Physics marking guide and response

External assessment 2024

Combination response (97 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.

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.

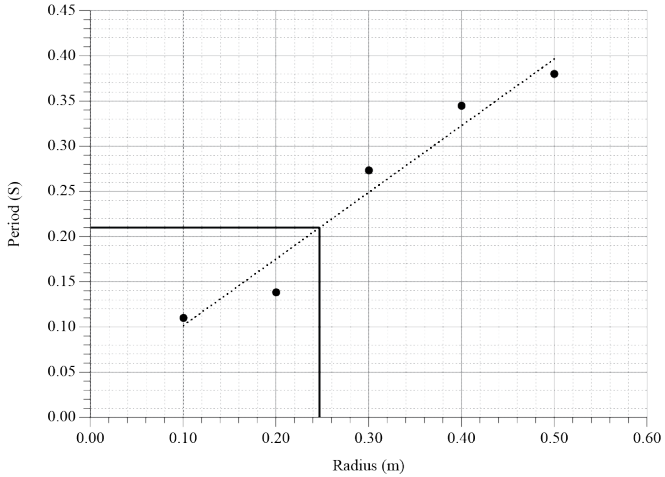
Marking guide

Multiple choice

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

Paper 1: Short response

Q	Sample response	The response:
21	The Feynman diagram represents the interaction between an electron and a positron. During this interaction the two particles are annihilated into a photon. The photon will then 'pair produce' another electron and positron.	• identifies that the interaction involves an electron and a positron **[1 mark]** • identifies that a photon is created through annihilation **[1 mark]** • describes 'pair produced' creation of another electron and positron **[1 mark]**
22	Since muons are short-lived particles, they shouldn't reach the Earth's surface according to Newtonian physics. But muons travel at close to the speed of light. As muons enter the atmosphere, an observer external to the particles' frame of reference will witness them existing longer than expected due to time dilation. Muons experience length contraction, so they can travel further than predicted by Newtonian physics.	• identifies that muons have a very short half-life **[1 mark]** • explains that muons are unlikely to reach Earth's surface using Newtonian physics **[1 mark]** • identifies that muons travel at relativistic speeds **[1 mark]** • explains that from the observer's frame of reference, the muon's half-life will be longer due to time dilation **[1 mark]** • explains that from the muon's frame of reference, it experiences length contraction **[1 mark]**

Q	Sample response	The response:
23a)	 Period = 0.21 s	• identifies the period **[1 mark]**
23b)	$\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{0.40 - 0.10}{0.50 - 0.10}$ $= \frac{0.30}{0.40}$ $= 0.75 \text{ s m}^{-1}$ (to two significant figures) Since $v = \frac{2\pi r}{T}$, then $T = \frac{2\pi r}{v}$, therefore $\text{gradient} = \frac{2\pi}{v}$ $0.75 = \frac{2\pi}{v}$ $v = 8.38$ Speed = 8.38 m s^{-1}	• calculates gradient **[1 mark]** • recognises the relationship between gradient and average speed (i.e. $m = \frac{2\pi}{v}$) **[1 mark]** • determines the constant speed of the object **[1 mark]**

Q	Sample response	The response:
24a)	Energy change for the n = 4 to n = 2 transition $13.6 - 3.4 = 10.2 \text{ eV}$ $E = hf = \frac{hc}{\lambda}$ $10.2 \times 1.6 \times 10^{-19} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$ $\lambda = 1.22 \times 10^{-7}$ Wavelength = 1.22×10^{-7} m	• calculates the change in energy between n = 2 and n = 4 energy levels to be 10.2 eV **[1 mark]** • converts between eV and J **[1 mark]** • shows mathematical reasoning that $E = \frac{hc}{\lambda}$ **[1 mark]** • calculates the wavelength **[1 mark]**
24b)	The photon will be absorbed. Since the photon energy of 40.8 eV corresponds to the difference in energies between the first and second energy levels, an electron in the first energy level will absorb the photon and jump to the second energy level in its excited state.	• identifies photon is absorbed by electron **[1 mark]** • explains photon energy as equivalent to the gap between n = 1 and n = 2 **[1 mark]** • explains photon will be absorbed because electron in n = 1 will jump to n = 2 **[1 mark]**
25a)	According to Faraday's Law, when the magnetic flux linking a circuit changes, an emf is induced in the circuit proportional to the rate of change of the flux linkage. Therefore, in the transformer, the changing voltage in the primary coil will affect the rate of change of the magnetic flux in the second coil. Although the circuits aren't connected, a current will be induced in the secondary circuit.	• describes Faraday's Law **[1 mark]** • explains changing voltage in the primary coil affects rate of change of magnetic flux in secondary coil **[1 mark]** • explains an AC voltage is induced in the secondary coil by electromagnetic induction **[1 mark]**

Q	Sample response	The response:
25b)	A current will be induced in the second coil generating an AC voltage of: $\frac{V_p}{V_s} = \frac{n_p}{n_s}$ $\frac{240}{V_s} = \frac{48}{1}$ $V_s = 5\ \text{V}$	• determines secondary voltage to be 5 V **[1 mark]**
26	$F = \frac{1}{4\pi\epsilon_0}\frac{Qq}{r^2}$ $0.025 = \frac{9\times10^9 \times Q^2}{0.30^2}$ $Q = \sqrt{\frac{0.025\times0.30^2}{9\times10^9}}$ $= 5.0\times10^{-7}$ Charge = $5.0\times10^{-7}\,\text{C}$	• recognises the scenario relates to Coulomb's Law **[1 mark]** • recognises the charges have the same value in the equation **[1 mark]** • calculates the charge of the metallic spheres to be $5.0\times10^{-7}\,\text{C}$ **[1 mark]**

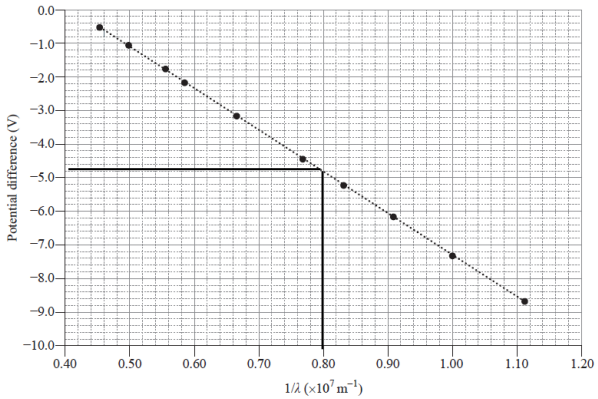
Q	Sample response	The response:
27	$s = ut + \frac{1}{2}at^2$ $s = 3.5t - 5.18t^2$ $u_x = \frac{3.5}{\tan 30}$ $= 6.06 \text{ m s}^{-1} \text{ right}$ Since $a_x = 0 \text{ ms}^{-2}$, u_x = constant $s_x = u_x t$ $= 6.06 \times 0.71$ $= 4.3026$ $= 4.3 \text{ m}$ Range = 4.3 m	• recognises trigonometric relationship between initial velocity and horizontal component **[1 mark]** • calculates the horizontal component of the initial velocity to be 6.06 m s^{-1} **[1 mark]** • recognises that horizontal acceleration is zero **[1 mark]** • determines the range (horizontal displacement) to be 4.3 m **[1 mark]**

Paper 2: Short response

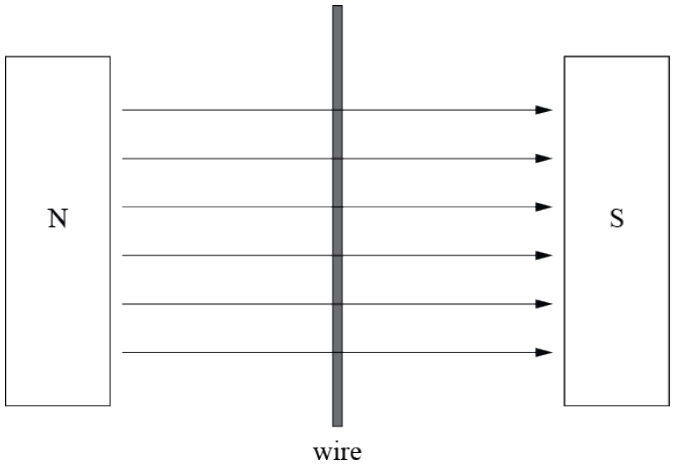
Q	Sample response	The response:
1	r = 1.4 cm = 0.014 m $A = \pi r^2 = \pi \times 0.014^2 \approx 6.16 \times 10^{-4}\,\text{m}^2$ $\text{emf} = -\dfrac{n\Delta\left(BA_{\perp}\right)}{\Delta t}$ $= -\dfrac{100 \times \left(0.030 - 0.510\right) \times \left(6.16 \times 10^{-4}\right)}{0.020}$ $= 1.48$ Magnitude of emf = 1.5 V	• converts the radius to SI units (from cm to m) **[1 mark]** • determines the area of the coil **[1 mark]** • recognises the scenario relates to induction of an electromotive force by using the equation **[1 mark]** • calculates emf **[1 mark]**
2a)	$g = \dfrac{GM}{r^2}$ $= \dfrac{6.67 \times 10^{-11} \times 1.9 \times 10^{30}}{(2.4 \times 10^{11} + 3.6 \times 10^{11})^2}$ $= \dfrac{1.27 \times 10^{20}}{(6.0 \times 10^{11})^2}$ $= 3.5 \times 10^{-4}$ Gravitational field strength = $3.5 \times 10^{-4}\ \text{m s}^{-2}$	• shows mathematical reasoning that relates to strength of a gravitational field $g = \dfrac{GM}{r^2}$ **[1 mark]** • recognises the distance is from centre of star to centre of the spaceship **[1 mark]** • calculates the gravitational field strength **[1 mark]**
2b)	$L = L_0\sqrt{1 - \dfrac{v^2}{c^2}}$ $= 6.0 \times 10^{11} \times \sqrt{1 - \dfrac{\left(1.9 \times 10^8\right)^2}{\left(3.0 \times 10^8\right)^2}}$ Distance = $4.6 \times 10^{11}\,\text{m}$	• recognises the scenario relates to length contraction **[1 mark]** • identifies proper length **[1 mark]** • calculates the distance from the spaceship's frame of reference **[1 mark]**

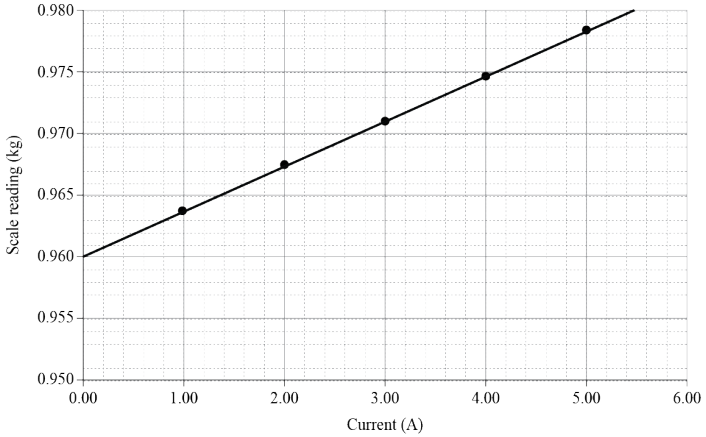
Q	Sample response	The response:
3a)	$F_{net} = F_g - F_f$ $ma = mg\sin\theta - F_f$ $a = g\sin\theta - \frac{F_f}{m}$ At sin 45°, on graph a = 5.85 ms^{-2} $5.85 = 9.8 \times 0.707 - \frac{F_f}{0.050}$ $F_f = \left[(9.8 \times 0.707) - 5.85\right] \times 0.050$ $= 0.0539$ Magnitude of frictional force = 0.054 N	• recognises the scenario relates to forces on an inclined plane **[1 mark]** • determines the component of weight down the inclined plane **[1 mark]** • identifies from graph the acceleration at sin 45° **[1 mark]** • shows appropriate mathematical reasoning **[1 mark]** • determines the frictional force **[1 mark]**
3b)	$v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 5.85 \times 2.4$ $v = 5.30$ Final velocity = 5.3 m s^{-1}	• selects appropriate equation/s of motion **[1 mark]** • performs correct substitution **[1 mark]** • calculates final velocity of the object **[1 mark]**

Q	Sample response	The response:
4	The satellite has inertia and, in the absence of the planet, would continue in a straight line with the same speed until acted upon by an unbalanced force. When the planet's gravitational force pulls the satellite towards it (perpendicular to the satellite's motion), the satellite changes direction and thus accelerates towards the planet, but its speed does not change. As a result, the satellite continues to move 'forward', but the planet's gravitational force pulls the satellite towards it. So the resultant motion is that the satellite has a constant speed (not velocity as direction is changing) travelling in a circle around the planet.	• describes inertia of satellite **[1 mark]** • identifies that planet provides a centripetal force **[1 mark]** • identifies that the centripetal force is perpendicular to the satellites motion **[1 mark]** • explains that changing direction means change in velocity which is acceleration **[1 mark]**
5	Threshold frequency is the minimum frequency of a photon required to eject a photoelectron from the surface of a metal. In this case, photons with frequencies equal to or greater than the threshold frequency will eject photoelectrons from the surface of the metal, while photons with a lower frequency will scatter off the metal's surface.	• describes threshold frequency as the minimum frequency of an incident photon required to eject a photoelectron **[1 mark]** • explains that photons with frequencies greater than the threshold frequency will have enough energy to eject a photoelectron **[1 mark]** • explains that photons with frequencies less than the threshold frequency will be scattered **[1 mark]**

Q	Sample response	The response:
6a)	$\frac{1}{\lambda} = \frac{1}{125\times10^{-9}} = 0.8\times10^{7}$ Refer to graph:  Potential difference = –4.8 V	• determines inverse wavelength to be $0.8\times10^{7}\ \mathrm{m}^{-1}$ **[1 mark]** • determines the potential difference from graph **[1 mark]**

Q	Sample response	The response:
6b)	$E_k = hf - W$ For the stopping voltage, $Vq = E_k$ For (0.8 × 10^7, –4.8): $hf = \frac{hc}{\lambda}$ $= (6.626\times10^{-34})\times(3\times10^{8})\times(0.8\times10^{7})$ $= 1.59024\times10^{-18}$ J convert to eV $hf = (1.59024\times10^{-18})\times(1.6\times10^{-19})$ $= 9.939$ eV $E_k = hf - W$ $4.8 = 9.939 - W$ $W \approx 5.1$ eV	• recognises the relationship between – maximum kinetic energy of photoelectrons and work function **[1 mark]** – maximum kinetic energy of photoelectrons and stopping voltage **[1 mark]** – frequency and wavelength of light **[1 mark]** • identifies appropriate data from the graph **[1 mark]** • shows appropriate mathematical reasoning **[1 mark]** • determines the work function in eV **[1 mark]**
6c)	Since the frequency is above the threshold frequency, increasing the intensity of light will produce more photons which, in turn, will increase the likelihood of more photoelectrons being 'knocked off' from the metal surface. More photoelectrons in the circuit will increase the current.	• explains that increasing light intensity will increase the number of photons **[1 mark]** • explains there will be an increase in the number of photoelectrons ejected from the emitter **[1 mark]** • explains there will be an increase in current in the circuit **[1 mark]**
7a)	Baryons are composed of three quarks. Whereas mesons are composed of one quark and one antiquark.	• identifies baryons are composed of 3 quarks **[1 mark]** • identifies mesons are composed of 1 quark and 1 antiquark **[1 mark]**

Q	Sample response	The response:
7b)	Quarks experience all four fundamental forces (strong nuclear force, weak nuclear force, electromagnetic force and gravitational force). Whereas leptons experience only the weak nuclear force, gravitational force and electromagnetic force (if they have a charge).	• recognises quarks experience all forces whereas leptons do not experience the strong nuclear force **[1 mark]** • identifies that only charged leptons would experience electromagnetic force **[1 mark]**
8a)		• sketches arrow/s from north to south **[1 mark]**

Q	Sample response	The response:
8b)	Mass of the magnet is equal to the y-intercept of the graph.  Mass = 0.96 kg	• identifies the mass of the magnet **[1 mark]**
8c)	$F = BIL\sin\theta$ $\sin 90 = 1$ $F_{Magnetic} = F_{Scale\,Reading} - F_{WeightOfMag}$ $F_{Scale\,Reading} - F_{WeightOfMagnet} = BIL$ Referring to (3.00,0.971) $0.971\times 9.8 - 0.960\times 9.8 = B\times 3.00\times 0.08$ $B = \frac{9.52-9.41}{0.240}$ $= 0.449\ \text{T}$	• recognises the scenario relates to magnetic field strength **[1 mark]** • recognises sin 90° = 1 **[1 mark]** • identifies appropriate data from the graph **[1 mark]** • shows appropriate mathematical reasoning **[1 mark]** • determines the magnetic field strength **[1 mark]**