

Outline of Physics 601, Graduate Solid State Physics, Fall 2009, Sept. 27 version

1. Quantum mechanical picture of a solid.
2. Non-interacting electrons
 - (a) Wave functions, counting states, density of states, ground state wave function.
 - (b) Finite temperatures
 - (c) Heat capacity of simple metals - theory and experiment
 - (d) Spin susceptibility of simple metals - theory and experiment.
 - (e) What changes we expect when other parts of Hamiltonian are included
3. Electron-electron interactions
 - (a) Hartree-Fock theory
 - (b) Cohesion of a simple metal. Energy and density.
 - (c) Spin susceptibility (OK) and heat capacity (not OK)
 - (d) Screening and dielectric functions
 - (e) Lindhard theory (RPA theory)
 - (f) Friedel oscillations - theory and experiment
 - (g) Screening of electron-electron interaction
 - (h) Plasma oscillations - theory and experiment
 - (i) Lifetime of an electron near Fermi surface \rightarrow Fermi liquid theory
4. Electronic structure
 - (a) Periodic structures
 - (b) Elastic neutron (x-ray) scattering
 - (c) Bragg planes and Brillouin zones
 - (d) Bloch's theorem and consequences
 - (e) Nearly free electron model and Fermi surfaces

- (f) Electron dynamics
- (g) The many body ground state. Metals and insulators
- (h) Implications for real solids
- (i) Methods for calculating electronic structure
- (j) Density functional theory.

5. Transport Properties

- (a) Qualitative description. Drude theory
- (b) Boltzmann equation
- (c) Solution for random impurity scattering
- (d) Calculation of cross sections - Friedel sum rule
- (e) Experiments. Qualitative on effect of lattice vibrations and Kondo stuff (more next semester).
- (f) Onsager relations
- (g) Thermoelectric effects
- (h) Magnetoresistance and Hall effect
- (i) Effect of Fermi surface and open orbits
- (j) Cyclotron resonance in metals and insulators (semiconductors)

6. Optical Properties