Homework 3: Due Friday 10/3/2014 in class

Required Reading:
You should have completed Chapter 3.

Additionally, read the paper by McKay et al. on the Greenhouse and anti-greenhouse effects on Titan. In a few sentences, ***explain*** what is meant by the term "anti-greenhouse effect", and ***describe*** a few scenarios (natural or otherwise) by which another planet (say, Earth or Mars) could acquire a significant anti-greenhouse effect, at least temporarily.

Questions:
For this assignment, do the following questions in the textbook:

Chapter 3: ***For everyone:*** 3.9, 3.12, 3.17; ***Graduate students only:*** 3.14

Also, ***everyone*** should answer the following (*part g is extra credit for the undergrads*): This problem is about the binary stars Kepler 16A and B, and their recently discovered planet Kepler 16b (which has been widely compared to "Tatooine" from *Star Wars*). Please show all your work.

a) The total flux measured from this system is 1.29×10^{-12} W/m^2. This flux decreases by 1.6% when star A completely eclipses star B. If this system is 200 light-years away, calculate the luminosity of each star (in solar units).

b) A spectrum of this binary is dominated by the light from star A. This spectrum peaks at a wavelength of 652 nm. What is the approximate temperature of star A?

c) Using the Hertzsprung-Russell diagram shown in class (lecture slides available online), and the luminosity you computed in part (a), estimate (very roughly) the temperature of star B.

d) What is the radius of each star (in solar radii)?

e) Star A's mass is $0.6897 M_\odot$ and star B's is $0.20255 M_\odot$. If the planet's observed orbital period is 228.776 Earth days, what is its orbital semi-major axis?

f) Kepler 16b has an estimated mass comparable to that of Saturn. Assuming a similar Bond albedo to Saturn (recall problem 2.33) and black body thermal emission, what is Kepler 16b's equilibrium temperature?

g) Stars A and B orbit their mutual center of mass with a combined semi-major axis of 0.2243 AU and eccentricity 0.15944. Assuming a circular orbit for Kepler 16b about this center of mass, what range of angular sizes does each star span on its sky? What range of angular separations do they display? How does this compare to the memorable scene from *Star Wars*, where both stars have the approximate angular diameter of Earth's Sun, and are seen separated from each other by only ~1–2 times this angular diameter?