ASTRONOMY 143
The History of the Universe
Professor Barbara Ryden

Problem Set # 4
Due Wednesday, October 28
at class time

NAME (print clearly): _____

SCORE (instructor use): _____

Reminder: The midterm exam will be on Friday, October 30, at class time.

1) [20 points] Suppose that you have used a Cepheid variable star as a "standard candle" to compute the distance to a particular galaxy. The distance you computed is $r = 35\,\mathrm{Mpc}$. Much to your embarrassment, you find that the Cepheid variable star has a luminosity L that is actually *twice* the luminosity you assumed when making your calculation. Is the galaxy *closer* or *farther* than you originally calculated? What is the true distance to the galaxy?

2) [20 points] As we have seen, hydrogen has an absorption line at a wavelength $\lambda_0 = 656.3$ nanometers (as long as the hydrogen is at rest). You observe a distant galaxy for which the same hydrogen absorption line has a wavelength $\lambda = 715.4$ nanometers.

a) What is the redshift, $z = (\lambda - \lambda_0)/\lambda_0$, of the galaxy?

b) What is the radial velocity of the galaxy, in kilometers per second?

c) From Hubble's law, what is the distance to the galaxy? [Hint: assume $H_0 = 71\,\mathrm{km/\,sec/\,Mpc}$.]

3) [20 points] As we have seen in lecture, if the Hubble constant is $H_0 = 71\,\mathrm{km/\,sec/\,Mpc}$, then the Hubble time is $1/H_0 = 14$ billion years. Edwin Hubble himself, because he grossly underestimated the distance to galaxies, believed that the Hubble constant was $H_0 = 500\,\mathrm{km/\,sec/\,Mpc}$. For $H_0 = 500\,\mathrm{km/\,sec/\,Mpc}$, what is $1/H_0$, in billions of years?

4) [40 points] Suppose you found a star within our Milky Way Galaxy whose age was measured to be twice the Hubble time. Would this discovery make you abandon the Big Bang model for the universe?
If the old star prompts you to abandon the Big Bang model, briefly explain an alternate model that would be consistent with Hubble's law ($v = H_0 d$).
If you do not abandon the Big Bang model, briefly explain how a Big Bang universe can contain stars twice as old as the Hubble time ($1/H_0$).