



**General Certificate of Education
June 2010**

Physics

PHA6/B6/X

Investigative and Practical Skills in A2 Physics

Unit 6

Final

Mark Scheme

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GCE Physics, PHA6/B6/X, Investigative and Practical Skills in A2 Physics

Section A, Task 1

Question 1		
(a)	accuracy $T_3 > T_2 > T_1$, values sensible ✓ (any) T from pT where $\Sigma p \geq 20$ ✓ $p)T_1$, $(p)T_2$ and $(p)T_3$ recorded consistently to 0.1 s or to 0.01 s ✓ [$T = \frac{T}{2}$ can earn 23✓✓; $T = nT$ or $T = \frac{1}{T}$ can earn only 3✓; n in fixed time can earn 1✓ only]	3
(b)	method $\log T$ and corresponding $\log n$ values correctly calculated for all three of T_3, T_2 and T_1 (tolerate $\log 10T, \ln T$ and $\ln n$) 1✓ all (of each set of \log values) recorded to 3 or to 4 dp 2✓ [if \ln values tabulated accept all to 3 sf or all to 4 sf] plots graph of $\log n$ (\uparrow) against $\log T$ (\rightarrow) [or vice-versa] and calculates gradient 3✓ points to occupy $\frac{1}{2}$ grid each way; Δ should occupy $\frac{1}{2}$ grid each way 4✓ [at least 2 $\frac{\Delta \log n}{\Delta \log (T/s)}$ evaluated 34✓✓; any $\frac{\Delta \log n}{\Delta \log (T/s)}$ 34✓] result valid working to show $x = 2$ (integer value only) ✓ [at least 2 n/T^2 confirming $x = 2$ ✓] (ecf allowed for $T = nT$; this can get 4 marks) method/ result [guesses that $x = 2$: calculates T^2 values and plot a graph of T^2 against n ; points to occupy $\frac{1}{2}$ grid each way 1234✓; straight line graph through the origin (confirming $x = 2$) ✓ = 2/4 max]	max 3 1
(c)	method measures directly or calculates length, l , of (any) paper clip chain; substitutes value into $2\pi \sqrt{\frac{l}{g}}$ to correctly find period of simple pendulum of length l 1✓, or 2✓ = 0 compares result with relevant measurement of T and shows these to be inconsistent 2✓ [measures directly or calculates length, l , of (any) paper clip chain; substitutes T into $\frac{T^2 g}{4\pi^2}$ to correctly find length of simple pendulum of period T 1✓ or 2✓ = 0; compares result with relevant measurement of l and shows these to be inconsistent 2✓] [measures directly or calculates length, l , of (any) paper clip chain; evaluates $\frac{T^2}{l}$ for paper clip pendulum 1✓ [reads off intercept on $\log n$ axis; evaluates k from ($10^{\text{intercept}}$) then calculates ($k \times c$); compares result with $\frac{4\pi^2}{g}$ [$4.02 \text{ s}^2\text{m}^{-1}$] and shows these to be inconsistent 2✓]	2
	Total	9

Question 2			
(a)	accuracy	time, τ , for energy transfer with 4 paper clips attached, to SV $\pm 20\%$ ✓ (penalise here, but not in (b) for $\tau = \frac{\tau}{2}$)	1
(b) (i)/ (ii)	accuracy	τ with 5 paper clips, result less than τ with 4 paper clips; τ with 6 paper clips, result less than τ with 5 paper clips ✓	1
(a)/(b)	method	any τ from repeated readings; raw readings consistently recorded to 0.1 s or 0.01 s ✓	1
(b) (iii)	explanation	three correct calculations of $\tau \times$ number of paper clips [or inverse of ($\tau \times$ number of paper clips)] ₁ ✓ valid comment about result of relevant calculation; accept statement that inverse proportion is proven if all results for ($\tau \times$ number of paper clips) $\leq 5\%$ of the mean and not proven if any result $\geq 10\%$ of the mean; accept either response if any result lies between 5% and 10% of the mean ₂ ✓ [other approaches: $\frac{\tau_a}{\tau_b}$ compared with $\frac{b}{a}$ and $\frac{\tau_a}{\tau_c}$ with $\frac{c}{a}$, or compared with $\frac{\tau_b}{\tau_c}$ with $\frac{c}{b}$, ₁ ✓; valid comment ₂ ✓] [correct use of 2 sets of data and valid comment is worth ₁₂ ✓]	2
(c)	method	(τ very long, hence) difficult to determine when pendulum has come to rest [reached zero/maximum amplitude] (and hence, when to start/stop the watch) ✓ reject 'time consuming' argument or statement that 'it is hard to tell when the displacement is zero/maximum')	1
Total			6

Section A Task 2

Question 1			
(a)	accuracy	nc recorded to mm and sensible, n (or Σn) ≥ 10 ; c calculated (and sensible, eg about 5 cm), result given to 3 sf or 4 sf ✓	1
(b)	accuracy	d found from average of at least 3 (sensible, eg about 1 mm) repeated readings; raw readings of d to 0.01 mm, final answer given to 3 sf or 4 sf ✓	1
(c)	tabulation	x /mm y /mm ✓ any missing label or separator loses the mark	1
	results	at least 10 sets of x and y (expect 12 or 13) ✓ $x = 0$ data set shown in table ✓ largest x value in range 355 mm to 380 mm ✓ (9/8 sets = 2 max, 7/6 sets = 1 max; ignore any details of junction/clip number in the tabulation; no credit for false/displaced data, or sets on the wrong side of catenary)	3
	significant figures	all x and all y to nearest mm ✓	1
	quality	at least 10 points to ± 2 mm of a smooth curve of continuously increasing, (positive) gradient (judge from graph; adjust criterion if graph is poorly-scaled) ✓ (do not penalise for graph showing the wrong/both sides of the catenary or for displaced data)	1
(d)	axes	marked y /mm (vertical) and x /mm (horizontal) ✓✓ deduct $\frac{1}{2}$ for each missing label or separator, rounding down [bald y (vertical) and x (horizontal) ✓] deduct a mark if the interval between the numerical values is marked on either axis with a frequency of > 5 cm	2
	scales	points should cover at least half the grid horizontally ✓ and half the grid vertically (do not penalise false data) ✓ (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; be lenient with displaced data or if the graph shows the wrong side or both sides of the catenary)	2
	points	all tabulated points plotted correctly, minimum of 10 points (check at least three including every anomalous point) ✓✓✓ 1 mark is deducted for every tabulated point not plotted, for every point > 1 mm from correct position and if any point is poorly marked; 9/8 points = 2 max, 7/6 points = 1 max no credit for false/displaced data, or sets on the wrong side of the catenary	3
	line	best fit line of positive, continuously increasing gradient ✓ maximum acceptable deviation from best fit line is 2 mm (adjust criterion if graph is poorly-scaled); any point of inflexion loses this mark (tolerate no more than one straight link between adjacent points); there is no credit for false data but be lenient with displaced data or if the graph shows the wrong side or both sides of the catenary)	1
		Total	16

Section B

Question 1		
(a)	<p>$n = 24$ correctly substituted; results for c and d correctly substituted (watch for mixed units) ✓</p> <p>L to mm (4 sf) or to cm (3 sf), to supervisor's value ± 50 mm (± 5 cm) (no ecf for false data) ✓</p>	2
(b) (i)	<p>percentage difference = $100 \times \left(\frac{2d}{c} - \frac{2d}{nc} \right)$ ✓✓</p> <p>or any two of the following points:</p> <p>as n increases, $2d(n - 1)$ increases ✓</p> <p>as n increases, the difference between L and nc increases ✓</p> <p>as n increases, $2d(n - 1)$ is a bigger proportion of L ✓</p> <p>percentage difference = $\frac{2d(n-1)}{L}$ ✓</p> <p>(b) (ii) the increase [change / difference] in percentage difference becomes smaller as n increases ✓ (accept use of data from Table 1 to illustrate answer)</p> <p>(b) (iii) sketch showing graph (accept axes either way round) of percentage difference against n [tolerate log n], eg as below ✓</p> <div style="text-align: center;"> </div> <p>read off along n axis where percentage difference = 4% (can be shown on sketch; (ecf if sketch shows wrong trend) ✓</p> <p>round down to the nearest (integer) value of n ✓</p> <p>use larger scale [false origin] to reduce uncertainty in n ✓ (reject: 'read off more points around % difference = 4%')</p> <p>[alternative method which can earn up to 3 marks: calculate percentage difference for values of n between 16 and 8 (accept values of $n < 16$ or values of $n > 8$) ✓ calculate percentage difference using $\frac{2d(n-1)}{L}$ ✓ required value of n is when percentage difference has largest value $< 4\%$ ✓]</p>	max 5
	Total	7

Question 2		
(a)	<p>method: evidence that a tangent, or a line parallel to the tangent, or a normal or a chord has been drawn at the curve where $x = 243$, $y = 260$, ie at 7th point (accept any as hypotenuse of Δ); y-step at least 8 cm and x-step at least 8 cm [minimum x-step and minimum y-step = 270 mm] ✓</p> <p>correct transfer of y-step and x-step data between graph and calculation ✓ (mark is withheld if points used to determine either step > 1 mm from correct position on grid)</p> <p>result must be min 2 sf, max 4 sf; ignore any unit given in error but do not allow ecf in (b)(i) and (c)</p> <p>(there is no credit for gradient calculations based on incorrect methods, eg $G = \Delta x/\Delta y$ or $G = \tan \theta$, in such cases there is no ecf to 1 (b))</p>	2
(b)	<p>(i) p 3 sf or 4 sf, correct substitution (allow ecf), answer with suitable unit;</p> <p>(ii) q 3 sf or 4 sf, correct substitution (allow ecf), answer with no unit ✓</p>	1
(c)	<p>r in range 366 mm to 448 mm (accept 4 sf) or 2 sf answer between 0.38 m to 0.44 m ✓✓ [305 mm to 365 mm or 449 mm to 509 mm or 2 sf between 0.31 m to 0.37 m or 0.45 m to 0.50 m ✓] (do not penalise for missing unit if also missed for p)</p>	2
Total		5

Question 3		
(i)	<p>sketch showing fiducial mark positioned at the centre of oscillation of the chain (or 0/2); some part of the mark should be below $\frac{3}{4}$ length of the chain, and ideally be positioned below end of chain ✓ (accept perspective sketch)</p>	1
(ii)	<p>(at centre of oscillation) because this is where the transit time is least [speed of chain is greatest] ✓</p>	1
Total		2

Question 4							
Table 2	n	mean τ /s	uncertainty/s	percentage uncertainty			
	3	113.5	2.30 [2.3]	2.03% [2.0%]			
	5	66.9	2.85 [2.9]	4.26% [4.3%]			
	7	47.6	2.15 [2.2]	4.51% or 4.52% [4.6%]			
(a)	mean τ /s values correct to 0.1 s; reject > 1 dp ✓					1	
(b)	(i)	uncertainty from $0.5 \times$ range, values correct, either all to 3 sf or all to 2 sf ✓ (no ecf from (a))					1
(b)	(ii)	percentage uncertainty from $100 \times \Delta T/T$, result to same sf as in (b)(i) ✓ [any two correct rows showing consistency in sf for cols 3 & 4 earns 1 mark]					1
(c)	(i)	$\tau = 62(.0) \pm 1 \text{ s}$ ✓					1
(c)	(ii)	period to 0.01 s in range 1.67 to 1.77 s (reject 1.7 s) ✓ or 0/2 from $n \times$ period where $\Sigma n \geq 20$ ✓ (reject cycles in a fixed time)					2
(d)	<p>statement of advantage (eg elimination of human error) and explanation (eg better precision) earns 2 marks – full credit can be gained for two linked answers: 1 mark can be earned for statement without explanation, but not vice-versa; only 2 marks max for each response</p> <p>statement do not have to release the bob and start timing at same moment [or other valid example associated with overcoming systematic error] ✓ (no credit for ‘avoid parallax error’)</p> <p>explanation τ is measured with greater accuracy (reject ‘more reliable’) ✓</p> <p>statement no human/random/reaction error is involved in the timing process ✓ and/or it is easier to ascertain the moment/point of maximum [minimum] amplitude ✓ and/or samples can be taken at very high frequency/greater sensitivity obtained using digital sensors (allow ‘can record to more decimal places; reject ‘can take more data’ and ‘measure over short intervals of time’) ✓ and/or can collect data for many cycles of energy transfer [over longer time] (hence can calculate a more reliable mean) ✓</p> <p>explanation τ is measured with greater precision (allow ‘more reliably’)</p> <p>statement the experiment does not require the experimenter’s constant attention (reject ‘data logger is automatic’ idea)/the information can be analysed or manipulated later/can scroll through the data line by line ✓ and/or the data is easily (transferred to a spreadsheet to be) graphed [can draw the envelope around the displacement – time graph to determine \bar{t}] ✓</p> <p>explanation data logging is convenient (allow ‘labour/time saving’) ✓</p> <p>(while giving credit for any valid improvement, do not credit the claim that this leads to better accuracy <i>and</i> better precision)</p>					4 max	
Total						10	