October 6, 2004 Name:_____

Astronomy 102: Stars and Galaxies

Sample Review Examination 2

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 seven questions, each with equal weight.

Possibly Useful Constants and Formulae

Earth-Sun Distance: 1.000 AU

Venus-Sun Distance: 0.72 AU

$$R_\odot = 6.96 \times 10^5 \text{ km}$$

$$L_\odot = 3.85 \times 10^{26} \text{ W}$$

$$M_\odot = 2.0 \times 10^{30} \text{ kg}$$

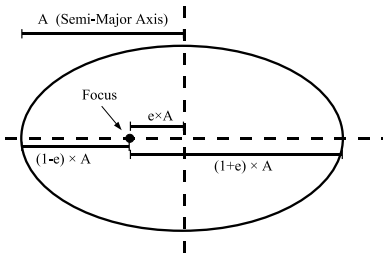
$$1\,\text{pc} = 206,265 \text{ AU}$$

$$1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}$$

$$1\,\text{km} = 1,000\,\text{m} = 0.62\,\text{miles}$$

$$1\,\text{hour} = 60\,\text{min}$$

$$1\,\text{min} = 60\,\text{sec}$$



$$A = \frac{h}{d}$$

$$d = \frac{1}{p}$$

$$\pi \text{ radians} = 180^\circ \qquad 206,265'' = 1 \text{ radian}$$

$$60'' = 1' \qquad 60' = 1^\circ$$

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

$$L = 4\pi\,R^2\,\sigma\,T^4$$

$$\lambda_{\max} = \frac{2.9 \times 10^7\,\text{Å K}}{T}$$

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

$$F = \frac{G\,M_1\,M_2}{d^2}$$

$$P^2 = A^3$$

$$E = h\,f$$

$$f\,\lambda = c$$

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

$$h = 6.626 \times 10^{-34}\,\text{J s}$$

$$1\,\text{W} = 1\,\text{J s}^{-1}$$

$$\frac{\lambda_{\text{obs}} - \lambda_{\text{orig}}}{\lambda_{\text{orig}}} = \frac{v}{c}$$

$$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\,\text{K}^{-4}$$

1. Astronomers discover an asteroid orbiting the Sun in an elliptical orbit. The asteroid's orbit just touches both Venus' and Earth's orbit.

(a) Draw a diagram showing the Sun, Venus' orbit, Earth's orbit, and the asteroid's orbit. Clearly label what is what.

(b) What is the semi-major axis of the asteroid's orbit?

(c) How long does it take the asteroid to go around the Sun?

2. Star A has a measured parallax of $0.10''$, and Star B has a measured parallax of $0.025''$. Star B appears twice as bright as Star A. What is L_A/L_B, the ratio of the luminosity of Star A to the luminosity of Star B?

3. **(a)** Suppose that the Sun were to suddenly, somehow, disappear, leaving nothing at the center of the Solar System. Describe the motion of the planets immediately thereafter.

(b) Suppose, in flagrant violation of our understanding of stellar evolution, the Sun were to collapse into a black hole, leaving a black hole of mass $1\,M_\odot$ at the center of the Solar System. Describe the motion of the planets after the change.

4. A commonly observed astronomical emission line known as Hα is seen in red light at 6563Å.

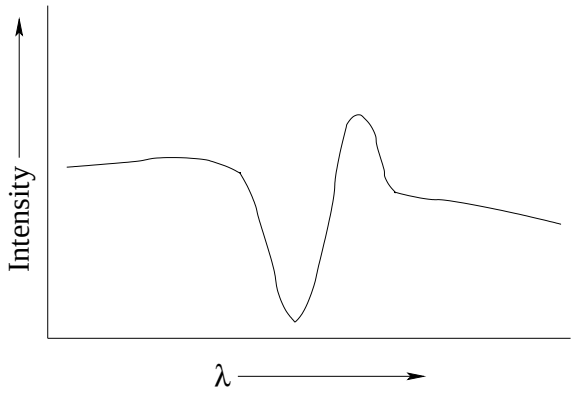
(a) What is the frequency of an Hα photon?

(b) What is the energy of an Hα photon?

(c) A 90mph fastball thrown by a baseball pitcher has about 120 Joules (120 J) of kinetic energy. How many Hα photons would you need to equal this much energy?

(d) Suppose the fastball has a Hα emitter on it. Suppose also that the batter is an astronomer with a spectrometer. At what wavelength will the batter observe the light emitted by the baseball?

5. A "P-Cygni" line profile is a peculiar type of line observed in some astronomical sources such as supernovae. It combines a *blueshifted* absorption line with an *unshifted* emission line:



This sort of line is observed if you have a spherical cloud of *expanding* low-density gas surrounding a hot high-density source. The cloud absorbs photons coming from the source (as electrons in the cloud atoms jump to higher orbitals), and the re-emit photons of the same wavelength (as cloud atoms jump to lower orbitals) equally in all directions.

(a) Draw a picture showing the hot source, the spherical cloud of low-density gas, arrows indicating the direction of the gas' expansion, and a figure showing where you are relative to this cloud looking at it.

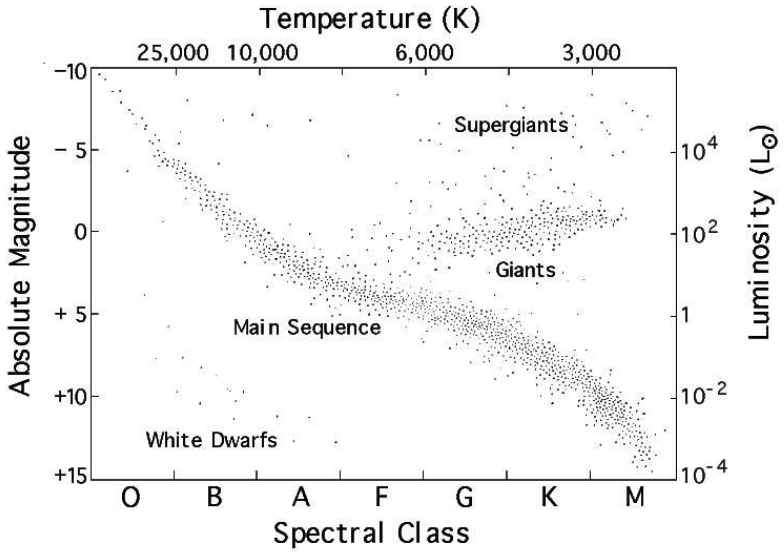
(b) Explain how this situation can give rise to a P-Cygni line profile. As part of this explanation, circle on the diagram the part of the source that is responsible for the absorption part of the line profile, and the part that is responsible for the emission part of the line profile.

6. You build a gigantic orbiting space telescope with enough resolution that you are able to resolve (measure the angular size of) many stars for the first time.

You pick out two stars of equal brightness to observe. You see that both of them have exactly the same *angular* size.

How do the colors of these two stars compare? Explain how you know.

7. Consider the following H-R diagram:



(a) You observe a star (Star A) that is bluish in color. You measure its spectrum, and find that the spectrum reaches a peak at an ultraviolet wavelength of 1,500Å. What is the temperature and spectral type of this star?

(b) You observe a star (Star B) that is reddish in color. You measure its spectrum, and find that the spectrum reaches a peak at an red/infrared wavelength of 7,800Å. What is the temperature and spectral type of this star?

(c) Star A and Star B have the *same* observed brightness. You measure the parallax of Star A to be $0.0080''$, and the parallax of Star B to be $0.080''$. What is the ratio of luminosities of the two stars?

(d) If you determine that Star A is a main sequence star, what kind of star (White Dwarf, Main Sequence, Giant, or Supergiant) is Star B? Explain.