Physics marking guide and response

External assessment 2025

Combination response (101 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.

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.

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.

For any calculation question, do not penalise for incorrect decimal places/significant figures/units/rounding except where specified.

Marking guide

Multiple choice

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

Paper 1: Short response

Q	Sample response	The response:
21	Since the box is stationary, $F_{net} = 0$, thus: $F_{\text{in rope}} = F_{\parallel}$	• recognises that the force parallel to the inclined plane is equal to the magnitude of the tension **[1 mark]**
	$= mg\sin\theta$ $= 4.0 \times 9.8 \times \sin 30$ $= 19.6$	• recognises that $F_{\parallel} = mg\sin\theta$ **[1 mark]**
	Magnitude of tension = 20 N	• determines the magnitude of the tension **[1 mark]**

Q	Sample response	The response:
22	$\Delta V = 8.0 - 2.0 = 6.0\ \text{V}$	• calculates potential difference **[1 mark]**
	$V = \frac{\Delta U}{q}$ $\Delta U = qV$ $= -1.6 \times 10^{-19} \times 6.0$ $= -9.6 \times 10^{-19}\ \text{J}$	• recognises that the scenario relates to work done on a charge **[1 mark]**
	Work done = $-9.6 \times 10^{-19}\ \text{J}$	• calculates work done **[1 mark]**

Q	Sample response	The response:
23a)	Kepler's second law states that a radius vector joining any planet to the Sun sweeps out equal areas in equal lengths of time.	• describes Kepler's second law of planetary motion **[1 mark]**
23b)	Convert time from year to seconds: 1 year = 365 × 24 × 60 × 60 = 31 536 000 s	• converts time **[1 mark]**
	$\frac{T_S^2}{r_S^3} = \frac{T_E^2}{r_E^3}$	• recognises that the scenario relates to Kepler's third law **[1 mark]**
	$\frac{T_S^2}{(1.43\times10^{12})^3} = \frac{(31536000)^2}{(1.49\times10^{11})^3}$ $T_S = \sqrt{\frac{(9.9452\times10^{14})\times(2.9242\times10^{36})}{3.3079\times10^{33}}}$ $T_S = 9.3749\times10^8 \text{ s}$	• provides appropriate mathematical reasoning **[1 mark]**
	Time taken = 9.37 × 10^8 s	• calculates time taken for Saturn to orbit the Sun **[1 mark]**

Q	Sample response	The response:
24a)	Electrons need to absorb a certain amount of energy to be ejected. If light acted as a wave only, as intensity of the light increased, electrons would eventually collect enough energy and photoelectrons would be detected. When light is thought of as a particle, increasing the intensity of light increases the number of particles. Since E=hf, the light needs to have a minimum frequency for the photons to have enough energy to give to the electrons.	• recognises – electrons need energy to be ejected **[1 mark]** – the lack of evidence of wave nature of light **[1 mark]** – the relationship between the photon's energy and its frequency **[1 mark]** • explains how the particle nature of light provides evidence for the – relationship between the intensity of the light and the number of particles **[1 mark]** – nature of the threshold frequency **[1 mark]**
24b)	$E_k = hf - W$	• recognises that the scenario relates to the kinetic energy of the photoelectric effect **[1 mark]**
	$W = hf - E_k$ $= 6.626\times10^{-34}\times8.50\times10^{14} - 4.25\times10^{-19}$ $= 1.38\times10^{-19}$ J	• provides appropriate mathematical reasoning **[1 mark]**
	$W = \frac{1.38\times 10^{-19}}{1.60\times 10^{-19}}$ $= 0.863$ Therefore work function = 0.863 eV	• converts work function units **[1 mark]** • calculates work function of the metal **[1 mark]**

Q	Sample response	The response:
25a)	As the angle of release increases, the horizontal displacement increases, up until 30°. After this, as the angle increases, the range decreases.	• identifies the trend **[1 mark]** • uses data from the graph **[1 mark]**
25b)	$u_x = 3.0\cos 80.0$ $\approx 0.52\ \text{ms}^{-1}$	• calculates horizontal velocity **[1 mark]**
	$s_x = 0.50\ \text{m (from graph)}$	• identifies horizontal range from graph **[1 mark]**
	$s_x = u_x t$	• recognises that the scenario relates to horizontal displacement **[1 mark]**
	$t = \frac{s_x}{u_x}$ $= \frac{0.5}{0.52}$ ≈ 0.960	• provides appropriate mathematical reasoning **[1 mark]**
	Time taken = 0.96 s	• determines time taken **[1 mark]**

Q	Sample response	The response:
25c)	Maximum height is when initial velocity = vertical velocity i.e. when launch angle = 90°	• indicates launch angle = 90° **[1 mark]**
	$v_y{}^2 = u_y{}^2 + 2gs_y$	• recognises that the scenario relates to an object undergoing projectile motion **[1 mark]**
	$0 = 3.0^2 + 2 \times -9.8 \times s_y$ $s_y \approx 0.46\ \text{m}$	• calculates vertical displacement **[1 mark]**
	Since initial height = 1.0 m (from question) $s_{total} = 0.46 + 1.0$ $= 1.46\ \text{m}$ Maximum height = 1.46 m	• determines the maximum height **[1 mark]**

Paper 2: Short response

Q	Sample response	The response:
1	1. a negatively charged antiproton in the nucleus 2. one positively charged positron	• identifies one component **[1 mark]** • identifies a second component **[1 mark]**

Q	Sample response	The response:
2a)	The rock can travel with a constant speed but, since it is moving in a circle, it is changing direction. Since there is a change in velocity, the rock is accelerating.	• recognises that circular motion means direction changes **[1 mark]** • explains relationship between change in velocity and acceleration **[1 mark]**
2b)	$F = \frac{mv^2}{r}$	• recognises that the scenario relates to centripetal force on an object **[1 mark]**
	$r = \frac{mv^2}{F}$ $= \frac{0.15 \times 6.2^2}{4.0}$ $= 1.4415$	• provides appropriate mathematical reasoning **[1 mark]**
	Length of string = 1.4 m	• calculates length of the string **[1 mark]**

Q	Sample response	The response:
3a)	The second postulate of special relativity states that the speed of light in a vacuum has the same value in all inertial frames of reference. Thus the speed of the signal will be $3 \times 10^8 \text{ m s}^{-1}$.	• recognises that the speed of light is the same in all inertial frames of reference **[1 mark]** • concludes speed of signal is equal to $3 \times 10^8 \text{ m s}^{-1}$ **[1 mark]**
3b)	$L = L_0\sqrt{1-\frac{v^2}{c^2}}$	• recognises that the scenario relates to length contraction **[1 mark]**
	$= 35\sqrt{1-\frac{(0.8c)^2}{c^2}}$ $= 35\sqrt{1-0.8^2}$ $= 21$	• provides appropriate mathematical reasoning **[1 mark]**
	Length of spaceship = 21 m	• calculates the relative length **[1 mark]**

Q	Sample response	The response:
4a)	$\Delta E = E_f - E_i$ $= 1.8 - 9.4$ $= -7.6\ \text{eV}$ Magnitude of energy change = 7.6 eV	• calculates energy change **[1 mark]**
4b)	If a different electron (e_{ii}) emits two photons, then one photon is emitted and the electron moves from n = 4 to n = 3 and the other photon is emitted as the electron moves from n = 3 to n = 2. The three photons produced from e_i and e_{ii} will have different wavelengths due to the different energies released between each level.	• explains that – photons are released when electrons move *down* energy levels **[1 mark]** – three photons are released due to the three transitions the electron can make **[1 mark]** – photons are different due to the different energies at each level **[1 mark]**
4c)	n = 4 to n = 3 photon will have the lowest energy of 3.4 eV	• determines that the n = 4 to n = 3 photon will have lowest energy **[1 mark]**
	$E = hf = \frac{hc}{\lambda}$	• recognises that the scenario relates to the photoelectric effect **[1 mark]**
	$\lambda = \frac{hc}{E}$ $= \frac{(6.626 \times 10^{-34}) \times (3 \times 10^{8})}{3.4 \times (1.6 \times 10^{-19})}$ $= 3.65 \times 10^{-7}$	• converts energy to J **[1 mark]**
	Maximum wavelength = 3.65×10^{-7} m	• determines maximum wavelength **[1 mark]**

Q	Sample response	The response:
5	$F = \frac{kQq}{r^2}$	• recognises that the scenario relates to the force between two charges **[1 mark]**
	$F_{\text{A on B}} = \frac{kQq}{r^2}$ $= \frac{(9\times10^9)\times(-4.2\times10^{-6})(8.4\times10^{-6})}{0.060^2}$ $= -88.2$ $= 88.2\text{ N attraction}$	• calculates magnitude of force between A and B **[1 mark]**
	$F_{\text{C on B}} = \frac{kQq}{r^2}$ $= \frac{(9\times10^9)\times(2.1\times10^{-6})(8.4\times10^{-6})}{0.140^2}$ $= 8.1$ $= 8.1\text{ N repulsion}$	• calculates magnitude of force between B and C **[1 mark]**
	$F_{\text{resultant}} = \sqrt{88.2^2 + 8.1^2}$ $= 88.57$ Magnitude of net force = 89 N	• determines magnitude of net force **[1 mark]**
	$\tan\theta = \frac{8.1}{88.2}$ $\theta = \text{N } 5.2^\circ \text{ W}$ Direction of net force = N 5.2° W	• determines direction of net force **[1 mark]**
6a)	The magnetic field produced would be in an anticlockwise direction, in concentric circles around the wire.	• describes the magnetic field's – anticlockwise direction **[1 mark]** – circular shape around the wire **[1 mark]**

Q	Sample response	The response:
6b)	As the distance from the wire increases, the magnetic field strength decreases.	• identifies trend between distance and magnetic field strength **[1 mark]**
6c)	Magnitude: The magnetic field strength at wire 1 produced by wire 2 is given by: $B_2 = \frac{\mu_0 I_2}{2\pi r}$ $= \frac{(4\pi \times 10^{-7}) \times 25}{2\pi \times 0.015}$ $= 3.33 \times 10^{-4}\ \text{T}$	• recognises that the scenario relates to the strength of a magnetic field around a wire **[1 mark]** • calculates strength of magnetic field **[1 mark]**
	The B force required ($F_{1,2}$) is the same as the force due to gravity due to wire 1. $F_W = m_1 g$ $= (8.0 \times 10^{-6} - 3.0 \times 10^{-6}) \times 9.8$ $= 4.9 \times 10^{-5}\ \text{N}$	• calculates apparent weight of wire **[1 mark]**
	Current in wire 1 and B_2 are perpendicular sin 90 = 1	• identifies perpendicular angle between B and I **[1 mark]**
	$F_{1,2} = B_2 I_1 L$ $I_1 = \frac{F_{1,2}}{LB_2}$ $= \frac{4.9 \times 10^{-5}}{0.90 \times (3.33 \times 10^{-4})}$ $= 0.163$	• recognises that the scenario relates to force acting on a wire in a magnetic field **[1 mark]** • provides appropriate mathematical working **[1 mark]**
	Magnitude of current = 0.16 A	• determines magnitude of current in wire 1 **[1 mark]**

Q	Sample response	The response:
	Direction Using RH grip rule, the current must run in same direction to attract wires together. Direction of current = left	• determines the direction of current in wire 1 **[1 mark]**

Q	Sample response	The response:
7a)	$F=\frac{GMm}{r^2}$	• recognises that the scenario relates to Newton's Law of Universal Gravitation **[1 mark]**
	$=\frac{(6.67\times10^{-11})\times(5.97\times10^{24})\times1500}{(6.37\times10^{6}+6.0\times10^{5})^2}$ $=\frac{5.973\times10^{17}}{(6.97\times10^{6})^2}$ $=\frac{5.973\times10^{17}}{4.858\times10^{13}}$ $\approx 12295 \text{ N}$ Gravitational force = 12 000 N	• calculates total radius **[1 mark]** • calculates gravitational force of attraction **[1 mark]**
7b)	$g=\frac{F}{m}$	• recognises that the scenario relates to gravitational field strength equation **[1 mark]**
	$=\frac{12295}{1500}$ ≈ 8.197 Gravitational field strength = 8.2 N kg^{-1}.	• calculates gravitational field strength **[1 mark]**

Q	Sample response	The response:
8a)	1. up quark 2. down quark	• identifies up quark and down quark **[1 mark]**
8b)	W boson	• identifies W boson **[1 mark]**
8c)	Symmetry in particle interactions means that the particles follow conservation laws, in particular baryon and lepton numbers. This means that predictions about the particles that are produced can be made.	• describes conservation of baryon and lepton numbers **[1 mark]** • describes that the produced particles can be predicted **[1 mark]**

Q	Sample response	The response:
9	The *ladder in the barn* paradox describes a scenario where a ladder that is too long to fit in a barn at rest approaches that barn at relativistic speeds. From the ladder's frame of reference, the barn's length will contract, meaning it will not fit within the barn with both doors shut. From the barn's frame of reference, the ladder's length will contract, so it will easily fit in the barn. The paradox is resolved using simultaneity. Since part of the ladder is moving towards and then away from the barn, in the ladder's frame of reference, the doors do not open and close simultaneously. The barn's frame of reference is the same as the doors' frame of reference, so the ladder will fit.	• describes the general scenario **[1 mark]** • identifies from ladder's frame of reference that length of barn will contract, so ladder will not fit in barn **[1 mark]** • identifies from barn's frame of reference that length of ladder will contract, so ladder will easily fit in barn **[1 mark]** • recognises that the paradox is resolved using simultaneity **[1 mark]** • explains that what is viewed as simultaneous in one frame of reference is not necessarily viewed as simultaneous in another frame of reference **[1 mark]**