Engineering marking guide and response

External assessment 2021

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.

Queensland Government | Queensland Curriculum & Assessment Authority

For all Queensland schools

Purpose

This document consists of a marking guide and a sample response.

The marking guide:

- 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.

The sample response:

- demonstrates the qualities of a high-level response
- has been annotated using the marking guide.

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.

Allowing for FT error — refers to ‘follow through’, where an error in the prior section of working is used later in the response, a mark (or marks) for the rest of the response can still be awarded so long as it still demonstrates the correct conceptual understanding or skill in the rest of the response.

Rounding for results to intermediate steps in calculation questions are considered correct when provided within a range of two to a maximum of nine decimal places as determined using a scientific calculator. Final answers must be provided to the nearest whole unit or as otherwise stated in the question

Marking guide

Multiple choice

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

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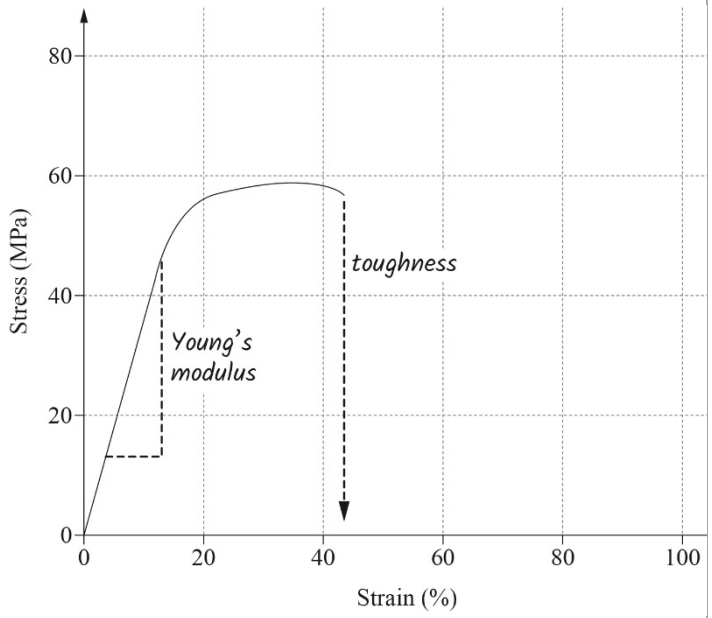
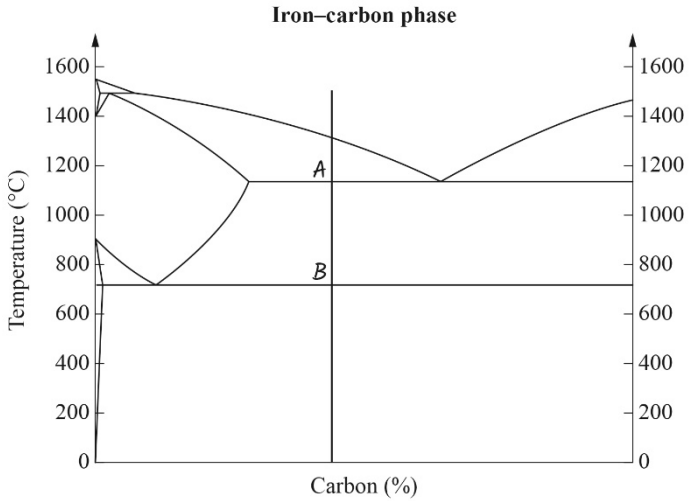
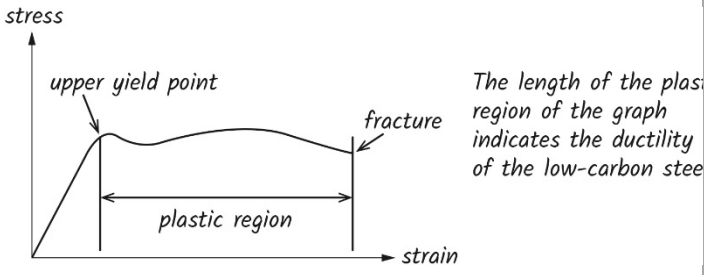
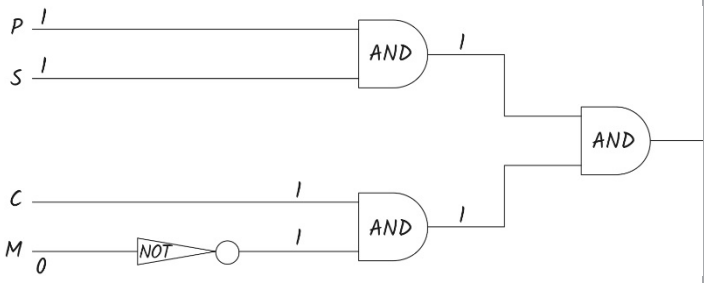
Short response

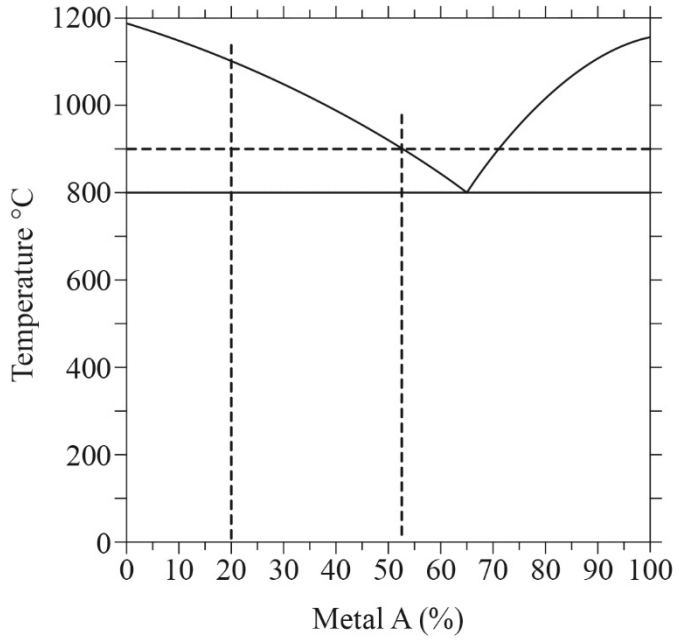
Q	Sample response	The response:
11		· sketches an appropriate stress–strain curve for nylon, including - a straight line proportion with strain less than 20% **[1 mark]** - a rupture point with less than 80% strain **[1 mark]** · accurately identifies toughness on the curve **[1 mark]** · accurately identifies Young's modulus on the curve **[1 mark]**
12	1. Electronics 2. Electrical 3. Mechanical 4. Materials	· provides a correct knowledge type **[1 mark]** · provides a second correct knowledge type **[1 mark]** · provides a third correct knowledge type **[1 mark]** · provides a fourth correct knowledge type **[1 mark]**

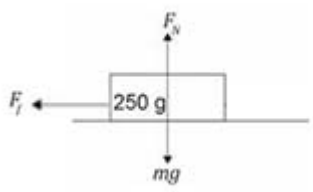
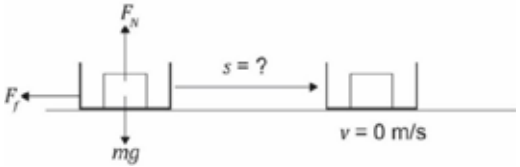
Q	Sample response	The response:
13	 When the eutectic temperature of approximately 1147º C is reached at point A, the residual liquid forms the eutectic mixture of austenite and cementite along with the previously formed austenite dendrites. As the temperature drops towards point B, carbon precipitates out of the austenite to be deposited as growing areas of eutectic cementite. When the eutectoid temperature of approximately 723ºC is reached at point B, the remaining austenite with 0.8% carbon changes to pearlite.	· explains appropriately using wording indicative of - upper eutectic residual liquid forms a mixture of austenite and cementite **[1 mark]** - carbon precipitates out of the austenite to form eutectic cementite **[1 mark]** - pearlite forms at the eutectoid **[1 mark]** · provides an appropriately annotated sketch indicating - an approximately correct location for 3% carbon **[1 mark]** - the eutectic and eutectoid temperatures (A and B locations) **[1 mark]**

Q	Sample response	The response:
14	 The stress–strain graph generated as a result of the tensile test displays the material's ability to withstand continued strain after yield, which is indicative of the material's ductility. This occurs within the area of the graph that shows plastic deformation of the material up to fracture.	· explains appropriately using wording that indicates - withstanding strain after yield point or UTS **[1 mark]** - plastic deformation **[1 mark]** - fracture **[1 mark]** · provides an appropriately annotated stress–strain diagram that accurately shows - the plastic region **[1 mark]** - the upper yield point **[1 mark]** - the point of fracture **[1 mark]**
15		· provides an appropriately annotated logic gate showing - inputs and outputs to produce a logic circuit 1 output **[1 mark]** - correct sensor labels for logic circuit inputs **[1 mark]** · includes use of the - AND gate for P and S sensors **[1 mark]** NOT gate for M sensor prior to AND gate **[1 mark]** - AND gate for C and M sensors **[1 mark]** - AND gate linked to an AND gate and an AND gate to acknowledge the two conditions of machine operation **[1 mark]**

Q	Sample response	The response:
16	The work done by the machine is determined by calculating the force required to lift the load multiplied by the distance raised. The bucket of water exerts a 98 N force on the machine during the 10-metre lift. The 980 J of work is done during the lift (98 N x 10 m = 980 J). The mechanical advantage of 1.27(assuming that efficiency is zero where MA = VR = $\frac{dE}{dL}$) reduces the effort being applied at the handle; however, the work done is still the same. Therefore the power, which is the rate of doing work, is calculated by dividing the work done by the time taken i.e. $\frac{980}{30}$ = 32.7W.	· explains appropriately showing logical organisation of relevant information about key steps that includes mathematical reasoning - using the correct formula for work **[1 mark]** - using the correct formula for power **[1 mark]** - using the correct value for MA **[1 mark]** · includes the correct determination of - work done **[1 mark]** - power used **[1 mark]**

Q	Sample response	The response:
17	Stoves in developing countries, such as India, use biomass such as timber as a fuel. Burning timber has been detrimental to the environment by contributing to poor air quality. Engineers have used their knowledge of 'high-tech' alloys and ceramics to develop low-cost appropriate stove solutions. They have improved the burning efficiency of the stoves by up to 50% by using metal alloys in their construction, reducing size, and using heat-efficient ceramics and effective designs, which reduce smoke output by up to 95%. Reducing the mass of timber that is burned has long-term and short-term community benefits, including improving air quality, which has associated benefits for people's respiratory health, and reducing the effects of burning timber on global warming.	· describes a relevant community problem related to a relevant sustainability issue **[1 mark]** · explains how engineers have - used relevant knowledge **[1 mark]** - to develop a solution **[1 mark]** · explains how the solution - reduced environmental impact **[1 mark]** - provided a relevant community benefit **[1 mark]** - provided another relevant community benefit **[1 mark]**

Q	Sample response	The response:
18	 $\text{solid} = \frac{52-20}{52-0} \times \frac{100}{1}$ $= \frac{32}{52} \times \frac{100}{1} = 61.54$ $= 62\%$ $\text{liquid} = \frac{20-0}{52-0} \times \frac{100}{1}$ $= \frac{20}{52} \times \frac{100}{1} = 38.46$ $= 38\%$	· provides evidence that the diagram is used to - determine the appropriate area representing 20% A and 80% B metal alloy **[1 mark]** - plot percentage A and B metal at 900 °C **[1 mark]** · includes correct use of the inverse lever rule **[1 mark]** · provides correct working to give correct percentage proportion of solid with correct unit provided **[1 mark]** · provides correct working to give correct percentage proportion of liquid with correct unit provided **[1 mark]**

Q	Sample response	The response:
19a)	Diagram  $u_s = 0.4$ $F_N = mg = 0.25 \times 9.8 = 2.45$ N $F_f = u_s \times F_N = 0.4 \times 2.45 = 0.98$ N ≈ 1 N	· provides an appropriate free-body diagram **[1 mark]** · provides correct working to give normal force acting on the box **[1 mark]** · provides correct working to give correct answer to the nearest whole unit with correct unit provided **[1 mark]**
19b)	 Assume initial velocity of combined carton and package is 3 m/s (5 m/s – 2 m/s) Total mass = 2 kg + 0.25 kg = 2.25 kg $u_k = 0.30$ $F_N = 2.25 \times 9.8 = 22.05$ N $F_f = u_k \times F_N = 0.30 \times 22.05 = 6.62$ N Deceleration $\approx a = \frac{F}{m} = \frac{6.62}{2.25} = 2.94$ m/s^2 $s = \frac{v^2 - u^2}{2a}$ $= \frac{0 - 3^2}{2 \times -2.94} = 1.53$ m $= 1530$ mm	· provides an appropriate free-body diagram **[1 mark]** · provides correct working to give correct normal force acting on the box and carton **[1 mark]** · provides correct working to give correct force of kinetic friction **[1 mark]** · provides correct working to give correct deceleration **[1 mark]** · provides correct working to give correct answer to the nearest whole unit with correct unit provided **[1 mark]**

Q	Sample response	The response:
20a)	At impact energy = 19.6 kJ Energy lost = 5.4 kJ Remaining energy = $19.6 - 5.4 = 14.2$ kJ KE after the impact = 14 200 J $\text{KE} = \frac{1}{2}mv^2$ $14\,200 = \frac{1}{2}(500 + 200)v^2$ $14\,200 = \frac{1}{2} \times 700 \times v^2$ $v = \sqrt{\frac{14\,200 \times 2}{700}}$ $v = 6.37$ m/s ∴ the velocity of the driver and pile just after impact is 6.37 m/s.	· provides correct working to determine remaining kinetic energy **[1 mark]** · provides correct formula and substituted values **[1 mark]** · provides correct working to give correct answer to two decimal places with correct unit provided **[1 mark]**
20b)	$v^2 = u^2 + 2as$ Final velocity = 0 m/s $s = \frac{v^2 - u^2}{2a} = \frac{0^2 - 6.37^2}{2 \times -30} = 0.676$ m ∴ The distance the pile is driven into the soil is 676 mm.	· provides correct formula and substituted values **[1 mark]** · provides correct working to give correct answer to the nearest whole unit with correct unit provided **[1 mark]**

Q	Sample response	The response:
21a)	$v = u + at$ $= 0 + 0.75\ \text{m/s}^2 \times 4$ $= 3\ \text{m/s}$	· provides correct formula and substituted values **[1 mark]** · provides correct working to give correct answer to the nearest whole unit **[1 mark]** · provides correct unit for velocity (m/s) **[1 mark]**
21b)	$s = ut + \frac{1}{2} \times at^2$ $25 = 0 \times 10 + \frac{1}{2} \times a \times 10^2$ $a = \frac{25 \times 2}{10^2}$ $a = 0.5\ \text{m/s}^2$	· provides correct formula and substituted values **[1 mark]** · provides correct working to give correct answer to one decimal place with correct unit provided **[1 mark]**
22a)	$W = Fd$ $= (20 \times 2) \times 9.8 \times 2$ $= 784\ \text{J}$ $P = \frac{W}{t}$ $= \frac{784}{30}$ $= 26.13\ W$	· provides correct working to give correct work **[1 mark]** · provides correct working to give correct answer to two decimal places with correct unit provided **[1 mark]**
22b)	Drum circumference $= 2\pi r$ $= 2\pi \times 0.25\ \text{m} = 1.57\ \text{m}$ $\therefore$ number of drum revolutions to lift 2 m $= \frac{2}{1.57} = 1.27$ Motor revolutions required to lift 2 m $=$ (GR $\times$ number of drum revolutions required to lift 2 m) $= \frac{100}{15} \times 1.27 = 8.466$ $\therefore$ the number of motor revolutions to lift 2 m $= 8.5$	· provides correct working to give correct drum circumference **[1 mark]** · provides correct working to give correct solution for drum revolutions per lift **[1 mark]** · provides correct formula and substituted values **[1 mark]** · provides correct working to give correct answer to one decimal place **[1 mark]**

Q	Sample response	The response:
23	$u = 0 \quad s = 10\text{ m} \quad v = ? \quad t = ? \quad a = 2\text{ m/s}^2$ $v^2 = u^2 + 2as$ $v = \sqrt{u^2 + 2as}$ $v = \sqrt{0^2 + 2 \times 2 \times 10} = 6.32\text{ m/s}$ $t = \dfrac{v - u}{a}$ $t = \dfrac{6.32 - 0}{2} = 3.16\text{ s}$ $20\%\text{ time reduction required} = 3.16 - (0.2 \times 3.16)$ $= 2.53\text{ s}$ $s = ut + \dfrac{1}{2}at^2$ $10 = 0 \times 2.53 + \dfrac{1}{2}a \times 2.53^2$ $10 = \dfrac{a \times 6.4}{2}$ $a = \dfrac{10 \times 2}{6.4} = 3.13\text{ m/s}^2$ $F = ma$ $= 2 \times 3.13 = 6.26\text{ N}$ $F_f = u_s \times F_N$ $u_s = \dfrac{F_f}{F_N}$ $= \dfrac{6.26}{2 \times 9.8} = \dfrac{6.26}{19.6} = 0.32$ ∴ the coefficient of static friction required between the component and conveyor at a 20% time reduction is 0.32.	· provides correct formula and substituted values for velocity **[1 mark]** · provides correct working to give correct velocity **[1 mark]** · provides correct formula and substituted values for time **[1 mark]** · provides correct working to give correct time **[1 mark]** · provides correct working to give correct 20% time reduction **[1 mark]** · provides correct formula and substituted values for acceleration **[1 mark]** · provides correct working to give correct acceleration **[1 mark]** · provides correct working to give correct force of friction **[1 mark]** · provides correct formula and substituted values for coefficient of static friction **[1 mark]** · provides correct working to give correct answer to two decimal places **[1 mark]**