NANO 705
Homework 6
Due: F-4/28, 10:00 AM

Show all work. Discuss results.

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1) Given the submatrices below of the hamiltonian matrix for a nanowire, find:

i) the matrix $\left[h(k)\right]$

ii) the energy eigenvalues (dispersion relations) $E^{(\ell)}(k)$

iii) the energy eigenstates $\left\{\psi^{(\ell)}\right\}$

iv) the group velocity for each band $v^{(\ell)}(k)$

v) the group-velocity matrix $\left[v(k)\right]$

a) $[\alpha]=[0]$, $[\beta]=\begin{pmatrix} t & 0 \\ 0 & -t \end{pmatrix}$ b) $[\alpha]=[0]$, $[\beta]=\begin{pmatrix} 0 & t \\ t & 0 \end{pmatrix}$

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2) The potential energy of an electron in a channel that is infinite in the *x* and *y* directions is related to the electron concentration $n(z)$ by:

$$\frac{d^2}{dz^2}U(z)=-\frac{q^2}{\varepsilon_r}\left[n(z)-n_0\right]$$

where n_0 is the concentration when the channel is neutral. Given the form of $U(z)$ below, find $n(z)$:

$$U(z)=-\frac{q^2}{\varepsilon_r}\cdot\left[\sum_{m=1}^{\infty}\left\{\frac{1}{2L}\cdot\left[\frac{L^2}{m^2\pi^2}\sin^2\left(\frac{m\pi z}{L}\right)+z\cdot(z-L)\right]\cdot f_{2D}\left(m^2\cdot\varepsilon_1-\mu\right)\right\}-\frac{1}{2}\cdot n_0\cdot z\cdot(z-L)\right]$$

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3) Consider the nanotransistor with grounded source/drain, having symmetric gate contacts (Fig. 7.2.2), with $\varepsilon_r=5$, $m_c/m_0=0.30$, $L_z=5$ nm. Plot the electron concentration $n(z)$ for each of the following:

a) $V_g=0.20$ V b) $V_g=0.40$ V c) $V_g=0.60$ V