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 1% Use $R_1 = 1 \text{k}\Omega$, $R_2 = 4 \text{k}\Omega$

(b) (15 points) Find the minimum unity gain bandwidth required for the op amp to settle to within 1% in 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: $C_L = 400\, \text{fF}$, $V_{DD} = 3.0\, \text{V}$, $I_{\text{bias}} = 400\, \mu\text{A}$, $k'_N = 120\, \mu\text{A}/\text{V}^2$, $k'_P = 40\, \mu\text{A}/\text{V}^2$, $\lambda_N = \lambda_P = 0.1$, $\gamma = 0$ (no body effect), $V_{TN} = 0.6\, \text{V}$, $V_{TP} = -0.6\, \text{V}$, $C_{\text{OX}} = 5\, \text{fF}/\mu\text{m}^2$, $C_{\text{PNjunction}} = 0.8\, \text{fF}/\mu\text{m}$ of W, $C_{\text{OVERLAP}} = 0.2\, \text{fF}/\mu\text{m}$ of W, and for the BJTs: $\beta_f = 100$, $V_A = 100$, $\tau_f = 10\, \text{ps}$, $C_{\text{je}} = 20\, \text{fF}$, $C_{\mu} = 10\, \text{fF}$, $C_{\text{cs}} = 40\, \text{fF}$
$W/L_1 = W/L_2 = 25/0.3$
$W/L_5 = W/L_6 = W/L_{13} = 75/0.3$
$W/L_7 = W/L_8 = 50/0.3$
$W/L_9 = W/L_{10} = 25/0.3$
$W/L_{11} = W/L_{12} = 50/0.3$

Assume $V_{bp}$ and $V_{bn}$ are chosen to set the headroom on M5,6 and M9,10 to 200mV each. Also assume the BJTs require a minimum $V_{bc} = 0\, \text{V}$ to stay in the forward-active region.
extra work space for problem 2
3. A two-stage op amp has a DC open-loop gain of 100 dB, 1 pole at 100 Hz, 2 poles at 100 MHz and a right 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 30 dB, what is the phase margin?
BONUS (5 points) If the op amp in problem 2 used MOSFETs instead of BJTs for the cascode devices, Q3 and Q4, would you expect the phase margin to increase or decrease? Explain your answer!