ECE 3200 Electronics II
Summer I 2012
EXAM 2

NAME: _____

INSTRUCTIONS:

1. **THIS EXAM IS CLOSED BOOK AND CLOSED NOTES** other than one-side of a 3"x5" note card. Write your name on the unused side of the card. **Turn your card in with the exam.**
2. You may use an approved calculator; **NO OTHER ELECTRONIC DEVICES ARE ALLOWED**.

   CALCULATOR MANUFACTURER: _____

   CALCULATOR MODEL: _____
3. Work each problem in the provided space.
4. Show ALL work required to arrive at a solution for either full or partial credit.
5. READ the entire question before answering.
6. CIRCLE YOUR ANSWERS.
7. Have your student ID on your desktop for inspection by the instructor.
8. SIGN the honesty pledge at the bottom of the page. Exams without a signature will receive no credit.

I have neither given nor received assistance from anyone in regards to completion of this exam. I have followed the instructions as provided on this sheet.

SIGNATURE: _____ DATE: _____

References

[1] K. C. Smith, *Laboratory Explorations for Microelectronic Circuits Fourth Edition*, Oxford University Press, 1998.

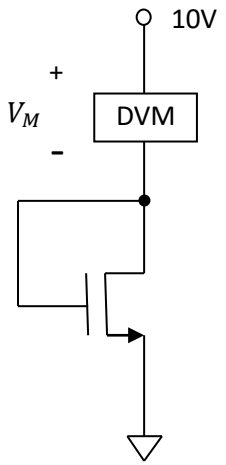
Note: some problems might be adapted from the course text or other sources. Schematics prepared using LTspice IV (linear.com).

Maximum exam score is 45 points.

1. (5 points) Using a graph, illustrate why the transconductance g_m of an NMOS transistor is POSITIVE and the transconductance g_m of a PMOS transistor is NEGATIVE.

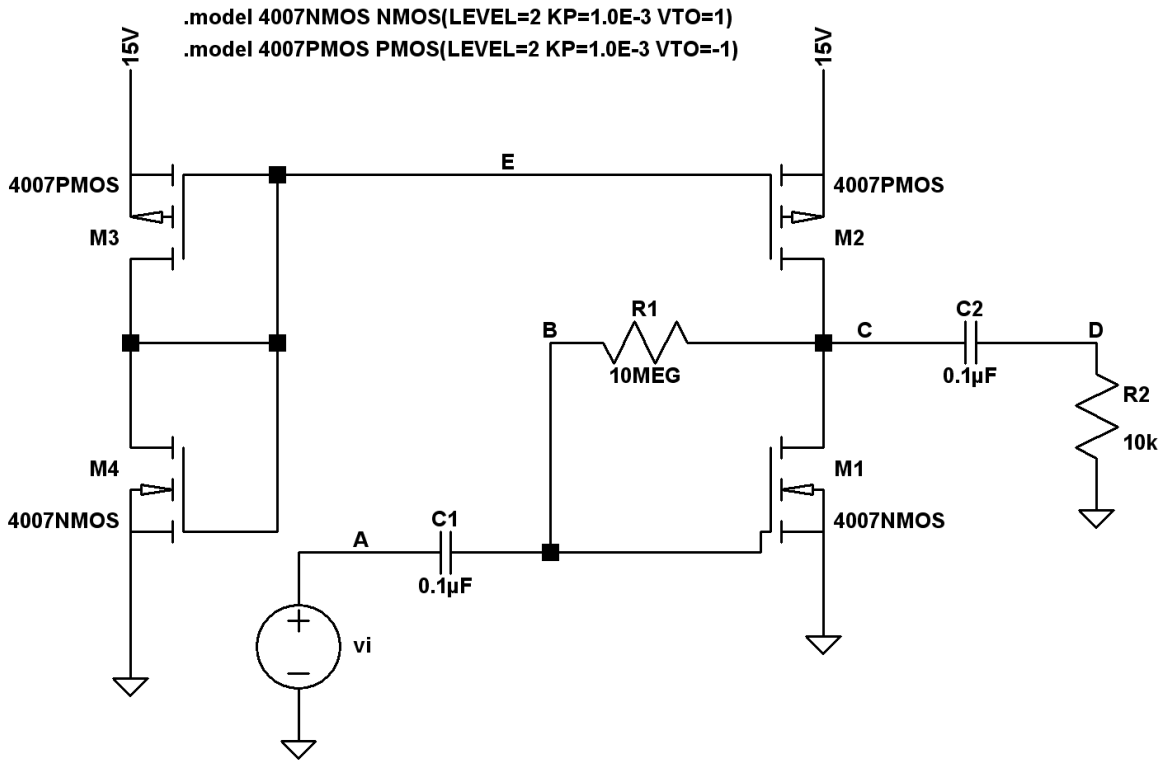
2. (5 points) Using a graph, illustrate the effect of the Early voltage $V_A = \frac{1}{\lambda}$ on the i_D vs. v_{DS} curves for a NMOS transistor.

3. (5 points) Consider the following circuit (adapted directly from [1]). Assume that the meter reads V_M=9V. What is the MOSFET threshold voltage V_{tn}? Carefully justify your answer using a graph.



4. (15 points) Consider the following circuit adapted directly from [1]. Assume that the transistors are in the saturation region.

   a. Conduct a DC analysis. Assume the transistors are matched. Find the DC voltages at nodes A, B, C, D, and E. Note that $k_n = k_p = 1$ mA/V^2 (includes W/L), $V_{tn} = 1$V, and $V_{tp} = -1$V. Ignore the channel-length modulation effect (λ=0).
   b. Draw the small signal equivalent circuit assuming that the capacitors are shorts at the frequencies of interest and ignoring the channel-length modulation effect (λ=0).
   c. Find the small signal voltage gain v_d/v_i.



5. (15 points) Consider the following circuit adapted from [1] where

$$\left(\frac{W}{L}\right)_8 = \left(\frac{W}{L}\right)_5 = \left(\frac{W}{L}\right)_7 = \left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = \left(\frac{W}{L}\right)_3 = \left(\frac{W}{L}\right)_4 = 1 \text{ and } \left(\frac{W}{L}\right)_6 = 2.$$

Assume that the transistors are in the saturation region, $k_n' = k_p' = 1$ mA/V^2 (does NOT include W/L), $V_{tn} = 1$V, and $V_{tp} = -1$V. Find the small signal voltage gain v_f/v_{id} where $v_{id} = (v_a - v_b)$. Ignore the channel-length modulation effect (λ=0) in the DC analysis. For the AC analysis let |λ|=1/(50V).