Problem 1. All transistors except the output transistors have Cje=20 fF, Ccb=40 fF and tau_f=1 ps. The push pull output transistors have Cje=200 fF, Ccb=400 fF and tau_f=1 ps. All transistors have infinite beta, and infinite Va, EXCEPT Q4 and Q5, giving them infinite beta but Va=100 Volts. The 2 diodes are matched to the 2 output transistors. The load resistance is 100 Ohm. Cx is infinity, which AC grounds the bases of the 3 transistors connected to it. The supplies are + and - 3.3 volts. Q6 and Q7 are biased at 10 mA. All transistors are matched in Ic, except Q6 and Q7, which have 10:1 larger Is. Choose R1 so that Q5 is biased at 5 mA emitter current. Choose R2 so that Q1 and Q2 are biased at 1 mA each. Rf1=100 Ohm, Rf2=10 Ohm. a) Find the DC bias conditions. Find the open-loop (Differential) gain of the operational amplifier. Choose Cf so that the loop bandwidth is 2 GHz.

b) High Frequency analysis. Assume Q7 is on and Q6 is off. With an infinite capacitor shorting Q3's collector and emitter, use the MOTC to find a1 and a2 associated with Q1 and Q2's input. (the high frequency analysis splits at Q2, because it is operating as a common base stage). Then, using the approximation that the time constant associated with (Ccb5+Cf) is much larger than other time constants in the Q4/Q5/Q7 signal path, find a1 and a2 associated with this part of the circuit. Find the overall transfer function of the form
•Draw Bode plots (Magnitude and phase) of Ad(f) and ß(f)
•Find the loop bandwidth and estimate from this the bandwidth of Vout/Vgen.
•Find the gain margin and the phase margin of the feedback loop. Is the amplifier stable?
(Note that there is a second signal path through the amplifier, as illustrated at left. This is somewhat beyond the scope of the class…we will simply assume in 137b that the 2 paths have similar time constants.)