ECE236C Spring 2009
Homework Set #1

Handed out: Apr 2 Due: Apr 14

Problem 1

1) Consider the simplified small-signal model of an HFET shown in figure 1 below. Derive the Y parameters associated with this structure in terms of the element values.
2) Discuss how the element values can be obtained based on measurements of Y parameters vs frequency.
3) Derive the Z parameters for the structure.
4) Derive the Y parameters for the circuit of figure 2 (which now has a gate resistance).

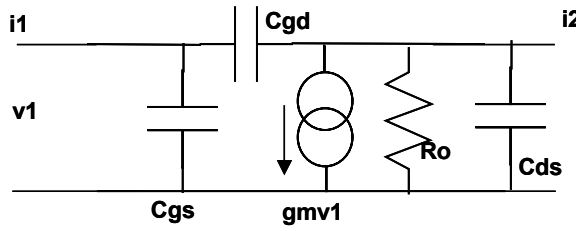

Figure 1

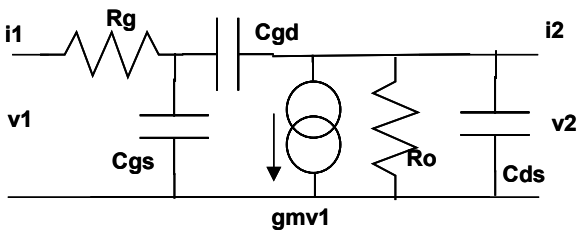

Figure 2

Problem 2

Consider a Heterostructure Field Effect Transistor whose channel (after gate recess) has the following structure:

AlGaAs	Doped layer	xAl=0.28	Nd=2e18cm-3	30 nm
AlGaAs	Spacer layer	xAl=0.28	Nd=0	2 nm
GaAs	Buffer layer&channel		Na=5e14cm-3	500 nm
GaAs	Substrate		Na=5e14cm-3	100 um

(Note the buffer layer and substrate concentrations correspond to an idealized situation, for simplicity).
A Schottky gate is applied, with a built-in potential of 0.75 eV.

1) Using analytic formulations, estimate the threshold voltage for channel conduction.
2) Using the 1D Poisson solver program, without quantum effects, determine the threshold voltage. (You may down Greg Snider's 1D Poisson-Schrodinger solver from our course web-site.)
3) Plot the band diagram at the following biases between gate and channel: 0V, +0.5V, -1V, -2V. Please include the fermi level in the metal and in the channel in your plot. You may focus on the conduction band only in the plot in order to show details with better resolution. But do not neglect the valence band! For negative

voltages you must be wary of how the 1D solver includes holes. Include statements of *no holes* where appropriate (and show the effect of doing so).
4) Plot the density of carriers in the 2DEG as a function of bias; determine the effective maximum channel carrier density. Plot also the number of carriers in the AlGaAs barrier layer as a function of bias.
5) Calculate the effective gate-channel capacitance from the density vs bias. Is the result reasonable?

Problem 3
1) For the same structure given in problem 1, use the Schrodinger solver to determine the energy levels of the 2D electron gas, for a bias voltage of -0.5V.
2) Plot the wavefunction magnitude squared for the two lowest energy subbands.
3) For representative additional voltages, compute and discuss the energy levels of the lowest subbands.
4) Compare the values of channel carrier density obtained with the quantum mechanical calculations with those obtained in the classical computations of Problem 1.