1. Sketch Bode plots for the magnitude of the following transfer function:

$T(s)=10^4(1+s/10^5)(1+s/10^3)^{-1}(1+s/10^4)^{-1}$.

From your sketches determine approximate values for the magnitude at $\omega=10^6$ rad/sec. (10%)

2. For the circuit in the following figure, let $R_B=100K\Omega$, $R_C=10K\Omega$, $V_{CC}=V_{BE}=10V$, and let the BJT have $\beta=100$ and $V_A=100V$. Find the values of

(a) V_B, (1%),
(b) V_E, (1%),
(c) I_C, (1%),
(d) V_C, (1%)

V_A is the Early voltage

Also, find the values of the small-signal model parameters (at room temperature)

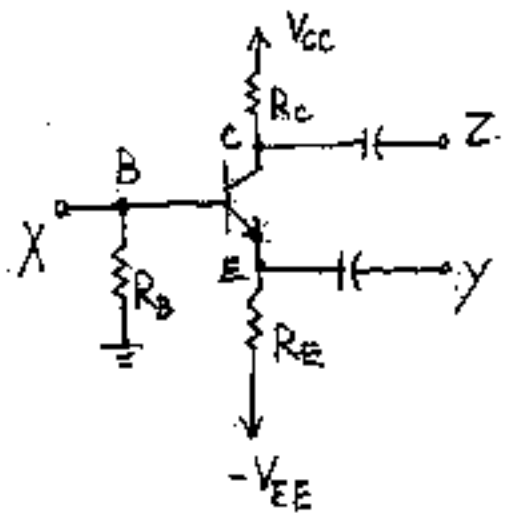
(e) g_m, (2%),
(f) r_e, (1%), r_e (emitter resistance $=\frac{V_T}{I_E}$)
(g) r_π, (2%),
(h) r_o (1%), r_π (input resistance $=\frac{V_{be}}{I_b}$)

at the bias point.

When connected in the common emitter configuration with $R_S=R_L=10K\Omega$, find the values of

(i) R_i, (2.5%),
(j) R_o, (2.5%),
(k) A_v, (2.5%)
(l) A_i, (2.5%)

R_S : source resistance
R_L : load resistance



3. A circuit as shown in figure A consists of an ideal operational amplifier A, two resistors R_1 and R_2, and an input signal source v_I. Assuming that the operational amplifier is powered by $\pm V_m$ and its output voltage limits are 1V short of the power rail voltages.

(a) Analyze the circuit behaviors, and plot the voltage transfer characteristics (v_O versus v_I), indicate all the voltages intersecting both v_O and v_I axes in terms of V_m, R_1, and R_2. (8%)

(b) From the results obtained in part (a), can you identify and give the common well-known name of the circuit? (2%)

(c) In your analysis in part (a), can you use the virtual ground concept which is often employed in analyzing circuits that contain operational amplifiers? Your answer must give supporting reasoning. (4%)

(d) If the circuit is intended to be used as a waveform shaping circuit, that is to shape a sinusoidal wave of $v_I = A_m \sin \omega t$ into a square wave at output v_O with an amplitude of B_m, what is the maximum of B_m? And what is the design constraint on the relation among the parameters B_m, R_1, R_2, and A_m? (6%)

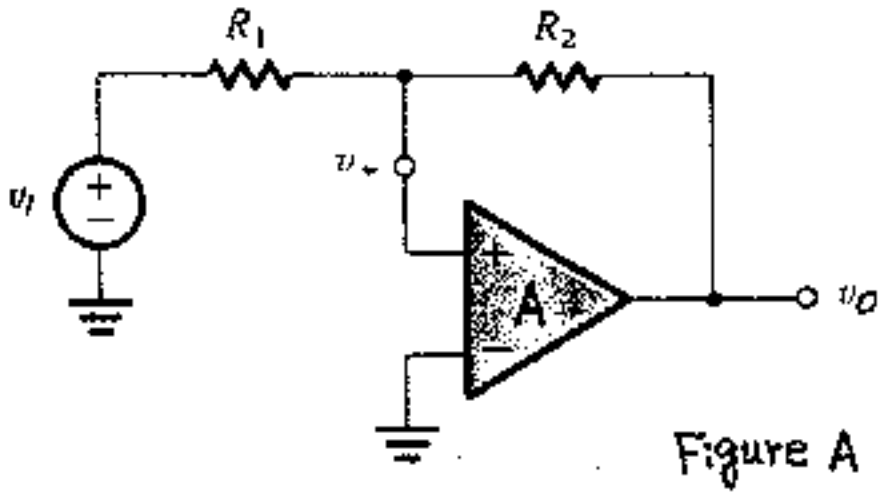
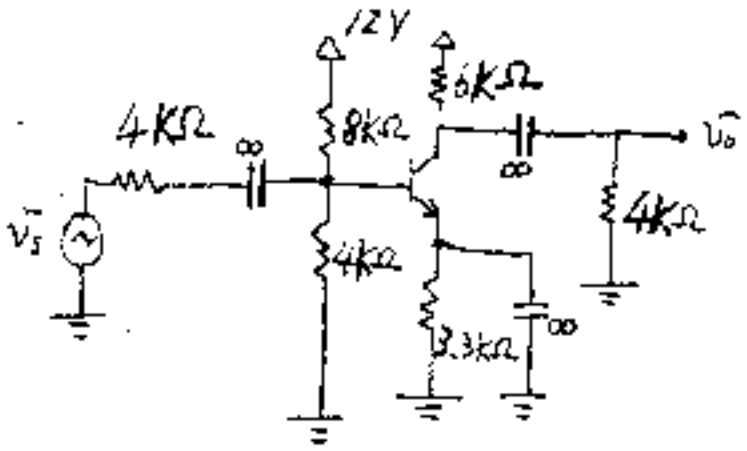
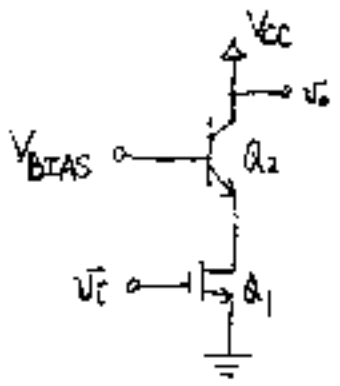


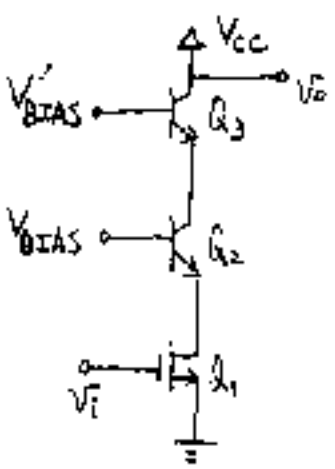
Figure A

4. Estimate the high-band corner frequency ω_H for the following circuit. Assume that $\beta=100$ and $c_\pi=10c_\mu=1$ pF. (15%)

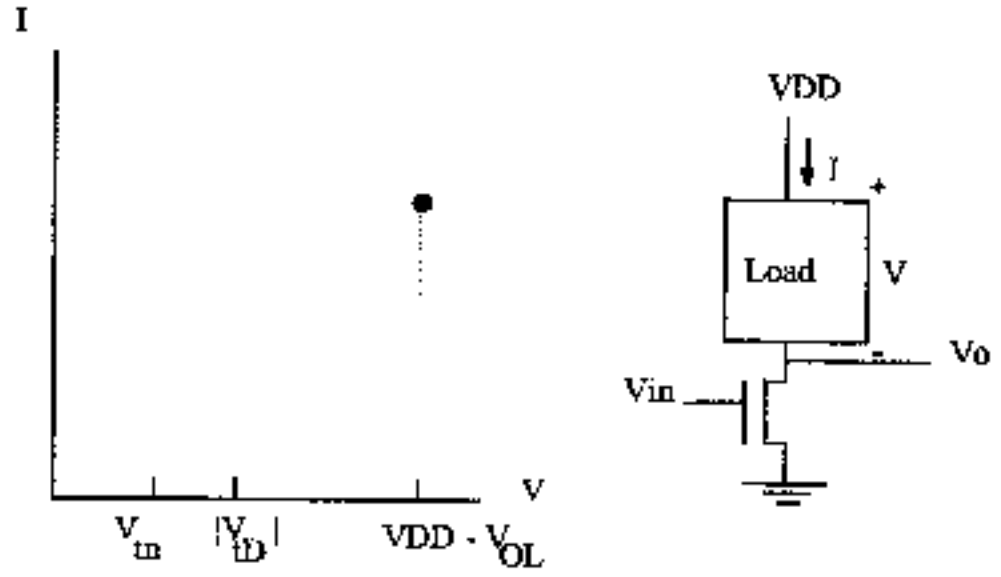


5. Explain why the output resistances of the following two cascode circuits are almost the same. (10%) How will you modify the circuits to obtain higher output resistances? (5%)





6. (10%) (a) Draw the connections of the depletion-NMOS load (with threshold voltage V_{tD}), the enhancement-NMOS load (with threshold voltage V_{tn}), and the resistor load (with value R) inverters as shown below. (b) Draw the I-V curves of these three implementations. Assume that all three curves meet at a point with V= VDD – V_{OL}.



7. (10%) Can you get an all pass filter from a (a) low-pass filter, (b) band-pass filter? Draw the circuit by using R, L, and C. (Hint: (a) first order and (b) second order)