

# 2002-2003 Physics Olympiad Preparation Program

– University of Toronto –

## Problem Set 1: General

*Due 28 October 2002*

Here are a few comments before starting your first problem set.

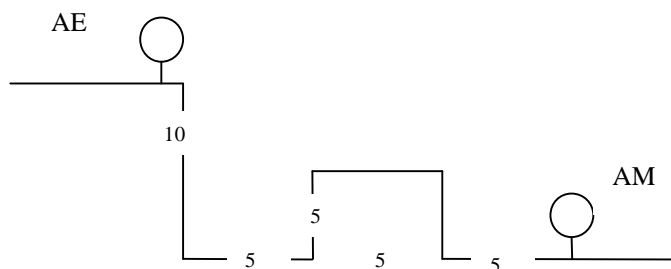
- If you want to know what kind of physics you might need to solve these problems, look at the Physics Olympiad syllabus at <http://www.jyu.fi/ipho/syllabus.html>. You do not have to know the syllabus by heart to do the problems, but you should recognize what you need to know so you can look it up.
- Don't forget to look at the information given in the POPBits™ section at the end of the problem set. It sometimes has information helpful or necessary for particular problems.
- 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 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, we can only give you zero. Your basic ideas may be right even if you make a mistake or get stuck.

### 1. Two Alberts

AE must throw a ball so that it reaches AM after hitting the ground one time. AM remains fixed at his position. The distances shown in the diagram are in metres.

(a) What should AE do to achieve the above? Ignore air resistance.

(b) Is there more than one way for AE to throw the ball so that it hits the ground only once before arriving at AM?



## 2. Two violins

How much louder are two violins compared to one violin? Suppose that each violin produces a single pitch (frequency) wave  $f(t)=A\sin(2\pi vt+\phi)$ , where  $A$  is the constant amplitude,  $v$  is the frequency, and  $\phi$  is a phase factor that might vary randomly in time for each instrument. You will need to consider several cases.

## 3. Temperature of the planet Venus

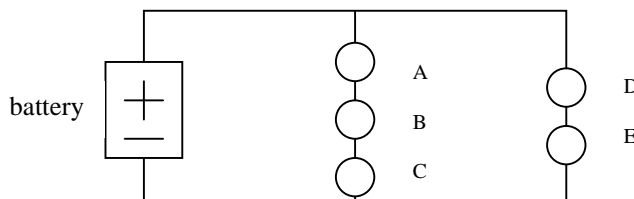
All objects emit radiation. The energy flux density  $J$  of this radiation is the energy emitted per unit time and per unit area. The Stefan-Boltzmann law is  $J=e\sigma T^4$ , where  $e=1$  for a perfect radiator,  $\sigma$  is a constant, and  $T$  is the temperature of the object. What is the equilibrium temperature of the planet Venus? Assume that the only radiation incident on Venus is from the Sun. Assume that Venus and the Sun are perfect radiators. If your calculated  $T$  is different from the measured temperature of Venus of about 700 Kelvin, speculate on why this is the case.

## 4. Can the can roll?

Rest an empty aluminum pop can on its side and on a table. Bring a charged object close to the can, but do not touch the can. Can you get the can to roll? If it does start to roll, why does it do so? Can you halt the can's motion by using the charged object, but without hitting the can? Describe the charged object you used in this experiment.

## 5. Circuits

When the following circuit is connected, how bright are the bulbs A, B, C, D, and E relative to one another? The bulbs are identical. If bulb A is removed from the circuit, what happens to the brightness of B, C, D, and E? If bulb A is replaced by two new bulbs, what happens to the brightness of the remaining bulbs? You can try this question experimentally and/or theoretically.



## POPBits™ – Possibly useful bits of information

### Constants and units<sup>1,2</sup>

Stefan-Boltzmann radiation constant	$\sigma$	$(5.670400 \pm 0.000040) \times 10^{-8} \text{ W/m}^2/\text{K}^4$
Mean Sun-Venus distance	$R_{sv}$	$1.08 \times 10^8 \text{ km}$
Temperature of the Sun	$T_S$	5800 K
Radius of the Sun	$R_S$	$6.96 \times 10^5 \text{ km}$

<sup>1</sup> <http://physics.nist.gov/cuu/Constants/index.html>

<sup>2</sup> [http://pdg.lbl.gov/2000/contents\\_sports.html](http://pdg.lbl.gov/2000/contents_sports.html)