Astronomy 102 Spring 2003: Exam 1 Solutions and Commentary

1. (e) Nothing. Because the red star is brighter than the blue star, it must either be closer *or* more luminous. But it could be smaller if it's much closer, or it could be futher away if it's much bigger.

2. (b) and (d).

3. (c). Remember $L = (4\pi R^2)(\sigma T^4)$ (from the front of the test). If L and T are the same, then there's no way for R to be different.

4. (c)

5. (c)

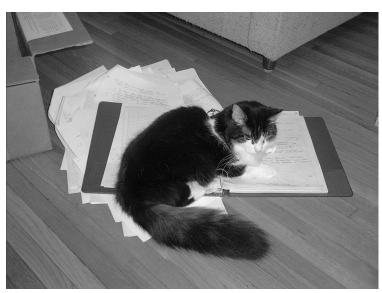
6. (d), (e), and (h). Note that both photons move at the same speed (the speed of light).

7. (a) and (f).

8. (a).

9. (a) Radiation
(b) Convection
(c) Radiation
(d) Conduction
(e) Radiation
(f) Conduction
(g) Convection
(h) Radiation (Convection further out)
(i) Radiation

10. Here is a picture of a related phenomenon from when I was grading homework:



11. (a)

$$\lambda f = c$$

$$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8 \text{ m/s}}{6563 \times 10^{-10} \text{ m}}$$

$$f = 4.57 \times 10^{14} \text{ Hz}$$

(b)

$$E = hf = (6.626 \times 10^{-34}\ \frac{\text{J}}{\text{Hz}})(4.56 \times 10^{14}\ \text{Hz}$$
$$= 3.03 \times 10^{-19}\ \text{J}$$

(c)

$$\frac{120\ \text{J}}{3.03 \times 10^{-19}\text{J/photon}}$$
$$= 4.0 \times 10^{20}\ \text{photons}$$

(d) (Using the right solar luminosity, rather than the slightly wrong one put on the board in class.)

$$\frac{120\ \text{J/s}}{3.85 \times 10^{26}\ \text{W}}$$

Remembering that 1 W = 1J/s, we can find the ration to be:

$$= 3.1 \times 10^{-25}$$

i.e. the Sun is 3.2×10^{24} times more luminous. Note that there are no units on this number! Many of you made this part much more complicated than it needed to be.

12. We have $d_A = 1/p_A = 10$ pc, and $d_B = 1/p_B = 50$ pc. If they are equally bright:

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

Multiply both sids by $4\pi\, {d_A}^2$ and divide both sides by L_B:

$$\frac{L_A}{L_B} = \frac{{d_A}^2}{{d_B}^2}$$

$$\boxed{\frac{L_A}{L_B} = \frac{1}{25}}$$

13. First of all, the star is *dimmer* as a result of the dust. If you don't know the dust is there, and it looks dimmer, you will conclude that it is further away than it really is, thus you get a value which is $\boxed{\textit{too large}}$ for the distance. Knowing that flux goes as one over distance squared, if your flux is wrong by a factor of 100, then your distance must be wrong by $\sqrt{100}$ or $\boxed{\text{you are of by a factor of 10 in distance}}$.

If you prefer to do this more mathematically, if we define F_{nodust} as the flux which would be observed had there been on dust, and F as the actual flux observed, we have $F = 0.01\, F_{\text{nodust}}$. Define d_{est} as the distance estimate you get from your measured flux, and d as the real distance to the star. Then:

$$F_{\text{nodust}} = \frac{L}{4\pi\, d^2} \qquad \text{thus :} \qquad d = \sqrt{\frac{L}{4\pi\, F_{\text{nodust}}}}$$

$$F = \frac{L}{4\pi\, {d_{\text{est}}}^2} \qquad \text{thus :} \qquad d_{\text{est}} = \sqrt{\frac{L}{4\pi\, F}}$$

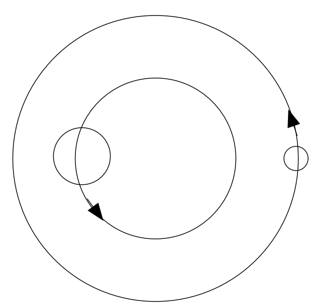
$$\frac{d_{\text{est}}}{d} = \sqrt{\frac{\frac{L}{4\pi\, F}}{\frac{L}{4\pi\, F_{\text{nodust}}}}}$$

$$\frac{d_{\text{est}}}{d} = \sqrt{\frac{F_{\text{nodust}}}{F}}$$

$$\frac{d_{\text{est}}}{d} = \sqrt{\frac{F_{\text{nodust}}}{0.01\, F_{\text{nodust}}}}$$

$$\frac{d_{\text{est}}}{d} = 10$$

14. (a)



(b) Physical separation of the star, in AU. (Note: a lot of you said "distance" without saying the distance *to* or *between* what. As such, that wasn't enough to fully answer the question.)

(c) Distance to the star (measured via parallax) and the angular separation. Put those to together to get the physical separation.

15. (a) Pluto's orbit is much larger than that of the Earth, so you'd get a much larger baseline for measuring parallax. For a star of a given distance, the parallactic angle you'd measure would be much larger, and therefore easier to measure.

Note: A number of you said "Pluto is much closer to the stars." This is *wrong* for two reasons. First, it would only be true in a "flat earth" cosmology, which by and large nobody believes any more. (Earth is down, everything else is up; the stars are more up than Pluto.) In fact, Pluto is closer to some stars, further from other stars; draw the three dimensional solar system (or even just in two dimensions, as viewed from above). Additionally, the distance between the Sun and Pluto is *much* less than the distance between stars. Even for those stars in the same direction from Earth as Pluto, Pluto is not enough closer to them for it to matter. It would be equivalent to taking two steps to the North and then saying it is now far easier to measure the distance to Canada because you're so much closer to it.

(b) Pluto's very long year would mean that you'd have to wait a lot longer to get the measurements at the full baseline.

That Pluto is not at 1 AU and as such the easy parallax formula would no longer work is not a real disadvantage. It would be very simple to work out the new formula because we know Pluto's orbit very well (even its elliptical orbit).

16. Start with the luminosity equations for the two stars:

$$L_B = (\sigma\,(5\,T_\odot)^4)(4\pi\,{R_B}^2) = 50,000\,L_\odot$$
$$(\sigma\,{T_\odot}^4)(4\pi,{R_\odot}^2) = L_\odot$$

Divide those two puppies (note that $5^4 = 625$):

$$\frac{625\,\sigma\,{T_\odot}^4\,4\pi\,{R_B}^2}{\sigma\,{T_\odot}^4\,4\pi\,{R_\odot}^2} = \frac{50,000\,L_\odot}{L_\odot}$$

Cancel out the stuff that appears in both the numerator and the denominator, and divide both sides by 625:

$$\frac{{R_B}^2}{{R_\odot}^2} = \frac{50,000}{625} = 80$$

To one sig fig:

$$\frac{R_B}{R_\odot} = 9$$