A high-gain amplifier stage is constructed using an NMOS common-source amplifier with a simple PMOS mirror as active load. The input voltage is $v_G = V_G + v_g$, where $V_G$ is the dc bias component and $v_g$ is the small-signal component. All devices have the same characteristics: $W = L = 10\mu\text{m}$, $\mu_nC_{ox}/2 = \mu_pC_{ox}/2 = K = 50\mu\text{A}/V^2$, $V_{tn} = |V_{tp}| = 1\text{V}$, $\lambda = 0.011/V$, $\gamma = 0$. The dc supply voltage is $V_{DD} = 10\text{V}$.

a) Sketch the complete circuit of the amplifier. Choose the resistance $R$ in the current mirror, and the dc bias voltage $V_G$, so that all devices operate in saturation, and so that the small-signal voltage gain is $A = v_o/v_g = -100$. What is the output resistance of the amplifier?

b) Do a DC sweep (.dc) PSpice simulation to plot the large-signal input-to-output ($v_O$ vs $v_G$) characteristic of the amplifier. Based on the result of the simulation, choose $V_G$ so that the dc output voltage is $V_O = V_{DD}/2$. How does this $V_G$ compare to the value obtained in the hand calculations of part (a)? With this $V_G$, do a transfer-function (.tf $v$(out) $v$(in)) simulation. From the PSpice output (.out) file, record the amplifier small-signal characteristics: output resistance and gain. How do these values compare to the hand calculations? In the Spice device models, include only the parameters $K_P$, $V_{TO}$, and $\lambda$.

c) It is required to modify the amplifier of part (a) so that the gain remains $A = -100$, but so that the output resistance satisfies $R_{out} \leq 5k\Omega$. Redesign the amplifier according to these specifications: you can add as many MOS devices as you need, but no additional discrete resistors are allowed. You can assume that all devices have the same $L = 10\mu\text{m}$. Sketch the complete circuit, specify all device sizes $W/L$, find all relevant DC voltages and currents, and show that the amplifier meets the specs for gain and output resistance. Verify your solution using PSpice and turn in relevant simulation results.