PHY 475
Homework 1
(Due by beginning of class on Monday, April 9, 2012)

Submit neat work, with answers or solutions clearly marked by the question number. Unstapled, untidy work will be charged a handling fee of 20% penalty. Writing only an answer without showing the steps used to get to that answer will fetch very few points, even if the answer is correct. Late homework will not be accepted.

1. The Hubble "constant" H_0 can be used to obtain a rough estimate of the age of the Universe under a certain assumption.

(a) We discussed the assumption in class. What is it?

(b) In class, we wrote that under the current consensus value of $H_0 = 70$ km s^{-1} Mpc^{-1} and the assumption above, the approximate age of the Universe is 14×10^9 yr, or 14 Gyr. Due to severe underestimates of his measured distances to galaxies, Hubble originally measured $H_0 = 500$ km s^{-1} Mpc^{-1}. What would this value of H_0 give you for the approximate age of the Universe? *For full credit, you must show all your calculation steps clearly.*

2. Suppose that you are in an infinitely large, infinitely old universe in which standard Euclidean geometry holds true.

(a) The density of stars in this universe is $n_\star = 10^9$ Mpc^{-3} and the average radius of a star is equal to the Sun's radius: $R_\star = R_\odot = 7 \times 10^8$ m. How far, on average, could you see in any direction before your line of sight struck a star?

(b) If the stars are clumped into galaxies with a density of $n_{\rm gal} = 1$ Mpc^{-3}, and average radius $R_{\rm gal} = 2000$ pc, how far, on average, could you see in any direction before your line of sight struck a galaxy?

(c) To make sense of your results, convert your answers in parts (a) and (b) to Mpc, and compare them to the approximate size of the Universe c/H_0, then comment on how this helps you with resolving Olbers' paradox.

3. Since you're made mostly of water, you're very efficient at absorbing microwave photons.

(a) The number density of CMB photons is $n_\gamma = 4.11 \times 10^8$ m^{-3}. If you were in intergalactic space, approximately how many CMB photons would you absorb per second? *If you like, you could assume you are spherical. Alternatively, you could be lazy like I was, and assume your surface area is 1 m^2.*

(b) What is the approximate rate, in watts, at which you would absorb radiative energy from the CMB?

(c) Ignoring any other energy inputs and outputs, how long would it take the CMB to raise your temperature by 1 nano Kelvin (i.e., 10^{-9} K)? *Since your body is mostly water, assume your specific heat capacity is the same as water* (= 4200 J kg^{-1} K^{-1}).