**Lab 2**

**HW 3**

**Midterm 1:** 2 weeks from today, in class

**Single pole systems**

- Gain vs. freq
- Transient step response

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**Last time:** lots of things look like single pole amps

\[
\frac{I_1}{I_2} = \frac{5V_s}{3Io} \quad \text{or} \quad \frac{V_1}{V_2} = \frac{5V_s}{3Io}
\]

- If source resistance is low, we are ignoring

\[
\text{source resistance} \approx \frac{V_i}{I_s}
\]

- So \( \frac{V_o}{V_i} = H(s) = \frac{-9mR_o}{1 + 3\omega_p R_o} \)

- \( \omega_p = \frac{1}{R_o C_o} \)

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\[
V_o = i_x R
\]

\[
i_x = \frac{V_o}{R} \quad \text{or} \quad V_o = i_x R C \quad \frac{V_o}{V_i} = \frac{1}{s C}
\]

\[
\frac{V_o}{V_i} = \frac{1}{s C} \quad \text{or} \quad V_o = \frac{i_x}{s C} = i_x \frac{1}{j\omega C}
\]

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**R = 1M \quad 1M**

**C = 1\mu F**

\[
Z = \frac{1}{j\omega C} \quad Z_p = \frac{1}{j\omega C}
\]

\[
Z_p = \frac{1}{j\omega C} \quad Z_p = \frac{1}{j\omega C}
\]

\[
\frac{V_o}{V_i} = \frac{1}{s C} \quad \text{error:} \quad \frac{V_o}{V_i} = \frac{1}{s C}
\]

**Max(1, 10m)**

**Worst case error:** \( \frac{1}{2} \)

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**error:** \( \frac{1}{2} \)

**Not super helpful for above \( \omega_p \)**
\[ A_V = H(s) = \frac{-g_m R_0}{1 + \frac{g_m R_0}{w C_D}} \]

\[ |H(iw_c)| = 1 \quad \text{unity gain} \]

\[ \left| \frac{g_m R_0}{1 + \frac{g_m R_0}{w C_D}} \right| = \frac{g_m R_0}{w R_0 C_D} = \frac{g_m}{w C_D} \]

\[ \frac{g_m}{w C_D} = 1 \implies w = \frac{g_m}{C_D} \]

\[ w_c = \frac{g_m}{C_D} \]

\[ w_p = \frac{1}{R_0 C_D} \]

\[ |A_V| = \frac{g_m R_0}{w C_D} \]

- Increase \( R_0 \) by multiple \( \alpha \)
- More gain, lower pole
- Gain above pole remains unchanged.

- Increase \( C_D \) by \( \alpha \)

- Increase \( g_m \) by \( \alpha \)
- \( w_p \) unchanged.
- More gain, more BW possible!