**AME 517, Fall 2009**
**Problem set #5**
**Assigned: 11/13/2009**
**Due: 11/24/2009, 4:30 pm**

*Homework may be submitted by email (ronney@usc.edu), by fax (213-740-8071) or put in my mailbox (down the hall from my office in the OHE 430 suites, in the small room with the copy machine). DEN students should submit through the usual channels.*

Note: the special symbols seem to work only on Internet Explorer, not Netscape or Safari. Click here for a pdf version of the assignment.

**Chapter 9:**

9.4. Hints:

a. The heat generation Q''' is $\nabla \bullet \mathbf{q}$ = dq/dz, where z is the direction parallel to the sun's rays, with z = 0 at the surface of the medium
b. Note that the incident radiation I(z=0) = 0 for all incident angles other than the direction parallel to the sun's rays
c. You need the index of refraction n to calculate the reflectivity of the surface, which is given by Eq. 3.80.
d. Answer: $Q''' = -(1-\rho)q_{sun}\kappa e^{-\kappa z}$

9.8. Answers:

$$\dot{Q}''' = \nabla \cdot \mathbf{q} = \kappa(4\pi I_b - G) = 2\kappa\sigma T^4 \int_{-1}^{+1} e^{-\tau_r\mu - \sqrt{\tau_R^2 - \tau_r^2(1-\mu^2)}} d\mu$$

where $\mu = \cos(\theta)$

$Q'''(r = 0) = 1.33 \times 10^7$ W/m$^3$
$Q'''(r = R) = 8.16 \times 10^7$ W/m$^3$

9.10. Answer: 40%

9.14. Answers:

a)

$$I_\eta = I_{b\eta}\left[1 - \left(\frac{1}{2} - \frac{1}{4}A_1\right)\tau_\eta\right]$$

b)

$$I_\eta = I_{b\eta}(1 - \tau_\eta) + \frac{1}{2}I_{b\eta}\,\tau_\eta = I_{b\eta}\left(1 - \frac{1}{2}\tau_\eta\right)$$

**Chapter 10:**

10.2. Answer: 4338K

10.6. Answer: 1.2 $cm^{-1}$.

10.7 Answers: Elsasser 0.491, Goody 0.368, Malkmus 0.329. Note that the "integrated absorption coefficient" is actually the "line strength" S which has units of $cm^{-2}$ per ($g/cm^3$) which is the same units (but not the same look and feel) as $cm^{-1}$ per $g/m^{-2}$. Use S to compute the dimensionless optical thickness parameter $x = SX/2\pi b_L$ (Eq. 10.37) which in turn is one of the two parameters you need for the narrow band models. Note that the Elsasser model needs x and beta = $\pi b_L/d$ (Eq. 10.54) which is the dimensionless line width, whereas the statistical models use $\beta$ and $\tau = 2\beta x$.

10.9 Answers: (a) 0.785, (b) 0.615; hints: (a) show that these conditions fall into the strong absorption line limit and use the result from the Goody or Malkmus model in this limit, (b) use Eq. 10.24 to determine the line width for this part knowing the line width at conditions for part (a) and the temperatures and pressures for both parts. Also for some reason Modest uses frequency ($\nu$), not wavenumber ($\eta$), for this problem; recall $c = \nu/\eta$.