Name:

Exam 1 Part 2 - Solid State Physics - Fall 2015

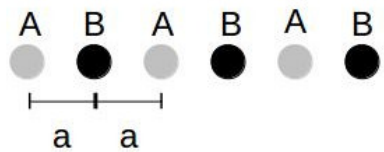
October 14, 2015

Directions: Please clear your desk of everything except for pencils and pens. The exam is closed book, and you are not allowed a formula sheets, but you may use a calculator. Leave substantial space between you and your neighbor. Show your work in the space provided on the exam. I can provide additional scratch paper if needed.

The entire exam is out of 100 points. Each subquestion, (a), (b), (c), ... is worth 5 points. This part of the exam is out of 50 points.

3. **Periodic Potential**

(a) A one dimensional lattice with alternating atoms (A and B) is shown below. Assume that atom A has an atomic energy level with energy E_A, and atom B has an atomic energy level E_B. Take the matrix element $\gamma = \langle A|\Delta U|B\rangle$ between adjacent atomic states to be real. What is the tight binding Hamiltonian for this model?



(b) What is the form of the tight binding wave function for this model? What is the range of the first Brillouin zone?

(c) Solve for the energy as a function of k for this tight binding model.

(d) Plot the energy as a function of k in the first Brillouin zone for the energy bands.

(e) What happens to $E(k)$ and the first Brillouin zone if we set $E_A = E_B$?

4. **Transport**

(a) Suppose the energy near the bottom of a band has the form $E = E_o + A|k|^2$. Write down the semiclassical equations of motion without scattering with a uniform magnetic field in the $\hat{z}$ direction.

(b) Solve the equations in k-space. What is the period of the motion in k-space?

(c) Next suppose that instead the energy has the form $E = E_o - A|k|^2$ near the top of a band. How do your results from part (a) and (b) change?

(d) In graphene near particular k-points the energy dispersion has the form: $E = B|k - k_o|$. Write down the semiclassical equations of motion (near this k-point) without scattering with a uniform magnetic field in the $\hat{z}$ direction and the graphene in the x-y plane.

(e) Solve the equations in k-space. What is the period of the motion in k-space?