Maritime University of Szczecin

Faculty of Marine Engineering

Department of Physics and Chemistry

Physics Laboratory

Laboratory Description

Transformations of mechanical energy on an inclined ramp

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Objectives:

- Getting acquainted with transformations of mechanical energy taking place while rolling down a body on an inclined ramp.
- Determination of the rotational inertia of a ball.

Questions and problems to solve:

- The principle of the conservation of mechanical energy.
- Steiner's theorem.
- The force and the moment of force acting on a ball rolling down an inclined ramp.

Short description:

The exercise starts from examination of rolling down a ball on an inclined ramp. Total mechanical energy of a ball is a sum of its potential energy E_p:

$$E_p = mgh \tag{1}$$

kinetic energy of progressive movement:

$$E_{k\,progr} = \frac{1}{2}mv^2 \tag{2}$$

and kinetic energy of rotational motion:

$$E_{k\,rot} = \frac{1}{2}I_0\omega^2 \tag{3}$$

where m, I_0, v and ω are: the mass, the rotational inertia, the linear velocity and the angular velocity of the ball, respectively, and h is the height at which the ball is placed. According to the rule of conservation of energy, the total mechanical energy of the rolling ball is constant:

$$E_t = mgh + \frac{1}{2}mv^2 + \frac{1}{2}I_0\omega^2 = const \tag{4}$$

We measure the mass m and the diameter d of the ball to obtain the radius R. We calculate the rotational inertia I_0 of the ball :

$$I_0 = \frac{2}{5}mR^2 \tag{5}$$

We measure the total length S and the height H of the inclined ramp. We place the ball at the top of the ramp and measure time t_1 after which the ball will reach the half length of the ramp and time t_2 after which the ball will be at the bottom of the ramp. We calculate velocities v_1 and v_2 in both positions of the ball:

$$v_1 = \frac{S}{t_1} \tag{6a}$$

$$v_2 = \frac{2S}{t_2} \tag{6b}$$

and corresponding angular velocities:

$$\omega_1 = \frac{v_1}{R} \tag{7a}$$

$$\omega_2 = \frac{v_2}{R} \tag{7b}$$

According to the formula (4) we calculate and compare the total mechanical energy of the ball at the top, at the half-length and at the bottom of the ramp. We repeat measurements and calculations for different angles of inclination and other bodies- balls or rollers. The rotational inertia I_0 of a roller is given by the equation:

$$I_0 = \frac{1}{2}mR^2 \tag{8}$$

Literature:

1. Resnick R., Halliday D., Walker J., *Fundamentals of Physics*, John Wiley & Sons, INC (available editions).