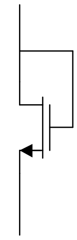
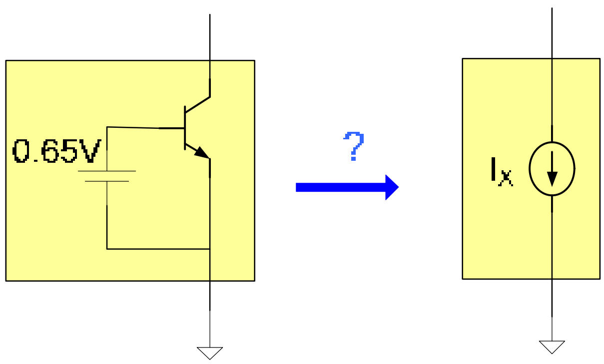
EE 434
Homework 6
Fall 2005

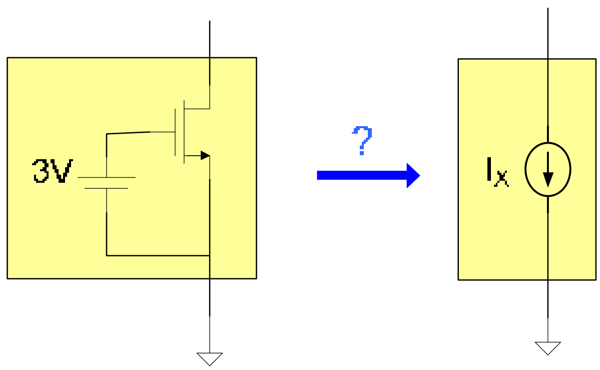
Unless stated to the contrary, assume all problems refer to the AMI 05u CMOS process available on the MOSIS WEB site

Problem 1 Consider the gate-drain connected circuit shown
a) Obtain an expression for and plot the I-V characteristics of this device
b) If the MOSFET shown is operating in the saturation region, determine the small signal equivalent circuit of the resultant two-terminal device.



Problem 2 The circuits shown have been proposed as current sources. If so, what are the currents and how good of current sources are they? Answer this question first under the assumption that $\lambda=0$ and $V_{AF}=\infty$ and then answer the same question if $\lambda=.01V^{-1}$ and $V_{AF}=100V$. State typical values for any other device parameters that are needed. Assume W=5u and L=1u for the MOSFET and $A_E=50u^2$ for the BJT.





Problem 3

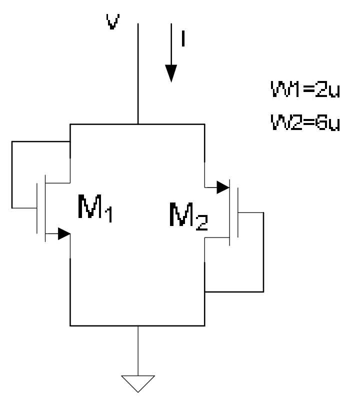
a) If a quiescent current of I = 100uA is flowing in the circuit shown, determine V.

b) Determine the small signal equivalent circuit at the Q-point determined in part a)

c) Plot I versus V using the square law model for the devices and from the slope and intercept at the Q-point determined in a), relate these results to the small signal equivalent circuit obtained in part c)

d) Using H-SPICE, repeat part c) with the level 49 model and compare the results with those obtained in part c)

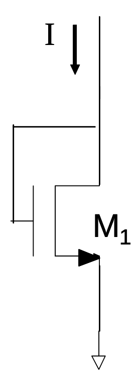
e) Comment on how the device will perform as a resistor if rather large signals are applied



Problem 4

a) If L=2u, determine W for the circuit shown so that the small signal equivalent circuit of this agrees with that of the previous problem at a quiescent current of I = 100uA

b) Quantitatively compare the linearity and signal swing of this "resistor" to that of the previous circuit.

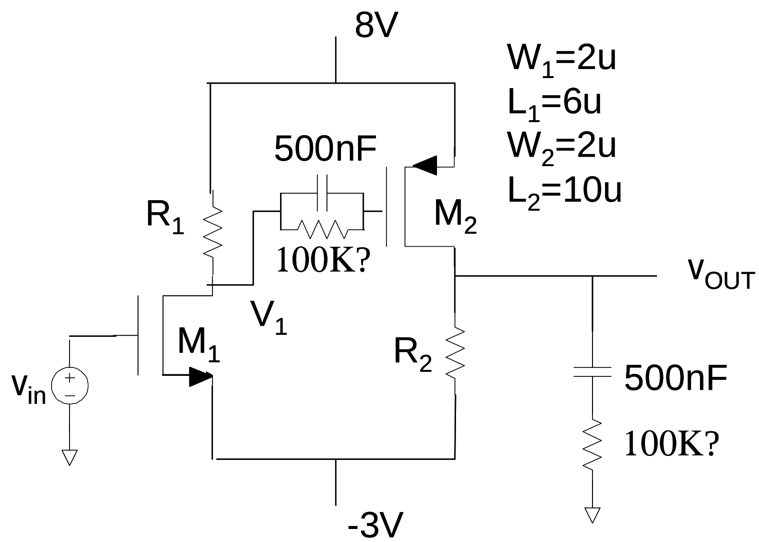


Problem 5

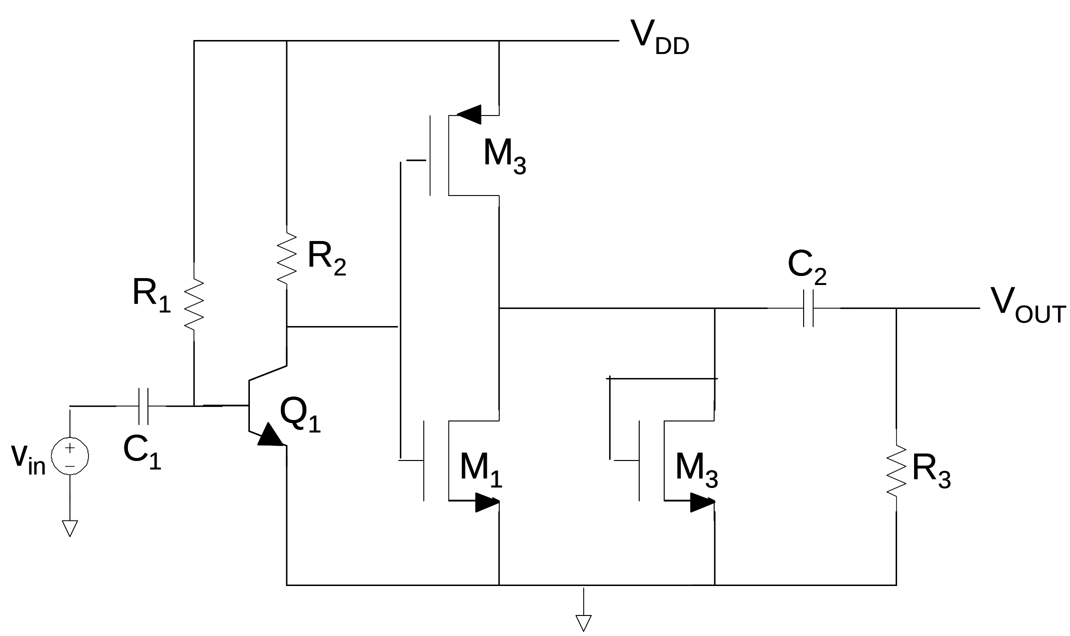
a) Determine R_1 so that V_{1Q}=5V

b) Determine R_2 so that V_{2Q}=2V

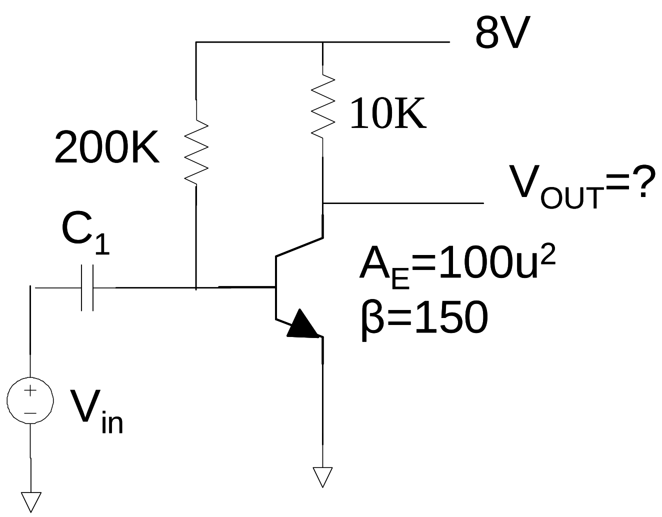
c) With the component values determined in part a) and b), determine the small signal voltage gain

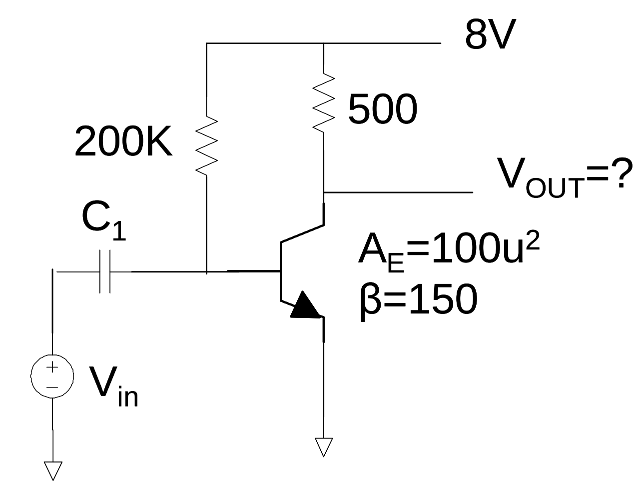


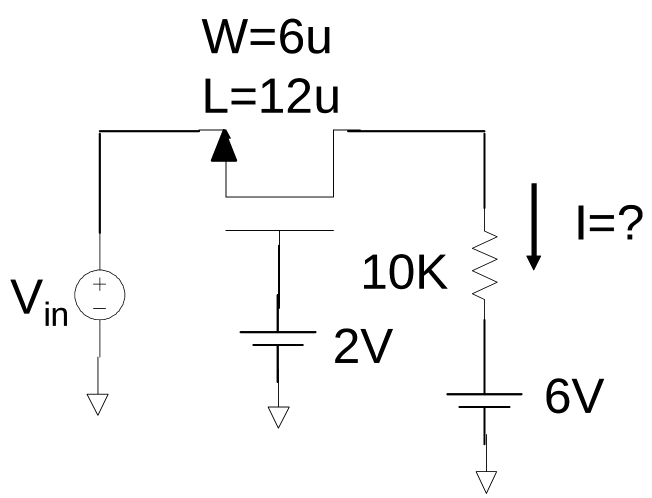
Problem 6 Assume all bipolar transistors are operating in the forward active region and all MOS transistors are in saturation. Draw the small signal equivalent circuit. Do not solve.

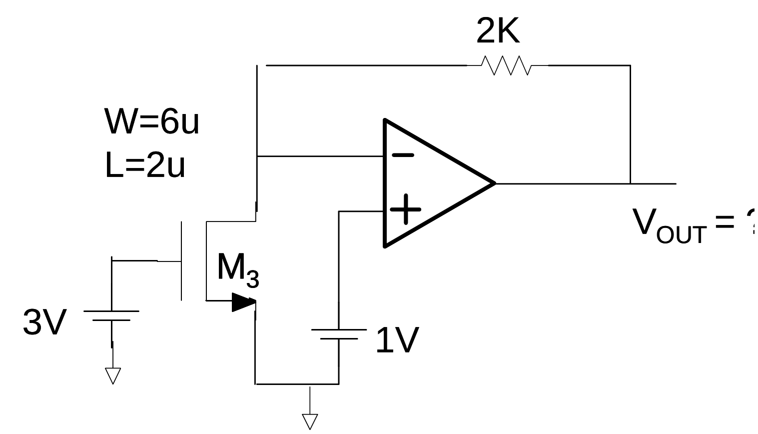


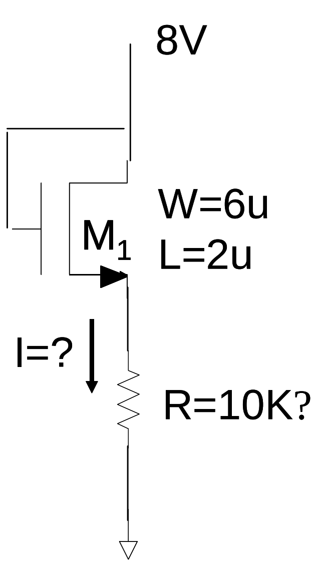
Problem 7 Determine the region of operation and the variable indicated.



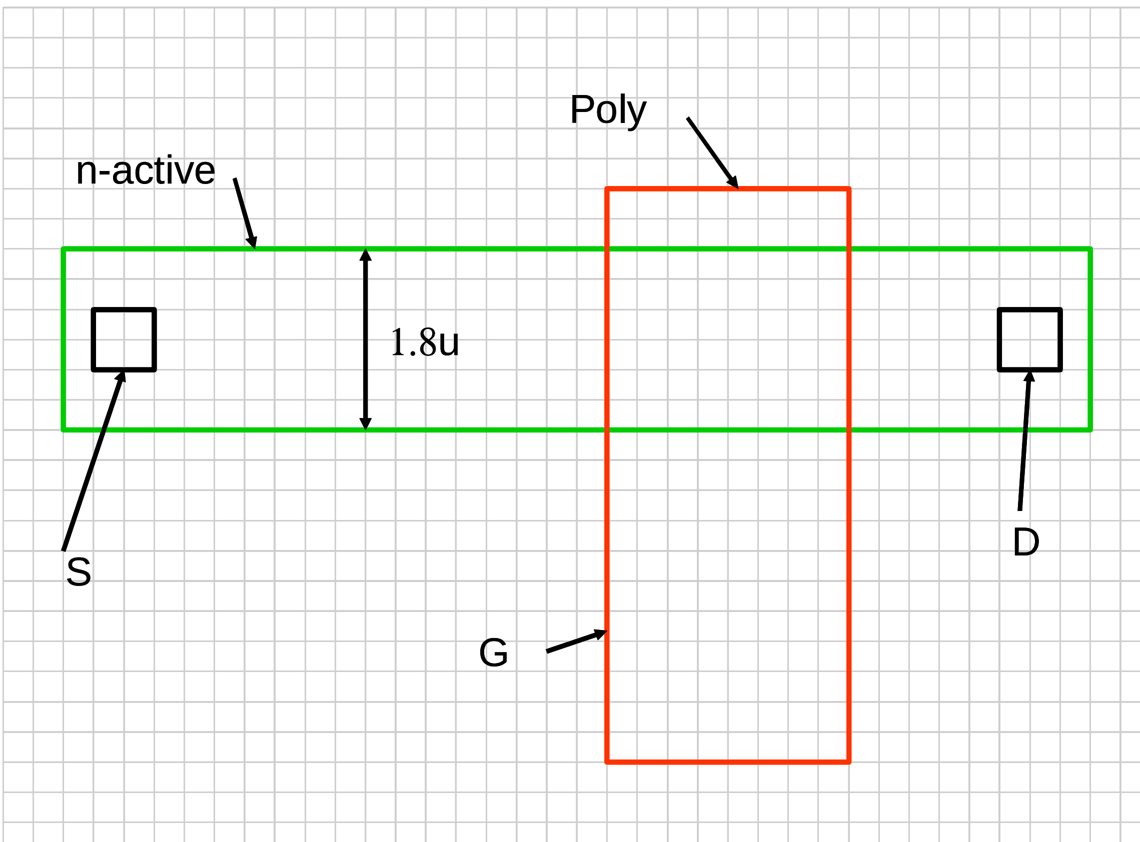








Problem 8 Determine the small signal model for the MOSFET, the parasitic capacitances and the series drain and source resistance for the device shown. Assume the device is biased to operate in the saturation region with a quiescent drain current of 25uA and a quiescent drain to source voltage of 4V.



Problem 9 For the circuit shown

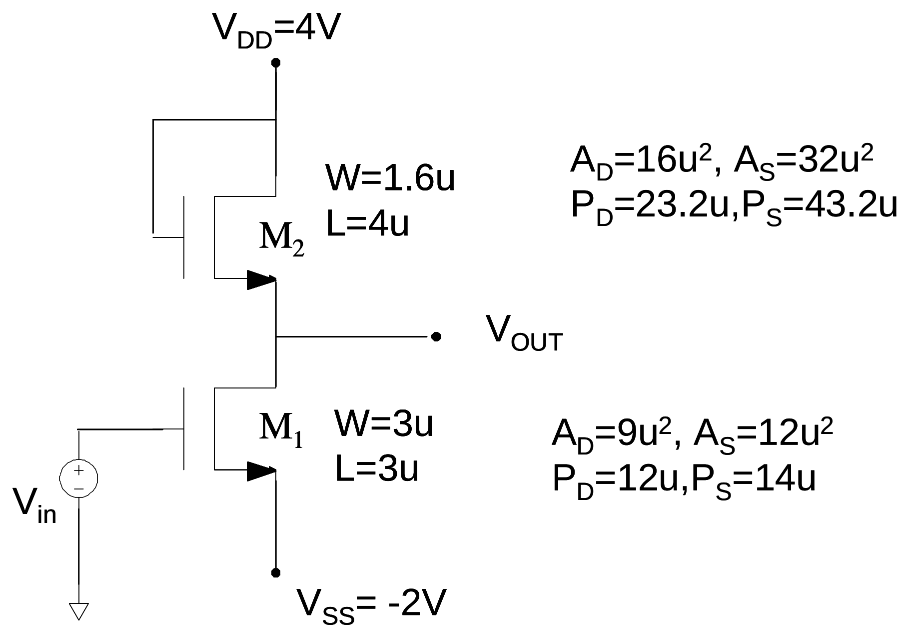
a) Analytically determine the small signal voltage gain.

b) Using HSPICE, obtain the small signal voltage gain versus frequency for frequencies from 1Hz to 1GHz. Use a logarithmic horizontal axis.

c) Using HSPICE, obtain $V_{OUT}(t)$ for a step input of 0.1V and a step input of 2V

d) Using HSPICE, obtain the output for a time domain input of Vi = .05sin1000t and compare those results with what you expect from part a) and b) above

e) What are the drain-bulk and source-bulk capacitances of these devices at the operating point established in this circuit? Compare analytical expressions with those obtained from HSPICE



Problem 10 Using the circuit structure of Problem 9, design a voltage amplifier that has a voltage gain of -6. In this design you should specify the values for V_{DD} and V_{SS} and all of the device sizes used. Attach a theoretical analysis and a spice simulation to substantiate that you have achieved the goal.

Problem 11

a) If R_1=10K and V_{CC}=8V and A_E=400u^2, determine the voltage V_{EE} so that the quiescent output voltage is 5Vat room temperature. Assume a value of J_S=2E-15A/u^2 and $\beta = 200$.

b) What is the small signal voltage gain of your circuit?

c) How much will the output voltage change if the temperature is increased by 50^{o}C?