Exam 1

ECE 559: MOS VLSI Design (Fall 2009)

ECE Department, Purdue University

October 1, 2009

Name: ______________________________

PUID: ________________________

Instructions: It is important that you clearly show your work and mark the final answer clearly, closed book, closed notes, no calculator.

Time: 1 hour 15 minutes

Scoring

Problem 1 (Total 30 points)

Part a) 15 points _____

Part b) 15 points _____

Problem 2 (Total 30 points)

Part a) 15 points _____

Part b) 15 points _____

Problem 3 (Total 40 points)

Part a) 30 points _____

Part b) 10 points _____

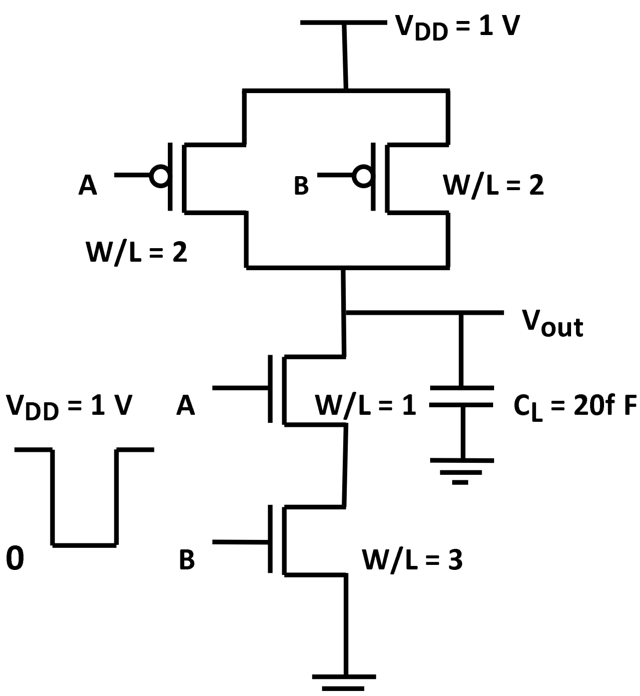
Total: 100 points _______

Problem 1: For the circuits and conditions given below, determine the energy dissipated. Clearly specify your assumptions, if any.

[30 points]

Part a) Inputs A and B are switching simultaneously from **V_{DD} to 0 followed by 0 to V_{DD}**. Assume V_{out} = 0 initially.

[15 points]



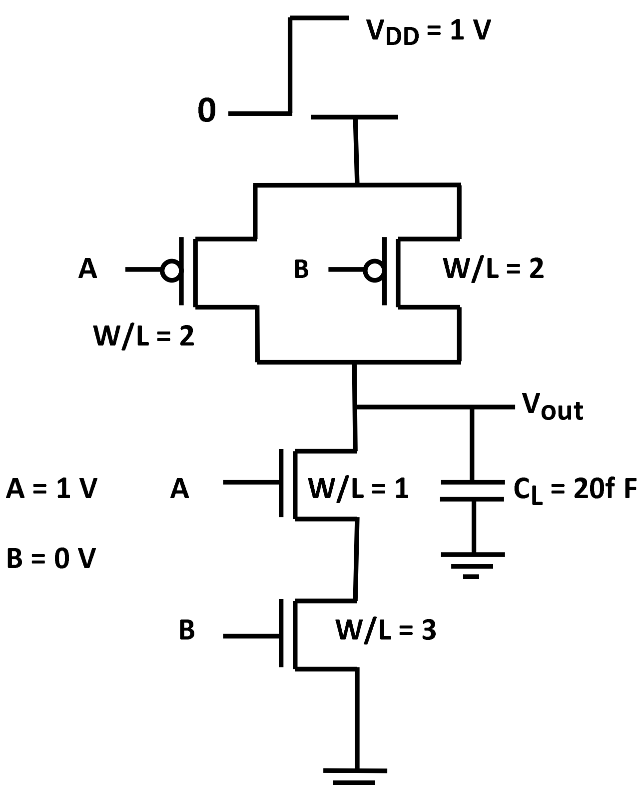
$K_p' = \mu_p C_{ox} = 30e\text{-}6\ A/V^2$

$K_n' = \mu_n C_{ox} = 60e\text{-}6\ A/V^2$

$V_{tp} = -0.3$ V, $V_{tn} = 0.3$ V

Part b) The voltage at the supply terminal is switching from **0 to V_{DD}**. Assume A = 1 V and B = 0.

[15 points]



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$K_n' = \mu_n C_{ox} = 60e\text{-}6\ A/V^2$

$V_{tp} = -0.3$ V, $V_{tn} = 0.3$ V

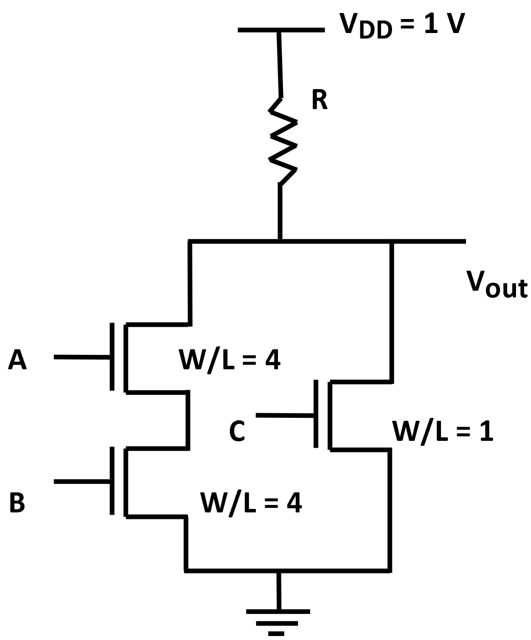
Problem 2:

[30 points]

Part a) For the circuit shown below, find the **minimum value of R** so that V_{OL} = 0.2 V. V_{OL} represents the output low voltage. Clearly state all of your assumptions.

What will be the V_{OH}? V_{OH} represents the output high voltage. Explain your answer.

[15 points]



$K_n' = \mu_n C_{ox}$ = 40e-6 A/V^2

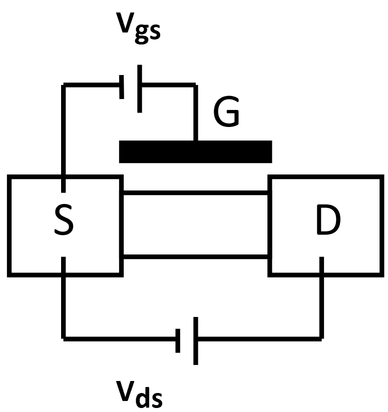
V_{tn} = 0.3 V

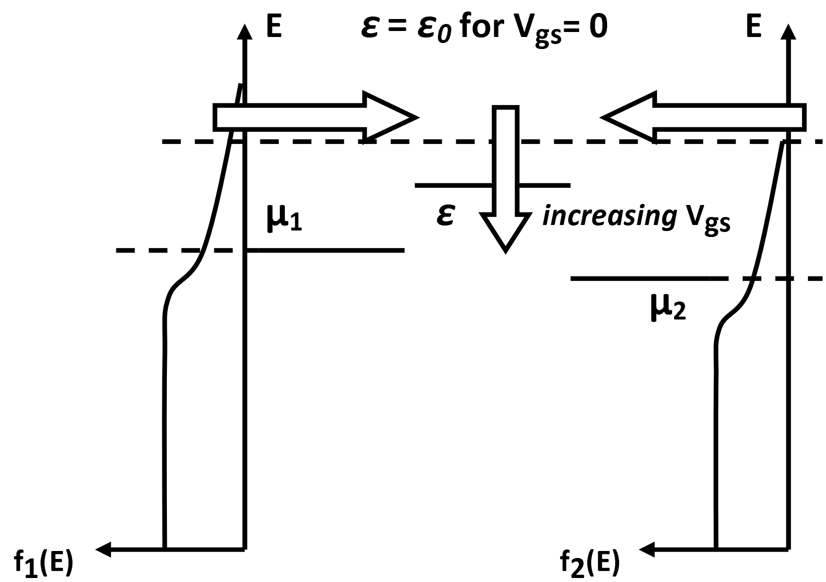
Part b) For the part a), explain qualitatively the **result of body effect** on V_{OL} and V_{OH}.

[15 points]

Problem 3:

[40 points]





Part a) For the NMOS shown above, derive an **expression of electron current** flowing from source (S) to Drain (D). μ_1, μ_2 are electro-chemical potential energies at the source and drain terminals, respectively. The Fermi distribution function *f(E)* specifies, under equilibrium conditions, the probability that an available state at an energy E will be occupied by an electron.

$$f(E) = \frac{1}{1 + e^{\frac{(E - E_F)}{KT}}}$$

where E_F is the Fermi level. Clearly show your steps, specify your assumptions, and name the parameters you are using.

[30 points]

Part b) Explain qualitatively the **effect of Drain Induced Barrier Lowering (DIBL)** on the current that you have derived in part a).

[10 points]

Rough Sheet 1

Rough Sheet 2