Date:____________________ Name:____________________

Astronomy 102: Stars and Galaxies

REVIEW FINAL

December 9, 2003

Instructions: No books or assistance from anyone is allowed. You are allowed one page of notes in your own handwriting. You will need a calculator. Please **write legibly and be brief and to the point!** The exam has 23 questions: 14 multiple choice (1-14) and 9 short answer (15-23). You have 2 hours 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 100 points available.

Potentially Useful Constants and Formulae

$$D = a\,d$$

$$F = \frac{G\,M\,m}{r^2}$$

$$d = \frac{1}{p} \quad (d \text{ in pc, } p \text{ in } '')$$

$$E = h\,f \qquad f\,\lambda = c$$

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

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

$$\frac{\lambda_{\rm obs} - \lambda}{\lambda} = \frac{v}{c}$$

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

$$P^2 = A^3 \quad (P \text{ in yr, } A \text{ in AU})$$

$$1 + z = \frac{\text{size today}}{\text{size then}}$$

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

$$v = H_0\,d$$

$$H_0 = 72\,\frac{\text{km/s}}{\text{Mpc}}$$

$$c = 3.00 \times 10^8\,\frac{\text{m}}{\text{s}} = 3.00 \times 10^5\,\frac{\text{km}}{\text{s}}$$

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

$$h = \text{Planck's Constant}$$

$$\sigma = \text{Stefan-Boltzmann Constant}$$

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. You are in Nashville (Latitude 36°). A star which is at a declination of +70°:
- **(a)** sets exactly 12 hours after it rises.
- **(b)** sets less than 12 hours after it rises.
- **(c)** sets 4 minutes later than it did the previous day.
- **(d)** never sets.
- **(e)** never rises.

2. The angular diameter of the Sun as measured from Jupiter would:
- **(a)** be smaller than the angular diameter measured from the Earth, because the Sun is farther away from Jupiter than it is from the Earth.
- **(b)** be larger than the angular diameter measured from the Earth, because the Sun is farther away from Jupiter than it is from the Earth..
- **(c)** be the same as the angular diameter measured from the Earth, because we're looking at the same Sun.
- **(d)** depend on the tilt of Jupiter's axis relative to the Sun.
- **(e)** be the same as the angular diameter of Jupiter as measured from the Sun.

3. The Earth exerts a gravitational pull on the Moon. However, despite this pull, the Moon does not fall to the Earth (thereby creating a global catastrophe) because:
- **(a)** The pull of the Sun's gravity counteracts the pull of the Earth's gravity and holds the moon up.
- **(b)** The Moon also exerts a gravitational force on the Earth, which counterbalances the Earth's pull on the Moon.
- **(c)** The Moon is moving fast enough perpendicular to the pull of the Earth's gravity to keep it in orbit.
- **(d)** The tides we see on Earth due to the Moon's gravity prevent the moon from crashing to Earth.
- **(e)** The pressure of the Earth's atmosphere counterbalances gravity, and the Moon is held up in equilibrium.

4. An astronomer observes two stars in the sky. One, a red star, appears brighter than another, a blue star. What can the astronomer conclude about these two stars? **More than one may be correct. Circle all that apply.**
- **(a)** The blue star must be more luminous than the red star.
- **(b)** The red star must be more luminous than the blue star.
- **(c)** The blue star must be bigger (larger radius) than the red star.
- **(d)** The red star must be bigger (larger radius) than the blue star.
- **(e)** The blue star must be closer than the red star.
- **(f)** The red star must be closer than the blue star.
- **(g)** None of the above.

5. Nearby elliptical galaxies do not appear to have formed any stars in the last couple of billion years. Most elliptical galaxies (even nearby ones) are far enough that it's difficult or impossible to resolve individual stars. If you take a spectrum of the galaxy, it will probably look most like:

(a) The spectrum of a massive, hot, luminous star.

(b) The spectrum of a red giant star.

(c) The spectrum of an open cluster.

(d) The spectrum of a white dwarf.

(e) The spectrum of an accretion disk around a neutron star.

6. You are able to observe the spectrum of a low-mass main sequence star many times over several years. You find that its spectral lines are shifted consistently to the red. Which of the following is best explanation for this?

(a) The redshift is because the star is in a distant galaxy.

(b) The star is in the halo of our own galaxy.

(c) The star has collapsed into a black hole and is showing a gravitational redshift.

(d) The star is moving away from us.

(e) The star has a planet orbiting it.

7. The "main sequence" of the H-R diagram is "main" because:

(a) Most stars spend all of their lives there.

(b) All stars spend most of their lives there.

(c) That's where all of the brightest stars observable from Earth are found, so those stars were identified first.

(d) That is where stars come to rest on the diagram once they are finished with fusion.

(e) Only stars with extremely low heavy element abundances are found there, indicating that they are very young and haven't yet done much fusion.

8. Which of the following are true about a core collapse (Type II) supernova? (**More than one may be correct. Circle as many as apply.**)

(a) It can leave behind a white dwarf.

(b) It can leave behind a neutron star.

(c) It can leave behind a black hole.

(d) It doesn't leave behind anything, but completely disrupts the star.

(e) The energy comes from neutrinos.

(f) The energy comes from fusion of Carbon to heavier elements.

(g) The energy comes from gravitational potential energy as the core gets much smaller.

(h) It only happens in a star of less than 1.4 solar masses.

(i) Though it's unlikely, we might see a gamma ray burst from it.

9. The spiral arms seen in a grand design spiral galaxy are (circle only one):

(a) Rotating at the same rate as the stars in the galaxy.

(b) Winding up due to the differential rotation of the galaxy.

(c) The stars in the galaxy spiraling into the black hole at the center.

(d) Density waves moving around the galaxy, temporarily clumping stars and gas and triggering star formation.

(e) The result of a reflection of the light from the bulge off of gas and dust particles in the arms.

10. The Moon shows phases because:

(a) as the Moon goes around the Earth, different parts of it fall into Earth's shadow.

(b) the same side of the Moon is always facing at the Earth, but as the Earth rotates during the day we see the Moon lit differently.

(c) as the Earth goes around the sun, the tilt of its axis changes.

(d) as the Moon goes around the Earth, the side we're looking at is at differing angles to the side lit by the Sun.

(e) of an atmospheric effect on Earth.

11. An astronomer observes the orbit of a binary star system, and labels the two stars Star A and Star B. She notices that Star A orbits in a larger circle than does Star B. From just this information, what else can the astronomer conclude about this star system? (**More than one may be correct. Circle as many as apply.**)

(a) Star A is moving with a faster orbital velocity than Star B.

(b) Star A is moving with a slower orbital velocity than Star B.

(c) Star A is more massive than Star B.

(d) Star B is less massive than Star B.

(e) If the system experiences a supernova, Star A will supernova before Star B.

(f) If the system experiences a supernova, Star B will supernova before Star A.

12. An ultraviolet photon has more energy than a radio photon. Which of the following are true? **More than one may be correct. Circle all that apply.**

(a) The ultraviolet photon has a longer wavelength than the radio photon.

(b) The ultraviolet photon has a higher frequency than the radio photon.

(c) The ultraviolet photon moves faster than the radio photon.

(d) The ultraviolet photon can be seen, but the radio photon can only be heard.

(e) If both photons were emitted by other galaxies and then observed at Earth, the ultraviolet photon must come from a much closer galaxy than the radio photon.

13. Suppose your astronomy professor told you he had discovered an O-type main-sequence star in our Galaxy composed entirely of hydrogen and helium. You should:

(a) Not believe him. Because O stars have short lifetimes, therefore the star must be young, and if the star is young, it must have formed from material which has been "polluted" by ejecta from previous generations of massive stars which will also contain elements heavier than H and He.

(b) Not believe him. Because O stars are massive enough to fuse H and He into heavier elements, which we should then see in this star.

(c) Believe him. Because professors are never wrong.

(d) Believe him. Because if the star formed shortly after the Big Bang, there would not have been an heavy elements around for it to form from.

14. As the Sun approaches the end of its life, it will swell into a red giant. During these late stages of its life, it will lose a reasonable fraction of its mass (something less than half) by shedding it out into the interstellar medium. When this gas has dispersed beyond the solar system:

(a) The planets will spiral in closer to the Sun due to the change in gravity.

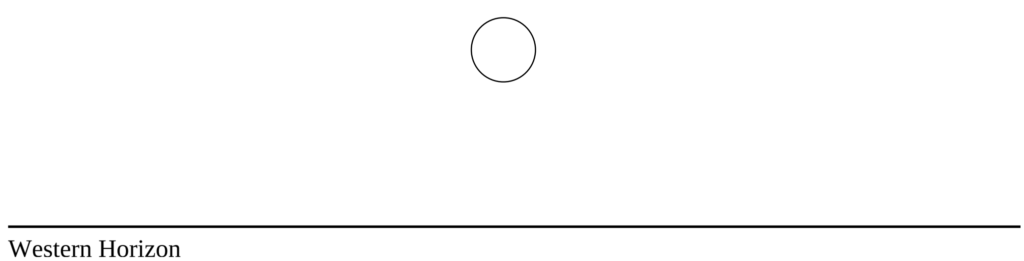
(b) The planets will spiral out to larger orbits due to a change in gravity.

(c) As the gravitational force due to the Sun's reduced mass goes down, the Sun will lose its grip on the planets and they will go flying off into interstellar space.

(d) The surface temperature of all the planets will go down due to the lower temperature of the redder Sun.

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 a few sentences of explanation, and others will require a calculation. **Write legibly, and be brief and to the point.**

15. [3 points] You are in Nashville (latitude=+36°). Consider the following drawing of what you see as you stand and face West shortly before sunset. As the Sun sets and crosses the horizon, draw the path it will move through from its current position until it has just set.



16. [4 points] Low mass stars are the most common sort of star, and low mass stars throw off a planetary nebula as they are ending their lives and becoming a white dwarf. Our galaxy has many billions of low mass stars, but only thousands of planetary nebula. What are the reasons for this disparity? (Give at least two.)

17. [6 points] We observe two stars. Star A is dimmed because it's behind a dust cloud, whereas we have a clear field of view to Star B. Star A is observed to have 8 times the flux that Star B does.

(a) We observe a parallax of $0.1''$ for Star A and $0.05''$ for Star B. What is the ratio d_A/d_B of the distances to the two stars?

(b) Suppose that we are able to determine that both stars have the same exact diameter, but that Star A has a surface temperature twice that of Star B. What is the ratio L_A/L_B of the two stars' luminosities?

(c) By what factor is the dust blocking Star A dimming its brightness? (I.e. what is the ratio of the brightness we *would* observe for Star A were the dust not there to the brightness we actually observe?)

18. [5 points] Suppose you have an extremely powerful telescope which is capable of seeing supernovae as far away as they are theoretically observable. Nearby (at low redshifts), we see both kinds of supernovae. Think about what you would see at the very highest redshifts where you can still see supernovae at all. Do you expect to find Type Ia (thermonuclear) and Type II (core collapse) supernovae out to similar redshifts? Or, do you expect that you'd find one type of supernova on out to higher redshifts than the other? Explain your reasoning.

19. [6 points] Consider looking for supernovae in relatively nearby galaxies.

(a) What type(s) of supernovae might you expect to see in an elliptical galaxy, and why?

(b) What type(s) of supernovae might you expect to see in a spiral galaxy, and why?

(c) In what part(s) of a spiral galaxy might you find the types of supernovae you listed in part (b)?

20. [8 points] We observe a standard candle in two distant galaxies. The standard candle appears 1/4 as bright in Galaxy B as the one in Galaxy A.

(a) What is the ratio d_A/d_B between the distances to each galaxy?

(b) Suppose we measure that Galaxy A is 30 Mpc away. If the Universe is expanding with a Hubble constant of $H_0 = 72\frac{\mathrm{km/s}}{\mathrm{Mpc}}$, what is v_A, the recessional velocity we measure for Galaxy A?

(c) What is v_B, the recessional velocity we measure for Galaxy B?

(d) One of the lines observed in each galaxy is Hα, normally at $\lambda = 6563\text{Å}$. At what wavelength λ_A and λ_B do we observe this line in each galaxy?

21. [5 points] The gas in elliptical galaxies is very hot and ionized. However, there are no hot massive young stars in these galaxies (which have no active star formation) to ionize that gas. What could be providing the energy that keeps this gas hot and ionized?

22. [5 points] Given that (a) the universe is undergoing a uniform expansion, and that (b) we do see a reasonable number of merging galaxies, would you expect that if we were able to measure the average mass of a galaxy showing a high redshift, would it be greater or lower than the average mass of a galaxy showing a low redshift? Why?

23. [5 points] High mass stars, after their life is done, leave behind a neutron star (or, rarely, a black hole), whereas low mass stars leave behind a white dwarf. Low mass stars are much more common than high mass stars. However, if you estimate the number of neutron stars and white dwarfs there should be in our galaxy, you find that the ratio of the number of neutron stars to white dwarfs is *larger* than the ratio of the number of high mass stars to low mass stars. How can you explain this disparity?