Physics marking guide and solution

External assessment 2021

Combination response (75 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

For all Queensland schools

Purpose

This document consists of a marking guide.

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.

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 be awarded so long as it still demonstrates the correct conceptual understanding or skill in the rest of the response.

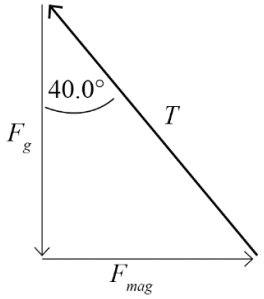
Marking guide

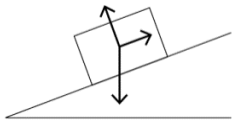
Paper 1: Multiple choice

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

Paper 1: Short response

Q	Sample response	The response:	Notes
21	Alternating current passing through the first coil creates a magnetic flux. This magnetic flux induces an EMF in the secondary coil. The induced EMF is proportional to the number of coils and the rate of change of the magnetic flux.	• recognises that alternating current creates a changing magnetic flux **[1 mark]** • recognises that EMF is induced in the second coil by the changing magnetic flux in the first coil **[1 mark]** • identifies that the induced EMF is proportional to the number of coils and the rate of change of magnetic flux **[1 mark]**	For *magnetic flux*, accept *magnetic field* or *electromagnetic field*.
22	Assume the planet is undergoing uniform circular motion. $F = \frac{mv^2}{r}$ This is equal to the force of gravity. $F = \frac{GMm}{r^2}$ Equating these two equations and rearranging for velocity gives: $v = \sqrt{\frac{GM}{r}}$ $v = \sqrt{\frac{6.67 \times 10^{-11} \times 3.38 \times 10^{31}}{4.23 \times 10^{11}}}$ v = 73 km s^{-1} or 73 005 m s^{-1} Average speed = 73 005 m s^{-1} (to the nearest whole number)	• recognises the scenario relates to uniform circular motion and universal gravitation **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the average speed **[1 mark]**	Allow FT error from incorrect substitution. Do not penalise for incorrect decimal places/significant figures.

Q	Sample response	The response:	Notes
23	There are three forces acting on the wire and they are balanced, forming a vector triangle.  From the vector triangle: $\tan\theta = \frac{F_{mag}}{F_g}$ Therefore $F_{mag} = F_g \tan\theta$ Therefore $F_{mag} = mg \tan 40^o$ Sub in magnetic force formula on the left-hand side: $BIL \sin\theta = mg \tan 40^o$ The magnetic field is at right angles to the current: $BIL \sin 90^o = mg \tan 40^o$ Since sin 90° = 1, rearranging $I = \frac{mg \tan 40^o}{BL}$ $I = \frac{(0.0100)(9.8) \tan 40^o}{(0.50)(0.080)}$ $I = 2.055\,794 \ldots$ Current = 2.1 A (to 1 decimal place)	• identifies the forces acting on the wire in the magnetic field **[1 mark]** • recognises that the force of gravity and the force of the magnetic field can be added to determine tension **[1 mark]** • identifies an equation for the relationship between F_g and F_{mag} **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the magnitude of the current **[1 mark]**	Allow FT marks due to error/s in prior working. Do not penalise for incorrect decimal places/significant figures.

Q	Sample response	The response:	Notes
24	 $F_{g,x} = mgsin\,\theta = 1.5 \times 9.8 \times \sin 30 = 7.4$ N $F_{net} = F_{g,x} - F_f = 7.4 - 4.5 = 2.9$ N Magnitude of net force = 2.9 N (to 1 decimal place)	• identifies the forces acting on the object **[1 mark]** • calculates the component of the gravitational force acting down the slope **[1 mark]** • calculates the magnitude of the net force **[1 mark]**	Allow FT error for the magnitude of the net force. Do not penalise for incorrect decimal places/significant figures.
25	$F = \frac{mv^2}{r}$ gradient = $\frac{v^2}{r}$ gradient = $\frac{6.0 - 0.0}{0.2 - 0.0} = 30$ $v = \sqrt{0.2 \times \text{gradient}}$ $v = \sqrt{0.2 \times 30}$ $v = 2.4$ m s^{-1} Speed = 2.4 m s^{-1} (to 1 decimal place)	• recognises how the scenario relates to $F = \frac{mv^2}{r}$ **[1 mark]** • identifies line of best fit **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the speed **[1 mark]**	*Appropriate mathematical reasoning* may include: – determining the gradient – substituting the gradient into a formula for v – or other suitable response consistent with a reasonable understanding. Allow FT error from the line of best fit (LOBF). LOBF may be identified by: – line drawn on graph – appropriate values derived from graph used in calculations. Accept reasonable variations in the LOBF. Do not penalise for incorrect decimal places/significant figures.

Q	Sample response	The response:	Notes
26	Each wavelength of light corresponds to a quantum of energy, which can be worked out using the following equation: $E = hf = \frac{hc}{\lambda}$ The energies that have produced the three wavelengths of light are: Line 1: 421 nm E = 4.72 x 10^{-19} J = 2.95 eV Line 2: 491 nm E = 4.05 x 10^{-19} J = 2.53 eV Line 3: 523 nm E = 3.8 x 10^{-19} J = 2.38 eV Compared to the energy level diagrams, only Atom 2 has three electron transitions that match the wavelengths given: 5 to 2, 4 to 2 and 3 to 2.	• recognises how absorption spectra relate to energy level diagrams **[1 mark]** • determines the energy of photons absorbed by the atom **[1 mark]** • converts from joules to eV **[1 mark]** • identifies energy level transitions corresponding to absorbed photons **[1 mark]** • determines the atom **[1 mark]**	Allow FT marks for error/s in prior working.

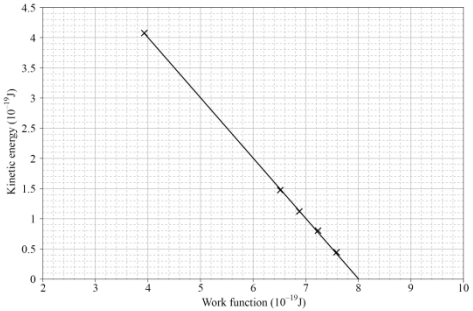
Paper 2: Short response

Q	Sample response	The response:	Notes
1	$F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ $r^2 = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{F}$ $r = \sqrt{\frac{1}{4\pi\varepsilon_0}\frac{Qq}{F}}$ $= \sqrt{9 \times 10^9 \times \frac{2.8 \times 10^{-7} \times 3.2 \times 10^{-7}}{0.52}}$ Distance = 0.039 m (to 2 significant figures)	• recognises the scenario relates to Coulomb's law **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the distance **[1 mark]**	Do not penalise for incorrect decimal places/significant figures.
2	1. Gluon 2. Photon 3. W boson 4. Z boson	• lists the four gauge bosons **[1 mark]**	Accept symbols: g, y, W, Z. If symbols and names are provided, they must match. Accept misspelling of boson names if it does not impede meaning.
3	$F = \frac{mv^2}{r}$ Let *R* be the radius of the new path $\frac{Mv^2}{r} = \frac{2Mv^2}{R}$ $\frac{1}{r} = \frac{2}{R}$ $R = 2r$ The radius will double.	• recognises the scenario relates to uniform circular motion **[1 mark]** • provides correct reasoning **[1 mark]** • indicates that the radius will double **[1 mark]**	

Q	Sample response	The response:	Notes
4	$F_{g,net} = 0$ Therefore $\lvert F_{g,A} \rvert = \lvert F_{g,B} \rvert$ $G\frac{m_s M_A}{r_A^2} = G\frac{m_s M_B}{r_B^2}$ $\frac{4M_B}{r_A^2} = \frac{M_B}{r_B^2}$ $4M_B \times r_B^2 = r_A^2 \times M_B$ $\frac{4M_B \times r_B^2}{M_B} = r_A^2$ $r_A^2 = 4r_B^2$ $r_A = 2r_B$ $120 = r_A + r_B$ $120 = 3r_B$ $r_B = 40$ Distance from Asteroid B = 40 km (to the nearest whole number).	• recognises the scenario relates to Newton's law of universal gravitation **[1 mark]** • recognises that no net force occurs when the forces are equivalent **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines distance from the asteroid **[1 mark]**	Appropriate mathematical reasoning may also be demonstrated by other suitable means, e.g. use of quadratic equations. Do not penalise for incorrect decimal places/significant figures.

Q	Sample response	The response:	Notes
5	The change in potential energy of an electric charge moving through an electric field is equivalent to the work done on the charge. $V = \frac{\Delta U}{q}$ $\Delta U = Vq$ $= 240 \times 3.2 \times 10^{-19}$ $= 7.68 \times 10^{-17}\ J = W$ The work done on an object is equal to the change in kinetic energy. $E_k = \frac{1}{2}mv^2$ $7.68 \times 10^{-17} = \frac{1}{2} \times 6.64 \times 10^{-27} \times v^2$ $v^2 = \frac{7.68 \times 10^{-17}}{\frac{1}{2} \times 6.64 \times 10^{-27}}$ $v = \sqrt{\frac{7.68 \times 10^{-17}}{\frac{1}{2} \times 6.64 \times 10^{-27}}}$ Velocity = 1.5×10^5 m s^{-1} (to 2 significant figures)	• recognises the scenario relates to work done on a moving charge in an electric field **[1 mark]** • identifies that work done on the charge equates to its kinetic energy **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • determines the velocity **[1 mark]**	Allow FT marks due to error/s in prior working. Do not penalise for incorrect decimal places/significant figures.
6a)	$B = \mu_0 nI$ $n = \frac{B}{\mu_0 I}$ $n = \frac{300 \times 10^{-6}}{4\pi \times 10^{-7} \times 2} = 119$ turns m^{-1}	• recognises the scenario relates to the magnetic field produced inside a solenoid **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the number of turns **[1 mark]**	
6b)	Left to right	• determines the field goes from left to right **[1 mark]**	Accept an arrow pointing to the right.

Q	Sample response	The response:	Notes
7a)	The mathematical proportionality is $s \propto t^2$ $\text{intercept} = 0$ $\text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$ $\text{gradient} = \frac{94 - 0}{36 - 0}$ $\text{gradient} = 2.6$ $s = 2.6t^2$	• identifies the *y*-intercept **[1 mark]** • determines the gradient of the graph **[1 mark]** • identifies a mathematical relationship **[1 mark]**	For the gradient, accept between 2.5 and 2.7 inclusive.
7b)	$s = ut + \frac{1}{2}at^2$ Therefore $2.6t^2 = \frac{1}{2}at^2$ This means that $\frac{1}{2}a = 2.6$ $a = 2 \times 2.6$ $a = 5.2\ \text{m s}^{-2}$ Acceleration = 5.2 m s^{-2} (to 2 significant figures)	• recognises the gradient can be used to find acceleration due to gravity **[1 mark]** • provides appropriate mathematical reasoning **[1 mark]** • calculates the acceleration due to gravity **[1 mark]**	Allow FT error from Question 7a). Do not penalise for incorrect decimal places/significant figures.

Q	Sample response	The response:	Notes
8	$E_k = hf - W$ $E_k = -W + hf$ The y-intercept of the line will be hf  $y = mx + c$ To determine the gradient, the data (6, 2) and (8, 0) were used $m = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{0 - 2}{8 - 6}$ $= -1$ Therefore $y = -1x + c$ Substitute (8, 0) $0 = -1 \times 8 + c$ $c = 8$ Therefore $hf = c$ $f = \frac{c}{h}$ $= \frac{8 \times 10^{-19}}{6.626 \times 10^{-34}}$ $\approx 1.2 \times 10^{15}$ Hz Wavelength = 248 nm (to the nearest whole number)	• recognises the scenario relates to $E_k = hf - W$ **[1 mark]** • uses appropriate features of the graph to determine a value for hf **[1 mark]** • provides correct reasoning **[1 mark]** • determines wavelength **[1 mark]**	Appropriate features of the graph include: – the *x*-intercept – a point on the line of best fit – or any other relevant feature. Do not penalise for incorrect decimal places/significant figures.

Q	Sample response	The response:	Notes
9	Young's double slit experiment consisted of light shining through two thin slits. This produced light and dark spots on a screen behind the slits, caused by constructive and destructive interference of the light. This interference is a behaviour seen in mechanical waves and provides evidence for the wave nature of light.	• describes the results of Young's double slit experiment **[1 mark]** • recognises that Young's experiment involves constructive and destructive interference **[1 mark]** • states that the result is similar to that of a mechanical wave **[1 mark]**	For *mechanical wave* accept other suitable responses consistent with a reasonable understanding of a transverse wave.