Name: ______________________________

SID: ______________________________

Name of student at your left:
______________________________ (1 point)

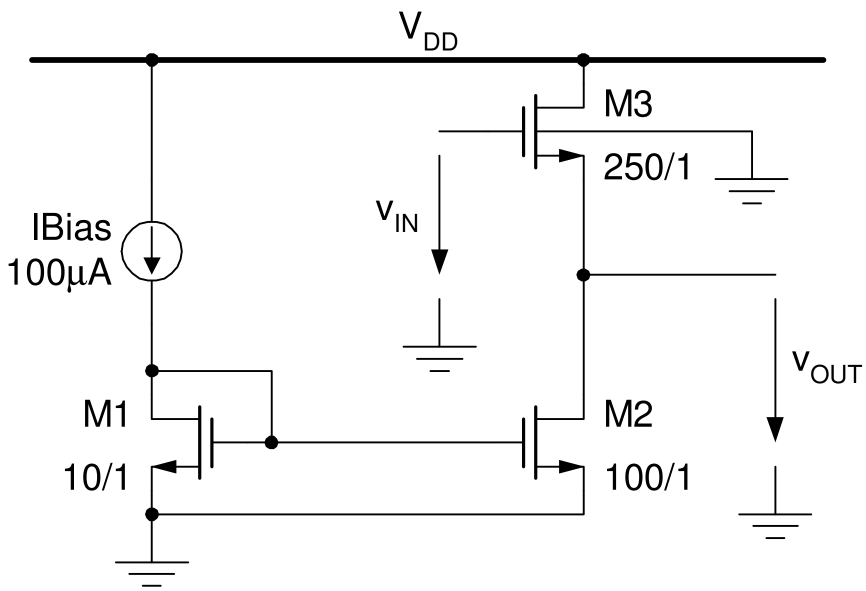
Name of student at your right:
______________________________ (1 point)

UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering
and Computer Sciences

	Midterm 2	**EECS 105**
B. E. BOSER	**October 26, 2004**	**FALL 2004**

- *Closed book, closed notes.*
- *No calculators.*
- *Copy your answers into marked boxes on exam sheets.*
- *Simplify numerical and algebraic results as much as possible.*
  Up to 5 points penalty for results that are not reasonably simplified.
- *Mark your name and SID at the top of the exam and all extra sheets.*
- *Be kind to the graders and write legibly. No credit for illegible results.*

Problem 1 [25 points]



Given: $\mu_n C_{ox}$ = 200μA/V^2, V_{TN}=1V, λ_n=0.01V^{-1} @ L=1μm
$g_m r_o >> 1$
The circuit is biased such that all transistors are in saturation.

a) [10 points] Find *numerical* values (not expressions) for:

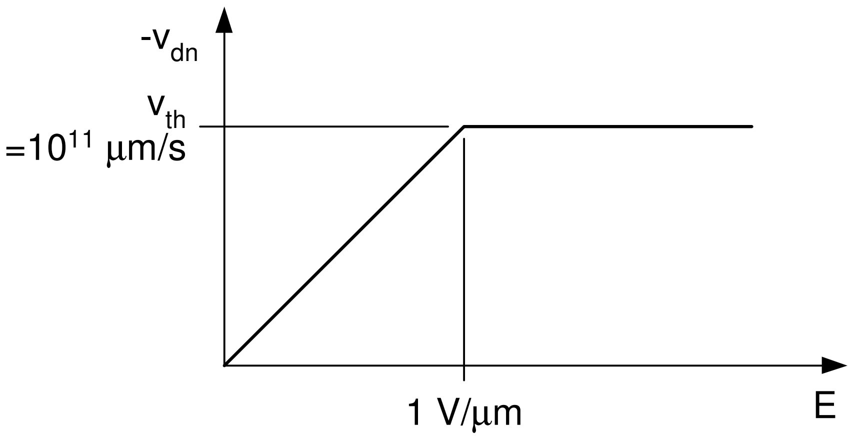
I_{D3} =	μA

g_{m3} =	μS

b) [15 points] Find an *algebraic* expression for the small signal output resistance (at terminal v_{OUT}) of the circuit as a function of transistor small-signal parameters. Use $g_m r_o >> 1$ to simplify your result as much as possible:

$r_{out} =$

Problem 2 [25 points]



The above sketch shows a rough approximation of the electron drift velocity versus the electrical field in Silicon. For an NMOS transistor with L=0.1µm, W=10µm, and C_{ox}=5fF/µm^2 calculate the following:

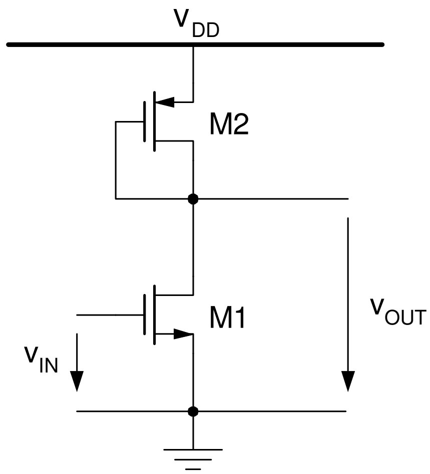
a) [10 points] What is the minimum V_{DS} (*numerical* value) for which current flow is limited by the thermal carrier drift velocity? Assume that the field in the channel is uniform.

V_{DS} =	V

b) [15 points] Find the *numerical* value of the maximum drain current I_D for V_{GS}-V_{TH}=1V. Hint: get the current from the channel charge and its velocity.

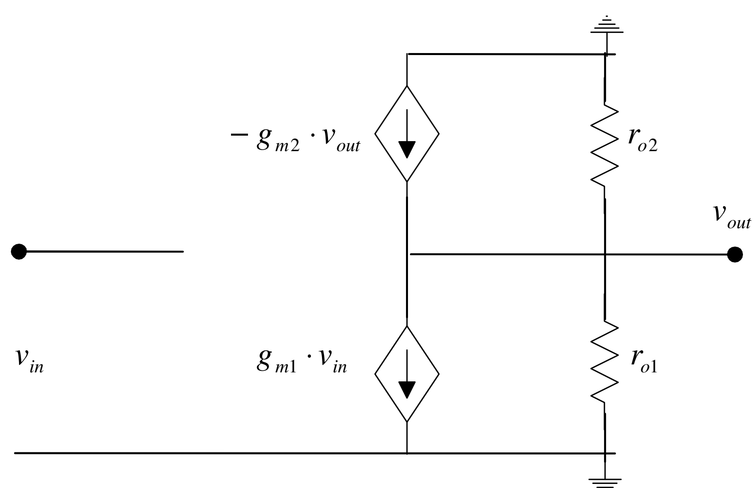
$I_D =$	mA

Problem 3 [25 points]



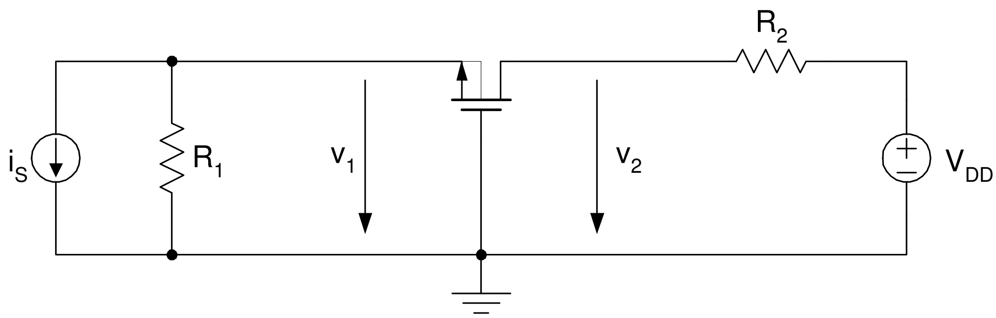
The circuit shown above is biased so that all transistors are in saturation. Draw a small signal model (label all elements with appropriate symbols, e.g. g_{m1}, r_{o2}) and find an *algebraic* expression for the small-signal voltage gain $a_v = v_{out}/v_{in}$ as a function of small-signal parameters (g_m's and r_o's). Use $g_m r_o >> 1$ to simplify your result.

Small-signal model (neatness counts) [13 points]:



$a_v =$

Problem 4 [23 points]



The circuit shown above is biased so that the transistor is in saturation.

a) [8 points] What is the type of this amplifier?

Common ____

b) [15 points] Find an *algebraic* expression for the small-signal voltage ratio v_2/v_1 for i_s=0 as a function of R_1, R_2, and transistor small-signal parameters.
Hint: you may find small-signal model very helpful to answer this question.

v_2/v_1 =