Physics marking guide and response

External assessment 2022

Combination response (98 marks)

Assessment objectives

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

1. describe and explain gravity and motion, electromagnetism, special relativity, quantum theory and the Standard Model
2. apply understanding of gravity and motion, electromagnetism, special relativity, quantum theory and the Standard Model
3. analyse evidence about gravity and motion, electromagnetism, special relativity, quantum theory and the Standard Model to identify trends, patterns, relationships, limitations or uncertainty
4. interpret evidence about gravity and motion, electromagnetism, special relativity, quantum theory and the Standard Model to draw conclusions based on analysis.

Note: Objectives 5, 6 and 7 are not assessed in this instrument.

Queensland Government | Queensland Curriculum & Assessment Authority

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.

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.

Allow FT mark/s — 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.

Marking guide

Paper 1: Multiple choice

Question	Response
1	B
2	C
3	A
4	B
5	B
6	A
7	C
8	C
9	B
10	A
11	D
12	A
13	C
14	C
15	D
16	D
17	A
18	B
19	D
20	D

Paper 1: Short response

Q	Sample response	The response:
21	The iron bar represents a model of black-body radiation, where the spectrum of radiation emitted is due to the conversion of the object's thermal energy. This is outlined by Wien's Law, where $\lambda_{max} = \frac{b}{T}$. As the temperature increases, the peak wavelength will be shorter and this is observed by the colour change from red to orange.	• describes the scenario in terms of black-body radiation **[1 mark]** • uses Wien's Law to explain the colour change in the iron bar **[1 mark]**

Q	Sample response	The response:
22	The relativistic speed of the mesons indicates they experience time dilation relative to the observed time over the distance travelled. This means the mesons appear to travel for a longer period of time and hence cover a larger distance.	• identifies that an object at relativistic speed experiences time dilation **[1 mark]** • explains the relationship between time travelled and observed distance **[1 mark]**

Q	Sample response	The response:
23a)	$\Delta E = E_f - E_i$ $= -13.60 - (-1.51)$ $= -12.09 eV$ $= -1.93 \times 10^{-18} J \text{ or } 1.93 \times 10^{-18} J \text{ released}$ Energy released = 1.93×10^{-18} J (to three significant figures)	• recognises the scenario relates to the change in electron energy as it moves between energy levels **[1 mark]** • determines the energy released **[1 mark]** • converts energy from electronvolts to joules **[1 mark]**
23b)	Emission spectrum lines relate to the wavelength of light produced by the release of energy as an electron moves from a higher energy level to a lower energy level within an atom. Since light in the visible spectrum corresponds to wavelengths between 400–700 nm, only energy emitted with wavelengths within this range will be observed. This corresponds to electrons moving between levels where n = 2, 3 or 4.	• explains the relationship between emission lines and orbital energies **[1 mark]** • identifies that only transitions occurring between orbitals where the energy difference corresponds to wavelengths between 400–700 nm would emit visible light **[1 mark]** • identifies specific aspects of the energy level diagram to support the explanation **[1 mark]**

Q	Sample response	The response:
24	If loop is rotated 60°, angle of the loop perpendicular to the magnetic field is $90° - 60° = 30°$ $\phi = BA\cos\theta$ $= 5\times10^{-3}\times0.06\times\cos30°$ $= 2.6\times10^{-4}Wb$ Change in flux = 2.6×10^{-4} Wb (to two significant figures)	• identifies the angle of the loop perpendicular to the magnetic field **[1 mark]** • recognises the scenario relates to the amount of magnetic flux passing through an area **[1 mark]** • calculates the change in flux **[1 mark]**
25	Oscillating charged particles induce a magnetic field. This subsequently induces an electric field perpendicular to the magnetic field.	• describes the production of an induced magnetic field **[1 mark]** • describes formation of an induced electric field, perpendicular to the magnetic field **[1 mark]**

Q	Sample response	The response:
26	Baryons Leptons	• identifies baryons and leptons **[1 mark]**
27	Point where lines intersect indicates distance from centre of A where net gravitational field strength is equal to zero. $r_A = 35;\ r_B = x - 35$ $g_A - g_B = 0$ $g_A = g_B$ $\frac{\cancel{G}M_A}{r_A^2} = \frac{\cancel{G}M_B}{r_B^2}$ $\frac{5\cancel{M}_B}{35^2} = \frac{\cancel{M}_B}{(x-35)^2}$ $\frac{35^2}{5} = (x-35)^2$ $\sqrt{\frac{35^2}{5}} = x - 35$ $x = \frac{35}{\sqrt{5}} + 35$ $= 50.7$ Total distance = 51×10^7 m (to two significant figures)	• recognises the scenario relates to gravitational field strength **[1 mark]** • identifies distance from A where net gravitational field strength is zero **[1 mark]** • constructs an equation that can be solved for the distance between the objects **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the distance between the centre of the two objects **[1 mark]**

Q	Sample response	The response:
28a)	$\text{distance} = 2\pi r \times \text{number of revolutions}$ $= 2\pi \times 0.25 \times \frac{3.9}{0.3}$ $= 20.4\ m$ Distance travelled = 20 m (to two significant figures)	• recognises the scenario relates to the circumference of circular motion **[1 mark]** • calculates total distance travelled **[1 mark]**
28b)	$v = \frac{2\pi r}{T}$ $= \frac{2\pi \times 0.25}{0.3}$ $= 5.236...\ \text{m s}^{-1}$ $F_{net} = \frac{mv^2}{r}$ $= \frac{0.2 \times 5.236^2}{0.25}$ $= 21.93\ N$ Centripetal force = 22 N (to two significant figures)	• recognises the scenario relates to velocity in circular motion **[1 mark]** centripetal motion **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • demonstrates correct substitution **[1 mark]** • calculates centripetal force of object **[1 mark]**

Paper 2: Short response

Q	Sample response	The response:
1	For astronaut A to observe simultaneity, light from the first spaceport will need to travel further than light from the second spaceport. However, two events can only happen spontaneously in one inertial frame of reference, and therefore Astronaut B loses simultaneity in this instance.	• explains simultaneity from the perspective of astronaut A **[1 mark]** • explains the loss of simultaneity for astronaut B **[1 mark]**

Q	Sample response	The response:
2	Up quarks are fundamental particles that experience the strong nuclear force and may be combined with other quarks to form mesons and baryons. Tau particles are also fundamental particles belonging to the lepton group of subatomic particles. These particles experience the weak nuclear force, and unlike quarks they do not combine with other leptons to form other subatomic particles.	• identifies a difference between the nature of particles **[1 mark]** interaction forces **[1 mark]**

Q	Sample response	The response:
3a)	Since $E = \frac{F}{q}$, gradient of graph is equivalent to $\frac{1}{q}$ $gradient = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{2.8 \times 10^{19} - 1.0 \times 10^{19}}{46 - 18}$ $= 6.43 \times 10^{17}$ $q = \frac{1}{6.43 \times 10^{17}}$ $= 1.6 \times 10^{-18}$ Charge of electron = 1.6×10^{-18} C (to two significant figures)	• recognises the scenario relates to electric field strength and electron charge **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the gradient **[1 mark]** • determines the average charge on the oil drops **[1 mark]**
3b)	From the graph: $F_g = 33\ N$ $\Delta U = W = Fs$ $= 33 \times 0.005$ $= 1.7 \times 10^{-1}$ Work done = 0.17 J (to two significant figures)	• determines the weight of the oil drop **[1 mark]** • recognises the scenario relates to the work done in an electric field **[1 mark]** • demonstrates correct substitution **[1 mark]** • determines the work done **[1 mark]**

Q	Sample response	The response:
4	$$F_A = F_B$$ $$m_A g \sin\theta = m_B g$$ $$m_A \times 9.8 \times \sin 35° = 15 \times 9.8$$ $$5.62 m_A = 147$$ $$m_A = 26$$ Mass of object = 26 kg (to two significant figures)	• identifies equivalent forces acting parallel to the plane **[1 mark]** • recognises the scenario relates to tensile force acting on the object on an inclined plane **[1 mark]** the component of force on the object acting down the plane **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the mass of the object **[1 mark]**

Q	Sample response	The response:
5	The Feynman diagram represents the interaction between an electron and a positron through Bhaba scattering. During this interaction, a photon is exchanged between the electron and positron, before both particles change velocity as they move away from each other.	• identifies that the interaction involves an electron and a positron **[1 mark]** • identifies that a photon is exchanged **[1 mark]** • describes that both particles change velocity due to the interaction **[1 mark]**

Q	Sample response	The response:
6a)	The electron would have curved to the right.	• identifies the direction of curvature **[1 mark]**
6b)	The *x*-intercept corresponds to the threshold frequency for the metal. Therefore, based on the line of best fit, the corresponding wavelength is $\frac{1}{1.65\times10^{6}\ m} = 606\ \text{nm}$. $f_0 = \frac{c}{\lambda}$ $= \frac{3.00\times10^{8}}{606\times10^{-9}}$ $= 4.95\times10^{14}\ Hz$ $W = hf_0$ $= 6.626\times10^{-34}\times4.95\times10^{14}$ $= 3.3\times10^{-19}\ J$ Work function = 3.3×10^{-19} J (to two significant figures)	• determines the threshold frequency **[1 mark]** • recognises the scenario relates to work function **[1 mark]** • provides appropriate reasoning **[1 mark]** • determines the work function **[1 mark]**

Q	Sample response	The response:
6c)	Inverse of wavelength = $\frac{1}{450\times10^{-9}} = 2.2\times10^{6}\ \text{m}^{-1}$ Maximum kinetic energy of photoelectron: $E_k = 0.7\times1.6\times10^{-19} = 1.12\times10^{-19}\ J$ Maximum velocity of photoelectron: $E_k = \frac{1}{2}mv^2$ $1.12\times10^{-19} = \frac{1}{2}\times9.109\times10^{-31}v^2$ $v = \sqrt{\frac{1.12\times10^{-19}}{4.55\times10^{-31}}}$ $= 5.0\times10^{5}\ \text{m s}^{-1}$ Force acting on photoelectron in the magnetic field: $F = qvB\sin\theta$ $= 1.6\times10^{-19}\times5.0\times10^{5}\times5.0\times10^{-6}\times\sin 90$ $= 4.0\times10^{-19}\ N$ Radius of photoelectron's path: $F = \frac{mv^2}{r}$ $4.0\times10^{-19} = \frac{9.109\times10^{-31}\times\left(5.0\times10^{5}\right)^2}{r}$ $r = 0.57\ m$ Radius of photoelectron's path = 0.57 m (to two significant figures)	• determines the corresponding inverse of wavelength **[1 mark]** • determines the maximum kinetic energy of the photoelectron **[1 mark]** • recognises the scenario relates to velocity of photoelectrons **[1 mark]** • determines the maximum velocity of the photoelectron **[1 mark]** • recognises the scenario relates to force on photoelectrons **[1 mark]** • determines the force on the photoelectron **[1 mark]** • recognises the scenario relates to the radius of the circular path **[1 mark]** • provides appropriate mathematical reasoning to determine radius **[1 mark]** • determines the maximum radius of the photoelectron's path **[1 mark]**

Q	Sample response	The response:
7	$F = \frac{GMm}{r^2}$ $3.3 \times 10^3 = \frac{6.67 \times 10^{-11} \times 2.7 \times 10^{17} \times 6.1 \times 10^{15}}{r^2}$ $r = \sqrt{\frac{6.67 \times 10^{-11} \times 2.7 \times 10^{17} \times 6.1 \times 10^{15}}{3.3 \times 10^3}}$ $= 5.8 \times 10^9$ m Distance between asteroids = 5.8×10^9 m (to two significant figures)	• recognises the scenario relates to Newton's Law of Universal Gravitation **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the distance between the asteroids **[1 mark]**

Q	Sample response	The response:
8	Given $F = \frac{GMm}{r^2}$, $gradient = GMm$ $gradient = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{24 - 8}{44 \times 10^{-13} - 16 \times 10^{-13}}$ $= 5.71 \times 10^{12}$ $gradient = GMm$ $5.71 \times 10^{12} = 6.67 \times 10^{-11} \times 750M$ $M = \frac{5.71 \times 10^{12}}{6.67 \times 10^{-11} \times 750}$ $= 1.1 \times 10^{20}\ kg$ Mass of asteroid = 1.1×10^{20} kg (to two significant figures)	• recognises the scenario relates to Newton's Law of Universal Gravitation **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the gradient **[1 mark]** • determines the mass of the asteroid **[1 mark]**

Q	Sample response	The response:
9a)	$v = \frac{2\pi r}{T}$ $= \frac{2\pi \times 0.8}{5 \div 12}$ $= 12.1\, m\, s^{-1}$ $a_c = \frac{v^2}{r}$ $= \frac{12.1^2}{0.8}$ $= 180\ \text{m s}^{-2}$ Centripetal acceleration = 180 m s^{-2} (to two significant figures)	• recognises the scenario relates to velocity in circular motion **[1 mark]** centripetal acceleration **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the centripetal acceleration of the object **[1 mark]**
9b)	$s_y = u_y t + \frac{1}{2}at^2$ $4.3 = 0 + \frac{1}{2} \times 9.8t^2$ $t = \sqrt{\frac{4.3}{4.9}}$ $= 0.94\ s$ $s_x = u_x t + \frac{1}{2}at^2$ $= 12.1 \times 0.94 + \frac{1}{2} \times 0 \times 0.94^2$ $= 11.4\ m$ Horizontal displacement = 11 m (to two significant figures)	• recognises the scenario relates to vertical component of projectile motion **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the time of flight **[1 mark]** • recognises the scenario relates to the horizontal component of projectile motion **[1 mark]** • calculates the total horizontal displacement **[1 mark]**