Name: ____________________________________

ATOC/ASTR 5560 Radiative Processes — Lab 1
August 31, 2001

The purpose of this computational lab is to gain familiarity with the Planck function and its integration across the spectrum. Log in to nit and copy the IDL file to your directory for this lab:

```
cp /home/rt/planck/planck.pro .
```

1. At the beginning of the IDL file are function definitions for the two Planck functions. Fill in the Planck expressions in the two functions.

2. Use section `PlanckSpectrum` to make spectrum plots of the Planck function per wavelength and per wavenumber for temperatures of 200, 250, and 300 K.

   a) Write down the wavelength/wavenumber and Planck function value at the maximum for each temperature. The IDL max function might be helpful, e.g.

   ```
   print, max(Blambda[*,0],im), lambdagrid[im]
   ```

   See if the results agree with Wien's displacement law.

   b) What is the dependence of the maximum Planck function value on temperature for both B_ν and B_λ (e.g. the slope of $\ln B(T)$ vs. $\ln T$ which is the exponent in $B_\nu \propto T^n$)? Use the 200 K and 300 K Planck values to determine this.

c) Do the maximums in terms of wavenumber correspond to those in wavelength (i.e. convert the ν_{max} to wavelength)? Why or why not?

d) For the 250 K temperature use the graph to find the wavenumbers and wavelengths at which the Planck functions fall to about 10% of the maximum. This is an estimate of the wavelength range of significant emission.

3. The integral of Planck function across a spectral band is part of a calculation of broadband fluxes and heating rates. The IDL file has a section `IntegratePlanck` that performs numerical integration of the Planck function between two wavenumbers. Examine the code to see how the trapezoidal integration is implemented. Perform a numerical integration across the whole longwave spectrum for blackbodies with temperatures of 250 and 300 K.

   a) Compare the broadband results with fluxes from the Stefan-Boltzmann Law.

b) Integrate the Planck functions at the two temperatures over the 8.5 to 12.5 μm spectral window in the Earth's atmosphere. What fraction of the total blackbody radiation is emitted in the window for each temperature?

4. The Planck spectral integral may be calculated accurately and quickly with series expansions.

   a) For the atmospheric window band in question 3b, calculate $x = c_2\nu/T$ to determine which series expansion to use. Finish the IDL code for the appropriate series expansion.

   b) Compare the trapezoidal rule and series expansion values to test the expansion. How many terms do you need to get agreement to better than 0.1%.

A Fortran implementation of series expressions for the Planck integral is available in `/home/rt/planck/planckint.f`.