2004-2005 Physics Olympiad Preparation Program

– University of Toronto –

We continue the competition for the best problems created by our POPTOR contestants. Name your self-made problem as "My Problem", and mail this problem and its solution on a separate sheet of paper as an attachment to the solutions of the POPTOR problems. You may send us any number of problems, but only self-made and unique will be considered. Authors of the best problems will be awarded regardless of their POPTOR results.

Problem Set 2: Mechanics

Due December 6, 2004

Problem 1

Two little balls with masses m_1 and m_2 are connected with a spring and lie on the smooth horizontal surface. The spring constant is k. The balls are brought close to each other, and the spring becomes compressed. Then they are simultaneously released.
Determine the period of the resultant oscillations of two balls.
The period of oscillations of a point mass on a spring is given by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Problem 2

A rope is thrown over a pulley with its one part on the table of height h, and its another part on the floor, as it is shown in fig.1. After the rope is released it starts to move.
Find the speed of the steady motion of the rope.

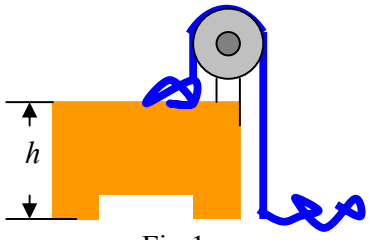

Fig.1

Problem 3

At the height of 200 km the density of the Earth's atmosphere is $1.6 * 10^{-10}$ kg/m^3. A satellite has a mass of 10 kg and a cross sectional area of 0.5 m^2.
Estimate the resistance force experienced by the satellite at this altitude.

Problem 4

Two identical little balls are connected with a string. One of them is thrown up with the initial speed v.
What is the maximum altitude of the system?

Problem 5

Propose an experiment to determine the acceleration due to gravity and perform it with the obligatory use of the following equipment: ramp, tape measure, timer, and a roll of a bathroom tissue. Any other facilities can also be added if necessary.
Your result must contain the explanation and diagram of the experiment, the value of the obtained acceleration $\boldsymbol{g}$, the value of the error.

For the hollow cylinder, moment of inertia about the principal axis of rotation equals $I = \frac{M(R_1^2 + R_2^2)}{2}$, where M is its mass, and R_1 and R_2 are the internal and the external radii.