Physics 313 Problem Set 1

Due at the end of class, Wednesday September 10^{th} (late assignments will not be accepted).

1. The density of nitrogen gas at standard temperature and pressure (STP, 0°C and about 1atm) is 1.25 kg/m^3, while the density of liquid nitrogen at atmospheric pressure is $0.81{\cdot}10^3$ kg/m^3. Let D denote a typical distance between nitrogen molecules is its gas phase and d denote the approximate average size of the nitrogen molecule.

(a) Assuming that the nitrogen molecules in the liquid are basically touching each other, estimate the ratio D/d (that is, compute its order of magnitude).

(b) Air is mostly (about 80%) nitrogen. Explain what your answer to part (a) tells you about treating air as an ideal gas at STP.

2. Consider a person who consumes about 2000 (food) calories a day (a fairly typical number). The food calorie is 1000 times bigger than the physics calorie, which in turn is defined as 1 cal = 4.2 J. Assuming that our hypothetical person has constant metabolism, is not currently gaining weight, and is not moving very much, compute the amount of heat they emit, per unit time, in watts.

What warms up a room more: a person, or a 60W light bulb?

3. Earth's radius is 6400km and its surface gravity is 9.8 m/s^2. Assuming that the Earth's atmosphere is a thin uniform shell, and that it exerts a pressure of 1atm everywhere, compute the total mass of the atmosphere.

The next three questions will help you review some math you are going to need in this course (partial derivatives, logarithms and the Taylor expansion).

4. Schroeder Problem 1.45 (page 31).

5. Schroeder Problem 2.12 (page 61) parts (a),(b) and (d), as well as part (e), below.

(e) Derive the next order approximation

$$\ln(1+x) \approx x - \frac{1}{2}x^2$$

Again, use you calculator to check the accuracy for x=0.1 and x=0.01. For which value of x going to a higher order improves the accuracy more significantly?

Hint: in (d) and (e) use Taylor expansion.

6. Schroeder Problem 2.13 (page 61).