Problem Set 1
Physics 240B

Due January 13, 2009

Do Ashcroft & Mermin 28.2, 28.6(a-c only), and the following. For 28.6, the correct assumption is really $N_d >> N_a$. Also note that for 28.6c, the equation (28.47) is off by a factor of 2. (The right-hand side should be divided by 2.)

1. Work from A&M equation 28.13 to 28.16. This includes (but is not limited to) Problem 28.3c. You may assume the results from Problem 28.3a-b.

2. Assume a semiconductor has a bandgap of 2 eV and effective masses of $m/4$ and $m/7$ for electrons and holes, respectively.

a) Sketch the dispersion relation, ε vs k. (You may assume a "direct" band gap; that is, that the conduction band minimum and valence band maximum occur at the same $\mathbf{k}$.)

b) Sketch the density of states as a function of energy. Put energy on the vertical axis for easier comparison to part a).

c) Find the concentrations of conduction electrons and holes at 300K and 350K. What is the chemical potential?

d) Repeat c) if the semiconductor is doped with 10^{11} holes per cm^3.

e) For many circuit applications, materials with temperature-independent resistance are desirable. From your answers to c) and d), would you expect resistance to be closer to temperature-independent in undoped or in doped semiconductors?