Maritime University of Szczecin

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Physics Laboratory

Laboratory Manual

Determination of the logarithmic decrement of a physical pendulum

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Instruments:

1. Physical pendulum.
2. Stopwatch.
3. Ruler.

Exercise:

1. Place the ruler on the table so that the zero scale coincides with the equilibrium position of the pendulum.
2. Measure the time t_{20} of 20 oscillations of closed pendulum. Perform this measurement five times. Calculate mean value $\bar{t}_{20}$ for 20 oscillations.
3. Using the equation:

$$T = \frac{\bar{t}_{20}}{20}$$

calculate oscillation period of the closed pendulum.

4. Deflect the pendulum from the equilibrium position so that the displacement on the ruler was equal to A = 25 cm.
5. During 10 whole oscillation periods measure the subsequent displacements A of the pendulum **(with an accuracy of 1 mm)** on both sides of the equilibrium position. Perform this measurement three times. Place the results in the table. Calculate mean values of $\bar{A}$. Since the oscillation period T of the closed pendulum is known, calculate the time t corresponding to the subsequent pendulum's displacement.
6. Using the definition:

$$\lambda_{def} = ln\left(\frac{\bar{A}\,(t)}{\bar{A}\,(t+T)}\right)$$

calculate value of the logarithmic decrement λ_{def} for subsequent times t and the mean value $\bar{\lambda}_{def}$.

7. Repeat the activities described in points 2 – 5 for the opened pendulum.
8. On one graph present the $\ln(\bar{A})$ as function of time t for closed and opened pendulum. Using the linear regression calculate the damping ratios β of examined pendulums:

$$\ln(\bar{A}) \;=\; -\beta \cdot t \;+\; \ln(A_0)$$

$$y \;=\; a \cdot x \;+\; b$$

For each of the pendulums calculate:

- damping constant: $B = 2\beta m$ (m = 361 g – pendulum's mass),
- relaxation times: $\tau_{reg} = \frac{1}{\beta}$,
- logarithmic decrements: $\lambda_{reg} = \beta T$.

9. On one graph present the pendulum's displacement as function of time and damping curve for both examined pendulums. Using the graph determine relaxation times τ_{graph} and logarithmic decrements λ_{graph}.
10. Enter the results into the table:

Physical quantity		**Symbol**	**Unit**	**Opened pendulum**	**Closed pendulum**
damping ratio					
damping constant					
oscillation period					
relaxation time	τ_{reg}				
	τ_{graph}				
logarithmic decrement	$\bar{\lambda}_{def}$				
	λ_{reg}				
	λ_{graph}				

11. Note the conclusions.