AQA

A-Level
Physics

PHA6/B6/X – Investigative and practical skills in A2 Physics
Mark scheme

2450/2455
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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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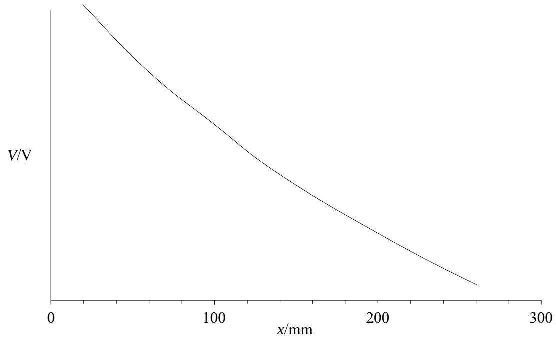
Section A Task 1				
1	(a)(i) & (a)(ii)	results:	7 sets of V, all recorded to 0.01 V or all recorded to 0.001 V ✓	**1**
	(a)(iii)	graph:	suitable vertical scale (7 or more major grid squares); 7 points plotted (check at least one including any that appear anomalous) ✓ (don't penalise twice for poor point(s) here and in Task 2) continuous smooth curve of increasing negative gradient; curve must pass within 2 mm of 6 of the 7 plotted points ✓ (don't penalise twice for poor line here and in Task 2)	**2**
	(b)(i)	description: direction	*E* is to the right [in direction that *x* increases / away from clip C / 'in the direction of the current' / 'positive to negative'] ✓ (reject 'clockwise')	**1**
	(b)(ii)	statement and explanation:	states that (magnitude of) *E* increases (as *x* increases): ignore mathematical suggestions $_1$✓ (reject '*E* becomes more negative (as *x* increases)') field strength = (–potential) gradient $_2$✓ (accept '$E \propto$ gradient' or (as strip narrows) 'field lines are closer together'; claims that $E = \frac{V}{d}$ forfeits this mark) [field strength = (–potential) gradient so field strength is greater where the graph is steeper $_1$✓$_2$✓; *E* is greater at *x* = 260 because gradient is larger $_1$✓$_2$✓]	**2**
2	(a)	method:	T_{100} and T_{200}, each from nT where $\Sigma n \geq 3$; $T_{100} > T_{200}$, raw readings all recorded to 0.1 s or all to 0.01 s; unit must be seen somewhere ✓ no interpolation allowed here; don't penalise for suspected 2*T* = *T* unless there is clear evidence to do so	**1**
		accuracy:	$\frac{T_{100}}{T_{200}}$ to 2 to 4 sf, no unit, in range 1.47 to 1.80, 1.6 or 1.7 ✓ **note that this is the only part of Section A where excessive sf are penalised**	**1**

	(b)	explanation:	in question 1 <u>current</u> (in conductive paper) = <u>constant</u> [accept argument based on potential divider theory]; $V \propto R$ or $V = IR$ $\left[\dfrac{V_{100}}{V_{200}} = \dfrac{R_{100}}{R_{200}}\right]$ $_1$✓ (reject $\dfrac{V_{100}}{V_{200}} \propto \dfrac{R_{100}}{R_{200}}$) [$\dfrac{V_{100}}{V_{200}} = \dfrac{IR_{100}}{IR_{200}}$ makes both points and earns $_1$✓] in question 2 <u>capacitance</u> C = <u>constant</u>; $T \propto R$ $\left[\dfrac{T_{100}}{T_{200}} = \dfrac{R_{100}}{R_{200}}\right]$ $_2$✓ (reject $\dfrac{T_{100}}{T_{200}} \propto \dfrac{R_{100}}{R_{200}}$) [$\dfrac{T_{100}}{T_{200}} = \dfrac{R_{100}C(\ln 2)}{R_{200}C(\ln 2)}$ makes both points and earns $_2$✓] <u>read off / find</u> (from Figure 3) V for x = 100 and x = 200 $_3$✓ $\dfrac{T_{100}}{T_{200}} = \dfrac{V_{100}}{V_{200}}$ seen or <u>evaluate</u> [work out / calculate] $\dfrac{V_{100}}{V_{200}}$] $_4$✓ (reject $\dfrac{T_{100}}{T_{200}} \propto \dfrac{V_{100}}{V_{200}}$) [evidence of suitable calculation showing both read offs in working can earn $_{34}$✓✓]	**4**
	(c)(i)	sketch:	smooth line of <u>continuously</u> <u>decreasing</u> <u>negative</u> gradient or 0/2 $_1$✓ line from (maximum) x = 20 to minimum x = 260 and maximum x = 280; $V \neq 0$ except at x = 280 $_2$✓  [if gradient = 0 for $x \geq 200$ but graph is otherwise correct $_{12}$✓] (ignore any numerical values added to V axis)	**2**
	(c)(ii)	explanation:	T_{100} is less [C will discharge quicker] <u>because R is less</u> (or 0/2) ✓ (reject 'T_{100} will be original result for T_{200}') (R is less) because (average cross-sectional) area [width] of the conductor is greater ✓ (reject 'paper is thicker')	**2**
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Section A Task 2				
1	(a)	explanation:	checked that ruler is perpendicular to the <u>floor</u> [bench] using a set-square [comparing edge of the ruler with the string of the pendulum acting as a plumb line] ✓ in two perpendicular directions (accept face and edge/side, 'all four sides' but not 'both sides' / 'two planes') ✓ (sketch may show all the detail required to award both marks; reject idea of measuring distance between the ruler and the string of the pendulum)	**2**
1	(b)	tabulation:	*l* / mm *h* / mm ✓ deduct this mark for any missing label or separator	**1**
		results:	(minimum of) 6 sets of *l* and *h* ✓✓ deduct 1 mark for each missing set deduct 1 mark if *l* range < 100 mm deduct 1 mark if the initial [largest] *l* is not ≥ 800 mm and is not ≤ 900 mm deduct 1 mark if *l* is not in the left-hand column of the table maximum deduction 2 marks	**2**
		significant figures:	all *l* and all *h* to nearest mm ✓ condone <u>all</u> raw readings to nearest 0.5 mm; reject <u>all</u> trailing zeros	**1**
1	(c)	axes:	marked *h*/mm (vertical) and *l*/mm (horizontal) ✓✓ deduct ½ for each missing label or separator, rounding down; no mark if axes reversed either or both marks may be lost if the interval between the numerical values is marked with a frequency of > 50 mm	**2**
		scales:	points should cover at least half the grid horizontally ✓ <u>and</u> half the grid vertically ✓ (if necessary, a false origin should be used to meet these criteria; either or both marks may be lost for use of a difficult or non-linear scale)	**2**
		points:	all tabulated points plotted correctly (check at least three including any anomalous points) ✓✓✓ 1 mark is deducted for every point missing and for every point > 1 mm from correct position deduct 1 mark if any point is poorly marked; no credit for false data	**3**
		line:	(ruled) best fit straight line of negative gradient ✓ maximum acceptable deviation from best fit line is 2 mm, adjust criteria if graph is poorly scaled; withhold mark if line is poorly marked	**1**

		quality:	5 of 6 points to ± 2mm of a straight line of negative gradient (judge from graph, providing this is suitably-scaled) ✓	**1**
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Section B			
1	(a)	correct transfer of y- and x-step data between graph and calculation **or** $_{12}$✓**= 0** (mark is withheld if points used to determine either step > 1 mm from correct position on grid; if tabulated points are used these must lie on the line) y-step and x-step both ≥ 8 semi-major grid squares [5 × 13 or 13 × 5] $_2$✓ (if a poorly-scaled graph is drawn the hypotenuse of the gradient triangle should be extended to meet the 8 × 8 criteria)	**2**
		G no unit, in range –1.78 to –1.96 or –1.9 ✓✓ [–1.68 to –2.06, –1.8 or –2.0 ✓] deduct 1 mark for omission of – sign tolerate 4 sf but deduct 1 mark for answers ≥ 5 sf **note that this is the only part of Section B where excessive sf are penalised**	**2**
1	(b)(i)	G unchanged (or 0/2) $_1$✓ idea that h only depends on the vertical distance between the rod and the bob [h will be the same for bob to reach the nail with same E_k [speed] / to have the same initial E_p / for the bob to follow the required path] $_2$✓ (for same value of h) each l value is increased <u>by the same amount</u> [allow ‘for same value of l each h is increased by same amount’ / h intercept higher / line [graph] shifted <u>up</u> / line [graph] shifted to the <u>right</u>] $_3$✓ (don’t allow ‘readings for l and for h increase by the same amount’) (for wrong physics eg $h \propto l$ $_{23}$✓=0)	**MAX 2**
	(b)(ii)	G is positive and has the <u>same magnitude</u> (or words to that effect; condone ‘G is now –G’ but don’t allow ‘roughly the same value’ or ‘G is the inverse’) (or 0/2) $_1$✓ because h is now (100 – h) [(1 – h) and (1000 – h)] $_2$✓ decreasing values of l produce decreasing values of h $_3$✓ because there is the same <u>change</u> in h [(100 – h)] for corresponding <u>change</u> in l $_4$✓ (ignore ‘values reversed’ or ‘values inverted’)	**MAX 2**
2	(a)	(mark should be at the equilibrium position) since this is where the mass moves with <u>greatest speed</u> [transit time is least] ✓	**1**

	(b)(i)	mean time for 20T (from sum of times ÷5) = 22.7 (s) $_1$✓ (minimum 3sf) uncertainty (from half of the range) = 0.3 (s) $_2$✓ (accept trailing zeros here) percentage uncertainty (from $\frac{0.3}{22.7}\times 100$)[$\frac{100}{5}\times\Sigma\frac{0.3}{20T}$] = 1.3(22) % $_3$✓ (allow full credit for conversion from 20T to T, eg 1.135 = $_1$✓ 0.015 = $_2$✓ ecf for incorrect $_1$✓ and/or $_2$✓ earns $_3$✓)	**3**
	(b)(ii)	natural frequency (from $\frac{20}{22.7}$ and minimum 2 sf) = 0.88(1) Hz [accept s^{-1}] ✓ (ecf for wrong mean 20T; accept ≥ 4 sf)	**1**
	(c)(i)	linear scale with at least 3 evenly-spaced convenient values (ie not difficult multiples) marked; the intervals between 1 Hz marks must be 40 ± 2 mm (100 ± 5 mm corresponds to 2.5 Hz) ✓ (ecf for wrong natural frequency: 100 ± 5 mm corresponds to $\frac{2.5f}{0.88}$ Hz)	**1**
	(c)(ii)	4 mm [allow ± 0.2 mm] ✓	**1**
	(d)(i)	student decreased intervals [smaller gaps] between [increase frequency / density of] readings (around peak / where A is maximum) ✓✓ [student took more / many / multiple readings (around peak) ✓] (reject bland 'repeated readings' idea; ignore ideas about using data loggers with high sample rates)	**2**
	(d)(ii)	new curve starting within ± 1 mm of A = 4 mm, f = 0 Hz with peak to right of that in Figure 12 ✓ (expect maximum amplitude shown to be less than for 2 spring system but don't penalise if this is not the case; likewise, the degree of damping need not be the same (can be sharper or less pronounced) peak at $\sqrt{2}$ value given in (b)(ii); expect 1.25 Hz so peak should be directly over 50 ± 5 mm but take account of wrongly-marked scale ✓	**2**

3	(a)	the travelling microscope won't interfere with / change the path / interrupt / affect the stream [flow] of water / affect the reading (being taken) [vernier callipers will interfere with etc] ✓ (reject 'cannot grip / clamp the flow')	**1**
	(b)(i)	straight best-fit line drawn passing within ± 2 mm of 1st and 5th points, 3rd and 4th points to be either side of line; attempt to measure the gradient (ie using $\frac{d(\log s)}{d(\log d)}$) from the line or from two of the plotted points if these lie on the line; do not penalise for small steps, false read-off(s) (including failure to take account of false origin) or for calculation error ✓ n = –4 (integer value only, eg reject –4.0) ✓	**2**
	(b)(ii)	$k = 10^{\text{intercept}}$ [antilog of (log s) intercept] ✓ [take values of log s and log d and evaluate $10^{(\log s - (-4)\log d)}$ ✓] ('log k = intercept' is insufficient)	**1**
	(b)(iii)	units of k = cm^5 [accept m^5 or mm^5; allow ecf for wrong or non-integer value for n, eg ecf for $cm^{(1-n)}$ ✓	**1**
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