2011 Physics

Advanced Higher

Finalised 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.

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
✳	– Wrong order of marks
.	- Dot above the mark to indicate sig. Fig.

No other annotations are allowed on the scripts.

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.

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.

(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 – eg marks can be awarded for data retrieval.**

(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.	$V=IR$ $7\cdot5=1\cdot5R$ $R=5\cdot0\Omega$	(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.	$R=\frac{V}{I}=\frac{7\cdot5}{1\cdot5}=4\cdot0\,\Omega$	(1½) Arithmetic error	GMI 7
7.	$R=\frac{V}{I}=4\cdot0\,\Omega$	(½) Formula only	GMI 4 and 1
8.	$R=\frac{V}{I}=$_____Ω	(½) Formula only	GMI 4 and 1
9.	$R=\frac{V}{I}=\frac{7\cdot5}{1\cdot5}=$_____Ω	(1) Formula + subs/No final answer	GMI 4 and 1
10.	$R=\frac{V}{I}=\frac{7\cdot5}{1\cdot5}=4\cdot0$	(1) Formula + substitution	GMI 2(a) and 7
11.	$R=\frac{V}{I}=\frac{1\cdot5}{7\cdot5}=5\cdot0\,\Omega$	(½) Formula but wrong substitution	GMI 5
12.	$R=\frac{V}{I}=\frac{75}{1\cdot5}=5\cdot0\,\Omega$	(½) Formula but wrong substitution	GMI 5
13.	$R=\frac{I}{V}=\frac{7\cdot5}{1\cdot5}=5\cdot0\,\Omega$	(0) Wrong formula	GMI 5
14.	$V=IR \quad 7\cdot5=1\cdot5\times R$ $R=0\cdot2\,\Omega$	(1½) Arithmetic error	GMI 7
15.	$V=IR$ $R=\frac{I}{V}=\frac{1\cdot5}{7\cdot5}=0\cdot2\,\Omega$	(½) Formula only	GMI 20

Data Sheet

Common Physical Quantities

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

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

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

Part Two: Marking Instructions for each Question

Section A

Question			Expected Answer/s	Max Mark	Additional Guidance
1	**a**	**i**	$E = mc^2$ (½) $2{\cdot}08 \times 10^{-10} = m \times (3{\cdot}0 \times 10^8)^2$ (½) $m = \dfrac{2{\cdot}08\times10^{-10}}{9{\cdot}0\times10^{16}}$ $m = 2{\cdot}3 \times 10^{-27}$ kg (1)	**2**	
1	**a**	**ii**	$m = m_o \times \left(\dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}}\right)$ (½) $2{\cdot}3 \times10^{-27} = 1{\cdot}673 \times 10^{-27} \times \left(\dfrac{1}{\sqrt{1-\dfrac{v^2}{(3{\cdot}0\times10^8)^2}}}\right)$ (½) $v = 2{\cdot}1\times10^8$ m s^{-1} (1)	**2**	
1	**b**	**i**	$E_k = ½\, m\, v^2$ (½) $3{\cdot}15 \times 10^{-21} = 0{\cdot}5 \times 1{\cdot}675 \times 10^{-27} \times v^2$ (½) $v^2 = 3{\cdot}76 \times 10^6$ $v = 1{\cdot}94 \times 10^3$ (m s^{-1}) $p = m\, v$ (½) $= 1{\cdot}675 \times 10^{-27} \times 1{\cdot}94 \times 10^3$ (½) **= 3·25 × 10^{-24} kg m s^{-1} (SHOW)**	**2**	For full credit, show questions must have **all** necessary equations stated and explicit substitutions into these equations.

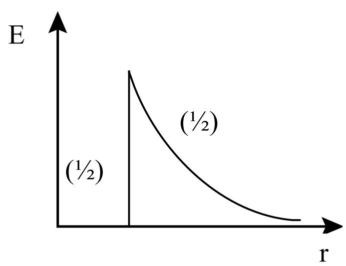
Question			Expected Answer/s	Max Mark	Additional Guidance
1	b	ii	$p = \frac{h}{\lambda}$ (½) $3 \cdot 25 \times 10^{-24} = \frac{6 \cdot 63 \times 10^{-34}}{\lambda}$ (½) $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{3 \cdot 25 \times 10^{-24}}$ $\lambda = 2{\cdot}04 \times 10^{-10}$ m (1)	**2**	<u>**Must**</u> use $3 \cdot 25 \times 10^{-24}$ as substitution otherwise (½) max for equation
1	c	i	Strong (nuclear) (force) (1)	**1**	
1	c	ii	10^{-14} m (1)	**1**	Allow a <u>statement</u> of less than 10^{-14} m but not a <u>value</u> of less than 10^{-14} m
1	c	iii	Quark (1)	**1**	Only accept (up/down) quarks

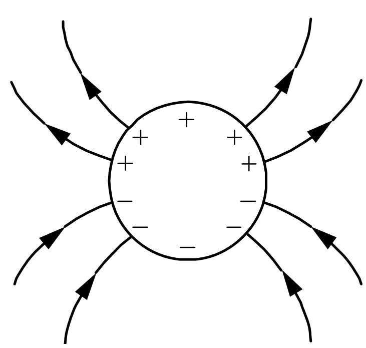
Question			Expected Answer/s	Max Mark	Additional Guidance
2	**a**	**i**	$I_{rod} = 1/3\ m\ l^2$ (½) $= 1/3 \times 0{\cdot}040 \times 0{\cdot}30^2$ (½) $= 1{\cdot}2 \times 10^{-3}$ kg m^2 (1)	**2**	
		ii	$I_{wheel} = (5 \times I_{rod}) + m_{(rim)}\ r^2$ (½)+(½) $= (5 \times 1{\cdot}2 \times 10^{-3}) + (0{\cdot}24 \times 0{\cdot}30^2)$ (½)+(½) $= 6 \times 10^{-3} + 0{\cdot}0216$ $= 0{\cdot}0276$ **= 0·028 (kg m²) (SHOW)**	**2**	(½) for 5 × answer used in (a)(i) (½) for equation $m_{(rim)}\ r^2$ **Equation mr^2 must be stated** (½) for numerical substitutions (½) for addition sign provided previous three ½ marks have been obtained
2	**b**	**i**	$v = \omega\ r$ (½) $19{\cdot}2 = \omega \times 0{\cdot}30$ (½) $\omega = \frac{19 \cdot 2}{0 \cdot 30}$ $\omega = 64$ rad s^{-1} (1)	**2**	
2	**b**	**ii A**	$\omega = \omega_o + \alpha t$ (½) $0 = 64 + \alpha \times 6{\cdot}7$ (½) $\alpha = -\frac{64}{6 \cdot 7}$ $\alpha = - 9{\cdot}6$ rad s^{-2} (1)	**2**	
2	**b**	**ii B**	$\tau = I \times \alpha$ (½) $= 0{\cdot}028 \times (-)\ 9{\cdot}6$ (½) $= (-)\ 0{\cdot}27$ Nm (1)	**2**	**Must use 0·028 as show that from previous question**

Question			Expected Answer/s		Max Mark	Additional Guidance
3	a		$\omega = \frac{2\pi}{T}$ **Must** have formula	(½)	1	
			$= \frac{2 \times 3 \cdot 14}{5 \cdot 6 \times 24 \times 60 \times 60}$	(½)		
			= 1·3 × 10^{-5} rad s^{-1} (SHOW)			**1 MARK ONLY**
3	b		$F_C = F_G$	(½)	3	
			$M_2 \omega^2 r = \frac{GM_1 M_2}{r^2}$	(½) + (½)		
			$2 \cdot 0 \times 10^{30} \times (1 \cdot 3 \times 10^{-5})^2 \times 3 \cdot 6 \times 10^{10} = \frac{6 \cdot 67 \times 10^{-11} \times 2 \cdot 0 \times 10^{30} \times M_1}{(3 \cdot 6 \times 10^{10})^2}$	(½)		
			$M_1 = 1 \cdot 2 \times 10^{32}$ kg	(1)		
3	c	i	$E_P = -\frac{GM_1 M_2}{r}$	(½)	1	Must have negative sign. **Must have equation. Or E_p=VM**
			$= -\frac{6 \cdot 67 \times 10^{-11} \times 2 \cdot 0 \times 10^{30} \times 1 \cdot 2 \times 10^{32}}{3 \cdot 6 \times 10^{10}}$	(½)		**Must give numerical value for G** Can use $E_p = -2E_k$ and $E_k = ½ mv^2$
			= $-4 \cdot 4 \times 10^{41}$ J (SHOW)			
3	c	ii	$v = r\omega$ $E_k = ½ mv^2$	(½)	2	(½) for **both** $½ mv^2$ and $r\omega$ or (½) for $E_k = ½ m(\omega r)^2$
			$= 3 \cdot 6 \times 10^{10} \times 1 \cdot 3 \times 10^{-5}$			Or $E_k = GM_1M_2/2r$. (½) Then (½) for correct substitution
			$= 4 \cdot 68 \times 10^5$			
			$E_k = ½ mv^2$			$E_k = \frac{1}{2} I\omega^2$ OK
			$= ½ \times 2 \cdot 0 \times 10^{30} \times (4 \cdot 68 \times 10^5)^2$	(½)		If E_k is stated as $-½E_p$ OK
			$= 2 \cdot 2 \times 10^{41}$ J	(1)		

Question			Expected Answer/s	Max Mark	Additional Guidance
3	**c**	**iii**	(E_{total} = $E_K + E_P$) E_{total} = $2{\cdot}2 \times 10^{41} + (-4{\cdot}4 \times 10^{41})$ = $-2{\cdot}2 \times 10^{41}$ J (1)	**1**	Must use $-4{\cdot}4 \times 10^{41}$ for E_p. **No ½ mark for equation**
3	**d**		Frequency increases or blue shift when star approaches (1) Frequency decreases or red shift when star recedes. (1)	**2**	

Question			Expected Answer/s	Max Mark	Additional Guidance
4	a		$y = A \sin \omega t$ (½) $\omega = \frac{2 \times \pi}{T}$ (½) $= \frac{2 \times 3 \cdot 14}{5 \cdot 7}$ $= 1 \cdot 1$, so $y = 2 \cdot 9 \sin 1 \cdot 1\, t$ [(½) for 2·9, (½) for 1·1] (1)	2	Accept $y = A \cos \omega t$
4	b		$a = -\omega^2 y$ (½) $= -1 \cdot 1^2 \times (\pm)\ 2 \cdot 9$ (½) $= (\pm)\ 3 \cdot 5$ m s^{-2} (1)	2	-ve sign is not required in final answer. Allow second differential of part (a) for equation (½)
4	c		F_{max} occurs at either maximum or minimum heights/ peaks and troughs/ $y = \pm 2 \cdot 9$ m/extremities of displacement/highest and lowest points (1)	1	
4	d		$E_k = ½ m \omega^2 (A^2 - y^2)$ (½) $= ½ \times 4 \cdot 0 \times 10^4 \times 1 \cdot 1^2 \times (2 \cdot 9)^2$ (½) $= 2 \cdot 0 \times 10^5$ J (1)	2	
4	e	i	Period unaffected (1)	1	
	e	ii	Amplitude is reduced (1)	1	

Question			Expected Answer/s	Max Mark	Additional Guidance
5	a	i	Bring a <u>negative</u> charged rod close to the balloon (½) earth (touch) sphere (½) remove earth (½) remove rod (½). Or Touch 2 balloons together (½), bring charged rod (½) near one, separate balloons **before removing rod** (½) identify which balloon is positive (½).	2	Must be **<u>negative</u>**/**polythene** rod. Can be expressed by pictures If breaking earth before remove rod connection, max (1) Accept movement of positive charges.
5	a	ii	$E = \frac{Q}{4\pi\varepsilon_o r^2}$ (½) $= \frac{(+)120\times10^{-6}}{4\pi\times8\cdot85\times10^{-12}(0\cdot35)^2}$ (½) $E = (+)\ 8\cdot8\times10^{6}\ \text{N C}^{-1}$ or V m^{-1} (1)	2	Accept k=9×10^9 this gives E=8·816×10^6 N C^{-1} Accept $E = k\frac{Q}{r^2}$
		iii		1	(½) curve from radius of balloon Curve must approach but not touch r axis (½) for zero inside sphere (0) marks if curve starting from E-axis
5	b	i	$F = qE$ (½) $E_w = Fd$ (½) $E_w = qV$ (½) $\left\{ \begin{array}{l} \cancel{q}V = \cancel{q}Ed \\ V = Ed \end{array} \right\}$ $E = \frac{V}{d}$ (½)	2	If only two equations stated max (1) Acceptable to leave as V=Ed

Question			Expected Answer/s	Max Mark	Additional Guidance
5	b	ii	$V = E \times d$ $V = 7{\cdot}23 \times 10^4 \times 489$ (½) $V = 3{\cdot}54 \times 10^7$ V (½)	1	NB No mark for formula as incorporated into above.
5	b	iii	$I = \frac{Q}{t}$ & $P = IV$ (both for ½) $I = \frac{5 \cdot 0}{348 \times 10^{-6}}$ (½) $I = 14367{\cdot}8$ A $P = 14367{\cdot}8 \times 3{\cdot}54 \times 10^7$ $P = 5{\cdot}1 \times 10^{11}$ W (1)	2	$E = QV$ and $P = \frac{E}{t}$ Both for (½) mark $E = 5{\cdot}0 \times 3{\cdot}54 \times 10^7 = 177 \times 10^6$ $P = \frac{1 \cdot 77 \times 10^8}{348 \times 10^{-6}}$ (½) $P = 5{\cdot}1 \times 10^{11}$ W (1) **CARE WITH ROUNDING $4{\cdot}9$-$5{\cdot}1\times 10^{11}$W**
5	c			2	(1) Q distribution (½) shape **(½) direction only if acceptable shape** lines should touch perpendicular to surface of balloon If clearly not touching (1) max for Q distribution

Question			Expected Answer/s	Max Mark	Additional Guidance
6	**a**	**i**	Increasing/changing current (½) leads to increasing /changing magnetic field (½) causes a back emf (1)	**2**	
6	**a**	**ii**	$E = -\frac{dI}{dt}L$ (½) $-12{\cdot}0 = -\frac{dI}{dt}0{\cdot}6$ (½) $\frac{dI}{dt} = 20$ $\frac{dI}{dt} = 20\ \text{A s}^{-1}$ (1)	**2**	If E not negative max of (½)
6	**a**	**iii**	(An inductor has an inductance of 1 Henry if) an emf of 1 volt is induced when a current changes at a rate of 1 A s^{-1}	**1**	
6	**a**	**iv**	generates a **large** (back) emf or **large** induced voltage (1) **quick** release of energy or indication of **quick** rate of change or **rapid** change (1) or **collapse** in **B-field or current**	**2**	(1) mark for large (back) emf dependent on no incorrect Physics. 2nd (1) mark can be given without the first (1) mark being awarded.
6	**a**	**v**	$V = IR$ (½) $12{\cdot}0 = I \times 28$ $I = \frac{12{\cdot}0}{28}$ $I = 0{\cdot}43$ A (½)	**1**	

Question			Expected Answer/s	Max Mark	Additional Guidance
6	b		$99\ \text{km h}^{-1} = \frac{99000}{3600} = 27\cdot5\ \text{m s}^{-1}$ (½) $v^2 = u^2 + 2as$ (½) $0^2 = 27\cdot5^2 + 2 \times -1\cdot0 \times s$ $0 = 756\cdot25 - 2s$ $s = \frac{756\cdot25}{2} = 378\ \text{m}$ (½) Yes before the signal (½)	2	If speed conversion wrong max of (½) for equation Or (½) for both equations below $v = u + at$ and $s = ut + \frac{1}{2}at^2$ No final numerical answer required so no penalty for sig. fig. issues.
6	c	i	Wavelength, $\lambda = \frac{v}{f_s}$ $\lambda_{obs} = \frac{v}{f_s} - \frac{v_s}{f_s}$ (1) The observed frequency, $f_{obs} = \frac{v}{\lambda_{obs}} = \frac{v}{\frac{1}{f_s}(v - v_s)}$ (1)	2	Any statement of the speed of sound changing = 0 marks
6	c	ii A	$f_{obs} = f_s\left(\frac{v}{v - v_s}\right)$ $f_{obs} = 294\left(\frac{340}{340 - 28\cdot0}\right)$ (½) $f_{obs} = 320\ \text{Hz}$ (½)	1	**1 MARK ONLY** Accept 320·38Hz
6	c	ii B	$f_{obs} = f_s\left(\frac{v}{v + v_s}\right)$ (½) $f_{obs} = 294\left(\frac{340}{340 + 28\cdot0}\right)$ (½) $f_{obs} = 272\ \text{Hz}$ (1)	2	Accept 271·63Hz

Question			Expected Answer/s	Max Mark	Additional Guidance
7	a	i	Towards Y/inwards/downwards (1) Cancellation of B-field between the wires (1) **OR** Opposite magnetic fields caused by each wire cause attraction. **OR** interpretation of F=BI*l*	2	
7	a	ii	$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$ (½) $\frac{F}{L} = \frac{4\pi \times 10^{-7} \times 4 \cdot 7 \times 4 \cdot 7}{2\pi \times 360 \times 10^{-3}}$ (½) $\frac{F}{L} = 1 \cdot 2 \times 10^{-5}$ N m^{-1} (1)	2	
7	b	i	$F = \frac{0 \cdot 0058 + 0 \cdot 0061 + 0 \cdot 0063 + 0 \cdot 0057 + 0 \cdot 0058 + 0 \cdot 0062}{6}$ F = 0·0060 N (1) - $F=BIl$ (½) $6 \cdot 0 \times 10^{-3} = B \times 1 \cdot 98 \times 0 \cdot 054$ $B = \frac{6 \cdot 0 \times 10^{-3}}{1 \cdot 98 \times 0 \cdot 054}$ (½) B = 0·056 T (1)	3	F=0·0059 N incorrect rounding deduct (½) - - - - - - - - - - - - - - - - - - -
7	b	ii	Scale Reading uncertainty (SRU) ±1 digit ⇒ ± 0·0001N (½) Random uncertainty (RU) (½) $= \left(\frac{\max - \min}{n}\right)$ $= \left(\frac{0 \cdot 0063 - 0 \cdot 0057}{6}\right)$ = 0.0001 N (½) $\Delta F = \sqrt{\text{SRU}^2 + \text{RU}^2 + \text{calibration uncert}^2}$ (½) $\Delta F = \sqrt{0 \cdot 0001^2 + 0 \cdot 0001^2 + 0 \cdot 00005^2} = \sqrt{2 \cdot 25 \times 10^{-8}}$ $\Delta F = 1 \cdot 5 \times 10^{-4}$ N (1)	3	

Question			Expected Answer/s	Max Mark	Additional Guidance
7	b	iii	$\frac{\Delta B}{B} = \sqrt{\left(\frac{\Delta F}{F}\right)^2 + \left(\frac{\Delta I}{I}\right)^2 + \left(\frac{\Delta l}{l}\right)^2}$ (½) $\frac{\Delta B}{B} = \sqrt{\left(\frac{1 \cdot 5 \times 10^{-4}}{0 \cdot 0060}\right)^2 + \left(\frac{0 \cdot 02}{1 \cdot 98}\right)^2 + \left(\frac{0 \cdot 0005}{0 \cdot 054}\right)^2}$ (½)+ (½)+ (½)+ $\frac{\Delta B}{B} = \sqrt{8 \cdot 12 \times 10^{-4}}$ $\frac{\Delta B}{B} = 0 \cdot 029$ $\therefore B = (0 \cdot 056) \pm 0 \cdot 0016$ T (1)	3	%Δ F = 2·5% (½) %Δ I = 1·0% (½) %Δ l = 0·93% (½) Allow carry through of incorrect ΔF must compare/combine with % uncertainties in I and l to show dominance if required 2·9% or 2·8% of B

Question			Expected Answer/s	Max Mark	Additional Guidance
8	a		$F = BIl\,(\sin\theta)$ or $F=BIl$ (½) $but\ I = \frac{q}{t}$ (½) $v = \frac{l}{t}$ (½) substitute to get $F = B\,\frac{q}{t}\,vt$ (½)	2	
8	b		$F = \frac{mv^2}{r} = Bqv$ (1) $v = \frac{Bqr}{m}$ alone 1 mark $v = \frac{3\cdot6 \times 10^{-3} \times 1\cdot6 \times 10^{-19} \times 2\cdot8 \times 10^{-3}}{9\cdot11 \times 10^{-31}}$ (½) $v = \frac{1\cdot6128 \times 10^{-31}}{9\cdot11 \times 10^{-31}}$ $v = 1\cdot77 \times 10^6$ $v = v_{total} \times sin\theta$ (½) $\frac{1\cdot77 \times 10^6}{2\cdot0 \times 10^6} = sin\theta$ $\theta = 62°$ (1)	3	(½) for mv^2/r and (½) for equality $F = Bqv$ alone (0) ALTERNATIVE $F = \frac{mv^2}{r} = Bqv$ (1) $\frac{m(v\ sin\theta)}{r} = Bq$ $sin\theta = \frac{Bqr}{mv}$ (½) Substitution below (½) $sin\theta = \frac{3\cdot6 \times 10^{-3} \times 1\cdot6 \times 10^{-19} \times 2\cdot8 \times 10^{-3}}{9\cdot11 \times 10^{-31} \times 2\cdot0 \times 10^{-6}}$ $sin\theta = 0\cdot885$ $\theta = 62°$ (1) **Possible range 62-64°**
8	c		Radius decreases (1) Pitch increases (1)	2	

Question			Expected Answer/s	Max Mark	Additional Guidance
9	a		Slits/gaps/threads in horizontal and vertical direction (1) Explanation of interference pattern (1)	2	Accept crest/trough etc In phase and out of phase Constructive and destructive The word interference alone is not enough as given in the question
9	b		$\lambda = \frac{d\Delta x}{D}$ (½) $4 \cdot 88 \times 10^{-7} = \frac{d \times 8 \cdot 0 \times 10^{-3}}{3 \cdot 6}$ (½) $d = 2 \cdot 2 \times 10^{-4}$ m (1)	2	**Beware ensure candidate is clearly finding d and not Δ*x***
9	c	i	B (1) Larger λ gives larger *x* (1)	2	Second mark dependent on first Can gain first mark independently 2nd mark dependent on correct use of Δx and d
		ii	D (1) As horizontal d increases horizontal *x* decreases (½) As vertical d decreases vertical *x* increases (½)	2	Second mark dependent on first Can gain first mark independently

Question			Expected Answer/s		Max Mark	Additional Guidance
10	**a**		A stationary wave is formed by the **interference** between waves, travelling in **opposite** directions or **reflecting** from the end supports.	(1) (1)	**2**	
10	**b**	**i**	$T = mg = 4 \cdot 02 \times 9 \cdot 8 = 39$ N $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ $f = \frac{1}{2 \times 0 \cdot 780}\sqrt{\frac{39}{1 \cdot 92 \times 10^{-4}}}$ $f = 290$ Hz Note is D	(½) (½) (½) (½)	**2**	No marks for formula given If m not converted to T (0)
10	**b**	**ii**	2 × answer to 10 b i $f = 2 \times 290 = 580$ Hz ($f = 2 \times 294 = 588$ Hz)		**1**	

[END OF MARKING INSTRUCTIONS]