2018 HSC Engineering Studies Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
• Describes in detail how both innovations are used to control the movement of the vehicle	3
• Describes in detail how one innovation is used to control the movement of the vehicle OR • Describes the two innovations with limited detail	2
• Provides some relevant information	1

Sample answer:

GPS use triangulation to determine the vehicle's position on the surface of the earth. Sensors are used to detect objects in the vehicle's path or its immediate environment in order to avoid collision.

Question 21 (b)

Criteria	Marks
• Outlines the benefits of using electric motors to power self-driving vehicles	3
• Identifies the benefits of using electric motors to power self-driving vehicles	2
• Provides some relevant information	1

Sample answer:

Electric motors allow increased use of renewable energy, reducing atmospheric particulate matter. Furthermore, vehicles with electric motors have improved power to weight ratio, decreased noise pollution and are easier to integrate into an automated vehicle control system.

Question 21 (c)

Criteria	Marks
• Calculates the correct value of kinetic energy with relevant working	3
• Calculates the kinetic energy using a correct method but with minor errors	2
• Applies an appropriate formula OR converts relevant values	1

Sample answer:

$v = 60$ km/hr

$m = 1.5$ t

Convert km/h to m/sec

$$v = 60 \text{ km/hr}$$
$$= 60\,000 \text{ m/hr}$$
$$= \frac{60\,0\cancel{0}\cancel{0}}{36\cancel{0}\cancel{0}} \text{ m/sec}$$
$$= 16.67 \text{ m/s}$$

$\text{mass} = 1.5 \text{ t} = 1500 \text{ kg}$

$$KE = \frac{1}{2}mv^2$$
$$= \frac{1}{2} \times 1500 \times 16.67^2$$
$$= 750 \times 277.88$$
$$= 208.416 \text{ J}$$

Answer = 208.4 kJ

Question 21 (d)

Criteria	Marks
• Explains how the three logic gates act together to control the brakes of the vehicle	3
• Explains how the logic gates act together to control the brakes of the vehicle but with minor error/s	2
• Provides some relevant information	1

Sample answer:

1. AND gate 1 – both inputs ON to produce ON output
2. OR gate – either input ON to produce ON output
3. AND gate 2 – both inputs ON to produce ON output (therefore brakes applied).

Question 22 (a)

Criteria	Marks
• Provides a reason for each material being included in the central wire	2
• Provides some relevant information	1

Sample answer:

Copper provides the electrical conductivity while the steel provides the tensile strength.

Question 22 (b)

Criteria	Marks
• Provides reasons why optical fibre is used in preference to copper cable	2
• Provides some relevant information	1

Sample answer:

Since optical fibres have lower signal attenuation and allow greater bandwidth to be transmitted, they can be used to transmit data across longer distances at the speed of light.

Question 22 (c)

Criteria	Marks
• Describes in detail how the three types of diodes function in telecommunication circuits	4
• Describes in detail how two of the diodes function in telecommunication circuits OR • Outlines how the three diodes are used in telecommunication circuits	3
• Describes in detail how one diode functions in telecommunication circuits OR • Outlines how two of the diodes function in telecommunication circuits	2
• Provides some relevant information	1

Sample answer:

Zener diodes act as a voltage regulator, by allowing current to flow above a designated (zener) voltage. They provide a stable reference voltage across a wide range of current values. Laser diodes emit a focused light beam when current flows through the circuit and are used to transmit pulses of light down an optical fibre to allow digital data transmission. Light emitting diodes emit a wide beam of light when current flows through the circuit. They are commonly used to indicate if power is on.

Question 22 (d)

Criteria	Marks
• Calculates the required resistance value with relevant working	3
• Demonstrates some understanding of the steps required to calculate the required resistance value	2
• Applies an appropriate method	1

Sample answer:

$V = V_{TOT} - V_{LED}$
$= 9 - 2.3$
$= 6.7$ Volts

$R = V/I$
$= 6.7/(25 \times 10^{-3})$
$= 268$ Ohms

Question 23 (a)

Criteria	Marks
• Completes the table with appropriate entries	3
• Substantially completes table with appropriate entries	2
• Provides some relevant information	1

Sample answer:

- Tyre – rubber
- Axle – hardness, toughness
- Light cover – injection moulded
- Chassis – stiffness/rigidity
- Body panels – GRP (Glass reinforced polymer)
- Electrical wire – drawing.

Question 23 (b) (i)

Criteria	Marks
• Calculates the correct value of Young's modulus, with relevant working	4
• Attempts to calculate a value for Young's modulus, with a minor error	3
• Attempts to calculate a value for Young's modulus, with some errors	2
• Applies an appropriate method	1

Sample answer:

$$E = \frac{F\ell}{eA}$$

$$= \frac{20 \times 10^3 \times 1020}{1 \times 100}$$

$$= 204 \times 10^3$$

$$= 204 \text{ GPa}$$

$F = 20 \times 10^3$ N

$\ell = 1020$ mm

$e = 1$ mm

$A = 100$ mm^2

Question 23 (b) (ii)

Criteria	Marks
• Describes the physical changes for each load	2
• Provides some relevant information	1

Sample answer:

The 20 kN load produces elastic deformation which means the specimen stretches then returns to its original length. When the 30 kN load is applied, the specimen undergoes plastic deformation and it remains deformed upon release.

Question 23 (c)

Criteria	Marks
• Justifies the use of the hollow tube, including reference to second moment of inertia and other relevant engineering or design features	3
• Provides an engineering or design reason that supports the use of the hollow tube	2
• Provides some relevant information	1

Sample answer:

The hollow steel tube is more rigid because it has a greater second moment of area than the solid steel bar. This rigidity is important in the chassis as it is subjected to continual flexural forces and moments when in use. Therefore stiffness is an important design requirement. Additionally, cables for the electrics can be fed along the axis of the hollow tube and be protected from damage.

Question 24 (a)

Criteria	Marks
• Outlines an in-service advantage of each plank material	3
• Identifies a feature of each plank OR • Outlines an in-service advantage of two plank materials	2
• Provides some relevant information	1

Sample answer:

Laminated timber planks are non-conductive and can be cut to length easily onsite to fit a non-standard opening. Aluminium scaffold planks have low density and can be easily handled onsite due to their light weight. Galvanised steel planks have high impact resistance and are suited to applications such as bricklaying where they are likely to be subjected to falling loads.

Question 24 (b)

Criteria	Marks
• Sketches in general terms the steps involved in extruding an aluminium alloy plank	2
• Provides some relevant information	1

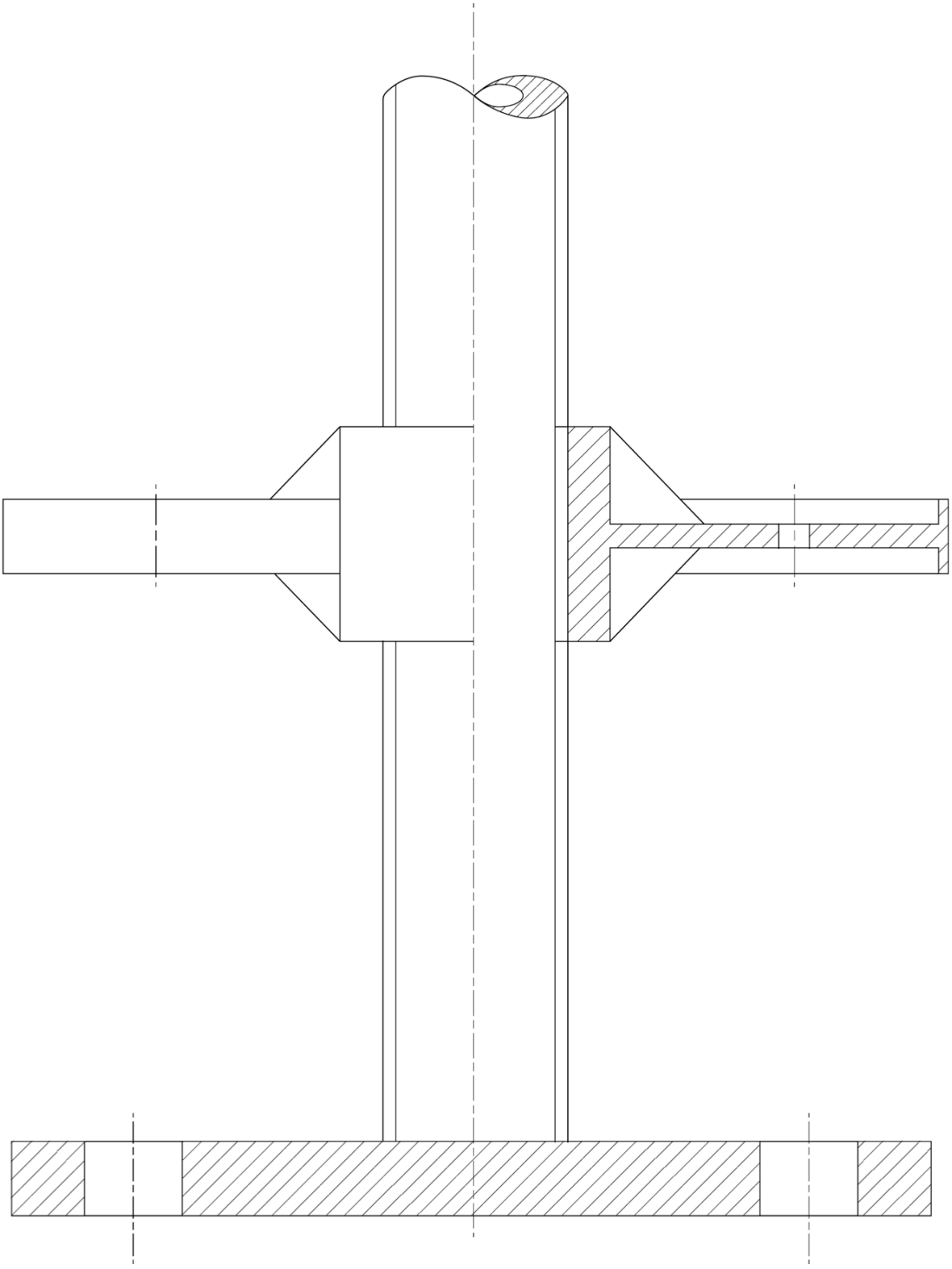
Sample answer:

The extrusion process involves an aluminium billet being heated to above its recrystallisation temperature, and then forced through a heated die to produce the desired cross-sectional shape.

Question 24 (c)

Criteria	Marks
• Provides a completed half-sectioned front view using AS 1100 conventions	6
• Provides a substantially completed half-sectioned front view using AS 1100 conventions, may have minor errors or omissions	4–5
• Provides some correct projection with a component drawn to standard	2–3
• Provides some aspects of a correct projection	1

Sample answer:

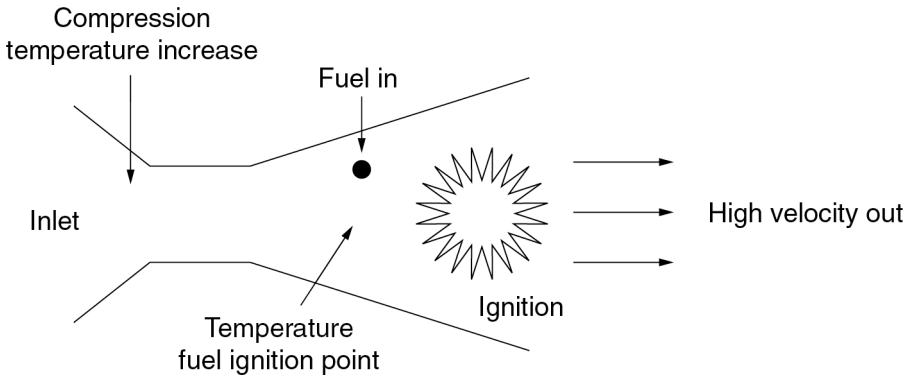


Question 25 (a)

Criteria	Marks
• Describes in detail the basic operational principles of jet propulsion, supported by a relevant labelled sketch	3
• Describes in some detail the basic operational principles of jet propulsion OR • Provides a suitably annotated sketch that demonstrates the basic operational principles of jet propulsion	2
• Provides some relevant information	1

Sample answer:

Jet propulsion occurs by compressing intake air to a point where it heats to a temperature above the ignition point of the fuel. Atomised fuel is then injected into the combustion chamber which generates higher velocity gas through expansion. This high velocity gas is expelled from the exhaust, generating thrust.

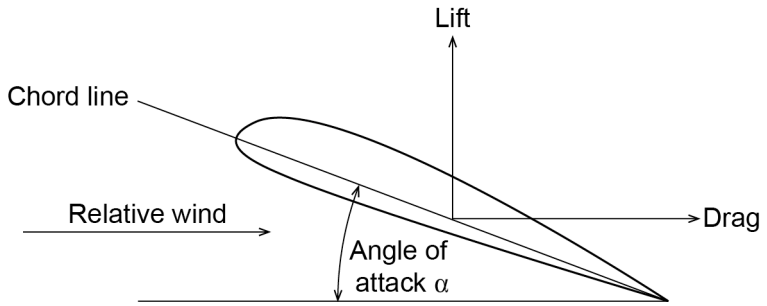


Question 25 (b)

Criteria	Marks
• Explains how the angle of attack influences the lift generated by the wings in flight, supported by a relevant labelled sketch	3
• Describes how the angle of attack influences the lift generated by the wings in flight OR • Provides a suitably annotated sketch that demonstrates how the angle of attack influences the lift generated by the wings in flight	2
• Provides some relevant information	1

Sample answer:

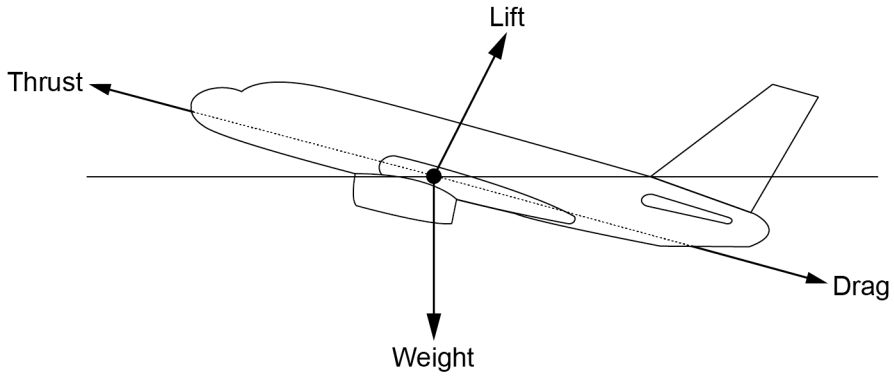
As the angle of attack increases, the upper surface separation point of the flow of air moves from the trailing edge towards the leading edge. At the critical angle of attack, upper surface flow is increasingly disconnected, with the wing producing its maximum coefficient of lift. If the angle of attack increases beyond the critical angle of attack lift begins to decrease and an aircraft will stall.



Question 25 (c) (i)

Criteria	Marks
• Completes the diagram indicating the four key forces of flight	2
• Indicates some correct forces of flight	1

Sample answer:



Question 25 (c) (ii)

Criteria	Marks
• Calculates the correct induced drag force with relevant working	3
• Calculates the induced drag force using a correct method but with minor errors	2
• Applies an appropriate method	1

Answers could include:

Weight $= mg$
$= 330 \times 10^3 \times 10$
$= 33 \times 10^5$ N

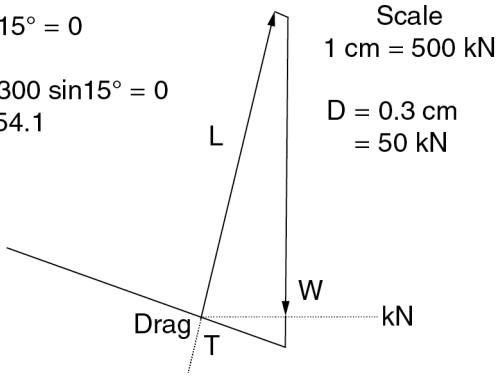
Thrust $= 510 \times 10^3 \times 2$
$= 102 \times 10^4$ N

T $= D + W \sin \gamma$

D $= T - W \sin \gamma$
$= 102 \times 10^4 - 33 \times 10^5 \sin 15°$
$= 102 \times 10^4 - 33 \times 10^5 \times 0.2588$
$= 102 \times 10^4 - 8.54 \times 10^5$
$= 166 \times 10^3$
$= \underline{166 \text{ kN}}$

Graphical solution

SF↗
L – 3300 cos15° = 0
SF↖
1020 – D – 3300 sin15° = 0
D = 1020 – 854.1
= 165.9 kN



Question 25 (d)

Criteria	Marks
• Identifies factors that contribute to stress corrosion cracking in aluminium alloy aircraft components	2
• Provides some relevant information	1

Sample answer:

Stress corrosion cracking occurs in the presence of moisture (corrosive environment) as well as a sustained tensile stress, which can be either externally applied or more commonly, residual (internal) tensile stress.

Question 26 (a)

Criteria	Marks
• Correctly calculates the compressive stress with relevant working	2
• Applies an appropriate method	1

Sample answer:

$\sigma = F/a$

$F = 17.3$ N
$a = \pi \times 21^2/4$
$= 346$ mm^2
$= 0.000346$ m^2

$\sigma = F/a$
$= 17.3/.000346$
$= 50\,000$ Pa

Question 26 (b)

Criteria	Marks
• Correctly calculates the normal force with relevant working	2
• Applies an appropriate method	1

Sample answer:

$F = \mu N$
$N = F/\mu$

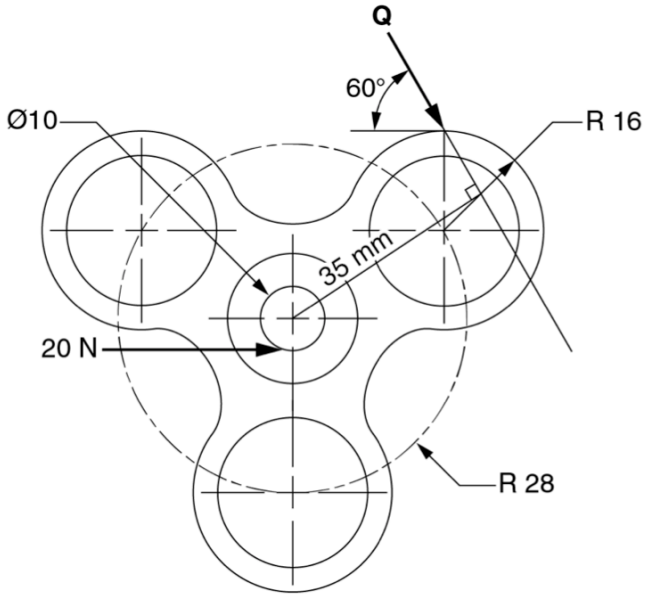
$F = 16$ N
$\mu = 0.2$

$N = F/\mu$
$= 16/0.2$
$= 80$ N

Question 26 (c)

Criteria	Marks
• Calculates the force **Q** accurately using a correct method	3
• Calculates the force **Q** using a correct method but with minor error/s	2
• Applies an appropriate method	1

Sample answer:



DRAWN TO SCALE

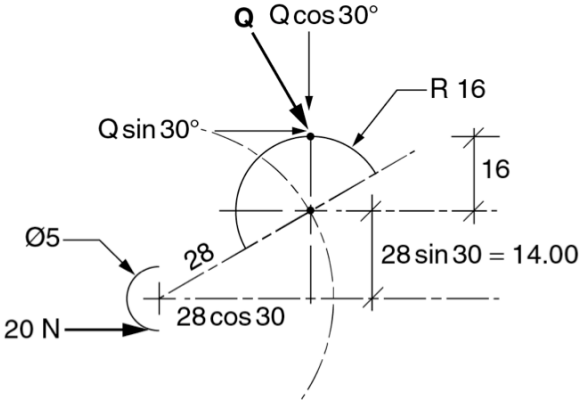
$\Sigma M = 0$

d = 35 (from scale drawing)

$20 \times 5 = P \times d$

$20 \times 5 = P \times 35$

$Q = 2.86$ N



Question 26 (d)

Criteria	Marks
• Provides a detailed comparison of the suitability of both materials for use as a bearing retainer	4
• Describes the suitability of each material for use as a bearing retainer	3
• Outlines at least one of the materials	2
• Provides some relevant information	1

Sample answer:

Both GFRN and stainless steel have excellent corrosion resistance, and are resistant to a wide range of organic solvents and greases used in bearings.

Nylon on steel has a much lower coefficient of friction than steel-on-steel, so GFRN bearings produce far less heat in operation from friction, run at higher speeds and produce lower noise levels. Stainless steel has a far wider range of operating temperatures than GFRN (which softens at high temperature and also turns brittle at low temperatures) so it will better resist shock loading or vibration.

Question 27 (a)

Criteria	Marks
• Produces correct shear force and bending moment diagrams supported by appropriate calculations	6
• Produces shear force and bending moment diagrams with minor errors or omissions in calculations or diagrams	4–5
• Produces shear force and/or bending moment diagrams with major errors or omissions	2–3
• Produces some aspects of a shear force or bending moment diagram	1

Sample answer:

Reactions: R_A and R_B

$+\uparrow \sum F = 0$

$\therefore R_A - 15 - 12 + R_B = 0$

$\therefore R_A + R_B = 27$

$+\downarrow \sum M_A = 0$

$\therefore 15 \times 2 + 12 \times 3 - R_B \times 6 = 0$

$\therefore 30 + 36 = 6\ R_B$

$R_B = 66/6$

$= 11$ kN

$\therefore \quad R_A = 27 - 11$

$= 16$ kN

Shear force

$SF_1 = +\uparrow \sum F$
$= 16 \text{ kN}$

$SF_2 = +\uparrow \sum F$
$= 16 - 15$
$= 1 \text{ kN}$

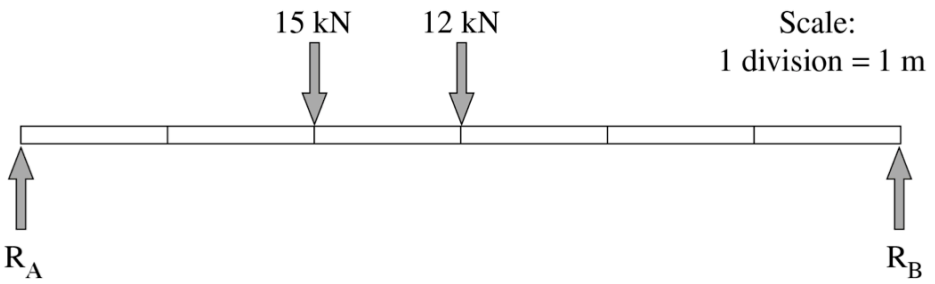
$SF_3 = +\uparrow \sum F$
$= 16 - 15 - 12$
$= -11 \text{ kN}$

Bending moment

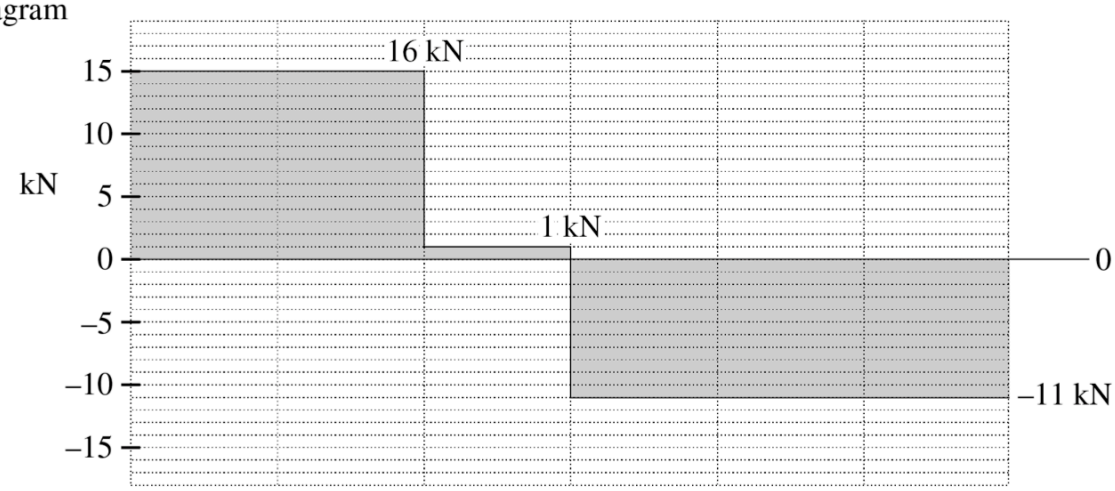
$BM_1 = +\downarrow \sum M$
$= 16 \times 2$
$= 32 \text{ kNM}$

$BM_2 = +\downarrow \sum M$
$= 16 \times 3 - 15 \times 1$
$= 48 - 15$
$= 33 \text{ kNM}$

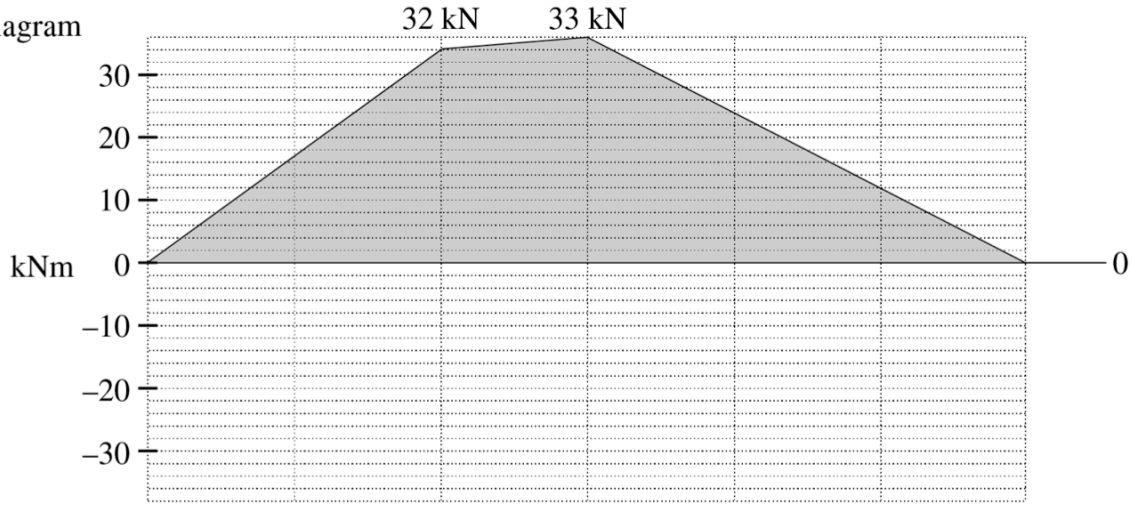
$BM_3 = +\downarrow \sum M$
$= 16 \times 6 - 15 \times 4 - 12 \times 3$
$= 96 - 60 - 36$
$= 0$



SF diagram



BM diagram



Question 27 (b)

Criteria	Marks
• Clearly provides reasons why an engineer would refer to shear force and bending moment diagrams when determining the effects of loads on a beam	4
• Provides some reason(s) for an engineer to refer to shear force and bending moment diagrams when determining the effects of loads on a beam	3
• Outlines the use of shear force diagrams and/or bending moment diagrams and/or the effects of loads on beams	2
• Provides some relevant information	1

Answers could include:

Shear force and bending moment diagrams are graphical tools used in conjunction with structural analysis to help perform structural design by determining the value of shear forces and bending moments at a given point of a structural element such as a beam. These diagrams provide a graphical representation of load systems which can then be used to assist in determining the type, size and material of a member in a structure so that a given set of loads can be supported without structural failure. For example, in steel beam design, bending moment diagrams can assist a structural engineer in deciding the lightest cross-section shape that can be used to carry a bending moment.

2018 HSC Engineering Studies Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Civil structures, Personal and public transport, Aeronautical engineering, Telecommunications engineering – communication p26	H3.2
2	1	Civil structures – mechanics p25	H2.1
3	1	Personal and public transport – mechanics p28	H3.1
4	1	Personal and public transport – communication p29 Civil structures – communication p26	H3.3
5	1	Civil structures – history p24	H4.2
6	1	Aeronautical engineering – mechanics p32	H1.1, H4.1
7	1	Personal and public transport – electronics p29	H3.1
8	1	Personal and public transport – materials p28	H1.2, H2.1
9	1	Personal and public transport – mechanics p28	H3.1
10	1	Civil structure – materials p25	H3.1
11	1	Aeronautical engineering – mechanics p32	H4.1
12	1	Aeronautical engineering – communication p33	H3.3
13	1	Telecommunications engineering – electronics p37	H1.1, H2.2, H4.1
14	1	Personal and public transport – materials p28	H1.2, H2.1
15	1	Telecommunications engineering – electronics, logic p37	H3.1, H3.3
16	1	Telecommunications engineering – materials, electronics p36	H3.1, H3.3
17	1	Aeronautical engineering – materials p33	H1.2, H4.1
18	1	Civil structures – mechanics p25	H3.1
19	1	Telecommunications engineering – materials p36	H1.2
20	1	Personal and public transport – mechanics p28	H3.1

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	3	Personal and public transport – electricity p29	H4.1, H4.2, H4.3
21 (b)	3	Personal and public transport – electricity p29	H4.1, H4.2, H4.3
21 (c)	3	Personal and public transport – mechanics p28	H3.1
21 (d)	3	Personal and public transport – electronics, logic p29	H3.1

Question	Marks	Content	Syllabus outcomes
22 (a)	2	Telecommunications engineering – materials p36, p37	H1.2, H4.1
22 (b)	2	Telecommunications engineering – materials p36, p37	H1.2, H4.1
22 (c)	4	Telecommunications engineering – materials, electronics p37	H1.2
22 (d)	3	Personal and public transport – electronics p29	H3.1
23 (a)	3	Personal and public transport – materials p28, p29,	H1.2, H2.1, H4.1
23 (b) (i)	4	Civil structures – mechanics p25	H3.1
23 (b) (ii)	2	Civil structures – mechanics p25	H1.2, H2.1
23 (c)	3	Civil structures – mechanics p25	H1.2, H2.1
24 (a)	3	Civil structures – materials p25, 26 Personal and public transport – materials p28, 29	H1.2, H2.1
24 (b)	2	Personal and public transport – materials p29	H2.1
24 (c)	6	Personal and public transport – communication p29	H3.3
25 (a)	3	Aeronautical engineering – mechanics p32	H1.1, H4.1
25 (b)	3	Aeronautical engineering – mechanics p32	H1.1, H2.2
25 (c) (i)	2	Aeronautical engineering – mechanics p32	H3.1
25 (c) (ii)	3	Aeronautical engineering – mechanics p32	H3.1
25 (d)	2	Aeronautical engineering – materials p33	H1.2
26 (a)	2	Civil structures – mechanics p25	H3.1
26 (b)	2	Personal and public transport – mechanics p28	H3.1
26 (c)	3	Personal and public transport – mechanics p28	H3.1
26 (d)	4	Personal and public transport – materials p28 Aeronautical engineering – materials p33	H1.2, H2.2
27 (a)	6	Civil structures – mechanics p25	H3.1
27 (b)	4	Civil structures – mechanics p25	H1.2, H3.1, H3.3