

# Markscheme

**May 2019**

**Physics**

**Higher level**

**Paper 2**

15 pages

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## Subject Details: Physics HL Paper 2 Markscheme

### Mark Allocation

Candidates are required to answer ALL questions. Maximum total = [90 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**” between the alternatives. Either answer can be accepted.
7. Words in angled brackets « » in the “Answers” column are not necessary to gain the mark.
8. Words that are underlined are essential for the mark.
9. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
10. 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.
11. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
12. 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. “Allow ECF” will be displayed in the “Notes” column.
13. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.
14. Allow reasonable substitutions where in common usage, eg ° for rad.

Question			Answers	Notes	Total
1.	a	i	time taken $\frac{2.0 \times 10^4}{7}$ «= 2860 s» = 2900«s» ✓	<i>Must see at least two s.f.</i>	1
1.	a	ii	use of $E = qV$ <b>OR</b> energy = $4.3 \times 10^4 \times 16$ «= $6.88 \times 10^5$ J» ✓ power = 241 «W» ✓	<i>Accept 229 W – 241 W depending on the exact value of t used from ai.</i> <i>Must see at least three s.f.</i>	2
1.	a	iii	use of power = force x speed <b>OR</b> force x distance = power x time ✓ 34 «N» ✓	<i>Accept 34 N – 36 N.</i>	2
1.	b	i	$66 \text{ g} \sin(3^\circ) = 34$ «N» ✓		1
1.	b	ii	total force $34 + 34 = 68$ «N» ✓ $3.5$ «ms <sup>-1</sup> » ✓	<i>Look for ECF from aiii and bi.</i> <i>Accept 3.4 – 3.5 «ms<sup>-1</sup>».</i> <i>Award [0] for solutions involving use of KE.</i>	2

(continued...)

(Question 1 continued)

Question			Answers	Notes	Total
1.	c		<p>«maximum» distance will decrease <b>OWTTE</b> ✓                      because opposing/resistive force has increased  <b>OR</b>                      because more energy is transferred to GPE  <b>OR</b>                      because velocity has decreased  <b>OR</b>                      increased mass means more work required «to move up the hill» ✓</p>		2
1.	d		<p>4 V dropped across battery <b>OR</b> <math>R_{\text{circuit}} = 1.85 \Omega</math> ✓                      so internal resistance <math>= \frac{4.0}{6.5} = 0.62 \text{ «}\Omega\text{»}</math> ✓</p>		2
1.	e	i	<p><math>\frac{16}{5} = 3.2 \text{ «V»}</math> ✓</p>		1
1.	e	ii	<p><b>ALTERNATIVE 1:</b>  <math>2.5r = 0.62</math> ✓  <math>r = 0.25 \text{ «}\Omega\text{»}</math> ✓  <b>ALTERNATIVE 2:</b>  <math>\frac{0.62}{5} = 0.124 \text{ «}\Omega\text{»}</math> ✓  <math>r = 2(0.124) = 0.248 \text{ «}\Omega\text{»}</math> ✓</p>	Allow ECF from (d).	2

Question			Answers	Notes	Total
2.	a	i	read off between 17 and 19 «deg» ✓ correct use of $d = \frac{\lambda}{\sin\theta} = 7.8 \times 10^{-15}$ «m» ✓ so radius = $\frac{7.8}{2}$ «fm» = 3.9 «fm» ✓	Award ecf for wrong angle in MP1.  Answer for MP3 must show at least 2 sf.	3
2.	a	ii	$R_{\text{Th}} = R_{\text{Si}} \left( \frac{A_{\text{Th}}}{A_{\text{Si}}} \right)^{\frac{1}{3}}$ or substitution ✓ 7.4 «fm» ✓		2
2.	a	iii	electron wavelength shorter than alpha particles (thus increased resolution) <b>OR</b> electron is not subject to strong nuclear force ✓		1
2.	a	iv	nuclear forces act ✓ nuclear recoil occurs ✓ significant penetration into nucleus / probing internal structure of individual nucleons ✓ incident particles are relativistic ✓		2 max

(continued...)

(Question 2 continued)

Question			Answers	Notes	Total
2.	b	i	${}_{15}^{30}\text{P} \rightarrow ({}_{14}^{30}\text{Si}) \checkmark$ $+ {}_{+1}^0\text{e} + \nu_e \checkmark$		2
2.	b	ii	<p>correct change of either u to d <math>\checkmark</math></p> <p><math>W^+</math> shown <math>\checkmark</math></p> <p>correct arrow directions for positron and electron neutrino <math>\checkmark</math></p>		3
2.	b	iii	<p>quarks cannot be directly observed as free particles/must remain bound to other quarks/quarks cannot be isolated <math>\checkmark</math></p> <p>because energy given to nucleon creates other particles rather than freeing quarks/<b>OWTTE</b> <math>\checkmark</math></p>		2

(continued...)

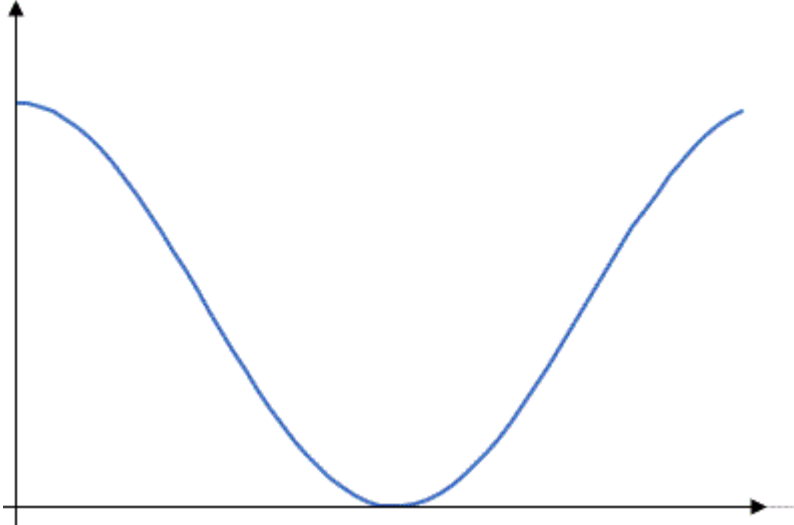
(Question 2 continued)

Question		Answers	Notes	Total
2.	c	models need testing/new information may change models/new technology may bring new information/Models can be revised/ <b>OWTTE</b> ✓		1
3.	a	two waves superpose/mention of superposition/mention of «constructive» interference ✓ they arrive in phase/there is a path length difference of an integer number of wavelengths ✓		2
3.	b	path difference = 0.062 «m» ✓ so wavelength = 0.031 «m» ✓ frequency = $9.7 \times 10^9$ «Hz» ✓	Award <b>[2 max]</b> for $4.8 \times 10^9$ Hz.	3
3.	c	intensity is modulated by a single slit diffraction envelope <b>OR</b> intensity varies with distance <b>OR</b> points are different distances from the slits ✓		1

(continued...)



(Question 3 continued)

Question		Answers	Notes	Total
3.	d	 <p>cos<sup>2</sup> variation shown ✓ with zero at 90° (by eye) ✓</p>	<p>Award <b>[1 max]</b> for an inverted curve with maximum at 90°.</p>	2

Question			Answers	Notes	Total
4.	a		weight of cylinder = $Ahg\rho$ ✓ pressure = $\frac{F}{A} = \frac{Ahg\rho}{A}$ ✓		2
4.	b	i	use of $PV = nRT$ and $V = \text{Area} \times (0.190)$ seen ✓ substitution of $P = p_0 + p_m$ «re-arrangement to give answer» ✓		2
4.	b	ii	recognition that $\frac{nRT}{A}$ is constant <b>OR</b> $190p_0 + 190p_m = 208p_0 - 208p_m$ <b>OR</b> $p_0 = \frac{398}{18} p_m$ ✓ pressure due to mercury $p_m = 0.035 \times 1.36 \times 10^4 \times 9.81 (= 4.67 \times 10^3 \text{ Pa})$ ✓ $1.03 \times 10^5$ ✓ Pa <b>OR</b> $\text{Nm}^{-2}$ <b>OR</b> $\text{kgm}^{-1}\text{s}^{-2}$ ✓	<i>Award MP4 for any correct unit of pressure (eg "mm of mercury / Hg").</i>	4
4.	b	iii	same number of particles to collide with a larger surface area <b>OR</b> greater volume with constant rms speed decreases collision frequency ✓		1

Question			Answers	Notes	Total
5.	a	i	gravitational attraction/force/field «of the planet/Mars» ✓	<i>Do not accept "gravity".</i>	1
5.	a	ii	the force/field and the velocity/displacement are at 90° to each other <b>OR</b> there is no change in GPE of the moon/Phobos ✓		1
5.	b	i	<p><b>ALTERNATE 1</b> «using fundamental equations» use of Universal gravitational force/acceleration/orbital velocity equations ✓ equating to centripetal force or acceleration. ✓ rearranges to get <math>k = \frac{G}{4\pi^2}</math> ✓</p> <p><b>ALTERNATE 2</b> «starting with <math>\frac{R^3}{T^2} = kM</math>» substitution of proper equation for T from orbital motion equations ✓ substitution of proper equation for M <b>OR</b> R from orbital motion equations ✓ rearranges to get <math>k = \frac{G}{4\pi^2}</math> ✓</p>		3

(continued...)

(Question 5 continued)

Question			Answers	Notes	Total
5.	b	ii	$m_{\text{Mars}} = \left( \frac{R_{\text{Mars}}}{R_{\text{Earth}}} \right)^3 \left( \frac{T_{\text{Earth}}}{T_{\text{Mars}}} \right)^2 m_{\text{Earth}}$ or other consistent re-arrangement ✓ $6.4 \times 10^{23}$ «kg» ✓		2
5.	c		read off separation at maximum potential 0.9 ✓ equating of gravitational field strength of earth and moon at that location OR $\frac{M_E}{0.9^2} = \frac{M_M}{0.1^2}$ ✓ $7.4 \times 10^{22}$ «kg» ✓	Allow ECF from MP1	3

Question			Answers	Notes	Total
6.	a	i	identifies T as 2.25 s ✓ L = 1.26 m ✓ 1.3 / 1.26 «m» ✓	Accept <u>any</u> number of s.f. for MP2. Accept <u>any</u> answer with 2 <u>or</u> 3 s.f. for MP3.	3
6.	a	ii	X labels any point <u>on the curve</u> where $E_k \frac{1}{4}$ of maximum/5 mJ ✓		1
6.	a	iii	$\frac{1}{2}mv^2 = 20 \times 10^{-3}$ seen <b>OR</b> $\frac{1}{2} \times 7.5 \times 10^{-2} \times v^2 = 20 \times 10^{-3}$ ✓ 0.73 «m s <sup>-1</sup> » ✓	Must see at least 2 s.f. for MP2.	2
6.	b	i	0.40 «m s <sup>-1</sup> » ✓		1
6.	b	ii	initial energy 24 mJ and final energy 12 mJ ✓ energy is lost/unequal /change in energy is 12 mJ ✓ inelastic collisions occur when energy is lost ✓		3
6.	b	iii	graph with same period but inverted ✓ amplitude one half of the original/two boxes throughout (by eye) ✓		2
6.	b	iv	mention of Doppler effect ✓ there is a change in the wavelength of the reflected wave ✓ because the wave speed is constant, there is a change in frequency ✓		3

Question			Answers	Notes	Total
7.	a	i	$T = \left( \frac{1360}{\sigma} \right)^{0.25} \checkmark$ <p>390 «K» ✓</p>	<p><i>Must see 1360 (from data booklet) used for MP1.</i></p> <p><i>Must see at least 2 s.f.</i></p>	2
7.	a	ii	<p>energy/Power/Intensity lower at B ✓</p> <p>connection made between energy/power/intensity and temperature of blackbody ✓</p>		2
7.	b		<p>(28%) of sun's energy is scattered/reflected by earth's atmosphere <b>OR</b> only 72% of incident energy gets absorbed by blackbody ✓</p>	<p><i>Must be clear that the energy is being scattered by the atmosphere.</i></p>	1

Question			Answers	Notes	Total
8.	a	i	$\text{length} = \frac{d \times C}{\text{width} \times \epsilon} \checkmark$ $= 0.33 \text{ «m»} \checkmark$ so 0.66/0.67 «m» «as two lengths required» $\checkmark$		3
8.	a	ii	$1.5 \times 10^6 \times 55 \times 10^{-6} = 83 \text{ «V»} \checkmark$ $q \text{ «= CV»} = 5.6 \times 10^{-6} \text{ «C»} \checkmark$		2
8.	b	i	$0.5 = e^{-\frac{t}{RC}} = e^{-\frac{t}{1200 \times 6.8 \times 10^{-8}}} \checkmark$ $t = \text{«-»} 1200 \times 6.8 \times 10^{-8} \times \ln 0.5 \checkmark$ $5.7 \times 10^{-5} \text{ «s»} \checkmark$ <p><b>OR</b></p> use of $t_{\frac{1}{2}} = RC \times \ln 2 \checkmark$ $1200 \times 6.8 \times 10^{-8} \times 0.693 \checkmark$ $5.7 \times 10^{-5} \text{ «s»} \checkmark$		3
8.	b	ii	mention of Faraday's law $\checkmark$ indicating that changing current in discharge circuit leads to change in flux in coil/change in magnetic field «and induced emf» $\checkmark$		2
8.	b	iii	decrease/reduce $\checkmark$ resistance (R) <b>OR</b> capacitance (C) $\checkmark$		2