Physics 4243/5243
Problem Set #8
Due Wednesday April 9th

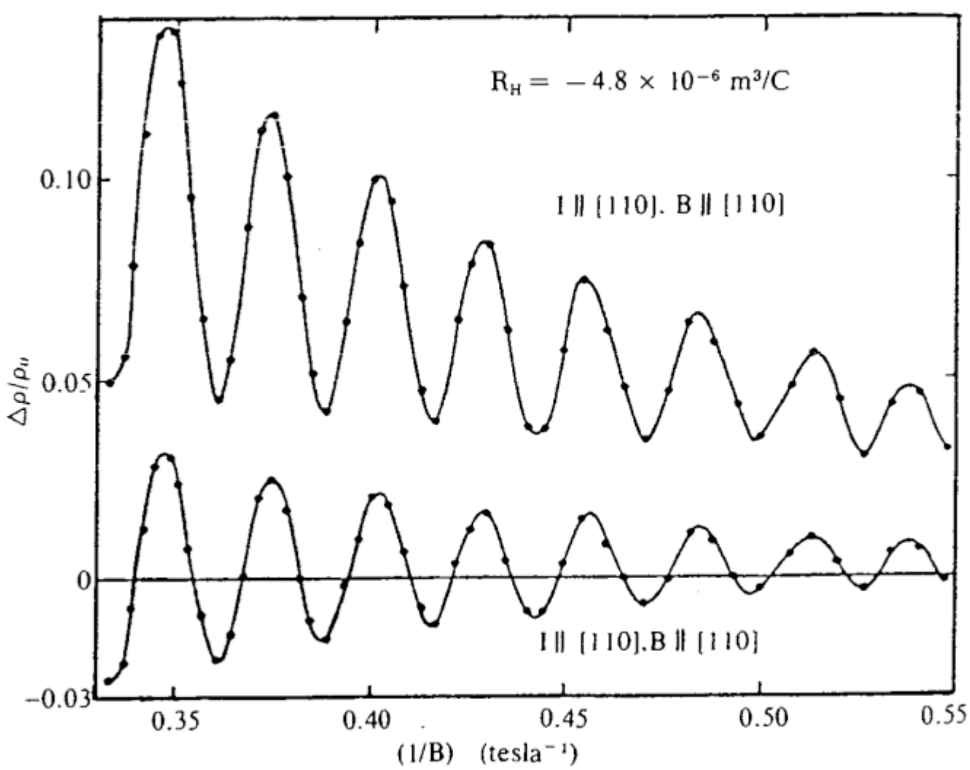
Problem 1:

The course website provides a link to a .pdf version of Kittel's Solid State Physics book. Read chapter 9 starting at page 242 on "Experimental Methods to Fermi Surface Studies". The basic idea is that under the influence of a magnetic field, electrons execute orbits along their Fermi surfaces. Because of quantum mechanics an electron must also enclose an integer number of flux quanta (flux has units of magnetic field X area), so only certain orbits are allowed. Because there are many possible orbits enclosing integer flux, no random orbit will dominate and you don't get any periodic behavior in measured quantities **EXCEPT** those orbits that are minimal and maximal orbits in momentum space. Because these are the extremal orbits they keep appearing again and again and becaue the electrons at the Fermi surface are so important in physical measurement, you get oscillations in measurable parameters like resistance, magnetization, heat capacity, susceptibility etc.

Then do problem 7 from Kittel Chapter 9.

Problem 2:
Consider a hypothetical monovalent monatomic simple cubic metal of lattice constant 4 Angstrom. Sketch the Fermi surface you would expect treating the valence electron as nearly free, such that the neck and belly are in the ratio of 1/5. Suppose you are able to use the de Haas-van-Alphen effect to investigate this Fermi surface. Describe what you would expect to see for the H field in the [100] and [110] and [111] directions and H approximately 1 Tesla. Sketch the extremal orbits in each case.

Problem 3:
The figure below is experimental data for a n-type GaSb (a semiconductor) at 4.2K. Show is the Schubnikov-de Haas (SdH) trace (ρ vs. 1/B). As can be seen the resistance ρ displays oscillatory behavior associated with the Landau levels piercing the Fermi surface. Also given is the Hall resistance R_H. Calculate the electron density from the SdH trace and see how it agrees with your calculation of the electron density from the Hall resistance.



Problem 4:
The graph below displays the intrinsic carrier concentrations for Ge, Si and GaAs as a function of inverse temperature. Determine E_g for each of the semiconductors using this graph.