

University of California
College of Engineering
Department of Electrical Engineering
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Problem Set 5
Due Monday August 7th

EE40
Summer 2006

Reading:

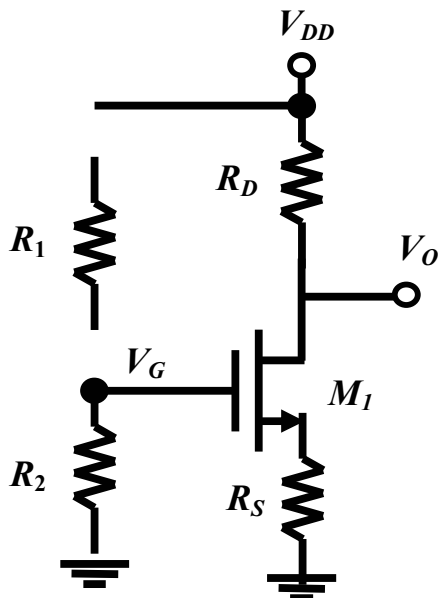
Chap 12.1-12.6 Hambley.
Chap 3.3 of Rabaey

Problems:

Chap 12: 12.15, 12.24, 12.30, 12.37, 12.40, 12.47 (midband refers to the frequencies at which the capacitors are short), 12.51

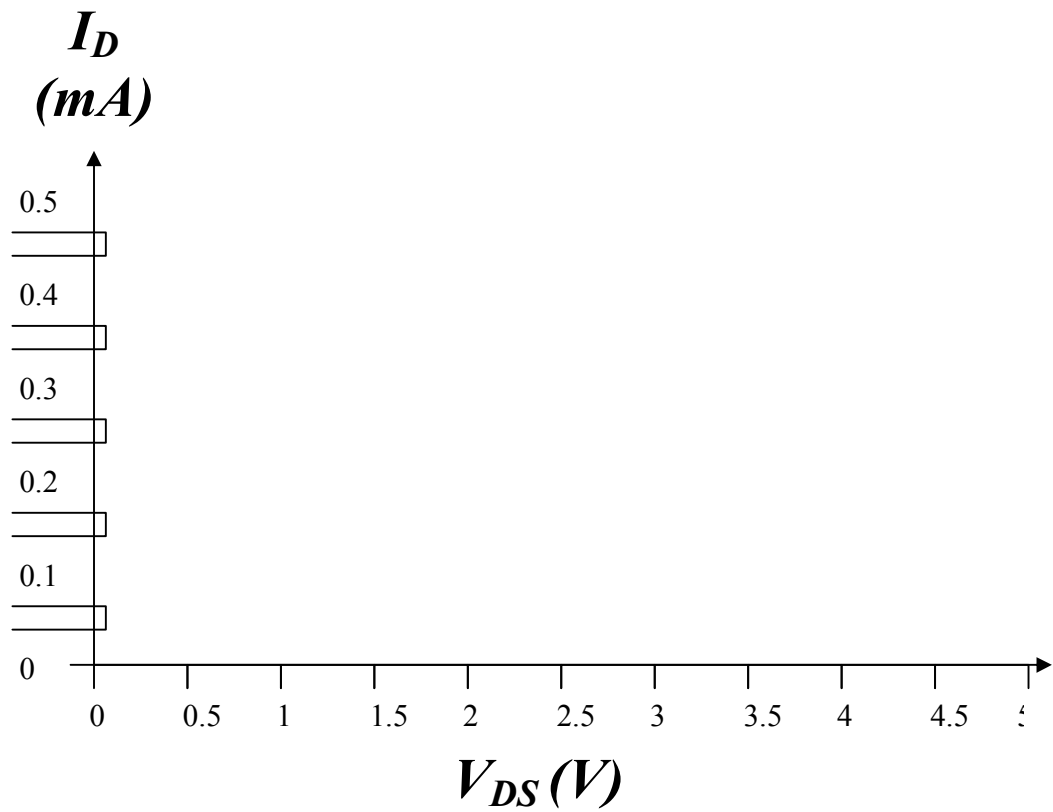
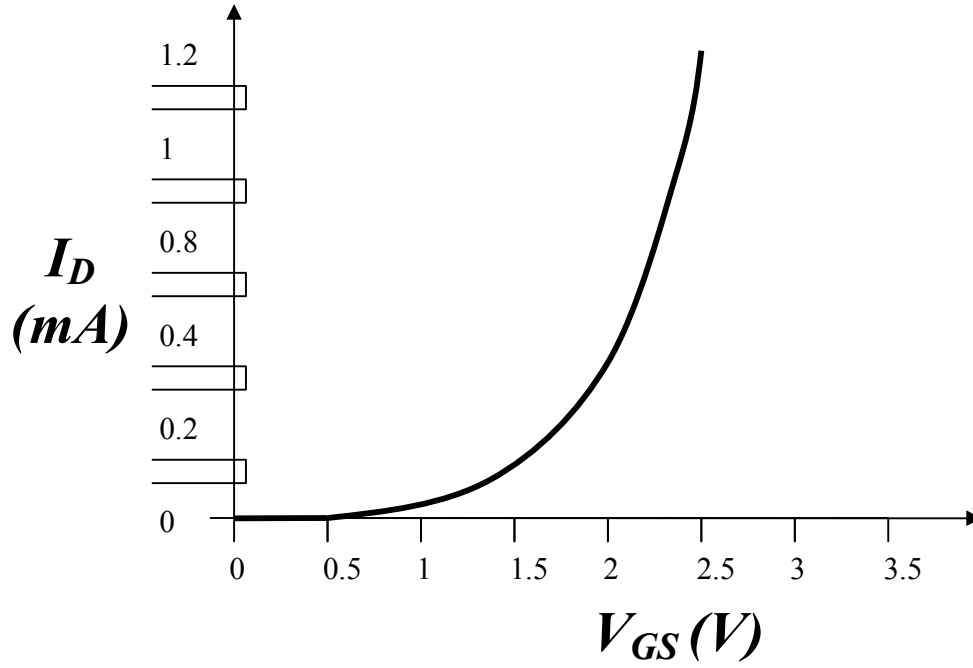
Additional Problems:

Problem 1



The circuit above has the following parameters:

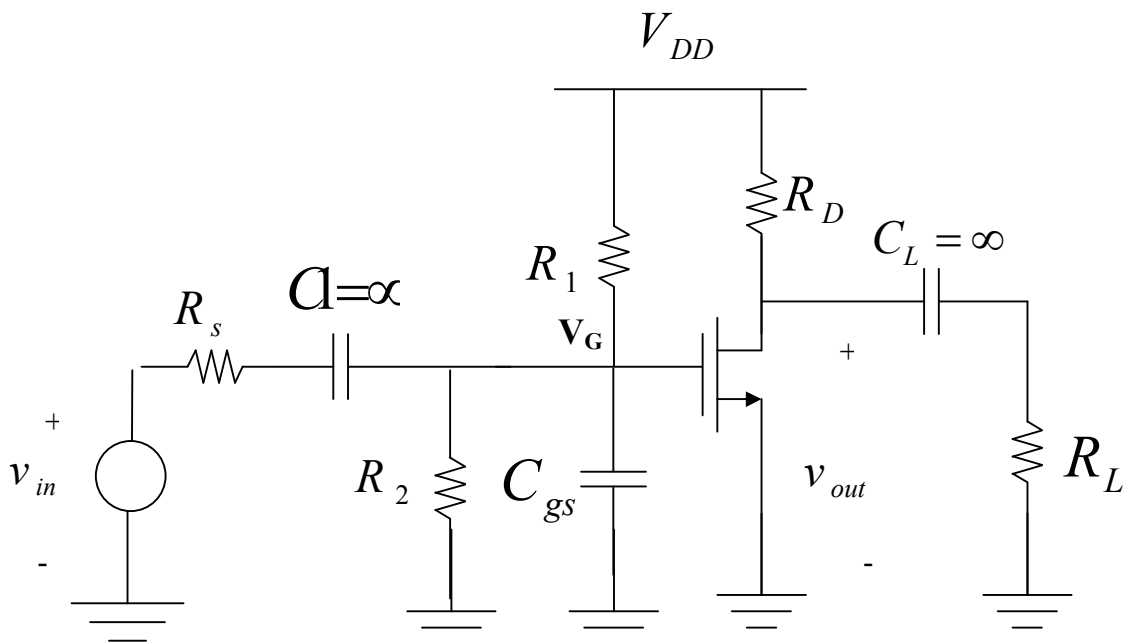
$V_{DD} = 5V$, $R_1 = 20k\Omega$, $R_2 = 30k\Omega$, $R_S = 1k\Omega$, $R_D = 9k\Omega$, $V_{Th}(M_1) = 0.5V$



a) Find the value of V_G .

- b) From the I_D vs. V_{GS} curve below, find the values of I_{DQ} , V_{GSQ} .
- c) From the values of I_{DQ} , V_{GSQ} and V_T , draw the I_D vs. V_{DS} curve for M_1 . **Assume $\lambda = 0$** . Annotate V_{GSQ} , I_{DQ} and the point where M_1 enters saturation.
- d) From the I_D vs. V_{DS} curve you drew, find the value of V_{DSQ} .
- e) Is M_1 in saturation?
- f) Find V_o .

Problem 2



Consider the Common Source amplifier above. C_{gs} is the capacitance between the gate and the source of the NMOS.

$$V_{DD} = 15 \text{ V}$$

$$V_{Tn} = 1 \text{ V}$$

$$\mu_n C_{ox} = 100 \frac{\mu A}{V^2}$$

$$\frac{W}{L} = 20$$

$$\lambda = 0$$

$$R_1 = 4 \text{ M}\Omega \quad R_2 = 1 \text{ M}\Omega \quad R_D = 2 \text{ K}\Omega \quad R_L = 20 \text{ K}\Omega \quad R_s = 10 \text{ K}\Omega$$

$$C_{gs} = 5 \text{ fF} \quad (1 \text{ fF} = 10^{-15} \text{ F})$$

a. What is I_{DSQ} and V_{DSQ} ?

Hint: All the capacitors, including C_{gs} , are open circuit for DC analysis.

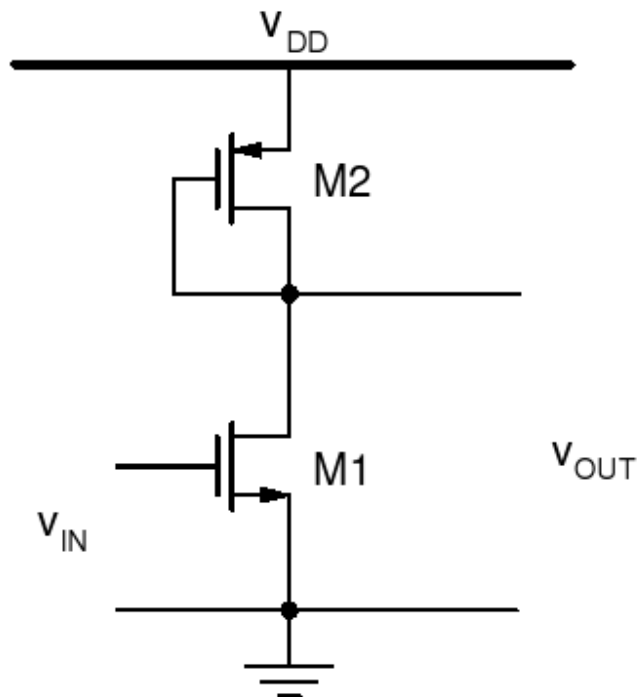
b. Draw the small signal model for the circuit and find the v_g/v_{in} .

*Hint: All the capacitors **except for** C_{gs} are short circuit for the small signal analysis.*

Do include C_{gs} in your small signal analysis.

c. Find the small signal transfer function, $\frac{v_{out}}{v_{in}}$. Draw the bode plot for the transfer function.

Problem 3



The circuit shown is biased

so that both transistors are in saturation. M1 is an N-MOS and M2 is a P-MOS. The source terminals are indicated by the arrows.

- Draw the small-signal model of the P-MOS transistor in saturation. (It should be very similar to an N-MOS, differing only by signs). Give expressions for g_{m2} and r_{d2} in terms of the MOSFET parameters and large-signal current.
- Draw the small-signal model of the whole circuit.
- Find the voltage gain of this circuit in terms of g_{m1} , g_{m2} , r_{d1} , and r_{d2} .

Problem 4

Find the transfer function of the following amplifier.

Use $R_1 = 10k$, $C_1 = 0.01\mu F$, $R_2 = 1k$, $C_2 = 0.001\mu F$, and $G_m = 0.01S$.

