1. In n-type silicon with doping $N_d = 2 \times 10^{16}$ cm$^{-3}$,
   (a) what is the probability of finding a hole at the valence band energy?
   (b) what is the probability of finding an electron at the valence band energy?
   (c) what is the probability of finding an electron 0.1 meV above the conduction band?
   (d) what is the probability of finding a hole at the conduction band energy?

2. A silicon sample is doped with acceptors such that there is 1 acceptor atom for every 10$^7$ silicon atoms.
   (a) What is the majority carrier and majority carrier concentration?
   (b) What is the minority carrier and minority carrier concentration?
   (c) Calculate the Fermi level energy with respect to the conduction band edge.
   To this doped silicon sample, donor impurities are added in the ratio of 1 donor for every 5 $\times$ 10$^6$ silicon atoms.
   (d) What is the majority carrier and majority carrier concentration?
   (e) What is the minority carrier and minority carrier concentration?
   (f) Calculate the Fermi level energy with respect to the conduction band edge.

3. A Si cube has side lengths of 1 mm. The doping is $n_0 = 10^{16}$ cm$^{-3}$.
   (a) What is the conductivity of this sample?
   (b) What is the resistivity of this sample?
   When a voltage of 0.5 V is placed across two opposing faces of the cube:
   (c) What is the hole current?; (d) What is the electron current?; (e) What is the total current?

4. A Si cube has side lengths of 1 mm. The resistivity of this sample from opposing faces is 2 $\Omega$cm.
   (a) What are the two possible doping values for this sample (give $N_d$ for n-type and $N_a$ for p-type)?
   For each doping case in part (a):
   (b) What are the majority and minority carrier concentrations for this sample?
   (c) What is the electron current in this sample when 3 V is placed across opposing faces?
   (d) What is the hole current in this sample when 3 V is placed across opposing faces?
   (g) What is the total current in this sample when 3 V is placed across opposing faces?

5. A silicon sample is doped with donors such that $n_0 = Cx$ and $n_0 >> p_0$, $n_i$, where C is a constant. Find the electric field that is built into the sample due to this doping gradient.

6. A silicon sample has a built-in electric field which is a function of x given by $E = 4 \text{ (V/mm}^2\text{)} x + 3 \text{ V/mm}$. Express the conduction band edge, $E_C$, as a function of x in this sample.