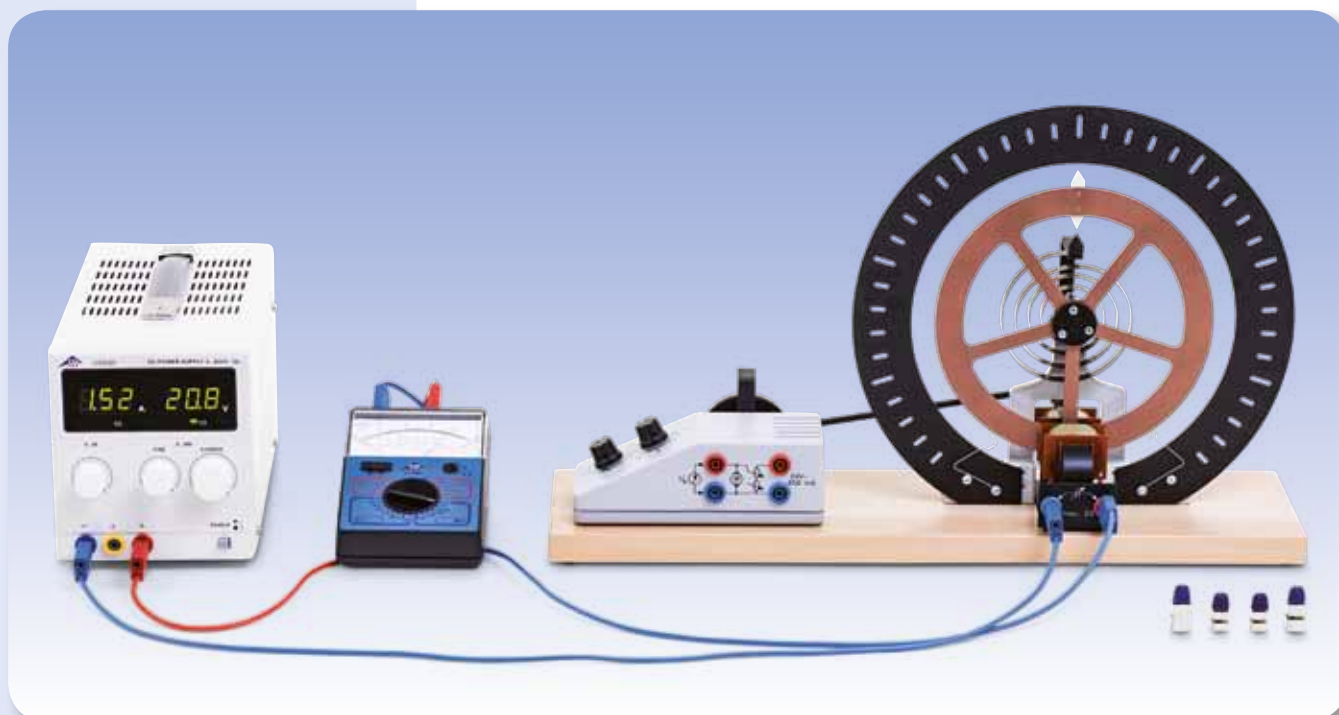## UE1050500   POHL'S TORSION PENDULUM

EXPERIMENT PROCEDURE

• Measure period of oscillation *T* for various initial deflections and velocities.

• Determine the damping constant δ when the rotating pendulum is damped.

OBJECTIVE
Measurement and analysis of simple harmonic rotary oscillation

SUMMARY

Pohl's wheel or rotating (torsional) pendulum allows for the investigation of simple harmonic rotary oscillation. The only forces acting on the wheel are the restoring torque provided by a spiral spring and damping torque supplied by means of an eddy current brake with an adjustable current. This experiment demonstrates how the period of oscillation is not dependent on the initial deflection or the initial velocity, and analyses the amplitudes of the oscillations.

REQUIRED APPARATUS

Quantity	Description	Number
1	Pohl's Torsion Pendulum	1002956
1	Mechanical Stopwatch, 15 min	1003369
1	DC Power Supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz)	1003312 or
	DC Power Supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz)	1003311
1	Analogue Multimeter AM50	1003073
1	Set of 15 Safety Experiment Leads, 75 cm	1002843

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BASIC PRINCIPLES

Pohl's wheel or rotating (torsional) pendulum allows for the investigation of simple harmonic rotary oscillation. The only forces acting on the wheel are the restoring torque provided by a spiral spring and damping torque supplied by means of an eddy current brake with an adjustable current.

The equation of motion for the angle of deflection φ of a freely oscillating, but damped torsional pendulum is as follows:

(1)
$$\frac{d^2\varphi}{dt^2} + 2 \cdot \delta \cdot \frac{d\varphi}{dt} + \omega_0^2 \cdot \varphi = 0$$

where $\delta = \dfrac{k}{2J}$, $\omega_0^2 = \dfrac{D}{J}$

J: moment of inertia

D: spring constant

k: damping coefficient

As long as the damping is not excessive and the condition $\delta < \omega_0$ is fulfilled, the equation of motion has the following solution:

(2)
$$\varphi(t) = \varphi_0 \cdot e^{-\delta \cdot t} \cdot \cos(\omega \cdot t + \psi)$$

where $\omega = \sqrt{\omega_0^2 - \delta^2}$.

The initial amplitude φ_0 and the phase angle ψ are arbitrary parameters which are dependent on the deflection and speed of the rotary pendulum at a time $t = 0$. The pendulum will therefore move back and forth with the following period of oscillation:

(3)
$$T = \frac{2\pi}{\omega}$$

The amplitude of the oscillations decreases over time according to the following equation:

(4)
$$\hat{\varphi}(t) = \varphi_0 \cdot e^{-\delta \cdot t}$$

In this experiment oscillations are investigated with various levels of damping, which can be set up by varying the current to the eddy current brake. The period of oscillation is measured with the aid of a stopwatch. It will be shown that the period of oscillation is not dependent on the initial deflection or velocity.

In order to determine the degree of damping the limits of each oscillation to the left and right are taken down. This simplifies the analysis since if such points are taken as the time zero, then the initial velocity will be zero.

EVALUATION

In equation (4) the amplitude of the oscillation is defined as a positive value. This implies that the absolute values for the limits of the motion to the left and right should be considered. If the natural logarithms of these values are plotted against time, a straight line with a gradient $-\delta$ should be obtained. In fact certain deviations from such linear behaviour will be observed, since the force of friction is not exactly proportional to the speed as assumed here.
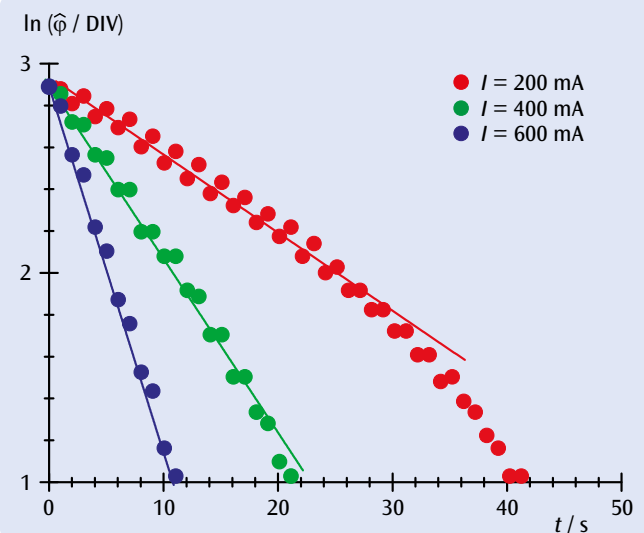

Fig. 1: $\ln(\hat{\varphi})$ as a function of time for various degrees of damping