Homework #1
Due 8 Sept 2005

1.) The 1-dimensional Gaussian wave function is $\Psi(x) = \left(\frac{1}{\pi}\right)^{1/4} e^{-x^2/2}$, which Fourier transforms to $\Psi(k) = \left(\frac{1}{\pi}\right)^{1/4} e^{-k^2/2}$.

a. Determine the particle probability density (in x) and plot it as a function of x.
b. Determine $\Delta x = \sqrt{\langle x^2 \rangle - \langle x \rangle^2}$, where $\langle x^2 \rangle = \int_{-\infty}^{\infty} \Psi^* x^2 \Psi dx$.
c. Calculate $\Delta k = \sqrt{\langle k^2 \rangle - \langle k \rangle^2}$.
d. What is $\Delta x \Delta k$ equal to?

2.) Using figures 5 and 6 in the textbook by Waser, sketch the density of states in the vicinity of the Fermi level for Cu, Ge, and Si. Show explicitly the approximate locations of the Fermi energy and conduction and valence band edges, where appropriate.

3.) Plot the Fermi distribution function as a function of W, for a series of absolute temperatures, 500K, 5 x 10^3 K, 5 x 10^4K, assuming that $W_f/k_B = 0.5$. At approximately what temperature can the Fermi distribution function be approximated by the Boltzmann distribution function?

4.) Estimate the time between collisions for Na at room temperature, assuming that the electron's effective mass is the actual mass of the electron. What are the electrons colliding with?