MSC 409 Spring 2007 HW #4
DUE APRIL 24 (Tuesday)

1. Consider solar radiation with a zenith angle of 0^0 that is incident on a layer of aerosols with a single scattering albedo ω_0 of 0.85, an asymmetry factor g=0.7, and an optical thickness τ = 0.1, averaged over the shortwave part of the spectrum. Assume a surface albedo of 0.15. Show the formulae you apply as well as numerical answer..

a. Write down the definitions of ω_0, g, and τ.
b. What fraction of the solar radiation is directly transmitted through to the surface ?
c. What fraction of the direct solar beam is absorbed by the aerosol ?
d. What fraction of the direct solar beam reflected back to space by the aerosol layer ?

To answer this question, you will need to do a small bit of trickery: g varies between -1 (complete backscatter) and 1 (complete forward scatter). Construct a backscatter fraction that varies between 0 and 1 and depends linearly on g.

e. What fraction of the direct solar beam is reflected upward by the surface ?
f. Of the answer to e. how much ends up getting reflected back to space ?

EXTRA CREDIT: Diagram the multiple scattering that occurs between the surface and aerosol layer and the portion that contributes to the total reflection back to space. You may be able to deduce the amount that is fully scattered back to space using $a\Sigma x^n = a/(1-x)$

2. A primary rainbow results from light rays that have undergone one internal reflection Assume an incident angle of 30^0 in the figure below. The exiting angle with respect to the original direction after one single internal reflection is given by $2\theta_i - 180^0 - 4\theta_r$. θ_r is calculated from Snell's law (Petty eqn 4.13) as $\sin\theta_r = \sin\theta_i/n$, where n is the index of refraction of water (the scattering angle Θ in the diagram below is 360+the angle you calculate). N also varies by wavelength, which explains the separation of colors in a rainbow. Assume, for violet light, n=1.343, and for red light, n=1.331. Calculate the exiting angles, relate it to your own experience of a rainbow as a surface-based observer. If stuck it may help to consult Wallace &Hobbs Fig. 4.16, replicated in my optics powerpoint available online. EXTRA CREDIT: Do the same but also for the secondary rainbow, which is scattered (I'm told) according to $2\theta_i - 360^0 - 6\theta_r$