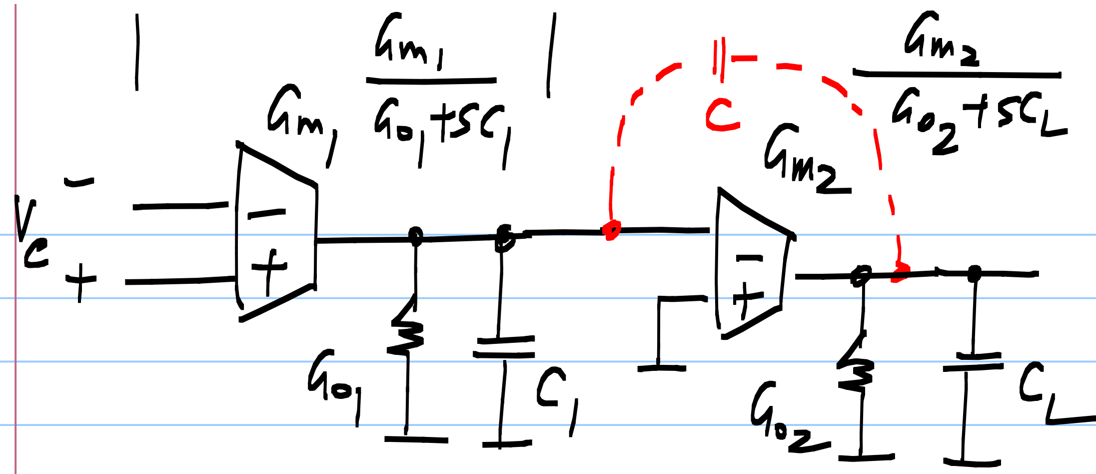


pole: $-\frac{G_{o1}}{C_1}$; $-\frac{G_{o2}}{C_L}$

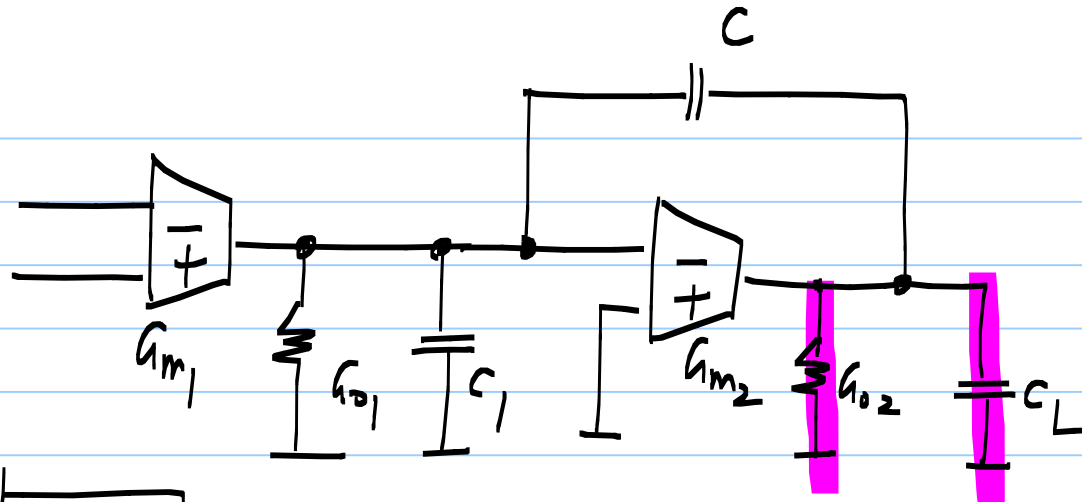
	Without C	With C
p_1	$-\dfrac{G_{o1}}{C_1}$	$-\dfrac{G_{o1}}{C\left(\dfrac{G_{m2}}{G_{o2}}+1+\dfrac{G_{o1}}{G_{o2}}\right)+C_1+C_L\cdot\dfrac{G_{o1}}{G_{o2}}}$
p_2	$-\dfrac{G_{o2}}{C_L}$	$-\dfrac{G_{o2}+G_{m2}\cdot\dfrac{C}{C+C_1}+G_{o1}\cdot\dfrac{C+C_L}{C+C_1}}{C_L+\dfrac{C\cdot C_1}{C+C_1}}$

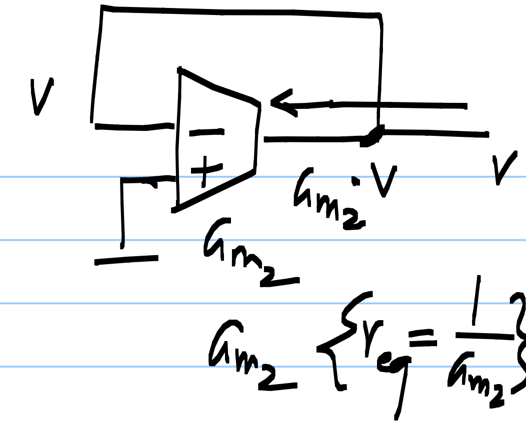
low frequency

high frequency

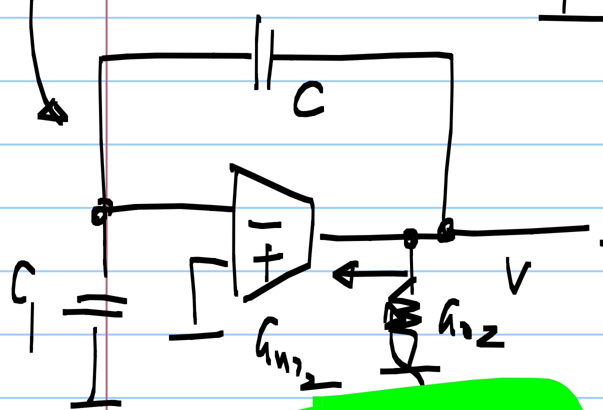
pole splitting

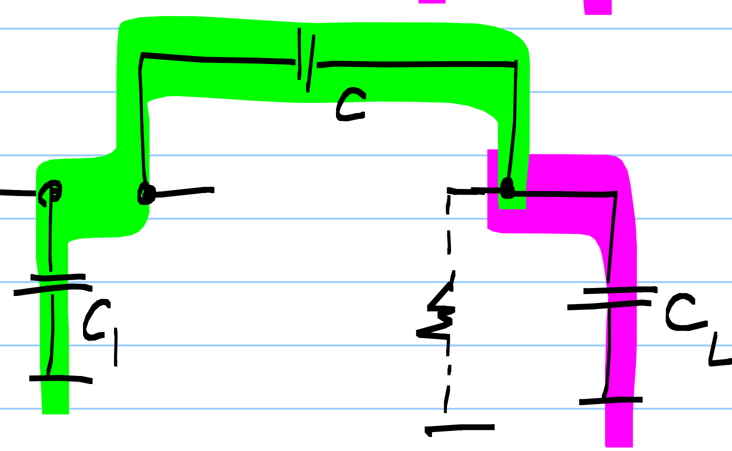
$$V \cdot \frac{C}{C + C_1}$$





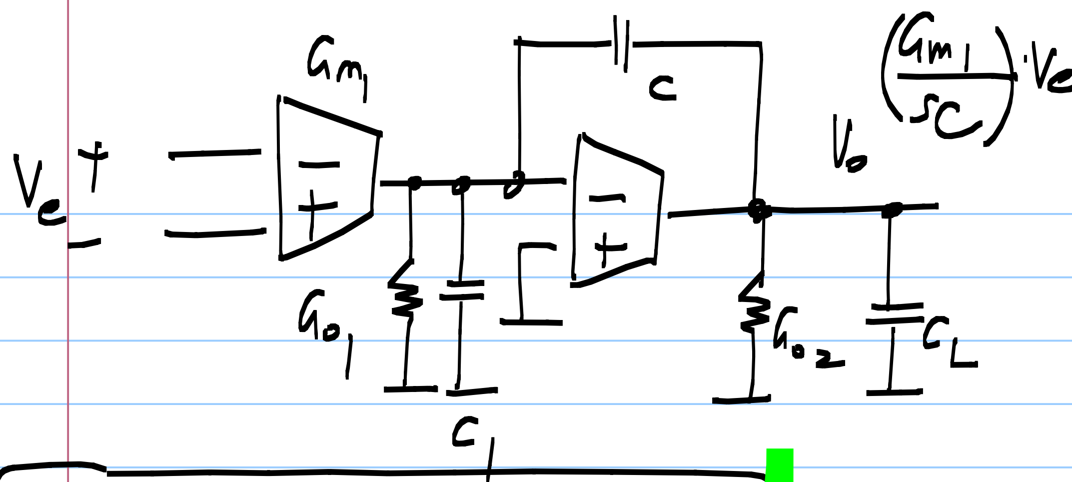
$$C_L + \frac{C \cdot C_1}{C + C_1}$$

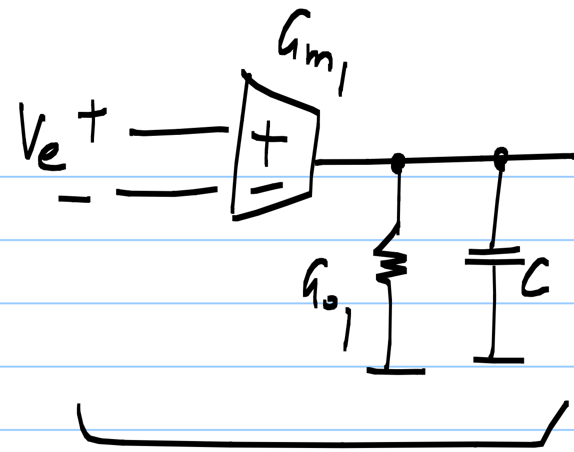




$$\frac{C}{C + C_1} \cdot G_{m_2} \cdot V$$

$$\frac{C}{C + C_1} \cdot G_{m_2} + G_{o_2}$$





Single stage opamp

$$\boxed{\text{dc gain} = \frac{G_{m1}}{G_{o1}} \cdot \frac{G_{m2}}{G_{o2}}}$$

$$p_1 \simeq -\frac{G_{o1}}{C\left(\frac{G_{m2}}{G_{o2}}+1\right)+C_1}$$

$$p_2 \simeq -\frac{G_{m2}\cdot\frac{C}{C+C_1}+G_{o2}}{C_L+\frac{C\cdot C_1}{C+C_1}}$$

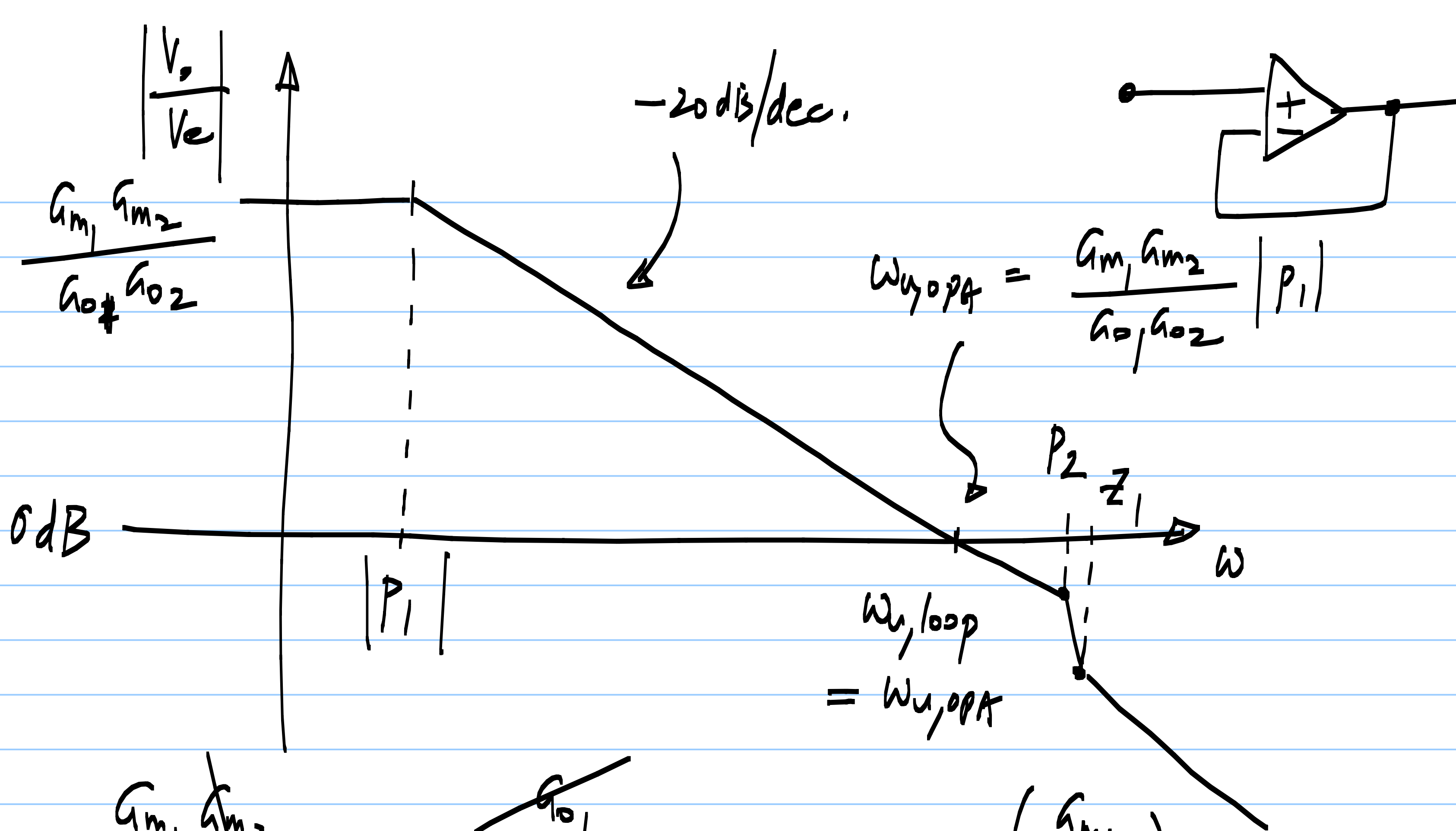
$$z_1 = +G_{m2}/C$$

$$\omega_u = \frac{G_{m1}}{C}$$

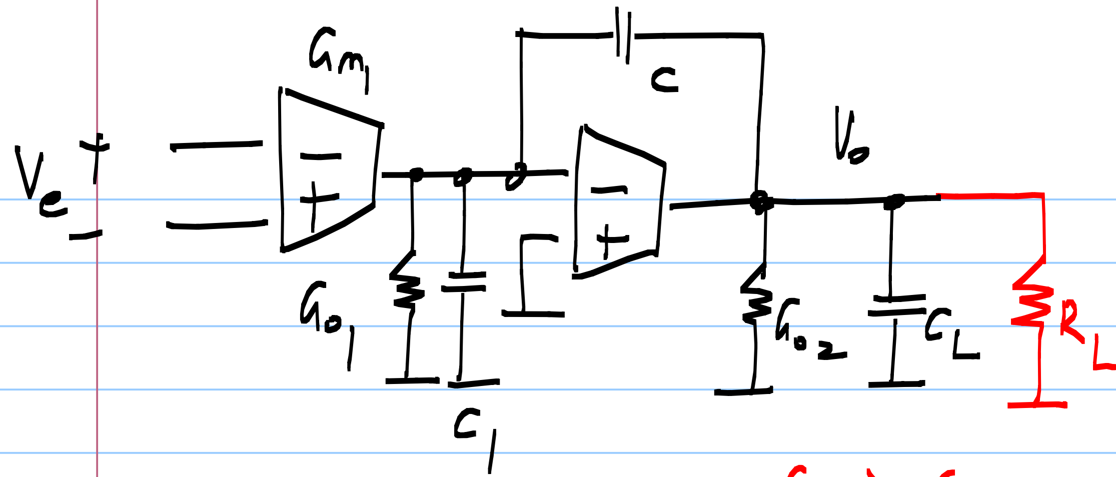
$$p_1 = -\frac{G_{o1}}{C}$$

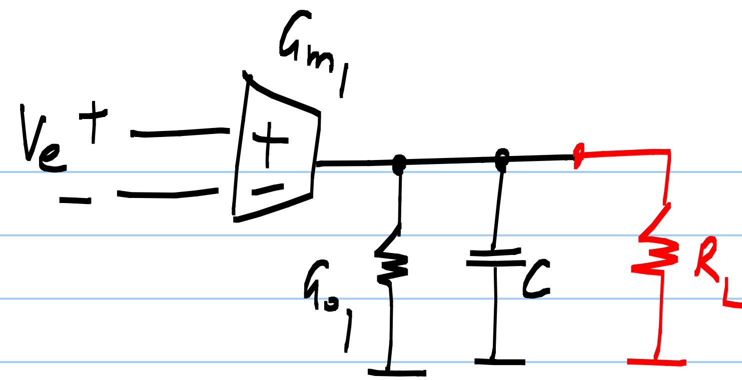
$$\omega_u = \frac{G_{m1}}{C}$$

$$\boxed{\text{dc gain} = \frac{G_{m1}}{G_{o1}}}$$



$$\frac{G_{m1}\,\cancel{G_{m2}}}{\cancel{G_{o1}}\,\cancel{G_{o2}}}\cdot\frac{\cancel{G_{o1}}}{\underbrace{C\left(\cancel{\frac{G_{m2}}{G_{o2}}+1}\right)}+\cancel{C_1}} \simeq \left(\frac{G_{m1}}{C}\right)$$

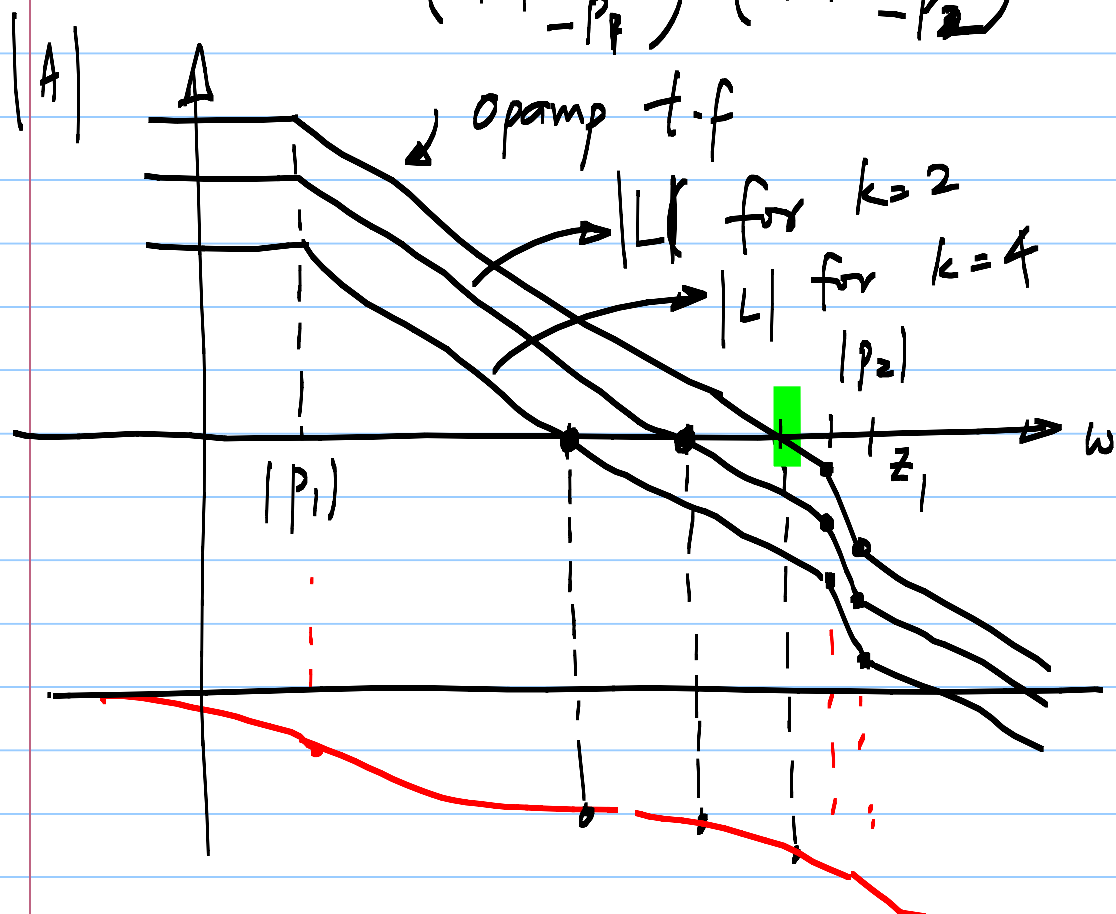


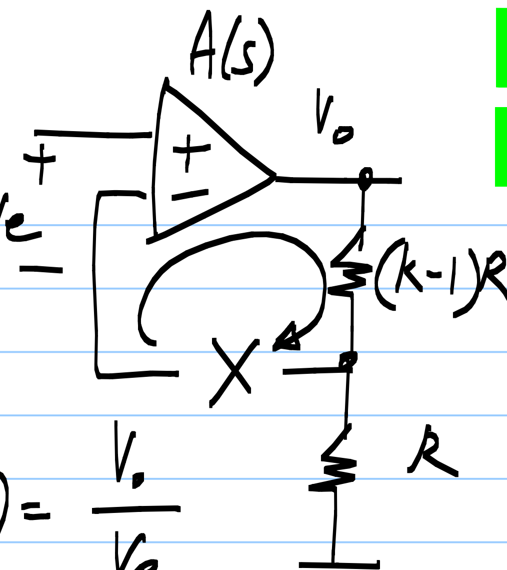


$G_L \gg G_{o2}$ $\qquad$ $G_L \gg G_{o1}$

$$\frac{G_{m1}}{G_{o1}} \; \frac{G_{m2}}{\cancel{G_{o2}} + G_L} \qquad\qquad \frac{G_{m1}}{\cancel{G_{o1}} + G_L}$$

$$\frac{V_o}{V_e} = \frac{A_o\left(1 - \frac{s}{z_1}\right)}{\left(1 + \frac{s}{-p_1}\right)\left(1 + \frac{s}{-p_2}\right)}$$





$$A(s) = \frac{V_o}{V_e}$$

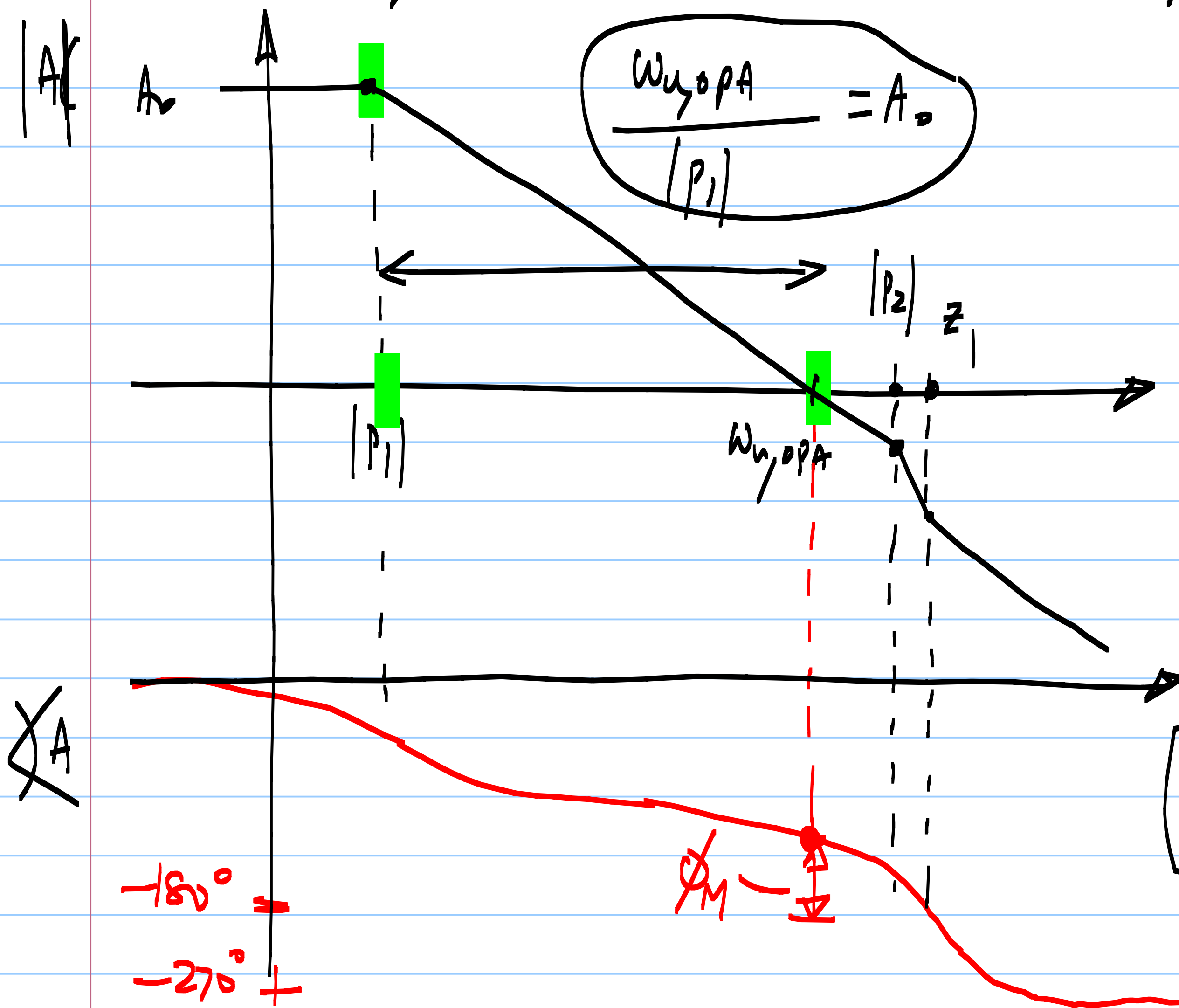
$$\frac{A(s)}{k} = L(s)$$

highest phase lag for $k = 1$

For $k=1$, $L(s) = A(s)$; $\omega_{u,loop} = \omega_{u,opA}$

RHP

$$A(s) = \frac{A_0\left(1 - \frac{s}{z_1}\right)}{\left(1 + \frac{s}{-p_1}\right)\left(1 + \frac{s}{-p_2}\right)}$$



$$\angle A(j\omega) = -\tan^{-1}\left(\frac{\omega}{z_1}\right) - \tan^{-1}\left(\frac{\omega}{-p_1}\right) - \tan^{-1}\left(\frac{\omega}{-p_2}\right)$$

$$\boxed{\phi_M = 60^\circ}$$

$$\phi_M = -\tan^{-1}\left(\frac{\omega_{u,loop}}{z_1}\right) - \tan^{-1}\left(\frac{\omega_{u,loop}}{-p_1}\right) - \tan^{-1}\left(\frac{\omega_{u,loop}}{-p_2}\right) + 180^\circ$$

$$= -\tan^{-1}\left(\frac{G_{m1}}{G_{m2}}\right) - 90^\circ - \tan^{-1}\left(\frac{\omega_{u,loop}}{p_2}\right) + 180^\circ$$

$$= 90^\circ - \underbrace{\left[\underbrace{\tan^{-1}\left(\frac{G_{m1}}{G_{m2}}\right)}_{14^\circ} + \underbrace{\tan^{-1}\left(\frac{\omega_{u,loop}}{p_2}\right)}_{16^\circ}\right]}_{30^\circ} = 60^\circ$$

G_{m2} has to more than G_{m1}; $\quad G_{m2} = 4 \cdot G_{m1}$

$$\tan^{-1}\left(\frac{1}{4}\right) \simeq 14^\circ$$

$$\tan^{-1}\left(\frac{\omega_{u,loop}}{p_2}\right) = 16^\circ$$

$$\frac{\omega_{u,loop}}{p_2} = \frac{G_{m_1}/C}{\left[\dfrac{G_{m_2}\cdot C/C+C_1}{C_L + \dfrac{C\cdot C_1}{C+C_1}}\right]} = \tan(16^\circ)$$

$$\left.\frac{\dfrac{G_{m_1}}{C}\left(C_L + \dfrac{C\cdot C_1}{C+C_1}\right)}{G_{m_2}\cdot\dfrac{C}{C+C_1}} = \tan(16^\circ)\right\}$$

$\boxed{\text{Quadratic equation in } C}$

$$\left(\frac{G_{m_1}}{G_{m_2}}\right)\cdot\frac{1}{C^2}\left(C_L\cdot C + C_L C_1 + C\cdot C_1\right) = \tan\left(16^\circ\right)$$

$$\tan 16^\circ\cdot\left(\frac{C^2}{C_L^2}\right) = \left(\frac{G_{m_1}}{G_{m_2}}\right)\left(\frac{C}{C_L} + \frac{C_1}{C_L} + \frac{C}{C_L}\cdot\frac{C_1}{C_L}\right)$$

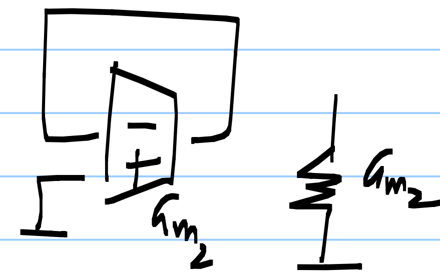
$$= \frac{G_{m_1}}{G_{m_2}}\left(\frac{C}{C_L}\left(1+\frac{C_1}{C_L}\right) + \frac{C_1}{C_L}\right)$$

$$\left(\frac{C}{C_L}\right) : \left\{\frac{G_{m_1}}{G_{m_2}},\ \tan^{-1}\phi_M',\ \frac{C_1}{C_L}\right\}$$

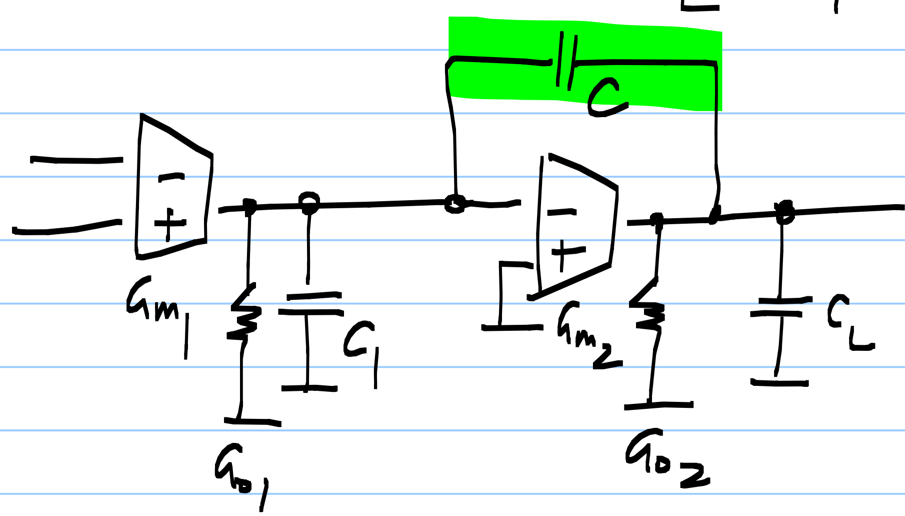
$$p_2 = -\frac{G_{o2} + G_{m2} \cdot \frac{C}{C + C_1}}{C_L + \frac{C \cdot C_1}{C + C_1}}$$

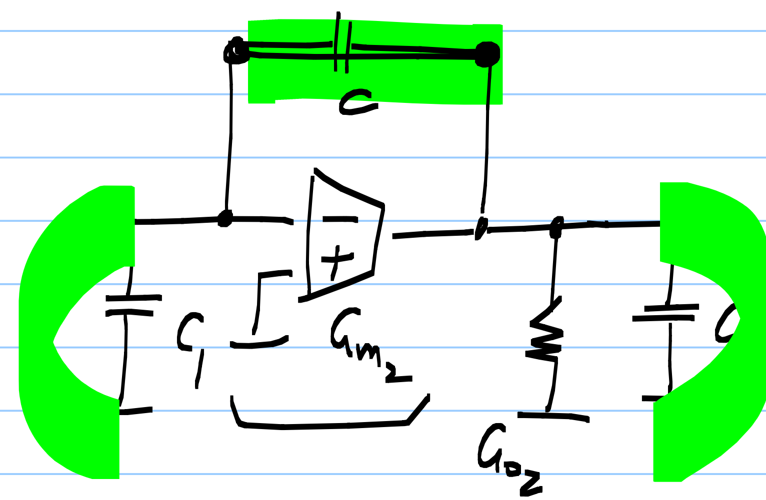
$C \gg C_1$

$C + C_1 \simeq C$



$$= -\frac{G_{o2} + G_{m2}}{C_L + C_1}$$





when $c \gg c_1$, $\quad p_2 \simeq \dfrac{G_{m2}+G_{o2}}{C_1+C_L}$

$$\tan^{-1}\left(\frac{\omega_{u,loop}}{p_2}\right) = 16^\circ$$

$$\frac{G_{m1}/C}{\dfrac{G_{m2}+G_{o2}}{C_1+C_L}} = \tan(16^\circ)$$

Linear equation in C