October 13, 2004 Name:________________________

Astronomy 102: Stars and Galaxies

Exam 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 six questions, each with equal weight.

Possibly Useful Constants and Formulae

Earth-Sun Distance: 1.000 AU

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

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

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

$$T_\odot = 6,000\,\text{K}$$

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

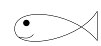
$$1\,\text{AU} = 1.496 \times 10^{11}\,\text{m}$$

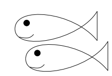
$$1\,\text{km} = 1,000\,\text{m} = 0.62\,\text{miles}$$

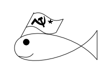
$$1\,\text{Å} = 10^{-10}\,\text{m}$$

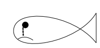
Red light: ~6500Å

Green light: ~5500Å

One Fish 

Two Fish 

Red Fish 

Blue Fish 

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

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

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

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

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

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

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

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

$$f\lambda = c$$

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

$$G = 6.67 \times 10^{-11}\,\text{m}^3\,\text{kg}^{-1}\,\text{s}^{-2}$$

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

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

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

$$P^2 = A^3$$

$$P^2 = \left(\frac{4\pi^2}{GM}\right) A^3$$

1. Most stars show a spectrum that is a blackbody continuum with absorption lines.

(a) Make a sketch of intensity vs. wavelength for a star's spectrum.

(b) What part of the star is responsible for the absorption lines? Draw a picture if this helps you explain.

2. You observe an astronomical source with a spectrometer. The spectrum you observe has *both* absorption and emission lines. The emission lines are all *blueshifted*, whereas the absorption lines show no shift at all.

You determine that you are looking at a very unusual sort of star which is *behind* a cold, dark, intervening cloud of low-density gas. Almost none of the atoms in this intervening gas cloud have electrons in excited orbitals.

Explain the following. Where are the emission lines coming from? Where is the light being absorbed to make the absorption lines? How can you explain the difference in the Doppler shift of the emission and the absorption lines? (Also, what is unusual about the star?)

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3. The Earth orbits the Sun in what is very close to a circular orbit, moving with a speed of 30 km/s.

(a) Draw a diagram with the Sun, the orbit of the Earth around the Sun, and the position of the Earth at some point along its orbit.

Now suppose that somehow, the mass of the Sun suddenly doubles. The Earth does not change position or speed at the moment that this happens.

On your diagram, draw the orbit of the Earth after the change in the mass of the Sun. Make sure to clearly label what is what.

(b) Now suppose that as the Sun's mass doubles, the Earth's speed also suddenly changes just enough to keep it in a circular orbit of the same radius. Is the new speed greater than or less than the old speed? What is its orbital speed after the change?

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4. A physicist receives a traffic ticket for running a red light. He tries to get out of it by explaining to the judge that light is subject to a Doppler Effect; because of his approach to the intersection, the light from the traffic signal was shifted from the red to the green. Therefore, the physicist argues, he thought the signal was in fact green, and he should not have a ticket.

(a) Does the physicist's story hold water? Specifically, for the red light to have appeared green, would the physicist have been approaching or moving away from the traffic signal?

(b) Regardless of his direction of motion, calculate how fast the physicist was moving in miles per hour. Comment whether another legal infraction may have occurred.

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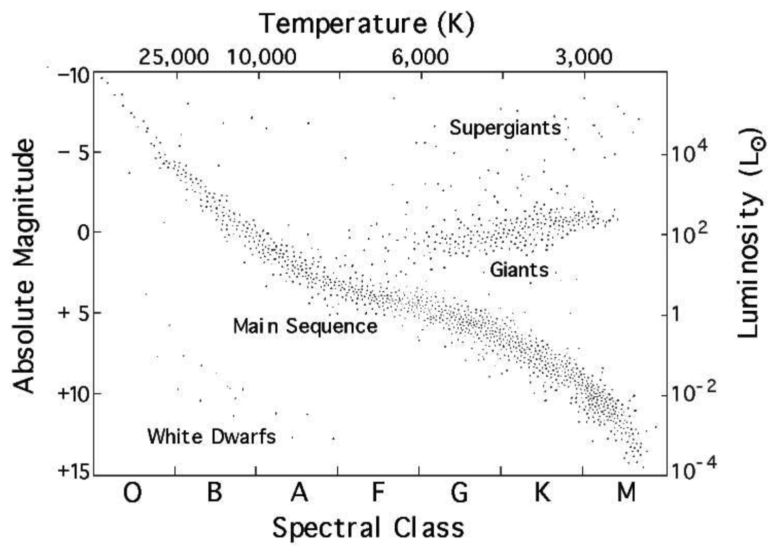
5. Consider the following H-R diagram:



(a) Indicate the spot where the Sun falls on this H-R diagram with a small circle; label that circle with the letter "A".

(b) Later in its life, the Sun will cool to about 3,000K, and will swell to 100 times its current radius. Indicate the spot where it will be on the diagram at this stage in its life with a small circle labelled "B". Be sure to show calculations you made (if any) in the space below.

(d) If you pick a random star out of the galaxy, without regard to how easy it is to observe from any spot, where on the diagram is it likely to be found? Outline and label this region with "D". Your region should be no more than an inch across.

(e) If you go outside at night, look up into the sky, and pick out a random star that you can see, where on the diagram is it likely to be found? Circle and label this region with "E". Your region may be as large as you like, but should encompass no *more* than half the diagram.

(f) What, physically, is the sequence OBAFGKM a sequence of?

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6. Sirius is the second brightest star in the sky. It turns out to be a binary system of two stars, although we can only see one with our naked eyes. (Sirius A is 10,000 times brighter than Sirius B.) Both stars are of spectral class A.

(a) Sirius has a measured parallax of $0.38''$. How far away is it?

(b) Sirius A is 1.2×10^{10} times less bright to an Earth-bound observer than the brightest star in the sky. What is the luminosity of Sirius A in both Watts and $L_{\odot}$?

(c) Is Sirius A a White Dwarf, a Main Sequence star, a Giant, or a Supergiant?

(d) Is Sirius B a White Dwarf, a Main Sequence star, a Giant, or a Supergiant?

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