Physics 101

E. S. Phinney

Order of Magnitude Physics

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Problem Set 6

Due in class *15 Feb 2007*

The TAs have been reporting problems deciphering some of the papers handed in as solutions. In hopes of encouraging improvements, they have been authorised to award a bonus point to exceptionally clear and legible solutions, and to deduct a point from illegible or incomprehensible ones.

Homework Problems:

1. **Evaporation**
   a) Estimate the evaporation time per centimeter depth for water maintained at 15 degrees centigrade in vacuum. At this temperature the equilibrium vapor pressure is about 13mm of Hg.
   b) Estimate the evaporation time per centimeter depth as a function of wind speed for water maintained at 15 degrees centigrade in air. Consider a puddle of 50cm diameter.
   c) Compare your answers in a) and b) to the timescale over which puddles disappear in cloudy weather following a rain storm.

2. **Hot Rocks**
   This problem outlines an oversimplified calculation of how the temperature varies on the surface of the moon. Starting at $t = 0$, a smooth, flat surface paved with cold ($T \approx 0$ K) black rocks is subjected to a constant, vertical flux, F, of optical radiation. Assume thatthe surface absorbs all of the incident radiation and radiates like a black-body at its surface temperature, T_s.
   a) What is the equilibrium value, T_{eq}, of T_s?
   b) Describe the time dependence of T_s before equilibrium is reached. Hint: The heat equation reads
   $$\rho c_p \frac{\partial T}{\partial t} = K \nabla^2 T.$$
   You are not expected to solve this equation.
   c) What is the characteristic time, t_{eq}, for the approach to equilibrium, and what is the depth, δ, of the thermal boundary layer at this time?
   d) Evaluate T_{eq}, t_{eq}, and δ for $F \approx 10^6$ erg cm^{-2} s^{-1}, a flux appropriate to solar heating of the moon.

3. **Balancing a Pencil**
   a) At room temperature in still air, how long can a pencil remain balanced on its point?
   b) How long at absolute zero?

4. **Geothermal sources**

   The temperature in the Earth's crust increases at a rate of 20 K per kilometer of depth.

   a) How cold would the Earth become with the sun turned off?

   b) Could geothermal sources provide a solution to the world's energy problem?

5. **Plant Growth**

   How fast can grass grow? Consider both wet and dry climates.

6. Invent a problem of your own (you don't have to know the answer). The most interesting problems submitted will be done in class, or assigned as homework in subsequent problem sets. Your problem can be like those above, or more general.