AY1

EXAMPLE FINAL EXAM

May 3, 2005

The questions below are examples of the type of questions you might be asked on the final exam, which you might treat as a "practice mid-term" (the questions cover only the part of the course that has been covered so far).

SECTION A: Multiple Choice

You may find the following helpful: $M_\odot = 2 \times 10^{33}$ g, $R_\odot = 7 \times 10^10$ cm, $L_\odot = 4 \times 10^{33}$ ergs s^{-1}, $T_\odot = 6000$ K, $M_\oplus = 6 \times 10^{27}$ g, $R_\oplus = 6400$ km, 1 AU$= 1.5 \times 10^{13}$ cm, $M_{\rm Jupiter} = 2 \times 10^{30}$ g, $c = 3 \times 10^{10}$ cm/s, 1 pc $= 3 \times 10^{18}$ cm. $G = 6.67 \times 10^{-8}$ (cgs units), $H_0 = 70$ km/s/Mpc. The rotational velocity of our Sun around the Galactic center is 220 km/s. The distance of our Sun from the Galactic center is 8.5 kpc.

1. Olbers' Paradox wonders why the night sky is dark instead of bright. The resolution to this conundrum is:

   (A) the finite time that stars have been around (B) the finite size of the Universe
   (C) both (A) and (B) (D) Nearby stars block the more distant ones

2. Arrange the following length scales in the proper order, from smallest to largest.

   (A) 1 AU; 1 light-minute; 1 parsec; 1 gigameter
   (B) 1 gigameter; 1 light-minute; 1 AU; 1 parsec
   (C) 1 light-minute; 1 AU; 1 gigameter; 1 parsec
   (D) 1 AU; 1 light-minute; 1 parsec; 1 gigameter

3. For nearby stars, stellar distances are measured by examining the apparent motion of stars as the Earth revolves around the Sun. Given that a star appearing to move $1''$ on the sky is defined to be at a distance of 1 parsec (pc) from the Sun, at what distance would you expect an object to be which moved $0.08''$?

   (A) 80 pc (B) 12.5 pc (C) 8 pc (D) .08 pc (E) 1000 pc

4. The star Vega has a surface temperature of about 10000 K (compared to 6000 K for the Sun), and a radius of about 3 $R_\odot$. How much more luminous is it than the Sun?

   (A) 5 times (B) 9 times (C) 70 times (D) 225 times

5. The assumption of isotropy states that the universe looks the same

   (A) at all times (B) in all locations (C) in all directions (D) all of the above

6. In the Luminosity-Temperature, or Hertzsprung-Russell diagram for stars, the stars of largest radius are where?

   (A) at the top (B) upper right (C) lower right (D) on the main sequence

7. What is the primary factor which determines whether a star ends up as a planetary nebula, a neutron star, or a black hole?

   (A) its composition (B) its mass (C) its rotation rate (D) the surrounding environment

8. Elliptical galaxies are predominantly red, compared to the very blue disks of spiral galaxies. Why is this?

   (A) Reddening due to intergalactic dust makes all the stars appear red, just like a Sunset. (B) All the large, hot, blue stars have evolved into dimmer stars. (C) Large, hot, blue stars don't form in elliptical galaxies because of the different gravitational potential. (D) Cosmological redshift makes the whole galaxy appear redder.

9. Astronomers calculate the age of the universe to be about 13,7 billion years. This calculation is based on

   (A) calculations of the density of matter in the universe (B) the Hubble law
   (C) the age of rocks on the Earth and Moon (D) all of the above

10. What causes a star to turn into a red giant? (choose most complete answer)

    (A) Over time, the star slowly cools off and gets bigger (B) The helium flash
    (C) Hydrogen is exhausted in the core of the star, it collapses, heats up and the greater luminosity causes the star to expand (D) Dust forming in the atmosphere feels radiation pressure

11. Which of the following relations describes the recession of galaxies due to the expansion of the Universe (V is the velocity of the receding galaxies, H_0 is the Hubble Constant, and R is the distance to the receding galaxies)?

    (A) $V = 1/(H_0 R)$ (B) $V = H_0 R^2$ (C) $V = H_0 log(R)$ (D) $V = H_0 R$

12. If you wanted to measure the angular diameter of a star (not the Sun), which of the following Palomar instruments might you want to use?

    (A) Hale 200-inch telescope (5-m aperture) (B) Oscar Mayer 60-inch telescope (2-m aperture) (C) Palomar Testbed Interferometer (100-m baseline) (D) None of the above

13. When we measure redshifts (z = fractional change in wavelength for the spectra) of distant galaxies, we find that:

    (A) $z < 1$, because nothing can travel faster than the speed of light. (B) the average z is zero, because the universe is homogenous,isotropic and expanding in all directions. (C) z increases to arbitrarily high values. (D) z is correlated with distance.

14. When observing the center of the Milky Way, why are infrared observations preferred over optical?

    (A) Diffraction-limited telescopes have better resolution in the infrared than in the optical. (B) Because of the expansion of the universe, most of the important parts of the spectra of stars at the center of the galaxy are located in the infrared. (C) Infrared emission is blocked out less than optical emissions by the vast amounts of dust in between us and the center of the galaxy. (D) Most of the massive young stars in the center of the galaxy emit primarily in the infrared.

15. **Most** extra-solar planets have been discovered by:

    (A) observing them in the infrared close to stars near the Sun (B) detecting their gravitational pull on their parent stars by their tidal effects (C) detecting their gravitational pull on their parent stars through motions of the stars (via doppler and position measurements) (D) their eclipsing of their parent stars

16. Which of the following statements about galaxy classifications are true?

    I. Elliptical galaxies have more young stars than spiral galaxies. II. Spiral galaxies contain more dust and gas than elliptical galaxies. III. The largest elliptical galaxies are larger than the largest spiral galaxies. IV. The Large and Small Magellanic Clouds are Spiral Galaxies. V. The components of a typical spiral galaxy are the disk, the bulge, and the halo (and possibly a nucleus or bar).

    (A) I and IV (B) II and III (C) I and IV (D) II, III, and V

17. Cepheid Variables can be used to calculate distances to nearby galaxies because:

    (A) All Cepheid Stars have the same intrinsic luminosity. (B) The number of Cepheid stars in a galaxy is directly related to the luminosity of the galaxy. (C) Cepheids have very narrow emission lines so that a redshift can be very easily calculated. (D) There is a direct relationship between the intrinsic luminosity of a Cepheid and its period of pulsation.

18. You are outside at midnight and observe the planet Venus directly overhead. Which of the following is most likely? (Hint : draw a sketch with Sun, Earth and Venus.)

    (A) you are at the Earth's equator (B) you are at the Earth's North Pole (C) it is the Vernal Equinox (D) you are hallucinating

19. Which of the following types of telescopes typically has its angular resolution limited by turbulence in the Earth's atmosphere?

    (A) Large optical telescopes, such as the 5-meter (200") Hale telescope at Palomar (B) Radio telescopes, such as Arecibo, as seen in *Contact* and *Golden Eye* (C) X-ray telescopes, such as Chandra and ROSAT (D) Gravitational wave observatories, such as LIGO and LISA

20. The Very Large Array (VLA) is a radio interferometer composed of 27 radio telescopes, each 25 m in diameter, spread over an area about 36 km across. Which of the following are true about the VLA?

    I. It has the angular resolution of a single radio telescope with a diameter of about 36 km. II. In a given amount of time, it can see objects as faint as a single radio telescope with a diameter of 36 km. III. The VLA has better angular resolution at shorter radio wavelengths than at longer wavelengths.

    (A) I only (B) II only (C) I and III (D) II and III

21. What kind of galaxy is the Milky Way?

    (A) Elliptical (B) Dwarf Spheroidal (C) Spiral (D) Starburst

22. What is the best argument for the energy source of quasars being less than 1 parsec in size?

    (A) The enormous luminosity of quasars (B) High velocity gas from Doppler shifts (C) Very rapid variations of the luminosity in time (D) Quasars look like stars

23. The Oort Cloud, the presumed site of origin of long-period comets, is located

    (A) between the orbits of Mars and Jupiter (B) just beyond Pluto's orbit (C) far beyond Pluto's orbit (D at about the distance of the nearest star

24. To measure the masses of stars, which would be the best to observe?

    (A) Field stars (i.e., single stars) (B) Globular Clusters (i.e., lots of stars close together) (C) Multiple systems (e.g., binaries, trinaries) (D) All of the above

25. The central temperature of the Sun is ?

    (A) 10^5 K, since it must be hotter than the surface to maintain pressure gradients which support the Sun against gravity (B) 10^7 K, since lower temperature would be inadequate for H fusion (C) 10^8 K, to enable He fusion (D) varying between 10^6 and 10^7 K, driving the solar oscillations

26. By analyzing a very detailed spectrum of a star which of the following properties of the star can be deduced?

    I. chemical composition II. radial velocity III. temperature

    (A) I only (B) II only (C) II and III (D) I,II, and III

27. Which is least likely to be a true planet?

    (A) Venus – its rotation is retrograde (B) Jupiter – way too massive and mostly hydrogen (C) Pluto – its orbital plane is highly inclined to ecliptic (D) Uranus – rotates with axis in the ecliptic

28. How long will it take for the major fuel in the Sun's center to be exhausted, ending the main sequence phase?

    (A) 5 million yr (B) 50 million yr (C) 1 billion yr (D) 5 billion yr

29. The "microwave background" radiation is believed to be a remnant of

    (A) The Big Bang (B) The formation of the Sun (C) a recent nearby supernova (D) bat droppings on the radio telescope dishes

30. The stellar evolution of a star of 20 $M_\odot$ will end as :

    (A) a white dwarf of radius about 6000 km (B) a black hole of radius about 3 km (C) a neutron star of radius 1 km (D) a brown dwarf ('failed star') of radius about 6000 km

31. What evidence leads us to believe that the universe is expanding?

    (A) The Big Bang theory (B) The expansion of the solar system (C) The redshift of most galaxies (D) All of the above

32. What is the Main Sequence?

(A) A strip on the H-R diagram that contains most 'normal' hydrogen burning stars (B) It describes how the Sun will evolve from its current state, into a red giant, through a planetary nebula phase, and ending up as a white dwarf (C) the evolutionary sequence for colling white dwarf stars (D) Describes the phases of a supernova explosion

33. You can calculate the event horizon or Schwarzschild radius of a black hole approximately by finding what radius requires an escape velocity equaling the speed of light. For the 3 million solar mass black in our galactic center, what is the radius of the event horizon ? ($V^2_{esc} = 2GM/R$)

(A) 3 km (B) 3 pc (C) 9×10^9km (D) 1 AU

34. The largest optical telescopes are reflectors (rather than refractors) because :

(I) only the front surface of the glass needs to be ground to proper (parabolic) shape (II) the large piece of glass can have support across its' entire back (III) since the light does not pass through the glass their are no chromatic aberations (IV) they can be made out of metal rather than glass and metal is stronger

(A) all of the above, (B) I, II, III (C) I & II (D) IV

35. Gravitational lensing, first predicted by Einstein, involves:

(A) the effect of one gravitating mass on another (B) light whose path is altered by gravitating mass (C) a means of manufacturing large optics for telescopes (D) a process that occurred during the early universe, but is no longer relevant today

36. The "habitable zone" for planets around solar-type stars is determined by:

(A) where life is observed to exist in our solar system (B) where liquid water is possible (C) where life is unlikely to be wiped out by rogue asteroids or other debris (D) where enough heavy elements exist to support carbon-based life forms

37. The dominant mechanism that explains the huge energy output of quasars is:

(A) conversion of graviational potential energy into radiation (B) He fusion ignited by very high temperatures and densities (C) matter being ripped apart by graviational forces (D) multiple supernova explosions in a small volume

SECTION B: Short Answers

Answer 5 of 7 of following questions in 2-3 sentences each, demonstrating your understanding. Feel free to use diagrams and/or numbers.

1. How can you estimate the mass of a gravitating system by measuring the radial velocities of sub-components?

2. How would you use objects of known physical size to measure distances?

3. What is the main reason for putting telescopes in space, rather than on the ground, for use at particular wavelengths?

4. How would the inferred age of the universe be affected if we were to discover that the Hubble constant is a factor of 2 smaller than what previously believed?

5. What are the primary difficulties in detecting planets around stars outside of our solar system? Use numbers to demonstrate you points.

6. Why was the nature of gamma ray bursts so difficult to determine until very recently?

7. Explain the difference between the end state of a 20 solar mass star and one of 2 solar masses. Which stars have been more important to the chemical enrichment of the interstellar medium?

SECTION C: Essay Questions

Write a paragraph or two (each) in answer to any four of these six questions.

1. If nothing, not even light, can escape from black holes, how can we detect them? Discuss several possible means of studying them.

2. Briefly describe the major stages of stellar evolution of a 1 $M_\odot$ star. Explain how a star is formed in the first place, how it spends most of its lifespan, and why it eventually must evolve. How does the rate of evolution of more massive stars compare with a 1 $M_\odot$ star, and why?

3. Compare the Hubble Space Telescope to the Keck Telescope, citing the advantages and disadvantages of each. Things you may want to discuss include basic design and engineering, cost, science objectives, surrounding environment, and resolution and sensitivity.

4. How do theories of how planetary systems form account for the following observable characteristics of our own solar system: a) the orbits of the planets lie in very nearly the same plane, b) all planetary orbits are almost circular, and c) planets orbit the Sun in the same direction the Sun rotates? If this theory is correct, does it suggest that other solar systems are common? Why?

5. Describe the Hubble classification scheme for galaxies. Which type of galaxies are most common? Which are most massive? Can the Hubble Sequence be thought of as an evolutionary sequence? Justify your answer.

6. Provide several arguments (and explain) why we believe that dark matter must be present and that it contributes more matter than ordinary "baryonic" matter.