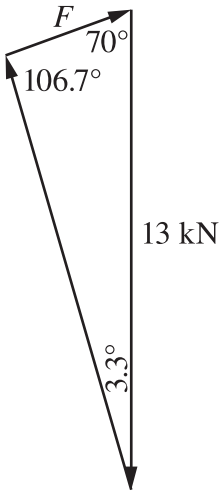
Question 26 (b) (i)

Criteria	Marks
• Correctly calculates the minimum force required in the cable	3
• Shows a substantial understanding of how to calculate tension in the cable	2
• Makes a relevant calculation	1

Sample answer:



$$\phi_s = \tan^{-1}\mu$$
$$\phi_s = \tan^{-1} 0.3$$
$$\phi_s = 16.7°$$



$$\frac{F}{\sin 3.3°} = \frac{13}{\sin 106.7°}$$
$$F = \frac{13 \times \sin 3.3°}{\sin 106.7°}$$
$$F = 0.781 \text{ kN}$$
$$F = 0.765 \text{ kN} \left(g = 9.8 \text{ m s}^{-2}\right)$$

Alternatively:

$$+\uparrow \quad \Sigma F_{perp} = 0$$
$$0 = R_N - mg\cos\theta$$
$$0 = R_N - 13\cos 20$$
$$R_N = 12.216 \text{ kN}$$

$$+\rightarrow \quad \Sigma F_{par} = 0$$
$$0 = F + \mu R_N - mg\sin\theta$$
$$0 = F + (0.3 \times 12.216) - 4.446$$
$$F = 0.781 \text{ kN}$$

Question 26 (b) (ii)

Criteria	Marks
• Correctly calculates the power required	3
• Shows a substantial understanding of how to calculate the power required (eg calculates power without applying efficiency)	2
• Makes a relevant calculation	1

Sample answer:

Force in cable:

$$\begin{aligned} \nearrow^{+} \quad \Sigma F_{par} &= 0 \\ 0 &= F - \mu R_N - mg\sin\theta \\ 0 &= F - (0.3 \times 12.216) - 4.446 \\ F &= 8.11 \text{ kN} \end{aligned}$$

Power to slide the boat:

$$\begin{aligned} P &= Fv \\ P &= 8.11 \times 0.7 \\ F &= 5.677 \text{ kW} \end{aligned}$$

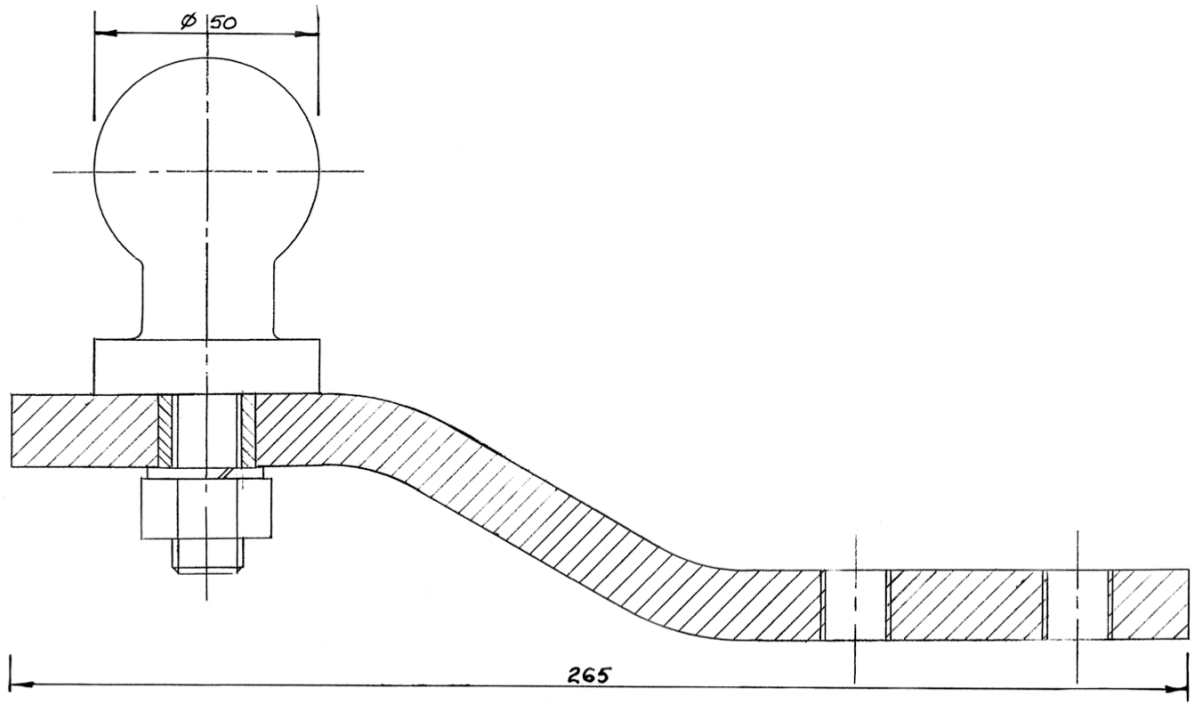
Power required by motor:

$$\begin{aligned} \eta &= \frac{P_{out}}{P_{in}} \\ P_{in} &= \frac{P_{out}}{\eta} \\ P_{in} &= \frac{5.677}{0.77} \\ P_{in} &= 7.37 \text{ kW} \end{aligned}$$

Question 27

Criteria	Marks
• Provides a correct full size sectional front view of the towbar to AS1100 standards with dimensions	8
• Provides a substantially correct full size sectional front view of the towbar to AS1100 standards, but with minor error(s) and/or omission(s)	6–7
• Provides a generally correct front view of the towbar with major errors and/or omissions	4–5
• Provides a drawing with some features of the front view of the towbar	2–3
• Demonstrates some knowledge of orthographic drawing	1

Sample answer:



Answers should include:

Correct dimension overall length
Correct dimension diameter
Correct representation nut three faces
Correct representation nut height
Correct representation nut point to point (1.8D)
Correct representation spring washer
Correct representation full thread on ball
Correct length of thread on ball
Correct representation thread chamfer on ball
Correct representation thread pitch on ball
Correct representation of threaded holes (diameter and pitch)
Correct representation sectioning of tongue
Correct representation sectioning to threaded holes
Correct representation sectioning sleeve to towbar thread
Correct representation sectioning sleeve
Correct representation angled piece width
Correct representation fillet curves
Correct representation ball not sectioned
Correct representation centre lines
Correct representation ball shoulder height line

Engineering Studies

2014 HSC Examination Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Engineering materials p25 Composites – concrete p26	H1.2
2	1	Testing of materials p25	H2.1
3	1	Testing of concrete p25	H2.1
4	1	Fundamental flight mechanics p32	H2.2
5	1	Heat treatment of steels p28	H2.1
6	1	Digital technology p37	H3.3
7	1	Simple circuits p29	H3.3
8	1	Specialised testing p36	H2.2
9	1	Pascal's Principle p32	H3.1
10	1	Graphical design p29	H3.1
11	1	Semiconductors p36	H1.2
12	1	Three force rule for equilibrium or moments p17	H3.1
13	1	Simple machines – pulleys p14	H3.1
14	1	AS1100 Drawing standards p33	H3.3
15	1	Concept of shear force and bending moment p25	H3.1
16	1	Structure and properties of ceramics p25	H2.1
17	1	Conservation of energy p28	H3.1
18	1	Simple machines – velocity ratio p28	H3.1
19	1	Heat treatment aluminium alloys p33	H1.2
20	1	Bending stress p25	H3.1

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	3	Engineering innovations in transport p27	H4.2, H6.2
21 (b)	3	Bernoulli's Principle p32	H4.2, H6.2
21 (c)	3	Engineering innovation in civil structure p24	H4.3
21 (d)	3	Corrosive environments p26	H1.2, H2.1

Question	Marks	Content	Syllabus outcomes
22 (a) (i)	3	Truss Analysis Reactions at supports p25	H3.1
22 (a) (ii)	3	Truss analysis – method of sections p25	H 3.1
22 (a) (iii)	2	Yield Stress p25	H3.1
22 (b) (i)	2	Manufacturing processes – rolling p28	H1.2, H2.1
22 (b) (ii)	2	Manufacturing processes – rolling p28	H1.2, H2.1
23 (a)	3	Thermosoftening polymers p29	H1.2, H2.1
23 (b)	3	Manufacturing processes – extrusion p29	H1.2
23 (c)	2	Stress Corrosion p26	H1.2
23 (d)	4	Development non-circular Transition Piece p33	H3.3
24 (a)	2	Forces – Moments of a force p17 Action of loads p25	H3.1
24 (b)	2	Fluid mechanics – Basic operation of pitot tube p32	H1.2
24 (c)	2	Fundamental flight mechanics – technological change p32	H4.1
24 (d)	6	Propulsion Systems – turbojet and turbofan p32	H2.2, H4.1
25 (a)	3	Control technology p29	H4.1, H4.2
25 (b)	3	Power generation in transport industry p29	H4.3
25 (c)	3	Fibre optics – applications p37	H1.1
25 (d)	3	Satellite communication systems – GPS p37	H2.2
26 (a) (i)	2	Potential energy p28	H3.1
26 (a) (ii)	4	Testing of materials p28	H1.2
26 (b) (i)	3	Friction p28	H3.1
26 (b) (ii)	3	Electrical energy and power p29	H3.1
27	8	Orthogonal drawing, sectioning AS1100 standards p29	H3.3