ASTRONOMY 143
The History of the Universe
Professor Barbara Ryden

Problem Set # 7: The Penultimate Problem Set
Due Wednesday, November 25
at class time

If you want to turn in your problem set early, you can
hand it in at Professor Ryden's office, 4035 McPherson.

NAME (please print clearly): _____

SCORE (instructor use only): _____

1) [20 points] The age of the universe (that is, the time since the Big Bang) is 13.7 billion years. The age of the Solar System is 4.56 billion years. Thus, the Solar System has existed for 33.3% of the age of the universe. For what percentage of the total age of the universe have the following things existed?
a) neutral (as opposed to ionized) atoms
b) the first galaxies to have formed
c) the Great Pyramid in Giza, Egypt (Its date of completion is something you can look up.)
d) you

2) [20 points] The Whirlpool Galaxy is at a distance $d = 7.1\,\mathrm{Mpc}$ from us. Using Hubble's law, what do you expect the radial velocity v of the Whirlpool Galaxy to be? What do you expect the redshift z of the Whirlpool Galaxy to be? When hydrogen is at rest, it produces an emission line with a wavelength $\lambda_0 = 656.281$ nanometers; what wavelength λ would you measure for the corresponding emission line from hydrogen in the Whirlpool Galaxy?

3) [20 points] We can detect a star with our naked eyes as long as its flux is above some minimum threshold, F_{min}. The flux of the Sun would be equal to F_{min} if it were at a distance of 17 parsecs from us. In other words, the maximum distance at which you would be able to see the Sun with your naked eyes is $r_{\text{sun}} = 17\,\text{pc}$. The luminosity of a supernova (that is, an exploding star) is $L_{\text{super}} = 3.6 \times 10^9 L_{\text{sun}}$. What is the maximum distance r_{super} at which you would be able to see a supernova with your naked eyes? If a supernova went off in the Andromeda Galaxy, would we be able to see it here on Earth without the aid of a telescope?

4) [40 points] Our old friend "Flat-Earth Fred" is up to some new tricks. He now believes that the Big Bang Model is bogus; he thinks that he lives in a static universe that is both infinitely large and eternally old. Describe what evidence you could provide that would convince Fred that the universe *cannot* be static, infinitely large, and eternally old. (Remember, skeptical Fred prefers evidence that he can see directly with his own eyes.)