**1.** Answer: (f). No statement is correct. Hopefully most are obvious; the only "trick" is (e), because, yeah, you can only see *most* stars at night, but the Sun is a star and you sure see that thing in the day.

**2.** Answer: (e).

**3.** Answer: (b). That's how you can get a color. Some of the other answers can give her a *partial* answer, but she'd still need something else. (Except for f, which just requires a lot of budget.)

**4.** Answer: (c).

**5.** Answer: (c).

**6.** Ansewr: (e). All of the above could potentially explain why the star is dim.

**7.** Answer: (a) is the only one which must be true. (b), (c), and (d) are all definitely false. (e) *might* be true, but that "must" in there rules it out. (We know nothing about how far away the two stars are just from the fact that we're observing red and blue photons.)

**8.** Answer: (b).

**9.** (a)

$$\lambda f = c$$

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m}/s}{0.21 \text{ m}}$$

$$f = 1.4 \times 10^9 \text{ Hz}$$

The only tricky thing about htis is making sure your units are right, i.e. divide by the wavelenght in meters (to be consistent with your speed in meters per second), *not* in centimeters.

(b)

$$E = hf = (6.626 \times 10^{-34}\ \frac{\text{J}}{\text{Hz}})(1.4 \times 10^9 \text{Hz})$$

$$E = 9.5 \times 10^{-25} \text{ J}$$

(c) Repeat (a) and (b) for a $\lambda = 4500$ Å photon. Or, just remember

$$E = \frac{hc}{\lambda}$$

$$\frac{E_{21\text{cm}}}{E_{\text{blue}}} = \frac{\frac{hc}{21 \text{ cm}}}{\frac{hc}{4500 \text{ Å}}}$$

$$\frac{E_{21\text{cm}}}{E_{\text{blue}}} = \frac{4500 \text{ Å}}{21 \text{ cm}} = \frac{4500 \times 10^{-9} \text{ m}}{0.21 \text{ m}}$$

$$\frac{E_{21\text{cm}}}{E_{\text{blue}}} = 2.1 \times 10^{-5}$$

**9.** (the other one)

$$d = \frac{1}{p}$$

Where $d$ is in pc and $p$ is in arcseconds. This is easy to solve for $p$:

$$p = \frac{1}{d}$$

$$p = \frac{1}{0.8 \times 10^{6} \text{ pc}}$$

$$p = 1.3 \times 10^{-6} \text{ arcseconds}$$

That's not very much.

**10.** (a) You can start by resorting to equations. Or, you can remember that for two stars of the same temperature, it's their surface area that determines the ratio of the luminosities. If one has twice the radius of the other, then it has four times the luminosity... and you're done. If you'd rather resort to equations, the one that tells you the luminosity of a star given its temperature and size is:

$$L_A = (\sigma {T_A}^4)(4\pi {R_A}^2)$$
$$L_B = (\sigma {T_B}^4)(4\pi {R_B}^2)$$

We also have $T_A = T_B$ and $R_A = 2R_B$. Divide the two equations above:

$$\frac{L_A}{L_B} = \frac{(\sigma {T_A}^4)(4\pi {R_A}^2)}{(\sigma {T_B}^4)(4\pi {R_B}^2)}$$

Cancel out the stuff that's the same on the top and the bottom... including the temperature, since $T_A = T_B$.

$$\frac{L_A}{L_B} = \frac{{R_A}^2}{{R_B}^2}$$

$$\frac{L_A}{L_B} = \frac{2{R_B}^2}{{R_B}^2}$$

$$\frac{L_A}{L_B} = 4$$

(b) Here, we don't need to remember anything about temperature or radius. How bright somethign appears (i.e. its flux) depends on its luminosity (which we've already figured out) and distance:

$$F_A = \frac{L_A}{4\pi {d_A}^2}$$
$$F_B = \frac{L_B}{4\pi {d_B}^2}$$

Cross multiply each equation to get:

$$F_A(4\pi {d_A}^2) = L_A$$
$$F_B(4\pi {d_B}^2) = L_B$$

(Note that if you didn't think the trick of cross multiplying was obvious, the usual trick of dividing the two equations would have worked, it would just have taken one extra step.)

Now divide the two:

$$\frac{F_A}{F_B}\frac{4\pi {d_A}^2}{4\pi {d_B}^2} = \frac{L_A}{L_B}$$

We have $L_A/L_B$ from the previous part, and since $F_A = F_B$, that first fraction cancels out. Divide the $4\pi$'s away, and we're left with:

$$\frac{{d_A}^2}{{d_B}^2} = 4$$

$$\frac{d_A}{d_B} = 2$$

Does this make sense? Both appear equally bright, so the one which is more luminous must be further away. Yes, we got that star A is further away, so at least we're going in the right direction!

**11.** First of all, the two stars are similar in many ways. The stars the same distance apart. However, one has a longer period, which means that the stars are moving *slower*. It takes more force to hold an object moving *faster* into a circular orbit of a given size. The way you get more force between two objects of a given separation is to make those objects more massive. Therefore the system which is orbiting faster (has a shorter period) must have more mass, or $\boxed{\text{System B has more mass}}$.

**The Other Half of 11.** (Yeah, there was a number missing in there.)

We can't measure smaller angles. So, we have to figure out a way of measuring more distant objects by measuring the same angles we can measure now. Remember that, given the small angle formula, the parallax formula told us that the angle we measured was the ratio between the Earth-Sun distance (1 AU) and the distance to the star. Aha! For the same angle, to measure a more distant star, we just need to move the Earth further from the Sun!

Well, OK, without budgetary constraints, you might just do that. It's a lot cheaper (though still expensive) to build a spacecraft you send out into the outer solar system, far from earth, to orbit the Sun and measure parallaxes with that longer baseline. (You'd have to wait longer, though; while it takes the Earth but a year to go around the Sun, things further away take longer.)

**12.** (a) No! Remember, it's the directness of the Sunlight, primarily (with the length of the day as a secondary effect) that makes the difference between summer and winter… and what's more, when it's summer here, it's winter in the Southern Hemisphere and vice versa! Thus, there never is a time when it's "winter on Earth". What's the problem then? If we're always the same distance from the Sun, why don't we always have the same surface temperature? Well, remember that our thermal equilibrium considerations only gave us the *average* surface temperature.

(b) No! Same reason as above.

**13.** You might think that you need the Steffan-Boltzman constant in order to solve this problem… and indeed you could use it if you had it. However, it's also possible to solve it just by comparing the white dwarf to the Sun. You'll need the radius of the Earth and the Sun to do that as well as the temperature of the Sun, though, so no matter what I had darn well *better* have given you something on the front of the test

$$L_{WD} = (\sigma {T_{WD}}^4)(4\pi {R_E}^2)$$
$$L_\odot = (\sigma {T_\odot}^4)(4\pi {R_\odot}^2)$$

We want the ratio, so divide them:

$$\frac{L_{WD}}{L_\odot} = \frac{(\sigma {T_{WD}}^4)(4\pi {R_E}^2)}{(\sigma {T_\odot}^4)(4\pi {R_E}^2)}$$

$$\frac{L_{WD}}{L_\odot} = \left(\frac{T_{WD}}{T_\odot}\right)^4 \left(\frac{R_E}{R_\odot}\right)^2$$

Some numbers from the front of the test:

$$T_\odot = 5780 \text{ K}$$
$$R_E = 6.4 \times 10^6 \text{ m}$$
$$R_\odot = 7.0 \times 10^8 \text{ m}$$

Stick 'em in:

$$\frac{L_{WD}}{L_\odot} = \left(\frac{10,000}{5780}\right)^4 \left(\frac{6.4 \times 10^6}{7.0 \times 10^8}\right)^2$$

(All units have nicely cancelled)

$$\frac{L_{WD}}{L_\odot} = 7.5 \times 10^{-4}$$

Even though it's rather hot, it's an awful lot smaller than the Sun, making our white dwarf not very luminous.