
2009 HSC Engineering Studies

Sample Answers

This document contains 'sample answers', or, in the case of some questions, 'answer may include'. These are developed by the examination committee for two purposes. The committee does this:

- (a) as part of the development of the examination paper to ensure the questions will effectively assess students' knowledge and skills, and
- (b) in order to provide some advice to the Supervisor of Marking about the nature and scope of the responses expected of students.

The 'sample answers' or similar advice, are not intended to be exemplary or even complete responses. They have been reproduced in their original form as part of the examination committee's 'working document'. While the handwritten notes have been typed for legibility, no further editorial change or addition has occurred.

Section II

Question 11 (a)

Sample answer/Answers could include:

Responsibilities include:

- OHS including documenting safe work practices
- Environmental restrictions
- Material ordering, storage and use
- Quality control of construction processes
- Budgetary control
- Keeping documentation up-to-date
- Planning construction tasks
- Supervising site staff including sub-contractors.

Question 11 (b)

Sample answer/Answers could include:

Materials:

- Rolled steel sections available for 1990s bridge not available for 1890s
- Embankment stabilisation materials and methods not available for 1890s
- Concrete available for abutment construction

Construction Methods:

- Capacity of lifting devices (cranes) greater in 1990s
- Electrical and pneumatically powered tools available in 1990s
- Portable lighting available in 1990s allowing for 24 hour construction work to take place.

Question 11 (c) (i)

Sample answer/Answers could include:

- Sourcing appropriate timber and wrought iron elements may be difficult– timber of appropriate size needs to be seasoned, difficult to get old-growth timber
- Traffic loads on bridge may need to be controlled so that structure isn't over-stressed as traffic loads of 1890s less than today
- Finding appropriately trained and experienced tradespeople may also be difficult.

Question 11 (c) (ii)

Sample answer/Answers could include:

Scope of knowledge needed for project is too vast for one person to master.
Different expertise is needed for difficult aspects of the project.

Question 12 (a)*Sample answer/Answers could include:*

- Greater directional strength
- Less ductile
- Work hardened
- Harder on surface
- Stronger.

Question 12 (b) (i)*Sample answer/Answers could include:*

$$\Sigma V \uparrow = 0$$

$$R_A + R_{VB} - 75 - 12 = 0$$

$$R_A + R_{VB} = 19.5$$

$$\Sigma \vec{H} = 0$$

$$8 - R_{HB} = 0$$

$$R_{HB} = 8 \text{ kN}$$

$$\Sigma \vec{M}_B = 0$$

$$+20R_A + (8 \times 3) - (7.5 \times 16) - (12 \times 4) = 0$$

$$20R_A = 120 + 48 - 24$$

$$= 144$$

$$R_A = \frac{144}{20} = 7.2 \text{ kN}$$

Substitute

$$R_{VB} = 19.5 - 7.2$$

$$= 12.3 \text{ kN}$$

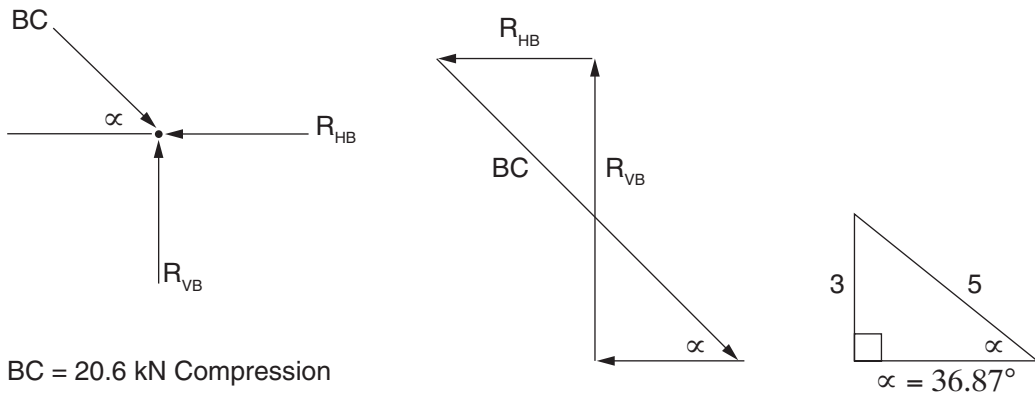
Answer: $R_A = 7.2 \text{ kN}$

$$R_{VB} = 12.3 \text{ kN}$$

$$R_{HB} = 8 \text{ kN}$$

Question 12 (b) (ii)

Sample answer/Answers could include:



OR

$$\sum V \uparrow = 0$$

$$R_{VB} - BC \sin \alpha = 0$$

$$12.3 - BC \sin 36.87 = 0$$

$$BC = \frac{12.3}{\sin 36.87}$$

$$BC = 20.5 \text{ kN}$$

Question 12 (c) (i)

Sample answer/Answers could include:

Location 'A' would have least effect on the strength of the beam as it passes through the middle of the web where bending stresses are least.

Question 12 (c) (ii)

Sample answer/Answers could include:

Reduces stress concentration thus reduces the chance of reduction in strength of the beam. Distributes load over greater area. Reduces crack propagation.

Question 13 (a) (i)

Sample answer/Answers could include:

- Dye penetrant test
- X-ray
- Ultrasonic testing

Question 13 (a) (ii)

Sample answer/Answers could include:

Hardening – Induction

The outside of railhead is heated above its critical temperature and then rapidly cooled to room temperature.

Question 13 (b)

Sample answer/Answers could include:

Polymer core holds shattered glass together. Impact energy dissipated– large glass shards not produced. One layer of glass may not necessarily break, holding matrix together.

Question 13 (c)

Sample answer/Answers could include:

- Input 1– Driver request
- Input 2– Brakes off
- Input 3– Emergency

Question 14 (a) (i)*Sample answer/Answers could include:*

$$65M = 15 \times 9$$

$$M = \frac{15 \times 9}{65} = 2.08 \text{ tonne}$$

Question 14 (a) (ii)*Sample answer/Answers could include:*

$$\sum V \uparrow = 0 \quad B - 4 - 9 = 0$$

$$B = 13t = 130 \text{ kN (act. vert. up)}$$

$$\sum M_B = 0$$

$$9 \times 15 = 135$$

$$135 \times 1000 \times 10 = 1.35 \text{ MNm}$$

Question 14 (b) (i)

Sample answer/Answers could include:

Stress A is within elastic range; stress B is within plastic range.

Stress A is below the yield point with allowance for factor of safety; stress B is at ultimate tensile strength.

Stress value at B could lead to catastrophic failure.

Question 14 (b) (ii)

Sample answer/Answers could include:

$$\delta = \frac{4P}{\pi d^2} \quad d = \sqrt{\frac{4P}{\pi\delta}}$$

$$d^2 = \frac{4P}{\pi\delta} = \frac{4 \times 76.35 \times 10^3}{\pi \times 300 \times 10^6} = 3.24$$

$$d = \sqrt{3.24}$$

$$= 0.018 \text{ m}$$

$$= 18 \text{ mm diameter}$$

Question 14 (c)

Sample answer/Answers could include:

PWM can be used to vary the speed by changing the average voltage across the armature. This is accomplished by changing the duty cycle of the pulse. Increasing the length of the pulse (increasing the duty cycle) will increase the average voltage, resulting in an increase in speed.

Question 15 (a) (i)

Sample answer/Answers could include:

Air is drawn into the engine, compressed and burnt with fuel to drive a turbine. The turbine turns a main shaft attached to a propeller, which produces thrust. Gearbox reduces speed of turbine to match required propeller speed.

Question 15 (a) (ii)

Sample answer/Answers could include:

The elevators produce lift. If the elevator moves up, it disrupts airflow and loses lift, causing the centre of the lift to move forward and the aircraft to pitch up. If the elevator moves down, it increases lift, causing the centre of the lift to aft and the aircraft to pitch down.

Question 15 (b)

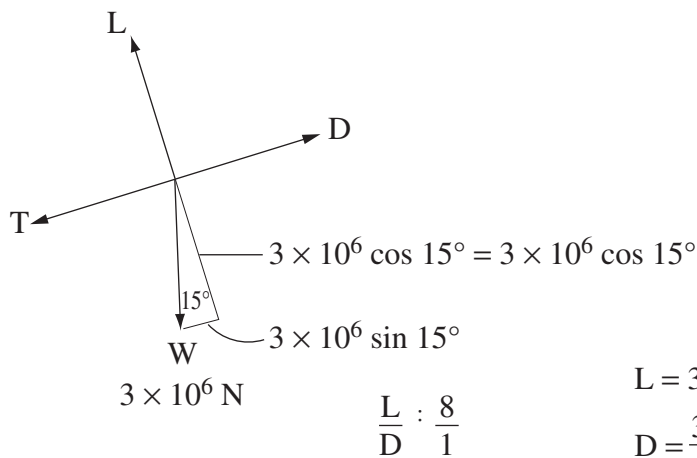
Sample answer/Answers could include:

Many components in modern aircraft are made from composite materials and cannot be successfully riveted. Adhesives provide a means of bonding these, spread the applied load over a greater area, are less prone to corrosion and provide a smooth aerodynamic flight surface. Polymer adhesives can be difficult to affect repairs and detect progressive failure.

Question 15 (c)

Outcomes assessed: H3.1

Sample answer/Answers could include:



$$\frac{L}{D} : \frac{8}{1}$$

$$L = 3 \times 10^6 \cos 15^\circ = 8 D$$

$$D = \frac{3 \times 10^6 \cos 15^\circ}{8} = 362.2 \text{ kN}$$

Question 15 (d)

Sample answer/Answers could include:

$$\text{Area} = \frac{\pi D^2}{4} = \frac{\pi}{4} (95^2) = 7088.2 \text{ mm}^2$$

$$\text{Force} = \text{pressure} \times \text{area}$$

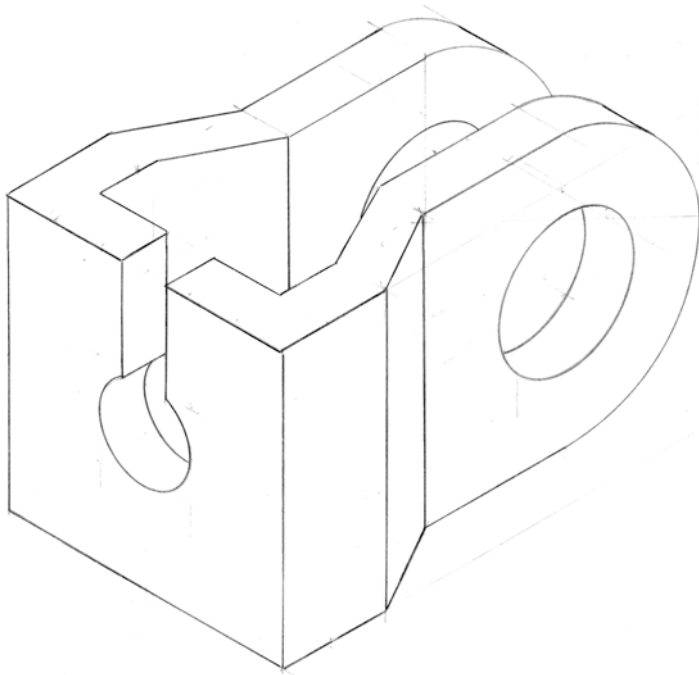
$$= (10.3 \times 10^6 \times \text{Area})$$

$$\text{Force} = (10.3 \times 10^6 \times 7088.2 \times 10^{-3})$$

$$= 73 \text{ kN}$$

Question 15 (e)

Sample answer/Answers could include:



Question 16 (a)***Sample answer:***

- Unshielded twisted pair:
 - Advantage– low cost
 - Disadvantage– relatively low data rate
- Coaxial cable:
 - Advantage– relatively immune to effects of noise
 - Disadvantage– suitable for only short to medium distance
- Optical fibre:
 - Advantage– high data rate
 - Disadvantage– high cost.

Answers could include:

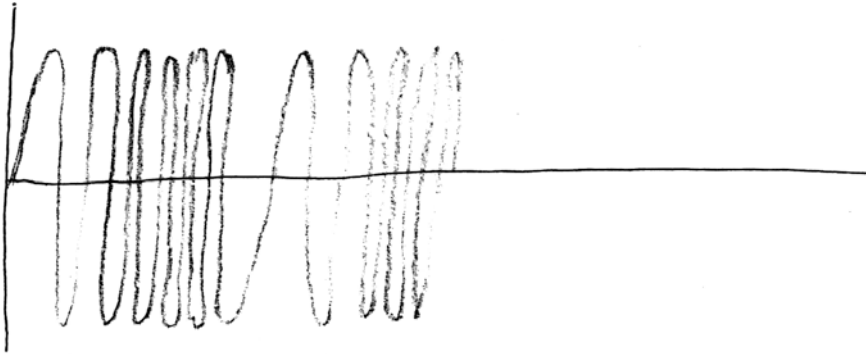
- Ease of installation
- Suitable only for short distances
- Data rate > for twisted pair
- Suitable only for short to medium distances
- Immune to electrical noise
- More difficult installation.

Question 16 (b)***Sample answer/Answers could include:***

Multiplexing in a telecom system is a technique for sharing a common resource between multiple users to enhance the utilisation and efficiency of a communications channel. For example, several low bandwidth signals can be combined to form one high BW signal.

Question 16 (c)

Sample answer/Answers could include:

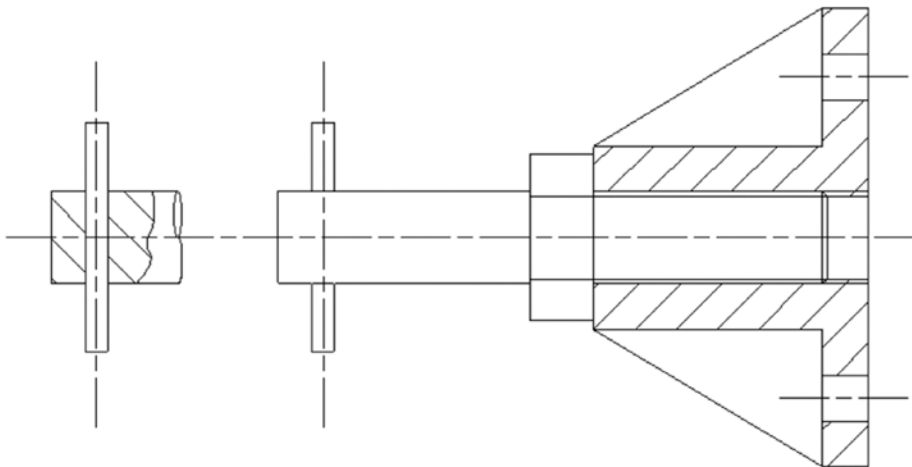
**Question 16 (d)**

Sample answer/Answers could include:

- Sound– FM: amplitude of message signal changes frequency of the carrier
- Picture– AM: amplitude of message signal changes amplitude of the carrier
- Both components of TV signal need separate modulation techniques
- Need to mention carrier and message signal.

Question 16 (e)

Sample answer/Answers could include:



Question 17 (a) (i)***Sample answer/Answers could include:***

Collision with the steel cable barrier would result in less injury to people, therefore reducing health costs, as well as less damage to the vehicle. Both of these would have a flow-on effect to insurance costs.

Question 17 (a) (ii)***Sample answer/Answers could include:***

Barriers are used to absorb energy and to deflect impact. Less damage to vehicles. Elastic behaviour of steel cable barrier absorbs energy.

Question 17 (b) (i)***Sample answer/Answers could include:***

- Cost
- Materials
- Installation
- Visibility
- Impact resistance
- Energy absorption

Question 17 (b) (ii)***Sample answer/Answers could include:***

Steel

- Good elastic behaviour
- High strength
- Toughness

Polypropylene

- Corrosion resistant
- Light
- Relatively cheap

Question 17 (c)*Sample answer/Answers could include:*

$$\begin{aligned}\text{Strain} = \frac{\delta L}{L} = 0.02 \quad E = \frac{PL}{A\delta L} \quad \therefore P &= \frac{EA\delta L}{L} \\ &= 195 \times 10^9 \times 180 \times 10^{-6} \times 0.02 \\ &= 702000 \text{ N} \\ &= 702 \text{ kN}\end{aligned}$$

Question 18 (a)***Sample answer/Answers could include:***

Number of facilities to be accommodated on pole system, e.g. traffic and street lights, signage, temporary flags/ banners, safety benefits of reduced roadside obstructions, material longevity in given environment.

- Safety
- Efficiency
- Less visual impact
- Ease of installation
- Off-site assembly
- Less poles in city

Question 18 (b)***Sample answer/Answers could include:***

Electrical insulator, lighter weight for strength, chemically inert/ non-reactive/ not susceptible to corrosion, more complex moulded shapes possible overcast aluminium alloy.

Question 18 (c) (i)***Sample answer/Answers could include:***

Required voltage drop = 4.5 V; Required current 15 mA

$$R = \frac{E}{I} = \frac{4.5}{15} \times 1000 = 300 \Omega$$

Question 18 (c) (ii)***Sample answer/Answers could include:***

Circuit 1:

- Advantage: Less components
- Disadvantage: One component failure causes complete circuit failure

Circuit 2:

- Advantage: Circuit can tolerate some component failures and provide a reduced form of operation
- Disadvantage: more components=more expensive to manufacture
- Voltage V_1 has to be higher voltage than V_2
- Current supplied by the power source V_2 is larger than that for V_1 .