Experiment No : M6

Experiment Name: Determining the restoring torque of the torsion axle

Objective:

1. Measuring the period of oscillation of a thin transverse rod with weights on a torsion axle as a function of the distance of the weights from the torsion axle.
2. Confirming the proportionality between the moment of inertia of the weights and the square of the distance.
3. Determining the restoring torque of the torsion axle.

Keywords: Rotational motions, moment of inertia, torque, oscillation, period.

Theoretical Background:

The moment of inertia is a measure of the inertia that a body exhibits when a torque acts on it causing a change of its rotational motion. It corresponds to the inertial mass in the case of translational motions. In rotational oscillations, for example, the period of oscillation *T* is the greater, the greater the moment of inertia *I* of the oscillating system is. More specifically:

$$T = 2\pi\sqrt{\frac{I}{D}} \quad (6.1)$$

where *D* is restoring torque. The moment of inertia of a point like mass *m* moving on a circular path with radius *r* is

$$I_1 = mr^2 \quad (6.2)$$

The moment of inertia of two equal masses *m* that are rigidly connected and have the same distance *r* from the axis of rotation is

$$I_2 = 2mr^2 \quad (6.3)$$

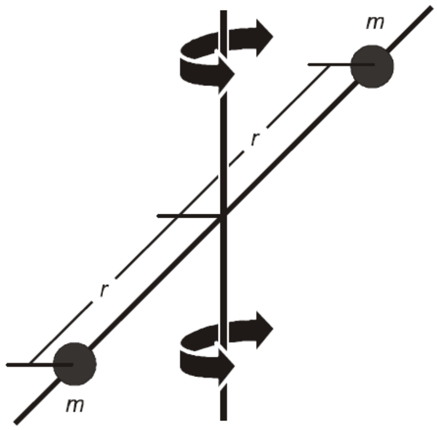

Figure 6.1: Schematic illustration

In both cases, the moment of inertia is proportional to the square of the distance r. In the experiment, the rigid connection between the two masses is established by means of a thin rod whose middle is fixed to the torsion axle (see Fig. 6.1). After deflection from the equilibrium position, the system oscillates with the period of oscillation T. From Eq. 6.1 it follows that

$$I = D\left(\frac{T}{2\pi}\right)^2 \qquad 6.4$$

However, the moment of inertia is composed of the moment of inertia I_2 of the two weights and the moment of inertia I_0 of the rod

$$I = 2mr^2 + I_0 \qquad 6.5$$

Therefore the period of oscillation T_0 of the rod without weights is measured in another measurement, which leads to

$$D\left(\frac{T}{2\pi}\right)^2 = 2mr^2 + D\left(\frac{T_0}{2\pi}\right)^2 \text{ or } T^2 = \frac{8m\pi^2}{D}r^2 + T_0^2 \qquad 6.6$$

Thus a linear relation between the square of the period of oscillation T and the square of the distance r is obtained. From the slope of the straight line a,

$$a = \frac{8m\pi^2}{D} \qquad 6.7$$

the restoring torque D can be calculated if the mass m is known.