October 1, 2003 Name:________________________

Astronomy 102: Stars and Galaxies

Examination 2 SAMPLE REVIEW

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 13 questions (eight multiple choice and five 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 each question it is worth; there are a total of 64 points.

Possibly Useful Constants and Formulae

$$f\,\lambda = c$$

$$E = h\,f$$

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

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

$$z = \frac{v}{c} \quad \text{for } v \ll c$$

$$z = \frac{\lambda_{\rm obs} - \lambda_0}{\lambda_0}$$

$$\text{Volume of a sphere: } V = \frac{4}{3}\pi\,r^3$$

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

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

$$h = 6.626 \times 10^{-34}\ \frac{\text{J}}{\text{Hz}}$$

$$\text{Solar Mass: } M_\odot = 2.0 \times 10^{30}\,\text{kg}$$

$$\text{Solar Luminosity: } L_\odot = 3.85 \times 10^{26}\,\text{W}$$

$$1\,\text{pc} = 206265\,\text{AU} = 3.086 \times 10^{16}\,\text{m}$$

$$1\,\text{radian} = 206265''$$

$$\pi\,\text{radians} = 3.1416\,\text{radians} = 180^\circ$$

$$1\,\text{Å} = 10^{-10}\,\text{m} \qquad 1\,\text{J} = 1\,\frac{\text{kg m}^2}{\text{s}^2} \qquad 1\,\text{W} = 1\,\frac{\text{J}}{\text{s}}$$

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?
- (a) All stars appear the same color.
- (b) All stars have the same flux measured at Earth.
- (c) All stars have the same luminosity.
- (d) All stars are the same distance from Earth.
- (e) We can only see any stars from the surface of the Earth during night time.
- (f) No statement in (a) through(e) is true.

2. An artist who likes working with sources of light decides to make a modern sculpture out of electrified glass tubes that contain a very thin (rarefied) gas. When the sculpture is finished, and the electricity is turned on, the tubes glow with a rich red color. What we are primarily seeing is:
- (a) A cool spectrum
- (b) A continuous spectrum
- (c) An absorption spectrum
- (d) A thermal spectrum
- (e) An emission spectrum

3. Using a pair of binoculars, you observe a section of the sky where there are stars of many different apparent brightnesses. You find one star that appears especially dim. This star looks dim because it is:
- (a) Radiating most of its energy in the infrared region of the spectrum.
- (b) Very far away
- (c) Very low in luminosity
- (d) Partly obscured by an interstellar cloud
- (e) It could be more than one of the above; there is no way to tell which answer is right by just looking at the star.

4. Photon A is observed to be at a higher frequency than Photon B. Which of the following statements are true? **More than one answer may be correct; circle all that apply.**
- (a) Photon A is moving faster than Photon B.
- (b) Photon A is moving slower than Photon B.
- (c) Photon A has a higher wavelength than Photon B.
- (d) Photon A has a lower wavelength than Photon B.
- (e) Photon A has more energy than Photon B.
- (f) Photon A has less energy than Photon B.
- (g) Photon A is redder in color than Photon B.
- (h) Photon A is bluer in color than Photon B.

5. If you know that the distance from the Earth to the Sun is 93 million miles (9.3×10^7 miles), which best expresses what you know about how long it takes the light from the Sun to reach the Earth?

(a) The Sun's light reaches the Earth instantaneously.

(b) It takes 0.3 seconds for the Sun's light to reach the Earth.

(c) It takes 0.31 seconds for the Sun's light to reach the Earth.

(d) It takes 8.3132 minutes for the Sun's light to reach the Earth.

(e) It takes 8.3 minutes for the Sun's light to reach the Earth.

(f) The Sun's light never reaches the Earth; any light you see is a reflection of the sheer brilliance of your professor.

6. Many of the first batch of planets found outside our solar system were in systems very different from ours, with gas giants the mass of Jupiter in orbits smaller than the Earth's orbit about the Sun. Why is this?

(a) Large planets close to their stars are easier to find both because the gravitational pull of a closer planet on the star is greater, and because the shorter period means you don't have to observe the star as long.

(b) Large planets close to their stars are easier to find because they block out more of the star's light when they pass in front of the star.

(c) Planets close to the star are easier to find because the planet is moving a lot faster than one father out would.

(d) Our Solar System, with gas giants far from the Sun and small rocky planets close to the Sun, is extremely unusual, and it's unlikely there are many others like it.

7. A rocketship in the vicinity of Earth (i.e. not on the Earth, but orbiting the Sun at a distance of 1 AU) wants to fly out to Mars. It does this by firing its engines and putting itself into an elliptical orbit which just touches Earth's orbit about the Sun (on the closest, or "perihelion" side of its orbit) and also just touches Mars' orbit (on the farthest, or "aphelion" side of its orbit). (Such an orbit is called the Hohmann Transfer Orbit.) Which of the following statements about the energy of the rocketship's orbit is correct? **More than one may be correct. Circle all that apply.**

(a) Because of Conservation of Energy, the rocketship has the same energy when it's in the Hohmann transfer orbit as when it's in a 1 AU orbit.

(b) The rocketship has less energy when it's in the Hohmann transfer orbit as compared to when it's in a 1 AU orbit.

(c) The rocketship has more energy when it's in the Hohmann transfer orbit as compared to when it's in a 1 AU orbit.

(d) The rocketship could have saved itself energy (fuel) by blasting straight away from the Sun towards Mars' orbit instead of putting itself in this elliptical transfer orbit.

8. You a a source which is approaching you with velocity 3000.00 km/s. This source has atomic Hydrogen which is emitting light at 6562.85Å. At what wavelength do you observe the light from this emission line?

(a) 6497.22Å
(b) 6562.78Å
(c) 6562.85Å
(d) 6562.92Å
(e) 6628.48Å

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)** [2 points] The Virgo cluster approximately 30 giant galaxies (i.e. galaxies like the Milky Way, in contrast to dwarf galaxies) packed in a sphere of diameter 3 Mpc (where 1 Mpc=10^6 pc). If each giant galaxy masses $10^{12}\,M_\odot$, what is the mass density in the core of the Virgo cluster (in units of $M_\odot/pc^3$)?

(b) [2 points] There are 23 stars within 3.5 pc of the Sun, with an average mass of about 0.6 $M_\odot$. What is the mass density in the Solar neighborhood (in units of $M_\odot/pc^3$).

(c) [3 points] Does anything strike you as odd about the comparison of (a) and (b), given what we've discussed previously about the size:distance ratios for stars and galaxies? How can you reconcile this oddness, if it exists? (Hint: consider an analogy which uses the words "cottonball" and "bullet".)

10. [8 points] 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 fastball thrown by a baseball pitcher has about 120 Joules of kinetic energy. How many Hα photons would you need to equal this much energy?
(d) If an object was emitting the number of Hα photons you found in part (c) every second, what would the luminosity of that object in Hα be compared to the total luminosity of the Sun? (In other words, what is the ratio of the hypothetical object's Hα luminosity to the Sun's total luminosity?)

11. [5 points] Star A has a measured parallax of 0.1″, and Star B has a measured parallax of 0.02″. Both stars appear equally bright in the sky. What is L_A/L_B, the ratio of the luminosity of Star A to the luminosity of Star B?

12. [6 points] Consider a star behind a cloud of dust that dims its brightness by a factor of 100. Suppose that you do not realize that the dust is there. If you determine its distance based on its apparent brightness (i.e. you know the stars true luminosity), will you get a value that is too large or too small compared to the actual distance? How much in error will your estimate of the distance of the star be (i.e. what is the ratio between your estimated distance and the true distance)?

13. [6 points] An astronomer observes a binary star system. He knows, somehow, that one star is more massive than the other. He also knows, somehow, that he's looking down on the plane of the orbit. (I.e., just as if you were looking down on the solar system "from above" so that you'd see the planets orbiting in circles.)

(a) The astronomer observes the stars orbit through one period. If the binary system is in a circular orbit, on the diagram below draw the two circles through which each star moves. (The larger circle indicates the more massive star.)

(b) Now that the astronomer has observed the period, there is one more physical quantity about the binary stars that he would need to know in order to estimate the masses of the stars. What would that be? (Also indicate the units in which the astronomer might want to measure this physical quantity.)

(c) What two quantities can be measured by the astronomer on Earth in order to allow the astronomer to calculate the physical quantity in part (b)?