PHYSICS 113
Practice Test #3
SOLUTIONS

MULTIPLE CHOICE

1. a
2. d
3. b (not on the test)
4. a
5. c
6. b
7. e
8. d
9. d
10. c
11. e
12. c
13. e
14. d
15. e
16. c
17. b
18. c
19. c
20. d
21. c
22. b
23. b
24. c
25. e
26. c
27. a
28. a
29. b
30. c

SHORT ANSWERS

1. (i) As we look at distant objects in the universe (such as active/young galaxies and quasars), we are looking back in time since it has taken light millions/billions of years to reach us. Thus we see objects in the universe when they were young. We can see that the early universe was much different than the present-day universe. For example, we only see quasars at great

distances (i.e., the light from these quasars was emitted when they were young [i.e., early universe] and is now only reaching us). There are no quasars in the present-day universe. Thus the universe has evolved.
(ii) The big bang model predicts that the universe should be expanding. In fact, we observe all distant objects to be moving away from us (they are all redshifted) and that the farther the distance, the greater the rate at which these objects are moving away from us. This is in complete agreement with the big bang model of an evolving (i.e., expanding) universe.
(iii) The big bang model predicts that the universe started out as incredibly hot and infinitely dense. The radiation that was leftover from the primeval (big bang) fireball would have cooled as the universe expanded. We now can observe this radiation (cosmic background radiation [CBR]) and we see that it has a temperature of approximately 3 degrees Kelvin. This is further observational evidence for the evolution of the universe (the expanding universe has caused the CBR to cool).

2. The three possible fates of the universe depend on the mass density of the universe. If the mass density is high enough, then there will be enough gravity to cause the universe to collapse back to a "single point" (i.e., the big crunch).
(i) Closed Universe (the universe collapses back onto itself)
(ii) Open Universe (the universe expands forever)
(iii) Flat Universe (the universe expands but the rate of expansion eventually slows to zero)

3. An intermediate mass star is 5 to 10 times more massive than the sun. Once the protostar collapses and reaches the (zero-age) main sequence, it spends most of its lifetime burning hydrogen and maintains a similar luminosity and surface temperature. Once all of the hydrogen has been fused in the center of the star and a helium core starts to form, the subgiant phase begins and the star moves to the right in the HR diagram. Once the helium core becomes large enough, the outer layers expand and the star climbs the red giant branch. During this time its temperature remains approximately constant but its luminosity (and radius) increases significantly. Eventually helium burning is ignited in the core and carbon is formed. The star moves slightly to the left in the HR diagram and occupies a region called the horizontal branch. After all of the helium has been burned up (fused) in the center, a carbon core forms and the star undergoes a second red giant phase (AGB; asymptotic giant branch). During this time its luminosity increases enormously. At some point, carbon in the core is fused into heavier elements such as neon and sodium. Subsequently, violent pulsations and the superwind leads to the production of a planetary nebula and a hot white dwarf (core of the star). The white dwarf is nothing more than a hot ember that can only cool. Thus its luminosity decreases and so does its surface temperature. In the final stage of its existence, the star is referred to as a black dwarf.

3. Dark matter is sometimes referred to as the "missing mass" or to as "invisible matter". Using various methods, such as the determination of the rotation curves of galaxies and by measuring the speeds of galaxies and clusters, astrophysicists can determine the amount of gravity that exists and then deduce the amount of mass that must be producing this gravity. After this is done, they measure the brightness and infer how much mass would actually have to be there in the form of luminous matter (i.e., main sequence stars) in order to account for this brightness. The difference between the mass that we believe should be present in the form of luminous mass

(i.e., stars) and the actual mass that is needed to produce the observed gravity is known as the dark matter. The "dark matter problem" is the single most important problem in astronomy. The following explanations have been devised:
(i)
(ii) The dark matter could also exist in the form of massive neutrinos (i.e., neutrinos that have mass), or some other exotic particles in physics that have not yet been discovered.
(iii) It is also possible that our physical theories about gravity breakdown and thus are no longer valid on large distance scales!

4. The bottom-line answer to this question is that you can hide much more mass in the form of old (low luminosity) white dwarfs than you can in the form of main sequence stars (such as our Sun) for each solar luminosity of brightness that you actually observe. For example, if a typical old white dwarf has a luminosity of the 0.001 solar luminosities, then it would take 1000 of them (1000 x 0.001 = 1 solar luminosity) to produce the same amount of light as a one solar mass star. But, in fact, these 1000 white dwarfs would have a mass nearly equal to 1000 solar masses. Thus a lot of mass can be hidden in the form of low luminosity objects (e.g., white dwarfs, brown dwarfs, planets, neutron stars).

5. (i) The distances to the nearest planets (and the Sun and the Moon) can be measured using radar ranging. This allows us to measure distances up to several A.U.'s.
(ii) The distances to the nearest stars in the Milky Way Galaxy (up to 100 parsecs) can be measured using stellar parallax (obviously this first requires an accurate measurement of the astronomical unit). To determine distances to stars farther away, we measure the spectrum of a star and determine its spectral type. By using the HR diagram we can deduce its luminosity (assuming that the star is on the main sequence). By next measuring the star's apparent brightness, we can then deduce its distance. We can measure distances in excess of 10,000 parsecs using this method. This method is known as spectroscopic parallax (also known as main sequence fitting). Distances to globular clusters (in the halo of our galaxy) can also be determined by measuring the apparent brightnesses of RR Lyrae stars (we know their absolute brightnesses).
(iii) The distances to nearby galaxies (up to 10 Mpc=10,000,000 parsecs) can be determined by measuring the light curves of Cepheid Variables. By establishing the period (in days) of their brightness changes, we can deduce their luminosity. By measuring their apparent brightness, we can thus determine their distance. Note that Cepheids can also be used to measure distances within our own galaxy as well. In fact, the absolute luminosity of Cepheids in our Galaxy was only established after their distances were determined by some other method.
(iv) The distances to more remote galaxies can be determined by observing the apparent brightnesses of Type I supernovae, or by measuring the apparent brightnesses of the brightest supergiants and/or globular clusters in the galaxy (we assume that the brightest ones are similar from galaxy to galaxy). These methods work for distances up to and including 100 Mpc.
(v) The distances to the most remote objects in the universe (e.g. quasars) are found by measuring the redshift of those objects and then by converting the redshift to a velocity of recession using Doppler's formula. Once this is calculated, Hubble's law can be used to calculate the distance.
All of these steps make up the cosmic distance ladder.

6. A standard candle is any astronomical object for which you know its intrinsic brightness (i.e., its luminosity). By measuring the apparent brightness of a standard candle, you automatically know how far away it is (since you know how intrinsically bright it is). The best standard candles will be the brightest standard candles because you can see them from the farthest distances. Thus they can be used to estimate distances to the farthest objects that can actually be seen in the universe. Five standard candles that can be used (in order of increasing distance and therefore importance) are: 1) RR Lyrae stars, 2) Cepheid Variables, 3) supergiants, 4) globular clusters, 5) Type I supernovae. For the supergiants and globular clusters, we assume that the intrinsic brightness of the brightest of these they will be the same from galaxy to galaxy. Also look at the solution for question #5 above for more information about the usage of these standard candles.

7. EXTRA QUESTION: Draw the Hubble Sequence (i.e., tuning fork diagram) for galaxies and describe the properties of spiral and elliptical galaxies.
See the class notes or the text for the diagram and the description of the various classifications (e.g., Sc, SBa, E5, etc). One important thing to note is that spiral galaxies appear much bluer than elliptical galaxies. The reason for this is that star formation is taking place in the disks spiral galaxies (where the gas and dust is) and thus massive stars are constantly being formed. These massive stars are extremely hot and luminous (e.g., O and B stars) and are emitting lots of blue and ultraviolet light. Elliptical galaxies do not have the gas or dust that will permit the formation of stars and thus all of their massive stars have already burned themselves out. Consequently elliptical galaxies appear much redder than spiral galaxies.