2010 Physics

Advanced Higher

Marking Instructions

Part One: General Marking Principles for Physics – Advanced Higher

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this Paper. These principles must be read in conjunction with the specific Marking Instructions for each question.

(a) Marks for each candidate response must always be assigned in line with these general marking principles and the specific Marking Instructions for the relevant question. If a specific candidate response does not seem to be covered by either the principles or detailed Marking Instructions, and you are uncertain how to assess it, you must seek guidance from your Team Leader/Principal Assessor. You can do this by posting a question on the Marking Team forum or by e-mailing/phoning the e-marker Helpline. Alternatively, you can refer the issue directly to your Team Leader by checking the 'Referral' box on the marking screen.

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) 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.)

(c) 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.

(d) The total for the paper should be rounded up to the nearest whole number.

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.) Excess significant figures
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.
"X"	–	Wrong Physics
✳	–	Parts or all of questions in the wrong sequence for adding for EMC entry.

No other annotations are allowed on the scripts. DO NOT WRITE ANY COMMENTS ON THE SCRIPT.

3. **General Instructions (Refer to National Qualifications Marking Instructions 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 than 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. To obtain the ½ mark for substitution the numerical values of constants must be substituted with the exception of π.
However, when the numerical answer is given or a derivation of a formula is required every step must be shown explicitly.

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

In a numerical show question if the candidate gives the incorrect unit in the final answer deduct ½ mark. If no unit is given, no deduction.

(e) Where, for example, 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 (eg. wrong formula, wrong substitution) **unless specifically allowed for in the marking scheme – eg. marks can be awarded for <u>data</u> retrieval. Failure to convert units correctly should be treated as a unit error at the end and not wrong substitution.**

(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.

The exceptions to this are:

- where the numerical answer is given
- where the required equation is given.

(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.**

Max ½ mark deduction per question. Max 2½ deduction from question paper.

(m) Squaring Error

$E_K = ½ mv^2 = ½ \times 4 \times 2^2 = 4J$ **Award 1½** Arith error

$E_K = ½ mv^2 = ½ \times 4 \times 2 = 4J$ **Award ½ for formula.** Incorrect substitution.

The General Marking Instructions booklet should be brought to the Markers' Meeting.

Physics − Marking Issues

The current in a resistor is 1·5 amperes when the potential difference across it is 7·5 volts. Calculate the resistance of the resistor.

	Answers	Mark + comment	Issue
1.	$V = IR$ $7{\cdot}5 = 1{\cdot}5R$ $R = 5\cdot0\Omega$	(½) (½) (1)	Ideal Answer
2.	$5\cdot0\Omega$	(2) Correct Answer	GMI 1
3.	5·0	(1½) Unit missing	GMI 2(a)
4.	$4\cdot0\Omega$	(0) No evidence/Wrong Answer	GMI 1
5.	_____Ω	(0) No final answer	GMI 1
6.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=4{\cdot}0\,\Omega$	(1½) Arithmetic error	GMI 7
7.	$R=\frac{V}{I}=4{\cdot}0\,\Omega$	(½) Formula only	GMI 4 and 1
8.	$R=\frac{V}{I}=$ _____Ω	(½) Formula only	GMI 4 and 1
9.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=$ _____Ω	(1) Formula + subs/No final answer	GMI 4 and 1
10.	$R=\frac{V}{I}=\frac{7{\cdot}5}{1{\cdot}5}=4{\cdot}0$	(1) Formula + substitution	GMI 2(a) and 7
11.	$R=\frac{V}{I}=\frac{1{\cdot}5}{7{\cdot}5}=5{\cdot}0\,\Omega$	(½) Formula but wrong substitution	GMI 5
12.	$R=\frac{V}{I}=\frac{75}{1{\cdot}5}=5{\cdot}0\,\Omega$	(½) Formula but wrong substitution	GMI 5
13.	$R=\frac{I}{V}=\frac{7{\cdot}5}{1{\cdot}5}=5{\cdot}0\,\Omega$	(0) Wrong formula	GMI 5
14.	$V=IR \quad 7{\cdot}5=1{\cdot}5\times R$ $R=0{\cdot}2\,\Omega$	(1½) Arithmetic error	GMI 7
15.	$V=IR$ $R=\frac{I}{V}=\frac{1{\cdot}5}{7{\cdot}5}=0{\cdot}2\,\Omega$	(½) Formula only	GMI 20
16.	$R=\frac{7.5}{1.5}=4\Omega$	(1½) Implied formula with an arithmetic error	GMI 12

Data Sheet

Common Physical Quantities

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Gravitational acceleration on Earth	g	$9{\cdot}8\ ms^{-2}$	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31} kg$
Radius of Earth	R_E	$6{\cdot}4 \times 10^{6} m$	Charge on electron	e	$-1{\cdot}60 \times 10^{-19} C$
Mass of Earth	M_E	$6{\cdot}0 \times 10^{24} kg$	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27} kg$
Mass of Moon	M_M	$7{\cdot}3 \times 10^{22} kg$	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27} kg$
Radius of Moon	R_M	$1{\cdot}7 \times 10^{6} m$	Mass of alpha particle	$m_\propto$	$6{\cdot}645 \times 10^{-27} kg$
Mean Radius of Moon Orbit		$3{\cdot}84 \times 10^{8} m$	Charge on alpha particle		$3{\cdot}20 \times 10^{-19} C$
Universal constant of gravitation	G	$6{\cdot}67 \times 10^{-11} m^3 kg^{-1} s^{-2}$	Planck's constant	h	$6{\cdot}63 \times 10^{-34} Js$
Speed of light in vacuum	c	$3{\cdot}0 \times 10^{8} ms^{-1}$	Permittivity of free space	ε_0	$8{\cdot}85 \times 10^{-12} Fm^{-1}$
Speed of sound in air	v	$3{\cdot}4 \times 10^{2} ms^{-1}$	Permeability of free space	μ_0	$4\pi \times 10^{-7} Hm^{-1}$

Refractive Indices

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Glycerol	1·47
Glass	1·51	Water	1·33
Ice	1·31	Air	1·00
Perspex	1·49	Magnesium Fluoride	1·38

Spectral Lines

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers		
Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 } 10590 }	Infrared
Helium-neon	633	Red

Properties of selected Materials

Substance	*Density*/ kg m^{-3}	*Melting Point*/K	*Boiling Point*/K	*Specific Heat Capacity*/ J kg^{-1} K^{-1}	*Specific Latent Heat of Fusion*/ J kg^{-1}	*Specific latent Heat of Vaporisation*/ J kg^{-1}
Aluminium	$2{\cdot}70 \times 10^3$	933	2623	$9{\cdot}02 \times 10^2$	$3{\cdot}95 \times 10^5$	….
Copper	$8{\cdot}96 \times 10^3$	1357	2853	$3{\cdot}86 \times 10^2$	$2{\cdot}05 \times 10^5$	….
Glass	$2{\cdot}60 \times 10^3$	1400	….	$6{\cdot}70 \times 10^2$	….	….
Ice	$9{\cdot}20 \times 10^2$	273	….	$2{\cdot}10 \times 10^3$	$3{\cdot}34 \times 10^5$	….
Gylcerol	$1{\cdot}26 \times 10^3$	291	563	$2{\cdot}43 \times 10^3$	$1{\cdot}81 \times 10^5$	$8{\cdot}30 \times 10^5$
Methanol	$7{\cdot}91 \times 10^2$	175	338	$2{\cdot}52 \times 10^3$	$9{\cdot}9 \times 10^4$	$1{\cdot}12 \times 10^6$
Sea Water	$1{\cdot}02 \times 10^3$	264	377	$3{\cdot}93 \times 10^3$	….	….
Water	$1{\cdot}00 \times 10^3$	273	373	$4{\cdot}19 \times 10^3$	$3{\cdot}34 \times 10^5$	$2{\cdot}26 \times 10^6$
Air	$1{\cdot}29$	….	….	….	....	….
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20	$1{\cdot}43 \times 10^4$	....	$4{\cdot}50 \times 10^5$
Nitrogen	$1{\cdot}25$	63	77	$1{\cdot}04 \times 10^3$	….	$2{\cdot}00 \times 10^5$
Oxygen	$1{\cdot}43$	55	90	$9{\cdot}18 \times 10^2$	….	$2{\cdot}40 \times 10^5$

The gas densities refer to a temperature of 273 K and pressure of $1{\cdot}01 \times 10^5$ Pa.

Part Two: Marking Instructions for each Question

Section A

Question			Expected Answer/s	Max Mark	Additional Guidance
1	**a**		$v = \frac{s}{t}$ (½) $v = \frac{2\pi r}{T}$ (½) for $s = 2\pi r$, (½) for sub (1) $\omega = \frac{2\pi}{T}$ **Must be stated** (½) **Acceptable to use t or T** $v = r\omega$ **In proofs, each step must be shown explicitly**	**2**	$v = \frac{s}{t}$ (½) **Accept d for s.** $v = \frac{r\theta}{t}$ (1) (½) for $s = r\theta$ (½) for sub $\omega = \frac{\theta}{t}$ (½) **Must be stated** $v = r\omega$ **No mark for final line** $s = r\theta$ $(\frac{1}{2})$ $\frac{ds}{dt} = \frac{rd\theta}{dt}$ $(\frac{1}{2})$ $v = \frac{ds}{dt}$ $(\frac{1}{2})$ $\omega = \frac{d\theta}{dt}$ $(\frac{1}{2})$ All 4 explicitly shown
1	**b**	**i**	$\omega = \frac{\theta}{t}$ (½) $= \frac{3\cdot1}{4\cdot5} = 0\cdot69$ (½) $v = r\omega$ $= 0\cdot69 \times 0\cdot148$ $= 0\cdot10 \text{ m s}^{-1}$ (1)	**2**	1

Question			Expected Answer/s	Max Mark	Additional Guidance
1	**b**	**ii**	$\% \Delta \theta = \frac{0 \cdot 1}{3 \cdot 1} \times 100 = 3{\cdot}2\%$ $\% \Delta t = \frac{0 \cdot 1}{4 \cdot 5} \times 100 = 2{\cdot}2\%$ $\% \Delta r = \frac{0 \cdot 001}{0 \cdot 148} \times 100 = 0{\cdot}68\%$ (1) **Check correct rounding** $\% \Delta \omega = \sqrt{(\% \Delta \theta^2 + \% \Delta t^2 + \% \Delta r^2)}$ (½) $= \sqrt{(3{\cdot}2^2 + 2{\cdot}2^2 + 0{\cdot}68^2)}$ $= 3{\cdot}9$ (%) (½)	**2**	Fractional uncertainties okay, but must convert to % in final line for the **(½)**
1	**b**	**iii**	(A) velocity changing or changing direction (B) towards centre (of turntable)	**1** **1**	

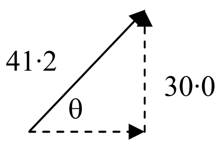
Question			Expected Answer/s	Max Mark	Additional Guidance
2	a		$F = m r \omega^2$ (½) $= 0{\cdot}2 \times 0{\cdot}35 \times 6.0^2$ (½) $= 2{\cdot}5$ N (1)	2	
2	b		$\tan\theta = \frac{m\omega^2 r}{mg}$ or $= \frac{\omega^2 r}{g}$ or $= \frac{v^2}{rg}$ (½) $= \frac{2\cdot5}{0\cdot2\times9\cdot8}$ or $\frac{6.0^2\times0\cdot35}{9\cdot8}$ or $\frac{2\cdot1^2}{0\cdot35\times9\cdot8}$ (½) (1) $\theta = 52°$	2	
2	c		θ decreases (independent mark) (1) Centripetal force or $r\omega^2$ or v^2 / r decreases (1)	2	

Question			Expected Answer/s	Max Mark	Additional Guidance
3	a		$\alpha = \frac{\omega - \omega_0}{t}$ (½) $= \frac{35-0}{0 \cdot 55}$ (½) $= 64$ rad s^{-2} (1)	2	$\alpha = -64$ rad s^{-2} (½) for equation only
3	b		θ = area under graph (½) = ½ × b × h (½) = ½ × 0·55 × 35 (½) = 9·6 rad (½) s = r × θ (½) = 0·14 × 9·6 (½) = 1·3 m **Leniency with rounding in this question.**	3	**Show question** $\theta = \bar{\omega}\, t$ (½) $\bar{\omega} = 35 / 2 = 17 \cdot 5$ (½) θ = 17·5 × 0·55 (½) = 9·6 rad (½) **Or** $a_t = r\alpha$ (½) = 0.14 x 64 = 8.96 (½)+(½) $s = ut + ½ at^2$ (1) $= 0 + ½ \times 8.96 \times 0.55^2$ (½) Rounding to 64 gives 1.4 m - **Do not penalise as no mark for final line.** $\theta = \omega_o t + \frac{1}{2}\alpha t^2$ (1) $\theta = 0 \times 0.55 + \frac{1}{2} \times 64 \times 0.55^2$ ($\frac{1}{2}$) $\theta = 9.68$ ($\frac{1}{2}$) accept 9.6 $s = r\theta$ ($\frac{1}{2}$) $s = 0.14 \times 9.68$ ($\frac{1}{2}$) gives 1.36 m

Question			Expected Answer/s	Max Mark	Additional Guidance
3	c		$mgh = 2{\cdot}5 \times 9{\cdot}8 \times 1{\cdot}3$ (1) $v = \omega \times r$ (½) $= 35 \times 0{\cdot}14$ $= 4{\cdot}9\ ms^{-1}$ (½) $mgh = \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2$ (½) $2{\cdot}5 \times 9{\cdot}8 \times 1{\cdot}3 = \frac{1}{2} \times 2{\cdot}5 \times 4{\cdot}9^2 + \frac{1}{2} \times I \times 35^2$ (½) $31{\cdot}85 = 30{\cdot}01 + 612{\cdot}5 \times I$ $I = \left(\frac{1.84}{612.5}\right)$ $= 3{\cdot}0 \times 10^{-3}\ kg\ m^2$ (1)	4	

Question			Expected Answer/s		Max Mark	Additional Guidance
4	a		**Total angular** momentum before (an event) = **total angular** momentum after (an event) in the absence of external torques	(½) (½)	1	
4	b	i	$L = I \times \omega$ $= 4{\cdot}1 \times 2{\cdot}7$ $= 11$ kg m^2 s^{-1} or kg m^2 rad s^{-1}	(½) (½) (1)	2	
4	b	ii	$I_m = m r^2 = (2{\cdot}5 \times 0{\cdot}60^2) = \mathbf{0{\cdot}90}$ kg m^2 $I_T = (4{\cdot}1 + 0{\cdot}90) = \mathbf{5{\cdot}0}$ kg m^2 $I_0 \times \omega_0 = I_T \times \omega_T$ $11 = 5.0 \times \omega$ $\omega = 2{\cdot}2$ rad s^{-1}	(½) (½) (½) (½) (1)	3	
4	b	iii	ω increased r reduced / I reduced since L or I ω constant	(1) (½) (½)	2	
4	c		$\alpha = \frac{\omega - \omega_0}{t}$ $= \frac{0 - 1\cdot 5}{0\cdot 75}$ $= -2{\cdot}0$ rad s^{-2}	(½) (½)	3	α = +2.0 (½) max possible for equation
			$\tau = I \times \alpha$ $= 4{\cdot}5 \times -2$ $= -9$ N m	(½) (½) (1)		

Question			Expected Answer/s	Max Mark	Additional Guidance
5	a		$a = -\omega^2 y$ (½) $-35 = -\omega^2 \times 0{\cdot}012$ or $35 = -\omega^2 \times (-0{\cdot}012)$ (½) $\omega = 54$ rad s^{-1}	1	
5	b		y = 0·012 sin or cos 54t (1) (½) (½)	2	
5	c		$v = \frac{dy}{dt}$ or $\frac{d(0 \cdot 012 \sin 54t)}{dt}$ (½) v = (+) 0·65 cos 54t **or** v = – 0·65 sin 54t (1½)	2	Must be consistent with (b) can be sin or cos .
5	d		$E_k = ½ m \omega^2 A^2$ (½) $= ½ \times 1{\cdot}4 \times 54^2 \times 0{\cdot}012^2$ (½) = 0·29 J (1)	2	

Question			Expected Answer/s	Max Mark	Additional Guidance
6	**a**		$E = \frac{Q}{4\pi\varepsilon_o r^2}$ (½) $E = \frac{(-)1\cdot92\times10^{-12}}{4\times\pi\times8\cdot85\times10^{-12}\times(1\cdot00\times10^{-3})^2}$ (½) $E = (-)\,1\cdot73\times10^{4}\ NC^{-1}$ (1)	**2**	
6	**b**	**i**	Student A (1)	**1**	
6	**b**	**Ii**	E-field is zero inside a hollow conductor. (1) E-field has inverse square dependence outside the conductor. (1)	**2**	
6	**c**	**i**	$F = \frac{Q_1Q_2}{4\pi\varepsilon_o r^2}$ (½) $F = \frac{(-)2\cdot97\times10^{-8}\times(-)1\cdot92\times10^{-12}}{4\times\pi\times8\cdot85\times10^{-12}\times(4\cdot12\times10^{-2})^2}$ (½) $F = 3\cdot02\times10^{-7}\ N$ (1)	**2**	
6	**c**	**Ii**	 $\sin\theta = \frac{30\cdot0}{41\cdot2}$ (½) $\theta = 46\cdot7°$ $F = F\times\sin\theta$ (½) $F = 3\cdot02\times10^{-7}\times\sin 46\cdot7°$ $F = 2\cdot20\times10^{-7}\ N$ (1)	**2**	Accept 47° or accept 43°

Question			Expected Answer/s	Max Mark	Additional Guidance
6	c	iii	Resultant F = $4 \times F$ = $8{\cdot}80 \times 10^{-7}$ N (1)	1	
6	c	iv	Resultant F = $m \times g$ (½) $8{\cdot}80 \times 10^{-7}$ = $m \times 9{\cdot}8$ (½) m = 9.0×10^{-8} kg (1)	2	

Question			Expected Answer/s	Max Mark	Additional Guidance
7	**a**		Magnetic field is out of the page (1)	**1**	
7	**b**		$q \times v \times B = m \times \frac{v^2}{r}$ (½) (½) (½) (1½) $r = \frac{m \times v}{q \times B}$ $= \frac{1 \cdot 673 \times 10^{-27} \times 6 \cdot 0 \times 10^{6}}{1 \cdot 6 \times 10^{-19} \times 0 \cdot 75}$ (½) sub $r = 8{\cdot}4 \times 10^{-2}$ m (1)	**3**	
7	**c**		$q \times E = q \times v \times B$ (½) $E = v \times B$ $= 6{\cdot}0 \times 10^{6} \times 0{\cdot}75$ (½) $E = 4{\cdot}5 \times 10^{6}$ Vm^{-1} (1)	**2**	
7	**d**	**i**	$½ \times m \times v^2 = \frac{qQ}{4\pi\varepsilon_0 r}$ (1) $r = \frac{qQ}{2 \times \pi \times \varepsilon_0 \times m \times v^2}$	**1**	Both equations correctly equated for one mark (1) or (0)
7	**d**	**ii**	$r = \frac{qQ}{2 \times \pi \times \varepsilon_0 \times m \times v^2}$ $= \frac{1 \cdot 60 \times 10^{-19} \times (29 \times 1 \cdot 6 \times 10^{-19})}{2 \times \pi \times 8 \cdot 85 \times 10^{-12} \times 1 \cdot 673 \times 10^{-27} \times (6 \cdot 0 \times 10^{6})^2}$ (2) $r = 2{\cdot}2 \times 10^{-13}$ m (1)	**3**	(½) for substitution (½) for **proton mass** data (1) for **atomic no. copper** data (gives 4.64×10^{-18} C = Q_{Cu})

Question			Expected Answer/s	Max Mark	Additional Guidance
7	**d**	**iii**	Strong (nuclear) force. (1)	**1**	
7	**e**		Reverse direction of magnetic field. (1) Reduce strength of magnetic field. (1)	**2**	

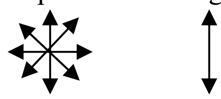
Question			Expected Answer/s	Max Mark	Additional Guidance
8	**a**		$q \times V = \frac{1}{2} \times m \times v^2$ (½) $1{\cdot}60 \times 10^{-19} \times 2400 = \frac{1}{2} \times 9{\cdot}11 \times 10^{-31} \times v^2$ (½) $v^2 = 8{\cdot}43 \times 10^{14}$ $v = 2{\cdot}90 \times 10^{7}\ ms^{-1}$ (1)	**2**	Must have both equations.
8	**b**	**i**	(Constant) force / acceleration / electric force / electric field in **vertical direction / upwards / downwards** (½) (Constant) motion / speed in horizontal direction (½)	**1**	
8	**b**	**ii**	No (unbalanced) force / field / attraction acting on electron. (1)	**1**	
8	**c**	**i**	$E = \frac{V}{d}$ $= 100/0.01$ (½) $= (10^4\ Vm^{-1})$ $F = QE$ $= 1{\cdot}60 \times 10^{-19} \times 100/0{\cdot}01$ (½) $= 1{\cdot}60 \times 10^{-15}\ N$ $a = \frac{F}{m}$ (½) $= \frac{1.60 \times 10^{-15}}{9{\cdot}11 \times 10^{-31}}$ (½) $a = 1{\cdot}76 \times 10^{15}\ ms^{-2}$	**2**	
8	**c**	**ii**	$t = \frac{s_H}{v_H}$ (½) $= 5{\cdot}17 \times 10^{-10}\ s$ (½) $v_v = u_v + a_v \times t$ (½) $= 0 + 1{\cdot}76 \times 10^{15} \times 5{\cdot}17 \times 10^{-10}$ (½) $v_v = 9{\cdot}10 \times 10^{5}\ ms^{-1}$ (1)	**3**	

Question			Expected Answer/s	Max Mark	Additional Guidance
8	**d**		Length scanned decreases. (1) v_H increases / greater acceleration. (½) Shorter time between plates (½) **or** vertical speed is less on leaving the plates.	**2**	

Question			Expected Answer/s	Max Mark	Additional Guidance
9	a		f = 2·4 Hz (1)	1	
9	b		λ = 0.5 m (½) v = f λ (½) = 2·4 × 0·5 = 1·2 ms^{-1} (1)	2	
9	c		y = 4·3 × 10^{-2} sin 2 π (2·4t + 2·0x) (2) (1) (1)	2	

Question			Expected Answer/s	Max Mark	Additional Guidance
10	a		Fringes produced by **interference** of light (1) reflected from **top** and **bottom** surfaces of the film. (½) Different thicknesses / wavelengths / positions / (½) angles affect colours seen.	2	
10	b		For non-reflecting coating, **Optical P.D.** = $\lambda/2$ (½) for **destructive** interference (½) **Optical** P.D. = 2nd (½) 2nd = $\lambda/2$ (½) $d = \dfrac{\lambda}{4 \times n}$	2	
10	c		$2 \times n \times d = (1½) \times \lambda$ (½) $2 \times 1{\cdot}3 \times d = 1{\cdot}5 \times 7{\cdot}80 \times 10^{-7}$ (½) $d = 4{\cdot}50 \times 10^{-7}$ m (1)	2	**or** λ in material = $7{\cdot}80 \times 10^{-7} / 1.3$ = $6{\cdot}0 \times 10^{-7}$m, (½) so add $3{\cdot}0 \times 10^{-7}$m (½)
10	d	i	$E_k = ½ \times m \times v^2$ (½) $4{\cdot}12 \times 10^{-21} = ½ \times 1{\cdot}43 \times 10^{-25} \times v^2$ (½) $v = \sqrt{\dfrac{2 \times 4{\cdot}12 \times 10^{-21}}{1{\cdot}43 \times 10^{-25}}}$ $v = 240$ ms^{-1} (½) - - - - - - - - - - - - $p_{ru} = m \times v$ (½) $= 1{\cdot}43 \times 10^{-25} \times 240$ $p_{ru} = 3{\cdot}43 \times 10^{-23}$ kg ms^{-1} (1)	3	

Question			Expected Answer/s	Max Mark	Additional Guidance
10	d	ii	$p_{ph} = \frac{h}{\lambda}$ (½) $= \frac{6 \cdot 63 \times 10^{-34}}{7 \cdot 80 \times 10^{-7}}$ (½) $p_{ph} = 8{\cdot}50 \times 10^{-28}$ kg ms^{-1} (1)	2	
10	d	iii	$N \times p_{ph} = p_{ru}$ $N \times 8{\cdot}50 \times 10^{-28} = 3{\cdot}43 \times 10^{-23}$ (½) $N = 4{\cdot}04 \times 10^{4}$ photons (½)	1	

Question			Expected Answer/s	Max Mark	Additional Guidance
11	**a**		unpolarised light (½) => Electric field vector oscillates or vibrates in all **planes** polarised (½) => Electric field vector oscillates or vibrates in **one plane**	**1**	do not accept directions, movement or axis or travels or transmitted for polarised light Accept **labelled** diagrams  Unpolarised Polarised
11	**b**	**i**	$\theta = 0°$ (1) $\theta = 180°$ (1)	**2**	
11	**b**	**ii**	Collecting all relevant data (1) Appropriate method of analysis (1) Appropriate conclusion using all data (1) .	**3**	Measure I and θ for at least 5 different values of θ. (1) Plot graph of I against $\cos^2 \theta$. (1) Graph produced is a straight line through the origin (1)

[END OF MARKING INSTRUCTIONS]