# Phys 404
## Spring 2011
## Homework 9, CHAPTERS 6 AND 7
## Due Thursday, April 14, 2011 @ 12:30 PM

**HOUR EXAM THURSDAY, APRIL 21, WILL COVER CHAPTERS 3 - 7.** Once again, no notes, books, electronics, screens, phones, or calculators are allowed in the exam. You may write any formulas or calculations you wish on a single 8 ½" x 11" sheet of paper and bring it with you to the exam.

**Chapter 6 assignment:**
Read chapter 6, then do

**1.** K+K Chapter 6, Problem 9

**2**. K+K Chapter 6, Problem 12

**Chapter 7 assignment:**
Read chapter 7, then do

**3**. K+K Chapter 7, Problem 1

**4.** K+K Chapter 7, Problem 5

**5**. Free energy of a degenerate Fermi gas I. The Sommerfeld expansion gives the energy of a low-temperature (or degenerate) Fermi gas as

$$U = U_o + \frac{\pi^2}{6} D(\varepsilon_F)\tau^2 \tag{1}$$

where $D(\varepsilon_F)$ is the density of states at the Fermi energy.
a) From this result, derive an expression for the heat capacity, Eq. (37) in Chapter 7.
b) Using the result of part a), derive an expression for the entropy.
c) From the expression of for the energy, Eq. (1) above, and the answer to part b), show that the Helmholtz free energy of a degenerate Fermi gas can be written in the form

$$F = U_o - A\tau^2 \tag{2}$$

and give an explicit expression for the function A in terms of $D(\varepsilon_F)$.

**6**. Free energy of a degenerate Fermi gas II. The Sommerfeld expansion gives that the chemical potential of a degenerate Fermi gas is given by

$$\mu = \varepsilon_F - \frac{1}{3}\left(\frac{\pi}{2}\right)^2 \frac{\tau^2}{\varepsilon_F}. \tag{3}$$

a) From this expression, derive the Helmholtz free energy. (It should be the same result as part c of problem 5.)
b) Find the pressure of a degenerate Fermi gas.
c) Give a physical reason for the non-zero value of the pressure at $\tau=0$.