ECE137A Problem set #5

Problem 1

The transistors Q1 and Q2 have beta=60 and $V_{a}=75$ V, $V_{cc}=+10$ Volts, $R_{gen}=2$ kOhm, $R_L=2$ kOhm. Bias Q1 at 0.25 mA collector current, Q2 at 2 mA collector current, bias the emitter of Q2 at 8V, the Q2 collector at 5 V, and the Q1 emitter at 1 V. The parallel combination of $R_{b1}$ and $R_{b2}$ is to be 10 kOhm.

(a) Find all unspecified resistor values.
(b) Find the small signal gain and the input impedance of Q2 ($V_{c2}/V_{b2}$) and $R_{in2}$
(c) Find the small signal gain and the input impedance of Q1 ($V_{c1}/V_{b1}$) and $R_{in1}$

Problem 2

The NMOSFETs have $K_{\mu}=10\text{mA/V}^2\cdot(W_g/\mu\text{m})$ $K_{v}=2.0\text{mA/V}\cdot(W_g/\mu\text{m})$ $\Delta V=100\text{mV}$, $1/\lambda=5$ Volts, and a 0.25 V threshold. The PMOS FETs are the same, except have -0.25 V threshold. All FETs are to operate with $|V_{gs}|=0.35V$, and $I_{d3}=I_{d4}=0.1\text{mA}$, $I_{d5}=0.1\text{mA}$. The supplies are +/- 1 V. The gate of Q5 is at +0.25 V. $R_{g1}=10\text{MegOhm}$, $R_L=10\text{MOhm}$, $R_{g5a}=500\text{kOhm}$, $R_{gen}=1\text{MOhm}$. $V_{out}$ is zero volts.

(a) find all resistor values and FET widths.
(b) find the drain currents, and the drain, gate, and source voltages of all transistors
(f) find $V_{in}/V_{gen}$, $V_{out}/V_{in}$, and $V_{out}/V_{gen}$ of the amplifier.
(g) find the maximum signal swing of the amplifier. This will involve finding the maximum signal swings of Q1, Q2,
input impedance of Q1.

Problem 3

The NMOSFETs have
\( K_\mu = 10 \text{mA/V}^2 \cdot (W_g / \mu \text{m}) \)
\( K_v = 2.0 \text{mA/V} \cdot (W_g / \mu \text{m}) \)
\( \Delta V = 100 \text{mV}, \ 1/\lambda = 5 \) Volts, and a 0.25 V threshold. The PMOS FETs are the same, except have -0.25 V threshold. The FETs are to all operate at |Vgs| = 0.35 V. \( I_{d5} = I_{d6} = I_{d7} = I_{d8} = 0.2 \) mA. The supplies are +/- 1 V. \( V_{d1} = V_{d2} = +0.2 \) V. \( V_{out} = 0 \) V. \( RL = 10*RL_4 \).
(a) find all resistor values, all FET widths.
(b) find the drain currents, and the drain, gate, and source voltages of all transistors
(e) find \( V_{in}/V_{gen} \), \( V_{out}/V_{in} \), and \( V_{out}/V_{gen} \) of the amplifier.
(f) Do not at this time find the maximum signal swings

(c) find the small signal gain of the differential pair Q3/Q4
(d) find the small signal gain of the differential pair Q1/Q2. Note that because both outputs (the drains of both Q1 & Q2) are used, the gain is doubled.