10th APhO

Experimental Competition

28 April 2009

Marking Scheme

General marking guidelines

1. Giving correct answers without calculations	Deduct up to 50% of the total points for that part
2. Minor mistakes in the calculations e.g. wrong signs, symbols, substitutions	Deduct 30%
3. Missing units in the final numerical answers (for each part)	Deduct 0.1 point
4. Final answers (for each part) containing too few or too many significant figures.	Deduct 0.1 point
5. Using wrong physical concepts (despite correct answers)	No points awarded
6. Error propagated from earlier parts: minor errors	Full points
7. Error propagated from earlier parts: major errors (such that the solution becomes trivial).	Deduct up to 20%

Marking Scheme: Problem 1

No.	Description	Scores
Section I	Derivation of formula	**1 point**
	- the horizontal magnetic field for a coil of a single turn $B_{\mathrm{PX}} = 4\frac{\mu_0 i}{2\pi d}\frac{(a/2)}{\sqrt{d^2+\left(\frac{a}{2}\right)^2}}\cos\phi$ (0.3 point) $d = \sqrt{x^2+\left(\frac{a}{2}\right)^2}$ (0.1 point) $\cos\phi = \frac{(a/2)}{\sqrt{x^2+\left(\frac{a}{2}\right)^2}}$ (0.1 point) - For a coil of N turns, replace the current with iN (0.2 point) $B_{px} = \left(\frac{\mu_0 a^2 iN}{2\pi}\right)\left[\frac{1}{\left(x^2+\left(\frac{a}{2}\right)^2\right)\sqrt{x^2+2\left(\frac{a}{2}\right)^2}}\right]$ (0.3 point)	
Section II		
	Measurements to justify that we can ignore the torsion of the string	**0.8 point**
	- Tabulated data of lengths and periods (total 0.8 point) - At least 1 data point for length of the string from 0 to 10 cm (where the effect of torsion is prominent (0.2 point) - At least 3 data points for length of the string greater than 10 cm (where the effect of torsion is negligible) (0.2 each = 0.6 point)	

Section III		
	- Provide the value of the distance	**0.2 point**
(a)	**Coil's magnetic field and Earth's magnetic field are in the same direction**	**5.0 points**
	- Show that $\frac{1}{T^2} = \beta B + \beta B_H$, $\beta = \frac{m}{4\pi^2 I}$ (0.2 point) - Tabulated data from measurements for at least 5 different values of x (total 3.0 points) Provide values of B (1.0 point) Provide values of T (minimum 5 measurements with at least 10 oscillations each) (1.5 points) Provide values of $\frac{1}{T^2}$ (0.5 point) - Provide a complete graph of $\frac{1}{T^2}$ and B (0.8 point) - Provide a value of the slope of the graph. (0.3 point) - Provide a value of the interception of the graph (0.1 point) - Provide a numerical value of B_H (0.2 point) - Provide a numerical value of m (0.2 point) - Error estimation (0.2 point)	
(b)	**Earth's magnetic field only**	**1.0 point**
	Measure the period accurately (minimum 5 measurements with at least 10 oscillations each) (0.3 point) B_H is from 0.25 to 0.35 gauss (max 0.5 point) B_H is 0.1- 0.25 or 0.4 - 0.5 gauss (0.3 point) Otherwise (0.0 point) - Error estimation (0.2 point)	

(c)	**Coil's magnetic field and Earth's magnetic field are in opposite direction**	**2.0 points**
	If B_H is from 0.2 to 0.4 gauss, (max. 2.0 points) - Provide the correct value of x_0 and its measurement details. (1.0 point) - Provide the correct value of B_H. (0.5 point) - Estimate the error of B_H. (0.5 point) If B_H is 0.1-0.2 or 0.4-0.5 gauss, (max. 1.0 point) - Provide the correct value of x_0 and its measurement details. (0.3 point) - Provide the correct value of B_H. (0.2 point) - Estimate the error of B_H. (0.5 point) For other value of B_H, - Estimate the error of B_H. (0.5 point)	

************** End of Problem 1*************

Marking Scheme: Problem 2

No.	Description	Scores
Section I	Derivation of formulae	**2.0 points**
	• $m_1 = \rho\pi\left[R^2-(R-t)^2\right]L = \rho\pi\left(2Rt-t^2\right)L$ (0.1 point) • $m_2 = \rho\pi(0.6\,\text{cm})R^2$ (0.1 point) • $m_3 = \pi(R-t)^2 L$ (0.1 point) • $M = m_1+2m_2+m_3$ (0.1 point) • $I_y = \frac{1}{2}m_1\left[R^2+(R-t)^2\right]+2\left[\frac{1}{2}m_2R^2\right]$: realize that the water does not contribute to the inertia (0.5 point), correctly use the formula for the disc (0.2 point) • Measurements of R, h, L with errors. (0.3 point) • Numerical expressions: for example $m_1 = 339.3t-67.86t^2$ g, (0.1 point) $m_2 = 31.8$ g, (0.1 point) $m_3 = 157.1-125.7t+25.13t^2$ g, (0.1 points) $M = 220.7+213.6t-42.73t^2$ g (0.1 point) $I_y = 198.8+2121t-1273t^2+339.3t^3-33.93t^4$ g cm^2 (0.2 point)	
Section II		
(a)	**Angular oscillation about the axis of symmetry**	**4.0 points**
	- Provide the measured value of T_y Let n be the number of oscillations. (max. 0.8 point) $n \geq 30$, (0.8 point) ($20 \leq n < 30$, (0.6 point)) ($10 \leq n < 20$, (0.2 point)) ($n < 10$, (0 point))	

	Number of data points (max. 0.8 point) $n \geq 5$, (0.8 point) ($3 \leq n < 5$, (0.6 point)) ($n = 2$, (0.2 point)) ($n < 2$, (0 point)) - Provide the error of T_y (0.2 point) - Provide the polynomial equation for t (0.3 point) - Perform numerical iteration (0.5 point) - Provide the value of t (max. 0.5 point) $0.60 \leq t \leq 0.70$, (0.5 point) $0.50 \leq t < 0.60$ **or** $0.70 < t \leq 0.80$**,** (0.3 point) $0.80 < t \leq 0.90$**,** (0.1 point) $t < 0.50$ **or** $t > 0.90$ (0 point) - Provide the numerical values of m_1, m_2, m_3 and M (0.1 each = 0.4 point) - Provide the error of t with a correct method (0.5 point)	
(b)	**Angular oscillation about the central axis perpendicular to the length**	**2.8 points**
	- Provide the measured value of T_x Let n be the number of oscillations. (max. 0.8 point) $n \geq 30$, (0.8 point) ($20 \leq n < 30$, (0.6 point)) ($10 \leq n < 20$, (0.2 point)) ($n < 10$, (0 point)) Number of data points (max. 0.8 point) $n \geq 5$, (0.8 point) ($3 \leq n < 5$, (0.6 point)) ($n = 2$, (0.2 point)) ($n < 2$, (0 point))	

	- Provide the error of T_x (0.2 point) - Provide the numerical value of I_x^{Exp} (0.5 point) - Provide the numerical value of I_x^{Theo} (0.5 point)	
(c)	**Comparing experimental and theoretical values of the moment of inertia**	**1.2 points**
	- Provide the correct value of ΔI_x (0.3 point) - Show that ΔI_x is statistically significant (0.2 point) - Provide the value of the percentage (0.7 point)	

************** End of Problem 2*************