Maritime University of Szczecin

Faculty of Marine Engineering

Department of Physics and Chemistry

Physics Laboratory

Laboratory Manual

Confirming the principle of conservation of total energy

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Equipment:

1. A device for testing the rotary motion possessing three mandrels for winding the rope. Mandrels' diameters: d_1 = 23.4 mm, d_2 = 33.6 mm, d_3 = 45.6 mm.
2. Weights for the rotating disc.
3. A set of weights with hooks.
4. Rope.
5. Stopwatch.

Attention! The device for testing the rotary motion is very delicate. Exercise must be performed with caution-so as not to damage the device. In particular, the disc should be stopped by gentle grasping the base or the top of the reel.

Exercise:

1. Get acquainted to the instruction manual of the stopwatch used in the exercise.
2. Determine mass *m* of the weight with.
3. Place weights on the target according to the instructor's instructions.
4. Tighten the weight to one of the ends of the rope. Insert the rope through the pulley and hook the other end to the holder located next to the drum (mandrel) indicated by the teacher.
5. Wind the rope on the drum. Make sure that the rope coils forming a single layer and does not touch the table below the pulley. Position the disk in a way that the mark placed on its edge is in front of the pulley.
6. Measure the height h_0 on which the weight hangs above the floor.
7. Measure the height h_n on which the weight hangs above the floor, when the disc will turn to the angle $\alpha = 2\pi \cdot n \ \ (n = 1, 2, 3, 4)$.
8. Again wind the rope on the drum.
9. Release the disc, at the same time turning on the stopwatch. Measure time in which the disc will turn to the angle $\alpha = 2\pi \cdot n \ \ (n = 1, 2, 3, 4)$. Stop the stopwatch and the disc. Record all measured times *t*.
10. Repeat steps described in 8 and 9 twice. Calculate mean value of the time of disc rotation $\bar{t}$.
11. Using equations:

$$\alpha = \frac{1}{2}\varepsilon\bar{t}^2 \, , N = m(g - \varepsilon r) \ and \ M_N = rN \, , \omega = \varepsilon t, V = \omega r$$

    Calculate angular acceleration ε, the tension strength of the rope *N*, the torque M_N of the rope tension, the angular velocity of the disc ω and the linear velocity of the weight.
12. Repeat the steps described in points 2 – 11 three times, winding the rope over another drum and using different weights tensioning the rope.
13. On one graph show the dependence of the angular acceleration ε from the applied torque M_N for all examined cases. Using the linear regression method, taking into account all measuring points simultaneously, determine the moment of inertia *I* of the disc together with weights and an accident moment of resistance torque of resistance M_T.

$$\varepsilon = \frac{1}{I} \cdot M_N + \frac{M_T}{I}$$

$$y = a \cdot x + b$$

14. For each examined case, calculate:
    - potential energy of the weight: $U_c = mgh$,
    - kinetic energy of the weight: $K_c = \frac{1}{2} mV^2$,
    - kinetic energy of the disc: $K_{tar} = \frac{1}{2} I\omega^2$,
    - change of the internal energy of the system: $\Delta U_{int} = -M_T \alpha$,
    - total energy of the system,

   at the initial moment and after each turn of the disc.

15. Present on the graph the dependence of the values of each energy in the function of the number of disc rotations. The graph should be done separately for each of the four examined cases.

Tables:

m=…….kg, r =…….m, h_0 = …….m

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<tr><th rowspan="2">n</th><th>h</th><th>α</th><th>t_i</th><th>$\bar{t}$</th><th>ε</th><th>N</th><th>M_N</th><th>ω</th><th>V</th></tr>
<tr><th>[m]</th><th>[rad]</th><th>[s]</th><th>[s]</th><th>[rad·s^{-2}]</th><th>[N]</th><th>[Nm]</th><th>[rad·s^{-1}]</th><th>[m·s^{-1}]</th></tr>
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n	U_c [J]	K_c [J]	K_{tar} [J]	ΔU_{int} [J]	E_{total} [J]
0					
1					
2					
3					
4					

Attention: both tables should be copied four times.