2016 HSC Engineering Studies Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a) (i)

Criteria	Marks
• Outlines benefits of using this type of modular seating system	3
• Identify benefits of using this type of modular seating system OR • Outlines a benefit of using this type of modular seating systems	2
• Identifies a benefit of a bus shelter	1

Sample answer:

The benefits of using this type of modular seating system include the fact that it can be manufactured off-site using reusable moulds and then transported to the site. This reduces site disruption. Modules can be added as required to improve seating.

Question 21 (a) (ii)

Criteria	Marks
• Explains why steel is suitable for reinforcing concrete	3
• Shows some understanding of why steel is suitable for reinforcing concrete	2
• Identifies a reason for the use of steel in reinforced concrete	1

Sample answer:

Steel is suitable for reinforcing concrete because its coefficient of thermal expansion is similar to concrete's. Steel also provides tensile strength, while concrete provides compressive strength to the composite. Steel can also be bent to shape to match complicated mould design.

Question 21 (a) (iii)

Criteria	Marks
• Calculates Young's Modulus	3
• Calculates Young's Modulus using a correct method with minor errors	2
• Applies an appropriate method	1

Sample answer:

$$\sigma = \frac{F}{A} = \frac{26000}{\pi \times 6^2} = 229.9 \text{ MPa}$$

$$\varepsilon = \frac{e}{L} = \frac{1}{900} = 1.1^1 \times 10^{-3}$$

$$E = \frac{\sigma}{\varepsilon}$$

$$= \frac{229.9}{1.1^1 \times 10^{-3}} \text{ MPa}$$

$$= 206.9 \times 10^3 \text{ MPa}$$

$$\therefore E = 206.9 \text{ GPa}$$

Question 21 (b)

Criteria	Marks
• Justifies the use of PVC in this application by explaining appropriate properties	3
• Shows some understanding of the reasons for using PVC in this application	2
• Identifies an appropriate property	1

Sample answer:

PVC is a durable and waterproof material. It is very suitable for mass production, resulting in low cost per unit, and when plasticised, is durable at room temperature, providing appropriate rigidity while retaining some flexibility, reducing potential for accidental breakage.

Answers could include:

• ease of manufacture – can be calendered to incorporate chip and image if needed
• range of finishes – can be easily coloured
• light weight.

Question 22 (a)

Criteria	Marks
• Provides a relevant contribution of each device towards the advancement of telecommunications	3
• Provides contributions of the communication devices towards telecommunications	2
• Identifies a feature of one communication device	1

Sample answer:

The MC key allowed cost-effective and high speed long-distance communication. This allowed communication between people previously isolated. The telephone added voice communication that required no technical knowledge to use. The smartphone added multiple functions to the device such as internet and photography.

Question 22 (b)

Criteria	Marks
• Provides characteristics and features of TWO methods of generating electricity	3
• Provides characteristics and features of a method of generating electricity	2
• Shows a basic understanding of power generation	1

Sample answer:

Traditionally, electricity is produced by steam turbines turning a generator. The steam is generated through heating water. Solar power essentially uses a photosensitive diode that generates electric potential when exposed to visible light.

Answers could include:

Heat sources could also include coal, nuclear, geothermal, coal seam gas, methane collection and solar furnaces.
Other technologies convert moving mass to electricity through a turbine. These include:
• Hydroelectric
• Tidal flow
• Wind power.

Question 22 (c)

Criteria	Marks
• Provides a sectioned front view using AS 1100 standards with no major errors or omissions	6
• Provides a sectioned front view using AS 1100 standards with a major error or omission	4–5
• Provides some correct projection with a component drawn to standard	2–3
• Provides some aspects of a correct projection	1

Sample answer:
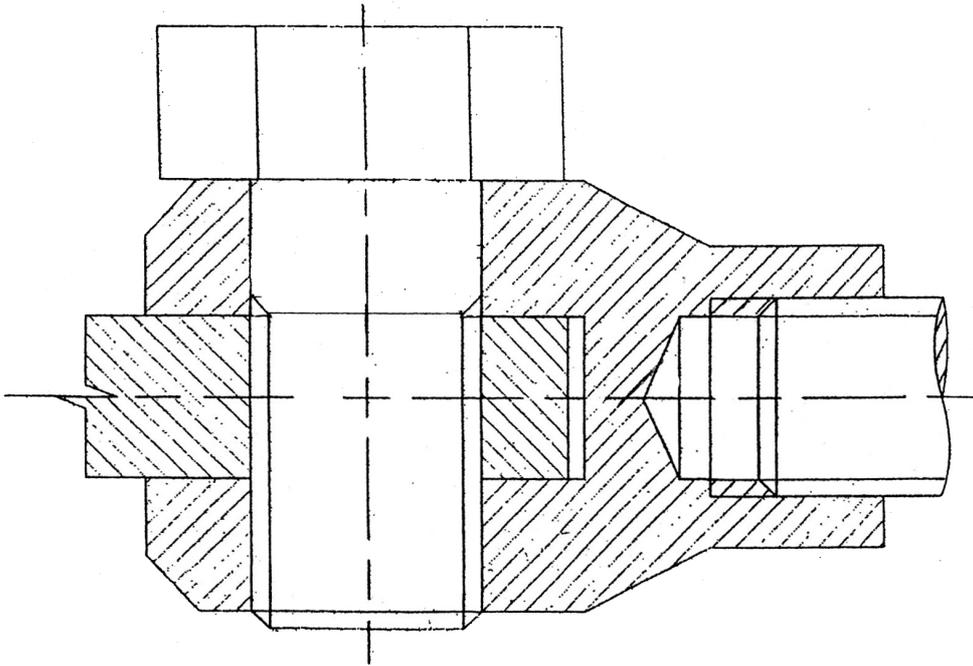
Question 23 (a)

Criteria	Marks
• Explains the benefits of using AS 1100 drawing standards	3
• Outlines a reason for using AS 1100 drawing standards OR • Identifies reasons for using AS 1100 drawing standards	2
• Identifies a reason for using AS 1100 drawing standards	1

Sample answer:

The use of AS 1100 standards reduces ambiguity and improves the quality and accuracy of communication between designers and manufacturers. It also allows drawings to be transferred between countries as AS 1100 is based on international standards.

Answers could include:

Allows multiple designers to work on the one project.
Saves businesses time and money by minimising interpretation errors.

Question 23 (b) (i)

Criteria	Marks
• Outlines relevant properties	3
• Identifies relevant properties OR • Outlines a relevant property	2
• Identifies a relevant property	1

Sample answer:

Asphalt is suitable for highway pavement surfaces as it is easy to lay compared to concrete and more durable than gravel. It moulds to the contour of the road, can be shaped easily and is usable within minutes of being laid.

Answers could include:

- Has an appropriate friction coefficient
- Can carry a load
- Aggregate can be pressed into substrate, producing a smooth surface
- Allows ease of repair
- Flexible to allow for earth movement.

Question 23 (b) (ii)

Criteria	Marks
• Explains why geotextiles are used in highway pavements	3
• Describes a function of geotextiles in highway pavements OR • Lists several functions of geotextiles in highway pavements	2
• States a function of geotextiles	1

Sample answer:

Geotextiles are used to prevent silt from undermining the road base, causing collapse of the road. Geotextiles also filter silt from subsurface drainage, preventing blockage of underground drainage.

Question 23 (c)

Criteria	Marks
• Calculates power required	3
• Calculates the power required using a correct method with minor errors	2
• Applies an appropriate method	1

Sample answer:

Velocity = 90 km/h = 90 000/3 600 = 25 m/sec

$P = F \times s/t = F \times v$

$P = 18\ 000 \times 25$ m/sec = 450 kW

Question 24 (a)

Criteria	Marks
• Provides similarities or differences between both windscreen types	3
• Provides a characteristic of each windscreen type	2
• Identifies a characteristic feature of a windscreen type	1

Sample answer:

Toughened glass and the laminated windscreen are both transparent and hard, which resists scratching from dust and impact of small particles. They are both easy to clean. When they are broken, the toughened glass breaks into small cubes and the laminated windscreen maintains structural integrity and visual acuity.

Answers could include:

Toughened glass
- Fracture shards are safer if it shatters
- More impact resistance
- Cheaper to make
- Lighter.

Laminated glass
- Maintains visibility when windscreen fractures (safer)
- Can drill and shape corners
- Safer in general use
- Can internally embed defrosting elements
- Absorbs more UV – reduces light fading internally.

Question 24 (b)

Criteria	Marks
• Gives reasons for the use of aluminium alloy in truck side panels	2
• Identifies a reason why aluminium alloy is appropriate	1

Sample answer:

Aluminium alloy is chosen for this application as it has a good strength to weight ratio, is easily shaped, waterproof, corrosion resistant and is easy to fabricate and install.

Question 24 (c)

Criteria	Marks
• Explains why this combination of materials has been chosen	3
• Provides relevant features of rubber and steel	2
• Identifies an appropriate feature of rubber or steel	1

Sample answer:

Rubber has the following properties that make it suited to tyre construction; resilience, wear resistance, formability, and high coefficient of friction. However it is highly flexible and elastic. Rubber would be too flexible by itself. The high tensile steel band limits distortion of the rubber.

Question 24 (d)

Criteria	Marks
• Calculates the diameter	3
• Calculates a diameter using a suitable method with errors	2
• Applies an appropriate method	1

Sample answer:

Max load $= 2000$ N

Max shear $= 56$ MPa

F of S $= 2$

$$\sigma_A = \frac{\sigma}{2} = 28 \text{ MPa}$$

$$\sigma = \frac{P}{A}$$

$$A = \frac{P}{\sigma} = \frac{\pi d^2}{4} = \frac{P}{\sigma}$$

$$\pi \sigma^2 \sigma = 4P$$

$$d^2 = \frac{4P}{\pi \sigma}$$

$$d^2 = \frac{4 \times 2\,000}{\pi \times 28\,000\,000}$$

$$= 9.09 \times 10^{-10}$$

$$d = 9.53 \times 10^{-3}$$

$$= 9.5 \text{ mm (minimum)}$$

Question 25 (a) (i)

Criteria	Marks
• Explains how the drone achieves flight	3
• Outlines a principle that the drone uses to achieve flight OR • Identifies factors that the drone uses to achieve flight	2
• Identifies an appropriate factor	1

Sample answer:

The drone achieves flight by rotating propellers to produce lift (vertical thrust) that counteracts the weight of the drone. If the lift exceeds the weight, the drone will fly. By changing motor speed, control of the climb or descent is made possible.

Answers could include:

• Changing the rotational speed of the propellers influences the thrust and direction of flight

• Battery systems provide power for flight

• Propellers rotate in opposite directions (as two pairs).

Question 25 (a) (ii)

Criteria	Marks
• Describes a suitable manufacturing method for each propeller type	3
• Describes a suitable manufacturing method for one propeller type	2
• Names a suitable manufacturing method OR • Identifies components of a suitable method OR • Describes a polymer manufacturing method	1

Sample answer:

Vacuum layup of carbon fibre composites and injection moulding for nylon hobby model propellers.

Impregnated carbon fibre sheet is laid onto a mould.
The assembly is placed into a vacuum bag.
The bag and assembly are placed into an autoclave, the bag is evacuated and then the assembly is heated to allow it to set.

Nylon propellers are injection moulded.
Nylon pellets are fed into a heated chamber with a screw. The screw rotates, and a combination of friction, pressure and external heat melts the nylon.
The molten nylon is then pumped into a multi-cavity mould and allowed to cool/set.

Question 25 (b)

Criteria	Marks
• Contrasts the two flight control systems	3
• Outlines the features of either flight control system	2
• Lists a feature of either system	1

Sample answer:

Fly-by-wire	
Advantages	*Disadvantages*
• Removes weight of wires and pulleys from aircraft • Computers take over the control functions • Multiple redundancies	• Pilots need to be retrained as systems are so different • Possible failure of the computers

Cables	
Advantages	*Disadvantages*
• Direct connect between pilot and control surface • Provides direct feedback system to pilot	• Physical loads on pilots • High maintenance of mechanics (pulley, wheels) • Limited redundancies

Question 25 (c)

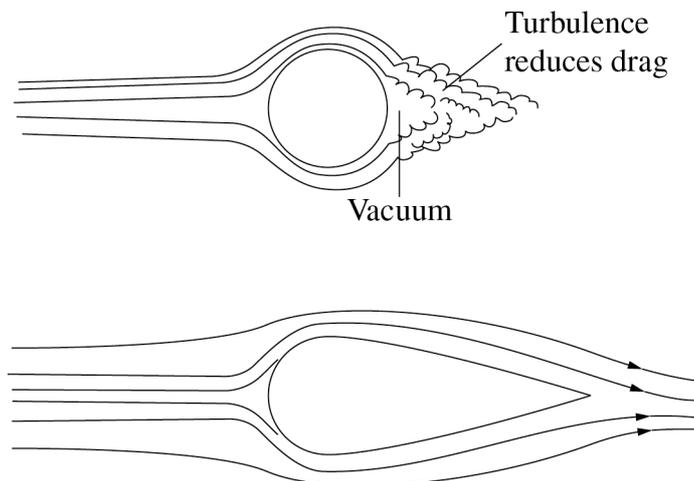| Criteria	Marks
• Explains how each profile impacts drag, uses diagram to assist response	3
• Explains how either profile impacts drag OR • Identifies using suitable diagrams how drag is impacted	2
• Identifies an appropriate reason	1

Sample answer:

The non-aerodynamic shape creates a low pressure behind the cable that acts to pull the wire backwards and create significant drag.
The cable has a rough surface that generates significant surface drag.
The cable also generates significant vortices behind it that act to produce drag.
The symmetrical aerofoil has a smooth surface and aerodynamic shape that minimises turbulence behind the aerofoil and significantly reduces drag.

Air flow around the cable

Question 26 (a) (i)

Criteria	Marks
• Calculates reaction forces correctly including angle	4
• Calculates a value for the reaction forces using a correct method with minor errors	3
• Calculates a value for the reaction forces using an appropriate method	2
• Applies an appropriate method	1

Sample answer:

Reaction at A = 249kN acting vertically, up

Reaction at B = 120kN acting vertically, down and 27kN acting horizontally, to the right.
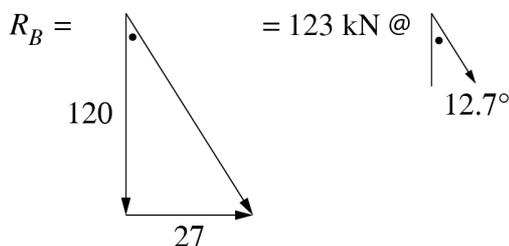= 123kN @ 12.7° acting down and to the right.
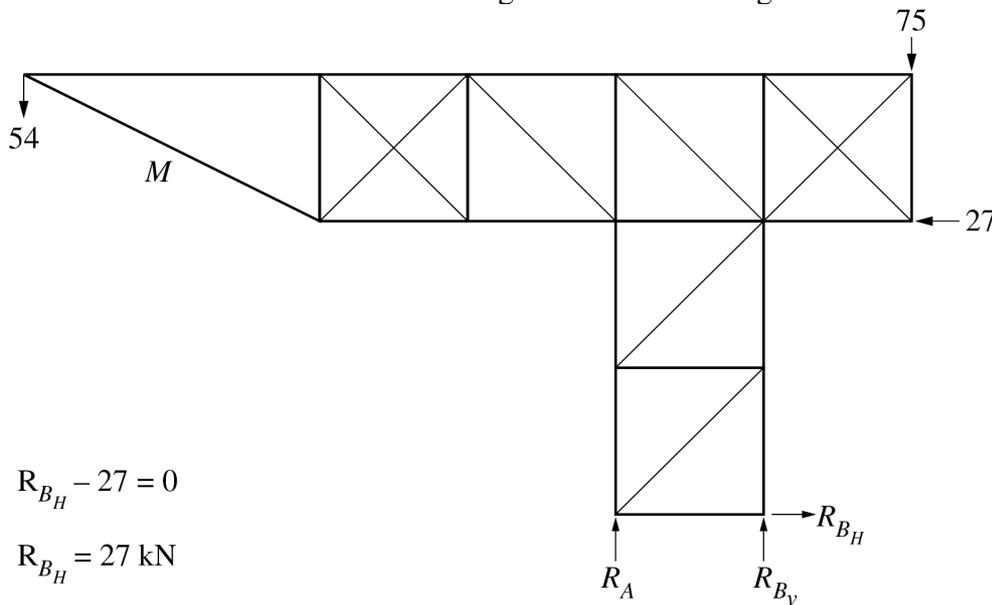
$R_{B_H} - 27 = 0$

$R_{B_H} = 27 \text{ kN}$

By inspection, $R_{B_H} = 27 \text{ kN} \rightarrow$

$+) \Sigma M_B = 0 = 27 \times 2 + 54 \times 5 - 75 \times 1 - R_A \times 1$

$\qquad R_A = 54 + 270 - 75$
$\qquad = 324 - 75$
$\qquad = 249 \text{ kN} \uparrow$

$+\uparrow \Sigma F_V = 0 = 249 - 75 - 54 + R_B$

$\qquad R_B = 129 - 249$
$\qquad = -120 \text{ kN}$
$\qquad = 120 \text{ kN} \downarrow$

$\therefore R_A = 249 \text{ kN} @ 0° \uparrow$

$R_B = \qquad = 123 \text{ kN} @$

120

27

12.7°

Question 26 (a) (ii)

Criteria	Marks
• Determines the magnitude and nature of force in member *M*	2
• Applies an appropriate method OR • Determines the nature of the force in member *M*	1

Sample answer:

Force in *M* = 121 kN (Compression)
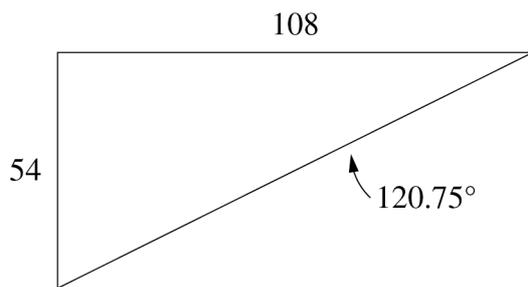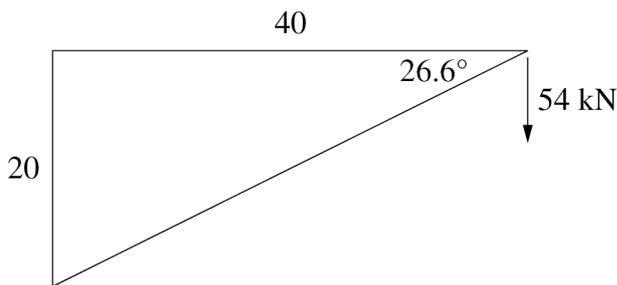
Question 26 (b)

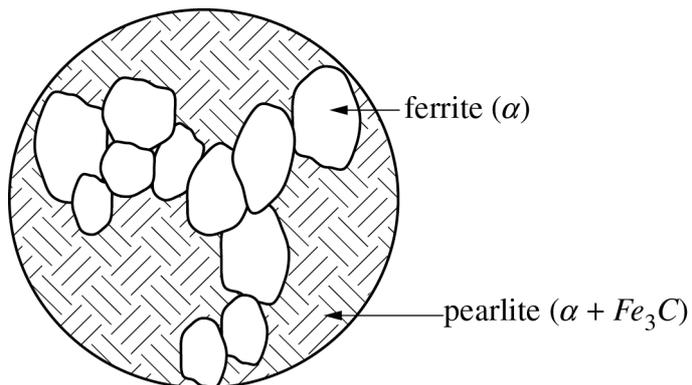| Criteria	Marks
• States what a redundant truss member is	2
• Identifies a relevant feature of a redundant truss member	1

Sample answer:

A redundant member is a member in a truss that carries no load under current conditions. The load in the truss member may vary under different load conditions, which means it may not necessarily become redundant.

Question 26 (c)

Criteria	Marks
• Explains with a labelled sketch why normalising was chosen as the heat treatment process, resulting in a correct microstructure	4
• Provides a partial explanation with the aid of a labelled sketch why normalising was chosen as the heat treatment process, resulting in a correct microstructure	3
• Explains why normalising was chosen as the heat treatment process OR • Provides a labelled sketch that represents the resulting microstructure	2
• Identifies an appropriate reason OR • Provides a sketch that represents the resulting microstructure	1

Sample answer:

Normalising of a steel beam produces a fine uniform grain structure that produces an increase in strength through grain size strengthening.
It is economical when compared to other methods of strengthening.
It relieves stress.

ferrite (α)
pearlite ($\alpha + Fe_3C$)

Question 27 (a)

Criteria	Marks
• Explains how/why different transport systems are still required	2
• Identifies a relevant reason	1

Sample answer:

These systems are still required for the following reasons:
• Convenience
• Access to a range of passengers
• Travelling long distances
• Journey times
• Safety.

Question 27 (b)

Criteria	Marks
• Provides a complete explanation of how engineering innovations in the three transport systems affect the environment	7
• Provides a sound explanation of how engineering innovations affect the environment in at least two transport systems	5–6
• Provides a sound explanation of one engineering innovation and its effect on the environment and some description of a second engineering innovation OR • Provides some description of three engineering innovations	4
• Provides a sound explanation of an engineering innovation in one transport system OR • Provides some description of two engineering innovations	3
• Lists characteristics of relevant innovations or environmental impacts	2
• Identifies an innovation or environmental impact	1

Sample answer:

Cars
Weight, fuel injection, turbo, engine management systems, streamlining, tyre choice. Regenerative braking, reduction in drive train losses. ABS brakes.

Relevant innovations in car transport that have impacted the environment positively by improving fuel efficiency include weight reduction through the development of stronger aluminium alloys and carbon fibre composite components that reduce vehicle weight, therefore reducing fuel consumption. The use of carbon fibre composites and GRP also allows production of aerodynamic shapes which reduce drag. By reducing drag and fuel consumption, the car emits less CO_2 pollution.

Trains
AC vs DC motors on electric trains. Turbo driven diesel engines, efficient track alignment.

The predominant efficiency improvement in trains is the use of AC motors instead of DC motors in the drive train. Historically, DC was used as AC motor current and torque could not be controlled. By using modern VVVF drives, torque and voltage on an AC motor are controlled more efficiently than DC control, as DC control wastes electricity as heat. Use of AC motors allows regenerative braking to occur as the train slows down or descends. This improved efficiency results in the use of less electricity (urban trains) and diesel fuel (country trains), which reduces CO_2 emissions. Magnetic levitation braking, disc brakes.

Aircraft
Weight reduction through use of improved alloys and composites (specific strength and specific stiffness), improved turbofan efficiency (higher temp, bypass air), reduced drag. Use of adhesives to remove rivet-induced turbulence. Improved aerodynamic shape possible through use of composites.

In passenger jets, thrust is produced in a turbofan engine through bypass air becoming entrained in the exhaust stream. The mass of this air produces up to 90% of the total thrust of the engine. Modern turbofan engines are designed to optimise the entrainment of bypass air, which dramatically improves the fuel efficiency. Modern wing design, including the use of winglets and flow control devices, minimises wing tip vortices which reduces drag and improves lift. This, therefore, improves efficiency, with a consequent reduction in fuel consumption.

2016 HSC Engineering Studies Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Engineering Materials p28	H1.2
2	1	Engineering Mechanics p25	H3.1, 3.3
3	1	Engineering Graphics p29	H3.1, 3.3
4	1	Electronics p36	H1.2
5	1	Aeronautical p32	H3.1
6	1	Engineering Materials p25	H1.2, 2.1
7	1	Aeronautical p32	H3.1, 4.1
8	1	Engineering Mechanics p28	H3.1
9	1	Telecommunications p37	H1.1, 4.1
10	1	Engineering Mechanics p25	H3.1, 3.3
11	1	Aeronautical – Engineering Mechanics p32	H2.2, 4.1
12	1	Engineering Graphics p33	H3.1, 3.3
13	1	Electronics p29	H3.1, 4.1
14	1	Engineering Materials p25	H1.2, 2.1
15	1	Telecommunications p37	H3.1, 3.3
16	1	History p27	H4.3
17	1	Engineering Materials p25	H1.2, 2.1
18	1	Engineering Mechanics p28	H3.1
19	1	Engineering Graphics p29	H3.1, 3.3
20	1	Engineering Mechanics p25	H3.1, 3.3

Section II

Question	Marks	Content	Syllabus outcomes
21 (a) (i)	3	Engineering Materials p24, p26	H1.2, 2.1, 4.1
21 (a) (ii)	3	Engineering Materials p26	H1.2, 2.1, 4.1
21 (a) (iii)	3	Engineering Mechanics p25	H3.1
21 (b)	3	Engineering Materials p26	H1.2, 2.1, 4.1
22 (a)	3	History p36	H4.1, 4.3
22 (b)	3	Electronics p37	H1.1, 1.2

Question	Marks	Content	Syllabus outcomes
22 (c)	6	Engineering Graphics p29	H3.1, 3.3
23 (a)	3	Graphics p26, p29, p33	H3.1, 3.3
23 (b) (i)	3	Engineering Materials p26	H1.2, 2.1
23 (b) (ii)	3	Engineering Materials p26	H1.2, 2.1, 4.1
23 (c)	3	Engineering Mechanics p28	H3.1
24 (a)	3	Engineering Materials p29	H1.2, 2.1
24 (b)	2	Engineering Materials p29	H1.2, 2.1
24 (c)	3	Engineering Materials p29	H1.2, 2.1
24 (d)	3	Engineering Mechanics p25	H3.1
25 (a) (i)	3	Aeronautical Engineering – Mechanics p32	H1.2, 2.2, 4.1
25 (a) (ii)	3	Aeronautical Engineering – Materials p33	H1.2, 2.2, 4.1
25 (b)	3	Aeronautical Engineering – History p32	H1.1, 4.1
25 (c)	3	Aeronautical Engineering – History p32	H1.1, 4.1
26 (a) (i)	4	Engineering Mechanics p25	H3.1
26 (a) (ii)	2	Engineering Mechanics p25	H3.1
26 (b)	2	Engineering Mechanics p25	H2.1
26 (c)	4	Engineering Materials p28	H1.2, 2.1
27 (a)	2	History p27	H2.1, 4.1, 4.2, 4.3
27 (b)	7	History p27	H2.1, 4.1, 4.2, 4.3