

2006-2007 Physics Olympiad Preparation Program

– University of Toronto –

We continue the competition for the best problems created by POPTOR contestants. Name your self-made problem as “My Problem”, and mail this problem and its solution on a separate sheet of paper along with 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 during the POPTOR Weekend.

Problem Set 2: Mechanics

Due December 4, 2006

Problem 1

Two similar prisms with an angle $\alpha = 30^\circ$ at the base have smooth surfaces and are initially placed one over the other and both on a frictionless horizontal desk as shown in Fig.1.1. The mass of the smaller prism is m , and the mass of the bigger prism is $4m$. After the smaller prism is released, it starts to slide down without friction. At some moment, the relative speed of the upper prism with respect to the lower one is v_{rel} .

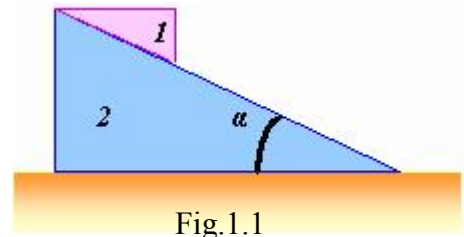


Fig.1.1

What is the speed of the bigger prism at this moment measured by an observer in a laboratory?

Problem 2

A very light pulley is attached to a ceiling of an elevator moving upwards with a constant acceleration a_0 . Two blocks with masses m_1 and m_2 are connected by a string of negligible mass passing over a pulley.

Find (a) an acceleration of the block with m_1 with respect to the elevator; and
(b) a force exerted by the pulley on the ceiling of the elevator.

Problem 3

A period of harmonic oscillation of a simple pendulum of a length l is given by:

$$T_p = 2\pi\sqrt{\frac{l}{g}} \quad (3.1)$$

The period of harmonic oscillation of a mass m on a spring with a spring constant k is given by:

$$T_m = 2\pi\sqrt{\frac{m}{k}} \quad (3.2)$$

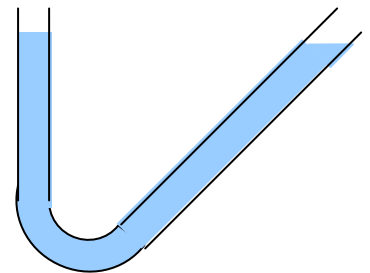


Fig.3.1

Basing on a similarity of harmonic processes, find the period of harmonic oscillation of a liquid in a glass tube shown in Figure 3.1. The left section of the tube is vertical; the right bend makes an angle of 30° with the vertical; and the cross-sectional area of the tube is everywhere same.

Problem 4

On the North Pole of the Earth, an object is projected upward with an initial speed v_i which is less than the escape speed for the Earth.

- (a) What altitude does the object reach?
- (b) Does it change if the object is launched from Toronto? Why?

Check the **Science Links** on our front web page to find other necessary data for this problem.

Problem 5 (experimental)

For this experiment you need a spool with threads as shown in Figure 5.1.

Place the spool on a horizontal surface, rough enough to prevent slipping of the spool while rolling along the surface. Permit the length of a free end of the thread to be about 20 cm.

(a) Pulling the thread make the spool to roll towards your hand.

(b) Pulling the thread make the spool to roll away from your hand.

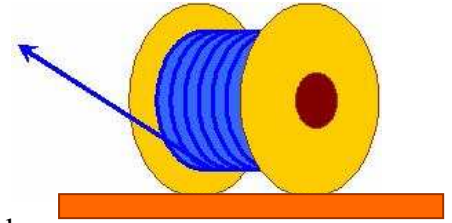


Fig.5.1

Exercise 1.

Describe variables that can switch motion (a) to motion (b) and vice versa.

Exercise 2.

Propose a formula to calculate a linear acceleration of the axle of rotation of the spool along the horizontal surface without slipping.

Exercise 3.

Experimentally prove the correctness of your formula and give a complete description of the experiment and its results.