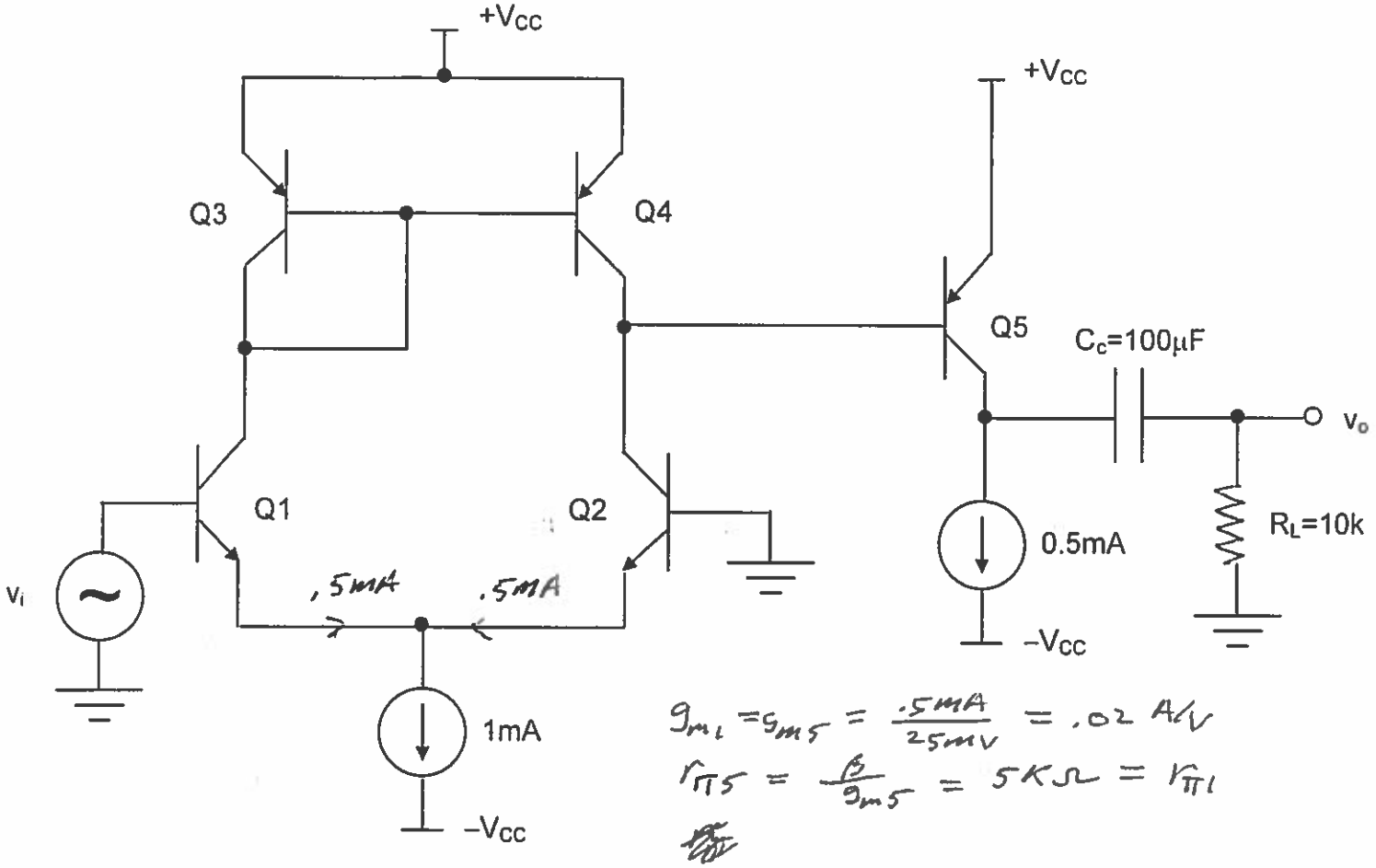
Problem 1 (40 points):

Consider the following amplifier comprised of a BJT Diff Amp in cascade with a BJT CE Amp driving an output load, R_L. Assume β=100 and r_o=infinity for all five transistors. You may make reasonable approximations in your analysis. Note that there is no formal DC analysis required in this problem (i.e., this is a small-signal AC midband analysis only).

$V_T = 25mV$



$g_{m1} = g_{m5} = \frac{.5mA}{25mV} = .02\ A/V$

$r_{\pi 5} = \frac{\beta}{g_{m5}} = 5K\Omega = r_{\pi 1}$

a) Calculate the overall midband gain, $A_m = v_o/v_i$.
(Hint: Consider the gain of each amp separately and then multiply them together to get the overall gain).

b) Calculate R_{in} (looking into the Q1 input).

c) Calculate R_{out} (looking into the output node and **not including** R_L).

a.) $A_m = A_1 * A_2 = \left[+g_{m1}\{r_{o2} \| r_{o4} \| r_{\pi 5}\}\right] * \left[-g_{m5}\{r_{o5} \| R_L\}\right]$

$= [+g_{m1}\ r_{\pi 5}] * [-g_{m5} R_L]$

$= [+100] * [-200] = \boxed{-20{,}000\ V/V}$

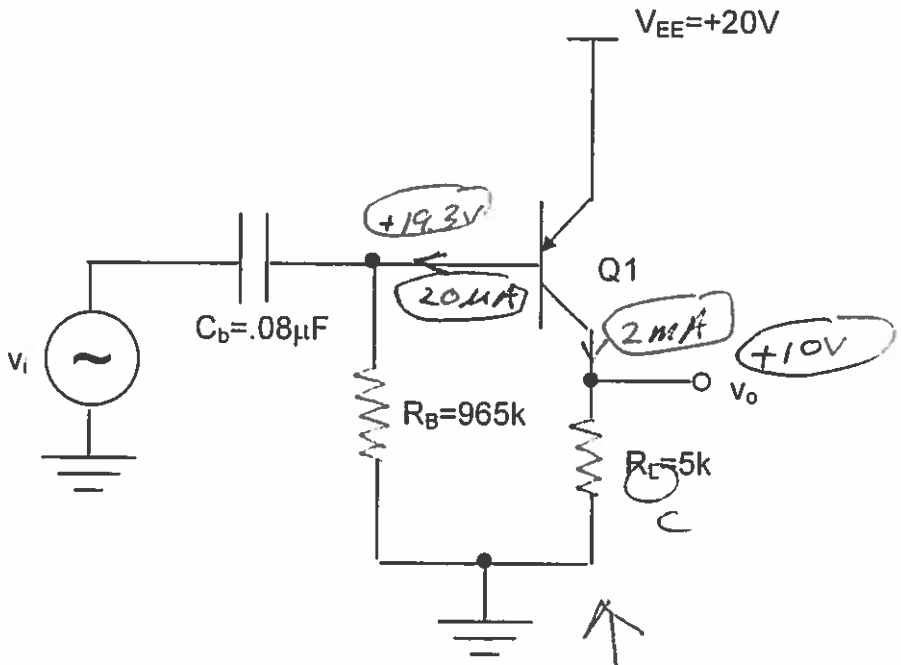
b.) $R_{in} = 2r_{\pi 1} = \boxed{10K\Omega}$

c.) $R_{out} = \boxed{\infty}$

Problem 2 (60 points):

Consider the following simple BJT CE Amplifier. Assume β=100, $V_{BE\text{-}on}$=0.7V, C_π=20pF, C_μ=0.2pF and r_o=infinity. You may make reasonable approximations in your analysis.

$V_T = 25mV$



a) DC Analysis: Calculate V_B, I_B, I_C and V_C.

b) SS AC Midband Analysis: Sketch and label the midband SS AC circuit model and calculate A_m, R_{in} and R_{out} (i.e., R_{out} looking into the output node and **including** R_L).

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c) SS AC Low Frequency Analysis: Sketch and label the low frequency SS AC circuit model and calculate ω_L using SCTC's.

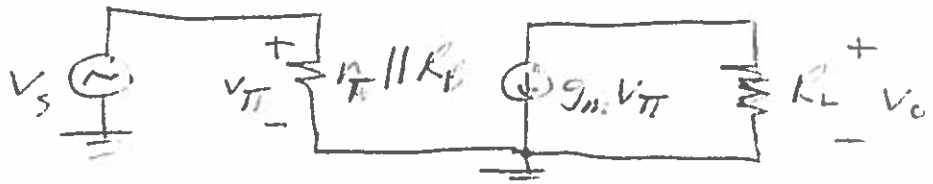
d) SS AC High Frequency Analysis: Sketch and label the high frequency SS circuit model and calculate ω_H using OCTC's.

e) Determine $T(s)=V_o/V_i(s)$. Sketch the "magnitude" Bode Plot only.

f) Calculate the f_T of the BJT.

Hint: The form of T(s) is $A_m \frac{s/\omega_z}{(1+s/\omega_p)(1+s/\omega_{p_2})}$

b.) SS AC MF:



$g_m = \frac{2mA}{25mV} = .08A/V$

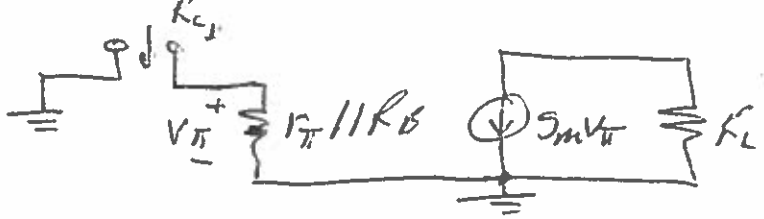
$r_\pi = \frac{\beta}{g_m} = 1.25k\Omega$

$A_m = -g_m R_L = \boxed{-400\ V/V}$

$R_{in} = r_\pi \| R_B \approx r_\pi = \boxed{1.25\ k\Omega}$

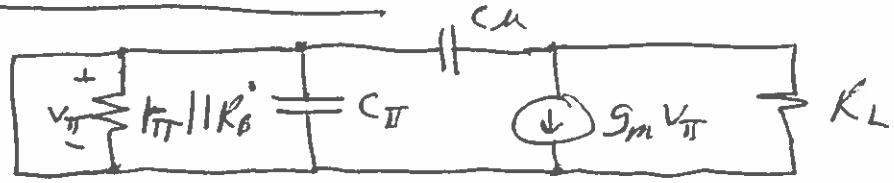
$R_{out} = R_L = \boxed{5k\Omega}$

c.) SS AC LF:



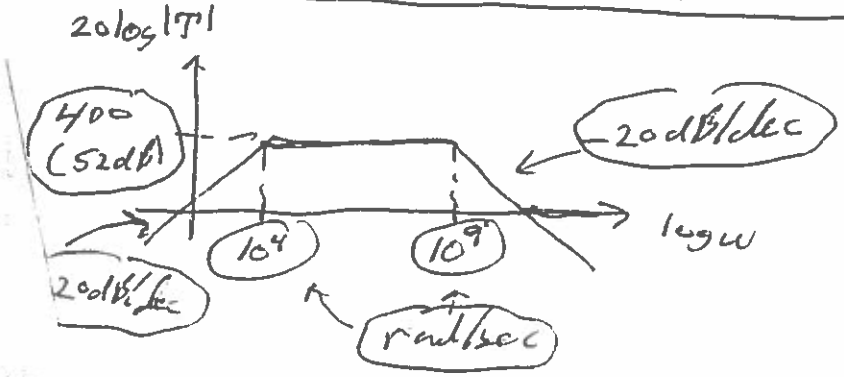
SCTC's $\Rightarrow$ $\omega_L = \frac{1}{\tau_{C_b}} = \frac{1}{R_{C_b} C_b} = \frac{1}{(r_\pi \| R_B) C_b} = \boxed{10^4\ rad/sec}$

d.) SS AC HF!



OCTC's $\Rightarrow$ $\omega_H = \frac{1}{\sum \tau_{j0s}} = \frac{1}{\tau_{k_\pi} + \tau_{C_\mu}} = \frac{1}{0 + R_L C_\mu} = \boxed{10^9\ rad/sec}$

e.) $$\boxed{T(s) = (-400)\ \frac{s/10^4}{(1 + s/10^4)(1 + s/10^9)}}$$



f.) $f_T = \frac{g_m}{2\pi [C_\pi + C_\mu]}$

$= \boxed{630\ MHz}$