# Engineering marking guide

External assessment

## Combination response (85 marks)

### Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

1. recognise and describe machine and mechanism problems, and mechanics, materials science and control technologies concepts and principles, in relation to machines and mechanisms
2. symbolise and explain ideas and solutions in relation to machines and mechanisms
3. analyse machine and mechanism problems, and information in relation to machines and mechanisms
5. synthesise information and ideas to predict possible machine and mechanism solutions.

**Note:** Objectives 4, 6, 7 and 8 are not assessed in this instrument.

# Purpose

This document is an External assessment marking guide (EAMG).

The EAMG:

- Provides a tool for calibrating external assessment markers to ensure reliability of results
- Indicates the correlation, for each question, between mark allocation and qualities at each level of the mark range
- Informs schools and students about how marks are matched to qualities in student responses.

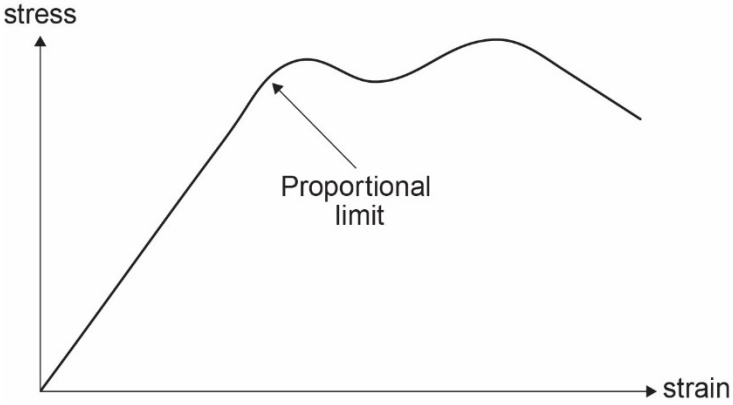
# Mark allocation

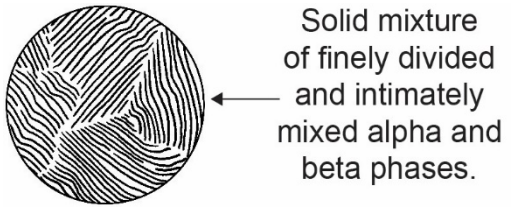
Where a response does not meet any of the descriptors for a question or a criterion, a mark of ‘0’ will be recorded. Where no response to a question has been made, a mark of ‘N’ will be recorded.

# External assessment marking guide

## Multiple choice

| Question | Response |
|---|---|
| 1 | C |
| 2 | A |
| 3 | B |
| 4 | C |
| 5 | B |
| 6 | B |
| 7 | C |
| 8 | A |
| 9 | B |
| 10 | D |

| Q | Sample response | The response: |
|---|---|---|
| 11 | The proportional limit is the greatest stress that a material can withstand without losing straight-line proportionality between stress and strain within the material's elastic limit.<br>  <br> | • explains correctly using wording indicative of<br>- greatest stress **[1 mark]**<br>- straight-line proportionality **[1 mark]**<br>- within the elastic limit of the material **[1 mark]**<br>• provides an appropriately annotated stress–strain diagram sketch **[1 mark]** |
| 12 | 1. Biodegradable<br>2. High tensile strength<br>3. Non-toxic in solid form<br>4. Resistant to chemicals | • provides 4 correctly identified PLA properties **[4 marks]**<br>OR<br>• provides 3 correctly identified PLA properties **[3 marks]**<br>OR<br>• provides 2 correctly identified PLA properties **[2 marks]**<br>OR<br>• provides 1 correctly identified PLA property **[1 mark]** |

<table>
<tr><th>Q</th><th>Sample response</th><th>The response:</th></tr>
<tr><td>13</td><td>Microstructure changes occur when the cooling of the completely soluble liquid solution reaches the eutectic temperature of 183 °C. Here the liquid solution completely freezes to become a totally solid eutectic mixture with partial solid solubility as the temperature continues to fall.<br> 
</td><td>• explains changes correctly using wording indicative of the<br>- laminar structure [1 mark]<br>- mixture solidifies directly from liquid to solid [1 mark]<br>- eutectic mixture [1 mark]<br>• provides a sketch that<br>- indicates a laminar structure [1 mark]<br>- is appropriately annotated [1 mark]</td></tr>
<tr><td>14</td><td><table><tr><th>A</th><th>$\overline{A}$</th><th>B</th><th>C</th><th>D</th><th>E</th><th>S</th></tr><tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr></table></td><td>• provides a truth table including<br>- 7 columns correctly labelled [1 mark]<br>- 8 rows under the header row [1 mark]<br><br>LogGO<br>• includes correct logic gate outputs for all 4 columns $\overline{A}$, D, E, S [4 marks]<br>OR<br>• includes correct logic gate outputs for any 3 columns $\overline{A}$, D, E or S [3 marks]<br>OR<br>• includes consequentially correct logic gate outputs for any 2 columns $\overline{A}$, D, E or S [2 marks]<br>OR<br>• includes consequentially correct logic gate outputs for any 1 column $\overline{A}$, D, E or S [1 mark]</td></tr>
</table>

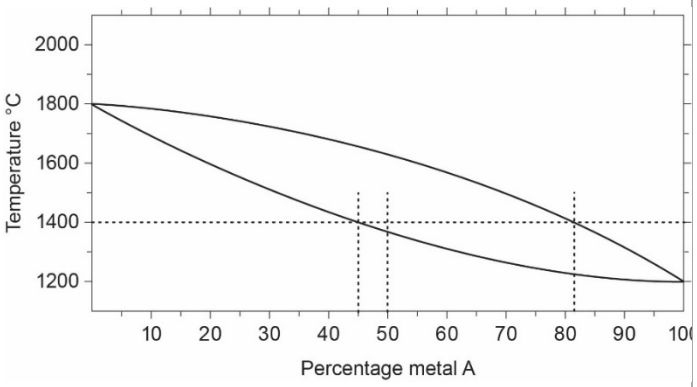
| Q | Sample response | The response: |
|---|---|---|
| 15 | The engineer would have considered the local environmental conditions. Effective use of solar energy requires that most days are cloud free. This would allow the solar-powered pumps to operate efficiently. On overcast, cloudy days when rain is likely, the solar pumps would operate less often, saving water.<br>The engineer would also have considered the economics of the use of solar water pumps. The initial cost of the pumps is possibly high when compared to other methods, but running costs are low, which allows the community to transport water cheaply and efficiently.<br>It would be important to have a sustainable water supply, as solar pumps are able to supply large volumes of water. The engineer would have considered the sustainability of the solar pumps and the irrigation system, as breakdowns in the system would need to be repaired. This aspect of implementation of any mechanical system would need to be considered in the maintenance of the system. | • explains appropriately using<br>- 1 relevant environmental factor **[1 mark]**<br>- another relevant environmental factor **[1 mark]**<br>• explains appropriately using<br>- 1 relevant economic factor **[1 mark]**<br>- another relevant economic factor **[1 mark]**<br>• explains appropriately using<br>- 1 relevant sustainability factor **[1 mark]**<br>- another relevant sustainability factor **[1 mark]** |

| Q | Sample response | • The response: |
|---|---|---|
| 16 | A gear ratio of the system is determined using the distance travelled by the rack for each revolution of the pinion gear B. The pitch of the teeth on the rack is 10 mm, which means that each revolution of the pinion gear that has 30 teeth will raise the rack by 300 mm. To lift the platform 1.2 m, the pinion gear must rotate 4 times. The gear ratio between gear A and gear B is 30 divided by 15 or 2:1. To raise the rack 1.2 metres, gear A is required to turn 8 times to turn gear B 4 times. Therefore, the gear ratio of gear A to gear C is 1 to 150 mm. | • explains correctly and includes<br>- identification of rack and pinion gears **[1 mark]**<br>- an accurate numerical relationship between linear and rotational movement of the rack and pinion gears **[1 mark]**<br>- an accurate gear ratio of gear A to B **[1 mark]**<br>- an accurate gear ratio of gear A to C **[1 mark]**<br>- evidence of mathematical reasoning **[1 mark]** |
| 17 | High-carbon steel has a chemical composition that includes 0.60% to 1.25% carbon. This carbon content facilitates the formation of pearlite in the microstructure. Pearlite is a fine laminar mixture of ferrite and cementite. The mechanical properties of pearlite are intermediate to soft, ductile ferrite and hard, brittle cementite. The finer pearlite microstructure of high-carbon steel increases toughness, strength, hardness and wear resistance, which makes the steel useful for industrial applications such as cutting tools, punches, dies and springs. | • explains correctly and includes<br>- the carbon content of high-carbon steel **[1 mark]**<br>- the microstructure of high-carbon steel **[1 mark]**<br>- 2 industrial/mechanical uses for high-carbon steel **[1 mark]** |
| | | Prpt<br>- 2 mechanical properties of high-carbon steel **[2 marks]**<br>OR<br>- 1 mechanical property of high-carbon steel **[1 mark]** |

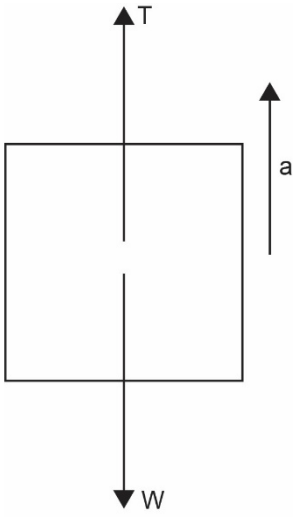
| Q | Sample response | The response: |
|---|---|---|
| 18 | a)<br>$\mu_s = \tan\theta = \tan 30 = 0.58$ | • provides correct working to give correct coefficient of static friction to two decimal places **[1 mark]** |
| | b)<br>Acceleration on Mars = $\frac{9.8}{3} = 3.27$ m/s$^2$<br>$F_f = \mu_s F_N$<br>$F_f = \mu_s mg\cos\theta$<br>$= 0.58 \times 900 \times 3.27 \times \cos 30$<br>$= 1478.25\ \text{N} \approx 1478\ \text{N}$ | • provides correct formula and substituted values **[1 mark]**<br>• provides correct answer to the nearest whole unit with correct unit provided **[1 mark]** |
| | c)<br>The coefficient of static friction depends only on the angle of repose. Therefore $\mu_s$ will be the same quantity on both Mars and Earth. | • explains using wording indicative of<br>- $\mu_s$ depends only on the angle of repose **[1 mark]**<br>- $\mu_s$ is the same on Mars and Earth **[1 mark]** |

| Q | Sample response | The response: |
|---|---|---|
| 19 | a)<br>$P = \frac{W}{t}$<br>$4355 = \frac{W}{90}$<br>$W = 4355 \times 90 = 391\,950$ J<br>$W = F \times d \approx \text{PE} = mgh$<br>$\therefore W = mgh$<br>$391\ 950 = m \times 9.8 \times 20$<br>$m = \frac{391\,950}{9.8 \times 20}$<br>$= 1999.75 \approx 2000$ kg<br>∴ The mass of the full scrap metal bin is 2000 kg. | • provides correct working to give correct result for work done **[1 mark]**<br>• provides correct formula and substituted values **[1 mark]**<br>• provides correct working to give correct answer to the nearest whole unit with correct unit provided **[1 mark]** |
| | b)<br>KE on impact $= \text{PE} = mgh$<br>$= 5 \times 9.8 \times 20$<br>$\therefore \text{KE} = 980$ J<br>$\text{KE} = \frac{1}{2} \times m \times v^2$<br>$v^2 = \frac{980}{0.5 \times 5}$<br>$v = \sqrt{392}$<br>$= 19.80 \approx 20$ m/s<br>∴ The velocity of the scrap metal on impact with the ground is 20 m/s. | • provides correct working to give correct KE **[1 mark]**<br>• provides correct formula and substituted values **[1 mark]**<br>• provides correct working to give correct answer to the nearest whole unit with correct unit provided **[1 mark]** |

| Q | Sample response | The response: |
|---|---|---|
| 20 | a)<br>gear ratio of double-thread worm and wheel<br>$= \frac{\text{worm wheel teeth}}{\text{worm teeth}}$<br>$= \frac{40}{2} = 20 \therefore \text{VR} = 20$<br>$\eta = \frac{\text{MA}}{\text{VR}}$<br>$0.45 = \frac{\text{MA}}{20}$<br>$\text{MA} = 0.45 \times 20 = 9$<br>$\text{MA} = \frac{\text{L}}{\text{E}}$<br>$\text{L} = \text{MA} \times \text{E}$<br>$= 9 \times 50 = 450\ \text{N}$<br>$F = mg$<br>$m = \frac{F}{g} = \frac{450}{9.8} = 45.92 \approx 46\ \text{kg}$ | • provides correct working to give correct gear ratio (VR) **[1 mark]**<br>• provides correct formula and substituted values for mechanical advantage **[1 mark]**<br>• provides correct working to give correct L **[1 mark]**<br>• provides correct formula and substituted values for mass **[1 mark]**<br>• provides correct working to give correct answer to the nearest whole unit with correct unit provided **[1 mark]** |
| | b)<br>$\eta_{\text{total}} = \eta_1 \times \eta_2$<br>$0.36 = 0.45 \times \eta_2$<br>$\eta_2 = \frac{0.36}{0.45} = 0.80$<br>$\eta = \frac{\text{MA}}{\text{VR}}$<br>$\text{VR} = \frac{\text{MA}}{\eta} = \frac{9}{0.80} = 11.25$ | • provides correct formula and substituted values for effort wheel efficiency **[1 mark]**<br>• provides correct working to give correct effort wheel efficiency **[1 mark]**<br>• provides correct formula and substituted values for velocity ratio **[1 mark]**<br>• provides correct working to give correct answer to two decimal places **[1 mark]** |

| Q | Sample response | The response: |
|---|---|---|
| 21 |  <br>$\text{solid} = \frac{82-50}{82-45} \times \frac{100}{1}$<br>$= \frac{32}{37} \times \frac{100}{1} = 86.49 = 86\%$<br>$\text{liquid} = \frac{50-45}{82-45} \times \frac{100}{1}$<br>$= \frac{5}{37} \times \frac{100}{1} = 13.51 = 14\%$ | • provides evidence that the diagram is used to plot percentage of metal A and B **[1 mark]**<br>• includes correct use of the inverse lever rule to calculate solid **[1 mark]**<br>• provides correct working to give correct percentage of solid to the nearest whole unit with correct unit provided **[1 mark]**<br>• provides correct use of the inverse lever rule to calculate liquid **[1 mark]**<br>• provides correct working to give correct percentage of liquid to the nearest whole unit with correct unit provided **[1 mark]** |

| Q | Sample response | • The response: |
|---|---|---|
| 22 | Constant velocity<br>$F_f = mg \sin\theta$<br>$= 30 \times 9.8 \times \sin 20 = 100.55$ N<br>$F_N = mg \cos\theta$<br>$= 30 \times 9.8 \times \cos 20 = 276.27$ N<br>$F_f = u_k F_N$<br>$u_k = \frac{F_f}{F_N}$<br>$= \frac{100.55}{276.27} = 0.36$<br>∴ coefficient of kinetic friction for chute with cushion is 0.36.<br>$v^2 = u^2 + 2as$<br>$a = \frac{v^2 - u^2}{2s}$<br>$= \frac{0 - 1}{2 \times 3} = -0.17$ m/s$^2$<br>$-a = 0.17$ m/s$^2$<br>$F_{dec} = ma = 30 \times 0.17 = 5.10$ N<br>$F_f$ required $= 5.10 + mg \sin 20$<br>$= 5.10 + 100.55 = 105.65$ N<br>$F_f = u_k F_N$<br>$u_k = \frac{F_f}{F_N}$<br>$= \frac{105.65}{276.27} = 0.38$<br>∴ coefficient of kinetic friction for the modified chute is 0.38.<br>∴ the difference in kinetic friction between the cushioned and modified surface chute is $0.38 - 0.36 = 0.02$. | • provides correct working to give correct force of friction **[1 mark]**<br>• provides correct working to give correct normal force **[1 mark]**<br>• provides correct working to give correct coefficient of kinetic friction **[1 mark]**<br>• provides correct formula and substituted values **[1 mark]**<br>• provides correct working to give correct deceleration **[1 mark]**<br>• provides correct working to give correct force of deceleration **[1 mark]**<br>• provides correct working to give correct force of friction required for deceleration **[1 mark]**<br>• provides correct working to give correct coefficient of kinetic friction required for bag deceleration **[1 mark]**<br>• provides correct working to give a correct answer to two decimal places **[1 mark]** |

| Q | Sample response | The response |
|---|---|---|
| 23 |  <br>$ma = T - W$<br>$= 30\,000 - (2500 \times 9.8)$<br>$= 5500$ N<br>$a = \frac{5500}{2500} = 2.20$ m/s$^2$<br>$v = u + at$<br>$10 = 0 + (2.20 \times t)$<br>$t = \frac{10}{2.20} = 4.55$ s<br>$s = ut + \frac{1}{2}at^2$<br>$= (0 \times 4.55) + \frac{1}{2}(2.2 \times 4.55^2)$<br>$= 22.77$ m<br>∴ the elevator travels 23 m during acceleration | • provides an appropriate force diagram **[1 mark]**<br>• provides correct working to give correct force required for acceleration **[1 mark]**<br>• provides correct working to give correct acceleration **[1 mark]**<br>• provides correct working to give correct time to complete acceleration **[1 mark]**<br>• provides correct formula and substituted values **[1 mark]**<br>• provides correct working to give correct answer to the nearest whole unit (m) with correct unit provided **[1 mark]** |