ENEE 306 Final Exam
All transistors in this exam have $\beta=200$; $V_{be}=0.7$ for DC.

Part I (32 pts.): The following questions refer to Figure P-I. Take $C_\mu=1.0$pf. You can neglect $C_\pi$. You can neglect the effects of $g_m$ and $r_\pi$ for the AC calculations in Part I.

1. Calculate the AC voltage gain at midband frequencies.
2. Use the SCTCA to find the approximate low frequency pole of this circuit.
3. Use Miller’s theorem to find the approximate high frequency pole of this circuit.
4. Sketch the Bode plot for this circuit.
5. What is the maximum AC voltage swing this circuit can have without distorting?

![Figure P-I](image)

Part II (33 pts.): Now suppose the circuit in Figure 1 is slightly modified by adding a very large capacitor in parallel with the 1K resistor between the emitter and ground. The new capacitor is large enough so that we can take it to be a perfect short circuit for AC signals and an open circuit for DC.
Take $C_\mu=1.0$pf. You can neglect $C_\pi$. You can neglect $g_m$ and $r_\pi$ where appropriate, but not everywhere. The following questions refer to the revised circuit.

1. Calculate the AC voltage gain at midband frequencies.
2. Use Miller’s theorem to approximate the high frequency pole of this circuit.
3. Calculate the midband gain of the circuit if a 1k load resistor is added between the output and ground.
4. Show how you would connect an emitter follower circuit to increase the voltage gain of the circuit with the applied 1k load.
5. Calculate the new gain with your emitter follower added.
Part III (35 pts.): The following questions refer to the circuit in Figure P-III: Take the Early voltage \( V_a = 100V \) for all transistors. Take the capacitor as DC open and AC short. Calculations are at midband frequencies.

1. Calculate the AC voltage gain.
2. Sketch the signal at the output for an input signal of \( 0.025\sin(2\pi \times 10^6) \) V. Use the correct voltage and times scale on your plot.
3. Show how you would replace the 5k collector resistors of the diff-amp with a current mirror to have an active load for this circuit.
4. Calculate the AC voltage gain for the circuit with the active load.
5. Attach a feedback loop to have a closed loop gain of 15 for this circuit. Make sure you explain in words which inputs you’re taking as the inverting and noninverting ones, respectively, and why.

Figure P-III

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\begin{align*}
V_t &= 0.25V \\
r_o &= \frac{V_a}{I_c} \\
\beta/g_m &= r_{\pi} \\
p_m &= -1/R_{mCm} \\
g_m &= \frac{I_c}{V_t} \\
p_o &= \sum -(1/R_{iC})
\end{align*}
\]