A-level

Physics (Specifications A & B)

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

2450/2455
June 2014

Version 1.0 Final

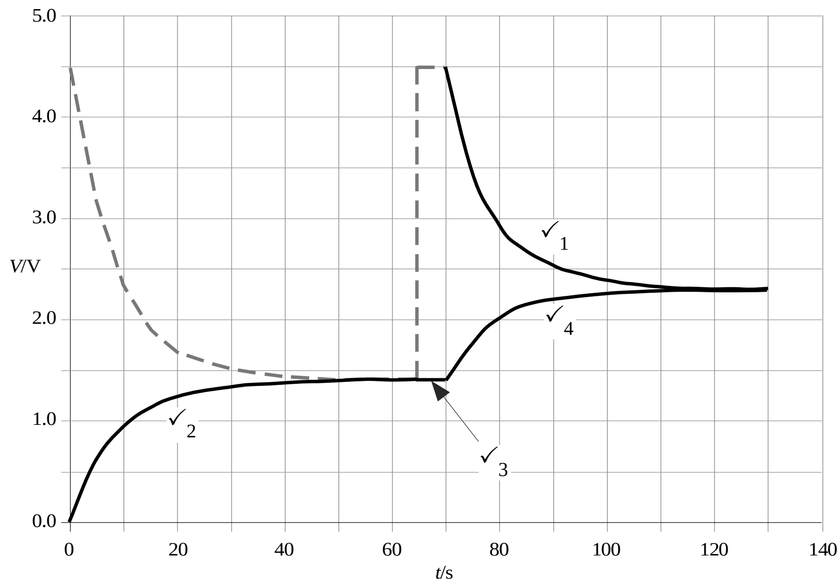
Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this 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.

Further copies of this Mark Scheme are available from aqa.org.uk

Section A Task 1				
1	(a)	results:	ε recorded with unit; if ε not to same precision as V_A and V_B readings then withhold mark in 2(a) sensible readings for time (from 80% of ε) to reach 40% of ε and 20% of ε, (raw readings) both to 0.1 s or both to 0.01 s; both should be repeated at least once and an average calculated: $_1$✓ $\frac{t_{V=20\%}}{t_{V=40\%}}$ in range 1.95 to 2.05 $_2$✓ (examiner should record ratio alongside candidate's table; if repeats are shown but no average is calculated, determine ratio from last pair of timings)	**2**
1	(b)	explanation:	states that reading has been shown to decay exponentially [accept 'yes it does'] because the time to fall (from 80%) to 40% ≈ time to fall from 40% to 20% [time to fall (from 80%) to 40% ≈ half the time to fall (from 80%) to 20%, or use half life divided by $\log_e 2$ to compare time constants] (reject 'when voltage halves time doubles') ✓ [for data that fails to earn (a) $_2$✓ but produces ratio in range 1.90 to 2.10 allow (b) mark as above; for any ratio that falls outside the range 1.90 to 2.10 only allow (b) mark if candidate states that reading has been shown **not** to decay exponentially]	**1**
1	(c)	method and calculation:	resistance of R in range 11.0 kΩ to 13.0 kΩ or 12 kΩ ✓✓ [10.0 kΩ to 14.0 kΩ, 11 kΩ or 13 kΩ ✓] (don't deduct for >4 sf answers)	**2**
1	(d)	explanation:	voltmeter is (a resistor) in parallel with R $_1$✓	**1**
			circuit resistance is halved or time constant [CR, τ, half life] is halved $_2$✓	**1**
			[parallel resistance calculation shown e.g. $\left(\frac{1}{\text{total resistance}}\right) = \frac{1}{R} + \frac{1}{R}$ or $\text{total resistance} = \frac{R^2}{2R}$ is worth $_1$✓$_2$✓]	
			(calculated) result for R is halved $_3$✓	**1**
			[result for R is reduced with suitable justification: time constant is reduced / resistance of circuit [time constant] is reduced / time for pd to halve [half life] is reduced / capacitor will discharge in less time $_{23}$✓ = 1 MAX]	

2	(a)	results:	six readings of V_A and six readings of V_B all to 0.01 V or all to 0.001 V; initial V_A and V_B <u>should be same</u> as $\varepsilon \pm 0.010$ V✓	**1**
2	(b)	calculation:	$\frac{2\varepsilon - V_A}{V_B}$, no unit, in range 2.72 to 3.68 or 2 sf in range 2.8 to 3.6; withhold mark for answer $\geq$ 5 sf ✓ **note that this is the only part of Section A Task 1 where excessive sf are penalised**	**1**
2	(c)(i)	deduction:	line for V across C1 for $t \geq 70$ s: starting from $t = 70$ s, $V = 4.5$ V line is a <u>smooth</u> curve of decreasing negative gradient until $t = 100$ s at the earliest; after $t = 120$ s, V does not change by more than 0.1 V (i.e. by no more than one grid square) line terminates at $t \geq 130$ s when V is in the range 2.0 V to 2.5 V $_1$✓	
2	(c)(ii)	deduction:	line for V across C2 for $t \leq 70$ s: starting from $V = 0$ V at $t = 0$ s, line is a smooth curve of decreasing positive gradient until $t = 40$ s at the earliest; between $t = 50$ s and $t = 65$ s, V does not change by more than 0.1 V (i.e. by no more than one grid square) $_2$✓	**4**
			$V = 1.45 \pm 0.05$ V from $t = 65$ s and <u>until $t = 70$ s</u> $_3$✓	
			line for V across C2 for $t \geq 70$ s: starting at point reached at end of previous stage (expect $t = 70$ s and $V = 1.45 \pm 0.05$ V) line is a smooth curve of decreasing positive gradient so that by $t = 120$ s V across C1 = V across C2, $\pm$ 0.1 V (i.e. by no more than one grid square) $_4$✓ [allow ecf if $_3$✓ = 0, e.g. increasing at $t = 65$ s and/or at V reached after first discharge of C1; allow ecf if $_1$✓ = 0, e.g. terminating at same time <u>and at same pd</u> $\pm$ 0.1 V as where line for V across C1 terminates]	
			for any line for V across C2 that goes above line for V across C1, $_{34}$✓ = 0	
			[See graph on next page]	**14**

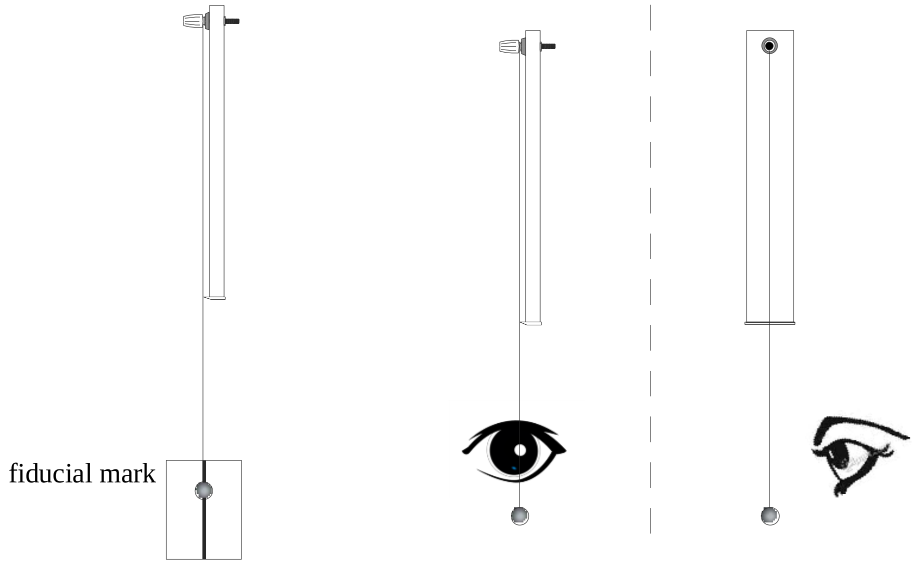


Section A Task 2				
1	(a)	accuracy:	*x* to nearest mm in range 240 mm to 260 mm (suitable unit required) [condone '25 cm' but deduct SF mark in (b)] ✓	**1**
1	(b)	tabulation:	*l* / mm *nT* /s *T* (/s) ✓ withhold mark for any missing label or separator	**1**
		results:	5 sets of *l* and *nT* ✓✓ deduct 1 mark for each missing set, if *l* range < 300 mm, if any *T* is **not** from *nT* where *n* or Σ*n* ≥ 20, or if *l* values are not tabulated in the left-hand column of the table (maximum deduction 2 marks)	**2**
		significant figures:	all (raw) *nT* to nearest 0.1 s or all to nearest 0.01 s; all *l* (including *x* in part (a)) to nearest mm ✓	**1**
1	(c)	tabulation:	$\sqrt{l+x}-\sqrt{l}$ (/m$^{1/2}$) $\frac{1}{T}$ [frequency] (/s^{-1}) ✓	**1**
		significant figures:	all $\sqrt{l+x}-\sqrt{l}$ recorded to 3 or all to 4 sf; all $\frac{1}{T}$ recorded to 3 or all to 4 sf (tolerate extra sf for *T* < 1 s sets: accept combined table for (b) and (c)) ✓	**1**
		axes:	marked $\sqrt{l+x}-\sqrt{l}$ /m$^{1/2}$ [$\sqrt{\text{m}}$] (vert.), $\frac{1}{T}$ /s^{-1}[Hz] (horiz.) ✓✓ 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 > 5 cm	**2**

		scales:	points should cover at least half the grid horizontally ✓ and half the grid vertically ✓ (if necessary, a false origin should be used to meet these criteria and this must be clearly marked; either or both marks may be lost for use of a difficult or non-linear scale)	**2**
		points:	5 points plotted correctly (check at least three including any anomalous points) ✓✓✓ 1 mark is deducted for each tabulated point that has not been plotted and no credit should be given for any plotted point for which the data has not been tabulated 1 mark is deducted for each item of false data 1 mark is deducted if any point is poorly marked and for every point > 1 mm from correct position	**3**
		line:	(ruled) best fit straight line of positive 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:	all 5 points to ± 2mm of a straight line of positive gradient (judge from graph, providing this is suitably-scaled) ✓	**1**
				16

False *T*, e.g. *T* = *nT*, *T* = *T*/2, *T* = 1/*T*: (a) *x* = 1; (b) T = 1 / R = 0 / SF = 1; (c) T = 1 / SF = 1 / A = 2 / S = 2 / P = 0 / L = 1 / Q = 1 ; total = 11 MAX

Section B			
1	(a)(i)	valid attempt at gradient calculation and 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 at least 8 semi-major grid squares $_2$✓ [5 by 13 or 13 by 5] (if a poorly-scaled graph is drawn the hypotenuse of the gradient triangle should be extended to meet the 8 × 8 criteria)	**2**
	(a)(ii)	$\frac{G}{X}$ in range 0.95 to 1.05 s m$^{-1/2}$ or 1.0 s m$^{-1/2}$ ✓✓ [0.90 to 1.10 s m$^{-1/2}$ ✓]; tolerate 4 sf but deduct 1 mark for answers ≥ 5 sf: other acceptable answers: 0.095 to 0.105 s cm$^{-1/2}$ or 0.10 s cm$^{-1/2}$ ✓✓ [0.090 to 0.110 s cm$^{-1/2}$ ✓] 0.0300 to 0.0332 s mm$^{-1/2}$, 0.031 or 0.032 s mm$^{-1/2}$ ✓✓ [0.0285 to 0.0348 s mm$^{-1/2}$, 0.029, 0.030, 0.033 or 0.034 s mm$^{-1/2}$ ✓] (allow ecf for wrong units transferred from graph but no ecf for graph with reversed axes) **note that this is the only part of Section B where excessive sf are penalised**	**2**
1	(b)	annotation to <u>side view</u> showing the fiducial mark at the centre of oscillation, i.e. aligned with the string; some part of the mark should be below the ruler that interrupts the swing (mark can be below bob but don't insist on this as most will find this impractical: allow mark to lie in horizontal plane, e.g. nail clamped horizontally) [give credit if the mark is shown at a suitable height in the front view and it is stated that this was positioned at the <u>equilibrium</u> position / at the centre] $_1$✓ annotation to <u>front view</u> showing (side view of) eye looking [direction of view intersecting string] in a direction perpendicular to plane of oscillations or suitable unambiguous statement, e.g. 'viewed from the side' [annotation to side view showing (front view of) eye looking in a direction perpendicular to plane of diagram / eye looking vertically along line of string and it is stated that oscillations are viewed from the side] $_2$✓ [don't insist that the apparatus is viewed in a direction parallel to the ground as this is impractical; the eye can be shown to the side and above the ruler but if the is apparatus is viewed from <u>directly</u> above (so the string below ruler is obscured by the terminal (or if the ruler is used as the fiducial mark) $_{12}$✓ = 1 MAX} [See diagram on next page]	

<table>
<tr><td>1</td><td>(b)
(cont.)</td><td>
</td><td>2</td></tr>
</table>

<table>
<tr><td rowspan="4">1</td><td>(c)(i)</td><td>graph / line is higher up [the point<u>s</u> on student A's graph are shifted (vertically) upwards];
(statement that $\sqrt{(l+x)}-\sqrt{l}$ values increase is not sufficient;
withhold mark for 'all shifted up by same amount', 'gradient unchanged' but allow possible ecf in (c)(iii)); withhold mark for 'intercept increased' $_1$✓
(as $\frac{1}{T}$ values are increased) $\sqrt{(l+x)}-\sqrt{l}$ values increase at a decreasing rate [<u>decreasing</u> gradient / curves <u>downwards</u>] $_2$✓</td><td>2</td></tr>
<tr><td>(c)(ii)</td><td>in student B's graph G decreased [G smaller, line shallower etc.] (any suggestion that line is displaced by a fixed amount (to the right), hence different intercept, loses this mark) $_1$✓
because T all smaller <u>by same fraction</u> (reject T results get smaller by a decreasing amount) $_2$✓
[$\frac{1}{T}$ all bigger by same fraction / this is a percentage systematic error (in $\frac{1}{T}$)
(reject $\frac{1}{T}$ get bigger by an increasing amount) $_2$✓]</td><td>2</td></tr>
<tr><td></td><td>in (c)(i) and (c)(ii) allow ecf if candidate plots a graph with the axes reversed</td><td></td></tr>
<tr><td>(c)(iii)</td><td>student A's graph <u>will be a curve</u> [will be non-linear] (and student B's graph will still be a straight line) ✓
[if (c)(i) answer states that points [condone $\sqrt{l+x}-\sqrt{l}$ values] increase by <u>same amount</u> [points / line shifted up but gradient unchanged] then must state that student A's graph <u>will not pass through origin</u> [will have non-zero intercept] (and student B's graph does go through the origin)]</td><td>1</td></tr>
</table>

2	(a)	digital meter has higher resistance [allow 'very high' / 'infinite'] / capacitors do not discharge (quickly) through the meter / voltmeter readings will not decrease [change] before readings are taken (reject parallax argument) ✓	**1**
	(b)	largest possible capacitance (accept either μF or F), $C_U = \frac{1200 \times 2.4}{(5.9 - 2.4)}$ ₁✓ 823 μF or 8.2(3) × 10^{-4} F; accept minimum of 2 sf, i.e. 820 μF, 8.2 × 10^{-4} F (don't deduct for >4 sf answers) ₂✓ ($C_U = \left(\frac{1000 \times 2.3}{(6.0 - 2.3)} + 200\right)$ or <u>any</u> unsupported answer loses both marks)	**2**
	(c)	frequency = 0.107 or 0.11 (Hz) (allow > 3sf, reject 0.106, 0.10 or 0.1 (Hz)) ₁✓ straight line (deviation may not be > 1 mm at any point) marked on Figure 11 <u>through / from</u> *R* = 5 kΩ (to ± 1 mm) passing through the frequency axis to the capacitance axis (to ± 1 mm) ₂✓ (if ₂✓=0 then withhold ₃✓) *C* in range 710 to 850 (μF) (allow ≥ 2 sf) ₃✓	**3**

3	(a)	(800 × 0.05 =) 40 (samples); (any unit supplied loses mark) ✓	**1**
	(b) (i)	ASE symbol for ammeter [current sensor, correctly shown] in series and ASE symbol for voltmeter [voltage sensor, correctly shown] in parallel with the heater [condone voltmeter connected across power supply] (don't deduct for inclusion of a series variable resistor unless its inclusion prevents valid measurements being made to determine the power) ✓	**1**
	(b) (ii)	measure multiple readings of *V* and *I*; calculate *V* × *I* (for each pair), then calculate an <u>average</u>/<u>mean</u> ✓ (reject 'work out average *V* and average *I*; multiply these results together' or idea of plotting *IV* graph and finding area below line; any suggestion that the pd or current are to be deliberately varied e.g. using a variable resistor, loses this mark)	**1**
	(c) (i)	the temperature rises because (until t ≈ 700 s) <u>the heater is</u> (still) <u>hotter than the water</u> [(temperature continues to rise because) heater and water have yet to reach thermal <u>equilibrium</u> / <u>same temperature</u>] ✓ (reject 'heater would still be hot' or 'still supplies heat to water' as inadequate)	**1**
	(c) (ii)	valid method used [numerical working illustrating valid method] or ₁₂₃✓=0, e.g. $P \times \Delta t = m \times c \times \Delta\theta$ or $P = m \times c \times gradient$ or working to that effect, e.g. $c = \frac{15.2 \times 220}{119 \times 10^{-3} \times 6.2}$ ₁✓ based on θ values not greater than 29.0 °C and not less than 22.8 °C, and a time interval in the range 200 to 220 s ₂✓ *c* in range 4.50 to 4.65 × 10^3 or 4.6 × 10^3 (J kg^{-1} K^{-1}); allow ≥ 4 sf ₃✓	**3**

	(c) (iii)	some heat [(thermal) energy] is transferred to the flask [to the temperature sensor / to air inside flask / convection out of the neck of the flask or other relevant physics]; accept idea that water may contain impurities [water is not distilled] ✓ (reject 'heat is transferred to the surroundings/room' or 'water may not have been stirred') [if due to error in calculation result for *c* is less than 4180 allow mass is less than 119 due to evaporation or spillage during pouring etc.]	**1**
			25