University of Kentucky, Physics 420
Homework #1, Rev. A, due Monday, 2015-09-14

1. Planck's law—Derive Wien's displacement law $\lambda_{max}T = b$, and the Stephan Boltzman law $I = \sigma_{SB}T^4$ from Planck's law. Calculate the numerical value of the constants b and σ_{SB}. In Mathematica, you can use the functions `D`, `NSolve`, and `Integrate`.

2. Compton Edge—Similar to atomic spectra measured with a diffraction grating, nuclear spectra (gamma emission due to nuclear transitions from one state to another) can be observed by histogramming the photon energy detected directly in a High Purity Germanium (HPGe) detector. However, some of the photons do not deposit all of their energy, but Compton scatter off of electrons in the HPGe crystal and exit the detector. Explain the shape of Compton background in this ^{60}Co γ-spectrum at Wikipedia: Cobalt-60, which has two lines, one at 1.17 MeV and the other at 1.33 MeV. Calculate the two *Compton Edges*, below which background count rates become much higher.

3. Bohr's Oscillator—Follow the same steps used by Bohr quantize a 3-dimensional ideal frictionless harmonic oscillator of mass m and natural angular frequency ω, (ie. spring constant $k = m\omega^2$). If you start with quantization of angular momentum, show that the correspondence principle holds; or vice versa.

4. 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 in the $\langle 111 \rangle$ planes in Si. Calculate the angle of incidence that matchs the Bragg diffraction angle so that exiting split beam is symmetric with the blade, as shown below. Assuming a 30 mm separation of each of the three blades, calculate the phase difference in the two paths, due to gravitational retardation in the top path (see Neutron interferometry, page 41).