HW3
Lab 2

IC Design?
Single pole model

Circuit design - library of building blocks
CS, CG, CD, direct pair, current mirror (cascade, ...)

Find operating point
Solve nonlinear algebraic equations

Find linear model there

Redraw circuit in local coordinates v_2, i_0, n_0

Design

Estimate nonlinear effects
Output swing, gain variation

What are the specs that we work from?
Often vague - "you're the analog person - figure it out!"

Try to translate into

Gain, bandwidth
Power, (noise)
Input/output swing
Source, load impedance
Gain stability (feedback, stability)

What are we designing?

Choose a collection of building blocks & assemble
Each transistor has design choices

Bipolar: emitter area, current

MOS: \( I_d = \frac{W}{L} (V_G - V_T)^2 (1 + \frac{1}{2} V_D) \)

Process parameters
Sometimes w/ a few discrete choices, e.g.
Thick oxide, high V_T,

Project helps you tie it all together
Simplify: \[ V_i - | \quad V_0 \]

Low freq:
\[ V_0 = -5_m R_0 \]

High freq
\[ \frac{5_m V_i}{C_0} \]
\[ V_0 = \frac{-9_m}{j\omega C_L} \]

At high freq above \( \frac{1}{2\pi f_c} \)
\[ V_0 = \frac{5_m}{3/(\omega C_L)} \]

KCL @ \( V_0 \):
\[ 5_m (V_0 - V_i) + 5_m V_i + \frac{1}{R_0} V_0 + \frac{5}{S_0} V_0 = 0 \]
\[-(9_m - 5_m S_0) V_i = V_0 \left( 5_m C_0 + \frac{1}{R_0} + 5_m S_0 \right) \]
\[ H(s) = \frac{V_0}{V_i} = \frac{-9_m (1 - \frac{5_m S_0}{5_m})}{\frac{1}{R_0} + S (C_0 + C_L)} \]
\[ = -5_m R_0 \frac{1 - \frac{3}{\omega_p}}{1 + \frac{3}{\omega_p}} \]
\[ \omega_p = \frac{R_0 (C_0 + C_L)}{5_m} \]

Simplify even further:
\[ C_0 = 0 \]
\[ N(s) = \frac{V_o}{V_i} = \frac{-9_m R_0}{1 + \frac{3}{\omega_p}} = \frac{A_v}{1 + \frac{3}{\omega_p}} \]

\[ |H(j\omega)| = \frac{A_v}{\omega_0} \]
\[ \begin{align*}
\text{At } & 0 \quad \frac{A_v}{V_i} \\
\text{At } & \omega_p \quad \frac{A_v}{V_i} \\
\text{At } & 3 \omega_p \quad \frac{A_v}{V_i} \\
\text{At } & 4 \omega_p \quad \frac{A_v}{V_i} 
\end{align*} \]

\[ \log |H(j\omega)| \]
\[ \omega \quad 0 \quad \omega_p \quad 3 \omega_p \quad 4 \omega_p \]

\[ 7 - 1 \quad -20 \log \frac{1}{V_i} \]