

2005-2006 Physics Olympiad Preparation Program

– University of Toronto –

Problem Set 1: General

Due October 31, 2005

We start 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 rewarded regardless of their POPTOR results.

Since this is the first problem set, a few comments before starting:

- If you want to know what kind of physics you might need to solve these problems, look at the Physics Olympiad syllabus at <http://www.jyu.fi/ipho/syllabus.html>. You do not need to know the syllabus by heart to do the problems, but you do need to be able to recognize what you need to know, so you can look it up.
- Pay attention to words like “estimate” or “about”. They indicate that the expected answer is not exact because either the input data is not precisely known or because approximations or simplifying assumptions are necessary. Much of real physics is learning how to turn insoluble exact problems into soluble approximations.
- “*Nothing ventured, nothing gained*”: Whether you finish a problem or not, please make sure your reasoning and analysis are clear. If you write down nothing, it is easy for us to mark – we just give you zero – but pretty boring. Your basic ideas may be right even if you make a mistake or get stuck. You may be on the way to your own Great Discovery!

Problem 1

A billiard-ball with mass m collides elastically and head-on with another ball that has mass M and is initially at rest.

Examine the relationship between the energy lost in the collision by the ball, which was initially moving, and the ratio of masses of the balls. How can we apply the result to the problem of slowing down neutrons in a nuclear reactor?

Problem 2

We want to boil one liter of water in a light thin-walled vessel. For this purpose, we start to heat water by an electric heater, with the label “500 W. Made in Wonderland”. However, after the temperature becomes 60°C , it stops increasing. We become bored with waiting and switch off the heater. Our measurements show that during the first 20 seconds water becomes 2 degrees cooler.

How many watts contains the “Wonderland’s watt”?

Problem 3

Fig.3.1 shows a bridge circuit used to measure the unknown resistance R_x . Resistances R_1 and R_2 are given; the resistance of a battery is negligible; R is the variable resistance. G is a galvanometer – an electric instrument to measure either currents or voltages. It has a scale with zero in the middle. Galvanometer in a circuit is usually an indicator of zero current or voltage, or of the direction of change of current or voltage.

a) Explain the way to measure the unknown resistance with the bridge circuit.

b) Propose the method to measure the internal resistance r of the galvanometer using only the parts of the same circuit without additional meter.

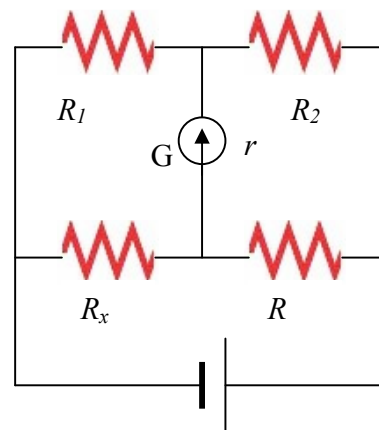


Fig.3.1

Problem 4

Fine sand is sprinkled on the horizontal membrane, which vibrates in the vertical direction with frequency $f = 500 \text{ Hz}$. The sand particulates bounce at the height of 3 mm over the level of the position of equilibrium of the membrane.

What is the amplitude of the membrane's vibration?

Problem 5

You can manufacture the equipment for this experimental problem yourself, or try to imagine the result.

To measure acceleration, a bent arc-shaped sealed glass tube filled with water is used. There is a little air bubble inside (Fig. 5.1).

- Sketch the diagram for this experiment.
- Explain the method of measurement in detail.
- Find the relationship between the position of the bubble and acceleration of the tube.

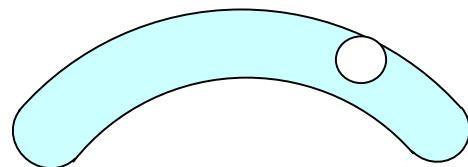


Fig. 5.1