Homework 2

Due: Friday, 7 February 2014 at 1pm

This is an individual assignment!

PROBLEM 1 (10pts):
Derive the expressions for input resistance R_{in}, output resistance R_{out}, voltage gain $A_v = v_{out}/v_{in}$ as a function of small-signal parameters (i.e. gm, rpi, ro, etc.) and given circuit elements for circuits in Figure 1a,b. Assume that all capacitors have infinite values.

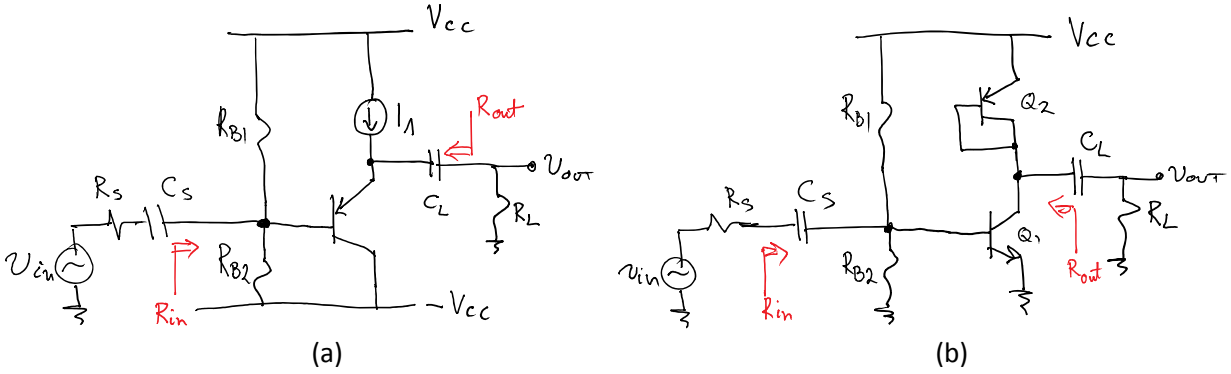


Figure 1

PROBLEM 2 (10pts):
An NMOS transistor has parameters W=10µm, L=1µm, k'=190µA/V^2, $\lambda = 0.02\text{V}^{-1}$, t_{ox}=80Å, $\phi_f = 0.3$V, V_{t0}=0.6V and N_A=5x10^{15}cm^{-3}. Ignore velocity saturation effects.
(a) Sketch the I_{DS}-V_{DS} characteristics for V_{DS} from 0 to 2V and V_{GS} = 1V.

(b) Sketch the I_{DS} – V_{GS} characteristics for V_{DS} = 2V as V_G varies from 0 to 2Vwith V_{SB} = 0 and 1V.

(c) Derive and sketch the *complete* small-signal equivalent circuit for the device with V_{GS}=1V, V_{DS}=2V, and V_{SB}=1V. Use ψ_0=0.7V, C_{sb0}=C_{db0}=20fF, and C_{gb}=5fF. Overlap capacitance from gate to source and gate to drain is 2fF.

PROBLEM 3 (10pts):
For circuit in Figure 2 sketch the $V_O(V_I)$ output characteristic as V_I goes from 0V to VDD=2V. Mark the regions and type of operation for both M1 and M2. Assume $V_{t1} = V_{t2} = 0.5$V and $k_1 = 10k_2$. Find V_I for which the small-signal gain is the largest.

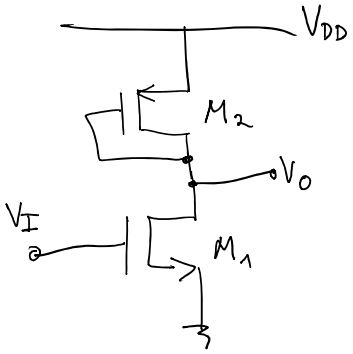


Figure 2

PROBLEM 4 (10pts):
Derive the expressions for input resistance R_{in}, output resistance R_{out}, voltage gain $A_v = v_{out}/v_{in}$ as a function of small-signal parameters and given circuit elements for MOS circuit in Figure 3. Assume that all capacitors have infinite values.

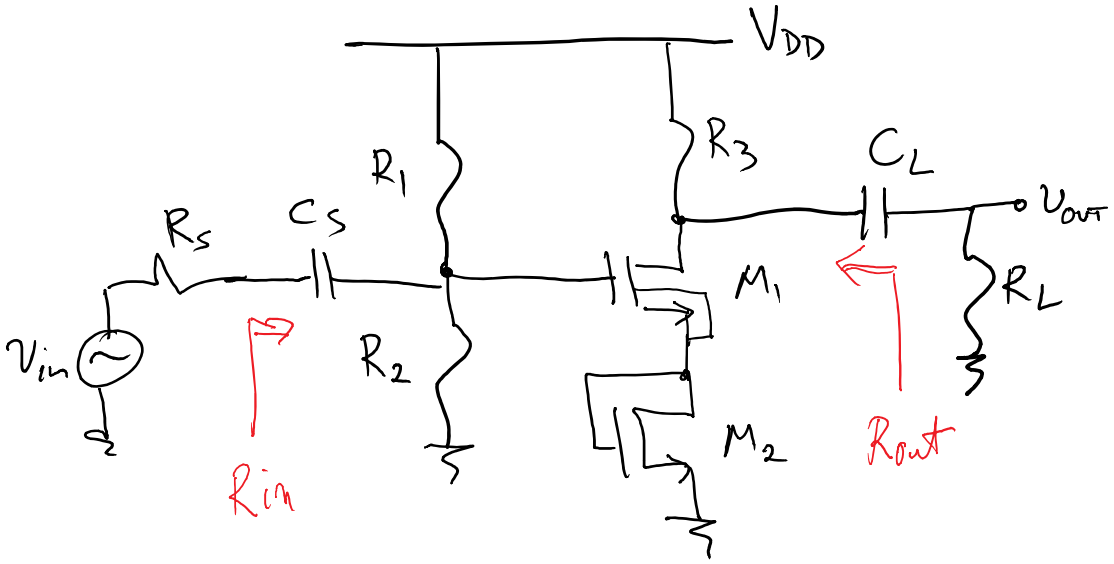


Figure 3

PROBLEM 5 (10pts):
Derive the expressions for input resistances $R_{in1,2}$, output resistances $R_{out1,2}$, voltage gains $A_{v1} = v_{out1}/v_{in}$, $A_{v2} = v_{out2}/v_{in}$ as a function of small-signal parameters and given circuit elements for BiCMOS circuit in Figure 4. Assume that all capacitors have infinite values.

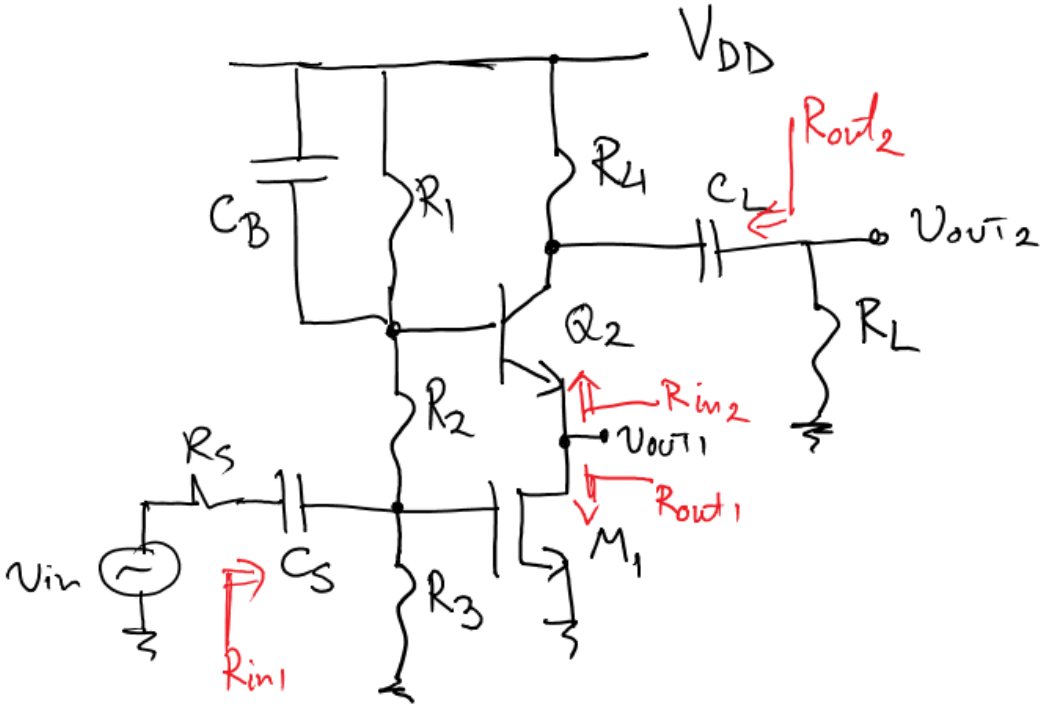


Figure 4

EXTRA PROBLEMS FOR EE 240A STUDENTS:

PROBLEM 5 (10pts):
Derive the expressions for input resistance R_{in}, output resistance R_{out}, voltage gain $A_v = v_{out}/v_{in}$ as a function of small-signal parameters and given circuit elements for circuit in Figure 5. Assume that all capacitors have infinite values. Determine the biasing resistor values RE, RB, RC to maximize the output swing and voltage gain. Assume β_F=100, I_C=1mA, V_A=∞ and R_S=10Ω.

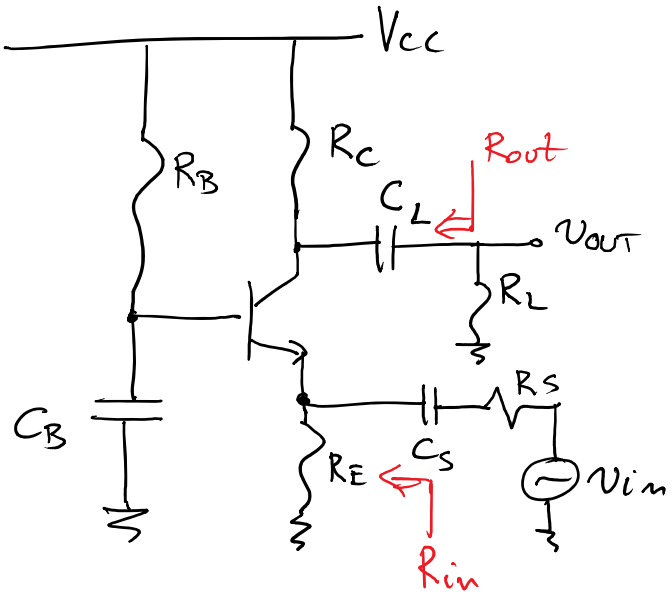


Figure 5

PROBLEM 6 (10pts):
Derive the expressions for input resistances $R_{in1,2}$, output resistances $R_{out1,2}$, voltage gains $A_{v1} = v_{out1}/v_{in}$, $A_{v2} = v_{out2}/v_{in}$ as a function of small-signal parameters and given circuit elements for circuit in Figure 6. Assume that all capacitors have infinite values.

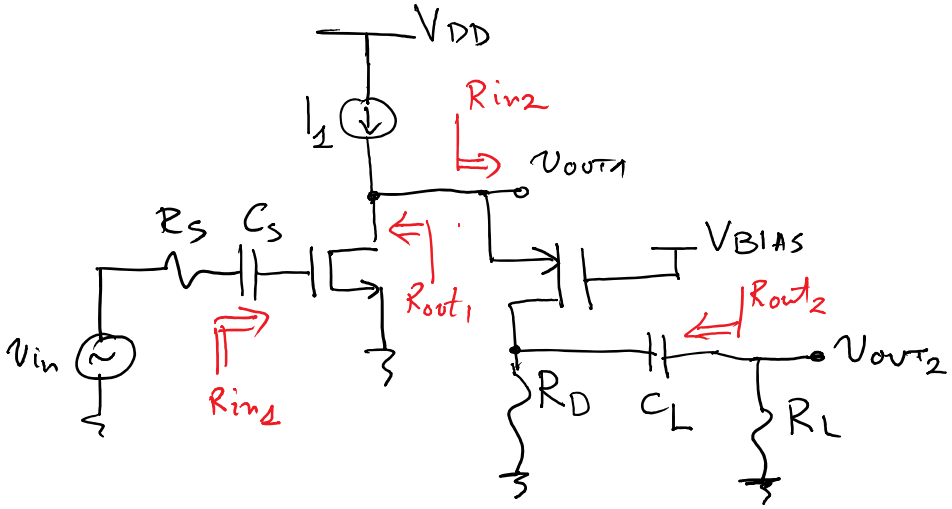
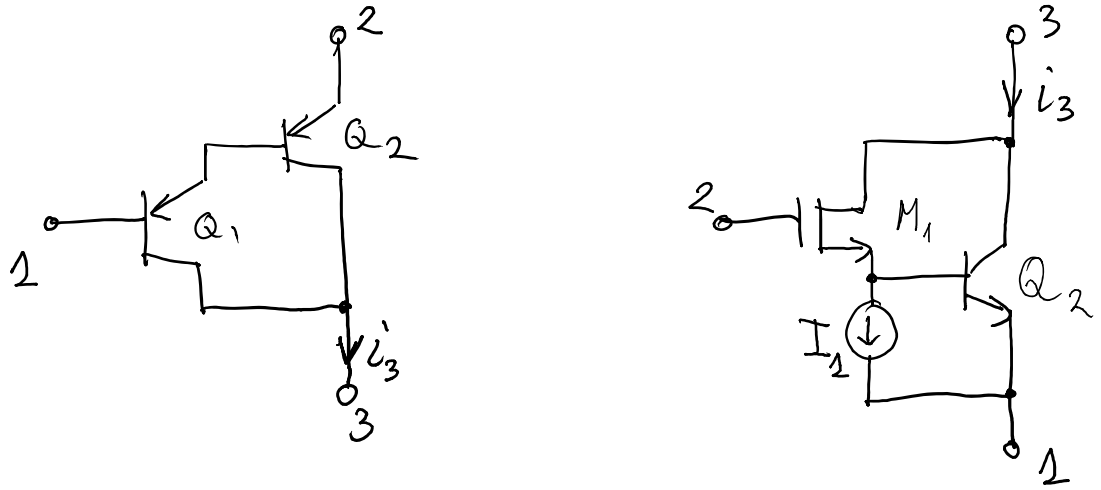


Figure 6

PROBLEM 7 (10pts):
Determine the small-signal transconductance $i_3/(v_2-v_1)$ for circuits in Figure 7a,b, as a function of small-signal transistor parameters.



(a) (b)

Figure 7