1. (a) (15 points) For the circuit shown below, find the minimum DC open-loop op amp gain required in order for the closed-loop gain to be accurate within 0.25 \%. Use $R_1 = 1 \, \text{k}\Omega$, $R_2 = 9 \, \text{k}\Omega$.

(b) (15 points) If the op amp has a unity gain bandwidth of $f_T = 1 \, \text{GHz}$, find the % settling error if the op amp is allowed to settle for 5 nsec.
2. (a) (30 points) Find the bandwidth and phase margin for the op amp shown below in unity gain. (b) (10 points) Find the maximum peak-to-peak differential output voltage swing. Use: $C_L = 2\text{pF}$, $V_{DD} = 3.0\text{V}$, $I_{bias} = 2\text{mA}$, $k'_N = 120\mu\text{A/V}^2$, $k'_P = 40\mu\text{A/V}^2$, $\lambda_N = \lambda_P = 0.1$, $\gamma = 0$ (no body effect), $V_{TN} = 0.6\text{V}$, $V_{TP} = -0.6\text{V}$, $C_{OX} = 5\text{fF/}\mu\text{m}$, $C_{PN\text{junction}} = 0.8\text{fF/}\mu\text{m}$ of W, $C_{\text{OVERLAP}} = 0.2\text{fF/}\mu\text{m}$ of W, $W/L_1 = W/L_2 = 375/0.3$, $W/L_3 = W/L_4 = 250/0.3$, $W/L_5 = W/L_6 = W/L_9 = 125/0.3$, $W/L_7 = W/L_8 = 250/0.3$, $W/L_{10} = 375/0.3$, $W/L_{11} = W/L_{12} = 750/0.3$

Assume $V_{bp}$ and $V_{bn}$ are chosen to set the headroom on M5,6 and M9,10 to 200mV each.
extra work space for problem 2
3. An op amp has a DC open-loop gain of 80dB, poles at 1kHz, 10MHz and 100MHz and a left half-plane zero at 1 MHz.
   (a) (20 points) Sketch the Bode plot, both magnitude and phase, for the op amp on the graph below.
   (b) (10 points) If this op amp is used with a closed-loop gain of 0dB, what is the phase margin?
BONUS (5 points) If the op amp in problem 2 is used as a unity gain buffer, would the output swing be the same as you found in problem 2, greater, or less? Explain your answer!