Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Physics

Higher level

Paper 2

18 pages

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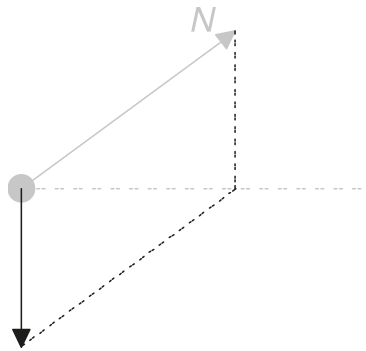
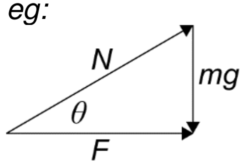
Question			Answers	Notes	Total
1.	a	i	towards the centre «of the circle» / horizontally to the right ✓	*Do not accept towards the centre of the bowl*	**1**
1.	a	ii	downward vertical arrow of any length ✓ arrow of correct length ✓	*Judge the length of the vertical arrow by eye. The construction lines are not required. A label is not required* *eg*: 	**2**
1.	a	iii	***ALTERNATIVE 1*** $F = N\cos\theta$ ✓ $mg = N\sin\theta$ ✓ dividing/substituting to get result ✓ ***ALTERNATIVE 2*** right angle triangle drawn with *F*, *N* and *W/mg* labelled ✓ angle correctly labelled and arrows on forces in correct directions ✓ correct use of trigonometry leading to the required relationship ✓	*eg:*  $tan\theta = \frac{O}{A} = \frac{mg}{F}$ $F = \frac{mg}{tan\theta}$	**3**

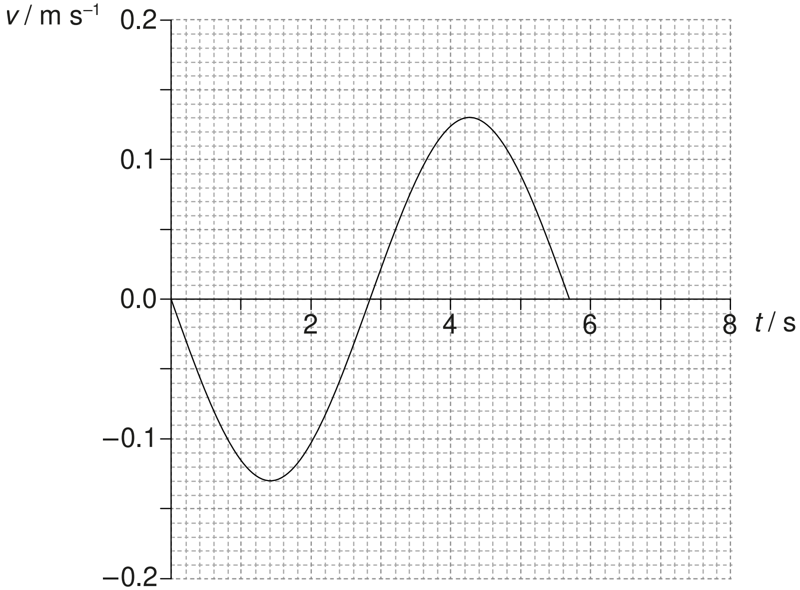
(continued…)

(Question 1 continued)

Question			Answers	Notes	Total
1.	**b**		$\frac{mg}{\tan\theta} = m\frac{v^2}{r}$ ✓ $r = R\cos\theta$ ✓ $v = \sqrt{\frac{gR\cos^2\theta}{\sin\theta}}$ / $\sqrt{\frac{gR\cos\theta}{\tan\theta}}$ / $\sqrt{\frac{9.81\times 8.0\cos 22}{\tan 22}}$ ✓ $v = 13.4 / 13$ «m s^{-1}» ✓	*Award **[4]** for a bald correct answer* *Award **[3]** for an answer of 13.9/14 «ms^{-1}». MP2 omitted*	**4**
1.	**c**		there is no force to balance the weight/N is horizontal ✓ so no / it is not possible ✓	*Must see correct justification to award MP2*	**2**

(continued…)

(Question 1 continued)

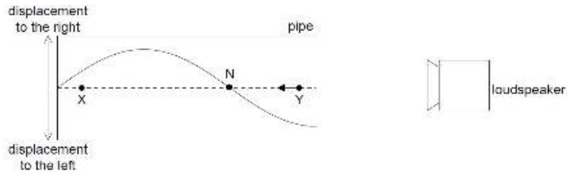
Question			Answers	Notes	Total
1.	**d**	**i**	the «restoring» force/acceleration is proportional to displacement ✓	*Direction is not required*	**1**
1.	**d**	**ii**	$\omega =$ «$\sqrt{\frac{g}{R}}$» $= \sqrt{\frac{9.81}{8.0}}$ «$= 1.107\ \text{s}^{-1}$» ✓ $T =$ «$\frac{2\pi}{\omega} = \frac{2\pi}{1.107} =$» 5.7 «s» ✓	*Allow use of* $g = 9.8$ *or* 10 *Award **[0]** for a substitution into* $T = 2\pi\sqrt{\frac{l}{g}}$	**2**
1.	**d**	**iii**	sine graph ✓ correct amplitude «0.13 m s^{-1}» ✓ correct period and only 1 period shown ✓	*Accept* $\pm$ *sine for shape of the graph. Accept 5.7 s or 6.0 s for the correct period.* *Amplitude should be correct to* $\pm\frac{1}{2}$ *square for MP2* *eg*: 	**3**

(continued…)

(Question 1 continued)

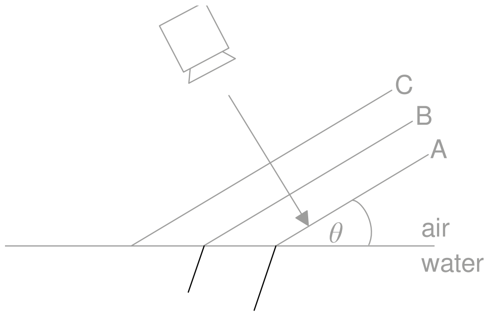
Question			Answers	Notes	Total
1.	**e**		speed before collision $v =$ «$\sqrt{2gR} =$» 12.5 «m s^{-1}» ✓ «from conservation of momentum» common speed after collision is $\frac{1}{2}$ initial speed «$v_c = \frac{12.5}{2} = 6.25\,\text{m s}^{-1}$» ✓ $h =$ «$\frac{v_c^{\,2}}{2g} = \frac{6.25^2}{2 \times 9.81}$» 2.0 «m» ✓	*Allow 12.5 from incorrect use of kinematics equations* *Award **[3]** for a bald correct answer* *Award **[0]** for $mg(8) = 2mgh$ leading to $h = 4\,m$ if done in one step.* *Allow ECF from MP1* *Allow ECF from MP2*	**3**

Question			Answers	Notes	Total
2.	**a**	**i**	a gas in which there are no intermolecular forces ***OR*** a gas that obeys the ideal gas law/all gas laws at all pressures, volumes and temperatures ***OR*** molecules have zero PE/only KE ✓	*Accept atoms/particles.*	**1**
2.	**a**	**ii**	$N = «\frac{pV}{kT} = \frac{5.3\times10^{5}\times2.1\times10^{-4}}{1.38\times10^{-23}\times310}» 2.6\times10^{22}$ ✓		**1**
2.	**a**	**iii**	«For one atom $U = \frac{3}{2}kT$» $\frac{3}{2}$ ă 1.38 ă 10^{-23} ă 310 / 6.4 ă 10^{-21} «J» ✓ $U = «2.6\times10^{22}\times\frac{3}{2}\times1.38\times10^{-23}\times310» 170$ «J» ✓	*Allow ECF from (a)(ii)* *Award **[2]** for a bald correct answer* *Allow use of* $U = \frac{3}{2}pV$	**2**
2.	**b**	**i**	$p_2 = «5.3\times10^{5}\times\frac{2.1\times10^{-4}}{6.8\times10^{-4}}» 1.6\times10^{5}$ «Pa» ✓		**1**
2.	**b**	**ii**	«volume has increased and» average velocity/KE remains unchanged ✓ «so» molecules collide with the walls less frequently/longer time between collisions with the walls ✓ «hence» rate of change of momentum at wall has decreased ✓ «and so pressure has decreased»	*The idea of average must be included* *Decrease in number of collisions is not sufficient for MP2. Time must be included.* *Accept atoms/particles.*	**2 max**

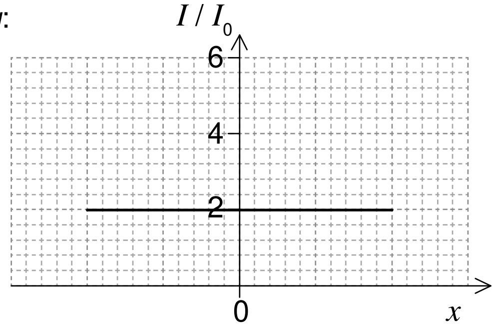
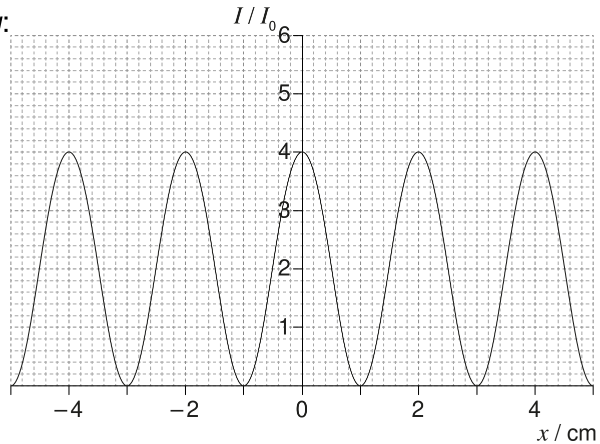
Question			Answers	Notes	Total
3.	**a**	**i**	the incident wave «from the speaker» and the reflected wave «from the closed end» superpose/combine/interfere ✓	*Allow superimpose/add up* *Do not allow meet/interact*	**1**
3.	**a**	**ii**	Horizontal arrow from X to the right ✓	*MP2 is dependent on MP1* *Ignore length of arrow*	**1**
3.	**a**	**iii**	P at a node ✓		**1**
3.	**a**	**iv**	wavelength is $\lambda = «\frac{4 \times 0.30}{3} =» 0.40 «m»$ ✓ $f = «\frac{340}{0.40} =» 850 «Hz»$ ✓	*Award **[2]** for a bald correct answer* *Allow ECF from MP1*	**2**

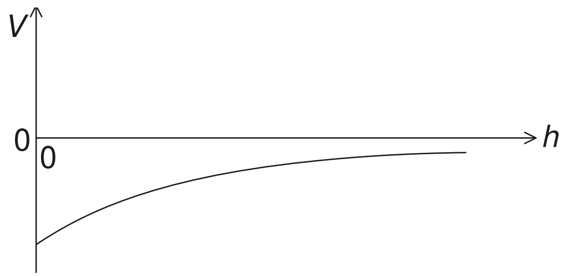
(continued…)

(Question 3 continued)

Question			Answers	Notes	Total
3.	b	i	$\frac{\sin\theta_C}{340} = \frac{1}{1500}$ ✓ $\theta_C = 13$ «°» ✓	*Award **[2]** for a bald correct answer* *Award **[2]** for a bald answer of 13.1* *Answer must be to 2/3 significant figures to award MP2* *Allow 0.23 radians*	**2**
3.	b	ii	correct orientation ✓ greater separation ✓	*Do not penalize the lengths of A and B in the water* *Do not penalize a wavefront for C if it is consistent with A and B* *MP1 must be awarded for MP2 to be awarded* *eg*: 	**2**

Question			Answers	Notes	Total
4.	**a**		the work done per unit charge ✓ in moving charge from one terminal of a cell to the other / all the way round the circuit ✓	*Award **[1]** for "energy per unit charge provided by the cell"/"power per unit current"* *Award **[1]** for "potential difference across the terminals of the cell when no current is flowing"* *Do not accept "potential difference across terminals of cell"*	**2**
4.	**b**	**i**	the resistance is proportional to length / see 0.35 ***AND*** 1«.00»✓ so it equals 0.35×80 ✓ «$= 28\,\Omega$»		**2**
4.	**b**	**ii**	current leaving 12 V cell is $\frac{12}{80} = 0.15$ « A » ***OR*** $E = \frac{12}{80} \times 28$ ✓ $E =$ «$0.15 \times 28 =$» 4.2 « V » ✓	*Award **[2]** for a bald correct answer* *Allow a 1sf answer of 4 if it comes from a calculation.* *Do not allow a bald answer of 4 «V»* *Allow ECF from incorrect current*	**2**
4.	**c**		since the current in the cell is still zero there is no potential drop across the internal resistance ✓ and so the length would be the same ✓	*OWTTE*	**2**

Question			Answers	Notes	Total
5.	a		horizontal straight line through $I = 2$ ✓	*eg*:  *Accept a curve that falls from I = 2 as distance increases from centre but not if it falls to zero.*	**1**
5.	b		«standard two slit pattern» general shape with a maximum at $x = 0$ ✓ maxima at $4I_0$ ✓ maxima separated by «$\frac{D\lambda}{s} =$» 2.0 cm ✓	*Accept single slit modulated pattern provided central maximum is at 4. ie height of peaks decrease as they go away from central maximum. Peaks must be of the same width* *eg*: 	**3**
5.	c		fringe width/separation decreases ***OR*** more maxima seen ✓		**1**

Question			Answers	Notes	Total
6.	**a**	**i**	the «gravitational» force per unit mass exerted on a point/small/test mass ✓		**1**
6.	**a**	**ii**	at height h potential is $V=-\frac{GM}{(R+h)}$ ✓ field is $g=\frac{GM}{(R+h)^2}$ ✓ «dividing gives answer»	*Do not allow an answer that starts with* $g=-\frac{\Delta V}{\Delta r}$ *and then cancels the deltas and substitutes* $R+h$	**2**
6.	**a**	**iii**	correct shape and sign ✓ non-zero negative vertical intercept ✓	*eg*: 	**2**
6.	**b**		$V=$ «$-2.2\times(3.1\times10^6+2.4\times10^7)=$» «$-$» $6.0\times10^7\ \text{J kg}^{-1}$ ✓	*Unit is essential* *Allow eg* MJ kg^{-1} *if power of 10 is correct* *Allow other correct SI units eg* m^2s^{-2}, N m kg^{-1}	**1**

(continued…)

(Question 6 continued)

Question			Answers	Notes	Total
6.	c		total energy at $P = 0$ / KE gained = GPE lost ✓ «$\frac{1}{2}mv^2 + mV = 0 \Rightarrow$» $v = \sqrt{-2V}$ ✓ $v =$ «$\sqrt{2 \times 6.0 \times 10^7} =$» 1.1×10^4 «m s^{-1}» ✓	*Award **[3]** for a bald correct answer* *Ignore negative sign errors in the workings* *Allow ECF from 6(b)*	**3**
6.	d		***ALTERNATIVE 1*** force on asteroid is «$6.2 \times 10^{12} \times 2.2 =$» 1.4×10^{13} «N» ✓ «by Newton's third law» this is also the force on the planet ✓ ***ALTERNATIVE 2*** mass of planet = 2.4 x 10^{25}«kg» «from $V = -\frac{GM}{(R+h)}$» ✓ force on planet «$= \frac{GMm}{(R+h)^2}$» $= 1.4 \times 10^{13}$ «N» ✓	*MP2 must be explicit*	**2**

Question			Answers	Notes	Total
7.	a	i	Average height = 127 «m» ✓ Specific energy «$= \frac{mg\bar{h}}{m} = g\bar{h} = 9.81 \times 127$» $= 1.2 \times 10^3$ J kg^{-1} ✓	*Unit is essential* *Allow $g = 10$ gives 1.3×10^3 J kg^{-1}* *Allow ECF from 110 m (1.1×10^3 J kg^{-1}) or 144 m (1.4×10^3 J kg^{-1})*	2
7.	a	ii	mass per second leaving dam is $\frac{1.2 \times 10^5}{60} \times 10^3 =$ «2.0×10^6 kg s^{-1}» ✓ rate of decrease of GPE is $= 2.0 \times 10^6 \times 9.81 \times 127$ ✓ $= 2.49 \times 10^9$ «W» / 2.49«GW» ✓	*Do not award ECF for the use of 110 m or 144 m* *Allow 2.4 GW if rounded value used from (a)(i) or 2.6 GW if $g = 10$ is used*	3
7.	a	iii	efficiency is «$\frac{1.8}{2.5} =$» 0.72 / 72% ✓		1
7.	b		water is pumped back up at times when the demand for/price of electricity is low ✓		1

Question			Answers	Notes	Total
8.	a		$C =$ «$\varepsilon \frac{A}{d} =$»$8.8 \times 10^{-12} \times \frac{1.2 \times 10^{8}}{1600}$ ✓ «$C = 6.60 \times 10^{-7}$ F»		1
8.	b	i	$V =$ «$\frac{Q}{C} =$»$\frac{25}{6.6 \times 10^{-7}}$ ✓ $V = 3.8 \times 10^{7}$ «V» ✓	*Award **[2]** for a bald correct answer*	2
8.	b	ii	***ALTERNATIVE 1*** $E =$ «$\frac{1}{2}QV =$» $\frac{1}{2} \times 25 \times 3.8 \times 10^{7}$ ✓ $E = 4.7 \times 10^{8}$ «J» ✓ ***ALTERNATIVE 2*** $E =$ «$\frac{1}{2}CV^{2} =$» $\frac{1}{2} \times 6.60 \times 10^{-7} \times \left(3.8 \times 10^{7}\right)^{2}$ ✓ $E = 4.7 \times 10^{8}$ «J» / 4.8×10^{8} «J» if rounded value of V used ✓	*Award **[2]** for a bald correct answer* *Allow ECF from (b)(i)* *Award **[2]** for a bald correct answer* *Allow ECF from (b)(i)*	2
8.	c	i	$Q =$ «$Q_{0}e^{-\frac{t}{\tau}} =$» $25 \times e^{-\frac{18}{32}}$ ✓ $Q = 14.2$ «C» ✓ charge delivered $= Q = 25 - 14.2 = 10.8$ «C» ✓ «≈ -11 C»	*Final answer must be given to at least 3 significant figures*	3
8.	c	ii	I «$= \frac{\Delta Q}{\Delta t} = \frac{11}{18 \times 10^{-3}}$» ≈ 610 «A» ✓	*Accept an answer in the range 597 – 611 «A»*	1

(continued…)

(Question 8 continued)

Question			Answers	Notes	Total
8.	d		the base of the thundercloud must be parallel to the Earth surface ***OR*** the base of the thundercloud must be flat ***OR*** the base of the cloud must be very long «compared with the distance from the surface» ✓		**1**

9.	a		«most of» the mass of the atom is confined within a very small volume/nucleus ✓ «all» the positive charge is confined within a very small volume/nucleus ✓ electrons orbit the nucleus «in circular orbits» ✓		**2 max**
9.	b		the electrons accelerate and so radiate energy ✓ they would therefore spiral into the nucleus/atoms would be unstable ✓ electrons have discrete/only certain energy levels ✓ the only orbits where electrons do not radiate are those that satisfy the Bohr condition «$mvr = n\frac{h}{2\pi}$» ✓		**3 max**

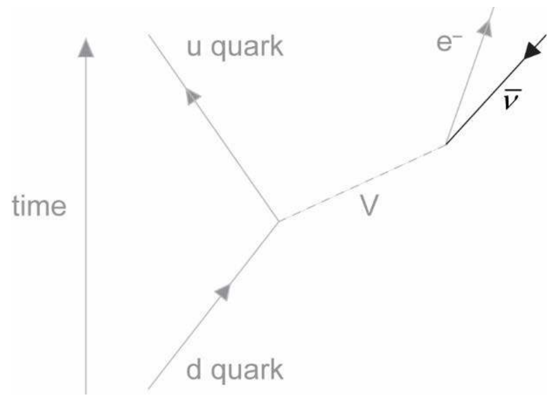
(continued…)

(Question 9 continued)

Question			Answers	Notes	Total
9.	**c**	**i**	$\frac{m_e v^2}{r} = \frac{ke^2}{r^2}$ ***OR*** $\text{KE} = \frac{1}{2}\text{PE}$ hence $\frac{1}{2}m_e v^2 = \frac{1}{2}\frac{ke^2}{r}$ ✓ «solving for *v* to get answer»	*Answer given – look for correct working*	**1**
9.	**c**	**ii**	combining $v = \sqrt{\frac{ke^2}{m_e r}}$ with $m_e vr = \frac{h}{2\pi}$ using correct substitution ✓ «*eg* $m_e^{\,2}\frac{ke^2}{m_e r}\ r^2 = \frac{h^2}{4\pi^2}$ » correct algebraic manipulation to gain the answer ✓	*Answer given – look for correct working* *Do not allow a bald statement of the answer for MP2. Some further working eg cancellation of m or r must be shown*	**2**
9.	**c**	**iii**	« $r = \frac{(6.63\times10^{-34})^2}{4\pi^2\times8.99\times10^9\times9.11\times10^{-31}\times(1.6\times10^{-19})^2}$ » $r = 5.3\times10^{-11}$ «m» ✓		**1**
9.	**d**	**i**	the energy released is $3.54 - 0.48 = 3.06$ «MeV» ✓ this is shared by the electron and the antineutrino ✓ so the electron's energy varies from 0 to 3.06 «MeV» ✓		**3**
9.	**d**	**ii**	the palladium nucleus emits the photon when it decays into the ground state «from the excited state» ✓		**1**

(continued…)

(Question 9 continued)

Question			Answers	Notes	Total
9.	**d**	**iii**	Photon energy $E = 0.48\times10^{6}\times1.6\times10^{-19} =$ «$7.68\times10^{-14}\,J$» ✓ $\lambda =$ «$\frac{hc}{E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{7.68\times10^{-14}} =$» 2.6×10^{-12} «m» ✓	*Award **[2]** for a bald correct answer* *Allow ECF from incorrect energy*	**2**
9.	**e**	**i**	line <u>with arrow</u> as shown labelled anti-neutrino/$\bar{\nu}$ ✓	*Correct direction of the "arrow" is essential* *The line drawn must be "upwards" from the vertex in the time direction i.e. above the horizontal* *eg*: 	**1**
9.	**e**	**ii**	$V = W^-$ ✓		**1**