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 0.5%. Use $R_1 = 1 \, \text{k}\Omega$, $R_2 = 19 \, \text{k}\Omega$

(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 10 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: $C_L = 2\text{pF}$, $V_{DD} = 3.0\text{V}$, $I_{\text{bias}} = 2\text{mA}$, $k'_N = 120\mu\text{A}/\text{V}^2$, $k'_P = 40\mu\text{A}/\text{V}^2$, $\lambda_N = \lambda_P = 0.1$, $\gamma = 0$ (no body effect), $V_{TN} = 0.6\text{V}$, $V_{TP} = -0.6\text{V}$, $C_{\text{OX}} = 5\text{fF}/\mu\text{m}^2$, $C_{\text{PN junction}} = 0.8\text{fF}/\mu\text{m}$ of W, $C_{\text{OVERLAP}} = 0.2\text{fF}/\mu\text{m}$ of W, $W/L_1 = W/L_2 = 125/0.3$, $W/L_3 = W/L_4 = 250/0.3$, $W/L_5 = W/L_6 = W/L_8 = W/L_{10} = 375/0.3$, $W/L_7 = W/L_9 = 250/0.3$, $W/L_{11} = W/L_{12} = 250/0.3$

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 60dB, poles at 10kHz, 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 10dB, 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!