OCR
RECOGNISING ACHIEVEMENT

Physics B (Advancing Physics)

Advanced GCE **H559**

Advanced Subsidiary GCE **H159**

Mark Scheme for the Units

June 2009

HX59/MS/R/09

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All Examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the Report on the Examination.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

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Advanced Subsidiary GCE Physics B (Advancing Physics) (H159)

MARK SCHEMES FOR THE UNITS

G491 – Physics in Action

Question	Expected Answers	Marks	Additional guidance
1 (a)	J s-1 ✓	1	not W accept J / s
1 (b)	A s ✓	1	not C
1 (b)	A V-1 ✓	1	not S accept A / V
2 (a)	B ✓	1	
(b)	response times in range 4 to 6 (s) ✓	1	method not any credit for gradient i.e. interpreting T as time not dependent / independent variables
(c)	ΔV / ΔT / 0.8 / 75 ✓ m	1	evaluation accept 0.01 allow 1.2 / 75 = 0.016 for 1 /2 marks unit mark standalone not ecf
	0.0107 / 0.011 ✓ e	1	
	V °C-1 ✓	1	
3 (a)	eg. possibly weakened when cut / possible dynamic / asymmetric loading / typographic error in this reading / reliability of spring balance used for the 4.5 N reading ✓	1	AW expect cause and sense of weakening accept any plausible practical point that could explain weakening eg. small tear in paper, wet paper, lower width, sample of different paper etc. not just repeat the readings / different length / just human error / random / systematic error / weak strip allow misreading of force-meter

Question	Expected Answers	Marks	Additional guidance
3 (b)	method: sensible attempt to find an average / mean = (2x6.5+3x7.0+7x7.5+10x8.0+4x8.5 +1x9.0+ 2x9.5)/29 / = 228.5 / 29 ✓ m = 7.9 ✓ ± 1.5 (N) ✓ e / = 8 ± 1 / 1.5 / 2 (N) by eye	1 2	allow 1 small error setting up mean then penalise evaluation eg. 220.5 / 29 = 7.6 N / 233 / 30 = 7.8 N not just take mean / average accept mention of selecting median / middle / modal value allow answers expressed to 1 or 2 SF accept ± 1.6 / 2 N penalise 3 or more SF once only in average or variability accept median = 8 / mode = 8 correct answers without any sensible method max 2/3
4	stiffness ✓ brittleness ✓	1 1	not Young modulus / stiff not brittle
5 (a)	losing higher frequency components ✓ / creates aliases / generates spurious low frequencies	1	accept AW / good quality before + after diagrams not less quality / missing details / frequencies / information / restatement of Nyquist
5 (b)	b = log2 (Vtotal / Vnoise) ⇒ b = 10.97 ✓	1	accept 10.9 / 10.96 allow 211 = 2048 ORA not any credit for only qualitative answers not just b = 11 must do a show that calculation
5 (c)	(at least 12 x 103 x 11) =1.3(2) x 105 (bit s-1) ✓	1	132 000 not any other values unless justified eg. a higher sampling f or stereo calculation

Question	Expected Answers	Marks	Additional guidance
6 (a)	(1350 / 45) = 30 ✓	1	accept correct answer without method not any other value
6 (b)	(u = v / M = 2.1 / 30) = 0.07(0) m ✓ P or 1 / f = 1 / 2.1 - 1/ (-0.07) ✓ = 14.76 (D) / 14.8 (D) ✓	1 1 1	accept either + / - signs for evaluation of u allow ecf on magnification from a eg. M = 0.033 ⇒ u = 63.6 m ⇒ P = 0.49 (D) for full marks method signs must be correct accept real is +ve convention allow ecf on incorrect u not any ecf on incorrect signs accept 1/ v small so P ≈ 1/ 0.07 ; = 14.(3) D for last 2 marks accept ORA i.e. using P = 15 D ⇒ u = 0.0688 m ≈ 0.07 m for max 2/3
7 (a)	B ✓	1	
7 (b)	A ✓	1	
	Section A total	**23**	

Question	Expected Answers	Marks	Additional guidance
8 (a)	(480 x 10 x 580 x 10) = 2 .784 x 107 (km2) ✓e	1	accept 2 .8 x 107 / 27 840 000 (km2) look out for powers of ten errors
8 (b) (i)	(255 x 33) = 8 415 (m) ✓ e	1	accept 8400 (m) / 8.4(2) x 103 (m) / 8.4(2) k(m) accept 8448 (m) (= 33 x 256)
8 (ii)	depth can vary within distance of 10 km ✓	1	accept depth can vary within pixel (size / length / area) must explain not just pixel represents area not depths quantised in 33m steps / wave / tidal variations
8 (c)	shallow water in range 2.2 to 2.7 km deep / cliff height in range 3.9 to 4.4 km / deep water up to about 6.6 km deep / drop off in range 800 to 1200 km (from W / E) ✓✓	2	accept any 2 quantitative estimates of distances not pixels quantitative aspect can be depth / distance estimate for one mark each or gradient for both marks
(d)	4 km deep is pixel value ≈ 121 / area under graph OR no. pixels ∝ area reqd ✓ area under graph to 121 or pixels up to 121 total area under graph total pixels ✓	1 1	accept ≈ 120 / 122 QWC penalise either mark for lack of clarity eg. confusing area under graph with area of seabed / 2 or more spelling errors across whole question place X on pen symbol if QWC penalty accept technical / mathematical symbolism
8 (e)	finds sudden changes in the gradient (of the greyscale values) ✓	1	accept AW but concept must be clear for H mark not just edge detection not just sudden changes in depth accept a complete correct mathematical description: eg. {this pixel value x 4 – (N + S + W + E)} / by diagram
	Total	**8**	

Question	Expected Answers	Marks	Additional guidance
9 (a) (i)	V = I R / = 0.25 x 5.8 ✓ m = 1.45 (V) ✓ e OR V = ε - I r ✓ m = 1.55–0.25 x 0.4 =1.45 (V) ✓e	2	accept 1.5 (V) allow other correct methods ORA
9 (ii)	energy is used / dropped driving current through the internal resistance ✓	1	accept p.d. / voltage / emf for energy accept other AW not just volts used up in cell / just mention of internal r
9 (b) (i)	current is constant for about 9 or 10 hours ✓ then falls rapidly / to zero over last few hours ✓ first 10 hours: internal r remains constant / cell	1 1	accept few = ½ to 2 hours if numerical values accept AW
(ii)	operates at constant e.m.f. ✓ last hour: cell's (chemical / potential) energy is used up (so ε or I fall) ✓ OR internal r increases (causing drop in operating p.d. or current) ✓	1 1	reasons for behaviour described not power is constant accept supply voltage is constant not just voltage constant accept cell polarises not cell runs out of power / current / emf / p.d. / charge
9 (iii)	est. no. squares ≈ 25 x 25 + 35 ≈ 660 ✓ m each graph square of charge = 10 x 10-3 x 2 x 3600 / 5 = 14.4 C ✓ m total charge delivered ≈ 9.5 kC ✓ e ≈ 2.6(4) Ah with C {9 kC from Q = 0.25 x 10 x 3600 scores 2/3} {10 kC from Q = 0.25 x 11 x 3600 scores 2/3}	1 1 1	method accept 655 to 665 method not any tolerance on this value if evaluated accept Q = Σ I Δt / area under graph / counting squares for 1 method mark in absence of any evaluation evaluation accept 9.4 to 9.6 kC / 9500 C / 9.5 x 103 C 3rd mark is for quality estimate within range above each extra error eg. power of ten / hr to s conversion -1 each accept Q = I t ⇒ 0.25 x (3600 x 10.5) = 9.45 kC full credit
	Total	**10**	

Question	Expected Answers	Marks	Additional guidance
10 (a) (i)	current limiting / protective resistor ✓ / prevent damage / overheating of LED / resistor to drop remainder of p.d. from the battery / to act as potential divider (with R of LED)	1	accept any one correct statement or AW not control resistor / to keep current constant not varying I or V or P not just to stop LED breaking / blowing
10 (a) (ii)	for correct use of VR = 9.0 – 2.1 = 6.9 V ✓m (R = V / I = 6.9 / 0.025) = 276 (Ω) ✓ e	1 1	part method evaluation accept 280 (Ω) allow 1 max on 360 Ω / 84 Ω values only allow full credit for correct potential divider method
10 (iii)	= 0.025 x 6.9 / ✓ s = 6.9 2 / 276 / = 0.025 2 x 276 = 0.17(3) (W) ✓ e	1 1	correct substitution allow ecf on incorrect VR from (ii) evaluation allow ecf on R value from ii eg. 360 Ω ⇒ 0.225 (W) / 84 Ω ⇒ 0.0525 (W) for 2 marks
10 (b) (i)	green LED starts to conduct at higher voltage than the red / at same current green LED drops more voltage/ at same voltage red LED draws more current ✓	1	look for difference accept AW quantitative not needed not green LED has higher voltage / power / resistance unless same current is specified not LEDs get brighter
(b) (ii)	red LED switches on first / green second ✓ red LED at 1.6 V green LED at 1.9 V / green takes more p.d to strike / excite / conduct / emit light / overcome barrier / threshold voltage ✓	1 1	statement accept red is brighter than green once both are on / red draws more current explanation accept because red draws more current (at same p.d. / in parallel) credit once only / because it has less resistance

Question	Expected Answers	Marks	Additional guidance
10 (iii)	total current = 5 + 20 mA / = 25 mA ✓	1	from graph accept 24 to 26 mA or two separate values from the graph totalling 24-26 mA.
	(G = I / V) = 0.025 / 7 = 3.6 X 10-3 (S) ✓	1	accept 3.57 m(S) allow ecf on incorrect current / 7 correctly evaluated
	Total	**10**	

Question	Expected Answers	Marks	Additional guidance
11 (a)	strong or 3-d bonding (makes fibres strong) ✓ no slip / no dislocation movement (to allow plastic flow) ✓ linked to because randomised orientations of ionic groups lack of short range order / directional bonding ✓	1 1 1	accept AW but must convey the sense can be in any order accept cracks propagate easily must be explicit link between 2nd & 3rd marks accept lack of regularity in structure / different sized atoms seize up the structure not just the glass is brittle
11 (b)	scratches (on surface) weakens material ✓ scratches have stress concentrations at their tips ✓ cracks propagate through material ✓ correct direction of bending is to open the crack ✓ (credit well annotated diagrams) causing brittle fracture along the length of scratch ✓ local stress cannot be relieved by slip / plastic flow or due to lack of short range order ✓	3	credit any 3 separate marking points QWC penalise absence of all / misspelling of any one of these technical terms: stress concentration / crack propagation / cracks propagate / brittle fracture place X on pen symbol if QWC penalty not glass is polycrystalline / has grains
11 (c)	in solid ions are locked rigidly in position ✓ near melting temperature ions gain mobility as glass softens ✓ in solid ions cannot flow / move to carry current / near melting temperature charge flows as ions can move ✓	1 1 1	accept AW but must convey the sense credit any 2 separate marking points max 1/3 for suggestions using free electron or charge carrier density increasing with temperature
	Total	**9**	
	Section B total:	**37**	

G492 – Understanding Processes, Experimentation and Data Handling

Physics B (Advancing Physics) mark schemes – an introduction

Just as the philosophy of the *Advancing Physics* course develops the student's understanding of Physics, so the philosophy of the examination rewards the candidate for showing that understanding. These mark schemes must be viewed in that light, for in practice the examiners' standardisation meeting is of at least equal importance.

The following points need to be borne in mind when reading the published mark schemes:

- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Open questions, such as the questions in section C permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts.
- Final and intermediate calculated values in the schemes are given to assist the examiners in spotting whether candidates are proceeding correctly. Mark schemes frequently give calculated values to degrees of precision greater than those warranted by the data, to show values that one might expect to see in candidates' working.
- Where a calculation is worth two marks, one mark is generally given for the method, and the other for the evaluation of the quantity to be calculated.
- If part of a question uses a value calculated earlier, any error in the former result is not penalised further, being counted as *error carried forwar*d: the candidate's own previous result is taken as correct for the subsequent calculation.
- Inappropriate numbers of significant figures in a final answer are penalised by the loss of a mark, generally once per examination paper. The maximum number of significant figures deemed to be permissible is one more than that given in the data; two more significant figures would be excessive. This does not apply in questions where candidates are required to show that a given value is correct.
- Where units are not provided in the question or answer line the candidate is expected to give the units used in the answer.
- Quality of written communication will be assessed where there are opportunities to write extended prose.

Question		Expected Answers	Marks	Additional guidance
1 (a) (b)		power (1); force (1); velocity (1)	1 2	Both correct and no others (2); Two correct and one other (1); 1 correct and one or no other: (1); No other combination gains marks
2		$(n)\lambda = d \sin\theta$ $\lambda = 2.0 \times 10^{-6} \times \sin(17°)$ (1) m & s; $= 5.8 \times 10^{-7}$ m (1) e	2	First mark is for choice of correct equation and substituting values. Bare answer gets (2).
3		$E = ½mv^2 = 0.5 \times 120 \times 10^{-6} \times 3^2$ (1) m & s $= 5.4 \times 10^{-4}$ J (1) e	2	First mark is for choice of correct equation and substituting values even if m incorrectly converted
4 (a) (b)		$s = ½gt^2 \Rightarrow$ t = $\sqrt{(2s/g)} = \sqrt{(36/9.8)}$ (1) m & s $= \sqrt{3.67} = 1.92$ s $\approx$ 2 s (1) e $s = u\,t = 5 \times 1.92 = 9.6$ m (1)	2 1	Needs evidence of calculation, viz. 1.9 s. Allow g=10 m s-2 Allow 2 s $\Rightarrow$ 10.0 m Ecf possible from (a)
5 (a) (b)		Use/reference to 'tip to tail' adding/use of Pythagoras (1); Calc./measurement of hypotenuse=$\sqrt{5}$ =2.2±0.1 units (1) $P \propto (A_{res})^2$ (1)	2 1	Scale drawing OK. May need to use scoris ruler to measure. If triangle drawn, must show clearly that 2<hypotenuse<3 Allow A for Ares. Allow P = (Ares)2
6 (a) (b)		Four parallel wavefronts, either spreading out or curved more at ends than centre(1); constant λ similar to approaching λ (1) Diffracted through larger angle owtte (1)	2 1	 judge λ by eye between wavefronts added eg. 'spreads more', 'more curved'

Question	Expected Answers	Marks	Additional guidance
7 (a)	$f = v/\lambda$ = 0.08/500 000 = 1.6×10^{-7} (Hz) (1)m (1)e	2	1.6×10^{-7} gets (2); calc. with one incorrect conversion gets (1)
(b)	Very low amplitude (1); very slow moving (1); very long wavelength/few waves to see across ocean (1); very long period (1); lots of other waves present/background noise hard to distinguish from random wave motion (1)	2	Any two distinct points with their relevance clear.
	Section A total:	**20**	

Question	Expected Answers	Marks	Additional guidance
8 (a)	(i) N at one end/both ends and A in the centre (1) (ii) waves travelling in opposite directions (1); waves in phase (1); superpose constructively /interfere constructively (1); displacement varies from negative to positive (1)	1 2	 Any two points. Reflect…meet = waves in opposite directions 'add up' = superpose
(b)	(i) 3.8 m (1) (ii) μ = 0.008 kg (1); $T = 4L^2f^2\mu$ = 118 N ≈ 120 N (1)m (1)e	1 3	 Allow wrong μ in calculation, eg. 8 gives 118 000N (2) Ora from μ = 0.008 kg gives f =32.2 Hz
(c)	(i) three loops similar size(1) (ii) node where finger touches (1); pattern symmetry about centre/ example of higher harmonic pattern (1)	1 2	 eg. touching ¼ way down is same as touching ¾ way down
	Total:	**10**	

Question	Expected Answers	Marks	Additional guidance
9 (a)	(i) $f = 3 \times 10^8 / 470 \times 10^{-9} = 6.4 \times 10^{14}$ Hz (1); $E = hf = 6.6 \times 10^{-34} \times 6.4 \times 10^{14}$ $= 4.2 \times 10^{-19}$ J $\approx 4 \times 10^{-19}$ J (1)	2	or $E = hc/\lambda$ (1)m (1)e Needs calculator value 4.2×10^{-19} J for 'show that'.
	(ii) Blue photons are (higher frequency and hence) higher energy than red ones (1); larger voltage $\Rightarrow$ more energy (per electron) (1)	2	One mark is links λ ($\Rightarrow f$) $\Rightarrow E$; one mark links $V \Rightarrow E$ QWC is 'clear organisation' which applies when both marks have been earned.
	(iii) $20 \times 10^{-3} / 1.6 \times 10^{-19} = 1.25 \times 10^{17}$ (1);	1	
	(iv) $P = 1.3 \times 10^{17} \times 4.2 \times 10^{-19} = 0.054$ W (1)m (1)e	2	Photon energy must be 4×10^{-19} J or 4.2×10^{-19} J 4×10^{-19} J gives 0.05 W. Allow 0.1 W
(b)	(i) Ring around 470 nm peak (1)	1	Ring must enclose the maximum and should not include the peak to the right.
	(ii) Has (significant light intensity over) range of visible light/ contains all of the wavelengths (of visible light) (1).	1	
	(iii) blue photons have more energy than red ones (1); cannot emit photon if there's not enough energy (1)	2	
	Total:	**11**	

Question	Expected Answers	Marks	Additional guidance
10 (a)	(i) Takes more time for P→ER than for ER→ M (1) (ii) method of detecting change of direction (1); explains how this method distinguishes them (1) (iii) Easier to read/ easier to use/clearer presentation / aesthetically more satisfactory/used to this format (1).	1 2 1	 eg. feel motion, use compass, observe next carriage
(b)	(i) sin(1°) or cos(89°)= 0.017 ≈ 1/50 or 0.02 (1) Parallel component of W = W sin(1°) (1); (ii) Will decelerate/slow down as it approaches (1); and accelerate/speed up as it leaves station (1). (iii) Energy argument here (any two points) • flat track involves braking and loss of energy (1); • climbing into station increases gravitational PE (1); • gravitational PE → KE as train leaves station (1)	 2 2 2	Or vector triangle with identified forces (1); ratio of 1:50 (1) (something) × sin(1°) or (something) × cos(89°) is enough to identify component of that something. NOT tan(1°). Not just force arguments. Doing work to climb = gaining GPE
	Total:	**10**	

Question	Expected Answers	Marks	Additional guidance
11 (a)	(i) Radius of orbit = 7.7×10^6 m (1) Circumference of orbit = $2\pi \times 7.7\times10^6$ m = 4.8×10^7 m (1) Speed = 4.8×10^7 m /6800s = 7100 m s^{-1}(1) (ii) time = $(2 \times 1.3 \times 10^6$m)/ 3.0×10^8 m s^{-1} = 8.7×10^{-3} s; (1) distance = 7100 m $s^{-1}\times8.7\times10^{-3}$ s= 62 m (1)	3 2	Or diameter =1.54×10^7 m Ecf throughout part (i). $R = 6.4\times10^6$ m $\Rightarrow$ circumf = 4.0×10^7 m$\Rightarrow v$ = 5910 m s^{-1} =(2) If time = 4.3 ms, correct evaluation of next stage gives a mark of (1), other times get (0) for (ii) Allow ecf for speed of satellite from (i). 7000 m s^{-1} gives 61 m; 5900 m s^{-1} gives 51 m. Look for half echo distance; 4.3 ms $\Rightarrow$ 30 m or 26 m from 7000 m s^{-1} and 5900 m s^{-1} respectively

<table>
<tr><th>Question</th><th>Expected Answers</th><th></th><th>Marks</th><th>Additional guidance</th></tr>
<tr><td rowspan="10">11 (b)</td><td colspan="2">Advantage:</td><td rowspan="10">4</td><td rowspan="10">Same feature may feature as advantage and disadvantage as separate attributes are explained.
May have mark for either factor or explanation or both.

QWC: first mark is conditional on no more than 1 mis-spelling per 15 words and no gross errors in punctuation.</td></tr>
<tr><td>Factor:
• larger area of wavefront striking sea</td><td>Explanation:
• Averages out different bits of sea/smoothes out waves
• Data taken from more ocean surface (per second)</td></tr>
<tr><td>• larger area of wavefront reaching Jason’s orbital path</td><td>• More likely to receive reflected information</td></tr>
<tr><td colspan="2">Disadvantage:</td></tr>
<tr><td>Factor:
• larger area of wavefront striking sea</td><td>Explanation:
• Poorer resolution in terms of area of sea surface
• More noise due to waves etc.</td></tr>
<tr><td>• larger area of wavefront reaching Jason’s orbital path</td><td>• Weaker signal
• Signal/noise ratio worse</td></tr>
<tr><td>• different possible paths</td><td>• Distance calculated would not be accurate/consistent
• Interference between different parts of signal
• Separate pulses overlap
• Low pulse frequency needed</td></tr>
<tr><td>• Part of wavefront misses Jason</td><td>• Some information lost</td></tr>
<tr><td></td><td colspan="2">Total:</td><td>9</td><td></td></tr>
<tr><td></td><td colspan="2">Section B total:</td><td>40</td><td></td></tr>
</table>

Question	Expected Answers	Marks	Additional guidance
12 (a)	(i) 1.4 (1); ± 0.2 (1) m	2	Allow 3 sf for mean; allow 2 sf for spread if mean has 3 sf
	(ii) 1.8 not > 2 × spread from mean (1)	1	Must apply this rule: '1.4 + 2 × 0.2 = 1.8' is enough
(b)	(50%) increase in one value makes a small contribution to the mean when compared with 11 others (1);	1	Mean: must state/imply that it is just one reading in many, eg. ref. to 'all the data'; Spread: should refer to highest and lowest data
	Presence of this single high reading has increased the range by 0.2 / spread by 0.1/ made spread or range 50% larger (1)	1	Can recalculate: mean = 1.4(4) (1) spread = 0.3 (1)
(c)	factor correctly identified (1)	1	eg. compression of spring, angle of launch, friction in tube, mass of marble.
	direction of change stated (1);	1	eg. spring compressed too much, angle decreased/nearer 45°, mechanism for reduced friction suggested, marble has smaller mass.
	Total:	**7**	

Question	Expected Answers	Marks	Additional guidance
13 (a)	$\frac{1}{100}$ mm = 10^{-5} m or 10^{-4} m = 1/10 mm (1); quantitative comparison of the two values obtained (1)	2	Can calculate eg. percentage uncertainty 10% for (2) Uncertainty of + - half a scale division is OK, giving 5%
(b)	$V = Ax = \pi r^2 x$ (1); $\rho = m/V$ and substituting above (1)	2	Needs to have explicit volume and density definitions. Dimensional analysis gets no marks.
(c)	(i) Substituting values correctly (1); Correct calc. / rearranging $\Rightarrow r = 4.0976 \times 10^{-5}$ m (1)	2	If Δx and/or x not correct in metres, no marks. No ecf allowed. $\sqrt{1.679 \times 10^{-9}}$ is evidence of calculation 4.0976×10^{-5} m gets (2) even if substitution not clear.
	(ii) least accurate datum /Δx (or E) recognised (1); 2 s.f. indicated by uncertainty of data (1);	2	Not 'all the data' or 'the data' Idea of constraint due to uncertainty of data needed for this mark.
	(iii) x is already very accurate / should tackle the least accurate measurement / most accurate measurement is the least significant source of uncertainly (1)	1	
	(iv) Recalculation with Δx = 2.5 cm (4.18×10^{-5} m) **or** 2.7 cm (4.02×10^{-5} m) (1)m (1)e Percentage uncertainty = 100 × (difference in r) / r (1); (Δx = 2.5 cm $\Rightarrow$2.0%, Δx = 2.7 cm $\Rightarrow$1.9%) Rounding answer to 1 s.f. (2%) (1)	4	Any point. First mark is using extreme value(s) of Δx, second is evaluation. Allow attempts using combination of uncertainties: Percentage uncertainty in Δx = 3.8% (1)m(1)e Percentage uncertainty in Δr =½ that in Δx = 1.9% (1) = 2% (1) Treat all consideration of uncertainties in F and x as neutral.

Question	Expected Answers	Marks	Additional guidance
(d)	(i) Identifying Δx and m as the main contributors to uncertainty in method 1 and method 2 respectively (1); Conclusion: method 2 is less uncertain justified in terms of fractional/percentage uncertainties(1)		Needs quantitative comparison: m: 1/72 =1.4% = 1% uncertain Allow attempt using combination of uncertainties: Treat all consideration of other uncertainties as neutral, but adding percentage uncertainties gives 1.7% for method 2 (1); and 4.7% for method 1 so method 2 is better (1)
	(ii) Method 1: produces (proportionately) bigger Δx /most uncertain measurement greatly improved (1); any reasonably comment on practicality (1)	2	If method 1, must comment on Δx.
	Method 2: produces (proportionately) bigger m / most uncertain measurement greatly improved (1); any reasonably comment on practicality (1)	2	if method 2, must comment on m
	Total:	**17**	

Question	Expected Answers	Marks	Additional guidance
14 (a)	No clocks accurate enough (1); accurate rulers easy to make (1)	2	Must state or imply comparison in precision of instruments
(b)	(i) $E_p = mgh = 0.025 \times 9.8 \times 1.0 = 0.245$ J (1); (ii) $E_k = ½mv^2$ $\Rightarrow v = \sqrt{(2\times0.25/0.025)} = 4.47$ m s^{-1}(>4 m s^{-1}) (1) (iii) $v = \sqrt{(10\times0.25/[7\times0.025])} = 3.8$ (1)m (1)e; units of m s^{-1} or m/s given (1) (iv) friction (1); bigger area in contact on flat mass / explaining why friction reduces v in terms of energy dissipation or reduced accelerating force (1)	1 1 3 2	NOT 0.025×9.8=0.245J Ora from 4 m s-1 and shows energy = 0.2 J < 0.25J E = 0.245 J gives v = 4.43 m s-1 0.245 J gives 3.7 m s-1; reverse calc. from 4 m s-1 not allowed. Unit mark is free-standing.
(c)	(i) 1.37 (3 s.f.) and 0.64 or 0.640 (2 or 3 s.f.) (1) (ii) points (0.30,0.64) and (0.65,1.37) correctly plotted (1); Best-fit straight line (1); Straight line (almost) through origin so $D^2 \propto H$ / Straight line not through origin so D^2 not $\propto H$ (1) [ecf from their line which must go back to axes]. (iii) gradient 2.3 (± 0.2) (1)m (1)e; [check for construction on graph if gradient outside this range] $Y = 7 \times 2.3/20 = 0.81 \approx 0.8$ m (1)	1 3 3	Overlay shows point positions; points should be within one small square of correct positions; line should be centred on all points plotted. Move overlay so that red square coincides with outside of graph grid to check points and line.
	Total:	**16**	
	Section C total:	**40**	

Grade Thresholds

Advanced GCE Physics A (H159/H559)
June 2009 Examination Series

Unit Threshold Marks

Unit		Maximum Mark	A	B	C	D	E	U
G491	Raw	60	36	31	26	22	18	0
	UMS	90	72	63	54	45	36	0
G492	Raw	100	62	54	47	40	33	0
	UMS	150	120	105	90	75	60	0
G493	Raw	30	24	21	18	16	14	0
	UMS	60	48	42	36	30	24	0

Specification Aggregation Results

Overall threshold marks in UMS (ie after conversion of raw marks to uniform marks)

	Maximum Mark	A	B	C	D	E	U
H159	300	240	210	180	150	120	0

The cumulative percentage of candidates awarded each grade was as follows:

	A	B	C	D	E	U	Total Number of Candidates
H159	21.3	35.5	51.4	67.8	82.1	100	5824

5824 candidates aggregated this series

For a description of how UMS marks are calculated see:
http://www.ocr.org.uk/learners/ums_results.html

Statistics are correct at the time of publication.

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