UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

E. Alon	**Midterm**	**EECS 240**
	Thursday, March 12, 2009	**SPRING 2009**

You should write your results on the exam sheets only. Partial credit will be given only if you show your work and reasoning clearly.

Name: _____

SID: _____

Problem 1 _____/ 13

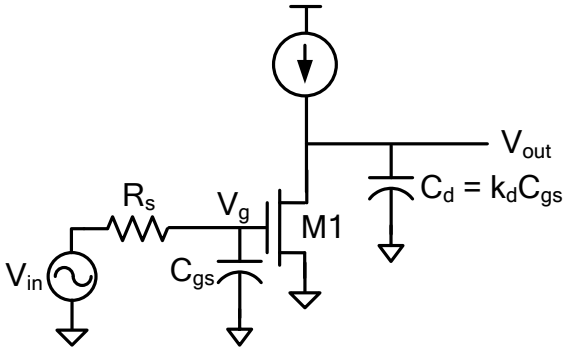
Problem 2 _____/ 10

Problem 3 _____/ 9

Total _____/ 32

Problem 1 (13 points) Capacitance and SNR

In this problem we will look at optimizing the SNR of the amplifier shown below.

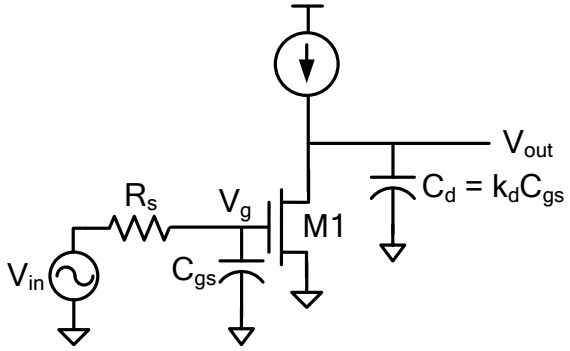


You should use the following assumptions and simplifications to solve this problem:

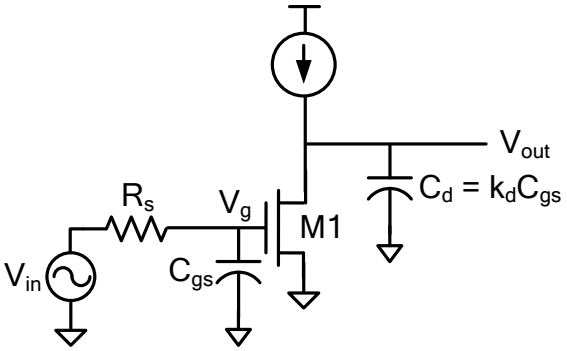
- The input of the amplifier (V_{in}) is a sinusoid with an angular frequency of ω_{in} and an amplitude of A_{in}.
- The transistor is biased with a fixed V* so that its gain ($g_m r_o$) is A_{v0}.
- Assume R_s is noiseless, and ignore all capacitors except those shown in the figure.
- You should assume that $1/(r_o C_d) >> \omega_{in}$. In other words, $V_{out}(j\omega_{in})/V_g(j\omega_{in}) = A_{v0}$.
- Your final answers should be a function of only k, T, γ, ω_{in}, A_{in}, k_d, A_{v0}, R_s, and C_{gs}.

a) **(4 pts)** What is the voltage noise variance $\overline{v_{on}^2}$ at the output of the amplifier?

b) **(4 pts)** What is the mean-squared signal voltage $\overline{V_{out}^2}$ at the output of the amplifier?

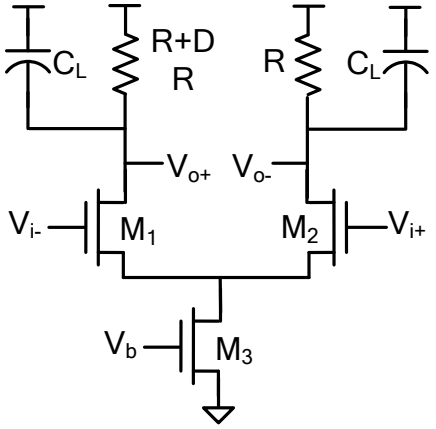


c) **(5 pts)** Keeping the V* of the transistor fixed, what value of C_{gs} maximizes the SNR $\overline{V_{out}^2}/\overline{v_{on}^2}$ at the output of the amplifier?

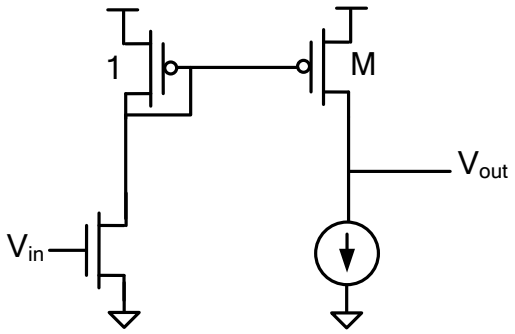


Problem 2 (10 points) Noise

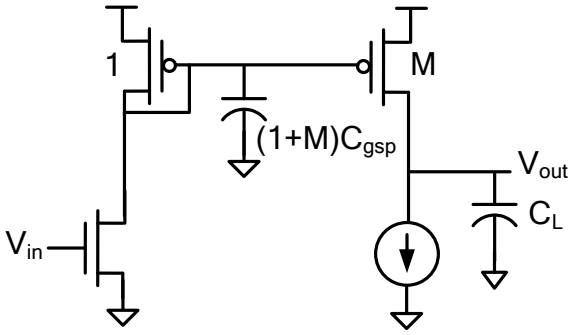
Considering only the noise current from M_3, what is the variance of the differential voltage noise at the output of the amplifier shown below? You can ignore all the r_o's of the transistors and all capacitors except those explicitly drawn in the schematic. You can assume that M_1 and M_2 are identical (i.e., $g_{m1} = g_{m2}$), and you should provide your answers in terms of k, T, γ, C_L, (g_{m3}/g_{m1}), $(\Delta R/R)$, and $A_{v,nom} = (g_{m1}R)$.



Problem 3 (9 points) Amplifier Design



a) **(4 pts)** Assuming that the V* of the NMOS and PMOS transistors are V_n* and V_p* respectively and ignoring the r_o of all of the transistors, what is the nf of the amplifier shown above? In other words, relative to the noise current from the input transistor, what is the noise current density that flows into the amplifier's output? You should provide your answer in terms of V_n*, V_p*, and M.



b) **(5 pts)** Now let's look at the stability of this amplifier under feedback using the model shown above (ignore the r_o's and all capacitors except the ones shown in the model). If the amplifier is placed into unity-gain feedback with a closed-loop bandwidth of ω_{gbw}, what is the maximum M that will provide at least 45° of phase margin? You should provide your answer in terms of ω_{gbw} and the ω_T of the PMOS transistors.