Homework 1

ECE 695-O Semiconductor Transport Theory

Due 2018.10.18

1) Assume a material for which the conduction band can be described by

$$\mathcal{E}(\mathbf{k}) = \frac{\hbar^2 k^2}{2m_0^*} - c\hbar^4 k^4$$

where m_0^* is the effective mass at $\mathbf{k} = 0$ and c is a small constant.

If the relationship between $\mathcal{E}(\mathbf{k})$ and $\mathbf{k}$ extends all the way to the zone edge, what must the value of c be?

Plot $\mathcal{E}(\mathbf{k})$, $v_g(\mathbf{k})$, and $m^*(\mathbf{k})$ vs. k. (Treat the problem in a 1 dimensional lattice)

Hint) The velocity v_g must be equal to zero at the zone edge. Think about why.

2) Consider the free electron energy bands of an fcc crystal lattice in the approximation of an empty lattice, but in the reduced zone scheme in which all $\mathbf{k}$'s are transformed to lie in the first Brillouin zone. Plot roughly in the [111] direction the energies of all bands up to six times the lowest band energy at the zone boundary at $\mathbf{k} = \boldsymbol{2\pi/a}\left(\frac{\mathbf{1}}{\mathbf{2}}, \frac{\mathbf{1}}{\mathbf{2}}, \frac{\mathbf{1}}{\mathbf{2}}\right)$**.** Let this be the unit of energy. (This problem shows why band edges need not necessarily be at the zone center. Several of the degeneracies (band crossings) will be removed when account in taken of the crystal potential.)