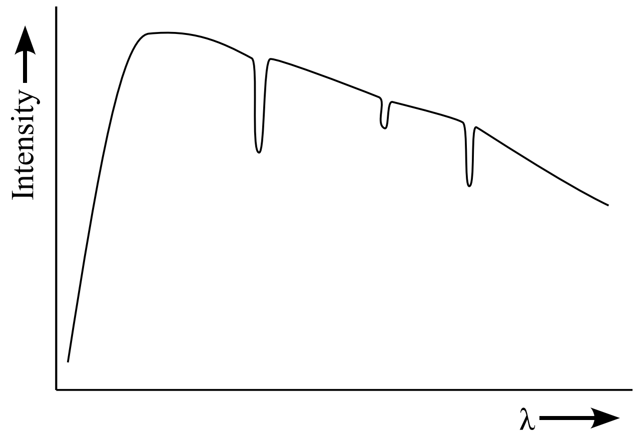
Astronomy 102, Fall 2004

Exam 2 Solutions

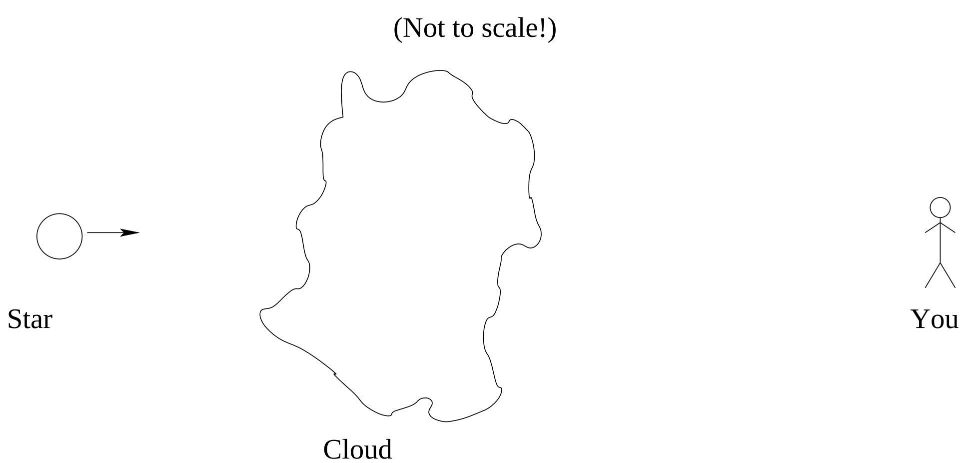
1. (a)



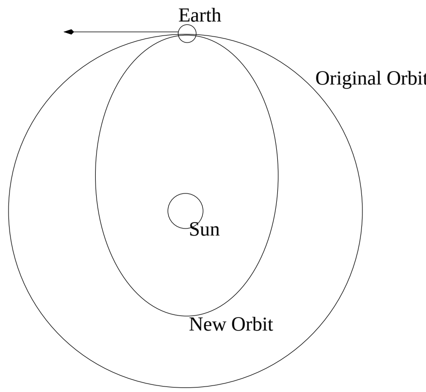
(b) The atmosphere of the star. This a very thin layer of low density gas right at the surface of the star.

2. If the intervening cloud is cold and dark, it can't be responsible for the emission lines. (Emission lines would make it not dark, and in any event you must excite a cloud somehow to make it emit emission lines, which would also make it unlikely to be cold— at least, if the emission lines we're talking about are optical emission lines.) Therefore, the star must be emitting the emission lines, which is unusal; most stars show absorption lines, not emission lines.

The intervening cloud is absorbing the light. To explain the difference in Doppler shift, the intervening cloud must be at rest, while the emission-line star is approaching you.



3. **(a)**



(b) Greater. Gravity is stronger, so you need more motion to counter it.

The speed of a planet in its orbit is $v = (2\pi A)/P$, where A is the radius of a circular orbit and P is the orbital period. We also know that:

$$P^2 = \left(\frac{4\pi^2}{GM}\right) A^3$$

Since A doesn't change, and $M_{\rm new} = 2M$, we know that

$$(P_{\rm new})^2 = 2\,(P_{\rm original})^2$$

Therefore, $P_{\rm new} = sqrt2\, P_{\rm original}$. This tells us that v must go up by a factor of $\sqrt{2}$; $\sqrt{2} \times 30$ is 42, so the final speed is $\boxed{42 \text{ km/s}}$.

4. **(a)** Sure! Green light is at a lower wavelength than red light, which means you need a blueshift to make red light look blue. To get a blueshift, you and the thing you're looking at much be approaching each other, which is the case with the physicist and his red light.

(b)

$$\frac{\lambda_{\rm obs} - \lambda_0}{\lambda_0} = \frac{v}{c}$$

$$v = c\left(\frac{\lambda_{\rm obs} - \lambda_0}{\lambda_0}\right)$$

$$v = (3 \times 10^8 \text{ m/s})\ \frac{5500\,\text{Å} - 6500\,\text{Å}}{6500\,\text{Å}}$$

$$v = (3 \times 10^8 \text{ m/s})\ (-0.154)$$

The negative velocity indicates approaching, as expected, so we'll just talk about speed (which is the magnitude of the velocity, without worrying about the direction):

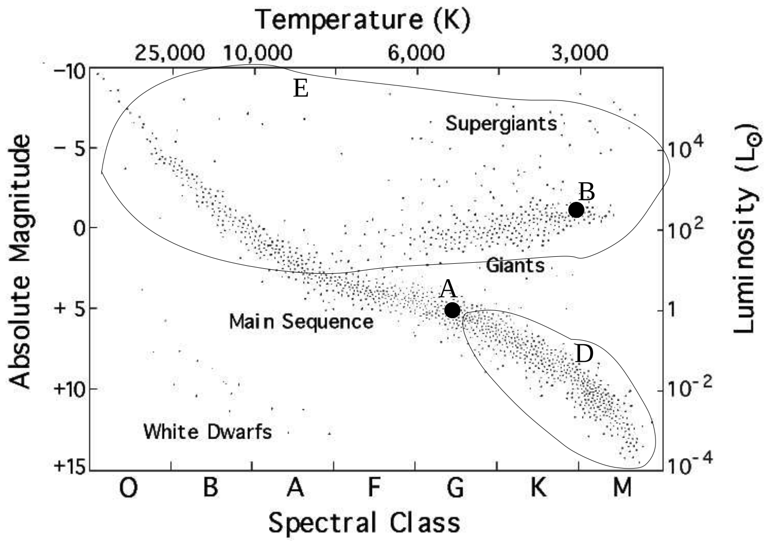
$$\text{speed} = \left(4.62 \times 10^7\,\frac{\text{m}}{\text{s}}\right)\left(\frac{0.62\,\text{mi}}{1{,}000\,\text{m}}\right)\left(\frac{3{,}600\,\text{s}}{1\,\text{h}}\right)$$

$$\boxed{\text{speed} = 1 \times 10^8\,\text{mph}}$$

A speeding ticket would probably be in order. Perhaps also reckless driving.

And, ya know, I suspect the guy went screaming around a corner *without using his bloody turn signal!* Sheesh.

5.



(b) You could just do it by remembering that the star is a red giant, there for much more luminous, and stick it somewhere in the giants branch at around 3,000K. Or, you could calculate the luminosity:

$$\frac{L_{\rm RG}}{L_\odot} = \frac{4\pi\,(100\,R)^2\,\sigma\,(3000\,K)^4}{4\pi\,(R)^2\,\sigma\,(6000\,K)^4}$$

$$\frac{L_{\rm RG}}{L_\odot} = (100)^2\left(\frac{1}{2}\right)^4$$

$$L_{\rm RG} = 600\,L_\odot$$

(Really the math gives you a ratio of 625, but this calculation only has one significant figure.)

Interpolate the vertical axis as best as you can to put the point somewhere reasonable. (It's a bit tricky because it's a logarithmic scale, but as long as it's above 10^2 and below where 10^3 is, you'd get full credit.)

c Color going from bluer to redder, and therefore also a sequence of decreasing surface temperature. It is *not* a sequence of decreasing luminosity or brightness!

6. **(a)**

$$d = \frac{1}{p} = \frac{1}{0.38}\,\text{pc}$$

$$\boxed{d = 2.63\,\text{pc}}$$

(b)

$$\frac{B_S}{B_\odot} = \frac{\frac{L_S}{4\pi\,{d_S}^2}}{\frac{L_\odot}{4\pi\,{d_\odot}^2}}$$

$$\frac{B_S}{B_\odot} = \left(\frac{L_S}{L_\odot}\right)\left(\frac{d_\odot}{d_S}\right)^2$$

$$L_S = \left(\frac{B_S}{B_\odot}\right)\left(\frac{d_S}{d_\odot}\right)^2 L_\odot$$

$$L_S = \left(\frac{1}{1.2\times 10^{10}}\right)\left(\frac{2.63\,\text{pc}}{1\,\text{AU}}\right)^2\left(\frac{206,265\,\text{AU}}{1\,\text{pc}}\right)^2 L_\odot$$

$$\boxed{L_S = 25\,L_\odot = 9.4 \times 10^{27}\,\mathrm{W}}$$

(c) Look at the HR diagram in question 5. A star that is of spectral type A but only 25 times the luminosity of the Sun is well within the main sequence band.

(d) White dwarf. It's way the heck dimmer than Sirius A, but the same temperature; this puts it down with the white dwarfs on the HR diagram.