

2003-2004 Physics Olympiad Preparation Program

– University of Toronto –

Problem Set 2: Mechanics

Due December 8, 2003

1. **Up or Down?**

Two masses m_1 and m_2 are connected by an ideal spring with coefficient of elasticity k (Fig.1). Initially this system is in equilibrium.

- What is the direction and minimum magnitude of displacement of the upper mass from the position of equilibrium to make lower mass to jump up?
- How does the answer to the question (a) depend on the ratio m_1/m_2 ? Explain the result.

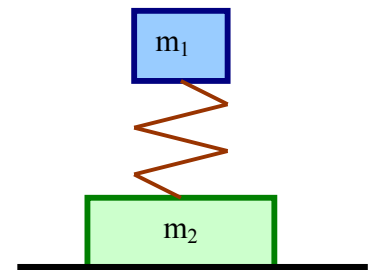


Fig.1

2. **Winter Physics**

Two connected sledges with masses m_1 and m_2 are sliding down the snow hillside with the angle of inclination α (Fig.2). Coefficients of kinetic friction between sledges and snow are μ_1 (new sledges) and μ_2 (old sledges), and $\mu_1 < \mu_2$.

Calculate the acceleration of the center of mass for two different kinds of connection:

- with a string; b) with a rod.
- Explain the result.

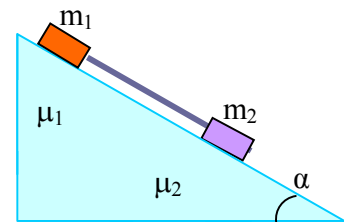


Fig.2

3. **Are You Sure You Can Weigh?**

An equal-arm balance with a uniform weigh beam of mass M , thickness d , and length $2L$ is in horizontal equilibrium position on the platform, which is moving with uniform acceleration $g/2$. Two equidimensional cubes with side b are motionless relative to the weigh beam (Fig.3).

Calculate the ratio of densities ρ_1/ρ_2 .

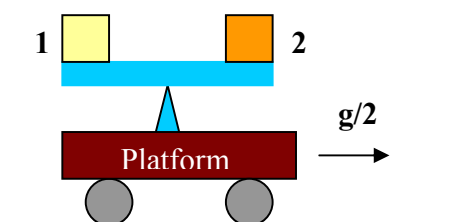


Fig.3

4. **A Science Fiction Story**

On December 8, 2103, Nick, Natalie and Paul were arguing about the possibility of traveling with a speed exceeding the speed of light in vacuum. Paul was sure such speed was impossible for any object. Nick and Natalie thought that the speed might be any if the proper frame of reference was chosen. They decided to prove that the Einstein's theory had already become outdated. They took their spacecrafts and very soon reached

the velocities of the opposite directions and of $0.8c$ each ($c=3 \times 10^8$ m/s), respectively Paul, who remained on the Earth.

What was the speed of Natalie's spacecraft, measured by Nick?

5. The Bouncing Ball (experiment).

Take any ball that won't break when hits the floor. You will probably need a ruler and a timer. Your task is to explore the kind of collisions of the bouncing ball with a floor.

You know two simple kinds of collisions: *elastic* and *perfectly inelastic* ones. Real collisions that we can observe in our everyday life can be only approximately elastic.

- a) Create preferably a dimensionless parameter to describe any collision quantitatively, as a degree of approximation to elastic or perfectly inelastic collision. Calculate the range of this parameter.
- b) Perform an experiment with the bouncing ball to find out the value of the created parameter in the collisions of the ball with the floor at your room. Compose a chart with your measurements and primary calculations.
- c) Calculate the proposed parameter for your specific experiment. Calculate the errors of measurements. Make a conclusion on the kind of the observed collisions: were they more like elastic or perfectly inelastic collisions.
- d) Why the ball of any kind does never reach one the same height more than once?