# ECE 656: Fall 2009
# Lecture 5 Homework

1) Work out the 1D ballistic conductance for finite temperature.

1a) Show that $\int_{\varepsilon_1}^{\infty} f_0(E)\,dE = \int_{\varepsilon_1}^{\infty} \frac{1}{1+e^{(E-E_F)/k_BT}}\,dE = k_BT\mathcal{F}_0(\eta_F)$

where $\mathcal{F}_0(\eta_F) = \ln\left(1+e^{\eta_F}\right)$

1b) Use the results of problem 1a) so show what $G_{1D} = \frac{2q^2}{h}\mathcal{F}_{-1}(\eta_F)$

1c) Show that $\mathcal{F}_{-1}(\eta_F) = e^{\eta_F}\big/\left(1+e^{\eta_F}\right)$

2) For single subband conduction, the diffusive conductance in 1D is

$$G_{1D} = \frac{2q^2}{h}\frac{\langle\lambda(E)\rangle}{L}\mathcal{F}_{-1}(\eta_F)$$

where

$$\langle\lambda(E)\rangle = \frac{\int_{\varepsilon_1}^{+\infty}\lambda(E)\left(-\frac{\partial f_0}{\partial E}\right)dE}{\int_{\varepsilon_1}^{+\infty}\left(-\frac{\partial f_0}{\partial E}\right)dE}$$

Assume power law scattering, $\lambda(E) = \lambda_0\left(E/k_BT\right)^r$ where *r* is a characteristic exponent that depends on the scattering physics. Work out an expression for $\langle\lambda(E)\rangle$ in terms of $\lambda_0$ and the characteristic exponent, *r*.

HINT: For the above two problems, you may find the following notes useful.

"Notes on Fermi-Dirac Integrals," 3rd Ed., by R. Kim and M. Lundstrom)
https://www.nanohub.org/resources/5475

3) Consider the conductance in the diffusive limit and under non-degenerate conditions. Assume that the energy dependent mean free path and mean scattering time can be written in power law form as

$$\lambda(E) = \lambda_0\left(E/k_BT\right)^r$$

Derive an expression for the mobility in terms of the pre-factor and the characteristic exponent.