

Exercise 104: MOMENT OF INERTIA

Keywords: moment of inertia; torsion spring; Steiner's theorem; linear regression.

The exercise aims at determining twisting moment of a torsion spring, mass moment of inertia, and experimentally proving Steiner's theorem.

Twisting moment:

1. Determine mass of the available weights, length of the rod, and distances between the marks on the rod.
2. Fix the middle point of the rod at the torsion spring and twist it by 90 degrees. Measure the time period ($t=5T$). Repeat the measurement two more times.
3. Place the weights on the rod in alignment with the marks closest to the center. Do the measurement and repeat it twice.
4. Continue the measurements with gradually increasing the distance of the weights from the center.
5. For each measurement: calculate an average period T .
6. Plot the function: $T^2 = f(f^2)$.
7. Determine the slope coefficient (linear regression) and determine the value of

$$D = 8\pi \frac{m_c}{a} \quad \text{where } m_c \text{ - weight, } a \text{ - slope coefficient.}$$

Moment of inertia:

1. Calculate the rod's moment of inertia: $I_p = D \left(\frac{T_p}{2\pi} \right)^2$.
 2. Determine mass and diameter of the disc and place in onto the torsion spring in alignment with the axis of rotation.
 3. Determine an average time period of the disc and its moment of inertia: $I = D \left(\frac{T}{2\pi} \right)^2$.
 4. Calculate theoretical values of the moment of inertia: $I = \frac{1}{12} ml^2$ and $I = \frac{1}{2} MR^2$.
 5. Compare experimental results with the theoretical ones.
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Steiner's theorem:

1. Resume the disc measurements by changing the distance from the center (step of 2 cm).
2. Determine average values of time periods and moments of inertia: $I = D \left(\frac{T}{2\pi} \right)^2$.
3. Calculate theoretical values of the disc's moment of inertia with respect to the different axes of rotation and compare them the experimental results.
4. Plot both theoretical and experimental values of $I = f(d^2)$ (on a single graph).
5. Does the Steiner's theorem hold?