Engineering marking guide and response

Sample external assessment 2020

Short 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

Introduction

The Queensland Curriculum and Assessment Authority (QCAA) has developed mock external assessments for each General senior syllabus subject to support the introduction of external assessment in Queensland.

An external assessment marking guide (EAMG) has been created specifically for each mock external assessment.

The mock external assessments and their marking guides were:

- developed in close consultation with subject matter experts drawn from schools, subject associations and universities
- aligned to the external assessment conditions and specifications in General senior syllabuses
- developed under secure conditions.

Purpose

This document consists of an EAMG and an annotated response.

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.

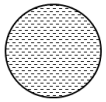
Where no response to a question has been made, a mark of 'N' will be recorded.

External assessment marking guide

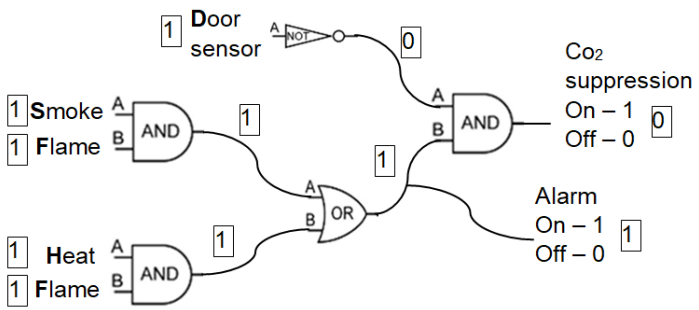
Multiple choice

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

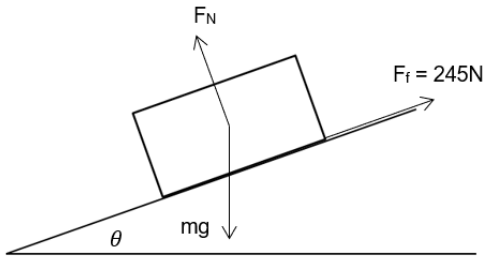
Question	Sample response	The response
11	Crank — the pedals are offset on the crank which produces a crank-lever mechanical advantage reducing the force required when pedaling because of the distance from the pedals to the rotating shaft.	• identifies one bicycle feature that provides a mechanical advantage **[1 mark]** • accurately describes the mechanical advantage provided **[1 mark]**
12	A wheel barrow is an example of a second-class lever, therefore the force required to raise the load is less than the weight force of the load. The mechanical advantage provided by the wheelbarrow is 3 and therefore the effort required to lift the load is 1/3 of the weight force of the firewood (980 N) = 327 N.	• includes – correct MA of 3 **[1 mark]** – correct effort of 327 N **[1 mark]** – correct mathematical reasoning **[1 mark]**
13	ABS has a reasonably high tensile yield strength, which allows the material to absorb stress while retaining its elastic ability to return to its original shape and structure. The ratio of stress to strain within the elastic limit indicates that ABS has good rigidity and strength. The combination of these properties gives ABS high toughness. For these reasons, ABS would be used in the manufacture of personal protective equipment, computer keyboards and power tool housings where higher impact strength or toughness is required.	• includes – the yield strength or elasticity of the material **[1 mark]** – the ratio of stress to strain within the material's elastic limit **[1 mark]** • identifies 1 material property **[1 mark]** • provides a material property for 3 industrial uses **[2 marks]** OR • provides a material property for 2 industrial uses **[1 mark]**

Question	Sample response	The response
14	Engineers have used their knowledge and expertise to develop a system to collect animal and human waste to generate biogas for cooking and lighting in communities without a sustainable energy supply. The solid waste output from the system is used to fertilise food crops. The system is easily maintained and consists of a polymer tank which is lightweight, strong and easily transported. There are few moving parts; the mechanism requires little maintenance and forces within the system are minimal as the biogases are not contained under high pressure. A reduced need for firewood has improved the local environment as erosion has reduced and community health has improved as drinking water is now cleaner and waste products are collected to generate energy.	• includes 2 community impacts/benefits **[2 marks]** OR • includes 1 community impact/benefit **[1 mark]** • explains 2 relevant properties of a material **[2 marks]** OR • explains 1 relevant property of a material **[1 mark]** • identifies 1 relevant force **[1 mark]** • identifies 1 relevant mechanism **[1 mark]**
15	**A** — a liquid solution of tin and lead  Liquid **B** — liquid plus alpha  Liquid + alpha **C** — eutectic plus cored alpha  Eutectic + cored alpha	• provides correct mixture for A, as shown in sample response **[1 mark]** • provides an appropriate sketch of the mixture for A **[1 mark]** • provides correct mixture for B, as shown in sample response **[1 mark]** • provides an appropriate sketch of the mixture for B **[1 mark]** • provides correct mixture for C, as shown in sample response **[1 mark]** • provides an appropriate sketch of the mixture for C **[1 mark]**

Question	Sample response	The response
16	Mild-, medium- and high-carbon steel vary in the amount of carbon that makes up part of their chemical composition. The differing amounts of carbon in their content changes the mechanical properties of the steel and allows for heat treatment, which makes the steel useful for particular mechanical applications. For example, mild-carbon steel includes 0.15% to 0.30% carbon as well as other alloying elements that increases the material's strength while allowing for an amount of ductility and workability in the forming of structural plates and sections, stampings and forgings. Medium-carbon steel includes 0.30% to 0.60% carbon, which makes it more wear resistant than mild-carbon steel but less brittle and hard than high-carbon steel (0.60% to 1.25% carbon). It is used for axles, gears and shafts that require wear resistance, but have an ability to withstand repeated impact loading after heat treatment. High-carbon steel is used in applications where surface hardness is required, such as cutting tools, punches and dies.	• provides the chemical composition and material properties of – mild-carbon steel **[1 mark]** – medium-carbon steel **[1 mark]** – high-carbon steel **[1 mark]** • provides 2 uses for mild-, medium- and high-carbon steel **[2 marks]** OR • provides 1 use for mild-, medium- and high-carbon steel **[1 mark]**

Question	Sample response	The response
17		• includes – an AND gate linking the door sensor NOT gate to the smoke, heat and flame condition **[2 marks]** OR – a NOT gate used for door sensor, but the condition is not met **[1 mark]** • includes – an OR gate used to link 2 AND gates for flame heat and smoke sensors to sound the alarm **[2 marks]** OR – an OR gate used but the condition is not met **[1 mark]** • includes a flame sensor input used for both AND gates **[1 mark]** • includes appropriate annotations **[1 mark]**

Question	Sample response	The response
18	a) $F = ma$ $= 500 \times 9.8 = 4900\ \text{N}$ $\text{Work} = F \times d$ $= 4900 \times 50 = 245000\ \text{J} = 245\ \text{kJ}$ b) $\text{Power} = \frac{\text{work}}{\text{time}}$ $= \frac{245000}{59} = 4153\ \text{W} \approx 4.15\ \text{kW}$	• provides correct formula and substituted values **[1 mark]** • provides a consequentially correct work, allowing for FT error **[1 mark]** • provides correct formula and substituted values **[1 mark]** • provides a consequentially correct power, allowing for FT error **[1 mark]**

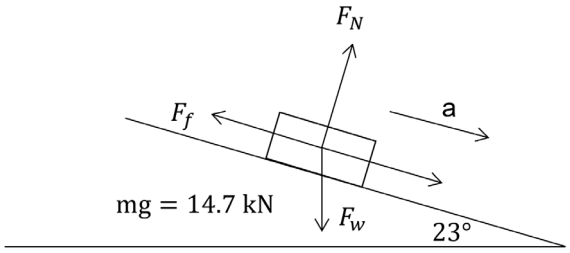
Question	Sample response	The response
19		• provides an appropriate free body diagram **[2 marks]** OR • provides a free body diagram with only normal and weight forces appropriately labelled **[1 mark]**
	ΣF acting parallel to the incline $= 0$ $m = 50\ kg$ $g = 9.8\ m/s^2$ $\therefore mg\sin\theta = 245N$ $50 \times 9.8 \times \sin\theta = 245N$ $\sin\theta = \frac{245}{490} = 0.5$ $\theta = \sin^{-1} 0.5 = 30°$	• provides correct formula and substituted values **[1 mark]** • provides correct working to give correct θ **[1 mark]**
	ΣF acting perpendicular to the incline $= 0$ $\therefore mg\cos\theta = F_N$ $F_N = 50 \times 9.8 \times \cos 30$ $= 490 \times \cos 30 = 424.35N$ $\therefore$ The normal force between the block and the inclined plane $= 424N$	• provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct normal force, allowing for FT error **[1 mark]**

Question	Sample response	The response
20	$\text{Total mass} = 500 + 150 = 650 \text{ kg}$ $\text{height (h)} = 5 \text{ m}$ $\text{time (t)} = 20 \text{ s}$ $\text{efficiency } [\eta] = 0.75$ $\text{change in PE of load} = mgh$ $= 650 \times 9.8 \times 5$ $= 31850 \text{ J}$ $\text{output of winch} = \frac{\text{change in PE [work done]}}{\text{time}}$ $= \frac{31850}{20}$ $= 1592.50 \text{ watts}$ $= 1.592 \text{ kW}$ $\eta = \frac{\text{output}}{\text{input}}$ $\text{input} = \frac{\text{output}}{\eta}$ $= \frac{1.592}{0.75}$ $\text{input power} = 2.12 \text{ kW}$	• provides correct formula and substituted values **[1 mark]** • provides correct working to give correct change in PE **[1 mark]** • provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct output power of winch, allowing for FT error **[1 mark]** • provides correct working to give a consequentially correct input power, allowing for FT error **[1 mark]**

Question	Sample response	The response
21	$\text{efficiency} = \eta$ $\text{VR} = 4$ $\text{MA} = \eta \times \text{VR}$ $= 0.85 \times 4 = 3.4$ $\text{Load} = 1 \text{ tonne} = 1000 \text{ kg} = 9800 \text{ N}$ $\text{MA} = \frac{\text{load}}{\text{effort}}$ $\text{effort} = \frac{\text{load}}{\text{MA}}$ $= \frac{9800}{3.4} = 2882\text{N} \approx 2.88 \text{ kN}$	• identifies correct VR **[1 mark]** • provides correct working to give correct efficiency **[1 mark]** • provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct effort, allowing for FT error **[1 mark]**

Question	Sample response	The response
22	$\text{VR} = \dfrac{\text{distance moved by effort}}{\text{distance moved by load}}$ To move the load up 6.5 mm the lever handle must be moved one complete turn, which is equal to the circumference or $2\pi r$. $= \dfrac{2\pi r}{6.5\text{ mm}}$ $= \dfrac{2 \times \pi \times 350}{6.5}$ $\text{VR} = 338.33$	• provides correct formula and substituted values **[1 mark]** • provides correct working to give correct VR **[1 mark]**
	Efficiency $= 45\% = 0.45$ and $\text{VR} = 338.34$ $\text{Efficiency } \eta = \dfrac{\text{MA}}{\text{VR}}$ $\text{MA} = \eta \times \text{VR}$ $= 0.45 \times 338.33$ $= 152.25$ $\text{MA} = \dfrac{\text{load}}{\text{effort}}$ $\text{Load} = 2.5 \text{ tonnes} = 2500 \text{ kg} = 24500 \text{ N}$ $\text{effort} = \dfrac{\text{load}}{\text{MA}}$ $= \dfrac{24500}{152.25}$ $= 160.92 \text{ N}$ $\therefore$ the minimum effort required to lift the car is 160.92 N	• provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct effort, allowing for FT error **[1 mark]**

Question	Sample response	The response
22 cont.	work done to lift the car 100 mm = effort [force] × distance moved by effort $F = 160.92N$ $D = 2\pi r \times$ number of turns of the lever handle $= 2\pi r \times \frac{100\text{ mm}}{6.5\text{ mm}}$ $= 2\pi r \times 15.4$ turns $= (2 \times \pi \times 350\text{ mm}) \times 15.4 = 33867.50\text{ mm}$ $= 33.87\text{ m}$ $W = 160.92 \times 33.87 = 5450.36\text{ Nm} = 5450.36\text{ J}$	• provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct work done, allowing for FT error **[1 mark]**
	$P = \frac{W}{t}$ $P = \frac{5450.36}{30} = 181.68\text{ watts}$ ∴ the power required to lift the car 100mm is $\approx 182\text{ W}$	• provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct input power, allowing for FT error **[1 mark]**

Question	Sample response	The response
23	a) $mg = 1500\ kg \times 9.8 = 14700\ N = 14.7\ kN$ For force of static (limiting) friction $F_f = \mu_s F_N$ $\mu_s = \frac{F_f}{F_N} = \frac{mg\sin\theta}{mg\cos\theta}$ $\mu_s = \tan\theta$ $0.5 = \tan\theta = 26.6 \approx 27°$	• provides correct working to give correct angle at which the load will slide **[1 mark]**
	Similarly for force of kinetic (sliding) friction $F_f = \mu_k F_N$ $\mu_k = \tan\theta$ $0.4 = \tan\theta = 21.8 \approx 22°$ ∴ The load will just begin to slide at an angle of 27º and it will stop sliding at an angle of 22º.	• provides correct working to give correct angle at which the load will stop sliding **[1 mark]**
	b) It is assumed that the load will still be on the tip tray after it has slid a further 3 m after locking at 23º.	• provides 1 relevant assumption **[1 mark]**
		• provides an appropriate force diagram **[2 marks]** OR • provides a force diagram with normal and weight forces appropriately labelled **[1 mark]**

Question	Sample response	The response
23 cont.	$F_f = \mu F_N = 0.4 \times 14.7\cos 23$ Resultant force acting down the tip tray $= 14.7\sin 23 - F_f$ $= 14.7\sin 23 - 0.4 \times 14.7\cos 23$ $= 5.74 - 5.41 = 0.33$ kN	• provides correct working to give correct resultant force acting down the tip tray **[1 mark]**
	$F = ma$ $0.33kn = 1.5 \times a$ $a = \frac{0.33}{1.5}$ $= 0.22$ m/s^2	• provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct load acceleration, allowing for FT error **[1 mark]**
	$V^2 = u^2 + 2as$ initial velocity $= 1.2$ m/s $V^2 = 1.44 + 2 \times 0.22 \times 3$ $V^2 = 2.76$ $V = \sqrt{2.76} \approx 1.66$ m/s ∴ The velocity of the load after it has slid a further 3 m down the tray is 1.7 m/s	• provides correct formula and substituted values **[1 mark]** • provides correct working to give a consequentially correct load velocity, allowing for FT error **[1 mark]**

Question	Sample response	The response
24	Fraction of solid $solid = \frac{70-55}{88-55} \times 100$ $= \frac{15}{33} \times 100$ $= 45.45\%$ As solid + liquid = 100% ∴ Liquid =100-45.45= 54.55% Solid = 45% Liquid = 55%	• provides a correct reading from the liquidus line **[1 mark]** • provides a correct reading from the solidus line **[1 mark]** • correctly applies the inverse lever formula **[1 mark]** • provides correct working to give correct percentage solid **[1 mark]** • provides correct working to give correct percentage liquid **[1 mark]**