EXPERIMENT PROCEDURE:

- **Plot the angle of rotation point by point as a function of time for a uniformly accelerated rotational motion.**
- **Confirm the proportionality between the angle of rotation and the square of the time.**
- **Determine the angular acceleration as a function of the torque and confirm agreement with Newton's equation of motion.**
- **Determine the angular acceleration as a function of the moment of inertia and confirm agreement with Newton's equation of motion.**

OBJECTIVE

Confirm Newton's equation of motion.

SUMMARY

For a body that rotates about a fixed axis with uniform acceleration, the angle of rotation φ increases in proportion to the square of the time *t*. From this proportionality factor it is possible to calculate the angular acceleration α, which in turn depends, according to Newton's equation of motion, on the accelerating torque (turning moment) and the moment of inertia of the rigid body.

REQUIRED APPARATUS

Quantity	Description	Number
1	Rotating System on Air Bed (230 V, 50/60 Hz)	1000782 or
	Rotating System on Air Bed (115 V, 50/60 Hz)	1000781
1	Laser Reflection Sensor	1001034
1	Digital Counter (230 V, 50/60 Hz)	1001033 or
	Digital Counter (115 V, 50/60 Hz)	1001032

BASIC PRINCIPLES

The rotation of a rigid body about a fixed axis can be described in a way that is analogous to a one-dimensional translational motion. The distance *s* is replaced by the angle of rotation φ, the linear velocity *v* by the angular velocity ω, the acceleration a by the angular acceleration α, the accelerating force *F* by the torque *M* acting on the rigid body, and the inertial mass *m* by the rigid body's moment of inertia *J* about the axis of rotation.

In analogy to Newton's law of motion for translational motion, the relationship between the torque (turning moment) *M* that is applied to a rigid body with a moment of inertia *J*, supported so that it can rotate, and the angular acceleration α is:

(1) $$M = J \cdot \alpha$$

If the applied torque is constant, the body undergoes a rotational motion with a constant rate of angular acceleration.

In the experiment, this behaviour is investigated by means of a rotating system that rests on an air-bearing and therefore has very little friction. The motion is started at the time $t_0 = 0$ with zero initial angular velocity $\omega = 0$, and in the time *t* it rotates through the angle

(2) $$\varphi = \frac{1}{2} \cdot \alpha \cdot t^2$$

The torque *M* results from the weight of an accelerating mass m_M acting at the distance r_M from the axis of rotation of the body, and is therefore:

(3) $$M = r_M \cdot m_M \cdot g$$

the gravitational acceleration constant.

$$g = 9.81 \frac{\text{m}}{\text{s}^2}$$

If two additional weights of mass m_J are attached to the horizontal rod of the rotating system at the same fixed distance r_J from the axis of rotation, the moment of inertia is increased to:

(4) $$J = J_0 + 2 \cdot m_J \cdot r_J^2$$

J_0: moment of inertia without additional weights.

A number of weights are provided, both for producing the accelerating force and for increasing the moment of inertia. The distances r_M and r_J can also be varied. Thus, it is possible to investigate how the angular acceleration depends on the torque and the moment of inertia in order to confirm the relationship (1).

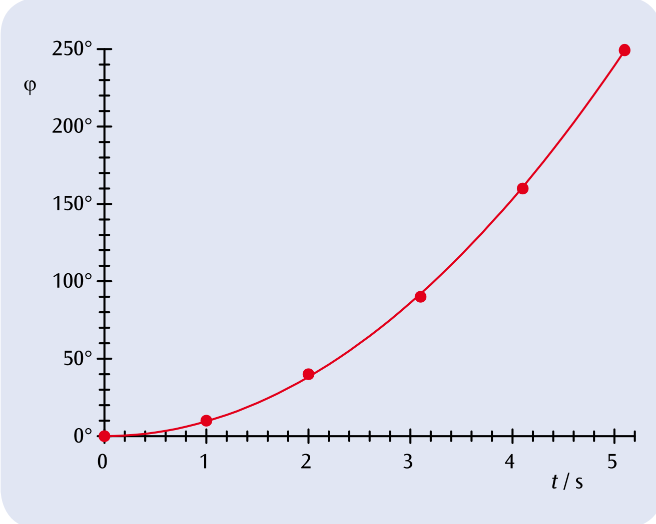

Fig. 1: Angle of rotation as a function of time for a uniformly accelerated rotational motion.

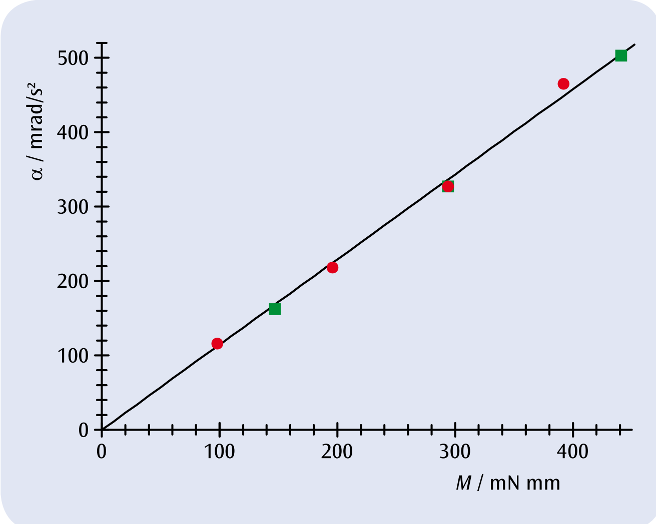

Fig. 2: Angular acceleration α as a function of the torque *M*.

EVALUATION

The proportionality of the angle of rotation to the square of the time is demonstrated by measuring the times for the angles of rotation 10°, 40°, 90°, 160° and 250°.

To determine the angular acceleration α as a function of the variables *M* and *J*, measure the time *t*(90°) needed for an angle of rotation of 90° with different values of the variable in both cases. For this special case the angular acceleration is

$$\alpha = \frac{\pi}{t(90°)^2}$$

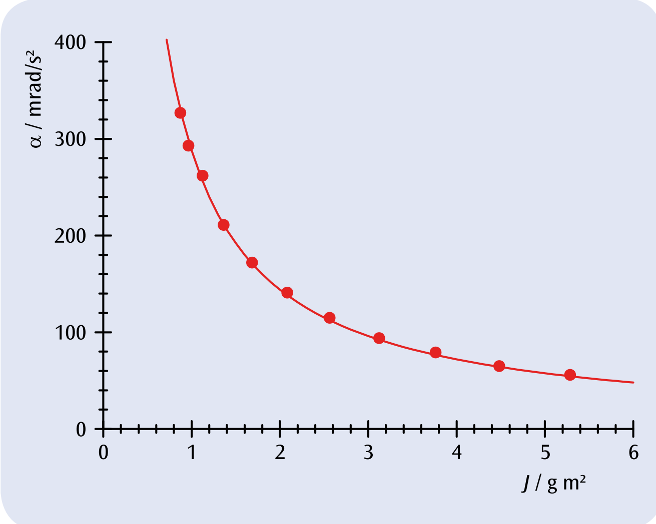

Fig. 3: Angular acceleration α as a function of the moment of inertia *J*.