Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2024

Physics

Standard level

Paper 2

12 pages

Subject Details: Physics SL Paper 2 Markscheme

Candidates are required to answer **all** questions. Maximum total = **50 marks**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a tick (✓) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative wording is indicated in the "Answers" column by a slash (*/*). Either wording can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading ***ALTERNATIVE 1*** *etc*. Either alternative can be accepted.

8. Words inside chevrons **« »** in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

11. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect) in the "Notes" column.

12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

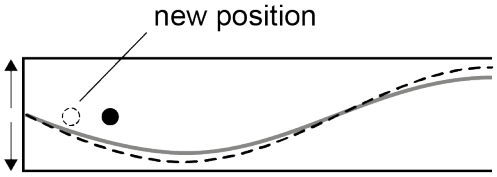
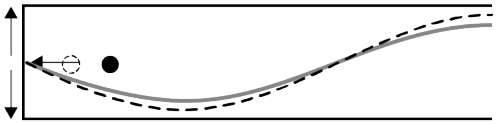
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script. "ECF acceptable" will be displayed in the "Notes" column.

14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

Question			Answers	Notes	Total
1.	(a)		$v = \ll \sqrt{2gh} = \gg \sqrt{2 \times 9.81 \times 28}$ ***OR*** 23.4 $\ll m\,s^{-1} \gg$ ✓	*Starting point can be suvat equations or conservation of energy.* *Answer must be seen to at least 3 s.f. or correct substitution shown.* *Allow 23.7 for use of g = 10*	**[1]**
	(b)	(i)	$[k] = \frac{\text{N}}{\text{m}^2\,\text{s}^{-2}} = \frac{\text{kgm s}^{-2}}{\text{m}^2\,\text{s}^{-2}}$ ✓ $[k] = \text{kgm}^{-1}$ ✓	*kg m s^{-2}* ***OR*** *m^2 s^{-2} seen for MP1*	**[2]**
	(b)	(ii)	***ALTERNATE 1*** Resistance/drag force/friction increases with speed ✓ Until it becomes equal to the weight ✓ Net force/acceleration is then zero **«**and so speed is constant**»**✓ ***ALTERNATE 2*** Resistance force increases with speed ✓ Until GPE lost no longer converted to KE ✓ But to thermal energy/work done against resistive force ✓		**[2 max]**
	(c)	(i)	28 <<m>>✓	*Accept range 25 to 31 <<m>> for those who counted squares* *Do not allow displacement or distance travelled. A value is required.*	**[1]**
		(ii)	***Alternate 1*** $mg = kv^2$ with v = 9.5 m s^{-1} ✓ $k = \text{«}\frac{mg}{v^2} = \frac{2.7 \times 10^{-3} \times 9.81}{9.5^2} = \text{»} 2.9 \times 10^{-4}$ ✓	*Allow 3.0 x 10^{-4} for use of g = 10.* *Allow ECF for MP2 from incorrect read off from graph.* *Ignore any units on k.*	**[2]**

			Alternate 2 Determination of acceleration from gradient of a tangent at any point other than t = 0✓ Use of $mg - kv^2 = ma$ to find k✓ For example: Gradient at t = 1 s is 3.9 «m s^{-2}» and speed is 7.4 «m s^{-1}» $k = «\frac{mg - ma}{v^2} = \frac{2.7 \times 10^{-3} \times (9.81 - 3.9)}{7.4^2} =» 2.9 \times 10^{-4}$	*Do not award MP1 for simply calculating the gradient and equating it to k. For MP1 there needs to be a recognition that the gradient is the acceleration.* *Range for Alternate 2* *(2.5 to 3.3) x 10^{-4}*	
	(d)		***ALTERNATE 1*** $\Delta p = «2.7 \times 10^{-3} \times (7.8 + 9.5) =» 0.0467$ «N s» ✓ $\ll 1.1 = \frac{\Delta p}{\Delta t}$ so $T = \frac{0.0467}{1.1} =\gg 0.042 \ll s \gg$ ✓ ***ALTERNATE 2*** $a =\ll \frac{F}{m} =\gg \frac{1.1}{2.7 \times 10^{-3}} = 407 \ll \text{m s}^{-2} \gg$ ✓ $T =\ll \frac{9.5 + 7.8}{407} =\gg 0.042 \ll s \gg$ ✓	*Watch for ECF from incorrect value of v in cii).* *Award [1] for t = 0.076 << s >> using an impact speed of 23 m s^{-1}.*	**[2]**

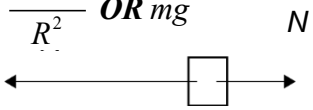
Question			Answers	Notes	Total
2.	(a)	(i)	$Q = \ll mc\Delta\theta = \gg 0.035 \times 2100 \times 10 = 735 \ll J \gg$ ✓ Average power $\ll \frac{735}{4 \times 60} \gg = 3.1 \ll W \gg$ ✓	*MP1 can be awarded for a correct substitution or value*	**[2]**
	(a)	(ii)	$Q = \text{«}3.06 \times 60 \times 60 = \text{»} 1.10 \times 10^4$ **«J»** ✓ $L = \text{«}\frac{Q}{m} = \frac{1.10 \times 10^4}{0.035} = \text{»} 3.1 \times 10^5$ **«Jkg^{-1}»** ✓	*Allow 3.1 x10^5 OR 3.2 x 10^5 <<J kg^{-1} >> Watch for ECF from ai).*	**[2]**
	(b)		The internal energy of the liquid water is greater than that of ice✓ As the <<random>> kinetic energy <<of the molecules>> is the same ***OR*** the <<intermolecular>> potential energy for water is greater✓		**[2]**

Question			Answers	Notes	Total
3.	(a)		The transfer/propagation of energy/momentum/information✓ Through oscillations/vibrations of medium/fields✓ Positions of maximum and minimum amplitude ***OR*** crests and troughs travel through a medium ✓		**[2 max]**
	(b)	(i)	The incoming wave is reflected «from the closed end»✓ <<The reflected and incoming wave>> superpose/interfere✓		**[2]**
	(b)	(ii)	$\lambda = «\frac{4L}{3} = \frac{4 \times 1.20}{3} =» 1.6 «\text{m}»$ ✓		**[1]**
	(b)	(iii)	$c =\ll \lambda f = 1.60 \times 210 =\gg 336$ ***OR*** $340 \ll \text{m s}^{-1} \gg$ ✓ Any answer to 2 ***OR*** 3 s.f. ✓	*Allow ECF from incorrect wavelength in bii)*	**[2]**
	(c)	(i)	 To the left of the equilibrium position on the same level✓	*Accept any distance to the left*	**[1]**
	(c)	(ii)	 Left horizontal arrow ✓	*Accept any arrow to the left inside the tube.*	**[1]**
	(d)		***ALTERNATE 1*** the pipe can only support standing waves with frequencies that are odd multiples of the first harmonic frequency ✓		**[2]**

			first harmonic frequency is 70 Hz ✓ ***ALTERNATE 2*** <<the new wavelength would be 2.4 m so>> a node would be formed at the open end ✓ An antinode is required at the open end to form a standing wave ✓		

Question			Answers	Notes	Total
4.	(a)		Conservation of «electric» charge✓	*Do not accept 'Kirchoff's law' as the sole answer.* *If conservation of charge and Kirchoff's Law are stated award [1].* *If conservation of charge is listed along with other fundamental laws e.g. conservation of energy, award [0].*	**[1]**
	(b)	(i)	***ALTERNATE 1*** Identification that the p.d across r is 0.300 V ***OR*** current in external R is $\frac{1.20}{5.00} = 0.240$ «A» ✓ «$V = E - Ir \Rightarrow r = \frac{E-V}{I} = \frac{0.300}{0.240} =$»1.25 «Ω» ✓ ***ALTERNATE 2*** Current is $I = \frac{E}{R+r}$ and so $V = E - \frac{Er}{R+r}$ ✓ $r = 1.25$ «Ω» ✓		**[2]**
	(b)	(ii)	V decreases✓ Current increases, so pd across r increases ✓	*Do not award marks from a calculation. These points must be stated.*	**[2]**
	(c)	(i)	Vertically down arrow from the proton✓	*If more than one arrow is included the velocity must be clearly labelled.*	**[1]**
	(c)	(ii)	$evB = \frac{m_p v^2}{R}$ ✓ $f = \frac{1}{T} = \frac{v}{2\pi R}$ ✓	*Both q and e are acceptable for the charge.*	**[3]**

			Algebra leading to required expression «$= \frac{eB}{2\pi m_p}$» ✓		

Question			Answers	Notes	Total
5.	(a)		$\frac{GMm}{R^2}$ ***OR*** mg  Arrow for *N* and correct labelling✓ $\frac{GMm}{R^2} - N = m\omega^2 R$ result follows✓	*N arrow must be shorter than weight. Award [0] if there are extra forces or incorrect length arrows in the diagram. On diagram allow Weight, W, F_g, gravitational force but not gravity. Allow rotated diagrams if the surface of the asteroid is shown. For MP2 the algebra must follow from a diagram with correct length arrows.*	**[2]**
	(b)	(i)	Selection of solar constant, 1360 seen✓ **«**Intensity is proportional to d^{-2} so**»** **«**$\frac{I}{1360} = \frac{\frac{P}{4\pi(4d)^2}}{\frac{P}{4\pi d^2}}$**»** $I = \frac{1360}{4^2} =$ **«**85.0 W m^{-2}**»** ✓	*Allow ECF for MP2 from incorrect solar constant.*	**[2]**
	(b)	(ii)	$\sigma T^4 = 85$ ***OR*** $T = \sqrt[4]{\frac{85}{5.67\times10^{-8}}}$ ✓ $T = 196.7 \approx 2.0\times10^2$ **«**K**»** ✓	*Award [2] for 140 K, if factor of ¼ is included*	**[2]**

Question			Answers	Notes	Total
6.	(a)	(i)	A particle without structure/constituents/component particles✓		**[1]**
	(a)	(ii)	Electromagnetic, weak <<nuclear>>, strong< <nuclear>> <<and gravitational>>✓	*Allow electroweak for electromagnetic and weak*	**[1]**
	(a)	(iii)	Weak✓ Decay violates strangeness **«**and only the weak interaction does**»**✓	*For MP2 allow comments that suggest that strangeness has changed in the interaction*	**[2]**
	(b)	(i)	According to $E = \Delta mc^2$ / identifies mass energy equivalence ✓ energy is released when nucleons come together / a nucleus is formed «so nucleus has less mass than individual nucleons» ***OR*** energy is required to «completely» separate the nucleons / break apart a nucleus «so individual nucleons have more mass than nucleus» ✓		**[2]**
	(b)	(ii)	$Q = 224 \times 7.679917 + 4 \times 7.073915 - 228 \times 7.645074$ ✓ $Q = 5.520$ **«**MeV**»** ✓	*Allow* $8.8 \times 10^{-13} J$ *Award [1max] if answer is negative.*	**[2]**