# Physics 481: Condensed Matter Physics - Homework 9

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due date: Friday, March 25, 2011

**Problem 1: Copper nanowire** (20 points)

Consider a long thin wire of copper along the $z$-direction with length $L = 1$ cm and a square cross section (width $a$ is a few Å). Treat the wire as a free electron gas, demanding that the wave function vanishes outside of the wire. Use periodic boundary conditions along the length of the wire. The electron density for copper is $8.49 \times 10^{22}$ electrons/cm$^3$.

a) Solve the Schrödinger equation for this geometry.

b) Which states are occupied at zero temperature? Qualitatively describe the dependence on the width $a$.

c) Calculate the maximum possible width $a$ of the wire such that only the ground state in $x$ and $y$ directions is occupied.

d) Calculate the low-temperature specific heat for the case when only the ground state in $x$ and $y$ directions is occupied (algebraic answer in terms of $a$ and the electron density OK).

**Problem 2: Electronic density of states** (10 points)

Calculate the electronic density of states of the free electron gas in one and two spatial dimensions. Discuss the character of the van-Hove singularity at $\epsilon = 0$ in these cases.

**Problem 3: Pressure of ideal Fermi gas** (Marder, problem 6.3, 10 points)

Find the pressure of the free electron gas in three dimensions at zero temperature.
Hint: Start from a thermodynamic relation, e.g., $p = -(\partial E/\partial V)_N$ (at zero temperature).