SCOTTISH
QUALIFICATIONS
AUTHORITY

2004 Physics

Advanced Higher

Finalised Marking Instructions

Detailed Marking Instructions – AH Physics 2003

1. **Numerical Marking**

   (a) The fine divisions of marks shown in the marking scheme may be recorded within the body of the script beside the candidate's answer. If such marks are shown they must total to the mark in the inner margin.

   (b) Negative marks or marks to be subtracted should not be shown. An inverted vee may be used instead.

   (c) The number recorded should always be the marks being awarded.
   The number out of which a mark is scored SHOULD NEVER BE SHOWN AS A DENOMINATOR. (½ mark will always mean one half mark and never 1 out of 2.)

   (d) Where square ruled paper is enclosed inside answer books it should be clearly indicated that this item has been considered. Marks awarded should be transferred to the script booklet inner margin and marked G.

   (e) Fractional marks, if awarded to individual questions, should be recorded in the grid, but the total script mark must be rounded up to the next whole number when transferred to the box at the top of the script.

2. **Other Marking Symbols which may be used**

TICK	–	correct point as detailed in scheme, includes data entry
SCORE THROUGH	–	any part of answer which is wrong. (For a block of wrong answer indicate zero marks.)
INVERTED VEE	–	a point omitted which has led to a loss of marks.
WAVY LINE	–	under an answer worth marks which is wrong only because a wrong answer has been carried forward from a previous part.
"G"	–	Reference to a graph on separate paper. You MUST show a mark on the graph paper and the SAME mark on the script.
"WP"	–	Marks not awarded because an apparently correct answer was due to the use of "wrong physics".
"ARITH"	–	Candidate has made an arithmetic mistake.

3. **General Instructions (Refer to National Qualifications Booklet)**

(a) No marks are allowed for a description of the wrong experiment or one which would not work.
Full marks should be given for information conveyed correctly by a sketch.

(b) Surplus answers: where a number of reasons, examples etc are asked for and a candidate gives more the required number then wrong answers may be treated as negative and cancel out part of the previous answer.

(c) Full marks should be given for a correct answer to a numerical problem even if the steps are not shown explicitly. The part marks shown in the scheme are for use in marking partially correct answers.

(d) Where 1 mark is shown for the final answer to a numerical problem ½ mark may be deducted for an incorrect unit.

(e) Where a final answer to a numerical problem is given in the form 3^{-6} instead of 3×10^{-6} then deduct ½ mark.

(f) Deduct ½ mark if an answer is wrong because of an arithmetic slip.

(g) No marks should be awarded in a part question after the application of a wrong physics principle (wrong formula, wrong substitution) unless specifically allowed for in the marking scheme.

(h) In certain situations, a wrong answer to a part of a question can be carried forward within that part of the question. This would incur no further penalty provided that it is used correctly. Such situations are indicated by a horizontal dotted line in the marking instructions.

Wrong answers can always be carried forward to the next part of a question, over a solid line without penalty.

(i) ½ mark should be awarded for selecting a formula.

(j) Where a triangle type "relationship" is written down and then not used or used incorrectly then any partial ½ mark for a formula should not be awarded.

(k) In numerical calculations, if the correct answer is given then converted wrongly in the last line to another multiple/submultiple of the correct unit then deduct ½ mark.

(l) Significant figures.
Data in question is given to 3 significant figures.
Correct final answer is 8·16J.
Final answer 8·2J or 8·158J or 8·1576J – No penalty.
Final answer 8J or 8·15761J – Deduct ½ mark.
Candidates should be penalised for a final answer that includes

- three or more figures too many
  or
- two or more figures too few.
  ie accept two higher and one lower

(m) Squaring Error

$E_K = ½ mv^2 = ½ \times 4 \times 2^2 = 4J$ (-½, ARITH)

$E_K = ½ mv^2 = ½ \times 4 \times 2 = 4J$ (½, formula) Incorrect substitution.

The General Marking Instructions booklet should be brought to the markers' meeting.

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Sample Answer and Mark Allocation	Notes	Marks	
1. (*a*) $m = 3m_o$ (½) $\Rightarrow 3m_o = \dfrac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}$ $3 = \dfrac{1}{\sqrt{1-\frac{v^2}{(3\times10^8)^2}}}$ (½) for c or 3×10^8 or 9×10^{16} $v = 2\cdot828\times10^8$ $v = 2\cdot8\times10^8\,\text{ms}^{-1}$ (1)	Could be "implied" in equation	2	**5**
(*b*) $v = 0\cdot9c$ $m = \dfrac{m_o}{\sqrt{1-\frac{v^2}{c^2}}}$ $m = \dfrac{9\cdot11\times10^{-3}}{\sqrt{1-\frac{(0\cdot9c)^2}{c^2}}}$ (½) for substitution $= \dfrac{9\cdot11\times10^{-31}}{\sqrt{1-0\cdot9^2}}$ $m = 2\cdot0899\times10^{-30}$ kg (½) $(m = 2\cdot1\times10^{-30}\,\text{kg})$	$v = 2\cdot7\times10^8\,\text{ms}^{-1}$		
$E = mc^2$ (½) $E = 2\cdot0899\times10^{-30}\times c^2$ (½) for substitution $E = 1\cdot8809\times10^{-13}$ $E = 1\cdot9\times10^{-13}\,\text{J}$ (1)	must calculate a value of m if $m = 9\cdot11\times10^{-31}$ kg taken max ($\frac{1}{2}$) for equation	3	

Sample Answer and Mark Allocation	Notes	Marks	
2. (*a*) (i) (gravitational) Ep (½) rotational Ek (½) (linear/translational) Ek (½) (ii) rotational Ek (½)	} Ek alone (½) E_p stated - no penalty	2	**9**
(*b*) $I = \frac{1}{2}Mr^2$ $I = \frac{1}{2} \times 0 \cdot 1 \times (0 \cdot 05)^2$ (½) $I = 0 \cdot 000125$ ($kg\ m^2$) (½) Total $I = 2 \times 0 \cdot 000125$ $= 2 \cdot 5 \times 10^{-4}$ kg m^2 (1)	Formula given	2	
(*c*) $w = 120$ rad s^{-1} Ek = Ep $\frac{1}{2}Iw^2 = mgh$ } (½) $\frac{1}{2} \times 0 \cdot 00025 \times 120^2 = 0 \cdot 2 \times 9 \cdot 8 \times h$ (½) $h = 0{\cdot}918367\ m$ $h = 0{\cdot}92\ m$ (1)		2	
(*d*) (i) the (5N) force of spring is not great enough to provide the required centripetal force. (1)	Any force outwards WP=0	1	
(ii) $F = mw^2r$ (½) $5 = (12 \times 10^{-3}) \times w^2 \times (10 \times 10^{-3})$ (½) $w^2 = 41666$ $w = 204{\cdot}12$ $w = 204$ rad s^{-1} (1)	*If* m = × 4 max ($\frac{1}{2}$) for formula	2	

Sample Answer and Mark Allocation	Notes	Marks	
3. (*a*) $w_o = \frac{600 \times 2\pi}{60}$ (½) $= 20\pi$ (rad s^{-1}) (½)	unit in question 62·8	1	**10**
(*b*) $\alpha = \frac{w - w_o}{t}$ (½) $\alpha = \frac{0 - 20\pi}{30}$ (½) $\alpha = -2 \cdot 1$ **OR** deceleration $\alpha = 2 \cdot 1$ rad s^{-2} (1)	$w = 20\pi$ $w_o = 0$ Wrong physics – max ½ for formula Accept $^2/_3\pi$ rad s^{-2}	2	
(*c*) $w^2 = w_o^2 + 2\alpha\theta$ (½) $0 = (20\pi)^2 - 2 \times 2 \cdot 1 \times \theta$ (½) $\theta = 939 \cdot 96$ (rad) (½) $\theta = 939 \cdot 96 \div 2\pi$ rev (½) $\theta = 150$ (rev) (1)	Can use $\theta = w_o t + ½\alpha t^2$	3	
(*d*) $T = I\alpha$ (½) $T = 2 \cdot 16 \times 10^{-3} \times 2 \cdot 1$ (½) $T = 0 \cdot 004536$ $T = 0 \cdot 0045$ Nm	$(4 \cdot 5 \times 10^{-3})$ Nm	2	
(*e*) *I* less - (1) α greater - (½) time less - (½)	*I* less, time less (1) only must mention α for full marks	2	

Sample Answer and Mark Allocation	Notes	Marks	
4. (*a*) $\frac{GM_E m}{r^2} = mw^2 r$ (1) $w = \frac{2\pi}{T}$ (½) correct maths → $\left[T = 2\pi\sqrt{\frac{r^3}{GM_E}}\right]$ (½)	Must start by equating forces or accelerations $v = \frac{2\pi r}{T}$ (½)	2	**6**
(*b*) (i) $\left[T = 2\pi\sqrt{\frac{r^3}{GM_E}}\right]$ given $T = 2\pi\sqrt{\frac{(6\cdot4\times10^6 + 8\times10^4)^3}{6\cdot67\times10^{-11}\times6\times10^{24}}}$ (½) (½) (½) $T = 5180\cdot88$ s (½) ($\doteqdot$ 86 min) given	Data marks	2	
(ii) $v = wr$ both formulae (½) $= 7\cdot3\times10^{-5}\times6\cdot4\times10^6$ $= 467\ \text{m s}^{-1}$ (½) $d = v\times t$ $= 467\times5181$ $= 2\cdot4\times10^6$m (1)	Accept $2\cdot420\times10^6$m	2	

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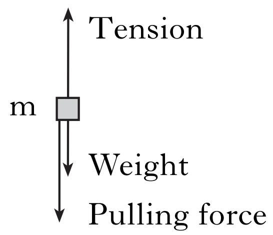
Sample Answer and Mark Allocation	**Notes**	**Marks**	
5. (*a*) vertically  Weight + Force = Tension (½) $4{\cdot}9 + F = 7{\cdot}0$ $F = 2{\cdot}1\text{N}$ (½)		1	**8**
(*b*) (i) "restoring" force (½) proportional to displacement (½)	$F = -kx$ (½) (½) for the minus sign	1	
(ii) $a = \frac{F}{m} = \frac{2\cdot 1}{0\cdot 5} = 4\cdot 2\text{ms}^{-2}$ (½) (½) (1)	carry forward 5(*a*)	2	
(iii) amplitude = 0·06 m (**or** 60 mm)		1	
(*c*) (i) the acceleration		1	
(ii) $a\left(=\frac{d^2y}{dt^2}\right) = -w^2y$ when $y = 0{\cdot}06$ m, $a = 4{\cdot}2\text{ ms}^{-2}$ $\therefore\ 4\cdot 2 = (-)w^2 \times 0\cdot 06$ (½) $w^2 = \frac{4\cdot 2}{0\cdot 06} (= 70)$ $w = 8\cdot 366$ $f = w/2\pi = 1\cdot 3\text{Hz}$ (½) (1)	carry forward 5*b*(ii)(iii) Accept 1·331 Hz	2	

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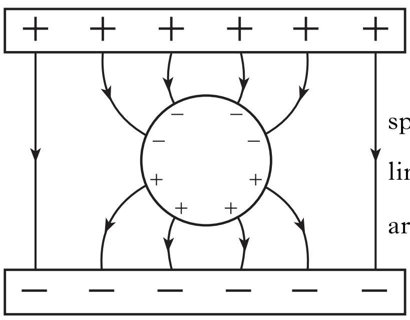
Sample Answer and Mark Allocation	Notes	Marks	
6. (*a*) (i) the force per <u>unit positive</u> (charge placed at a point in the field)	Must state both <u>unit and positive</u>	1	**7**
(ii) $F = qE$ (½) work in moving charge between plates $= Fd = qEd$ (½) also $= qV$ (½) So $\not{q}V = \not{q}Ed$ $V = Ed$ **or** $E = \frac{V}{d}$ (½)	$E = \frac{V}{d}$ alone (0)	2	
(*b*) (i)  sphere lines (1) lines (½) arrows (½)	lines ⊥ to plates + sphere (judgement) No lines to sphere (0) sphere lines (1)	2	
(ii) as shown in (i) $- \uparrow + \downarrow$ (1)		1	
(iii) E = O		1	

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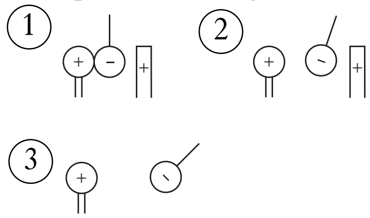
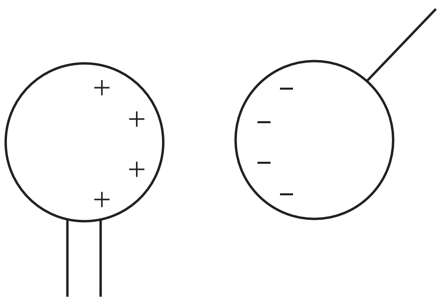
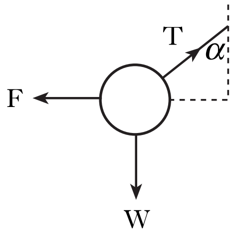
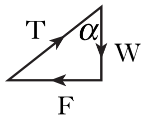
Sample Answer and Mark Allocation	Notes	Marks	
7. (*a*) $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ (1)	or equivalent statement in words	1	**13**
(*b*) ① spheres touching (½) ② bring insulator near (1) ③ separate spheres (½)	Not touching - WP - (0) or equivalent diagrams 	2	
(*c*) (i) $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$ (½) $3\times10^{-5} = \frac{q^2}{4\pi\times8\cdot85\times10^{-12}\times(40\times10^{-3})^2}$ (½ data) $q^2 = 5\cdot33819\times10^{-18}$ (½) $\left[q = 2\cdot3\times10^{-9}C\right]$ given		2	
(ii) $V = \frac{Q}{4\pi\varepsilon_0 r}$ (½) $V_x = \frac{2\cdot31\times10^{-9}}{4\pi\times8{\cdot}85\times10^{-12}\times10\times10^{-3}}$ $(=2070(V))$ (½) $V_y = \frac{-2\cdot31\times10^{-9}}{4\pi\times8{\cdot}85\times10^{-12}\times50\times10^{-3}}$ $(=-413\cdot62(V))$ (½) $V = V_x + V_y = 1654\cdot49$ subtraction (½) $=1700V$ (1)	No subtraction - max(1½)	3	
(iii) 	charges displaced towards centre	1	

Sample Answer and Mark Allocation	Notes	Marks
7. (continued) (*d*) (i)   (½) $T^2 = F^2 + W^2$ (½) $= (3\times10^{-5})^2 + (2\cdot5\times10^{-5}\times9\cdot8)^2$ (½) $T^2 = 6\cdot0925\times10^{-8}$ $T = 2\cdot47\times10^{-4}\text{N}$ $= 2\cdot5\times10^{-4}\text{N}$ (1)	**OR** components method $T\ \cos\ \alpha\ =\ W$ (½) $T\ \sin\ \alpha\ =\ F$ (½) (diagram (½)) $\left[\tan\alpha = \frac{F}{W}\right.$ $\left.\text{see part (ii)}\ (1½)\right]$ then substitution to find T (i) Accept $2\cdot47\times10^{-4}\text{N}$	2½
(ii) $\alpha = \tan^{-1}\frac{F}{W}$ (½) $\alpha = \tan^{-1}\frac{3\times10^{-5}}{(2\cdot45\times10^{-4})}$ (½) $(\alpha = 7°)$ (½)	Accept $\alpha = \text{Sin}^{-1}\frac{F}{T} = \frac{3\times10^{5}}{2\cdot5\times10^{-4}}$ $v = \cos^{-1}\frac{W}{T} = \frac{2\cdot45\times10^{-4}}{2\cdot5\times10^{-4}}$ Accept 0·12 rad	1½

Sample Answer and Mark Allocation	Notes	Marks	
8. (*a*) $\frac{mv^2}{r} = qvB$ (½) (½) (½) for equating correct maths (½) $\left(\Rightarrow \ = \frac{mv}{qB}\right)$		2	**6**
(*b*) $t = \frac{s}{v}$ (½) $s = \pi r$ (½) $\therefore t = \frac{\pi r}{v} = \frac{\pi}{v}\frac{mv}{qB}$ $\therefore t = \frac{\pi m}{qB}$ (1) (no v)	Accept $T = \frac{2\pi m}{qB}$ Where T = period	2	
(*c*) $t = \frac{\pi m}{qB} = \frac{\pi \times 9 \cdot 11 \times 10^{-31}}{(-)1 \cdot 6 \times 10^{-19} \times 5 \times 10^{-5}}$ (½) (½) $t(= 3 \cdot 577 \times 10^{-6}) = 3 \cdot 6 \times 10^{-6}\text{s}$ (1)	data marks	2	

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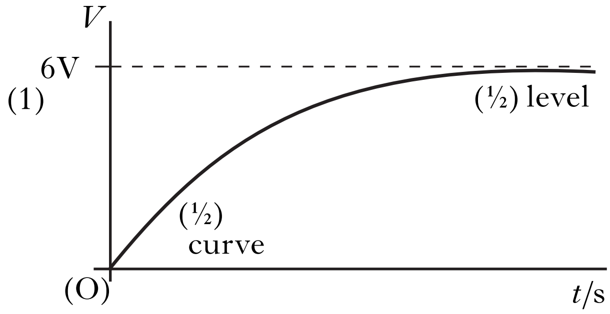
Sample Answer and Mark Allocation	**Notes**	**Marks**	
9. (*a*) 	Curve incorrect - (O)	2	**5**
(*b*) $V = IR$ $= 0 \cdot 2 \times 12\,\Omega$ (½) $= 2 \cdot 4\text{V}$ (½) ε across $L = 6\text{V} - 2 \cdot 4 = 3 \cdot 6\text{V}$ (½) $\varepsilon = -L\dfrac{dI}{dt}$, $\dfrac{dI}{dt} = \dfrac{-\varepsilon}{L}$ (½) $\therefore \dfrac{dI}{dt} = \dfrac{(+)3 \cdot 6}{4} = (+)0 \cdot 9\text{As}^{-1}$ (1)	if $-0{\cdot}9\text{As}^{-1}$ max(2)	3	

Sample Answer and Mark Allocation	Notes	Marks	
10. (*a*) At wire 2 $B = \frac{\mu_0 I_1}{2\pi r}$ (1) $\therefore F = BI_2L$ $= \frac{\mu_0 I_1}{2\pi r} I_2 L$ (1) $\left(\text{hence } \frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}\right)$		2	**9**
(*b*) (i) $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$ (given) $= \frac{4\pi \times 10^{-7} \times 850 \times 850}{2 \times \pi \times 4}$ (½) $= 0 \cdot 03612$ $= 0 \cdot 036\text{Nm}^{-1}$ (1)		1½	
(ii) apart (½)		½	
(iii) $B_1 = \frac{\mu_0 I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 850}{2\pi \times 2}$ (½) (½) $= 8 \cdot 5 \times 10^{-5}\text{T}$ (½) B_2 same $\therefore$ total $B = 1 \cdot 7 \times 10^{-4}\text{T}$ (1) direction upwards (½)	If 4 m used max (1) - Formula (½) direction (½) direction (½) independent	3	
(*c*) $F = BIL\sin\theta$ $\frac{F}{L} = BI\sin\theta$ } (½) $\frac{F}{L} = 52 \times 10^{-6} \times 850 \times \sin 60°$ (½) $= 0 \cdot 038\text{Nm}^{-1}$ (1)	Sin 30° used –(½) max for formula if 60 rad used $\left(\frac{F}{L} = -0 \cdot 01347\right)\text{Nm}^{-1}$ (-½) Arith	2	

Sample Answer and Mark Allocation	Notes	Marks	
11. (*a*) (i) by comparison with "standard" $y = A\sin 2\pi\left(ft - \frac{x}{\lambda}\right)$ (½) $2\pi f = 12$ (½) $f = 1\cdot 9(09)\text{Hz}$		1	**8**
(ii) $\frac{2\pi}{\lambda} = 0\cdot 5$ (½) $\lambda = 12\cdot 56$ $\lambda = 13\text{m}$ (½)		1	
(*b*) (i) $\Delta x = 1\text{m}$ (½) $\Delta\phi = \frac{\Delta x}{\lambda}\times 2\pi$ (½) $\Delta\phi = \frac{1}{13}\times 2\pi$ (½) $\Delta\phi = 0\cdot 48$ (½) (rad)		2	
(ii) $v = f\lambda = 1\cdot 9\times 13 = 24\cdot 7(\text{ms}^{-1})$ (½) (½) (1) $t = \frac{d}{v} = \frac{1}{24\cdot 7} = 0\cdot 040(48)\text{s}$ (1)	carry forward *a*(i), (ii) accept 0·041s Also 0·042s if λ = 12·56m	2	
(*c*) $y = A\sin(12t \oplus 0\cdot 5x)$ (1) bracketed term where $A < 8$ (1)	smaller amplitude (1) bracket term with + (1)	2	

Sample Answer and Mark Allocation	Notes	Marks	
12. (*a*) (i) the (electric part of the) waves vibrate or oscillate in the same plane		1	**6**
(ii) the picture will get poorer (or disappear)	Accept suddenly disappears (1)	1	
(*b*) (i) $n = \frac{\sin i_p}{\sin r}$ (½) but $i_p + r = 90°$, $r = 90 - i_p$ (½) so $n = \frac{\sin i_p}{\sin(90 - i_p)}$ (½) $n = \frac{\sin i_p}{\cos i_p} = \tan i_p$ (given) (½)	Must be sequential 90° shown in proof	2	
(ii) n perspex $= 1 \cdot 49$ (½) $\therefore 1 \cdot 49 = \tan i_p$ (½) $i_p = 0 \cdot 9797$ $= 0 \cdot 98$ rad, $= 56°$ (1)		2	

Sample Answer and Mark Allocation	Notes	Marks	
13. (*a*) $\lambda = \overset{(½)}{\frac{d\Delta x}{D}} = \overset{(½)}{\frac{0\cdot52\times10^{-3}\times(2\cdot6\times10^{-2}\div10)}{2}}$ $\lambda = 6\cdot76\times10^{-7}\,m$ (1)	÷ 10 missed → WP (½) max ÷ 11 → WP (½) max for formula	2	**8**
(*b*) % uncertainty in $d = \frac{0\cdot02}{0\cdot52}\times100 = 3\cdot8\%$ (½) in $\Delta x = \frac{2}{26}\times100 = 7\cdot69\%$ (½) in $D = \frac{0\cdot01}{2}\times100 = 0\cdot5\%$ (½)	÷ 10 WP (1 max)		
% in $\lambda = \sqrt{3\cdot8^2 + 7\cdot69^2(+0\cdot5^2)}$ (½) $= 8\cdot592$ $= 8\cdot6\%$ (1)	okay to include	3	
(*c*) increase D (1) increases Δx (½) + reduces uncertainty in Δx (½) OR measure more fringes (1) reduces % uncertainty in Δx (1)	use a travelling microscope to measure Δx (1) reduces scale reading uncertainty (1)	2	
(*d*) division of wavefront (1)		1	

[*END OF MARKING INSTRUCTIONS*]