HOMEWORK 3 – Thermal radiation and diffraction - due April 25

1 a) What is a "black-body"?
b) What is "emissivity", and what is the emissivity of a "black body"?
c) Sketch black-body radiation curves for i) the Sun and ii) the Earth on the same graph.
d) Describe the two main features of the graph. What two laws describe these features?
e) Use Wien's law to calculate the wavelength of peak thermal emission i) the Sun and ii) the Earth.

2 a) Are thermal sensors active or passive?
b) State the wavelength range that is classified as thermal radiation.
b) List three satellite sensors that operate in the thermal bands.
c) What are four applications of thermal remote sensing.
d) Why is the resolution of a satellite instrument operating at thermal wavelengths lower than that of a visible instrument (use an equation to explain this).
e) Why is thermal imagery used for monitoring fires, rather than visible imagery?
f) Why is thermal radiation useful for monitoring the Antarctic ice sheet?

3) What is the approximate resolution of a microwave antenna having an aperture of 1m (diameter) and orbiting at an altitude of 700 km? Use a wavelength of 0.05 m. Resolution means the diameter of the first zero crossing of the illumination pattern.
(b) Suppose you mounted this same antenna on an aircraft flying at an altitude of 7 km. What is the approximate resolution now?

4) Starting with Planck's law for the radiance per unit wavelength as a function of wavelength: (see http://topex.ucsd.edu/rs/radiation.pdf)
a) Integrate Planck's law to arrive at the Stefan-Boltzmann law. (Feel free to use any integration tools including the symbolic toolbox in Matlab or Mathematica, etc.)
b) Take the derivative of Planck's law to arrive at Wein's law.
c) Take the limit of Planck's law for large wavelength to arrive at the Rayleigh-Jeans approximation.

5) Derive an expression for the fourier transform of $f(x) = \cos\left[2\pi k_o \left(x - x_o\right)\right]$ where k_o is a constant. What is the fourier transform of $\frac{\partial f}{\partial x}$?