October 28, 2003 Name:_____

Astronomy 102: Stars and Galaxies
Sample Review Test for Examination 3
Do not open the test until instructed to begin.

Instructions: Write your answers in the space provided. 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 12 questions (eight multiple choice and four short answer); you have 50 minutes in which to answer them. All exams must be turned in at the end of the period. Each problem indicates the number of points it is worth; there are a total of 64 points available.

Possibly Useful Constants and Formulae

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

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

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

$$\lambda_{\rm peak} = \frac{2900\,K}{T}\,\mu{\rm m}$$

$$z = \frac{\lambda_{\rm obs} - \lambda_{\rm em}}{\lambda_{\rm em}}$$

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

d in pc, p in $''$ (arcseconds)

$$v = H_0\,d$$

$$(1+z) = \frac{\text{Size Now}}{\text{Size at Emission}}$$

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

$$1\,\mu{\rm m} = 10^{-6}\,{\rm m}$$

$$1\,{\rm \AA} = 10^{-10}\,{\rm m}$$

$$1\,{\rm AU} = 1.50 \times 10^{11}\,{\rm m}$$

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

$$\pi\,{\rm rad} = 3.141592654\,{\rm rad} = 180^\circ$$

$$1^\circ = 60' = 3600''$$

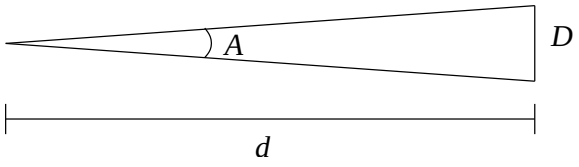
$$1\,{\rm rad} = 206,265''$$

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

$$T_\odot = 5780\,{\rm K}$$

$$R_\odot = 6.96 \times 10^8\,{\rm m}$$

$$M_\odot = 2.00 \times 10^{30}\,{\rm kg}$$



Small angle formula : $A = \frac{D}{d}$ (for A in radians, $A \ll 1$)

Multiple Choice Questions: The first eight questions are multiple choice. Except where explicitly noted, only one answer is correct for each question. Circle the letter of the correct answer. Each multiple choice question is worth **4 points**

1. Which of the following statements is true? (Only one is true.)

(c) Two stars of the same luminosity and the same temperature will be the same size (have the same radius).

(b) Suppose two stars are in a binary system, so we know that they are the same distance away. If they have the same luminosity, then they have the same size (have the same radius).

(c) Two stars which appear equally bright and which have the same luminosity but different temperatures must be at different distances.

(d) Two stars of the same temperature which appear equally bright will be at the same distance.

(e) No statement in (a) through (d) is true.

2. To determine some properties of a star, you must know the distance to that star; other properties may be measured without knowledge of the star's distance. Which properties below require knowledge of the distance to calculate? **More than one answer may be correct; circle all that apply.**

(a) Luminosity

(b) Flux at Earth

(c) Color

(d) Temperature

(e) Chemical composition

(f) Radius

(g) Classification (O, B, A, F, G, K, or M)

(h) Angular size

3. An astronomy graduate student studies a new star and wants to determine its temperature. She would do this by:

(a) Measuring the wavelengths and the strengths of the star's absorption lines

(b) Measuring the brightness star at two different wavelengths and comparing the flux at each wavelength

(c) Measuring the intensity of ultraviolet the star gives off

(d) Measuring the total brightness of the star

(e) Measuring the parallax of the star

(f) Sending a space probe with a thermometer to the star

4. Which of the following statements about the expansion of the Universe are true? **More than one answer may be correct. Circle all that apply.**

(a) Current results indicate that the expansion of the Universe is accelerating.

(b) Current results indicate that the expansion of the Universe will eventually come to a halt.

(c) The Milky Way Galaxy is at the center of the expansion.

(d) Galaxies in the Virgo Cluster are at the center of the expansion.

(e) The cosmological redshift is the wavelength of light expanding together with the Universe and everything inside the Universe.

(f) The Cosmic Microwave Background is getting warmer as a result of the expansion.

(g) The Universe is expanding because it responded to SPAM suggesting that certain of its parts could be made larger.

5. Which of the following is a piece of evidence that supports the Big Bang theory?

(a) Stars moving towards us show a blueshift, while stars moving away from us show a redshift.

(b) Because light takes time to travel, looking to great distances is looking far back in time. We see more distant galaxies earlier in their history.

(c) Stars within 36 degrees of the North Celestial Pole are circumpolar when observed from Nashville.

(d) Stars farther out in our Galaxy orbit faster than we would expect given the gravity from the amount of matter we can see in the Galaxy.

(e) Every point on the sky where there is no star or galaxy is glowing with a near-uniform blackbody spectrum a few degrees above absolute zero.

6. Galaxies in the Hubble flow:

(a) Are moving faster if they're in the plane of our Galaxy than if they are in a direction perpendicular to the plane of our Galaxy, due to the effect of dark matter.

(b) Are all redshifted by the same amount as a result of the uniform expansion of the Universe.

(c) Get farther away from us at a rate that increases with distance.

(d) Are really at a constant distance away from us, and only appear to be getting farther away as a result of the optical illusion of redshift.

7. Star B is 16 times as far away as Star A, but is twice as big as star A. If they are observed to be the same brightness, which of the following statements are true? **More than one may be correct. Circle all that apply.**

(a) Star A is more luminous than Star B.

(b) Star B is more luminous than Star A.

(c) Star A is bluer than Star B.

(d) Star B is bluer than Star A.

(e) Stars A and B are the same color.

(f) If Star B is a G-type star, star B might be an O-type star.

(g) Star A has a higher parallax than Star B.

(h) Star B has a higher parallax than Star A.

8. Galaxies and clusters are observed to be clumped together with big voids between them, while the Cosmic Microwave Background (CMB) is observed to be smooth all the way across the sky to about one part in ten thousand. What can we conclude about our Universe from this statement?

(a) Galaxies did not form out of the same material that was in the Universe at the time when the CMB was emitted; they represent two completely different components of the matter in the Universe.

(b) Dark Energy is causing the Universe to become more smooth and homogeneous on small scales over time.

(c) Structure has grown with time, I.e. condensations of matter have become more condensed.

(d) Dust in galaxies is responsible for absorbing CMB photons and making the CMB appear smoother than it was originally.

(e) None of the above.

Short Answer Questions: Answer questions in the space provided. Indicate clearly if you must continue on the back of the page. Include any calculations or diagrams necessary. Some questions require only a word or a few words, others will require a sentence or two of explanation, and others will require a calculation. **Be brief and to the point.**

9. **(a)** [5 points] Describe and summarize the evidence that leads us to believe that most of the mass of our Galaxy is in the form of dark matter. **(b)** [3 points] Where is that dark matter in comparison to where the stars are?

10. [6 points] A star of spectral type B has a temperature of about 30,000 K, which is five times the temperature of the Sun. That same B-star is fifty thousand times as luminous as the Sun. What is the ratio of the radius of the B-star to the radius of the Sun?

11. An arc welder can reach temperatures as high as 20,000 K, appearing bright and blue.

(a) [1 point] If an arc welder emits a blackbody spectrum, what is the peak wavelength of that spectrum?

(b) [1 points] Although this temperature is higher than that of the Sun's surface, the Sun is much more luminous than an arc welder. Why?

(c) [2 points] What would be the luminosity (in units of $L_\odot$, solar luminosities) of a star the size of the Sun but the temperature of an arc welder?

(d) [2 points] How far away would this star need to be (in AU) for it to appear the same brightness to us as the Sun?

(e) [2 points] If the star were at the distance you calculated in part (d), what would be its angular size? Compare it to the angular size of the Sun (about 0.5°).

(f) [2 points] How big would a star be (in units of $R_\odot$, solar radii) that had the temperature of an arc welder but the luminosity of the Sun?

12. [8 points] Olber's Paradox is a famous "thought experiment" in cosmology. It states that if we live in an infinite, static Universe, every point on the sky— that is, every direction you can look— should look just like a point on the surface of the Sun. The reason is that in an infinite Universe, every line of sight will *eventually* intersect a star. For the Sun, lines of sight within about a 0.5° angular diameter intersect a star. Most stars have a much smaller angular diameter (the farther the star, the smaller the angular diameter). If the Universe were infinite and static, however, eventually, however far away, every line of sight would intersect a star.

(a) In fact, this is not observed. You can look off to the side of a star and see blank, dark night sky. What does this tell us about our Universe?

(b) Give *two* ways in which the Big Bang theory helps explain why we don't see what Olber's Paradox suggests we should see.