This file is Background Outline.doc, *version 20 December 2007*. These notes for Quantum Physics PHY 571 (Venables) are only intended as a summary, and to give references. They do not contain all the arguments. References are to the textbooks Gasiorowicz (G3 or G2 for the two editions) and Liboff (L4 or L3). Of course only one of these references is needed in general.

Background Material is in all the textbooks, and has been expanded via the web page http://venables.asu.edu/quant/backgro.html with the help of student projects. If any students want to do such a mini-project for credit early this semester, contact me right away. I will go quickly through this background material, in order to establish what we need to be able to assume is common ground for the course. You should alert me if you find any of these topics difficult.

1. Black-body Radiation (refs G3 p1-5, G2 p1-9, L4 p31-36, L3 p32-36). Here we establish the ideas of equipartition of energy, 1/2 *kT* per mode, as in kinetic theory, and apply these arguments to the modes of a cavity. This leads to the Rayleigh-Jeans law, and the Ultraviolet catastrophe. The problem is resolved via the Planck radiation law (1900) and the introduction of quanta with energy $E = h\nu = \hbar\omega$, the energy of a photon. We discuss energy/unit volume and emissive power/unit area quantitatively, and give examples of Astronomical and Materials interest. The role of units and tabulated values of constants is also discussed.

2. Photoelectric Effect (refs G3 p5-7, G2 p9-11, L4 p36-39, L3 p36-40). The theoretical result from Einstein in 1905 is further evidence that light is absorbed in energy quanta $E = h\nu = \hbar\omega$.

3. Compton Effect (refs G3 p7-9, G2 p11-13, L4 p50-52, L3 p50-53). This effect is the first example of inelastic scattering of X-rays by electrons in matter, and that photons also have momentum, *p*. The magnitude of $p = \hbar\omega/c = h/\lambda$; $p = h/\lambda$ is de Broglie's relation (1923). The Compton Effect (1923-24) can be considered as a 2-dimensional collision, but the relativistic relation between energy and momentum is needed. Since not all students have had relativity, we set a problem on the Compton effect, but in general not much relativity is needed in this course.

4. Particle Diffraction (refs G3 p10-14, G2 p13-15 (note mistake in an equation between 1.24 and 1.25), L4 p43-49, L3 p46-50). The de Broglie relation applies to both photons and material particles (electrons, neutrons, atoms and molecules in some circumstances) as initially determined using electrons by Davisson-Germer and G.P. Thomson, both in 1927.

5. The Bohr Atom (refs G3 p7-9, G2 p11-13, L4 p39-43, L3 p50-53). Starting as a guess in 1913, following Rutherford's model of the atom/ nucleus (1911), this model ushered in the "old quantum theory". Most teachers in high school use it, most other teachers mention it, and most specialists think it should be *consigned to history: we know it is incorrect*. My take on this topic is that the Bohr atom is very useful for several sub-topics, namely to
a) Discuss the fundamental constants involved in atomic physics, and the special role of the r^{-1} potential
b) Explore the importance of spectroscopy in comparing models with experiment
c) Establish ratios and units and understand the importance of relativistic effects.
We use various web pages, projects and computer-based visualizations to explore these topics.

6. The Uncertainty Principle and the **Wave-Particle Duality** (refs G3 p23-30, G2 p21-22, 27-38, L4 p53-59, L3 p53-59). The work of Heisenberg and Born (from 1925 onwards) is well known in popular culture. But less well known are the quantitative relations that are a consequence of conjugate variables and Fourier Transform pairs. With that we move into the main body of the course, using the Fourier-based methods, for which there is a separate web page at http://venables.asu.edu/quant/fourier.html.