Homework 2
Due 15 Sept 2005

1. In class we calculated the contact resistance when a narrow conductor with M modes is connected to two very wide contacts. If the number of modes in the contacts is not infinite, but some finite number, N, then the left-moving and right moving carriers inside the contacts have different electrochemical potentials, as shown in the figure below. Show that the contact resistance taking this into account is given by

$$R_c = (h/2e^2)[1/M - 1/N]$$

For further discussions on the nature of the contact resistance at different types of interfaces see Landauer (1989) *J. Phys. Cond. Matter*, **1**, 8099 and M. C. Payne (1989) *J. Phys. Cond. Matter*, **1**, 4931.

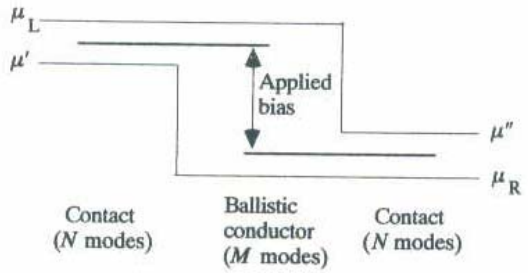

Fig. E.2.1. Spatial variation of the electrochemical potential for a ballistic conductor with *M* modes connected between two contacts having a finite number of modes (*N*).

2. Pure water has a dielectric constant of 80 in static electric fields but its index of refraction for visible light is 1.33. Calculate the ratio of the static to this high-frequency dielectric constant and account qualitatively for the discrepancy.

3. A large plane parallel capacitor is half filled with a uniform and homogeneous dielectric having the dielectric constant K. The conducting surfaces $x = -a$ and $x = a$ have potential V and $-V$ respectively, and $\varepsilon = \varepsilon_0$ where $-a < x < 0$, and $\varepsilon = K\varepsilon_0$ where $0 < x < a$.
   a. Find E and D where $-a < x < 0$.
   b. Find E and D where $0 < x < a$.
   c. Locate all charges and specify if they are real or polarization charges.