PHY 375
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. Carry out the following calculations, showing your steps clearly.

(a) In 1950, astronomer Jan Oort proposed that long-period comets come from a vast distant spherical shell of icy bodies that may extend as far out as 100,000 AU from the Sun. Express this distance in light years (LY) and in parsec (pc).

(b) The NGC 3795 galaxy in the Ursa Major group has a redshift $z = 0.004036$. Find its recession velocity, and use this to find the distance to NGC 3795 in Mpc. For the Hubble constant, use the value $H_0 = 70$ km s^{-1} Mpc^{-1}.

(c) Quasars are extremely luminous sources that are at great distances from us.. The most distant quasar was discovered last year at a redshift of $z = 7.1$. Calculate the recession velocity of this quasar, and hence find the distance to it in Mpc.

Note: You should use the full relativistic Doppler effect formula: $1 + z = \sqrt{\dfrac{(c+v)}{(c-v)}}$.