

Markscheme

May 2026

Physics

Higher level

Paper 2

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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. An alternative markscheme is indicated in the “Answers” column under the heading **ALTERNATIVE 1** etc. Any alternative can be accepted.
8. Words in angled brackets « » in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined 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. “Allow ECF” 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.
15. Allow reasonable substitutions where in common usage, *eg* ° for rad

Question			Answers	Notes	Total
1.	a	i	arrow at a tangent to the path, in the correct direction, starting at P ✓		[1]
1.	a	ii	arrow vertically downwards, starting at P ✓		[1]
1.	b	i	$2.4 = \frac{1}{2} \times 9.8 \times t^2 \quad \checkmark$ $t = 0.70 \text{ s} \quad \checkmark$	<i>Ignore units, they are not required for the answer, they have been included for clarity.</i> <i>Accept 0.69 « s » for use of $g = 10$.</i> <i>Do not award ECF for MP2 from distance 5.3 m.</i>	[2]
	b	ii	$\ll \frac{5.3}{0.70} = \gg 7.6 \text{ m s}^{-1} \quad \checkmark$		[1]

Question			Answers	Notes	Total
2.	a		has zero/negligible resistance OR zero/negligible pd when a current is in it ✓		[1]
2.	b		$R \approx 200 + 50 \Rightarrow 250\text{k}\Omega$ ✓ $\frac{9.0}{250 \times 10^3} = 3.6 \times 10^{-5} \text{ A}$ ✓	Unit not required. Allow answer expressed in e.g. mA as long as prefix and power of ten match. Allow ECF from MP1 .	[2]
2.	c	i	ALTERNATIVE 1 total «series» resistance decreases ✓ current increases so voltmeter reading increases ✓ ALTERNATIVE 2 R_{fixed} is an increasing fraction of the total resistance ✓ Pd across R_{fixed} increases so voltmeter reading increases ✓	Allow the argument based on R_{LDR} being a decreasing fraction of the total resistance.	[2]
2.	c	ii	ALTERNATIVE 1 «from $P = (emf) \times I$, » the current increases so P increases ✓ ALTERNATIVE 2 «from $P = \frac{(emf)^2}{R}$, » the total resistance decreases so P increases ✓	Justification must be seen.	[1]

Question			Answers	Notes	Total
3.	a		<i>Any 3 from:</i> radiation/light «of continuous spectrum» passes through the gas ✓ atoms/electrons absorb photons OR atoms/electrons can change energy levels ✓ photons whose energy matches the gap/energy difference between levels are absorbed ✓ «photon energy depends on frequency so dark lines are» missing wavelengths/frequencies «in the spectrum» ✓	<i>Accept atoms/electrons can jump energy levels.</i> <i>Do not allow 'dark lines' without a link to frequency/wavelength.</i>	[3] max
3.	b		$\frac{1.24 \times 10^{-6}}{309 \times 10^{-9}}$ OR 4.01 eV OR $\frac{1.24 \times 10^{-6}}{514 \times 10^{-9}}$ OR 2.41 eV ✓ «difference $\Rightarrow$ 1.60 eV ✓	<i>Unit not required.</i> MP1 is for a correct substitution or value for one energy transition. MP2 is for the correct answer. Allow energy transitions calculated in J for MP1.	[2]

Question			Answers	Notes	Total
4.	a		Any 2 from : «in the particle model» energy is transferred to an electron by a single photon at a time ✓ «in the particle model» the energy transferred to an electron depends on frequency «of light» ✓ intensity only affects the rate/number of the photons / emitted electrons ✓		[2] max
4.	b		$\Phi = 6.63 \times 10^{-34} \times 9.0 \times 10^{14} - 8.0 \times 10^{-20}$ OR 5.17×10^{-19} J ✓ $f_0 = \frac{5.17 \times 10^{-19}}{6.63 \times 10^{-34}}$ ✓ 7.8×10^{14} Hz ✓	Unit not required.	[3]
4.	c		the same gradient « equal to h » ✓ different axes intercepts «equal to the threshold frequencies/work functions of the metals» ✓	For MP2 mention of one intercept is sufficient.	[2]
4.	d		wavelength/frequency shift of scattered X-rays/photons ✓		[1]

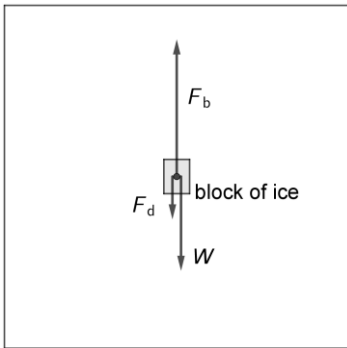
Question			Answers	Notes	Total
5.	a	i	$\ll \frac{0.75 - 0.45}{0.75} = \gg 0.40$ OR 40% ✓		[1]
5.	a	ii	process CD ✓	<i>Do not accept a single point e.g. C or D alone</i>	[1]
5.	a	iii	$3.0 \times 10^5 \times 1.8 \times 10^{-3} = 0.12 \times 8.31 \times T$ ✓ 540 K ✓	<i>Unit not required.</i>	[2]
5.	b	i	there is a magnetic flux «linkage» in the coil / coil cuts magnetic field ✓ this flux «linkage» changes as the angle varies/coil rotates ✓ «Faraday's law states that the » induced emf depends on the rate of change of flux «linkage with time» ✓	<i>For MP1 and 2 the candidate must be referencing this coil to gain the marks rather than making general statement.</i> <i>A general statement of Faraday's Law is acceptable for MP3.</i> <i>Allow formulae only if symbols are explained.</i>	[3]
5.	b	ii	90° ✓	<i>Accept 270°.</i> <i>Accept answers in rad.</i>	[1]
5.	b	iii	Correct attempt to obtain flux change, e.g. $\Delta\Phi = 5.0 \times 10^{-2} \times 0.04 (\cos 120^\circ - \cos 0^\circ) \ll = -3.0 \times 10^{-3} \text{ Wb} \gg$ ✓ average emf = $-1500 \times \frac{-3.0 \times 10^{-3}}{7.0 \times 10^{-3}} = 640 \text{ V}$ ✓	<i>Ignore negative signs in answers.</i> <i>Unit not required.</i> <i>Watch for ECF from MP1.</i>	[2]

Question			Answers	Notes	Total
6.	a	i	$\frac{15.7}{2\pi}$ OR 2.50Hz ✓	Calculation must be seen or answer to at least 3 sf.	[1]
6.	a	ii	15.7×0.450 OR 7.1 ms ⁻¹ ✓	Calculation must be seen or answer to at least 2 sf.	[1]
6.	b		$15.7^2 \times 0.450$ ✓ 111 m s ⁻² ✓	Unit not required. Ignore negative sign.	[2]
6.	c		sine-like curve oscillating between 0 and E_T with peaks separated by 0.2 s ✓ zero at $t = 0$ s ✓	At least one period must be shown.	[2]

6.	d		$500 \times \frac{340}{340 + 7.1} \quad \checkmark$ 490 Hz ✓	<i>Unit not required.</i> <i>Allow the use of 7 m s⁻¹.</i> <i>Award [1 max] for the answer obtained from the moving observer equation, i.e.</i> $500 \times \frac{(340 - 7.1)}{340} = 490$ <i>Allow ECF for MP2 if the frequency used is 2.5 Hz.</i> <i>Award [0] if maximum frequency calculated.</i>	[2]
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Question			Answers	Notes	Total
7.	a	i	into the page ✓		[1]
7.	a	ii	magnetic force is perpendicular to u so it does no work on the electron OR magnetic force is perpendicular to u so it does not change the electron's speed ✓	Allow 'perpendicular to motion' for 'perpendicular to u '.	[1]
7.	a	iii	$\frac{m_e u^2}{R} = euB$ ✓ $u = \frac{1.60 \times 10^{-19} \times 1.5 \times 10^{-3} \times 0.040}{9.11 \times 10^{-31}} = 1.1 \times 10^7 \text{ m s}^{-1}$ ✓	Unit not required.	[2]
7.	b	i	$eV = \frac{1}{2} m_e u^2$ ✓ attempt to eliminate u from this equation and the equation in (a)(iii), e.g. $u^2 = \frac{2eV}{m_e} = \frac{(eBR)^2}{m_e^2}$ ✓ «leading to $V = \frac{e}{2m_e} B^2 R^2$ hence » $k = \frac{e}{2m_e}$ ✓		[3]
7.	b	ii	C kg ⁻¹ OR V T ⁻² m ⁻² ✓	Watch for ECF from an incorrect expression for k in bi). Accept A s kg ⁻¹ . If a candidate states one of the 2 acceptable answers and then makes an error converting to fundamental units do not penalize the error.	[1]

Question			Answers	Notes	Total
8.	a	i	$\frac{v}{c} = \frac{\sin 33^\circ}{\sin 45^\circ} \checkmark$ $2.3 \times 10^8 \text{ m s}^{-1} \checkmark$	Unit not required.	[2]
8.	a	ii	wavelength decreases $\checkmark$ «as from $c = f\lambda$ »frequency stays the same AND speed decreases $\checkmark$		[2]
8.	a	iii	Angle on incidence at Q = $57^\circ \checkmark$ ALTERNATIVE 1 Critical angle $\theta_c = \ll \sin^{-1} 0.77 = \gg 50^\circ \checkmark$ $57^\circ > \theta_c$ so the light «is totally internally reflected and» doesn't emerge $\checkmark$ ALTERNATIVE 2 $\sin \theta_r = 1.09 \checkmark$ $\sin \theta_r > 1$, so the light doesn't emerge $\checkmark$	Allow ECF for MP2 and 3 from an incorrect angle of incidence. Allow angle undefined.	[3]
8.	b	i	net force = buoyancy force – weight $\checkmark$ $\text{acceleration} = \frac{(\rho_{\text{water}} - \rho_{\text{ice}})Vg}{\rho_{\text{ice}}V} \checkmark$ $\ll \frac{1000 - 920}{920} \times 9.8 = \gg 0.85 \text{ m s}^{-2} \checkmark$	Unit not required. Award [0] if the weight is not subtracted from the buoyancy force. Allow working with signs reversed.	[3]

8.	b	ii	decreases/tends to zero ✓	Award [0] for bald ‘decreases’	[1]
8.	b	iii	weight downwards buoyancy force upwards ✓ drag downwards ✓ 	Award [1] max if the magnitude of the total upward force is different from the total downward force (judge by eye).	[2]
8.	c	i	$\ll \frac{3.1}{0.50} \Rightarrow 6.2\text{N}$ ✓	Unit not required	[1]
8.	c	ii	$\ll \frac{6.2}{5.5 \times 9.8} \Rightarrow 0.12$ ✓	Watch for ECF from (c)(i). Allow 0.11 from $g=10$ or 9.81 Ignore any unit included.	[1]
8.	d	i	work done by F is transferred as thermal energy / internal energy of the ice ✓ energy transfer happens at the contact interface/bottom of the block OR the bottom surface is warmer than the top ✓	Do not accept heat.	[2]
8.	d	ii	$3.1 \ll - \Rightarrow 2.3 \times 7.5 \times 10^{-2} \times \frac{\Delta T}{0.080}$ ✓ $\Delta T \ll - \Rightarrow 1.4\text{K}$ hence $T = -6.6^\circ\text{C}$ ✓	Unit not required. Accept 266K.	[2]

8.	d	iii	«thermal conduction» out through the sides of the block OR «thermal conduction» to the table ✓	<i>The direction of energy conduction must be clear.</i>	[1]
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Question			Answers	Notes	Total
9.	a	i	Any 2 from: red giant has a: greater radius / physical dimensions ✓ lower surface temperature ✓ greater core temperature ✓ greater luminosity than the Sun ✓	<i>Allow reverse statements.</i> <i>Allow 'bigger/larger'.</i> <i>'Surface' or 'core' must be specified when comparing temperatures.</i> <i>Do not allow 'brighter'.</i>	[2] max
9.	a	ii	red giant is at a later evolutionary stage / the Sun is yet to become a red giant OR red giant has evolved off the main sequence AND the Sun is a main sequence star OR red giant has run out of hydrogen in the core/fuses heavier elements AND the Sun is at hydrogen fusion stage ✓	<i>Allow 'red giant is older'.</i>	[1]

9.	b	i	$12 \times 7.680 - (4 \times 7.074 + 8 \times 7.062) \checkmark$ $7.37 \text{ MeV} \checkmark$	<i>Unit not required.</i> <i>Accept $1.18 \times 10^{-12} \text{ J}$</i> <i>Allow working with reverse signs for MP1.</i> <i>The final answer must be positive for MP2.</i> <i>Do not award ECF for MP2 from incorrect calculation in MP1.</i>	[2]
9.	b	ii	always positive and decreasing curve $\checkmark$ asymptotically approaching zero $\checkmark$		[2]
9.	b	iii	«the negative of» the electric field strength $\checkmark$		[1]
9.	b	iv	$8.99 \times 10^9 \times \frac{2 \times 4 \times (1.6 \times 10^{-19})^2}{4.5 \times 10^{-15}} \ll = 4.1 \times 10^{-13} \text{ J} \gg \checkmark$ $2.6 \text{ MeV} \checkmark$	<i>Unit not required.</i>	[2]
9.	c	i	high density and temperature $\checkmark$		[1]

9.	c	ii	half-life is «very» short OR $9 \times 10^{-17} \text{ s}$ ✓ «high ρ and T are needed so that» time between collisions is short OR collision frequency is high OR Be-8 fuses before it decays ✓		[2]
9.	d	i	conservation of angular momentum used, e.g. $I\omega = I_0\omega_0$ ✓ $I = \frac{I_0}{25^2}$ so $\omega = 25^2 \omega_0$ ✓ $\ll 625 \times 0.2 \text{ rev s}^{-1} \Rightarrow 125 \text{ rev s}^{-1}$ ✓	Unit not required.	[3]

9.	d	ii	ALTERNATIVE 1 $E = \frac{1}{2} \frac{I_0}{25^2} (25^2 \omega_0)^2 \checkmark$ $E = \ll 25^2 \times \frac{1}{2} I_0 \omega_0^2 = \gg 625 E_0 \checkmark$ ALTERNATIVE 2 $E = \frac{L^2}{2 \times \frac{I_0}{25^2}} \checkmark$ $E = \ll 25^2 \frac{L}{2 I_0} = \gg 625 E_0 \checkmark$	Allow 400 from use of the 'show' value in di)	[2]
9.	d	iii	gravitational PE is transferred to rotational KE ✓ gravitational PE is transferred to thermal energy ✓	The idea of rotational KE must be present for MP1. Do not award the mark for simply 'KE'.	[2]