University of California
College of Engineering
Department of Electrical Engineering
and Computer Sciences

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TuTh 2-3:30

Thursday, November 9, 6:30-8:00pm

EECS 105: FALL 06 — MIDTERM 2

NAME	Last First

SID	

Problem 1 (7):

Problem 2 (8):

Problem 3 (10):

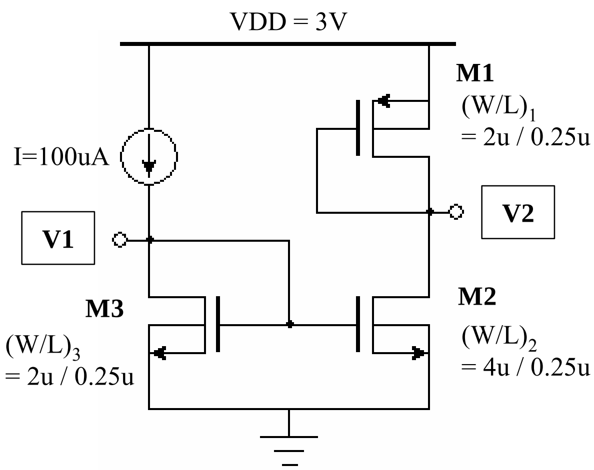
Total (25)	

Important Notice:
To get credit for a problem or sub-problem, it is essential for you to show the steps you took to get to the answer. No credit will be given if you just show the answer without any further explanation.

PROBLEM 1: MOS Transistors (7 pts)

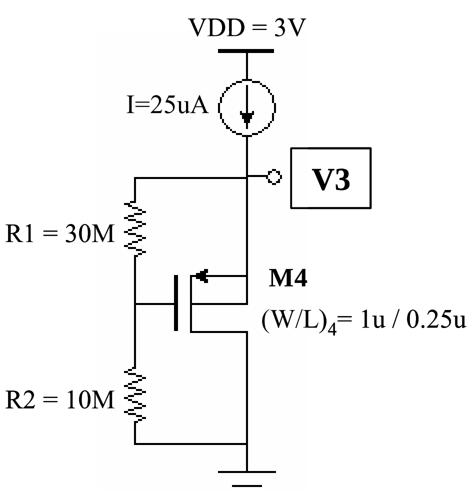
Calculate voltage V1, V2, V3, and V4, and specify the operation region of all the transistors. You must clearly show the procedure / proof of your answer.
k_n = 100uA/V^2, k_p = 50u A/V^2 , V_{tn} = 0.5V, V_{tp} = -0.5V, $\lambda_{n,p}$=0

a. **(4 pt)**



V1 =
V2 =

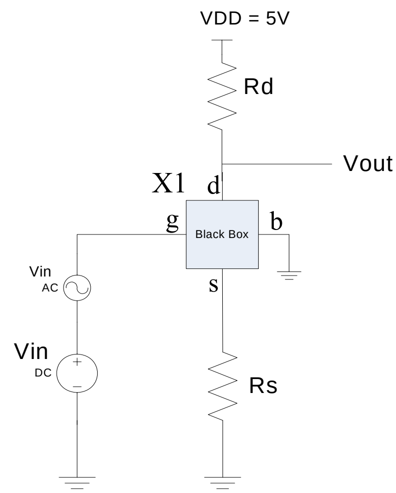
b. **(3 pt)**



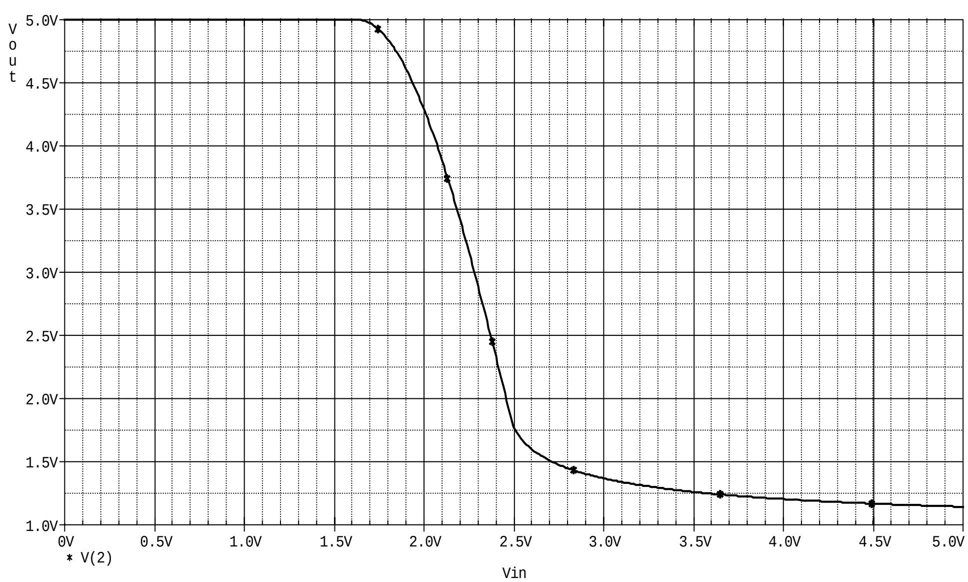
V3 =

PROBLEM 2: Amplifiers (8 pts)

Last week, while cleaning the office, we stumbled onto a board that contains a mystery amplifier, as shown in the picture below. One thing we could easily figure out the values of the resistors, being Rd = 35 KΩ , and Rs = 20KΩ.

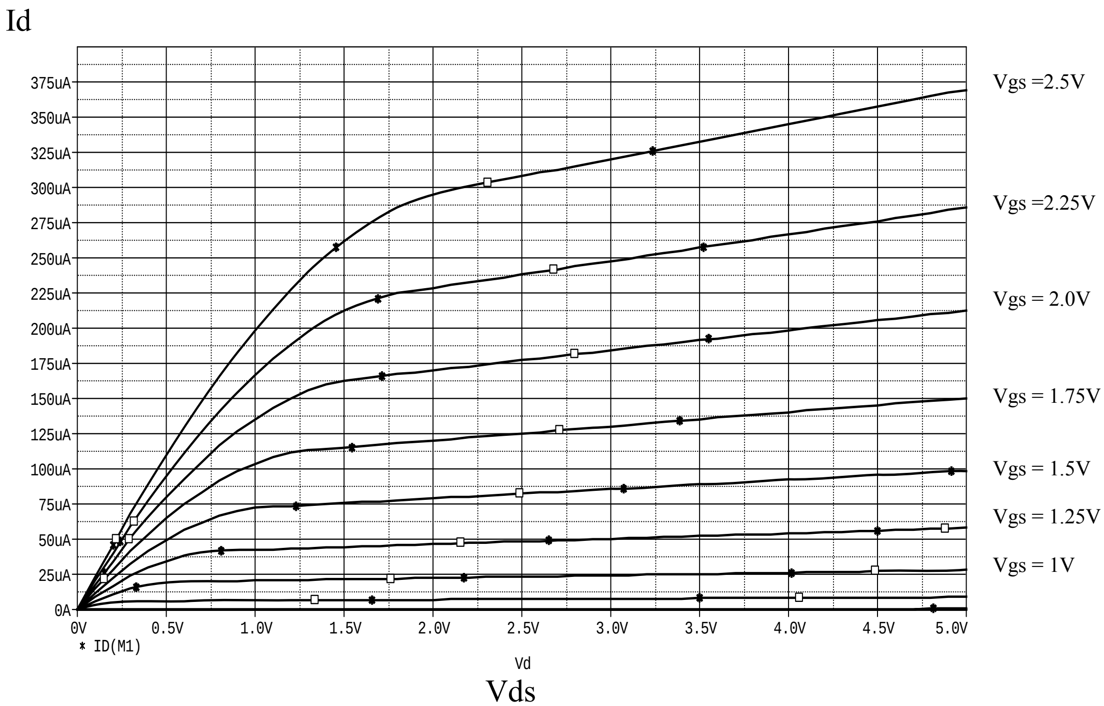


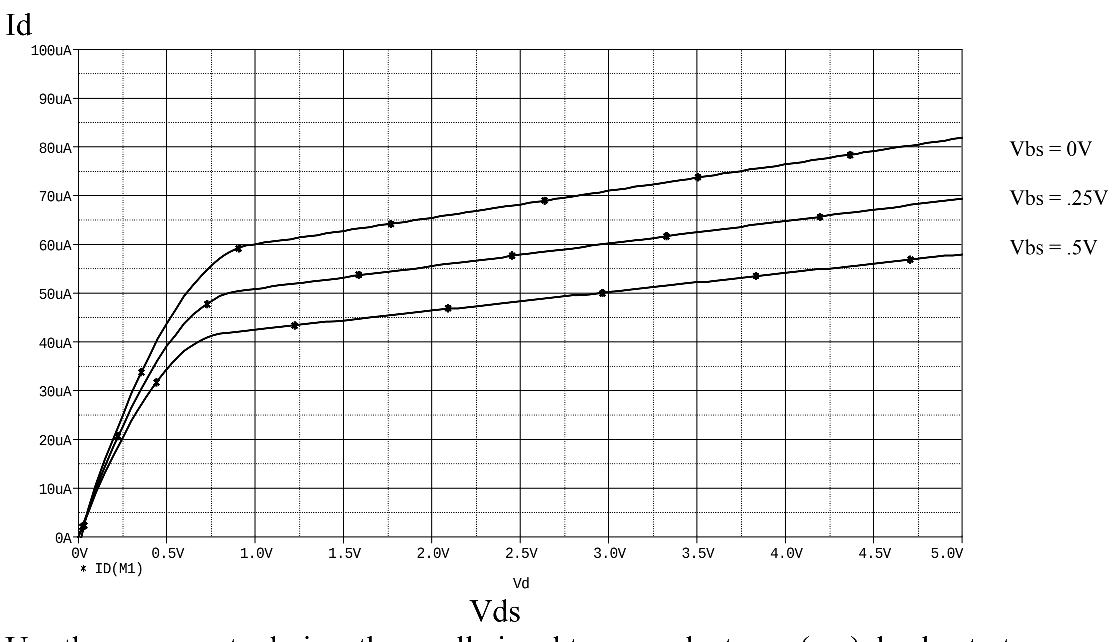
a. Using a sweep of the input voltage Vin, we plotted the input-output relationship of the amplifier as shown below. From this plot, determine (approximately) what operation point (as expressed by the bias voltage Vin) would achieve the highest linear output swing while still giving high gain. What is the low-frequency gain at this point? **(2 points)**



Vin =
A(Vin) =

b. Putting the 4-terminal "black box" device X1, which is at the core of the amplifier, on our advanced measurement equipment, we managed to extract some interesting curves, shown below. This surely looks like an MOS transistor (hence we will assume it is one, albeit with some strange deviations**). (3 points)**





Use these curves to derive, the small-signal transconductance (gm), backgate-transconductance (gmb), and output-resistance (ro) of the device at the operational point derived in **a**. You may assume that the input resistance (ri) is infinite.

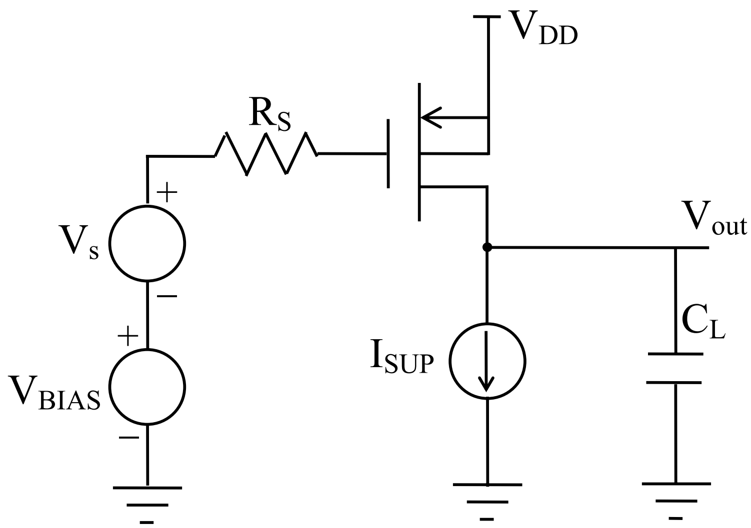
gm=
gmb =
ro =

c. Given what you obtained from the above, draw the small signal model of mystery amplifier. Determine its input and output resistance in the operation point. **(3 points)**

rin=
rout =

PROBLEM 3: Frequency Response (10 pts)

A p-channel common-source amplifier is loaded with a capacitor C_L as shown in the figure**. The main design goal is to achieve a 3-db bandwidth ω = 200 Mrad/sec and a low-frequency gain amplitude of 25.**
Assume the transistor is biased to operate in the saturation region and the DC output current is zero. Using the following parameters for your calculation: $\mu_p C_{ox} = 25\mu A/V^2$, $L = 2\mu m$, $\lambda_p = (0.1/L)V^{-1}$, where L is in μm, $r_{oc} = \infty$, $R_s = 100\Omega$, $C_L = 50fF$. For the rest of the question**, ignore all the internal capacitances** of the transistor.



a. Draw the small signal model of the amplifier. (1 point)

b. Derive an analytical expression for the transfer function V_{out}/V_s as a function of frequency. **(2point)**

Vout/Vs -=

c. Based on the above, derive the value of the bias current I_{SUP} so that a **3-db frequency of 200 Mrad/sec** is obtained. **(4 point). (Derive an expression of the 3db point first)**

I_{SUP} =

d. Size the transistor width W so that the **low frequency gain amplitude requirement of 25** is met. **(3 points)**

W =