PHYSICS 152B/232
Spring 2017
Homework Assignment #2

[1] Consider a tight-binding model of monovalent atoms on a two-dimensional rectangular lattice with primitive direct lattice vectors $\boldsymbol{a}_1 = a_x\,\hat{\boldsymbol{x}}$ and $\boldsymbol{a}_2 = a_y\,\hat{\boldsymbol{y}}$ and hopping integrals $t_{x,y}$.

(a) Assuming $a_x > a_y$, which of $t_{x,y}$ do you expect to be largest? Why?

(b) Find the dispersion relation $E(\boldsymbol{k})$.

(c) Sketch the Fermi surface within the Brillouin zone.

[2] Consider the one-dimensional Bloch oscillations discussed in §1.6.3 of the Lecture Notes. Setting $k(0) = 0$, show that a Taylor expansion of the motion $x(t)$ agrees with the ballistic result to order t^2, if the ballistic mass is taken to be the effective mass m^* at $k = 0$.

[3] Make a sketch of the extended Brillouin zones like in Fig. 2.2 of the Lecture Notes, but for the triangular lattice. Then make plots the free electron Fermi surface for valences $Z = 2$ and $Z = 3$, such as in Fig. 2.3.

[4] Suppose, in the vicinity of the Γ point for some material, the electron dispersion is of the form $E(\boldsymbol{k}) = \frac{1}{2}(m^*)^{-1}_{\mu\nu}\,k^\mu\,k^\nu$, where m^* is the effective mass tensor. Find an expression for the low-temperature molar heat capacity in terms of density n and temperature T. Your expression should involve the tensor m^* in some way.