SCOTTISH QUALIFICATIONS AUTHORITY

2003 Physics

Advanced Higher

Finalised Marking Instructions

Scottish Qualifications Authority
Detailed Marking Instructions — Advanced Higher Physics 2003

1. General Marking Instructions

SQA published *Physics General Marking Instructions* in July 1999. Please refer to this publication when interpreting the detailed marking instructions that follow.

2. Recording of marks

The following additional advice was given to markers regarding the recording of marks on candidate scripts.

(a) The total mark awarded for each question should be recorded in the outer margin. The inner margin should be used to record the mark for each part of a question as indicated in the detailed marking instructions.

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

(c) Numbers recorded on candidate scripts should always be the marks being awarded. Negative marks or marks to be subtracted should not be recorded on scripts.

(d) The number out of which a mark is scored should **never** be recorded as a **denominator**. (½ mark will always mean one half mark and never 1 out of 2)

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

(f) The mark awarded for each question should be transferred to the grid on the back of the script. When the marker has completed marking the candidate's response to all questions, the marks for individual questions are added to give the total script mark.

(g) The total mark awarded for an individual question may include an odd half mark – ½. If there is an odd half mark in the total script mark, this is rounded up to the next whole number when transferred to the box on the front of the script.

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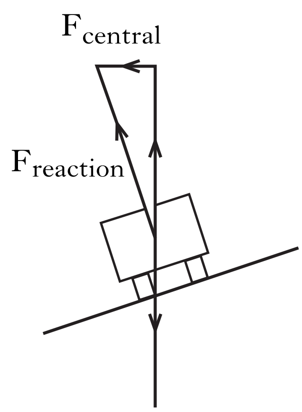
Sample Answers and Mark Allocation	**Notes**	**Marks**	
1. (a)(i) $s = ut + \frac{1}{2}at^2$ **(½)** ($u = 0$) $s = \frac{1}{2}at^2$ **(½)** $a = 2s/t^2$		1	13
(ii) $t = 2{\cdot}45$(s) **(½)** $a = \frac{(2 \times 3{\cdot}54)}{2{\cdot}45^2}$ $a = 1{\cdot}18\,\text{m s}^{-2}$ **(½)**		1	
(iii) Uncertainty = $(\pm)\frac{t_{max} - t_{min}}{n}$ **(½)** $= (\pm)\frac{2{\cdot}65 - 2{\cdot}29}{6}$ **(½)** $= (\pm)\ 0{\cdot}06\,\text{s}$ **(1)** ($= \pm\ 2{\cdot}45\%$)	Deduct **(½)** if % wrongly calculated.	2	
(iv) TIME % Uncertainty = $0{\cdot}06/2{\cdot}45 = 2{\cdot}45\%$ **(½)** % Uncertainty in $t^2 = 4{\cdot}9\%$ **(½)** DISTANCE % Uncertainty = $0{\cdot}01/3{\cdot}54 = 0{\cdot}28\%$ **(½)** ∴ ignore Uncertainty in $a = 4{\cdot}9\%$ **(½)**	Accept 2·4% Accept 5% Accept 5%	2	
(v) Uncertainty = $\frac{1{\cdot}18 \times 4{\cdot}9}{100} = 0{\cdot}06$ **(½)** $a = (1{\cdot}18 \pm 0{\cdot}06)(\text{m s}^{-2})$ **(½)**		1	

2003 Physics Advanced Higher Sample Answers and Mark Allocation	Notes	Marks
1. (*b*)(i) $a = \frac{v^2}{r}$ **(½)** $a = \frac{36}{4 \cdot 0}$ **(½)** $a = 9 \cdot 0\,\mathrm{m\,s^{-2}}$ **(1)**		2
(ii) $F_{\text{radial}} = \frac{mv^2}{r}$ **(½)** $F_{\text{radial}} = 2 \cdot 5 \times \frac{6^2}{4}$ **(½)** $F_{\text{radial}} = 22 \cdot 5$ (N) **(½)** (Radial) force sufficient to provide this (or equivalent) **(½)**		2
(*c*) Component of reaction now acts radially **(1)** Central force increased **(1)**	Diagram acceptable for first mark.  	2

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
2. (*a*) $I = mr^2$ **(1)**		1	13
(*b*) $I = 1{\cdot}5 \times 0{\cdot}20^2$ **(1)** $(= 0{\cdot}060\,\text{kg m}^2)$		1	
(*c*)(i) $T = Fr$ **(½)** $= (25 \times 4 \times 10^{-3})$ **(½)** Resultant $T = (25 \times 4 \times 10^{-3}) - 0{\cdot}070$ **(½)** $= 0{\cdot}030\,\text{N m}$ **(½)**		2	
(ii) $T = I\alpha$ **(½)** $\alpha = 0{\cdot}030/0{\cdot}060$ **(½)** $\alpha = 0{\cdot}50\,\text{rad s}^{-2}$ **(1)**		2	
(iii) N° of revolutions = cord length/circumference **(½)** $= 0{\cdot}5/(2 \times \pi \times 4 \times 10^{-3})$ **(½)** $= 19{\cdot}9$ **(½)** θ = N° of revolutions $\times 2\pi$ $\theta = 19{\cdot}9 \times 2\pi$ **(½)** $\theta = 125$ rad	Accept $\frac{0{\cdot}5}{4 \times 10^{-3}} = 125$ rad **(2)** Accept 126 rad if No of revolutions = 20	2	
(iv) $\omega^2 = \omega_o^2 + 2\,\alpha\theta$ **(½)** $\omega^2 = 0 + 2 \times 0{\cdot}5 \times 125$ **(½)** $\omega = 11\,\text{rad s}^{-1}$ **(1)**	$\theta = \omega_o t + \frac{1}{2}\alpha t^2$ $(\omega = \omega_o + \alpha t)$ Both equations required for this **(½)** $t = 22{\cdot}4\,\text{s}$ **(½)** $\omega = 11\,\text{rad s}^{-1}$ **(1)** Accept $11{\cdot}2\,\text{rad s}^{-1}$	2	
(v) $\alpha = T/I$ **(½)** $\alpha = (-)0{\cdot}07/0{\cdot}06$ $\alpha = (-)1{\cdot}2\ (\text{rad s}^{-2})$ **(½)** - - - - - - - - - - - - - - - - $\alpha = (\omega - \omega_o)/t$ **(½)** $t = (4{\cdot}2 - 11)/-1{\cdot}2$ **(½)** $t = 5{\cdot}7\,\text{s}$ **(1)** $(11{\cdot}2 - 4{\cdot}2)$ used max – **(1½)**	Accept $1{\cdot}17\,\text{rad s}^{-2}$ $a = (\omega_o - \omega)/t$ **(0)WP** –**(½)** for sign error 11·2 taken, $t = 5{\cdot}8\,\text{s}$ $\alpha = 1{\cdot}17$, $t = 5{\cdot}98\,\text{s}$ All acceptable	3	

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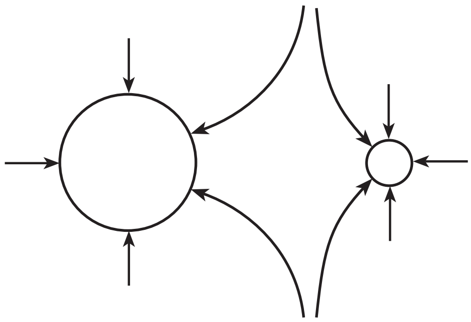
Sample Answers and Mark Allocation	Notes	Marks	
3. (*a*) 	Shape **(1)** Direction **(½)** Correct lack of symmetry **(½)**	2	8
(*b*)(i) (A) $E_p = -(GM_1M_2)/r$ **(½)** **(½)** **(½)** $= \frac{-(6{\cdot}67 \times 10^{-11} \times 7{\cdot}3 \times 10^{22} \times 15)}{1{\cdot}7 \times 10^6}$ $= -4{\cdot}3 \times 10^7$ J **(½)** (B) $E_p = \frac{-(6{\cdot}67 \times 10^{-11} \times 7{\cdot}3 \times 10^{22} \times 15)}{2{\cdot}2 \times 10^6}$ **(½)** $= -3{\cdot}3 \times 10^7$ J **(½)**	No negative –WP **(0)** $G = 6{\cdot}67 \times 10^{-11}$ **(½)** $M = 7{\cdot}3 \times 10^{22}$ **(½)**	3	
(*b*)(ii) $E_k = (-3{\cdot}3 \times 10^7) - (-4{\cdot}3 \times 10^7)$ **(½)** $E_k = 1{\cdot}0 \times 10^7$ J **(½)**	Accept $9{\cdot}8 \times 10^6$ J	1	
(b)(iii) $E_k = ½mv^2$ **(½)** $v = \sqrt{(2 \times 10^7/15)}$ **(½)** $v = \sqrt{(1{\cdot}33 \times 10^6)}$ $v = 1{\cdot}2 \text{ x } 10^3$ m s^{-1} **(1)**	Accept $1{\cdot}1 \text{ x } 10^3$ m s^{-1} if $E_k = 9{\cdot}8 \times 10^6$J is taken	2	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
4. (*a*) F_{spring} = weight of mass $F_{spring} = mg$ **(½)** $F_{spring} = 1{\cdot}5 \times 9{\cdot}8$ $F_{spring} = 15\,N$ **(½)**	Accept 14·7 N	1	6
(*b*)(i) $F_{spring} = (70 \times 15)/40$ **(½)** $F_{spring} = 26{\cdot}25$ (N) **(½)** $F_{UN} = F_{spring} - W$ $F_{UN} = 26{\cdot}25 - 15$ $F_{UN} = 11\,N$ **(1)**	$F = (-)kx$ **(½)** $k = \frac{(-)F}{x} = \frac{1{\cdot}5\times9{\cdot}8}{40\times10^{-3}} = 36{\cdot}8$ **(½)** Sub 30×10^{-3} 11 N **(1)** Accept 11·25 N **OR** consistent with (*a*) Alternative Solution 40 mm - - - - -15 N **(½)** 30 mm - - - - - $\frac{(15 \times 30)}{40}$ **(½)** =11 N **(1)**	2	
(*b*)(ii) $F_{UN} = (-)\, m\omega^2 x$ **(½)** $\omega^2 = 11/(1{\cdot}5 \times 0{\cdot}03)$ **(½)** $\omega^2 = 244$ $\omega = 15{\cdot}6$ (rad s^{-1}) **(½)** - $T = 2\pi/\omega$ **(½)** $T = 0{\cdot}40$s **(1)**	Accept 15·63 rad s^{-1} $T = 2\pi\sqrt{\frac{m}{k}}$ **(½)** k – **(1)** Sub – **(½)** $T = 0{\cdot}40$ s **(1)**	3	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
5. (*a*) Force per unit positive charge **(1)**	Must have unit AND positive. **(1,0)**	1	12
(*b*)(i) $F = QE$ **(½)** $= 1{\cdot}60 \times 10^{-19} \times 750$ **(½)** $(= 1{\cdot}20 \times 10^{-16}\,\text{N})$ $a = F/m$ **(½)** $a = (1{\cdot}2 \times 10^{-16})/(9{\cdot}11 \times 10^{-31})$ **(½)** $a = 1{\cdot}32 \times 10^{14}\,\text{m s}^{-2}$		2	
(*b*)(ii) $v^2 = u^2 + 2as$ **(½)** $v^2 = 2 \times 1{\cdot}32 \times 10^{14} \times 25 \times 10^{-3}$ **(½)** $v^2 = 6{\cdot}6 \times 10^{12}$ $v = 2{\cdot}57 \times 10^{6}\,\text{m s}^{-1}$ **(1)**	Accept $QV = \frac{1}{2}mv^2$ **(½)** $V = Ed$ $= 750 \times 25 \times 10^{-3}$ $= 18{\cdot}75$ **(½)** $v^2 = (2QV/m)$ $= \frac{(2 \times 1{\cdot}60 \times 10^{-19} \times 18{\cdot}75)}{9{\cdot}11 \times 10^{-31}}$ $v = 2{\cdot}57 \times 10^{6}\,\text{m s}^{-1}$ **(1)**	2	
(*c*)(i) $m = \frac{(9{\cdot}11 \times 10^{-31})}{\sqrt{\left(1 - \frac{(1{\cdot}5 \times 10^{8})^2}{(3{\cdot}0 \times 10^{8})^2}\right)}}$ **(½)** top DATA **(½)** Subst. $m = 1{\cdot}1 \times 10^{-30}\,\text{kg}$ **(1)**	Accept $1{\cdot}05 \times 10^{-30}\,\text{kg}$	2	
(ii) $E = mc^2$ **(½)** $E = 1{\cdot}1 \times 10^{-30} \times (3{\cdot}0 \times 10^{8})^2$ **(½)** $E = 9{\cdot}9 \times 10^{-14}\,\text{J}$ **(1)**	$M = 1{\cdot}05 \times 10^{-30}\,\text{kg}$ gives $E = 9{\cdot}5 \times 10^{-14}\,\text{J}$	2	
(*d*) $V = Q/(4\pi\varepsilon_0 r)$ **(½)** $E_k = QV$ **(½)** **(½)** **(½)** $r = \frac{(2 \times 1{\cdot}60 \times 10^{-19} \times 74 \times 1{\cdot}60 \times 10^{-19})}{(4 \times \pi \times 8{\cdot}85 \times 10^{-12} \times 1{\cdot}17 \times 10^{-12})}$ $r = 2{\cdot}91 \times 10^{-14}\,\text{m}$ **(1)**	$E_k = (Q_1Q_2)/(4\pi\varepsilon_0 r)$ **(1)** $74 \times 1{\cdot}60 \times 10^{-9}$ **(½)** $2 \times 1{\cdot}60 \times 10^{-9}$ **(½)**	3	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
6. (*a*) $F = BIl(\sin\theta)$ **(½)** $F = 0{\cdot}60 \times 0{\cdot}40 \times 0{\cdot}25$ **(½)** $F = 0{\cdot}06\,\text{N}$ **(1)**		2	7
(*b*) $T = 2 \times Fr$ **(½)** $T = 2 \times 0{\cdot}06 \times 0{\cdot}055$ **(½)** $T = 6{\cdot}6 \times 10^{-3}\,\text{N m}$ **(1)**	$T = Fr$ alone **(½) only**.	2	
(*c*) **(½)** **(½)** $T = 6{\cdot}6 \times 10^{-3} \times \cos 30°$ $T = 5{\cdot}7 \times 10^{-3}\,\text{N m}$ **(1)**		2	
(*d*) (Plane of) the loop is always parallel to the magnetic field. or Force will always act perpendicular to (the plane of) the loop. **(1)**	Idea of radial field. **(1)**	1	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
7. (*a*) $B = \mu_o I/2\pi r$ **(½)** $B = \frac{(4\pi \times 10^{-7} \times 0{\cdot}50)}{(2\pi \times 0{\cdot}12)}$ **(½)** $B = 8{\cdot}3 \times 10^{-7}$ T **(1)**		2	5
(*b*) $F/l = \mu_0 I_1 I_2/2\pi r$ **(½)** $F/l = 0{\cdot}75 \times 8{\cdot}3 \times 10^{-7}$ **(½)** $F/l = 6{\cdot}2 \times 10^{-7}$ N m^{-1} **(1)**	Accept $F/l = BI$ **(½)** Accept $6{\cdot}3 \times 10^{-7}$ N m^{-1}		
Force is repulsive or Force acts to the right **(1)**		3	

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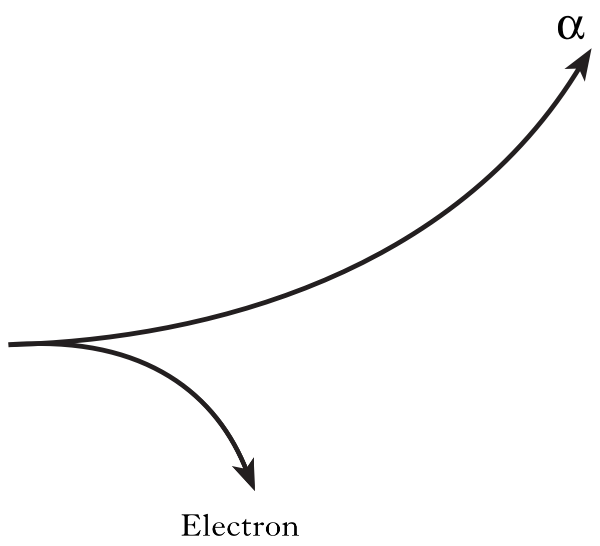
Sample Answers and Mark Allocation	**Notes**	**Marks**	
8. (*a*)(i) Force due to magnetic field and force due to electric field are balanced. **(1)**	**(½)** for "balanced." **(½)** for names of forces.	**1**	**7**
(ii) $F = QE$ **(½)** $F = QvB$ **(½)** $v = E/B$ $v = (4{\cdot}2 \times 10^3)/(2{\cdot}8 \times 10^{-3})$ $v = 1{\cdot}5 \times 10^6\,\mathrm{m\,s^{-1}}$ **(1)**	$v = E/B$ **(1)**	**2**	
(*b*) Speed of alphas equal to speed of electrons. **(1)** Speed of charged particles depends only on E and B **OR** Speed does not depend on Q or m **(1)**		**2**	
(*c*) Path of α has greater radius of curvature than path of electron **(1)** Paths in opposite directions **(½)** Paths in correct directions **(½)** 		**2**	

Sample Answers and Mark Allocation	Notes	Marks	
9. (*a*)(i) A changing/increasing current in the inductor generates a back e.m.f. **(1)**		1	10
(ii) $R = V/I$ $R = 2/0{\cdot}25$ **(½)** top and **(½)** bottom $R = 8\,\Omega$ **(1)**		2	
(ii) e.m.f. = (–) $L\frac{dI}{dt}$ **(½)** $L = 2/20$ **(½)** $L = 0{\cdot}10\,\text{H}$ **(1)**	$E = -2\,\text{V}$ required $L = -0{\cdot}10\,\text{H}$ **(½ max)**	2	
(iv) $E = \frac{1}{2}LI^2$ **(½)** $E = \frac{1}{2} \times 0{\cdot}10 \times 0{\cdot}25^2$ **(½)** $E = 3{\cdot}1 \times 10^{-3}\,\text{J}$ **(1)**		2	
(*b*) V_1 reading increases **(½)** Inductive reactance increases (or equivalent) **(1)** Current decreases ($V_2 = IR$) **(1)** so V_2 reading decreases **(½)**	Idea of conservation of energy acceptable ie as V_1 increases V_2 decreases	3	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
10. (*a*) Amplitude = 25 mm **(1)**		1	7
(*b*) $f = 55$ (Hz) **(½)** $\lambda = 16$ (mm) **(½)** – $v = f\lambda$ **(½)** $v = 55 \times 16$ **(½)** $v = 880\,\text{mm s}^{-1}$ ($v = 0{\cdot}88\,\text{m s}^{-1}$) **(1)**		3	
(*c*) $\phi = 2\pi x/\lambda$ **(½)** $\phi = 2\pi \times 24/16$ **(½)** $\phi = 3\pi\,\text{rad}$ **(1)**	Accept 16 mm - - - 2π 24 mm - - - 2π × 24/16 = 3π rad 1·5 λ **(½)** only. Must be in radians	2	
(*d*) Any multiple of 16 mm **(1)**		1	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
11. (*a*)(i) Constant phase difference/relationship between sources **(1)**		1	7
(ii) Optical path difference = Path difference × n **(1)**		1	
(iii) (A) Optical p.d. = $(n + \frac{1}{2})\lambda$ **(½)** (B) Optical p.d. = $n\lambda$ **(½)**		1	
(iv) There will be a phase change of π at the lower surface of the slide. **(1)**	$\frac{\lambda}{2}$ unacceptable	1	
(*b*)(i) Rays reflected from the surface of MgF <u>interfere destructively</u> with rays reflected from the glass surface. **(1)**		1	
(ii) $d = \lambda/4n$ **(½)** $d = \frac{(550 \times 10^{-9})}{4 \times 1{\cdot}38}$ ——— data ——— **(½)** $d = 9{\cdot}96 \times 10^{-8}$ m **(1)**		2	

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Sample Answers and Mark Allocation	**Notes**	**Marks**	
12. (*a*) Polarised Light – (The electric field vector of) the wave oscillates in one plane. Unpolarised Light – (The electric field vector of) the wave oscillates in many planes. **(1)**		**1**	**5**
(*b*) B Less than 5($W\,m^{-2}$) More than Zero **(½)** C Zero **(½)** D Less than 5($W\,m^{-2}$) More than Zero **(½)** E 5($W\,m^{-2}$) **(½)**	Units not required as given in table heading.	**2**	
(*c*) $n = \frac{\sin i_p}{\sin\theta_{glass}}$ **(½)** $i_p + \theta_{glass} = 90^\circ$ $\theta_{glass} = 90^\circ - i_p$ **(½)** $\frac{n_{glass}}{1} = \frac{\sin i_p}{\sin(90^\circ - i_p)}$ **(½)** $n_{glass} = \frac{\sin i_p}{\cos i_p}$ **(½)** $n_{glass} = \tan i_p$		**2**	

[*END OF MARKING INSTRUCTIONS*]