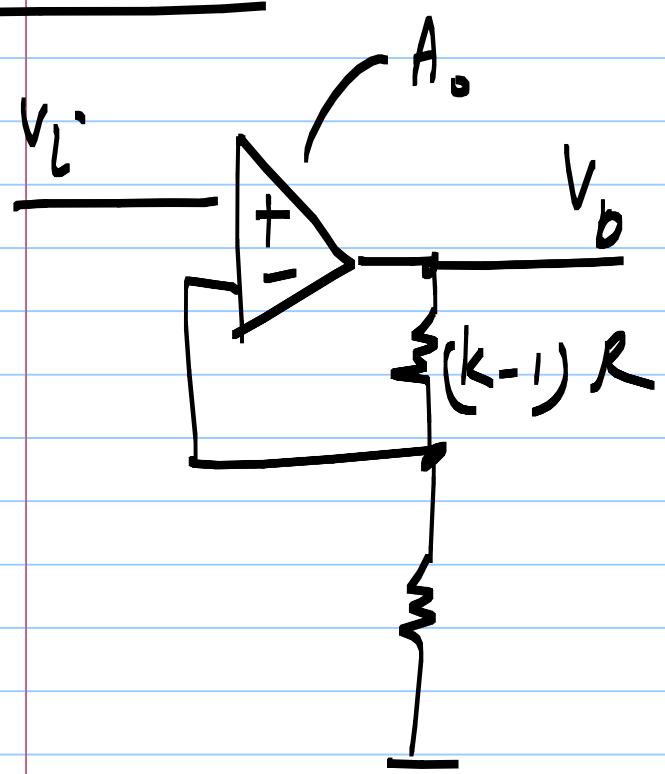
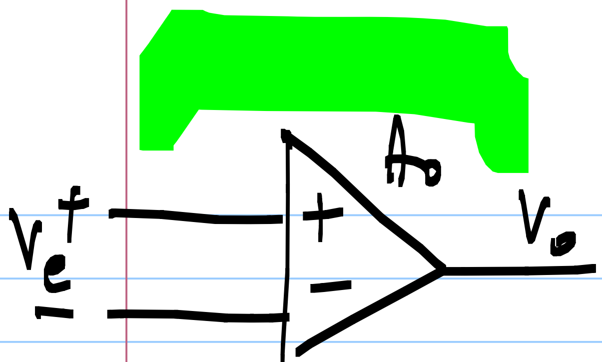
EE2019

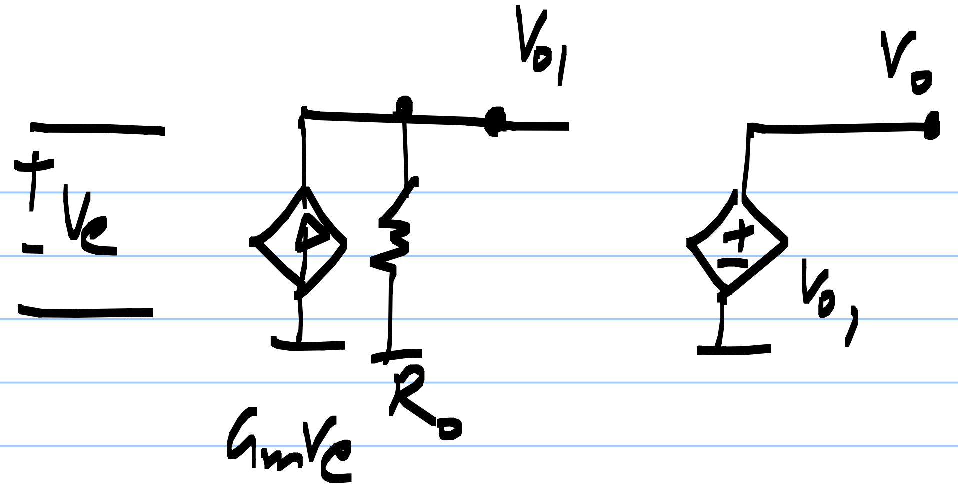
13/2/2018



$$\frac{V_o}{V_i} = k \, \frac{1}{1+\frac{k}{A_o}}$$

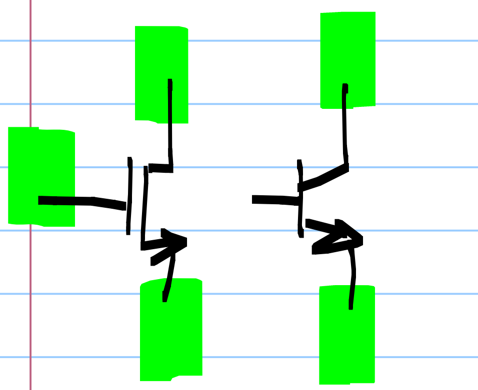


≡

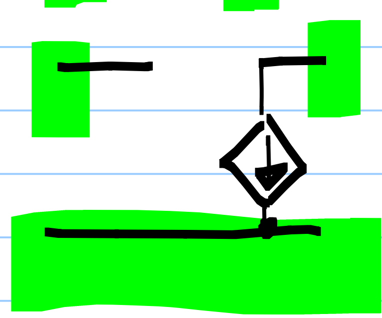


$$A_o : \underline{G_m R_o}$$

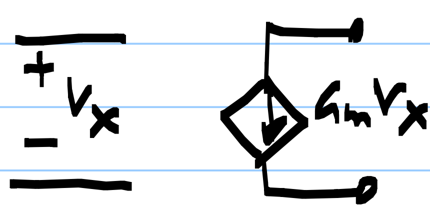
$$\frac{A_o}{k} \gg 1$$



≃

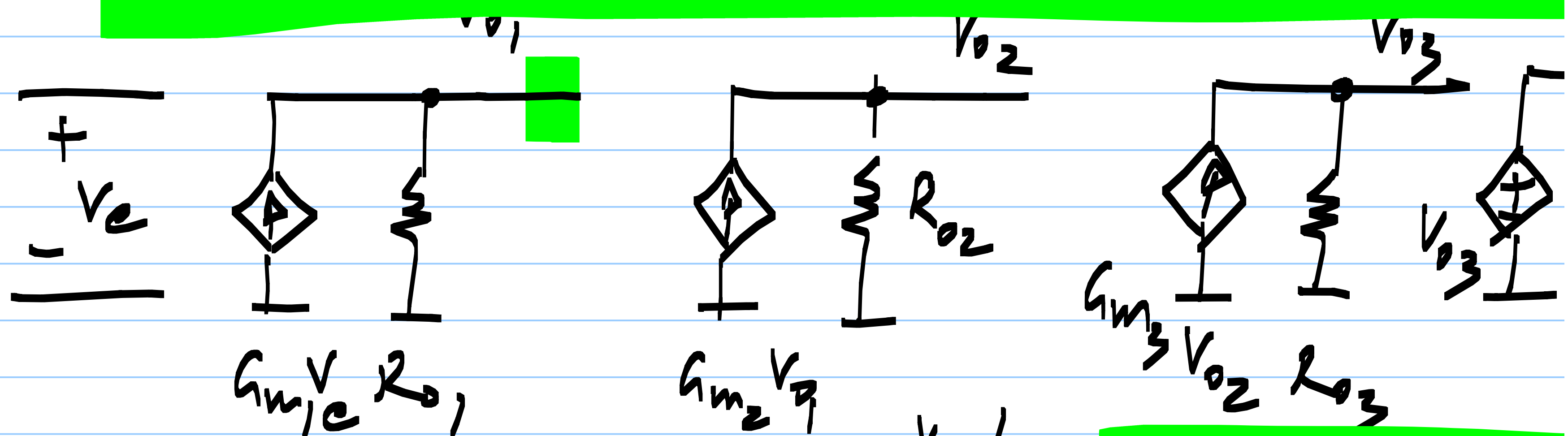


3-terminal source



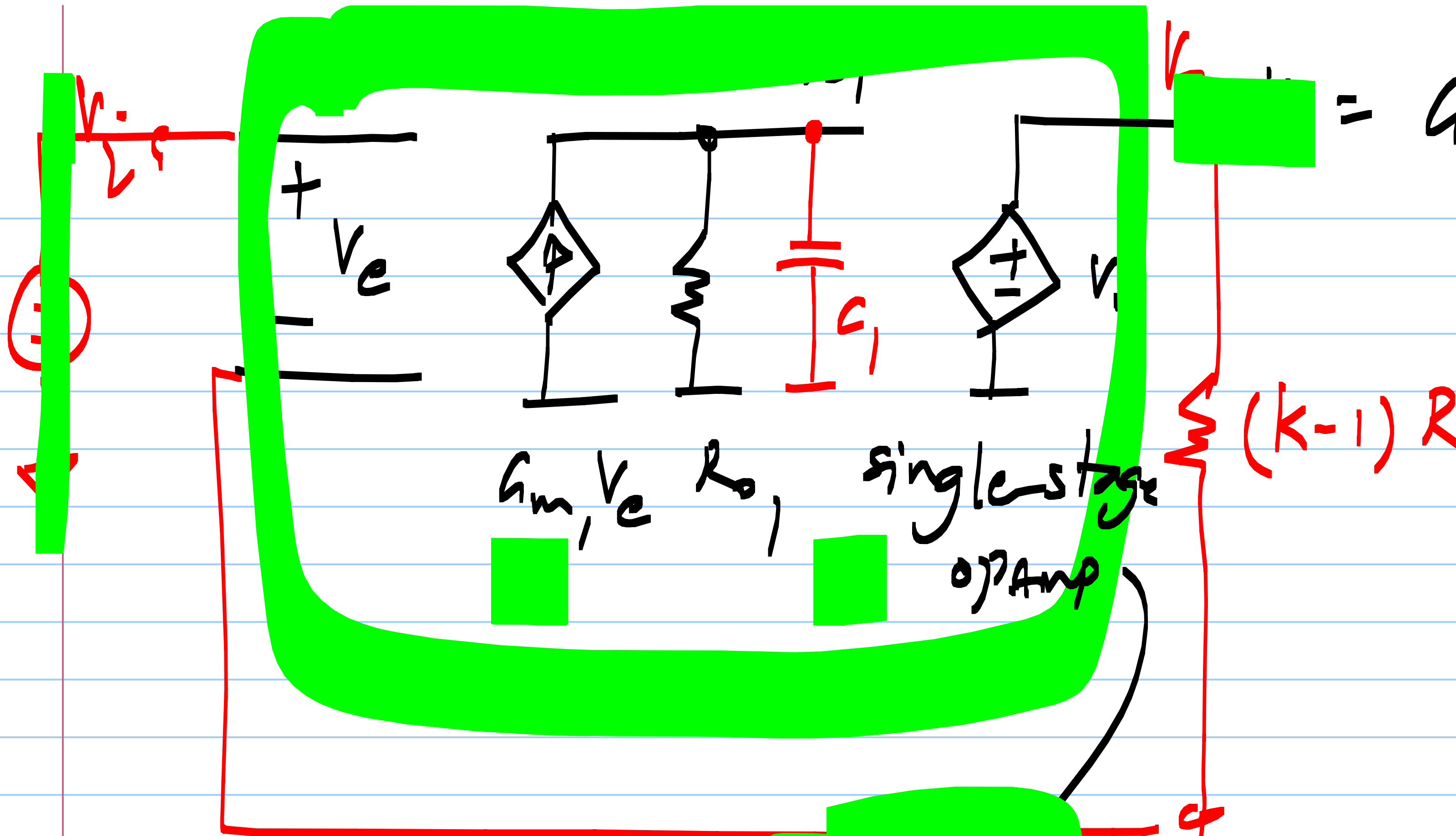
$G_m R_o$ of a VCCS using a transistor ~ 10s

~ 100s



$V_{o_3}/V_e =$

$$\frac{V_{o_1}}{V_e} = G_{m_1} R_{o_1} \qquad \frac{V_{o_2}}{V_e} = G_{m_1} R_{o_1} \cdot G_{m_2} R_{o_2}$$



$= G_{m1} R_{o1} \cdot V_e$

$$\frac{V_o}{V_e} = \frac{\overbrace{G_{m1} \cdot R_{o1}}}{1+s} = \frac{A_o}{1+s/p_1}$$

$$\frac{V_o}{V_i} = \frac{k}{1+\frac{k}{A(s)}} = \frac{k}{1+\frac{k}{A_0}\left(1+\frac{s}{p_1}\right)} \qquad \frac{\alpha}{1+s/\omega_B}$$

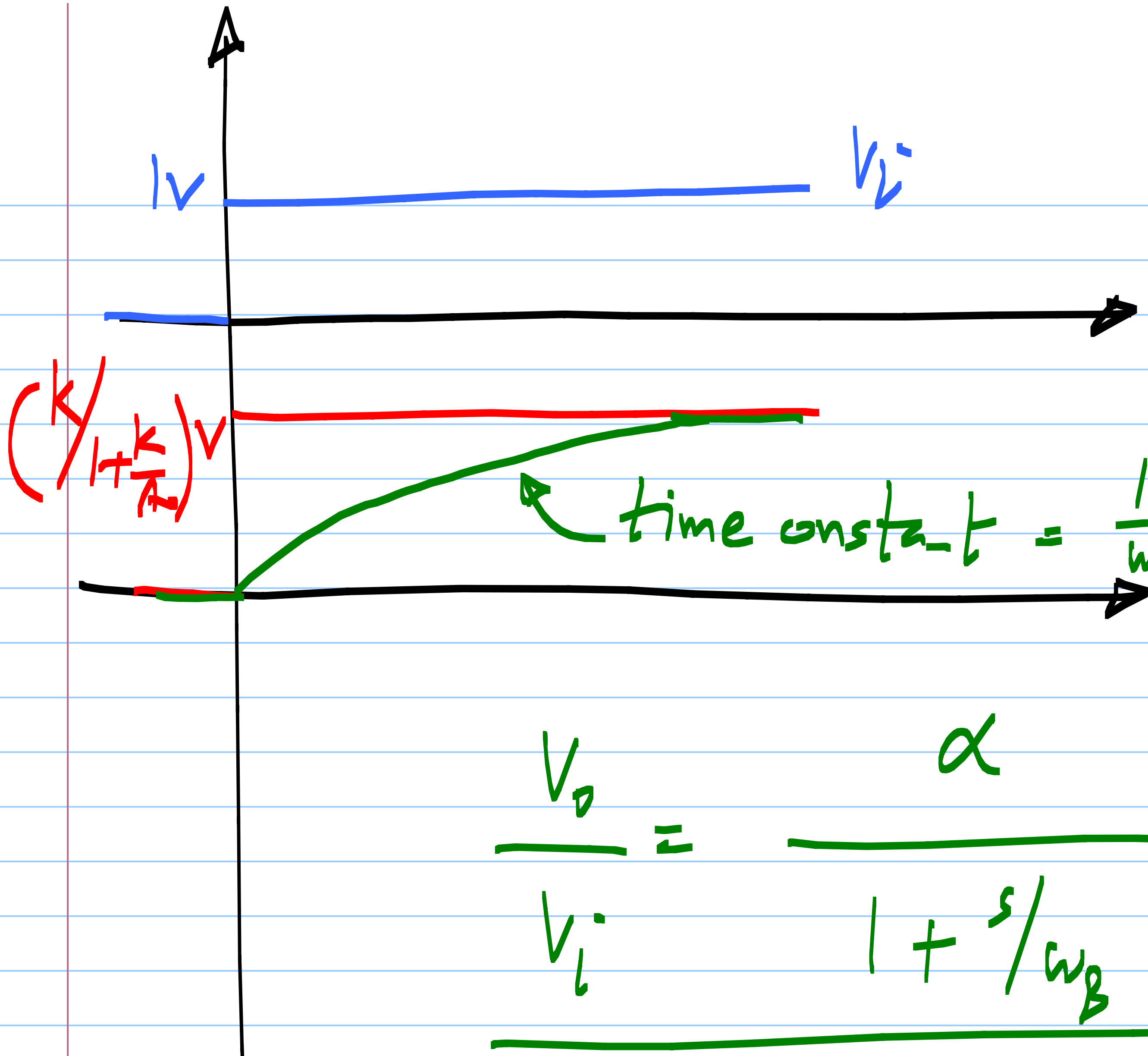
opamp: 1 pole @ $-p_1$

$$A(s) = \frac{A_0}{1+s/p_1}$$

$p_1 > 0$

$$\frac{V_o}{V_i} = \frac{k}{1+\frac{k}{A_0}+\frac{s}{A_0 p_1/k}} = \frac{\quad}{A_0} \cdot \frac{1}{1+\frac{s}{p_1\left(1+\frac{A_0}{k}\right)}}$$

dc gain: $\frac{k}{1+k/A_0}$; 1 pole @: $-p_1\left(1+\frac{A_0}{k}\right)$



time constant $= \dfrac{1}{\omega_B} = \dfrac{1}{p_1\left(\frac{A_o}{k}+1\right)}$

$p_1 > 0$

$$\frac{V_o}{V_i} = \frac{\alpha}{1 + s/\omega_B}$$

$$\omega_B = p_1\left(1 + \frac{A_o}{k}\right)$$

$$
\begin{tikzcd}
\begin{matrix} u(t) \\ x(t) \end{matrix} \arrow[r] \arrow[d, "\mathcal{L}"] & \boxed{H(s)} \arrow[r] & \begin{matrix} ? \\ y(t) \end{matrix} \\
X(s) \arrow[rr] & & X(s) \cdot H(s) \arrow[u, "\mathcal{L}^{-1}"'] \\
1/s \arrow[rr] & & \underbrace{1/s \; H(s)} \arrow[uu, bend right]
\end{tikzcd}
$$

$$
\frac{1}{s} \cdot \frac{\alpha}{1 + s/\omega_B} = \underline{\frac{1}{s} \cdot \alpha \cdot \frac{\omega_B}{s + \omega_B}}
$$

With a single-stage opamp $\overbrace{\frac{A_0}{1+s/p_1}}^{\text{opamp}} = A(s)$

* Closed-loop transfer function

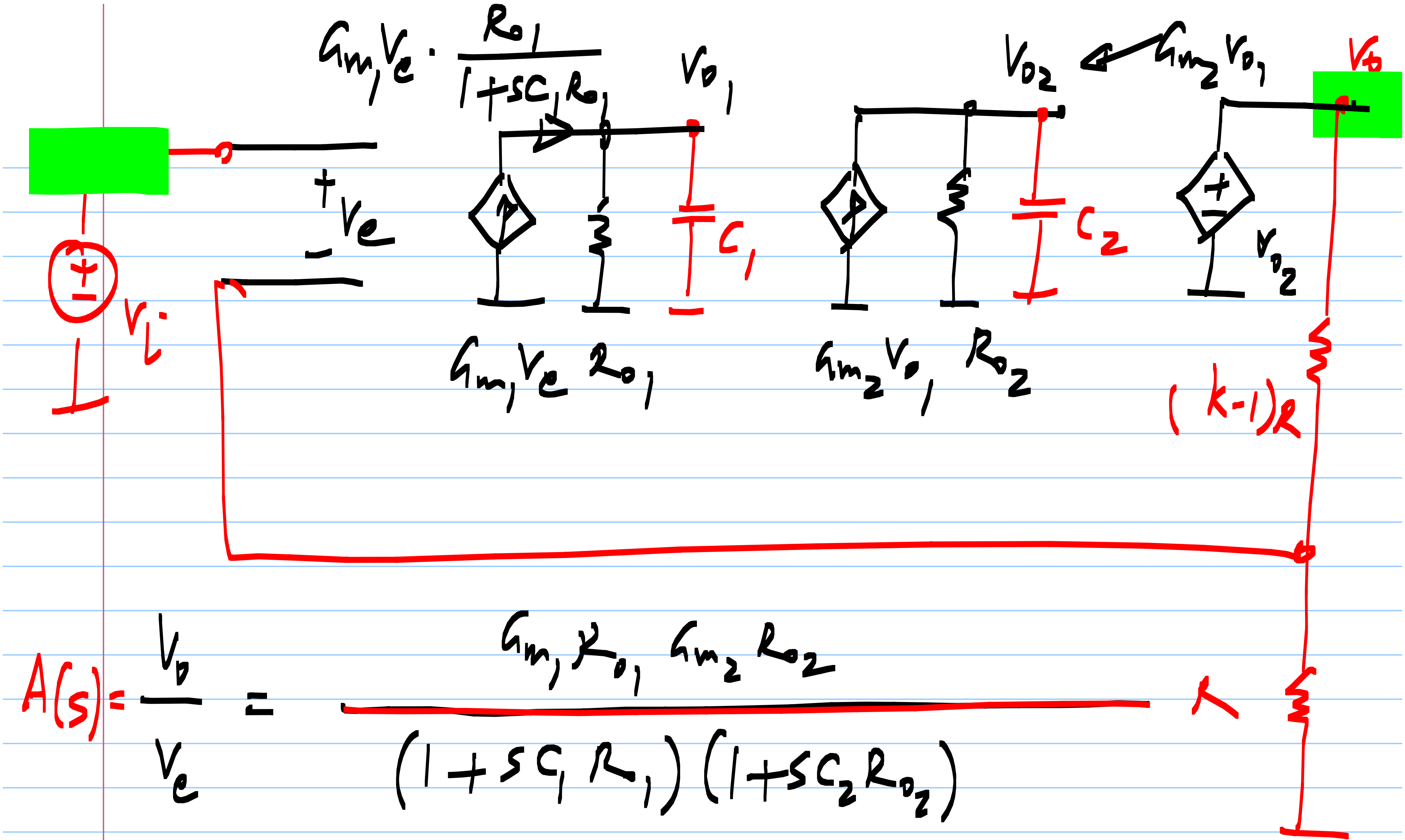
$$\frac{v_o}{v_i} = \frac{\alpha}{1+s/\omega_B} \qquad \alpha = \frac{k}{}$$

$$\omega_B = p_1\left(1+\frac{A_0}{k}\right)$$

→ pole @ $-\omega_B = -p_1\left(1+\frac{A_0}{k}\right)$

→ always in LHP, $\left\{ \begin{array}{l} p_1 > 0 \\ A_0 > 0 \\ k > 0 \end{array} \right.$

→ $\boxed{\text{stable}}$



$$A(s) = \frac{V_o}{V_e} = \frac{G_{m_1} R_{o_1} G_{m_2} R_{o_2}}{(1+sC_1R_1)(1+sC_2R_{o_2})}$$

2-stage opamp:

$$\frac{A_0}{(1+s/p_1)(1+s/p_2)} = A(s)$$

$$=$$

$A_0 = G_{m_1} R_{o_1} G_{m_2} R_{o_2}$

$p_1 = 1/C_1 R_{o_1}$

$p_2 = 1/C_2 R_{o_2}$

poles @ $-p_1, -p_2$

$$\frac{V_o}{V_i} =$$