NANO 705
Homework 1
Due: F-Jan. 27, 10:00 AM

Show all work. Use additional sheets. Use $kT = 0.025$ eV.

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1) A voltage difference $\Delta V = 0.50$ V applied across a straight, conducting rod produces a current $I = 9.0$ A.

a) Find the conductance of the rod.

b) The rod has cross-sectional area $a = 2.4 \times 10^{-4}$ m^2 and length $\ell = 0.64$ m. Find:

i) The average current density J (in A/m^2);

ii) The average electric field ε (in V/m);

iii) The conductivity σ [in $(\Omega \cdot \text{m})^{-1}$].

c) The conduction-electron density is $n = 1.0 \times 10^{28}$ m^{-3}. The electron mass is $m = 9.1 \times 10^{-31}$ kg.

Find:

i) The drift velocity v (in m/s);

ii) The relaxation time τ between collisions (in s).

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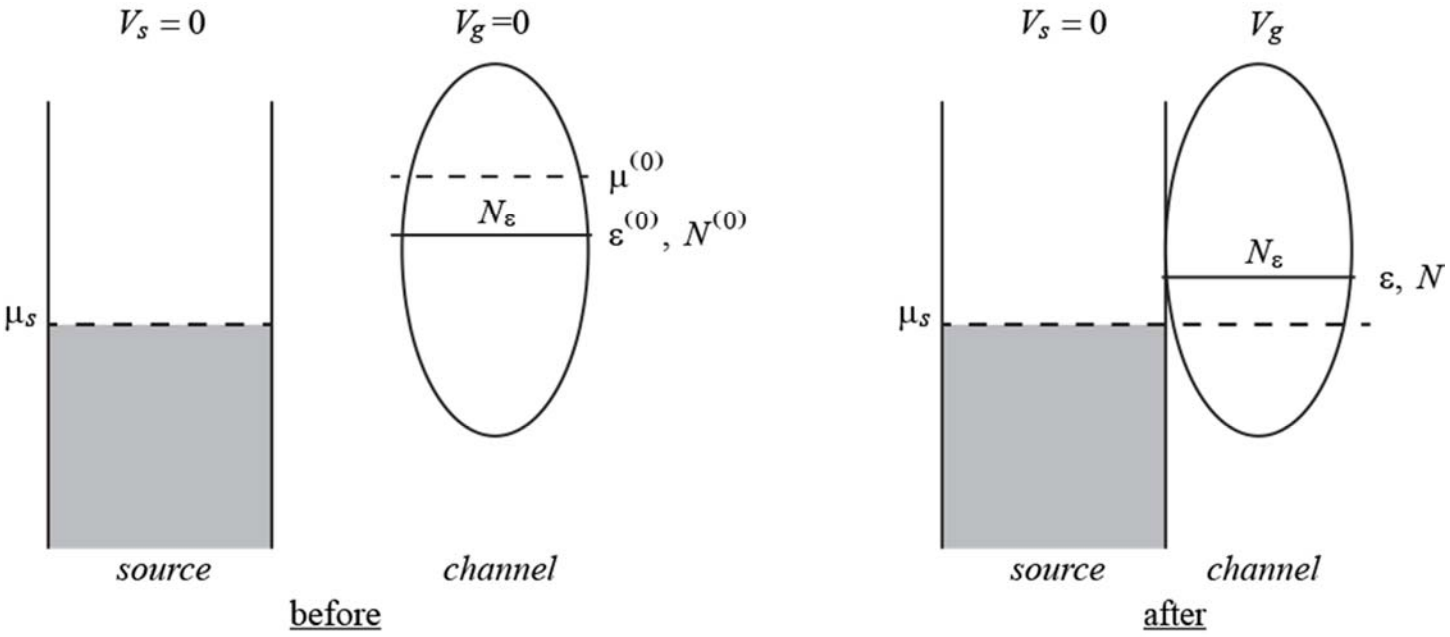
2) Consider the field-effect nanocapacitor show below before and after the source-channel contact is made.



The channel has a single (unbroadened) level with energy ε containing $N_\varepsilon = 10$ states.

The channel is initially neutral with $\varepsilon^{(0)} - \mu^{(0)} = -0.20$ eV, where $\mu^{(0)} - \mu_s = 0.50$ eV.

The gate is at potential V_g with respect to the source, which is grounded.

The electrostatic potential in the channel is $U = \left(N - N^{(0)}\right) \cdot U_p - U_L$

The single-electron charging energy is $U_p = 0.128$ eV.

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The change in channel potential due to the applied voltage is $U_L = (0.90) \cdot qV_g$.

The rate of carrier transport is $r = 5.0 \times 10^{12}\ \text{s}^{-1}$

a) Find the channel-to-source current formed *immediately* after the contact is formed, assuming $V_g = 0$.

b) The following gate voltages are applied:

i) $V_g = 0.50$ V; ii) $V_g = 0$; iii) $V_g = -0.50$ V

For each gate voltage, find:

A) the average number N of filled states in the channel;

B) the potential U (in eV) in the channel;

C) the position of the level $\varepsilon - \mu$ (where $\mu = \mu_s$).

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