EE-612 EXAM 2: Fall 2006 Hand out: Nov 1, 2006

Due. Mon. Nov. 6

NAME______________________________ ID # ________________________________

This is a **take home exam**. **It is to be your work and your work alone**. It will be handed out on Wed, Nov. 1 in class. Class will meet on Friday, Nov. 3 to address any questions or corrections.

You should hand in the exam at the beginning of class on Monday, Nov. 6.
Prior to coming to class, e-mail all Matlab scripts used for the exam to hpal@purdue.edu.
The name of Matlab scripts should contain your name, and lines should be clearly commented.
All Matlab scripts must be received before 2:30PM, Monday, Nov. 6.

You are not permitted to speak with or receive help of any sort from anyone. Any case of cheating (which includes either receiving or giving help) will be dealt with severely.

It is important that you CLEARLY show your work on the material that you hand in.
If we have trouble understanding what you did, the problem is yours, and there will be NO REGRADES. You will receive no credit for your answer, unless it is clear how you obtained the answer.

Scoring:

Part 1:	**20 points**
Part 2:	**20 points**
Part 3:	**20 points**
Part 4:	**20 points**
Part 5:	**20 points**

No exams will be accepted unless the following statement is signed.

I certify that this work is mine and mine alone. I have not discussed any portion of this exam with anyone.

Signature:______________________________ Date:____________________

Part I

In Lecture 12, I argued that the following equation,

$$I_D = q\frac{W}{L_{eff}}\left(\frac{n_i^2}{N_A}\right)\frac{(k_BT/q)^2}{E_S}\mu_{eff}e^{q\psi_S/k_BT}\left(1-e^{-qV_{DS}/k_BT}\right) \quad (1)$$

could be used to describe a MOSFET both below **and** above threshold. **Clearly describe a step-by-step procedure** that someone could use to write a computer program to compute $I_D(V_{GS,}V_{DS})$ for a MOSFET with uniform channel doping and no polysilicon depletion. The procedure should be continuous (i.e. you should not use a different treatments for above and below threshold.

You will need to make some assumptions; be sure to clearly identify them.

This approach will probably produce a high V_{DS} current that is too small. Explain why.

Part II

To actually compute the *I-V* characteristic, you will need to **specify some physical parameters**. Use the 2005 edition of the ITRS to specify the parameters for a 300K simulation of a 70nm node high-performance n-MOSFET. If there are parameters that are not available in the ITRS, determine a reasonable value for them. Clearly explain where each parameter you specify comes from (i.e. identify the specific chapter and table in the ITRS).

Part III

Write a Matlab script that follows the procedure described in part I and computes log10 I_D vs. V_{GS} for V_{DS} = 0.05V and V_{DS} = 1.1V. You should hand in the plots and the clearly documented Matlab script.

Part IV

Repeat part III, but for a **ballistic MOSFET** with $m^* = 0.19m_0$. You should explain how you modified the script for ballistic transport, hand in the plots, and hand in a clearly documented Matlab script.

Part V

Some people determine the threshold voltage from a plot of I_D vs. V_{GS} at low V_{DS} using a linear y-axis, and some people do it from a log10 I_D vs. V_{GS} plot by determining the gate voltage need to achieve a specific current.

a) Use your Matlab script from Part III to determine V_T(lin) from the linear plot.

b) Show where V_T(lin) falls on the log I_D vs. V_{GS} plot. Also show where the classical V_T for $\psi_S = 2\psi_B$ falls.

c) Show where V_T(lin) falls on a plot of g_m/I_D vs. V_{GS} where $g_m = \partial I_D/\partial V_{GS}\big|_{V_{DS}}$.

NOTE: If you were not able to complete Part III, use the I_D vs. V_{GS} data in the Appendix for this problem.

Appendix

I_D [A/µm]	V_G [V]
5.60e-009	4.10e-001
8.20e-009	4.24e-001
1.20e-008	4.38e-001
1.76e-008	4.51e-001
2.58e-008	4.65e-001
3.78e-008	4.78e-001
5.54e-008	4.92e-001
8.11e-008	5.06e-001
1.19e-007	5.19e-001
1.74e-007	5.33e-001
2.55e-007	5.47e-001
3.73e-007	5.61e-001
5.46e-007	5.76e-001
7.98e-007	5.91e-001
1.17e-006	6.07e-001
1.70e-006	6.24e-001
2.47e-006	6.42e-001
3.58e-006	6.63e-001
5.17e-006	6.88e-001
7.42e-006	7.17e-001
1.05e-005	7.53e-001
1.48e-005	7.99e-001
2.06e-005	8.58e-001
2.81e-005	9.34e-001
3.77e-005	1.03e+000
4.97e-005	1.16e+000