BOARD OF STUDIES
NEW SOUTH WALES

2010 HSC Engineering Studies
Sample Answers

This document contains 'sample answers', or, in the case of some questions, 'answers could 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 answers or responses. As they are part of the examination committee's 'working document', they may contain typographical errors, omissions, or only some of the possible correct answers.

Section II

Question 11 (a)

Answers could include:

Brick lift shafts replaced with cast reinforced concrete. Benefits – less labour, quicker to construct, stronger, lighter, less volume.

Hydraulic Ram shown is cast iron. Replace this with alloy steel for corrosion resistance. Passenger Cabin shown is timber. Replace with stainless steel for durability.

Question 11 (b)

Answers could include:

Roles involving Safety

- Safety engineers would be particularly concerned with braking systems that would operate in an emergency. They would be concerned with electrical safety (insulation, etc)
- The engineer would be concerned with motor control in terms of reliable and safe operation of the lift and other control technology monitoring lift speed and position
- Telecommunication engineers would play a role in the design of the lift – enabling contact to the outside world
- The engineer would develop and supervise maintenance schedules, designing components with ease of access for maintenance in mind

Roles involving Design

- The engineer would be given the role of researching the design of components – testing of materials, carrying out calculations, selection of materials, applying a factor of safety
- The chief engineer would monitor/ supervise construction. Maintain quality control (Australian Standards) during construction. They would give the final sign off after inspecting the completed product

Question 11 (c)

Sample answer/Answers could include:

Impact on the built environment

- High-rise buildings were limited in height when staircases were used. Passenger lifts enabled higher buildings, allowed quicker access to floors in buildings
- Taller buildings required an improved understanding of materials technology due to greater loads placed on footings
- Building design and construction methods have changed to reduce the weight of the buildings as they have increased in height

Impact on society

- Higher commercial and residential densities. Land has more value as more tenants can be housed in the same footprint
- Reduces urban sprawl – reduces need for more infra-structure in outer city areas
- Improved access for the elderly/disabled
- Taller buildings can take advantage of the view – top floors become more sought after, more expensive
- There has been a decrease in fitness levels with everyone taking the lift instead of walking up and down the stairs
- Tall buildings have a greater visual impact/overshadowing impact on neighbours

Question 11 (d)

Answers could include:

- The 2.5m hydraulic ram could be telescopic reaching 8 m when fully extended. The sleeves of the ram all slide inside one another when not needed
- A block-and-tackle system could take over from the hydraulic ram once it has reached its full extended length of 2.5 m

Question 12 (a) (i)

Sample answer:

$$\sum V^{\uparrow} = 0$$

$$R_{VA} + R_J = 50$$

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

$$15 = R_{HA}$$

$$\sum M_A = (15 \times 12) + (25 \times 4) = 0 = R_V \cdot 4$$

$$R_V = 70 \text{ kN}$$

$$\sum F^{\uparrow=0},\ R_A = 50 - 70$$

$$= 20 \text{ kN down}$$

$R_{VA} = 20$ kN down

$R_J = 70$ kN up

$R_H = 15$ kN to left

Question 12 (a) (ii)

Sample answer:

$$\uparrow \sum F_y = -25 - 25 + F_{Jy} + F_{Ay} = 0$$

$$F_{Jy} + F_{Ay} = 50 \text{ kN}$$

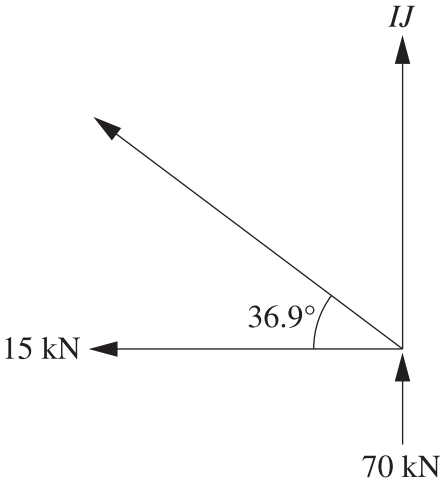
$$\rightarrow \sum F_x = 15 \text{ kN} + F_{Ax} = 0$$

$$F_{Ax} = -15 \text{ kN}$$

$$\circlearrowleft + \sum M_A = 15 \times 12 - F_{Jy} \times 4 + 25 \times 4 = 0$$

$$F_{Ay} = 70 \text{ kN}$$

$$\therefore \quad F_{Ay} = 50 - 70 = -20 \text{ kN}$$



$$\uparrow \sum F_y = 0 = 70 + IJ + BJ \sin 36.9$$

$$\rightarrow \sum F_x = 0 = -15 - BJ \cos 36.9$$

$$\therefore \quad BJ = \frac{-15}{\cos 36.9} = -18.76 \text{ kN}$$

$$\therefore \quad BJ = 18.76 \text{ kN compression}$$

Question 12 (a) (iii)

Answers could include:

- Made more rigid by additional bracing, or shorter members
- Redesign to tapered configuration

Question 12 (b) (i)

Sample answer:

D, the I cross-section. This section has the highest I_{xx} value, so will have the highest resistance to bending.

Question 12 (b) (ii)

Sample answer:

Depending on which I_{xx} used

Bending stress —

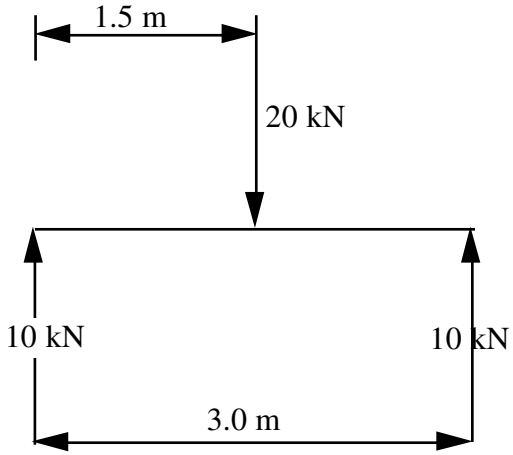
Correct formula: $\sigma = \frac{My}{I}$

Stress, $\sigma = \frac{My}{I}$

$= \frac{(15 \times 10^6) \times 150}{120.7 \times 10^6}$

$\therefore \sigma = 18.6$ MPa

Values changed at Q:



$M = 10 \times 10^3 \times 1500$

$= 15 \times 10^6$ Nmm

$MPa = \frac{N}{mm^2}$

Question 13 (a) (i)

Sample answer:

Aluminium silicon alloy

Question 13 (a) (ii)

Sample answer:

Molten aluminium/ silicon alloy injected (under pressure) into a permanent steel mould. Allowed to cool until solidified in mould then mould is separated and component is ejected.

Question 13 (b) (i)

Sample answer:

$$P = \frac{F \times s}{t} = 85 \times V_{av}$$

$$= 85 \times 8.3$$

$$\therefore \quad P = 708.3 \text{ W}$$

For F

$$W \sin\theta = 1700 \times \frac{1}{2}$$

$$= 85 \text{ N down hill}$$

For V_{av} m s^{-1}

30 km h^{-1} = 8.3 m s^{-1}

Question 13 (b) (ii)

Sample answer:

$$I = \frac{P}{V} = \frac{600}{12}$$

$$= 50 \text{ A}$$

Question 13 (b) (iii)

Sample answer:

$$\text{Duration of battery} = \frac{20}{45} \times 60$$

$$= 26.7 \text{ minutes}$$

$$\text{Distance} = 25 \times \frac{26.7}{60}$$

$$= 11.1 \text{ km}$$

Question 14 (a) (i)

Answers could include:

- Fewer moving parts, less noise
- Increased efficiency
- Reduced noise
- More reliable
- Lower maintenance
- Compact
- Increased safety
- Ease of operation

Question 14 (a) (ii)

Sample answer:

$$T - (2000 \times 9.81) = (2000 \times 0.4)$$

$$T = 800 + 19620$$

$$= 20.4 \text{ kN}$$

Question 14 (b) (i)

Sample answer:

Pressure is constant so force/area is constant

$$\frac{17}{\pi(150^2)} = \frac{F}{\pi \times (25^2)} \therefore F = 0.47 \text{ kN or } 470\text{N}$$

Question 14 (b) (ii)

Sample answer:

A suitable material for the seal would be neoprene as it is resistant to grease and oil and it is sufficiently flexible to form a good seal under pressure.

Question 14 (c)

Sample answer:

A tensile test could be used to test the mechanical properties of the steel in the crane hook. A sample would be place in a tensometer until tensile failure occurred and a load/extension graph plotted. This graph would be compared to a standard graph for the material to gauge its suitability.

Question 15 (a)

Sample answer:

An alternative engine could be a turbo-prop engine, however, the turbo-prop would be operating under conditions where it be less efficient due to relatively low altitudes and lower speeds, whereas internal combustion engines operate well under these conditions.

Answers could include:

Internal combustion engine probably lighter, readily available, easy to maintain.

Question 15 (b)

Sample answer:

Airbrakes disturb the linear flow over the wings, increasing drag and reducing lift. This allows better control of vertical (down) acceleration. Increasing drag reduces speed.

Question 15 (c)

Answers could include:

- Superior strength to weight ratio $\left(\text{specific strength} = \frac{\text{ultimate stress}}{\text{density}} \right)$
- Low corrosion characteristics
- Low drag surface
- Readily formed into complex shapes
- Good with adhesives as joining materials
- Superior specific stiffness $\left(\frac{E}{\text{density}} \right)$

Question 15 (d)

Sample answer:

Mechanical properties would change because the age-hardening would be destroyed by the subsequent high temperature, reheat from exhaust gases, causing:

- decrease in hardness
- decrease in tensile strength
- increase in ductility
- reduced toughness
- microstructure shows B phase
- not annealing.

Answers could include:

Mechanism of precipitation hardening – solution treatment and artificial aging destroyed.

Question 15 (e)

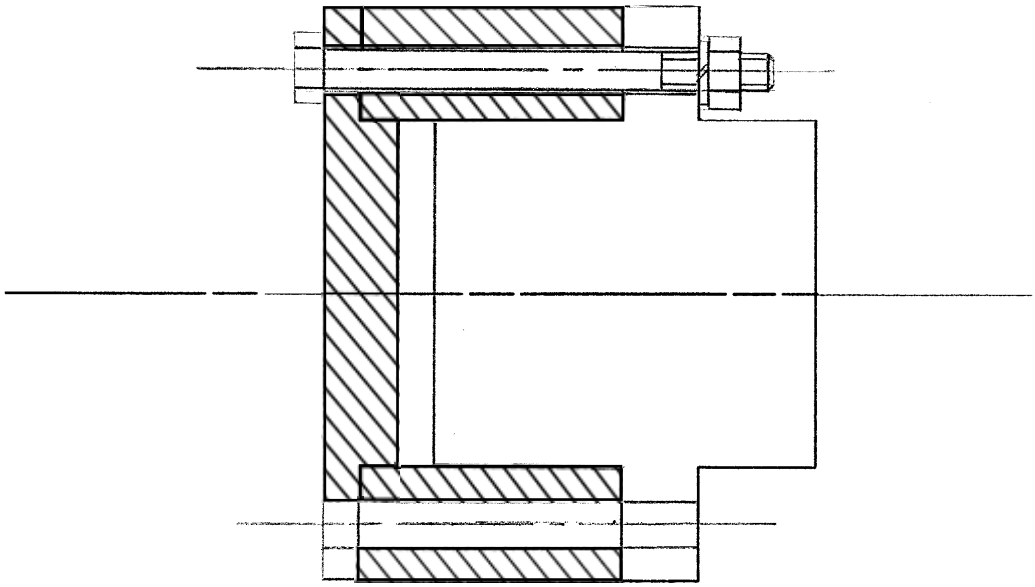
Sample answer:

High strength Al-Cu alloys (duralumin) are susceptible to corrosion, whereas pure aluminium has good corrosion resistance (passivated).

The thin layer of aluminium on the surface of the duralumin helps resist corrosion of the alloy skin.

Question 15 (f)

Sample answer:



Question 16 (a) (i)

Sample answer:

The microwave link is an unguided medium where the signal travels through air.

Answers could include:

The signal is not guided by any physical conductor.

Question 16 (a) (ii)

Sample answer:

Microwave communication link requires line of sight. It is susceptible to adverse weather conditions. The link has a large bandwidth and can therefore handle large quantities of data. There is no physical connection between the studio and antenna.

Question 16 (a) (iii)

Sample answer:

10^9–10^{10} Super high frequency (SHF)

Question 16 (b) (i)

Sample answer:

A series of measurements taken at regular instants in time

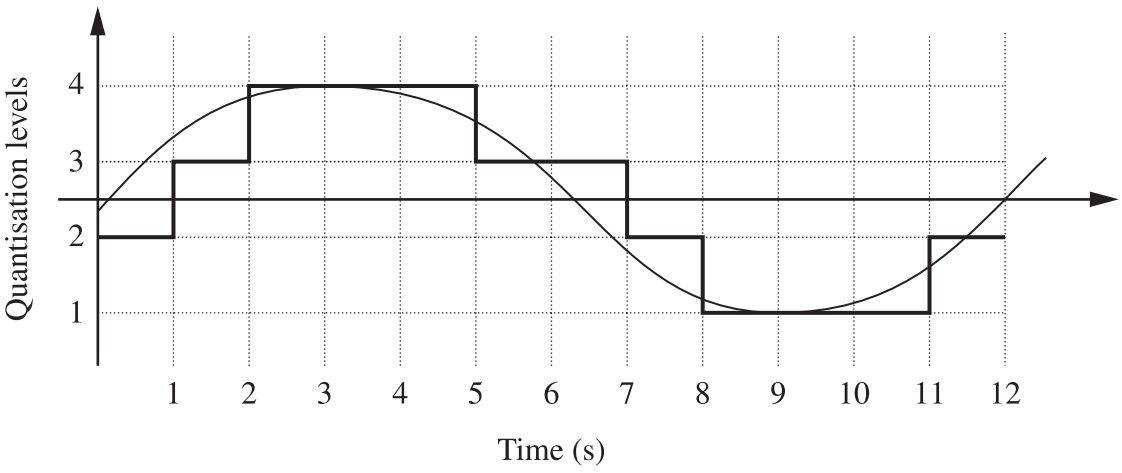
Question 16 (b) (ii)

Sample answer:

Quantisation is the process of approximating a measurement by the nearest value from a set of values.

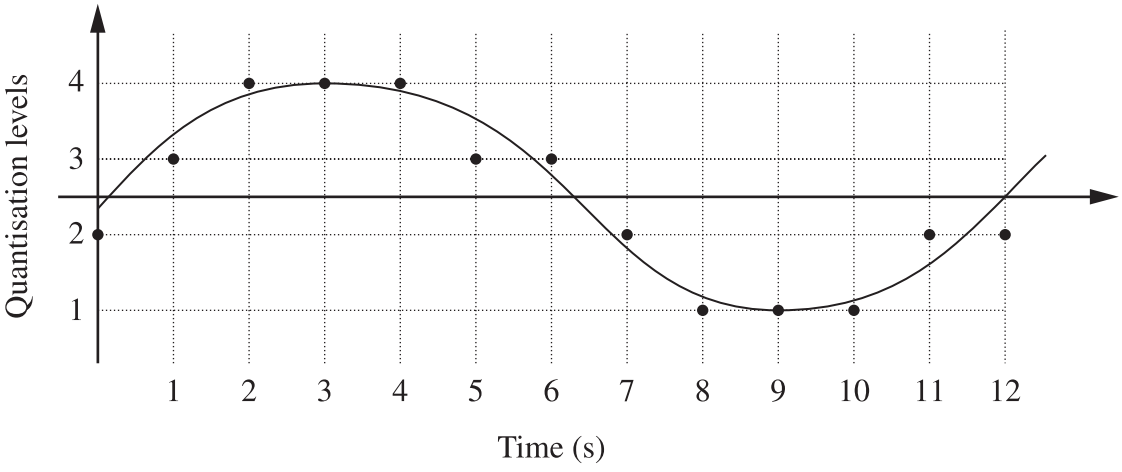
Question 16 (b) (iii)

Sample answer:



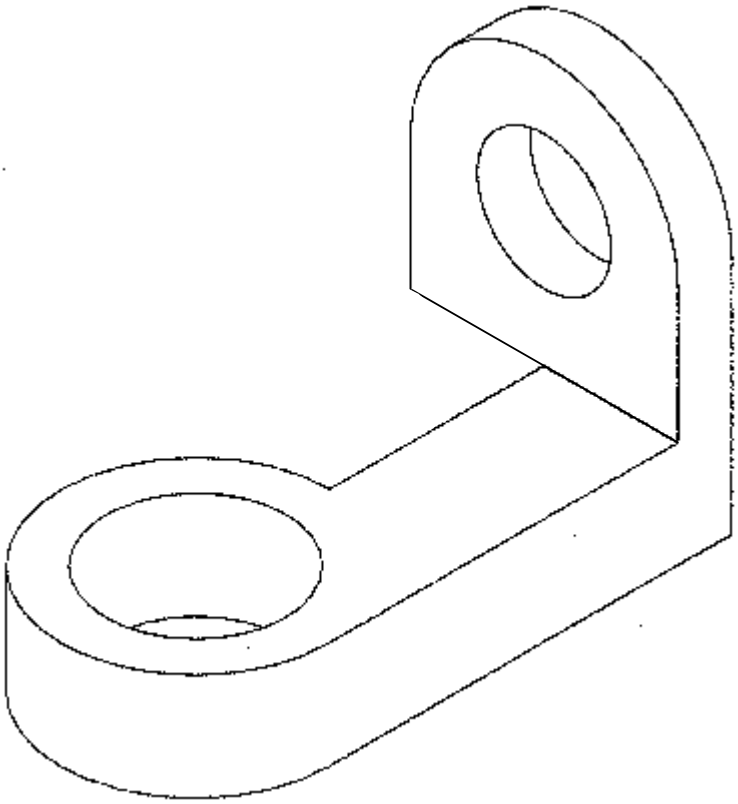
OR

Answer could include:



Question 16 (c)

Sample answer:



Section III

Question 17 (a) (i)

Answers could include:

- Ability of pole to withstand loads – including accidental loads caused by car crashes and freak weather.
- Ability of the pole to be insulated from the electricity.
- Deterioration of pole caused by weather, borers, termites, corrosion, etc
- Ability to last a long time, and to be easily replaced
- Ease of manufacture
- Availability of materials

Question 17 (a) (ii)

Answers could include:

- Timber is lighter than reinforced concrete and therefore easier to install
- Reinforced concrete does not rot as timber does
- Timber is prone to insect attack, while concrete reinforcement can corrode (concrete cancer)
- Reinforced concrete is stronger than timber

Question 17 (a) (iii)

Answers could include:

- Visual pollution/impact on surrounding landscape
- Danger to vehicles/car accidents
- Electromagnetic radiation
- Danger from falling power lines
- Interference with surrounding flora

Question 17 (b) (i)

Sample answer:

- Reports for engineering contractors may focus more on technical details than reports developed for community groups, upper management or those without engineering backgrounds
- Reports for accounts or project management staff may include more detail on project costings/timelines than design calculations/drawings

Question 17 (b) (ii)

Sample answer:

To reduce the power that is lost in the transmission. Power lost is proportional to I^2. By increasing voltage, current can be decreased for a given power hence power losses reduced.

Question 18 (a) (i)

Answers could include:

- An area clear of forest and other vegetation
- An area with good annual wind
- An area with reasonable wind velocity
- Clear of habitation (houses and people)
- Access
- Close to existing grid system

Question 18 (a) (ii)

Answers could include:

Carbon fibre reinforced composite or aluminium alloy; both materials offer a suitable strength to weight ratio and are light enough to allow the wind to easily spin the blades.

Composites using polymers reinforced with either glass fibre or Kevlar fibres are suitable materials. They offer good specific strength, are resistant to impact from objects and are not susceptible to corrosion.

- Epoxy/glass composite
- Epoxy/carbon fibre composite
- Epoxy/aramid (Kevlar) composite
- Polyester/glass composite
- Aluminum alloy

Question 18 (a) (iii)

Sample answer:

Force $= 300$ N

Distance $= 3$

$T = F \cdot d$

$= 3(3 \times 100)$

$= 900$ Nm

Question 18 (b) (i)

Sample answer:

Increasing the mechanical load causes the motor to slow which decreases the back EMF, hence increasing the rotor current.

Under load the rotational speed will decrease, which lowers the back EMF. The total rotor current will now increase as there is less back EMF to oppose it.

Question 18 (b)(ii)

Sample answer:

Voltage drop across rotor resistance

$V_d = IR$
$= 75.9 \times 0.1$
$= 7.59$ volts

Back EMF

$E_R = 250 - 7.59$

$E_R = 242.41$ volts