University of Kentucky, Physics 520
Homework #1, Rev. A, due Friday, 2015-09-02

0. Griffiths [2ed] Ch. 1 #1, #3.

1. Planck's law—The spectral energy density of thermal radiation inside a black body is $u(\nu, T) = 8\pi\hbar\nu^3/c^3(e^{\hbar\nu/kT} - 1)$. You can solve the following problems using the functions `D`, `NSolve`, and `Integrate` in Mathematica.

a) Show Wien's displacement law, that $u(\nu, T)/T^3$ depends only on $x = \hbar\nu/kT$, not ν or T individually. Calculate the value of x for which $u(\nu)$ attains its maximum at temperature T.

b) Integrate $\int_0^\infty u(\nu, T) d\nu$ to obtain the total energy density over all wavelengths. Show that the average forward intensity of radiation is $I = uc/4$ (see my notes) and calculate the constant σ_{SB} of the Stephan-Boltzman law $I = \sigma_{SB} T^4$.

2. COW Experiment—A beam of neutrons of de Broglie wavelength 2 Å passes through a Mach-Zehnder interferometer, with lattice spacing d=3.135 Å between the $\langle 111 \rangle$ planes of Si. These planes are alligned perpendicular to the blade faces, so that diffracted neutrons pass through the blade and are bent in the opposite direction as undiffracted neutrons, but at the same angle of incidence about the normal, as shown in the figure.

a) Calculate the Bragg scattering angle θ, which equals the angle of incidence and diffraction.

b) As neutrons rise and lose kinetic energy to the gravitational potential, their wavelength expands. Assuming an L = 30 mm separation between each of the three blades, calculate the phase difference between two inteferring paths. (see Neutron interferometry, page 41).