Physics 238A **Fall 2006**

Condensed Matter Physics **due 9:30 am Tuesday Oct. 10**

PROBLEM SET 2

Reading: Ashcroft and Mermin (AM) Chapters 2 and 3

1. Fermi Gases in Astrophysics

   (a) Use the relativistic relation between energy and momentum to find the relationship between the Fermi energy and the density in an ultrarelativistic electron gas.

   (b) Given that the sun is approximately electrically neutral, is composed mainly of light elements and weighs approximately 2×10^{30} kg, estimate the total number of electrons it contains.

   (c) In a white dwarf star this number of electrons may be ionized and contained in a sphere of radius $\sim 2 \times 10^6$ meters. Find the (order of magnitude of the) Fermi energy in eV. (Note: You will have to decide whether it is more sensible to apply the ultra-relativistic or nonrelativistic formula.)

   (d) Estimate *roughly* the temperature below which the electrons are degenerate.

2. **Deformation of the Fermi distribution by currents**

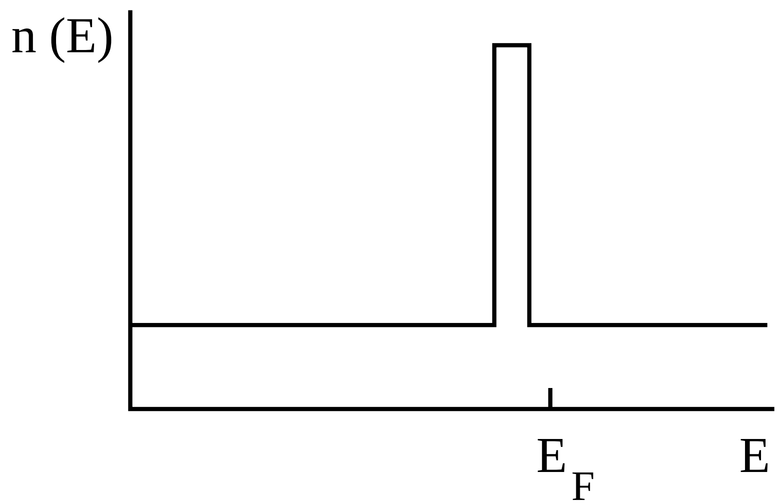
   Using general ideas about the way in which the distribution function f is distorted by current and heat flow, estimate the order of magnitude of the deviation of f from its equilibrium form (the Fermi–Dirac distribution function) in copper at room temperature

   (a) when an electric current of 1000 A/cm^2 flows, and

   (b) when it is subject to a thermal gradient of 1000 K/cm.

In the first case, estimate also the mean drift velocity of the electrons as a fraction of the Fermi velocity. (Look up any data you need on copper.) Note that the deviation from f_{eq} is appreciable only for $E \lesssim kT$.

3. A fictitious transition metal has the electronic density of states $n(E)$ shown below.



As the temperature T increases, does the chemical potential μ increase or decrease? Justify your answer.