July 5, 2006 Name:_____

Astronomy 102: Stars and Galaxies

Review Examination 3

Instructions: Write your answers in the space provided. If you need additional space, continue on the back of each page, but indicate **clearly** that you have done so. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. Please **write legibly and be brief and to the point!** The exam has seven questions; each question has equal weight.

Possibly Useful Constants and Formulae

$$L_\odot = 3.8 \times 10^{26}\ \mathrm{W}$$

$$d_\odot = 1\,\mathrm{AU} = 1.496 \times 10^{11}\,\mathrm{m}$$

$$L_{\mathrm{Vega}} = 55\,L_\odot$$

$$d_{\mathrm{Vega}} = 7.8\,\mathrm{pc}$$

$$c = 3.00 \times 10^8\ \mathrm{m\ s^{-1}}$$

$$1\,\mathrm{Mpc} = 10^6\ \mathrm{pc}$$

$$1\,\mathrm{pc} = 3.26\ \mathrm{lyr}$$

$$1\,\mathrm{pc} = 206,265\ \mathrm{AU}$$

$$1\,\mathrm{pc} = 3.086 \times 10^{16}\ \mathrm{m}$$

$$1\,\mathrm{km} = 1,000\,\mathrm{m}$$

$$L = A\,\sigma\,T^4$$

$$L = 4\pi {R_\odot}^2\,\sigma\,T^4$$

$$B = \frac{L}{4\pi\,d^2}$$

$$z = \frac{d}{c\,t_H} \quad (\mathrm{For}\ z \ll 1)$$

$$z = \frac{\lambda_{\mathrm{obs}} - \lambda_{\mathrm{orig}}}{\lambda_{\mathrm{orig}}}$$

$$z = \frac{v}{c} \quad (\mathrm{For}\ v \ll c)$$

$$z = \frac{\mathrm{Size\ Now}}{\mathrm{Size\ Then}}$$

$$t_H = 13.8 \times 10^9\ \mathrm{yrs} = 4.35 \times 10^{17}\ \mathrm{s}$$

Age of Solar System: 4.6×10^9 years

Age of Universe: 13.7×10^9 years

1. We've measured the current expansion rate of the Universe by looking at Cepheid variables and supernovae in relatively nearby galaxies. Suppose that we calculate an expansion rate by looking at the brightness and redshift of a supernova in a galaxy. Now suppose that we later discover that this supernova was hidden behind some dust. Have we *overestimated* or *underestimated* the expansion rate of the Universe? Explain.

2. You find a galaxy that is 50 Mpc away.

- **(a)** What is the redshift of this galaxy?
- **(b)** If you observe the Hyrogen Alpha emission line (rest wavelength 6562.8 Å) from this galaxy, at what wavelength will you see it?
- **(c)** If a star just like the Sun were in this galaxy, what would the brightness of that star be compared to Vega?
- **(d)** The Hubble Space Telescope (HST), if pushed, can observe stars that are about 10^{-11} as bright as Vega. What is the redshift (assuming it comes only from the expansion of the Universe) of the most distant galaxy in which we could see a star just like the Sun with the HST?
- **(e)** A certain Cepheid Variable star is 1,200 times as luminous as the Sun. What is the distance *and* redshift of a galaxy in which we could see this star with the HST?

3. You are not expanding at the same rate as the Universe; all of your sinews and bones and so forth are holding you together against that expansion. However, if you *were* expanding at the same rate as the Universe, how much would you expand over the rest of your lifetime? (If you don't know your height, assume you're 1.75 m tall. If you don't know how long you'll live, be optimistic and assume you'll be around for another 80 years.)

4. A Type Ia supernova (SN Ia) has a luminosity of $5.8 \times 10^9\, L_\odot$ at maximum light; it is this high luminosity that makes them visible to such great distances.

- **(a)** You discover and observe a supernova in a distant galaxy. In your telescope, you observe it to have a brightness that is 1.6×10^{-7} times the brightness you observe for Vega. How far away is this galaxy (in Megaparsecs (Mpc))?
- **(b)** You measure a redshift for this galaxy of $z = 0.062$. Using just the data from this galaxy and this supernova, what would you calculate the Hubble Time to be?
- **(c)** If a second supernova explodes in this galaxy 200 million years after the explosion of the supernova you observed, how long from now *or* how long ago does this second supernova explode? (Be sure to indicate whether it happens in the future or the past.)

5.

- **(a)** If the expansion rate of the Univesre were to stay the same as it is right now, what would people measure the Hubble Time to be five billion years from now?
- **(b)** Given what the expansion rate of the Universe is really doing, will people five billion years from now measure a Hubble Time that is less than, greater than, or equal to your answer from (a)?