**1.** The cascode in Figure 1 is biased by an ideal current source. Let $R_S = 51 \, \Omega$, $I_S = 1 \times 10^{-15} \, \text{A}$, $V_A = 100 \, \text{V}$, $\beta = 200$, $I_{SUP} = 1 \, \text{mA}$, $T = 300 \, \text{K}$, $v_{OUT,DC} = 3.5 \, \text{V}$, and $V_{BIAS2} = 2 \, \text{V}$. Calculate $V_{BIAS1}$ to match these biasing conditions.

Figure 1: Cascode amplifier with ideal current source

| V_{BIAS1} = |
2. What is the gain of this amplifier?

\[ A_v = \] 

3. Now perform a SPICE simulation on the circuit in Figure 1. You can find the 2N4401 SPICE model on the course website. Re-bias the input for the SPICE model using the instructions below (i.e., do not use your calculated \( V_{BIAS1} \)). Add a large resistor (on the order of 1 GΩ) from \( V_{CC} \) to \( v_{out} \) to avoid convergence errors (which result from the ideal current source having infinite output resistance). Find the gain \( (A_v) \) and the output impedance \( (R_{out}) \) of the amplifier using SPICE. Attach the SPICE netlist to the end of this prelab.

In order to determine the appropriate bias point for the circuit (which will differ from your hand calculations), perform a DC sweep of \( v_{in} \). Plot \( v_{out} \) vs. \( v_{in} \) in Awaves to find the point of maximum gain. Set \( v_{in} \) to this value in your netlist and perform a TF analysis to obtain the gain and input/output impedances.

\[ A_v = \] 
\[ R_{out} = \] 

![Figure 2: Multi-stage amplifier](image)

4. Now construct a SPICE netlist for the multi-stage amplifier shown in Figure 2. Let \( R_C = 10 \text{kΩ} \), \( R_S = 51 \text{kΩ} \), and \( R_{REF} = 200 \text{Ω} \). Bias transistor \( Q_1 \) with \( V_{BE1} = 560 \text{mV} \). What is the small signal
gain ($A_{v1}$) between $v_{IN}$ and $v_{OUT1}$? What is the small signal gain ($A_{v2}$) between $v_{OUT1}$ and $v_{OUT2}$? Using $A_{v1}$ and $A_{v2}$, find the overall gain ($A_{v,tot}$) between $v_{IN}$ and $v_{OUT2}$. Attach the SPICE netlist to the end of this prelab.

\[
\begin{align*}
A_{v1} &= \\
A_{v2} &= \\
A_{v,tot} &= 
\end{align*}
\]