# COLLEGE OF ENGINEERING & TECHNOLOGY

**Department: Electronics and Communications Engineering**
**Instructor: Dr. Amr Bayoumi**
**Course Title: Advanced Devices Fall 2014**
**Course No.: EC738 Sheet 5**
**Date: Jan. 4, 2014**

## Short Channel MOSFETs

For 130nm NMOS technology, the device parameters are:
$u_0 = 1.35x10^{-2}\ m^2V^{-1}sec^{-1}$, $v_{sat} = 1.3x10^{5} m/sec$, $n = 2$ for mobility equation.
$t_{ox} = 3nm$, $N_A = 9x10^{17}\ cm^{-3}$, $x_j = 35nm$, Gate workfunction = 4.05 eV.

Assume: $L_{metallurgical} = L_{gate} - 2*0.3*xj$

---

**Question 1**

Assume Vds=Vgs=1.3V, and Lgate=200m.

a) Find the saturation voltage $V_{dsat}$ (approximate with Long Channel value)
b) Find the field at the end of the inversion channel, $E_{sat}$ . Approximate potential with a straight line, and $L_{channel} \sim L_{metallurgical}$
c) Find the decrease in inversion channel length due to saturation using the 1D model
d) Repeat part c using the 2D model
e) Improve part b using the new channel length obtained from 1d.
f) Improve 1d (again) using the results of 1e.
NOTE: *The results of 1e and 1f are the ones to be used in the rest of Sheet 5 and Sheet 6*.
g) Find the electron velocity at the end of the inversion channel.
h) Find the effective mobility, ignoring the vertical effective field effect on mobility
i) Find the vertical effective field in the channel

---

**Question 2**

*Use the Charge Sharing Model*

a) Find threshold voltage dependence on L for Lgate=200nm and 1um, for $V_{ds}$ = 100mV and $V_{ds}$=1.3V (*Figure 3.19a*).
b) Plot the threshold voltage dependence on Vds for between $V_{ds}$ = 100mV and $V_{ds}$=1.3V, for Lgate = 200nm and Lgate=1μm.

---

**Question 3**

a) Repeat Question 3 using equations 3.67-3.68, p.182-183
b) Tabulate the results for Vth with those obtained using the charge sharing model

---

**Question 3**

***Hint:*** *use the results from Questions 1 and 3*

a) Plot the $I_{ds}/W$ vs. $V_{ds}$ between $V_{ds}$ =0 to 1.3V, $V_{gs}$ = 0.7V and 1.3V for Lgate=1μm.
b) Plot the $I_{ds}/W$ vs. $V_{ds}$ between $V_{ds}$ =0 to 1.3V, $V_{gs}$ = 0.7V and 1.3V for Lgate=200nm.

**Hint:** *Differentiate when there is pinchoff but not velocity saturation in the inversion channel (Channel Length Modulation needs to be taken into consideration for any W/L relationship)*

---

## Question 4

***Hint:*** *use the $V_{th}$ results from Question 1, and Eqn. 3.40-3.41*

For the following 4 cases:

a) Lgate = 1um, $V_{ds}$ = 100mV, $V_{gs}$ = 1.3V.
b) Lgate = 1um, $V_{ds}$ = 1.3V, $V_{gs}$ = 1.3V.
c) Lgate = 200nm, $V_{ds}$ = 100mV, $V_{gs}$ = 1.3V.
d) Lgate= 200nm, $V_{ds}$ = 1.3V, $V_{gs}$ = 1.3V.

- Find $I_{ds\ OFF}$ and subthreshold slope
- Find the off-state power dissipation between source & drain