Homework 1
due 10/7/2009
Physics 231

Ashcroft and Mermin, Chapter 1, Problems 1.1, 1.2, 1.3, 1.4

and this extra problem:

1. In this problem you'll try to obtain a relation between current fluctuations and resistance, related to "Nyquist's Theorem". You'll do this in the context of the Drude model applied to a wire of length L and cross sectional area A.

(a) In the Drude model, what is the average value of the velocity in the x direction at time t $v_x(t)$, given that the velocity at $t = 0$ is $v(0)$. Do this by dividing the problem up into two possible outcomes: no collision during the time interval $(0, t)$, or at least one collision in this same interval.

(b) From this and the equipartition theorem, calculate $\langle v_x(0)v_x(t)\rangle$.

(c) Define the current

$$I(t) = \frac{1}{L}\int j_x(\mathbf{r}, t)d^3r$$

where $j_x(t)$ is the current density. Write out the current density as the sum over the current density of the individual particles, and write the current density of a single particle in terms of its velocity and its density $n_i(\mathbf{r}, t)$. From this you should find a simple relation between I and the velocities of the individual particles.

(d) Using the above, calculate $\langle I(0)I(t)\rangle$. Remember to take into account the independence of different particles.

(e) Calculate

$$\int_{-\infty}^{\infty}\langle I(0)I(t)\rangle$$

and relate this the the resistance R of the wire.