Homework Assignment No. 1

This homework assignment is due in class on Friday, January 13, 2006.

The following transistor parameters should used unless otherwise stated.

MOSFETS

MOSFET Parameter	n-channel	p-channel	units
K'	24	8	$\mu A/V^2$
V_{T0}	0.75	-0.75	V
γ	0.8	0.4	$V^{0.5}$
ϕ	0.6	0.6	V
λ	0.01	0.02	V^{-1}

C_{ox} = 0.7fF/μm^2 LD(NMOS) = 0.45μm LD(PMOS) = 0.6μm

n^+ diffusion to p-well (junction, bottom) = 0.33fF/μm^2
n^+ diffusion sidewall (junction, sidewall) = 0.9fF/μm
p^+ diffusion to substrate (junction, bottom) = 0.38fF/μm^2
p^+ diffusion sidewall (junction, sidewall) = 1.0fF/μm
n-channel to bulk (junction, bottom) = 0.1fF/μm^2
n-channel to bulk (junction, sidewall) = 0.3fF/μm
p-channel to bulk (junction, bottom) = 0.1fF/μm^2
p-channel to bulk (junction, sidewall) = 0.3fF/μm

BJTS

BJT Parameter	NPN	PNP (lateral)	units
ß	100	50	A/A
V_t	26	26	mV
I_S	10	10	fA
ϕ_B	0.8	0.8	V
V_{AF}	100	50	V

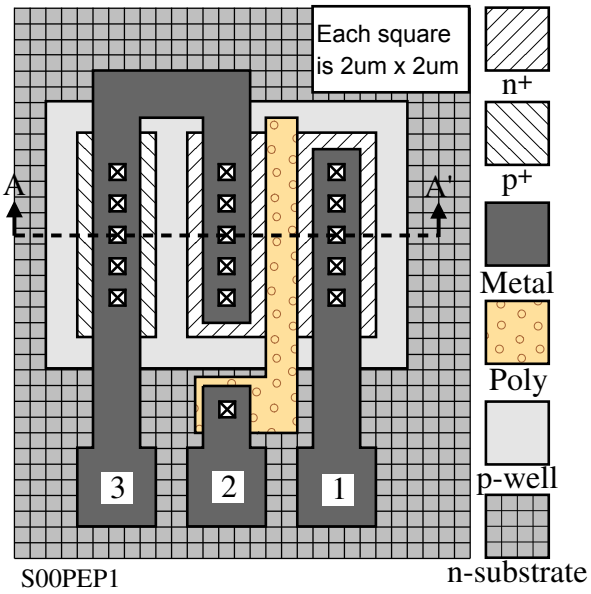
	C_{jE0}	C_{jC0}	C_{jS0}	n	ϕ_B	t_F
Vertical NPN	100fF	1000fF	2000fF	0.5	0.8V	0.5ns
Lateral PNP	80fF	500fF	2000fF	0.5	0.8V	5ns

Problem 1 - (10 points)

A top view of a MOS transistor is shown. (a) Identify the type of transistor (NMOS or PMOS) and its value of W and L.

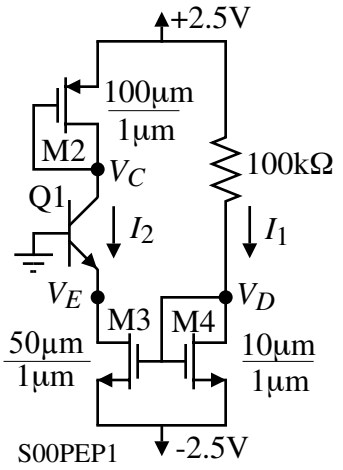
(b.) Draw the cross-section A-A' approximately to scale.

(c) Assume that dc voltage of terminal 1 is 5V, terminal 2 is 3V and terminal 3 is 0V. Find the numerical value of the capacitance between terminals 1 and 2, 2 and 3, and 1 and 3. Assume that the voltage dependence for pn junction capacitances is -0.5 (this is called MJ in SPICE).



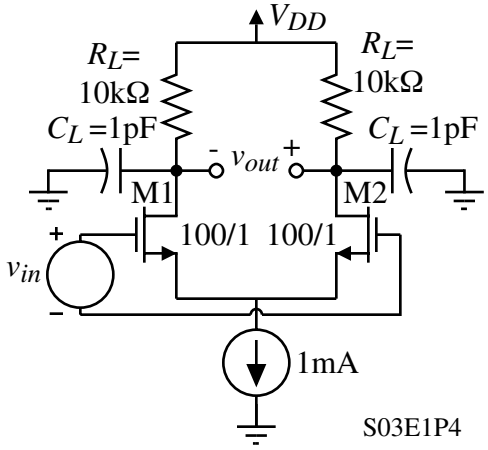
Problem 2 - (10 points)

Find the numerical values of I_1, I_2,V_D, V_E, and V_C to within ±5% accuracy.



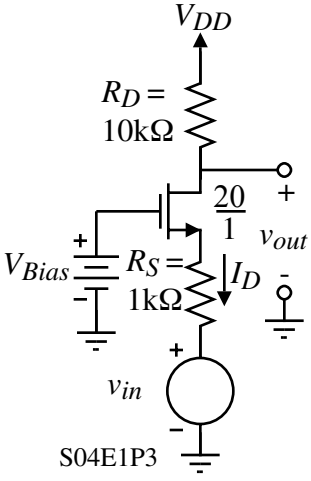
Problem 3 - (10 points)

Find the numerical values of all roots and the midband gain of the transfer function v_{out}/v_{in} of the differential amplifier shown. Assume that K_N' = 100μA/V^2, V_{TN} = 0.7V, and λ_N = 0.04V^{-1}. The values of C_{gs} = 0.2pF and C_{gd} = 20fF.



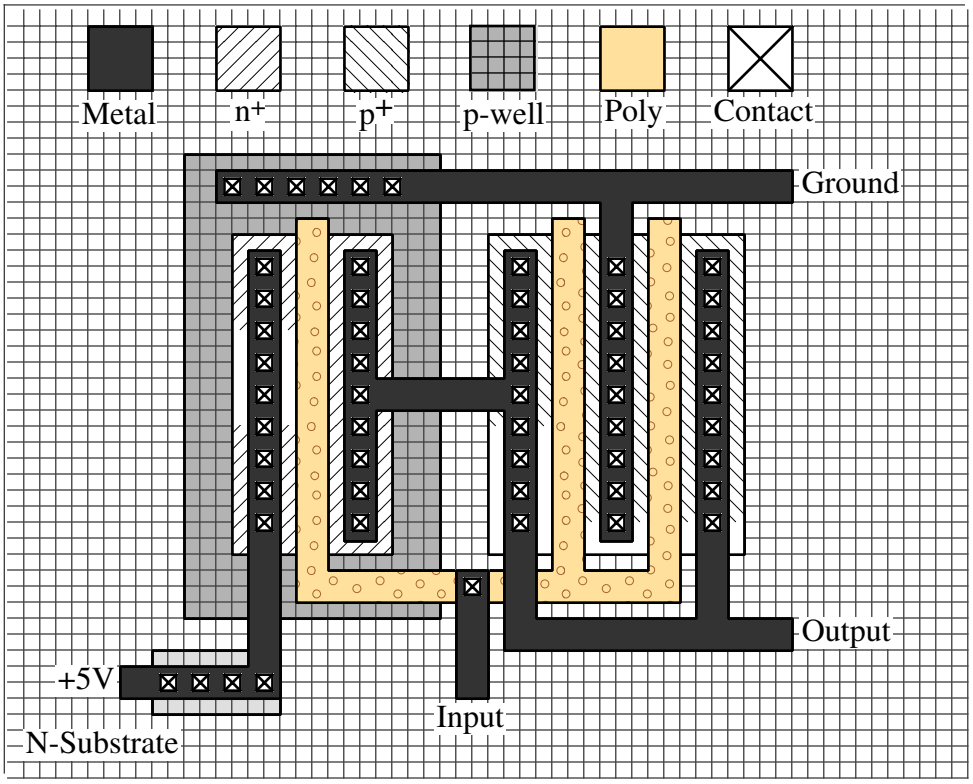
Problem 4 - (10 points)

Find the voltage transfer function of the common-gate amplifier shown. Identify the numerical values of the small-signal voltage gain, v_{out}/v_{in}, and the poles and zeros. Assume that I_D = 250μA, K_N' = 100μA/V^2, V_{TN} = 0.5V, $\lambda \approx 0$V^{-1}, C_{gs} = 0.5pF and C_{gd} = 0.1pF.



Problem 5 - (10 points)

Draw the electrical schematic using the proper symbols for the transistors. Identify on your schematic the terminals that are +5V, ground, input, and output. Label the transistors on the layout as M1, M2, etc. and determine their W/L values. Assume each square in the layout is 2 micron by 2 micron. Find the area in square microns and periphery in microns for the source and drain of each transistor.



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