SCOTTISH QUALIFICATIONS AUTHORITY

2002 Physics
Advanced Higher
Finalised Marking Instructions

Strictly Confidential

These instructions are **strictly confidential** and, in common with the scripts entrusted to you for marking, they must never form the subject of remark of any kind, except to Scottish Qualifications Authority staff. Similarly, the contents of these instructions must not be copied, lent or divulged in any way now, or at any future time, to any other persons or body.

Markers' Meeting

You should use the time before the meeting to make yourself familiar with the question paper, instructions and any scripts which you have received. Do **not** undertake any final approach to marking until **after** the meeting. Please note any points of difficulty for discussion at the meeting.

Note: These instructions can be considered as final only after the markers' meeting when the full marking team has had an opportunity to discuss and finalise the document in the light of a wider range of candidates' responses.

Marking

The utmost care must be taken when entering and totalling marks. Where appropriate, all summations for totals must be carefully checked and confirmed.

Where a candidate has scored zero marks for any question attempted, "0" should be entered against the answer.

Recording of Marks

The mark for each **question**, where appropriate, should be entered on the grid provided on the back page of the answer book.

The **Total** mark for each paper should be entered in the box provided in the top-right corner of the front cover of the answer book.

Always enter the **Total** mark (using red ink) as a **whole number**, where necessary by the process of rounding up.

The transcription of marks, within scripts and to the Mark Sheet, should always be checked.

Markers are reminded that they must not write comments on scripts.

22 May 2002

Detailed Marking Instructions – AH Physics 2002

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.
S.F.	–	Significant figures.

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) No marks should be awarded for a formula unless an attempt is made to substitute data from the question.

(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.
Date in question is given to 3 significant figures.
Correct final answer is 8·16J.
Final answer 8·2J <u>or</u> 8·158J <u>or</u> 8·1576J – No penalty.
Final answer 8J <u>or</u> 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) Wrong Transposition
Question requiring F = ma
Response F = ma

$$a = \frac{m}{f} = 0 \cdot 5 ms^{-2}$$

(½ for F = ma, ½ for unit)

Calculation of acceleration using F = ma
M = 4 kg, F = 8N
Response F = ma
8 = 4 a

$$a = \frac{4}{8} = 0 \cdot 5 ms^{-2}$$

(Deduct ½ mark)
(Arithmetic error)

Only applies when (½, ½) is allocated for final answer and unit.

(n) 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) In correction subst.

2002 Physics Advanced Higher

Sample Answer and Mark Allocation	Notes	Marks	
1. (*a*) $\frac{ds}{dt} = v \therefore ds = v.dt$ **(½)** $\int ds = \int (u + at).dt$ **(½)** $s = ut + \frac{1}{2}at^2 + c$ **(½)** at $t = 0,\ c = 0$ **(½)** $\therefore s = ut + \frac{1}{2}at^2$	Accept $s = \left(\frac{u+v}{2}\right)t = \frac{u+u+at}{2} \times t$ $= ut + \frac{1}{2}at^2$ Limits given $\Rightarrow t = 0 \quad c = 0$	2	**5**
(*b*) $m = \frac{m_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$ $= \frac{9 \cdot 11 \times 10^{-31}}{\sqrt{\left(1 - \frac{(2 \times 10^8)^2}{(3 \times 10^8)^2}\right)}}$ **(½)** $= 1 \cdot 22 \times 10^{-30}$ kg **(½)**	No unit necessary		
$E = mc^2$ **(½)** $= 1 \cdot 22 \times 10^{-30} \times (3 \times 10^8)^2$ **(½)** $= 1 \cdot 1 \times 10^{-13}$ J **(1)**		3	

2002 Physics Advanced Higher

Sample Answer and Mark Allocation	Notes	Marks	
2. (a) (i) $f = \frac{2500}{60}$ (½) = 42Hz (½) $w = 2\pi f$ (½) $= 2\pi \times 42$ (½) $= 260 \text{ rad s}^{-1}$ (262 rad s^{-1} ok)	No unit necessary or $w = \frac{\theta}{t} = \frac{2500 \times 2\pi}{60}$ (½) (1½) $= 260 \text{ rads}^{-1}$	2	**11**
(ii) $E = \frac{1}{2} I w^2$ (½) $= \frac{1}{2} \times 180 \times 260^2$ (½) $= 6 \cdot 1 \times 10^6 \text{ J}$ **(1)**	Accept $6 \cdot 2 \times 10^6$ J (π carried forward)	2	
(b) (i) $w = w_o + \alpha t$ (½) $0 = 260 + \alpha \cdot 40$ (½) $\alpha = (-)\ 6 \cdot 5 \text{ rad s}^{-2}$ **(1)**	(–) not required. $w = 0$ $w_0 = 260 \text{ rads}^{-1}$ ($w_0 = 0$ gets formula (½) max)	2	
(ii) $T = I\alpha$ (½) $= 180 \times 6 \cdot 5$ (½) $= 1200$ Nm (1170 Nm) $T = F.r$ (½) $1200 = F \times 0 \cdot 4$ (½) $F = 3000$ N **(1)** 2925 N	(½) for r = 0·4 Accept 2900N if $\frac{180 \times 6 \cdot 5}{0 \cdot 4}$ used.	3	
(c) I greater **(1)** α less (½) time greater (½) I less **(0)**	first (½) conditional on justification	2	

2002 Physics Advanced Higher			
Sample Answer and Mark Allocation	**Notes**	**Marks**	
3. (*a*) **(½)** $\frac{GM_E m}{r^2} = mw^2 r$ **(½)** $r^3 = \frac{GM_E}{w^2}$ **(½)** $w = \frac{2\pi}{T}$ **(½)** $r^3 = \frac{GM_E}{4\pi^2}T^2$	Alternative using $\frac{mv^2}{r}$ *and* $v^2 = \left(\frac{2\pi r}{T}\right)^2$	2	**10**
(*b*) (i) $F = 86400$ s **(½)** $r^3 = \frac{6 \cdot 67 \times 10^{-11} \times 6 \times 10^{24} \times 86400^2}{4\pi^2}$ **(½)** $r = 4 \cdot 23 \times 10^7$ m **(½)** Unit necessary	T = 1 day treat as unit error		
height $= r - R_E$ **(½)** $= 4 \cdot 23 \times 10^7 - 6 \cdot 4 \times 10^6$ **(½)** $= 3 \cdot 6 \times 10^7$ m **(½)**	Subtraction **(½)** Substitution **(½)**	3	
(ii) $v = \frac{2\pi r}{T}$ **(½)** $= \frac{2\pi \times 4 \cdot 23 \times 10^7}{86400}$ **(½)** $= 3 \cdot 1 \times 10^3$ ms^{-1} **(1)**	Accept $v = \sqrt{\frac{Gm}{r}} = \frac{6 \cdot 67 \times 10^{-11} \times 6 \times 10^{24}}{4 \cdot 23 \times 10^7}$ T = 1 day unit error	2	
(*c*) (i) (Minimum) velocity which object must have to escape gravitational field of planet **or** reach infinite distance from planet		1	
(ii) $v = \sqrt{\frac{2GM_e}{r}} = \sqrt{\frac{2 \times 6 \cdot 67 \times 10^{-11} \times 6 \times 10^{24}}{6 \cdot 7 \times 10^6}}$ **(1)** $= 1 \cdot 1 \times 10^4$ ms^{-1} **(1)**	(½) for $r = 6{\cdot}7 \times 10^6$ $r_E = 6{\cdot}4 \times 10^6$ m max **(1½)**	2	

2002 Physics Advanced Higher			
Sample Answer and Mark Allocation	**Notes**	**Marks**	
4. (*a*) (i) amplitude = 0·08 m **(1)** (ii) period = 2·4 s **(1)**	Accept 8 cm	2	**9**
(*b*) $w = \frac{2\pi}{T}$ **(½)** $= 2\cdot 6$ **(½)** $y = 0\cdot 08 \cos 2\cdot 6t$ **(½)** **(½)**	Accept $y = 8 \cos 2\cdot 6t$	2	
(*c*) (i) $y = 0\cdot 08$ as $2\cdot 6t$ $v = \frac{dy}{dt} = -0\cdot 08 \times 2\cdot 6 \sin 2\cdot 6t$ **(½)** $= -0\cdot 21 \sin 2\cdot 6t$ $a = \frac{dv}{dt} = -0\cdot 21 \times 2\cdot 6 \cos 2\cdot 6t$ **(½)** $= -0\cdot 55 \cos 2\cdot 6t$ **(1)**	**or** $y = A \cos wt$ $v = \frac{dy}{dt} = -Aw \sin wt$ **(½)** $a = \frac{dv}{dt} = -Aw^2 \cos wt$ **(½)** $= -0\cdot 55 \cos 2\cdot 6t$ **(1)** NB Rounded up twice—could come out as $-0\cdot 54 \cos 2\cdot 6t$	2	
(ii) $V = 0\cdot 21 \sin 2\cdot 6t$ (from above) V_{max} when $\sin 2\cdot 6t = \pm 1$ $V_{max} = 0\cdot 21$ **(1)** $E_{K\,max} = \frac{1}{2}mv^2$ **(½)** $= \frac{1}{2} \times 0\cdot 4 \times 0\cdot 21^2$ **(½)** $= 8\cdot 8 \times 10^{-3}$ J **(1)** **or** $E_K = \frac{1}{2}mw^2(A^2 - y^2)$ **(½)** max when $y = 0$ **(½)** $E_{K\,max} = \frac{1}{2}mw^2A^2$ **(½)** $= \frac{1}{2} \times 0\cdot 4 \times 2\cdot 6^2 \times 0\cdot 08$ **(½)** $= 8\cdot 7 \times 10^{-3}$ J **(1)**	Beware of consistency with (i) If $a = 8$ cm used then treat J as incorrect unit Answers differ because of rounding.	3	

2002 Physics Advanced Higher			
Sample Answer and Mark Allocation	**Notes**	**Marks**	
5. (*a*) (i) electron diffraction **or** electron microscopy	Professional Judgement	1	**5**
(ii) deflection tube **or** photoelectric effect **or** similar		1	
(*b*) (i) $\lambda = \frac{h}{mv}$ **(½)** $= \frac{6 \cdot 63 \times 10^{-34}}{0 \cdot 06 \times 55}$ **(½)** $= 2 \cdot 0 \times 10^{-34}$ m **(1)**		2	
(ii) λ too small to be observed.		1	

2002 Physics Advanced Higher

Sample Answer and Mark Allocation	Notes	Marks	
6. (*a*) $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$ **(½)** $= \frac{1}{4\pi\times8\cdot85\times10^{12}}\times\frac{(1\cdot6\times10^{-19})^2}{(0\cdot01\times10^{-3})^2}$ **(½)** $= 2\cdot3\times10^{-18}\,\text{N}$ **(1)**		2	**8**
(*b*) (i) Strong force **(1)** (ii) This force only operates over very short range ($< 10^{-14}$ m)	**or** only operates inside nucleus	2	
(*c*) $(E_K = E_P)$ **(½)** **(½)** $\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r}$ **(½)** **(½)** $Q = 79\times1\cdot6\times10^{-19} = 1\cdot26\times10^{-17}$ $q = 2\times1\cdot6\times10^{-19} = 3\cdot2\times10^{-19}$ **(½)** $\frac{1}{2}\times6\cdot7\times10^{-27}\times(2\times10^6)^2$ **(½)** $= \frac{1}{4\pi\times8\cdot85\times10^{-12}}\times\frac{1\cdot26\times10^{-17}\times3\cdot2\times10^{-19}}{r}$ $r = 2\cdot7\times10^{-12}\,\text{m}$ **(½)** **(1)**	**or** $E_K = \frac{1}{2}mv^2$ **(½)** $= \frac{1}{2}\times6\cdot7\times10^{-27}\times(2\times10^6)^2$ $= 1\cdot34\times10^{-14}$ **(½)** $E_K = E_P$ **(½)** $E_P = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r}$ **(½)** $1\cdot34\times10^{-14}$ $= \frac{1}{4\pi\times8\cdot85\times10^{-12}}$ **(½)** $\times\frac{1\cdot26\times10^{-17}\times3\cdot2\times10^{-19}}{r}$ **(½)**		
$r = \frac{2Qq}{4\pi t_0 mv^2}$ **(1½)**	$r = 2\cdot7\times10^{-12}\,\text{m}$ **(1)**	4	

2002 Physics Advanced Higher			
Sample Answer and Mark Allocation	**Notes**	**Marks**	
7. (*a*) $E_K = W.d$ $\frac{1}{2}mv^2 = qV$ **(½)** $\frac{1}{2} \times 9 \cdot 11 \times 10^{-31} \times v^2 = 1 \cdot 6 \times 10^{-19} \times 2000$ **(½)** $v = 2 \cdot 7 \times 10^7\ \text{ms}^{-1}$ **(1)**		2	**12**
(*b*) (i) A Vertical acceleration upwards **(1)** Constant horizontal speed **(1)** ∴ parabolic path **(½)** B No (unbalanced) forces **(½)** ∴ (Constant speed) in straight line **(½)**		3	
(ii) $E = \frac{V}{d}$ **(½)** $= \frac{250}{0 \cdot 02}$ **(½)** $= 1 \cdot 25 \times 10^4$ $F = Eq$ **(½)** $= 1 \cdot 25 \times 10^4 \times 1 \cdot 6 \times 10^{-19}$ **(½)** $= 2 \cdot 0 \times 10^{-15}$ $F = ma$ $2 \cdot 0 \times 10^{-15} = 9 \cdot 11 \times 10^{-31} \times a$ **(½)** $a = 2 \cdot 2 \times 10^{15}\ \text{ms}^{-2}$ **(½)**	**or** $F = Eq$**(½)** $= \frac{V}{d} \cdot q$ **(½)** $= \frac{250}{0 \cdot 02} \times 1 \cdot 6 \times 10^{-19}$ **(½)+(½)** $= 2 \times 10^{-15}\text{N}$ Then as before.	3	
(*c*) (i) Force always perpendicular to velocity **(½)** so directed to centre of circle (and speed is constant) **(½)**	Centripetal alone **(½)**	1	
(ii) $F = Bqv$ **(½)** $2 \times 10^{-15} = B \times 1 \cdot 6 \times 10^{-19} \times 2 \cdot 7 \times 10^7$ **(½)** $B = 4 \cdot 6 \times 10^{-4}\ \text{T}$ **(1)** into page **(1)**	**or** $B = \frac{E}{v} = \frac{1 \cdot 25 \times 10^4}{2 \cdot 7 \times 10^7}$ $= 4 \cdot 6 \times 10^{-4}\ \text{T}$ NB if no direction given max 2 out of 3 ($v = 2 \cdot 65 \times 10^7\ \text{ms}^{-1}$ gives $B = 4 \cdot 7 \times 10^{-4}\ \text{T}$)	3	

2002 Physics Advanced Higher

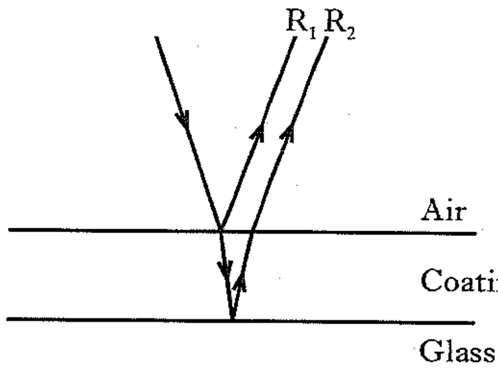
Sample Answer and Mark Allocation	Notes	Marks	
8. (*a*) (i) Average force $= \frac{3\cdot8+3\cdot4+3\cdot3+3\cdot7+3\cdot3}{5}$ $= 3\cdot5$ mN **(½)** $B = \frac{F}{I\ell} = \frac{3\cdot5\times10^{-3}}{2\cdot5\times0\cdot05} = 0\cdot028$ (T) **(½)**	Unit not necessary.	1	**13**
(ii) Random uncertainty in force $= \frac{3\cdot8-3\cdot3}{5}$ $= 0\cdot1$ mN **(½)** % uncertainty in force $= \frac{0\cdot1}{3\cdot5}\times100 = 2\cdot9\%$ **(½)** % uncertainty in current $= \frac{0\cdot01}{2\cdot5}\times100 = 0\cdot4\%$ **(½)** **ignore** **(½)** % uncertainty in length $= \frac{0\cdot001}{0\cdot05} = 2\%$ **(½)** % uncertainty in B $= \sqrt{2\cdot9^2+2^2}$ $= 3\cdot5\%$ **(½)** Absolute uncertainty in B $= 0\cdot001$ (T) **(1)**	Accept fractional uncertainties Unit unnecessary.	4	
(iii) Take more readings of force **(1)** to reduce random uncertainty **(1)** **or** use longer conductor **(1)** so percentage uncertainty is smaller **(1)** **or** More accurate balance **(1)** to give to 2dp **(1)**	**or** Vernier callipers **(1)** to reduce % uncertainty in ℓ **(1)**	2	
(*b*) (i) Current parallel to field (so no force)		1	
(ii) $F = BI\ell\times n$ **(½)** $= 0\cdot1\times2\cdot2\times0\cdot05\times20$ **(½)** $= 0\cdot22$N $T = F.r\times2$ **(½)** $= 0\cdot22\times0\cdot02\times2$ **(½)** $= 8\cdot8\times10^{-3}$ Nm **(1)**	$T = BInA\sin\theta$ acceptable Omit n (–1) Omit $\times 2$ (–1) $T = Fr$ (½) (alone) $F = BI\ell$ (½) Accept explanation based	3	
(iii) Torque is reduced **(1)** because perpendicular distance from axle to line of action of force is less **(1)**		2	

2002 Physics Advanced Higher			
Sample Answer and Mark Allocation	**Notes**	**Marks**	
9. (*a*) (–) 12 V **(1)**	ignore sign	1	**8**
(*b*) $\frac{dI}{dt} = 4 \cdot 5 \text{As}^{-1}$ **(1)** $(4-5)\text{As}^{-1}$		1	
(*c*) $E = -L\frac{dI}{dt}$ **(½)** $-12 = -L \times 4 \cdot 5$ **(½)** $L = (2 \cdot 4 - 3)\text{H}$ **(1)** Sign violation max penalty **(½)**	$E = L\frac{dI}{dt}$ –(0) W.P.	2	
(*d*) $V = IR$ **(½)** $12 = 0 \cdot 096 \times R$ **(½)** $R = 125\,\Omega$ **(1)**	(Accept 130 Ω)	2	
(*e*) $E = \frac{1}{2}LI^2$ **(½)** $= \frac{1}{2} \times 2 \cdot 7 \times (0 \cdot 096)^2$ **(½)** $= 0 \cdot 012\text{ J}$ **(1)**	Check for carry through errors.	2	

2002 Physics Advanced Higher

Sample Answer and Mark Allocation	Notes	Marks	
10. (*a*) (i) $V = f\lambda$ **(½)** $\lambda = \frac{0 \cdot 05}{3} = 0 \cdot 017$ (m) **(½)** $A = 0 \cdot 04$ m $f = 3$ Hz $y = \overset{(\frac{1}{2})}{0 \cdot 04} \sin 2\pi \left(\overset{(\frac{1}{2})}{3t} + \overset{(\frac{1}{2})}{\frac{x}{0 \cdot 017}} \right)$ **(½)**	(½) mark each for inserting A, f, λ and (½) for + sign Accept cos Accept $y = 0 \cdot 04 \sin (19t + 370x)$	3	**10**
(ii) intensity α (amplitude)^2 **(½)** $\frac{1}{2}$ amplitude $\Rightarrow$ $\frac{1}{4}$ intensity **(½)**	**or** <u>reduced</u> by factor of 4	1	
(*b*) Constructive, Antinode } **(1)** Destructive, Node } **(1)**		2	
(*c*) (i) $f = fs \times \frac{V}{V + Vs}$ **(½)** $= 200 \times \frac{340}{340 + 30}$ **(½)** $= 180$ Hz **(1)**	Accept 184 Hz	2	
(ii) Shift to red end $\Rightarrow$ lower frequency **(1)** (longer wavelength) lower frequency $\Rightarrow$ moving away **(1)** (longer wavelength)	First mark independent	2	

2002 Physics Advanced Higher

Sample Answer and Mark Allocation	Notes	Marks	
11. (*a*) (i)  **(1)** Phase difference between R_1 & R_2 is π **(½)** **or** optical path difference is $\left(\frac{\lambda}{2}\right)$ ∴ Destructive interference ∴ no reflection **(½)**	Diagram (1, ½, 0) If phase changes incorrect (–1)	2	9
(ii) $t = \frac{\lambda}{4n}$ **(½)** $= \frac{500\times10^{-9}}{4\times1\cdot38}$ **(½)** $= 9\cdot1\times10^{-8}$ m **(1)**	$n = 1\cdot38$ (½) data	2	
(iii) 500 nm is around middle of spectrum **(½)** so some red and some blue light reflected **(½)** They combine to give purple **(1)**		2	
(*b*) fringe spacing $= \frac{0\cdot1}{4}$ **(½)** $= 0\cdot025$ m **(½)**	Unit not necessary.		
$\lambda = \frac{\Delta x.d}{D}$ **(½)** $= \frac{0\cdot025\times5\times10^{-5}}{2}$ **(½)** $= 6\cdot3\times10^{-7}$ m **(1)**	5 fringes give $\lambda = 5\times10^{-7}$m	3	

[*END OF MARKING INSTRUCTIONS*]