ATM 348 - Spring 2014
Atmospheric Physics
Homework #6
Due on Thursday May 1st

1. (10 points) Which star is hotter, with the maximum emission observed at the wavelength of 0.5 μm, or with the maximum emission observed at frequency 10^{15} Hz (1 Hz = 1 s^{-1})?

2. (20) A parking lot with a temperature of 50^{o}C emits radiation as the blackbody at that temperature. What is the wavelength, in μm, of maximum emission? What is the radiative flux (over all wavelengths; called *irradiance*) coming from the parking lot, in Wm^{-2}? Assume that the emitted radiation is isotropic. (radiance of the blackbody is *B(T)* given below; don't forget to convert temperature to units of degrees of Kelvin; flux is not the same thing as radiance)

3. (10) The radiance at the surface depends only on zenith angle θ as $I(\theta,\varphi) = I_o \cos(\theta)$, where I_0 is the radiance at zero zenith angle. What is the flux F or irradiance in terms of I_0? Flux is computed by integrating radiance over all angles as $F = \int_0^{2\pi} d\varphi \int_0^{\pi/2} I(\theta,\varphi)\sin(\theta)\,d\theta$.

4. (20) If Sirius had an Earth-like planet that had the same irradiance at it's orbit as our Earth (1370 W/m^2) to support life similar to ours, estimate at what distance (in units of distance from the Earth to Sun) from Sirius it should orbit? The radius of Sirius is 70 % bigger than that of the Sun. The surface temperature of Sirius is 9940 K. (See exercise 4.2 in the "Atmospheric Science" textbook for some hints.)

5. (10) (This one should be worked on after lecture on Tuesday) It is known from observations that, on average, 30% of incoming solar radiation is reflected back to space, and only about 50% of it reaches the Earth's surface and gets absorbed. What is the effective optical path and corresponding transmittance of the Earth's atmosphere?

6. (5 points each) Explain or answer (briefly!):
a) State (in words only): Planck's law, Stefan-Boltzmann law, and Wien's displacement law.
b) (after Tuesday) Infrared absorptivity of atmosphere is 0.6. What is its emissivity? Why?
c) What is the key assumption Planck made to explain the blackbody radiation spectrum?
d) If $E_\lambda(T)$ represents the radiance of a black flat matte surface, what is the corresponding irradiance?
e) Is the typical wavelength of terrestrial radiation longer or shorter than that of solar radiation? How do you know?
f) Will there be radiative transfer of energy between the opposite walls that are at the same temperature and made of the same material?

$B(T) = \frac{\sigma}{\pi} T^4 \qquad \sigma = 5.67 \times 10^{-8} Wm^{-2}K^{-4} \qquad c = 3 \times 10^{8} ms^{-1} \qquad \lambda_{\max}(\mu m) = \frac{2897}{T} \qquad T_v = e^{-\tau}$