T.C.
GEBZE TECHNICAL UNIVERSITY
PHYSICS DEPARTMENT

PHYSICS LABORATORY I
EXPERIMENT REPORT

THE NAME OF THE EXPERIMENT

Steiner’s theorem (parallel axis theorem)

PREPARED BY

NAME AND SURNAME:

STUDENT NUMBER :

DEPARTMENT :

Signature:

Experimental procedure for Steiner's theorem (parallel axis theorem):

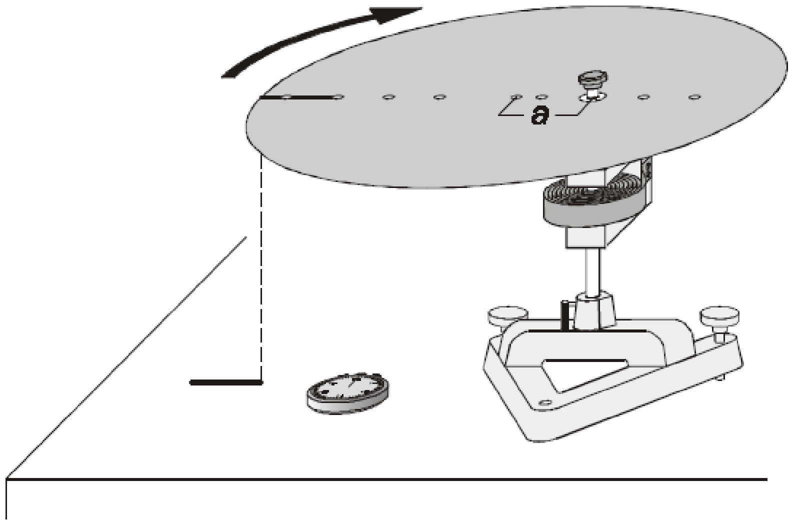
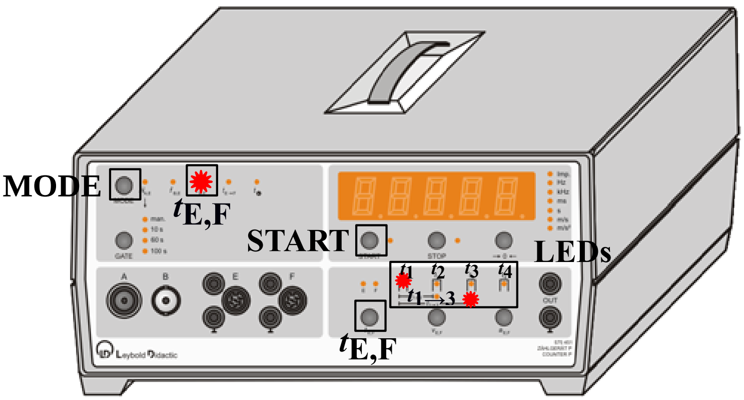


Figure 8.2: Experimental setup for the experimental confirmation of Steiner's theorem.

The experimental setup is illustrated in Fig 8.2.

1. Measure the mass of the disc *M*________ *kg* and radius *R* ______ *m*
2. Fix the centre of the circular disc to the torsion axle and, and locate the stipe on the disc so that it is in the photo gate in its equilibrium (rest) position.



3. Set the operation *MODE* on the digital counter to the symbol $t_{E,F}$ for measuring the period.
4. Rotate the disc from its rest position to the right by $< 180°$, press the start button of the digital counter and release the rod. Wait *all* the display of storage LED's light up.
5. Read the period *T* by pressing pushbutton $t_{E,F}$ and select of the time $t_{1\to3}$ stored in the operation mode $t_{E,F}$ to be displayed as the measured value. *In the storage display, the LED corresponding to the selected time shines more brightly than the others.*

6. Repeat the measurement four times, alternately deflecting the disc to the left and to the right.
7. Mount the circular disc on the torsion axle so that its centre is at a distance of 4 cm from the axle.
8. Measure the period of oscillations four times alternately deflecting the disc to the right and to the left.
9. Record measured the periods of oscillations T in table 8.1.
10. Repeat the measurement for other distances a of 8, 12 and 16 cm from the axis of symmetry (CM).

Calculate mean values of measured period of oscillations T, $(T/2\pi)^2$ and moment of inertia I^A, and fill in the Table 8.1. ***Use measured D, which is calculated in the previous experiment M6 (D=0.020 Nm/rad).***

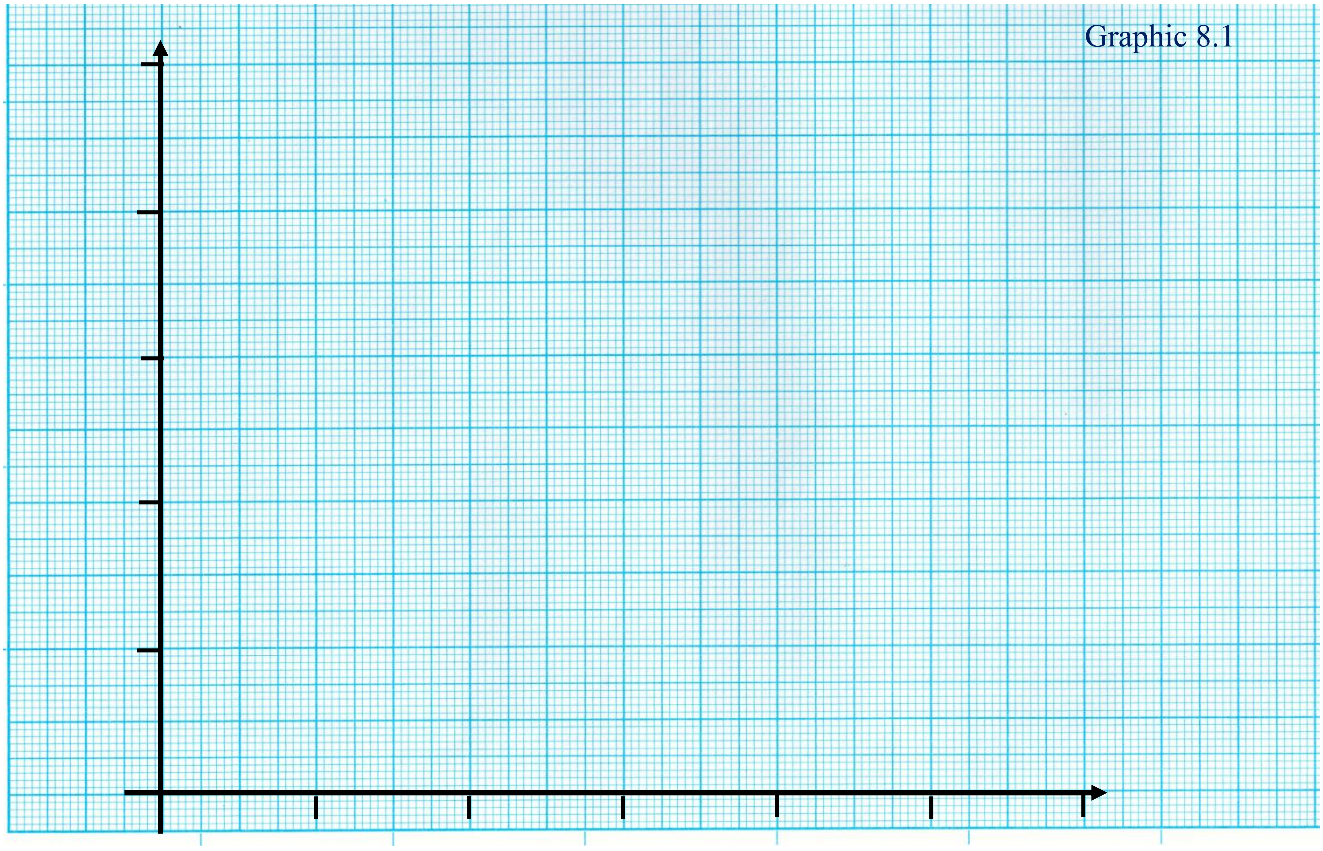
Table 8.1: Measured time of oscillations for various distances a between the axis of rotation and the axis of symmetry and oscillation periods T calculated from the mean value of the measured values.

a **(m)**	T_1**(s)**	T_2 **(s)**	T_3 **(s)**	T_4 **(s)**	T **(s)**	$\left[\frac{T}{2\pi}\right]^2$ **(s²)**	$I^A = D.\left[\frac{T}{2\pi}\right]^2$ **(kg.m²)**
0							
0.04							
0.08							
0.12							
0.16							

A) $I^A - a^2$ Plot

Plot the moment of inertia I^A as a function of the square of the distance a between the axis of rotation and the axis of symmetry (CM). Represent the values in table 8.1 as points on your graph.

If we take into account our theoretical considerations we expect a line to pass through those points. The Eqn. 8.8 $I^A = Ma^2 + I_{CM}$ describes a linear ($y=ax+b$) relation between I^A and a^2 with the slope M (mass of the disc) and the intercept of the ordinate I_{CM}. Use the slope M and the intercept point I_{CM}, which will be calculated in the following step, plot $y=ax+b$ line on your graph. Observe the fitness of the line to your data points.



You are expected to calculate the slope M of the line that is the mass of the disc. The slope of the line could be calculated using the values in the above table with the statistical fitting method called "*least squares method*". The formula that is derived from the least squares method will give you the slope M of the line and the intercept of the ordinate I_{CM}.

Calculate four terms that will be used in the equations below.

$$\sum_{i=1}^{5} a_i^2 =$$

$$\sum_{i=1}^{5} I_i^A =$$

$$\sum_{i=1}^{5} a_i^2 \, I_i^A =$$

$$\sum_{i=1}^{5} a_i^4 =$$

Substitute those values in the equations below and calculate the slope M_{disc} and the intercept of the ordinate I_{CM}:

$$M_{disc} = \frac{5.\sum_{i=1}^{5} a_i^2 I_i^A - \sum_{i=1}^{5} a_i^2 \sum_{i=1}^{5} I_i^A}{5.\sum_{i=1}^{5} a_i^4 - \left(\sum_{i=1}^{5} a_i^2\right)^2} =$$

$$I_{CM} = \frac{\sum_{i=1}^{5} a_i^4 \sum_{i=1}^{5} I_i^A - \sum_{i=1}^{5} a_i^2 I_i^A \sum_{i=1}^{5} a_i^2}{5.\sum_{i=1}^{5} a_i^4 - \left(\sum_{i=1}^{5} a_i^2\right)^2} =$$

Compare the calculated M_{disc} value to the mass M that you have directly measured.

The intercept of the ordinate equals to I_{CM} of the disc. Also, calculate the I_{CM} (a=0) with the help of period T and measured D from first section of the experiment *and* the theoretical formula for disc $I_{CM} = \frac{1}{2}MR^2$Moreover, divide the I_{CM} values with MR^2 and calculate the dimensionless coefficients of the moment of inertia of the disc.

I_{CM} derived from the least square fit:

units

$I_{CM} =$ (______) $\frac{I_{CM}}{MR^2} =$

I_{CM} calculated by using measured restoring torque D and and period T:

$I_{CM} = D\left[\frac{T}{2\pi}\right]^2 =$ (______) $\frac{I_{CM}}{MR^2} =$

I_{CM} calculated by using theoretical formula for disc:

$I_{CM}^{disc} = \frac{1}{2}MR^2 =$ (______) $\frac{I_{CM}^{disc}}{MR^2} = \frac{1}{2}$

Signature:

Compare these three results and discuss whether the experiment confirms Steiner's theorem (parallel axis theorem).

Conclusion, Comment and Discussion:

(Tips: Give detail explanation about what you've learned in the experiment and also explain the possible errors and their reasons.)

Signature:

Questions:

1) An object with equal length of each part and uniform mass density is rotated about an axle, which may be in positions A, B, C, or D. Rank the object's rotational inertia from smallest to largest with respect to the axle positions. Please explain, why?