2012 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

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

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

$E_K = ½\, mv^2 = ½ \times 4 \times 2 = 4\text{J}$ **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

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*	*Element*	*Wavelength*/nm	*Colour*
Hydrogen	656	Red	Cadmium	644	Red
	486	Blue-green		509	Green
	434	Blue-violet		480	Blue
	410	Violet	*Lasers*		
	397	Ultraviolet	*Element*	*Wavelength*/nm	*Colour*
	389	Ultraviolet	Carbon dioxide	9550 10590	Infrared
Sodium	589	Yellow	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	$2{\cdot}70 \times 10^{3}$	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	1·29	….	….	….	….	….
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20	$1{\cdot}43 \times 10^{4}$	….	$4{\cdot}50 \times 10^{5}$
Nitrogen	1·25	63	77	$1{\cdot}04 \times 10^{3}$	….	$2{\cdot}00 \times 10^{5}$
Oxygen	1·43	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**	**i**	$m = \dfrac{m_0}{\sqrt{1 - \dfrac{v^2}{c^2}}}$ (½) $1.8 = \dfrac{1}{\sqrt{1 - \dfrac{v^2}{(3 \times 10^8)^2}}}$ (½) $v = 2.5 \times 10^8 \text{ m s}^{-1}$ (1)	**2**	Look out for correctly calculating m. $m = 1.8 \times 9.11 \times 10^{-31} = 1.64 \times 10^{-30}$ kg
1	**a**	**ii**	$E = mc^2$ (½) $E = 1.8 \times 9.11 \times 10^{-31} \times (3.0 \times 10^8)^2$ (½) $E = 1.5 \times 10^{-13}$ J (1)	**2**	Must have correct mass
1	**a**	**iii**	Weak (force) (1)	**1**	
1	**b**	**i**	Electron Diffraction (1) Interference Fire electrons through crystals Thomson-Reid Experiment	**1**	Young's/ Double Slit (1) Bending (0) If explanation contradicts the example then WP (0) Defraction (0)
1	**b**	**ii**	Compton Effect (1) Photoelectric effect e/m experiment electrons deflected in a deflection tube electron's back scattering	**1**	Electrons repel (1) Any indication of Force due to electrostatic effects (1) Electrons can be accelerated (1) Electrons have mass/charge / momentum (0) Nuclear Fission (0) If explanation contradicts the example then WP (0) Milikan's oil drop (0) Rutherford's expt (0) Defract (0) **Must describe an effect**

Question			Expected Answer/s	Max Mark	Additional Guidance
2	a	i	$a = \frac{dv}{dt}$ $\int dv = \int a.dt$ or $\int \frac{dv}{dt} dt = \int a.dt$ (½) $v = at + c$ (½) at $t = 0$, $c = u$ (1) Must be specific with respect to time $v = u + at$ SHOW ME	2	$a = \frac{dv}{dt}$ $\int_u^v dv = \int_0^t a.dt$ (½) + (½) ½ for integrals, ½ for limits need both before can progress $[v]_u^v = [at]_0^t$ (½) $v - u = at\,(-0)$ (½) $v = u + at$
2	a	ii	$v^2 = (u + at)(u + at)$ $v^2 = u^2 + 2uat + a^2t^2$ (½) $v^2 = u^2 + 2a(ut + \frac{1}{2}at^2)$ (½) $v^2 = u^2 + 2as$ SHOW ME	1	SHOW ME Starting with $s=ut+ ½at^2$ ½ for substitution for t ½ for manipulation Check second line both *a* and *t* are squared.
2	b	i	$s = \frac{1}{2} \times 29.8 = 14.9\text{m}$ $v^2 = u^2 + 2as$ (½) $9.64^2 = 0^2 + 2 \times a \times 14.9$ (½) $a = 3.12\,\text{m s}^{-2}$ (1)	2	

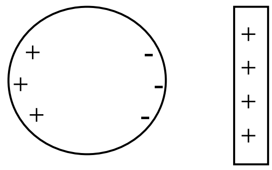
Question			Expected Answer/s	Max Mark	Additional Guidance
2	b	ii	$v^2 = u^2 + 2as$ (½) $10.9^2 = 9.64^2 + 2a(\pi \times 8.20)$ (½) + (½) sub and value of s $a = 0.5\,\text{m s}^{-2}$ $a = r\alpha$ (½) $0.5 = 8.2 \times \alpha$ $\alpha = 0.06\,\text{rad s}^{-2}$ (1)	3	$v = r\omega$ (½) $9.64 = 8.2 \times \omega_o$ $\omega_o = 1.18\,\text{rad s}^{-1}$ $10.9 = 8.2 \times \omega$ (½) for **both** substitutions for ω and ω_o $\omega = 1.33\,\text{rad s}^{-1}$ $\omega^2 = \omega_o^2 + 2\alpha\theta$ (½) $1.33^2 = 1.18^2 + 2\alpha\pi$ (½) $\alpha = \frac{1.77 - 1.39}{2\pi}$ $\alpha = \frac{0.3765}{2\pi}$ $\alpha = 0.06\,\text{rad s}^{-2}$ (1)
2	c	i	An indication of the central/ inward force (1) Provided by (horizontal) **component** of F (1)	2	independent marks Any indication of outwards/centrifugal force (0) Sideways no indications of central (0)
2	c	ii	(Central) force is no longer large enough to maintain her circular motion (1)	1	Any indication of outwards/centrifugal force (0) The centripetal force is now greater than the frictional force (1)

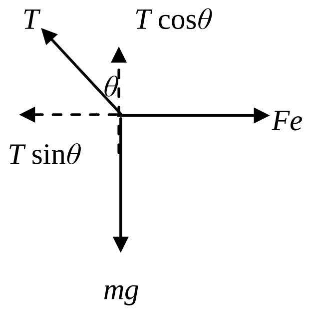
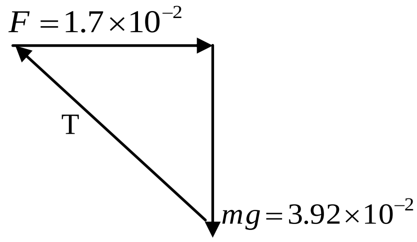
Question			Expected Answer/s	Max Mark	Additional Guidance
3	a	i	$y = A\sin\omega t$ or $y = A\cos\omega t$ (½) $\omega = 2\pi f$ $\omega = 2\pi \times 0.76$ $\omega = 4.8\,(\text{rad s}^{-1})$ (½) $A = 0.18\,(\text{m})$ (½) $y = 0.18\sin 4.8t$ (½) Or $y = 0.18\cos 4\cdot 8t$	2	Accept π in final answer ω=1.52π
3	a	ii	$g = (\pm)A\omega^2$ (½) $9.8 = A \times 4.8^2$ (½) $A = 0.43\,\text{m}$ SHOW ME	1	Must start with the equation $a = (\pm)A\omega^2$ (½) Value of g must appear OK to calculate a using A=0.43
3	b	i	Assume diver 2 rods about one end 33.0 kg per rod (½) $I = \frac{1}{3}ml^2$ (½) $I = \frac{1}{3} \times 33.0 \times 0.90^2 = 8.9\,(\text{kg m}^2)$ (½) $I = \frac{1}{3} \times 33.0 \times 0.94^2 = 9.7\,(\text{kg m}^2)$ (½) $I = 18.6\,\text{kg m}^2$ (1)	3	**NB 3 mark question** Accept *r* instead of *l* in equations Acceptable to use $I = \frac{1}{12}ml^2$ (1) $I = \frac{1}{12} \times 66.0 \times 1.84^2$ (1) $I = 18.6\,\text{kg m}^2$ (1) Cannot use an average length
3	b	ii	Some indication of uneven mass distribution. (1)	1	Diver not rigid (0). Distribution of weight (0). Consideration of uneven length(0)
3	b	iii	$(L =)I_1\omega_1 = I_2\omega_2$ (½) $10.25 \times 0.55 = 7.65 \times \omega_2$ (½) $\omega_2 = 0.74\,\text{rad s}^{-1}$ (1)	2	

Question			Expected Answer/s	Max Mark	Additional Guidance
3	c	i	$E_{krot} = \frac{1}{2} I_1 \omega_1^2$ $E_{krot} = \frac{1}{2} I_2 \omega_2^{\ 2}$ (½) $\frac{1}{2} \times 10.25 \times 0.55^2 = 1.55\,\text{J}$ (½) for either $\frac{1}{2} \times 7.65 \times 0.74^2 = 2.09\,\text{J}$ $\Delta E_{krot} = 0.54\,\text{J}$ (1)	2	**NB Only 2 marks** Accept 1.6 J Accept 2.1 J Depending on rounding can be 0.527 to 0.55J Accept if negative change in ΔE_{krot}
3	c	ii	Work is being done by the diver (1)	1	Energy provided by diver or equivalent Diver pulls his legs in (1)

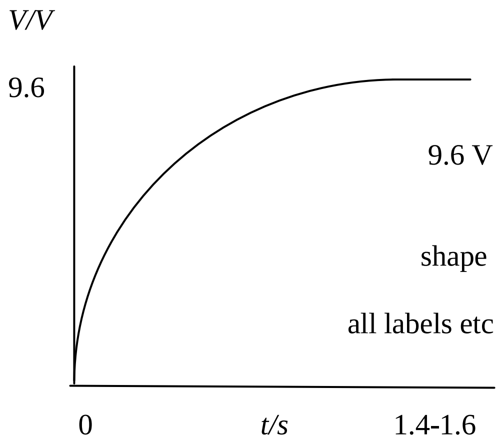
Question			Expected Answer/s	Max Mark	Additional Guidance
4	a		$mg = \frac{GM_p m}{r^2}$ (½) both equations (½) for equating SHOW ME	1	$g = \frac{F}{m}$ $g = \frac{GMm}{mr^2}$
4	b	i	$g = \frac{GM}{r^2}$ from graph $r = 1.2 \times 10^6$ m (½) $g = \frac{6.67 \times 10^{-11} \times 1.27 \times 10^{22}}{(1.2 \times 10^6)^2}$ (½) $g = 0.59$ N kg^{-1} or $m\,s^{-2}$ (1)	2	Accept 7.06 or 7.00 $V = -\frac{GM}{r}$ $V = -\frac{6.67 \times 10^{-11} \times 1.27 \times 10^{22}}{(1.2 \times 10^6)}$ $V = -7.06 \times 10^5$ $g = -\frac{V}{R_p}$ $g = -\frac{-7.06 \times 10^5}{1.2 \times 10^6}$ $g = 0.58$ N kg^{-1} If not double negative then WP ½ for both formula ½ for both substitutions 1 for final answer
4	b	ii	$E = -\frac{GMm}{r}$ (½) (½) $E = -\frac{6.67 \times 10^{-11} \times 1.27 \times 10^{22} \times 112}{1.80 \times 10^6}$ $E = -5.27 \times 10^7$ J (1)	2	No negative in equation (0) No negative in sub (½) max No negative in answer (1½) max Or from the graph accept values of V from -4.7 to -4.8 $E = Vm$ (½) $E = -4.8 \times 10^5 \times 112$ J (½) Range $E = -5.26$ to -5.4×10^7 J $V = -\frac{GMm}{r}$ (0)

Question			Expected Answer/s		Max Mark	Additional Guidance
4	**c**		$1.96 \times 10^7 - x$	(½)	**3**	If subscripts on M's and r's then can get (½) for equating two forces. Ignore loose subscripts on masses if denominators OK
			$\frac{GM_p m}{x^2} = \frac{GM_c m}{(1.96 \times 10^7 - x)^2}$	(½)		$\frac{x^2}{y^2} = \frac{7}{1}$ (2 marks if x+ y=1.96×10^7 defined)
			$\frac{7}{1} = \frac{M_p}{M_c}$ or $M_C = 1.81 \times 10^{21}$	(½)		Ensure masses are above the correct denominator
			$\frac{7}{1} = \frac{x^2}{(1.96 \times 10^7 - x)^2}$	(½)		
			$x = 1.42 \times 10^7$ m from Pluto	(1)		$x = 1.42 \times 10^7$ m from Pluto

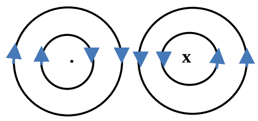
Question			Expected Answer/s	Max Mark	Additional Guidance
5	**a**		Electrons/negative charges in sphere move to rhs of sphere (leaving +ve charge on lhs of sphere). (1)	**1**	Diagram (1)  Must have roughly equal numbers of + charge and – charges for mark Any indication of sphere charged (0). Movement of protons /positively charged particles (0) Movement of positive charges (1)
5	**b**	**i**	$V = 3.0\times10^3 - (-2.0\times10^3)$ V (½) $= 5.0\times10^3$ V $E = V/d$ (½) $= 5.0\times10^3 / 0.042$ $= 1.2\times10^5$ V m^{-1} or N C^{-1} (1.19×10^5 V m^{-1}) (1)	**2**	If V= 1 kV then max (½) If use 5.0 V then (1½) max
5	**b**	**ii**	$F = qE$ (½) $= 140\times10^{-9}\times1.2\times10^5$ (½) $= 1.7\times10^{-2}$ N (1)	**2**	Ignore negatives $= 1.67\times10^{-2}$ N possible if number carried over in calculator.

Question			Expected Answer/s	Max Mark	Additional Guidance
5	b	iii	$\tan\theta = \frac{F}{mg} = \frac{1.7\times10^{-2}}{3.92\times10^{-2}}$ (½) eq (½) value of mg $\theta = 23.4°$ (½) $T = \frac{F}{\sin\theta} = \frac{1.7\times10^{-2}}{\sin 23.4}$ (½) eq or $T = \frac{mg}{\cos\theta}$ as an alternative $T = 4.3\times10^{-2}$ N (0.0427) (1) **Or** $T^2 = (1.7\times10^{-2})^2 + (3.92\times10^{-2})^2$ (1) $T = 4.3\times10^{-2}$ N (1) $\tan\theta = \frac{1.7\times10^{-2}}{3.92\times10^{-2}}$ (½) $\theta = 23.4°$ (½)	3	  (½) for Pythag and (½) for value of mg Treat θ and magnitude as independent **(2) marks for calculating T (1) mark for correct angle.**
5	c		Angle is unchanged (1) Uniform electric field/force acting is constant (1)	2	Angle increases/decreases (0)

Question			Expected Answer/s		Max Mark	Additional Guidance
6	a	i	(Point) Q	(1)	1	
6	a	ii	$Bqv = \frac{mv^2}{r}$ $\frac{q}{m} = \frac{v}{rB}$	(1)	1	SHOW ME Deduct (½) for any subsequent mistakes
6	a	iii	$q/m = \frac{v}{rB}$ $= \frac{2.29 \times 10^6}{0.0190 \times 2.50}$ $= 4.82 \times 10^7 \text{ (C kg}^{-1}\text{)}$ $\text{Alpha particle } q/m = \frac{3.20 \times 10^{-19}}{6.645 \times 10^{-27}}$ $= 4.82 \times 10^7 \text{ (C kg}^{-1}\text{)}$ Particle is alpha	 (½) (½) (½) (½) (1)	3	Calculation (2) Statement (1) Calculations independent Do not penalise for wrong unit. Justification needed for this mark
6	a	iv	$t = d/v$ $= \pi r/v = \frac{3.14 \times 0.019}{2.29 \times 10^6}$ $= 2.61 \times 10^{-8}$ s	(½) (½) (1)	2	Calculation of T (1) t=T/2 (1) $v = r\omega, \theta = \omega t$ both (½) Both substitutions (½) If s rounded $t = 2.62 \times 10^{-8}$ s
6	a	v	t is constant both v and **r double** or **directly proportional**	(1) (1)	2	As v doubles, r doubles $t = d/v = 2\pi r_1 / 2v_1 = \pi r_1 / v_1$ as before Not enough to say r increases
6	b	i	Particle is negatively charged	(1)	1	Smaller charge (0)
6	b	ii	Charge to mass ratio is smaller	(1)	1	**Must be q/m not m/q**

Question			Expected Answer/s	Max Mark	Additional Guidance
7	**a**	**i**	$\lambda = \frac{h}{p}$ (½) $= \frac{6.63 \times 10^{-34}}{6.26 \times 10^{-29}}$ (½) $= 1.06 \times 10^{-5}$ m (1)	**2**	NB 3 sig fig is correct so 1×10^{-5} is max (1½)
7	**a**	**ii**	If an e.m.f. of ±0.1 V is induced when the current is changing at the rate of 1 A s^{-1}, the inductance is 0.1 H. (1)	**1**	Or equivalent, eg 1 V for 10 A s^{-1}
7	**b**	**i**	Magnetic field strength increases (½) and reaches a maximum value/levels off (½)	**1**	**Any mention of magnetic field strength decreasing/ changing (0)**
7	**b**	**ii**	At $t = 0, dI/dt = 4.0$ A s^{-1}. At this time $E = -12$ V $E = -L\,dI/dt$ (½) $-12 = -L \times 4$ (½) $L = 3.0$ H (1)	**2**	Accept L=12/4 assume cancelled
7	**b**	**iii**	 9.6 V (1) shape (½) all labels etc (½) Maximum current $= E/Rt = 12/10 = 1.2$ A Maximum p.d. across 8Ω $= 1.2 \times 8 = 9.6$ V	**2**	If general trend of graph wrong (0) Labels= 0, 1.4-1.6, t(s), V(V) (½) Value of V missing or incorrect maximum (1) mark Must have origin for labelled for labels marked. Accept 1.6 s Or use voltage divider to find *V* $V_{8\Omega} = \frac{8}{10} \times 12 = 9.6$ V

Question			Expected Answer/s	Max Mark	Additional Guidance
7	**b**	**iv**	$E = \frac{1}{2}LI^2$ (½) $= 0.5 \times 3 \times 1.2^2$ (½) $= 2.2\ J$ (1)	**2**	Look out for carry forward of wrong answer Must have current = 1.2A, cannot carry through wrong current
7	**c**		Reading on A_1 will increase (½) as (capacitive) reactance decreases/ $I \propto f$ (½) Reading on A_2 will decrease (½) as inductive reactance increases/ $I \propto 1/f$ (½)	**2**	Alternative answer A_1 at higher frequencies the current drop in each half cycle is less. A_2 back emf increases Impedence OK Resistance not OK

Question			Expected Answer/s	Max Mark	Additional Guidance
8	a		$B=\dfrac{\mu_0 I}{2\pi r}$ (½) $=\dfrac{4\times\pi\times10^{-7}\times25}{2\times3.14\times0.006}$ (½) $=8.3\times10^{-4}$ T (1)	2	
8	b	i	(The current in each wire produces) a magnetic field. (1) Same direction of the magnetic fields between the wires. (1) OR interpretation of F=BI*l*	2	May use diagrams  Diagram (1) Explanation (1)
8	b	ii	$\dfrac{F}{l}=\dfrac{\mu_0 I_1 I_2}{2\pi r}$ (½) $=\dfrac{4\times\pi\times10^{-7}\times25\times I}{2\pi r}$ (½) $=\dfrac{5.0\times10^{-6} I}{r}$ SHOW ME	1	SHOW ME Must show $\mu_o=4\pi\times10^{-7}$ or 12.56×10^{-7}
8	b	iii	Weight per unit length $=5.7\times10^{-3}\times9.8$ (½) $=0.056(\text{N m}^{-1})$ (½) $\dfrac{5.0\times10^{-6} I}{0.006}=0.056$ (1) $I=67$ A (1)	3	If there is no calculation or value for weight (0)

Question			Expected Answer/s	Max Mark	Additional Guidance
9	**a**	**i**	Read from the graph $\lambda = 0.25\,\text{m}$ (1)	**1**	No tolerance
9	**a**	**ii**	Read from the graph $A = 0.58\,\text{m}$ (1)	**1**	accept 0.57 to 0.585m (1) 0.6m (0)
9	**a**	**iii**	$v = f\lambda$ $1.25 = f \times 0.25$ $f = 5.0\,\text{Hz}$ (1)	**1**	1 mark for the answer Can be carry through from 9ai
9	**a**	**iv**	$\emptyset = \frac{2\pi x}{\lambda}$ (½) $\emptyset = \frac{2\pi \times (0.44 - 0.25)}{0.25}$ (½) (1) Phase angle $= 1.5\pi = 4.7$ (rad)	**2**	Or $3/4 \times 2\pi$ rad or 3π/ 2 No tolerance in reading from graph accept 4.77 or 4.78 or 4.8 Answer not required but incorrect unit (-½) e.g. rads Can be carry through from 9ai
9	**b**		$y = (\pm)0.58\sin 2\pi(5.0t - \frac{x}{0.25})$ (2)	**2**	If not travelling wave equation (1) max for A and ω Accept $y = (\pm)0.58\sin(31t - 25x)$ $y = (\pm)0.58\sin 2\pi(5.0t - 4.0x)$ $y = (\pm)0.58\sin(10.0\pi\, t - 8.0\pi\, x)$ (½) for A, (½) for *t* term, (½) for *x* term, (½) for negative sign
9	**c**		$y = (\pm)0.29\sin(31t + 25x)$ (1)	**1**	If not travelling wave equation (½) max for A No requirement for same λ or *f* as part 9b. $y = (\pm)0.29\sin 2\pi(5.0t + \frac{x}{0.25})$ (½) for 0.29, (½) for positive sign Accept 0.3 but not 0.30

Question			Expected Answer/s		Max Mark	Additional Guidance
10	**a**	**i**	$v = ds/dt$	(½)	**2**	$\bar{v} = \frac{s}{t}$ $v = 2\bar{v}$ both equations (½) mark
			$= 8.2t$	(½)		$s = 4.1 \times 2^2 = 16.4$ $\bar{v} = \frac{16.4}{2}$
			$= 8.2 \times 2$			$v = 2 \times 8.2$
			$= 16\ \text{m s}^{-1}$	(1)		$16.4\ \text{m s}^{-1}$
10	**a**	**ii**	Frequency is increasing/increases	(1)	**2**	higher frequency (0) Frequency has increased (0)
			Waves become more and more squashed together as speed increases or time between wave continually decreasing	(1)		Can link to Doppler equation with v_s increasing
10	**b**		$f = \frac{v}{v - vs} \times fs$	(½)	**2**	
			$= \frac{340}{340 - 16} \times 595$	(½)		
			$= 624\ \text{Hz}$	(1)		$f = 625\ \text{Hz}$ with $v = 16.4$ If carry through of 8.2 m s^{-1} in part 10ai then f = 610 Hz

Question			Expected Answer/s	Max Mark	Additional Guidance
11	a	i	$\Delta x = \lambda D / d$ (½) Gradient of graph $= \frac{(1.30 - 0.30)}{(23 - 6) \times 10^{-3}}$ $= 58.8$ gradient (½) $d = 529 \times 10^{-9} \times 58.8$ $d = 3.1 \times 10^{-5}$ m (1)	2	**NB 2 mark question** If gradient only = 0.06 (0) Accept values from 58-60 Accept correct use of 1/gradient Do not penalise units in gradient at this stage. *d* can = 3.2×10^{-5} m
11	a	ii	Uncertainty too small (1)	1	Very precise measurement
11	a	iii	Any two from Measure distance between several spots Use a bigger range of values for *D* Increase value(s) of D (1) each Additional data points (mark spots on paper) and use travelling microscope to find Δx	2	Repeated measurements (0/1) max (1) mark for other correct statement Do not accept measure from middle of spots. Take more readings (0) Must specify higher precision instrument increase in λ (0/1) decrease d (0/1)
11	b		Spots blurred/ elongated in horizontal direction (1) Spacing increased (1)	2	Accept more elongated in the vertical direction Accept dimmer

[END OF MARKING INSTRUCTIONS]