Suggested Reading: Read as many of the following as you can. All of the recommended references are on reserve at Barker Library.

1. Lundberg sections 21–24 and 27.
2. Grebene section 7.

Problem 1: Actively Loaded Differential Pair

Find $\frac{v_{out}}{v_1 - v_2}$ at midband, assuming $\beta_{nnp}=200$, $\beta_{pnp}=50$, $V_{A,npp}=100\,\text{V}$, $V_{A,pnp}=50\,\text{V}$, Common-Mode Voltage $V_{CM}=0$ and $V_{BIAS}=4\,\text{V}$.
Problem 2: Op Amp Log Circuit

Assume that the following circuit is operated at room temperature \((T = 300K)\).

(a) When \(R_1=15.7R_2\), \(v_O\) is of the form \(v_O=A \log_{10}(x)\). Find \(A\) and \(x\).
(b) Solve for \(R_1\) in terms of \(R_2\) such that \(v_O\) exhibits a \(\log_2(x)\) behavior.

Problem 3: Op Amp Frequency Response

Assume that the following op amp has a finite gain with frequency response \(A(s)=\frac{a_o}{s+\tau}\) (where \(a_o=10^6\) and \(\tau=10^{-6}\)) and that \(f=[1 0.1 0.01 0.001]\).

(a) Solve for the closed-loop DC gain and upper \(-3\text{dB}\) Frequency for each value of \(f\).
(b) Sketch the Bode plot (magnitude only) of \(\frac{v_{OUT}}{v_{IN}}(s)\) for each value of \(f\).
(c) Sketch the unit step response of \(v_{OUT}(t)\) for each value of \(f\).

Make sure to label important features in your sketches including magnitudes, slopes, breakpoint frequencies, and times.

Problem 4: Lead-Lag Op Amp Configuration

Sketch the Bode plot (magnitude and phase) of \(\frac{v_{OUT}}{v_{IN}}(s)\). Make sure to label the magnitudes of each asymptote and its breakpoint frequency. Assume the op amp is ideal.