PHY 392K: Solid State Physics I, spring 2017
(tentative)

Unique #: 57060
T-Th 3:30-5:00 p.m. in RLM 5.120

Instructor: Prof. Alex Demkov
Office: RLM 13.206
Phone: 471-8560
e-mail: demkov@physics.utexas.edu
Office hours: Monday 2-4 p.m., and by appointment

TA:
Office:
Phone:
e-mail:
Office hours:

Reference Books:

- M.P. Marder, "Condensed matter physics", Wiley, 2000.
- O. Madelung, "Introduction to solid-state theory", Springer, 1981.
- C. Kittel, "Introduction to Solid State Physics" Wiley, any edition.
- N. Ashcroft & D. Mermin, "Solid State Physics", Clarendon Press, Oxford 1995.
- J.M. Ziman, "Principles of the theory of solids", Cambridge U. Press, 1999.
- W. A. Harrison, "Electronic Structure and the Properties of Solids", Dover, 1989.

Class website: http://www.ph.utexas.edu/classes/demkov/phy392K/

Syllabus:

The class will be hard. A solid grasp of Quantum mechanics, E&M and Stat. mech. is expected. Homework assignments will be tedious and will often require some computing. It is possible to fail this class. Best of luck.

Part I

1. **Remedial Atomic and Molecular Physics**
2. Hydrogen Atom
3. Hydrogen Molecule; Born Oppenheimer approximation
4. Spectral problem, total energy: Heitler-London and Hartree-Fock theories
5. Harmonic approximation; Transformation to normal coordinates
6. **Crystal state**
7. Bravais lattice, Lattice with a basis, Crystal classes, Space Groups
8. Mathematics of periodicity, Periodic Boundary Conditions; Bloch theorem
9. Reciprocal lattice
10. **Vibrations in solids**
11. Dynamical matrix, dispersion relations
12. Simple nearest neighbor chain, density of vibrational modes
13. General monoatomic chain, speed of sound, diatomic chain
14. Square lattice with 2nd NN interactions, 3D

15. Specific heat (Dulong-Petit)
16. Quantum description, phonons
17. Specific heat (Einstein and Debye), more on the density of modes
18. **Experimental techniques:** Neutron scattering, elastic, inelastic, Einstein model, Debye-Waller factor.

Part II

19. Electron in a periodic potential (single electron picture)
20. Bloch waves, lattice sums, periodic boundary conditions
21. Kronig-Penney Model
22. Empty Lattice, simple classification of solids according to the band theory
23. Nearly free electrons, band structure, band gasp, Brilloin zone, etc.
24. Philips-Kleinman pseudopotential
25. Cohen-Bergstresser empirical pseudopotential
26. Tight binding and LCAO
27. Basis functions, overlap, Bloch waves
28. Electronic structure, band population, density of states
29. Lattice with the basis, the origin of band gaps
30. ***kp*** Theory
31. Effective mass, two band model
32. Electronic structure of Si, minimal $\mathbf{sp^3}$ basis, Chadi-Cohen Hamiltonian
33. Band structure of semiconductors, spin-orbit interaction
34. Experimental techniques: ARPES

- **6 homework assignments**

- **February 21, Midterm I**
- **April 6, Midterm II**

- ***No class on April 20th, make-up classes TBD***

- **May XX, X:00-Y:00 Final**

- **Grading:** homework 40%, two mid-terms 20% each, final 20%