December 06, 2004 Name:________________________

Astronomy 102: Stars and Galaxies

Sample Review Final Exam

Instructions: Write your answers in the space provided; indicate clearly if you continue on the back of a page. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. The exam has six questions, each with equal weight. Be brief, and to the point.

Potentially useful formulae and constants

$$R_\odot = 6.96 \times 10^5 \text{ km}$$
$$L_\odot = 3.85 \times 10^{26} \text{ W}$$
$$M_\odot = 2.0 \times 10^{30} \text{ kg}$$
$$T_\odot = 6,000\,\text{K}$$
$$R_\oplus = 6,378 \text{ km}$$
$$M_\oplus = 5.97 \times 10^{24} \text{ kg}$$

Earth-Sun Distance: 1.000 AU

$$1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}$$
$$1\,\text{pc} = 3.26\,\text{light} - \text{years}$$
$$1\,\text{pc} = 206,265 \text{ AU}$$
$$1\,\text{Mpc} = 10^6\,\text{pc}$$
$$1\,\text{km} = 1,000\,\text{m} = 0.62\,\text{miles}$$
$$L = A\,\sigma\,T^4$$
$$L = 4\pi\,R^2\,\sigma\,T^4$$
$$B = \frac{L}{4\pi\,d^2}$$
$$F = \frac{G\,M_1\,M_2}{d^2}$$
$$d = \frac{1}{p}$$

$$c = 3.00 \times 10^8\,\text{m}\,\text{s}^{-1}$$
$$G = 6.67 \times 10^{-11}\,\text{m}^3\,\text{kg}^{-1}\,\text{s}^{-2}$$
$$\frac{\lambda_{\text{obs}} - \lambda_{\text{orig}}}{\lambda_{\text{orig}}} = \frac{v}{c}$$
$$\sigma = 5.67 \times 10^{-8} \text{ W}\,\text{m}^{-2}\,\text{K}^{-4}$$
$$P^2 = A^3$$
$$P^2 = \left(\frac{4\pi^2}{GM}\right) A^3$$
$$A = \frac{h}{d}$$
$$v = H_0\,d$$
$$H_0 = 72\,\frac{\text{km/s}}{\text{Mpc}}$$
$$z = \frac{v}{c} \quad (\text{for } \; v \ll c)$$
$$(1+z) = \frac{\text{Size Now}}{\text{Size Then}}$$
$$R = \frac{2\,G\,M}{c^2}$$

Lifetime of 8 $M_\odot$ star: 80 million years

Main-sequence lifetime of Sun: 10 billion years

1. The Sun takes 250 million years to orbit the galaxy once. How many times does a high mass star orbit the galaxy between when it forms and when it goes supernovae? If such a star forms right now, at what stage of stellar evolution will the Sun be when that star goes supernovae?

2. Consider two extrasolar planets, each discovered around a different star. The planets are discovered by observing the Doppler shifts due to the wobble of the stars. Both stars are very similar, and can be assumed to have the same mass, luminosity, radius, etc. The period of Planet A is half the period of Planet B. The star which Planet B orbits shows a greater maximum wobble than the star which Planet A orbits.

(a) Which planet is, on the average, closer to its star?

(b) What is the ratio R_A/R_B between the average distances of each planet from its star?

(c) Can you tell which planet is more massive? If so, which one, and how do you know? If not, suggest an observation you could make to determine which planet is more massive.

3. **(a)** You are in Nashville. You see a constellation high in the Southern sky. Where should you see it four hours from now?

(b) What one thing would you change about the Earth or its orbit in order to eliminate most seasonal variations?

(c) The Earth's orbit is elliptical such that we are slightly closer to the Sun in the northern-hemisphere winter than we are in the northern-hemisphere summer. Is the length of the full day (number of hours from the Sun being overhead one day to the next day) different in the winter than it is in the summer? If so, which is longer? Explain. (NOTE: this question is not about the number of hours of daylight.)

(d) There are some latitudes on Earth where some stars never set. What latitudes are those?

4. A certain supernova progenitor consists of a white dwarf and a red giant orbiting each other. Assume the white dwarf has a radius of 1 $R_\oplus$, and the red giant has a radius of 100 $R_\odot$. The white dwarf's surface temperature is 6,000 K, and the red giant's surface temperature is 3,000 K.

(a) What is the ratio B_W/B_R of the observed brightness of the white dwarf to the observed brightness of the red giant?

(b) Is it possible that both the red giant and white dwarf had the same size? Explain; be sure to consider the comparison of the stars' masses when they were both first formed.

(c) Suppose this supernova progenitor system is 500 light-years away. How far away would another identical white dwarf need to be to have the same brightness as the red giant in the progenitor system?

5. A satellite galaxy to our own has gas in it which has a lower heavy element abundance than much of the gas in the disk of our own Milky Way.

(a) What does this tell you about the history of star formation in the satellite galaxy?

(b) Can you say anything about the average star color of this galaxy as compared to the Milky Way? If so, what?

(c) Is the ratio of the gas mass to the star mass in this galaxy likely to be higher than or lower than the same ratio in the Milky Way?

6. With an amazing, revolutionary new telescope that has unprecedented resolution, you observe an individual star in a distant galaxy. The galaxy is 65 million light years away. The star is a red giant star, and you are able to measure a mass of 12 $M_\odot$ for the star,

(a) What might you observe from this galaxy in the future? What is the shortest and longest time you might have to wait for this?

(b) An alien astronomer is looking at what is present at the position of that star *right now*. What does this alien astronomer find?

(c) If you were to measure the redshift of this galaxy and interpret it as a Doppler shift, what recessional speed would you determine for it?

7. Summarize and explain the primary evidence we have that most of the Galaxy is made up of dark matter. Draw any diagrams you consider necessary.

8. Consider two stars, Star A and Star B. Both stars have exactly the same mass. Suppose (although this is not realistic) that both stars are spherical and have exactly the same radius, and that the density at a given depth from the surface of the star is the same for each star. Star A is not rotating at all, and Star B is rotating very quickly.

Do you expect the surface temperature of the two stars to be the same, or do you expect one star to have a higher surface temperature? Explain.