Astronomy 102, Spring 2003
Solutions to Final Review Probjems

1. (c)

2. (d)

3. (c) If we see Planet A moving more than Planet B, then Planet A must be closer. (Two reasons: first, the parallax from Earth is greater. Second, its orbital velocity is greater, so it gets further along in its orbit. Note that over the course of a few weeks, you wouldn't be able to conclude this, as it will depend on exactly where all the planets are in their orbits. Over the course of a year, though, you have enough information to decide which planet is closer.) If Planet A is closer, but the two planets have the same *angular* diameter, then Planet B must be bigger.

4. (a) and (d) (Typo alert: Star *A* is less massive than star B). We can't necessarily say which star might supernova first; the less massive star could be a white dwarf which will go in a Type Ia supernova; at the same time, the more massive star might be massive enough that it will go in a Type II supernova.

5. (b) (only)

6. (d). In a binary system, both stars are at very close to the same distance from us. If they're at the same distance, the brighter one is more luminous. The only way for the redder one (which has the lower temperature) to be more more luminous is for it to be bigger.

7. (a). That's what the brightest stars in the cluster are, and what dominate its light. (See the homework problem about the light and mass ratios of various stars, I believe from homework set #4.)

8. (a)

9. (c)

10. (a)

11. (b)

12. (b)

13. (a)

14. (c)

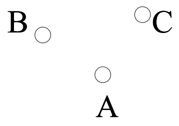
15. (f). (In fact, any answer but (d) may apply. Wouldn't it be nice if all multiple choice questions included an (f) like this one?)

16. (a) In this case, if Orion is much higher in the sky, you must be at a *lower latitude* (closer to the equator of the Earth) than where you usually live. You know from Lab that Orion is near the celestial equator; it will be at its highest (crossing the zenith) when you are very close to the Earth's equator. (Note that despite my three sentences here, all you would have needed to write on the final is "closer to the equator" or "at lower latitude".)

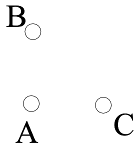
(b) You're in the southern hemisphere, at about the same *negative* latitude as the *northern* latitude where you usually live. (Note that as you look at the equator, the stars would look like they are going *backwards.* They're still rising in the east and setting in the west, but when you're in the southern hemisphere and facing the direction of the sky where you can see the celestial equator, you're facing *north*, so west is to the left and east is to the right. This is the opposite of what you see in the northern hemisphere.)

17. (Note that in all cases below the horizon is a horizontal line somewhere below the three stars.)

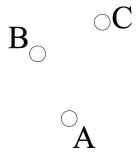
(a)



(b)



(c)



18. NOTE!! As originally written, this problem had an error. It said that the two stars were of the same physical size, but that should not have been there. The problem should just read "Consider two stars of the same luminosity. Star A has a surface temperature which is twice that of Star B."

(a)

$$\begin{aligned} L_A &= L_B \\ (4\pi\, {R_A}^2)(\sigma\, {T_A}^4) &= (4\pi\, {R_B}^2)(\sigma\, {T_B}^4) \\ {R_A}^2\, {T_A}^4 &= {R_B}^2 {T_B}^4 \end{aligned}$$

$$\begin{aligned}\left(\frac{T_A}{T_B}\right)^4 &= \left(\frac{R_B}{R_A}\right)^2\\ \frac{R_B}{R_A} &= \left(\frac{T_A}{T_B}\right)^2\end{aligned}$$

$$\boxed{\frac{R_B}{R_A} = 4}$$

Sanity check: if they have the same luminosity, the *hotter* one must be *smaller*. Sure enough, Star B, which is cooler, came out bigger than Star A.

(b) The small angle formula is $da = D$, where D is the object's physical diameter, a is the object's angular diameter, and d is the distance to the object. $D = 2R$, if R is the object's physical radius. We know from (a) that $D_B = 4D_A$. Since the two have the same angular diameter, we'll just use a without a subscript.

$$d_A\, a = D_A$$

$$d_B\, a = D_B$$

Divide these puppies:

$$\frac{d_A}{d_B} = \frac{D_A}{D_B}$$

$$\boxed{\frac{d_A}{d_B} = \frac{1}{4}}$$

Sanity check: if they have the same angular diameter, the one that is physically bigger must be farther away. Sure enough, Star A, which is smaller, is at a smaller distance.

(c)

$$\begin{aligned}F_A &= \frac{L_A}{4\pi\, {d_A}^2}\\ F_B &= \frac{L_B}{r\pi\, {d_B}^2}\\ \frac{F_A}{F_B} &= \frac{\frac{L_A}{4\pi\, {d_A}^2}}{\frac{L_B}{4\pi\, {d_B}^2}}\end{aligned}$$

Since $L_A = L_B$,

$$\frac{F_A}{F_B} = \frac{{d_B}^2}{{d_A}^2}$$

$$\frac{F_A}{F_B} = 4^2$$

$$\boxed{\frac{F_A}{F_B} = 16}$$

Sanity check: if they have the same luminosity, the star which is closer should have the higher flux. From (b), the distance to A is smaller than the distance to B, so A is closer, and indeed we have it here with the larger flux.

19. Type Ia supernovae. Those are explosions of relatively low-mass stars; low-mass stars leave behind white dwarfs, and white dwarfs with companions host Type Ia supernovae. Those pump a huge amount of energy into the interstellar medium of a galaxy, and if there are enough, they might keep the gas hot and ionized.

(Supernovae also keep a lot of the gas in our galaxy hot and ionized— that's where the hot ionized ISM comes from, by and large! Obviously, though, in our galaxy, they don't keep it all hot and ionized, since there are cool clouds from which stars form.)

20. Lower. If galaxies are merging, over time you would expect smaller galaxies to come together and make larger galaxies. The universe's expansion means that objects which have a higher redshift are farther away; therefore, light took longer to reach us, so when we see them, we're seeing them at an earlier epoch of the Universe's age than we are seeing galaxies at low redshift.

21. Two reasons. First, most of the high mass stars that have ever been made have already evolved all the way to a neutron star, since they do it so quickly. However, most of the low mass stars have a mass less than $0.8 M_\odot$, and those stars haven't yet had time to evolve all the way to a white dwarf.

A second possible reason is that very early generations of star formation made a greater fraction of high mass stars than the star formation today. Today, we only see the "high mass star fraction" from recent star formation, but the neutron stars and black holes left over should include some contribution from those earlier epochs when high mass stars were "overproduced".

(Either one of these answers by itself would have been enough for full credit on this question on the final.)

22. (a)

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

$$z = \frac{6694\text{Å} - 6563\text{Å}}{6563\text{Å}}$$

$$\boxed{z = 0.02}$$

(The significant figures on this problem are a little tricky. It looks like you have four, but after the subtraction you've only got two or three (really two). Since it is tricky, I would have had sympathy in this case if you had written the answer to too many significant figures.)

(b)

$$z = \frac{v}{c}$$

$$v = c\,z$$

$$v = (3.00 \times 10^8 \, \frac{\rm m}{\rm s})(0.02)$$

$$v = 6.0 \times 10^6 \, \frac{\rm m}{\rm s} = 6{,}000 \, \frac{\rm km}{\rm s}$$

(c)

$$\begin{aligned} v &= H_0\, d \\ d &= \frac{v}{H_0} \\ d &= \frac{6,000\,\mathrm{km/s}}{72\,(\mathrm{km/s})/\mathrm{Mpc}} \\ d &= 83\,\mathrm{Mpc} \end{aligned}$$

23. (a) You look for a periodic shift if the wavelengths of the lines; they should shift slightly to the blue, then slightly to the red, and so on and so forth.

(b) *Larger* planets which are *closer* to their star will be easier to detect. The first reason is the force of gravity: if a planet is closer, it exerts a stronger pull on its star, and similarly if a planet is larger (more massive), it exerts a stronger pull on its star. Thus, for large planets close to their star, the effect you're looking for should be larger. The second reason is that planets in closer orbits around their star orbit in less time, so you won't have to observe as long in order to detect the motion of the star first towards you, then away from you as a result of the planet pulling in different directions.