BOARD OF STUDIES
NEW SOUTH WALES

2013 HSC Engineering Studies Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
• Identifies a specific material and describes how its development has changed bicycle frames	3
• Identifies a specific material and sketches in general terms how its development has changed bicycle frames	2
• Identifies a specific material or provides some relevant information about change(s) in bicycle frames	1

Sample answer:

Carbon fibre composite frames are super lightweight with high rigidity and strength. This is due to the strength to weight ratio of carbon fibre together with its rigidity, which permits the use of thinner walled tubular frames.

Answers could also include:

Materials could include chromoly, aluminium alloy.
Joining can be done without brazing / welding.
An oval cross section in the tubing has allowed different aerodynamics and aesthetic appeal.
The shape of the frame is less reliant on a triangulated structure.

Question 21 (b)

Criteria	Marks
• Identifies two correct materials and contrasts their in-service properties	4
• Identifies two correct materials and contrasts one in-service property	3
• Identifies two correct materials and/or states two in-service properties OR • Identifies one correct material and sketches its in-service property	2
• Identifies one correct material or states one in-service property	1

Sample answer:

Early mudguards were generally made from low carbon steel and a modern alternative is polypropylene. An in-service property is corrosion resistance. Steel is likely to corrode unless protected, while polypropylene does not corrode but suffers UV degradation. Another in-service property is toughness. Polypropylene can withstand small impacts without deformation whereas steel is likely to dent.

Answer could include:

- Modern alternative: Aluminium, fibre reinforced plastics, HDPE
- Polypropylene is lightweight for sports bicycles
- Polypropylene has better fatigue resistance

Question 21 (c)

Criteria	Marks
• Provides a detailed explanation of why corrosion occurs in the welded area	2
• Provides limited information about corrosion occurring in the welded area	1

Sample answer:

The welding process promotes oxidation in the heat-affected zone. In addition, stresses caused by differential cooling of the weld, if left unprotected, lead to corrosion.

Answer could also include:

Differential grain structure.
Intergranular cracks around grain boundaries in HAZ.
Stress corrosion.

Question 21 (d)

Criteria	Marks
• Provides a clear link between the issues and the planning of the infrastructure	3
• Provides some link between the issues and the planning of the infrastructure	2
• Provides some relevant information	1

Sample answer:

The increased social and environmental pressure to reduce noise and air pollution created by motor vehicle emissions increases the demand for existing bicycle ways to be linked to create a continuous bicycle pathway network. Less social tolerance to risk means that there is more pressure for physical separation between bicycle, pedestrian and vehicular traffic. As the number of bicycles increases, there is a need to establish parking areas and storage facilities at transport interchanges.

Answers could also include:

Riding creates a more healthy lifestyle which increases the demand for bicycle ways.

Increased environmental pressure to reduce noise and air pollution created by motor vehicle emissions increases demand for cycle ways.

More cyclists creates less need for providing parking for cars.
New suburbs have bicycle lane design included in the planning stage.
Environmental impacts such as drainage from increased paved surface areas need to be integrated into the local surroundings.

Question 22 (a)

Criteria	Marks
• Provides a detailed explanation of why drop-forging is used in preference to sand casting	2
• Provides a limited explanation of why drop-forging is used in preference to sand casting OR • Mentions a disadvantage of sand casting or an advantage of drop-forging	1

Sample answer:

Drop forging produces grain flow which follows the profile of the teeth and is stronger and tougher than the uniform grain structure produced by casting. Sand casting is more susceptible to manufacturing defects.

Question 22 (b)

Criteria	Marks
• Demonstrates significant knowledge to calculate *MA*, *VR* and Efficiency	3
• Demonstrates significant knowledge to calculate any two of the following: *MA*, *VR* or Efficiency	2
• Demonstrates some knowledge to calculate *MA*, *VR* or Efficiency	1

Sample answer:

$$MA = \frac{L}{E} = \frac{72}{446} = 0.16$$

$$VR = \frac{168 \times 17}{49 \times 337.5} = 0.17$$

$$\text{Efficiency} = \frac{MA}{VR} = \frac{0.16}{0.17} = 94\%$$

Efficiency = 94%

Question 22 (c) (i)

Criteria	Marks
• Shows the difference in the operation of the motors	2
• Provides an aspect of the operation of one of the motors	1

Sample answer:

Brushless DC motors use electronics to switch the electric current to the armature fields whereas brushed DC electric motors use a brush to transmit the electric current to the armature. Brushless motors are more efficient and reliable.

Answer could also include:

Arcing brushes create electrical interference, are noisy, create ozone, absorb power and wear out.

Question 22 (c) (ii)

Criteria	Marks
• Provides a detailed description of how regenerative braking charges the battery	2
• Provides a basic description of how regenerative braking charges the battery	1

Sample answer:

Regenerative braking uses the kinetic energy of a vehicle during braking to rotate the electric motor. This turns the electric motor into a generator that generates electricity to charge the battery.

Question 22 (c) (iii)

Criteria	Marks
• Demonstrates significant knowledge to calculate Current, Time and Distance	3
• Demonstrates significant knowledge to calculate any two of the following: Current, Time or Distance	2
• Demonstrates some knowledge to calculate Current, Time or Distance	1

Sample answer:

$P = VI$

$$I = \frac{P}{V} = \frac{200}{24} = 8.3 \text{ A}$$

$$\text{Time} = \frac{\text{amp h}}{\text{amp}} = \frac{40}{8.3} = 4.8 \text{ h}$$

$$\text{Distance} = 8 \times 4.8 = 38.4 \text{ km}$$

Question 23 (a)

Criteria	Marks
• Demonstrates the correct method to calculate the magnitude and nature of force in both members	4
• Demonstrates significant knowledge to calculate the magnitude and nature of force in members	3
• Demonstrates knowledge to calculate the magnitude and nature of force in a member	2
• Demonstrates the correct method to calculate a reaction	1

Sample answer:

$$\sum M_A = \left(R_G \times 16\right) - \left(3.5 \times 11\right) - \left(2.5 \times 5\right) = 0$$

$$R_G = \frac{38.5 + 12.5}{16} = 3.2 \text{ kN}$$

To find BD, $\sum V$ (RHS) = $BD \sin 45° - 3.5 + 3.2 = 0$

$$BD = \frac{(0.3)}{0.707} = 0.42 \text{ kN (Tension)}$$

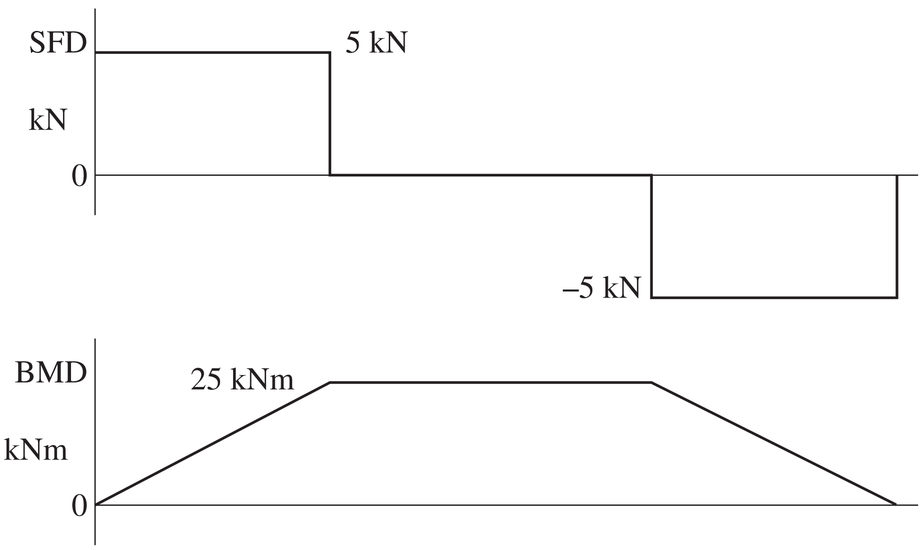
To find BC, analyse Joint C

$\sum V = 0 \qquad BC = 0$ (redundant member)

Question 23 (b) (i)

Criteria	Marks
• Draws and labels shear force and bending moment diagrams correctly	3
• Draws shear force and bending moment diagrams with only minor errors	2
• Draws a shear force or bending moment diagram correctly OR • Demonstrates some understanding of shear force and bending moment diagrams	1

Sample answer:



Question 23 (b) (ii)

Criteria	Marks
• Calculates maximum bending stress correctly	3
• Calculates maximum bending stress with minor error	2
• Identifies maximum bending moment OR • Attempts a calculation of bending stress	1

Sample answer/Answers could include:

$$\sigma = \frac{My}{I} = \frac{25 \times 10^3 \times 10^3 \times 150}{157.5 \times 10^6} = 23.8 \text{ MPa}$$

Question 23 (c)

Criteria	Marks
• Outlines TWO structural advantages of using laminated beams	2
• Outlines ONE structural advantage of using laminated beams	1

Sample answer:

Larger cross section of laminated beams is not limited by the size of the source tree.

Grain defects, knots and weaknesses can be removed.

Answers could include:

- Increases the strength of the beam.
- Beams can be shaped to match applied loads.
- Splitting and uneven shrinkage less likely.
- Less likely to warp.

Question 24 (a)

Criteria	Marks
• Determines the Lift to Drag ratio	3
• Determines Lift to Drag ratio with minor error(s)	2
• Does a relevant calculation OR • Provides some relevant information	1

Sample answer:

Analytical Solution

$W = mg = 260 \times 10^3 \times 10 = 2600$ kN

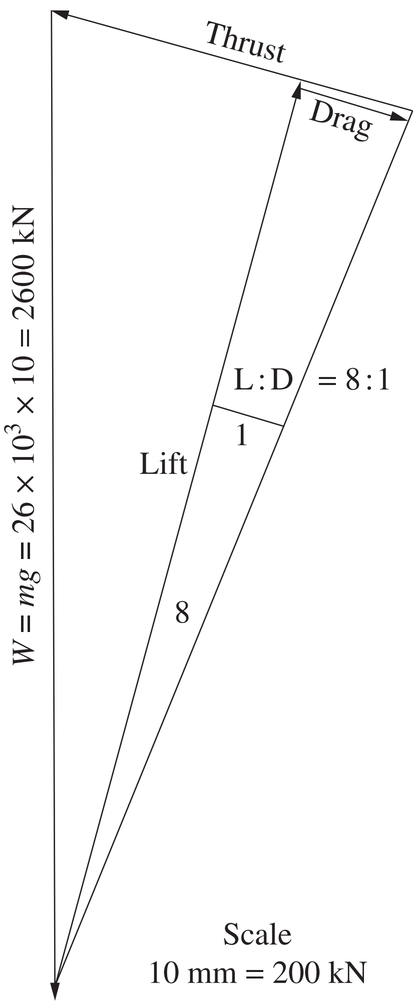
$L = W\cos 15° = 2600 \times 0.966 = 2511.4$ kN

$\sum F = T - W\sin 15° - D = 0$

$D = 987 - (2600 \times 0.259) = 987 - 672.9 = 314.1$ kN

$\frac{L}{D} = \frac{511.4}{314.1} = 8 : 1$

Answers could include:



Question 24 (b)

Criteria	Marks
• Clearly demonstrates how the drag is affected	3
• Provides some information about the effects on drag	2
• Provides some relevant information	1

Sample answer:

As the angle of attack is increased at slow speed, it generates more lift and increases the induced drag. As the angle of attack increases, the plane presents more frontal area and this will increase the parasite drag. As the airspeed increases, the angle of attack decreases which lowers the induced drag but increases the parasite drag.

Question 24 (c)

Criteria	Marks
• Gives a detailed description of the steps involved in the heat treatment process, including aging	3
• Gives a detailed description of the steps involved in the heat treatment process, without reference to aging OR • Gives a basic description of the steps involved in the heat treatment process, including aging	2
• Provides some relevant information about the heat treatment process	1

Sample answer:

The alloy is reheated to about 500°C where the $CuAl_2$ is reabsorbed to produce a single phase alloy.

This is now quench cooled to room temperature.

The alloy is then allowed to stand at room temperature for 5–7 days (Natural Aging) or may be replaced by artificial aging when the alloy is reheated to 120°C causing the precipitation of copper rich phase to occur within a few hours.

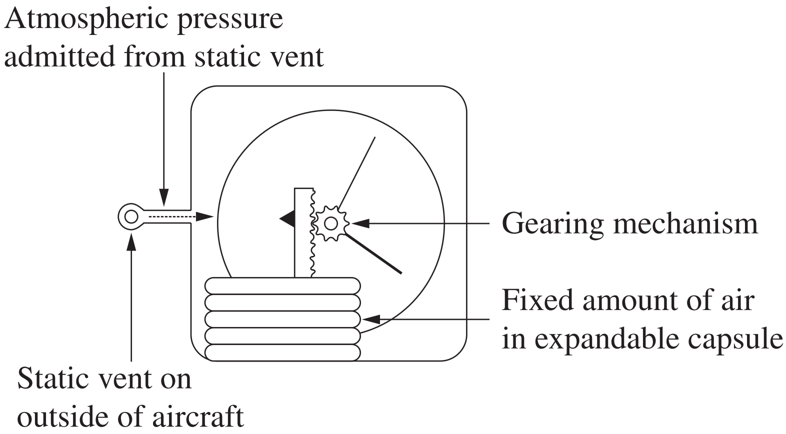
Question 24 (d)

Criteria	Marks
• Gives a detailed description of the basic operation of an altimeter	3
• Gives a limited description of the basic operation of an altimeter	2
• Provides some relevant information	1

Sample answer:

The altimeter is used to measure the altitude. The expandable capsule (aneroid) expands or contracts according to atmospheric pressure. Lower pressures at higher altitudes cause it to expand and vice versa. The movement of the aneroid rotates the dial hands on the gauge via a gearing mechanism to show the altitude.

Answers could include:



Question 25 (a)

Criteria	Marks
• Outlines three benefits of digital television signals over analogue television signals	3
• Outlines two benefits of digital television signals over analogue television signals	2
• Outlines one benefit of digital television signals over analogue television signals	1

Sample answer:

Digital television signals provide clearer, sharper pictures than analogue.

Digital television is broadcast in 'widescreen'. This means the picture is a third wider with an aspect ratio of 16×9.

Digital provides Electronic Program Guide (EPG) which is an interactive schedule of current and upcoming programs that a viewer can display on-screen.

Answers could include:

Reception television problems like ghosting which affect analogue viewers in built-up or hilly areas are removed as the digital signal is delivered more efficiently.

Analogue signals broadcast on low band frequencies are susceptible to local electrical interference.

Digital television has better sound with all programs broadcast in MPEG. Some special programs are also broadcast in Dolby Digital 5.1 for surround sound home theatre.
Digital transmission is much more efficient in the use of spectra which allow high definition TV, multichannelling, multiview and interactive television.

Question 25 (b)

Criteria	Marks
• Provides detailed information about how the display technologies are different	3
• Provides limited information about how the display technologies are different	2
• Provides a general statement about one display technology	1

Sample answer:

In plasma HDTVs, the phosphors that create the image on the screen light up themselves and don't require backlighting. For LCD HDTVs the liquid crystal screen requires a separate light source, such as cold cathode fluorescent lights, to illuminate the screen. LED screens use light emitting diodes to illuminate the display.

Question 25 (c)

Criteria	Marks
• Lists the main elements, including the type of satellite	3
• Lists at least two of the elements and the type of satellite	2
• Names at least one of the elements OR the type of satellite	1

Sample answer:

Satellite television communication systems include the following elements: programming source, broadcast centre, geostationary satellite, satellite dish and receiver.

Question 25 (d)

Criteria	Marks
• Calculates the kinetic energy	3
• Demonstrates appropriate substitution into relevant formulae with some minor error	2
• Provides some relevant substitution in formula	1

Sample answer:

$W = mg$

$m = \frac{5000}{9.2} = 543.5 \text{ kg}$

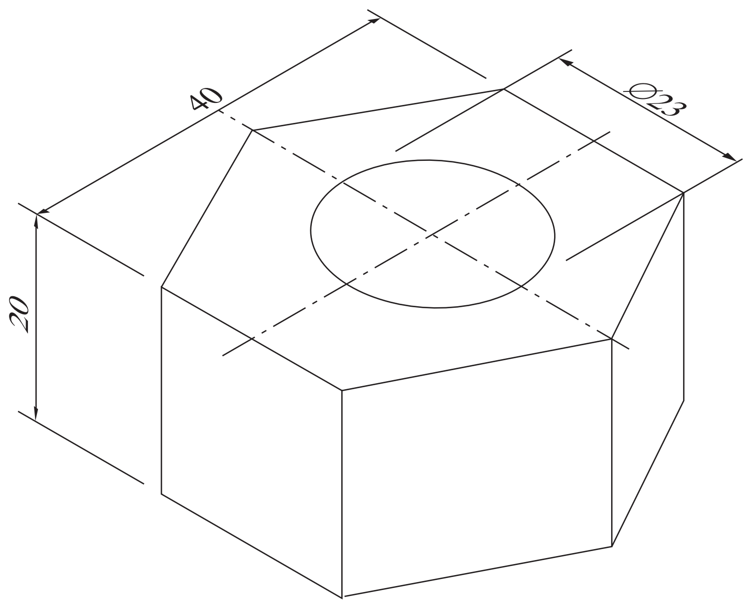
$v = \frac{27\,250}{3.6} = 7569.4 \text{ m/s}$

$KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 543.5 \times (7569.4)^2 = 15.57 \text{ GJ}$

Question 26 (a)

Criteria	Marks
• Provides a suitable, scaled pictorial sketch with appropriate dimensions	4
• Provides a substantially correct pictorial sketch with one appropriate dimension OR • Provides a substantially correct pictorial sketch to a correct scale	3
• Provides a substantially correct pictorial sketch	2
• Attempts a pictorial sketch	1

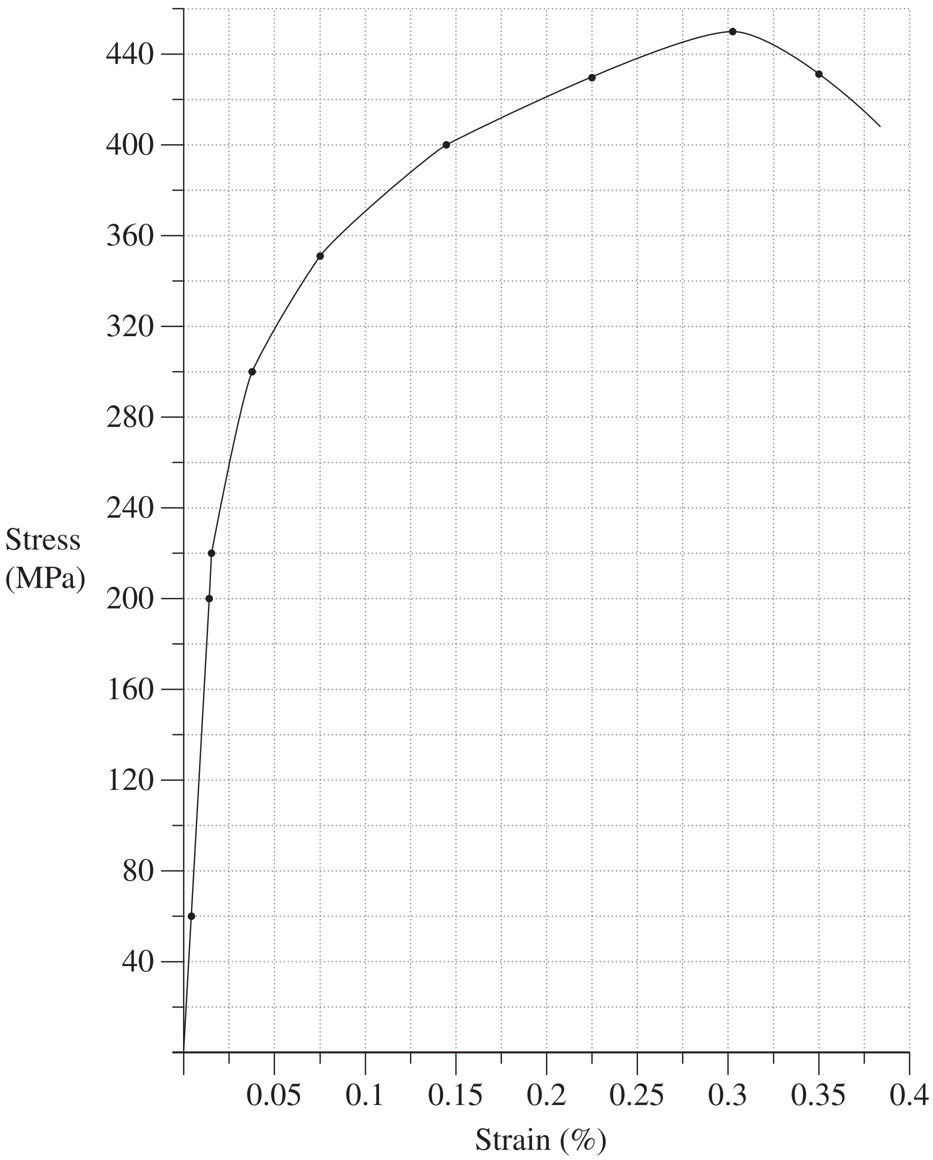
Sample answer:



Question 26 (b) (i)

Criteria	Marks
• Plots a correct stress-strain or force/extension diagram	2
• Plots an appropriate diagram with error(s)	1

Sample answer:



Question 26 (b) (ii)

Criteria	Marks
• Provides detailed explanation of how two properties would be used, supported with correct calculations for each property	6
• Provides detailed explanation of how two properties would be used, supported with calculations for each, with one minor error	5
• Provides detailed explanation of how two properties would be used, supported with calculations for each, with errors OR • Provides a limited explanation of how two properties would be used, supported with calculations for each	4
• Describes two properties and provides calculation of one of them OR • Provides detailed explanation of how one property would be used, supported with a calculation, with minor error	3
• Explains one or describes two properties, with incorrect or no calculations OR • Calculates two appropriate values, with minor error	2
• Describes one property with no calculations provided OR • Calculates one appropriate value, with minor error OR • Names two appropriate mechanical properties that can be derived from the graph	1

Sample answer:

Mechanical properties can include the ultimate tensile strength and the stiffness of the material.

The ultimate tensile strength is found at the top of the curve. It is found by dividing the maximum load with the original cross sectional area.

$$\text{UTS} = \frac{\text{Max Load}}{\text{Original CSA}} = \frac{220 \times 10^3}{491} = 448 \text{ MPa}$$

The UTS is used to determine the tensile capacity of a structural element.

The stiffness of the material is determined by the slope of the graph up to the elastic limit. The steeper the slope, the stiffer the material. This property is called the Modulus of Elasticity.

$$E = \frac{Fl}{eA} = \frac{100 \times 10^3 \times 200}{0.2 \times 491} = 203.7 \text{ GPa}$$

The stiffness of a material is used in determining the deflection of a structural element under load.

Question 27 (a)

Criteria	Marks
• Identifies what each label indicates	2
• Identifies what one of the labels indicates	1

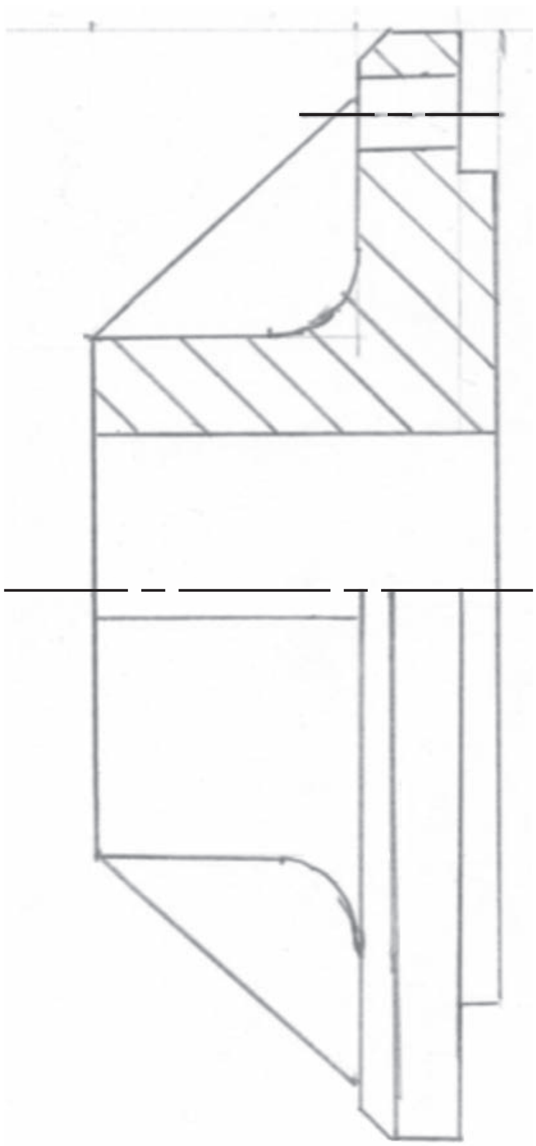
Sample answer:

- 4 holes have been drilled on a 92 mm Pitch Circle Diameter
- 3 mm Chamfer.

Question 27 (b)

Criteria	Marks
• Provides a correct full size half-sectional front view of the component to AS1100 standards	6
• Provides a full size half-sectional front view of the component with a minor error	5
• Provides a full size sectional front view of the component with minor errors or omissions	4
• Provides a generally correct drawing of the component with a major error	3
• Provides a partially correct drawing of the component with major errors	2
• Demonstrates some knowledge of orthographic drawing	1

Sample answer:



Drawings show the following:

- Correct representation webs not sectioned
- Correct representation half section
- Correct representation drilled hole rotated to section plane
- Correct representation 3 × 45° chamfer
- Correct representation webs
- Correct representation ∅30 hole
- Correct representation ∅50 boss
- Correct representation fillet curves
- Correct representation 10mm shoulder height
- Correct representation centre lines
- Correct representation 40 mm length
- Correct representation ∅80 spigot diameter

Engineering Studies

2013 HSC Examination Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Composites – Concrete	H2.1
2	1	Fundamental Flight	H2.2
3	1	Aluminium Alloys	H1.2
4	1	Simple Machines Moments	H3.1
5	1	Simple Circuit	H3.1
6	1	Logic Gates	H3.1
7	1	Hydraulics	H3.1
8	1	Copper Alloys	H1.2
9	1	Simple Circuits	H3.3
10	1	Developments, True Length	H3.1
11	1	Heat Treatment Ferrous Materials	H2.1
12	1	Modulation	H3.3
13	1	Methods of Joints	H3.1
14	1	Shear Stress	H3.1
15	1	Ferrous Materials	H1.2
16	1	Work	H3.1
17	1	Simple Machines	H3.1
18	1	Corrosion	H1.2
19	1	Bending Stress	H2.1
20	1	Friction	H3.1

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	3	Effects of engineering innovation in transport on society	H1.2, H2.1, H4.2
21 (b)	4	Effects of engineering innovation in transport on society	H1.2, H2.1, H4.2
21 (c)	2	Corrosive environments and types of corrosion	H1.2, H2.1
21 (d)	3	Critically examine the impact of civil structures upon society and environment	H4.3
22 (a)	2	Manufacturing process	H1.2, H2.1
22 (b)	3	Simple Machines	H2.1
22 (c) (i)	2	Electric Motors used in transport systems	H2.1
22 (c) (ii)	2	Power generation	H2.1
22 (c) (iii)	3	Power generation electrical energy and power	H3.1
23 (a)	4	Engineering mechanics: – truss analysis – actions (loads) – reactions – pin jointed trusses only – method of joints – method of sections	H3.1
23 (b) (i)	3	Concept of shear force and bending moment Shear force and bending moment diagrams	H3.1, H3.3
23 (b) (ii)	3	Bending stress induced by point loads only Concept of neutral axis and outer fibre stress calculation (second moment of area given)	H3.1
23 (c)	2	Composites Timber Laminates	H2.1
24 (a)	3	Fundamental flight mechanics Relationship between lift, thrust, weight and drag	H3.1
24 (b)	3	Fundamental flight mechanics Relationship between lift, thrust, weight, drag and lift to drag ratio	H2.2
24 (c)	3	Aluminium and aluminium alloys used in aircraft including aluminium copper Heat treatment of applicable alloys	H1.2

Question	Marks	Content	Syllabus outcomes
24 (d)	3	Fluid mechanics Pascal's principle Hydrostatic and dynamic pressure Applications to aircraft components and instruments	H2.2
25 (a)	3	Telecommunications including television transmission	H2.2, H4.1
25 (b)	3	Telecommunications including television transmission and display media	H2.2, H4.1
25 (c)	3	Satellite communication systems, geostationary satellite	H2.2
25 (d)	3	Basic calculations for energy Kinetic energy	H3.1
26 (a)	4	Freehand pictorial drawing	H3.1, H3.3
26 (b) (i)	2	Engineering mechanics Stress and strain	H3.1, H3.2, H3.3
26 (b) (ii)	6	Engineering mechanics Stress and strain	H3.1, H3.2, H3.3
27 (a)	2	Australian Standard AS1100	H3.3
27 (b)	6	Sectional Views Orthogonal drawings Australian Standard AS1100	H3.3