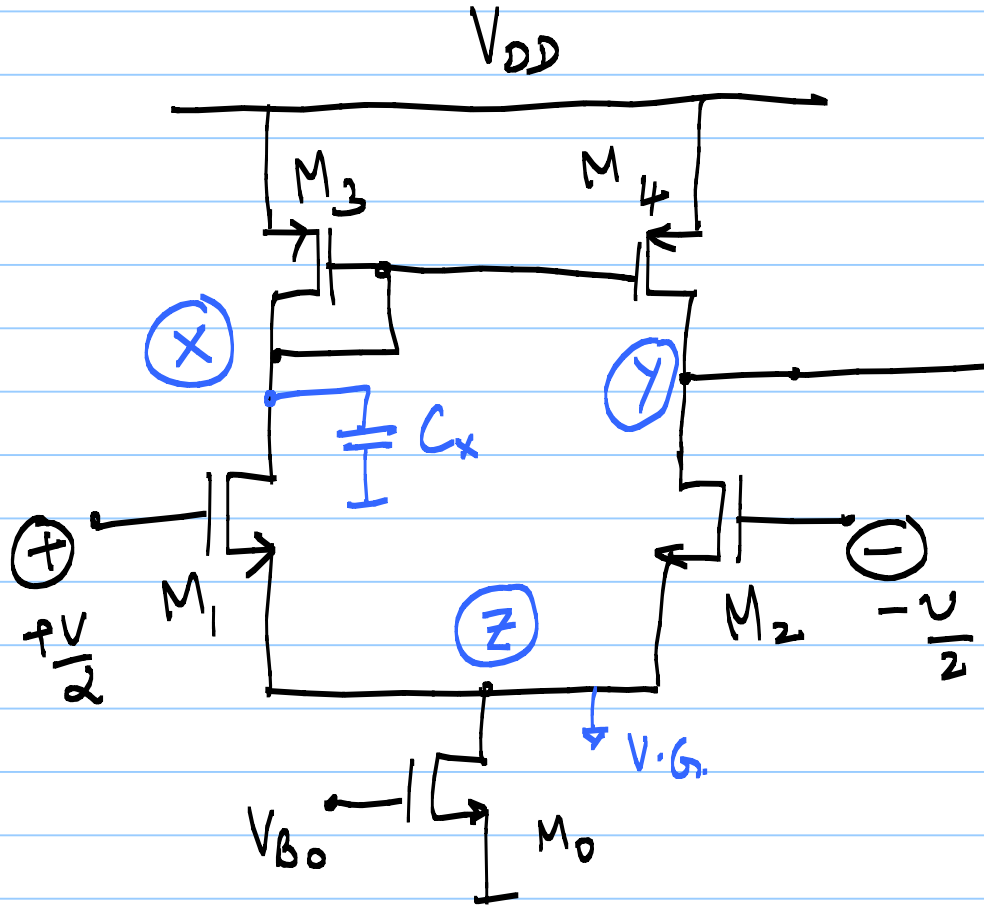
22/10/2020

Lecture 43

parasitic cap. @ x & y

2 poles in A(s)



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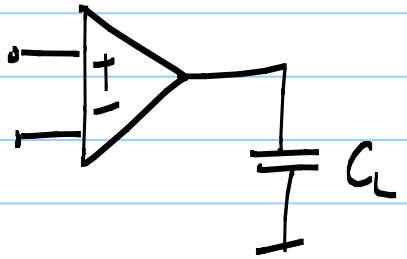
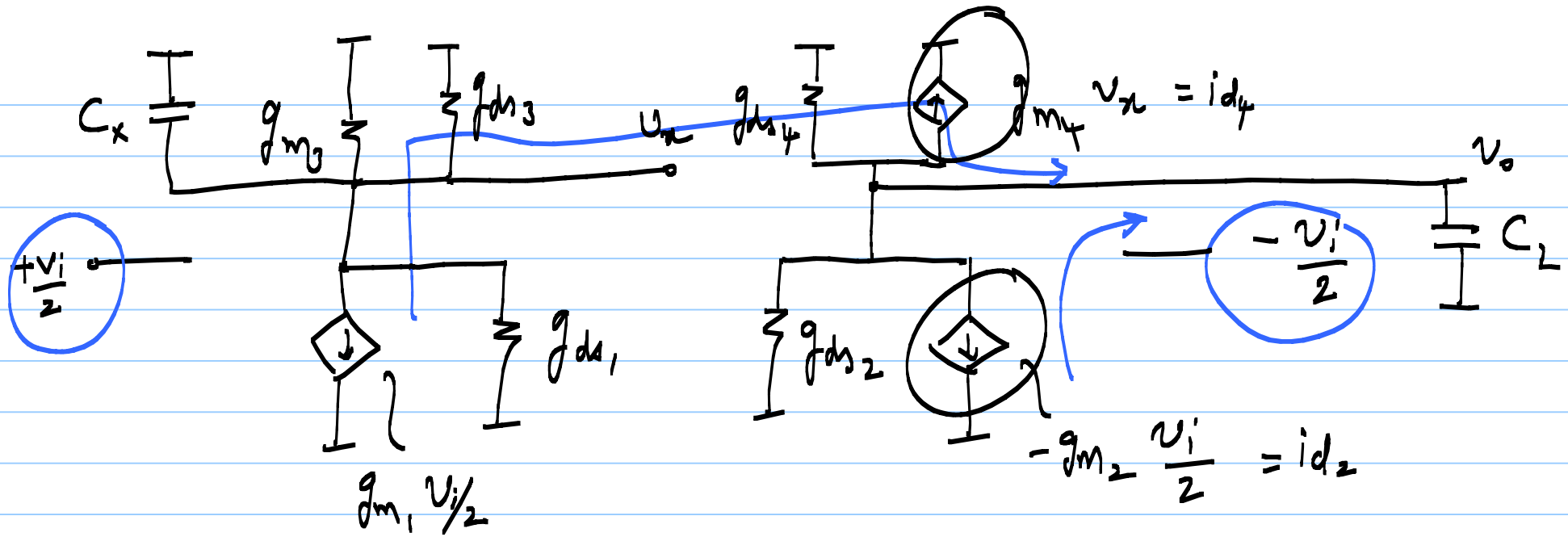




* all g_m's >> all g_{ds}'s

$$v_x = -\frac{+g_{m_1} v_i/2}{g_{m_3} + g_{ds_2} + g_{ds_1} + sC_x} \approx \frac{-g_{m_1} v_i/2}{g_{m_3} + sC_x}$$

$$v_x \approx \frac{-g_{m_1}}{g_{m_3}} \cdot \frac{1}{1 + sC_x/g_{m_3}} \cdot \frac{v_i}{2}$$

$$i_{d_4} = g_{m_4} \cdot v_x$$

$$= \frac{-g_{m_1}}{1 + \frac{sC_x}{g_{m_3}}} \cdot \frac{v_i}{2}$$

$$i_{d_2} = -g_{m_2} v_i/2$$

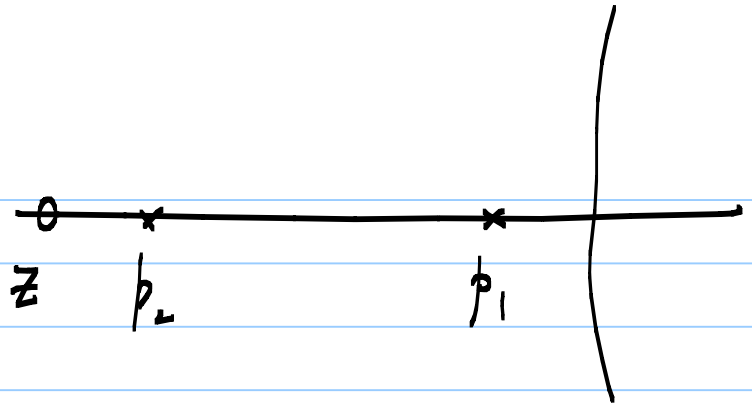
$$v_o = -\frac{(i_{d_2} + i_{d_4})}{g_{ds_2} + g_{ds_4} + sC_L}$$

$$v_o = -\frac{-g_{m_2} v_i/2 - \frac{g_{m_1}}{1 + sC_x/g_{m_3}} \cdot v_i/2}{g_{ds_2} + g_{ds_4} + sC_L}$$

$$= \frac{g_{m_1} v_i}{g_{ds_2} + g_{ds_4}} \cdot \frac{\frac{1}{2} + \frac{1/2}{1 + sC_x/g_{m_3}}}{1 + \frac{sC_L}{g_{ds_2} + g_{ds_4}}}$$

$$\boxed{\frac{v_o}{v_i} = \frac{g_{m_1}}{g_{ds_2} + g_{ds_4}} \cdot \frac{\left(1 + sC_x/2g_{m_3}\right)}{\left(1 + sC_x/g_{m_3}\right)\left(1 + sC_L/(g_{ds_2} + g_{ds_4})\right)}}$$

* $A_0 = \dfrac{g_{m_1}}{g_{ds_2} + g_{ds_4}}$
* 2 poles $\rightarrow$ @ (X) , (Y)
* 1 zero @ $2g_{m_3}/C_x$

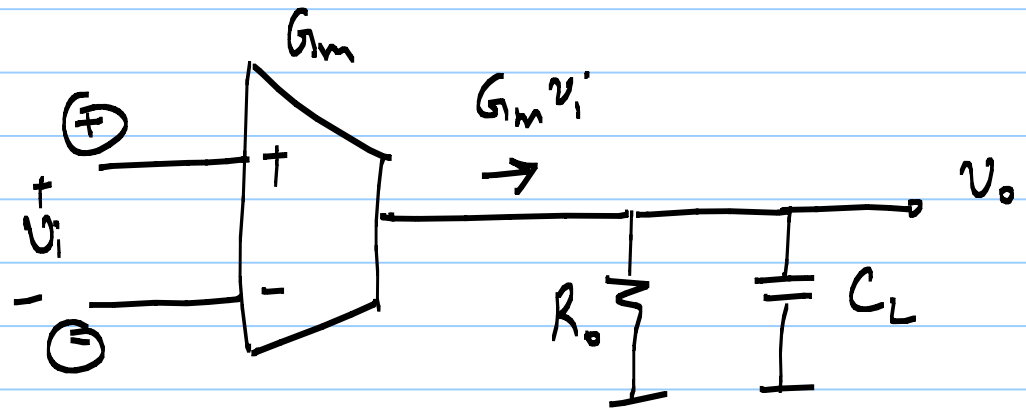


$$p_1 = \frac{g_{ds2} + g_{dsp}}{C_L}$$

$$p_2 = \frac{g_{m3}}{C_x}$$

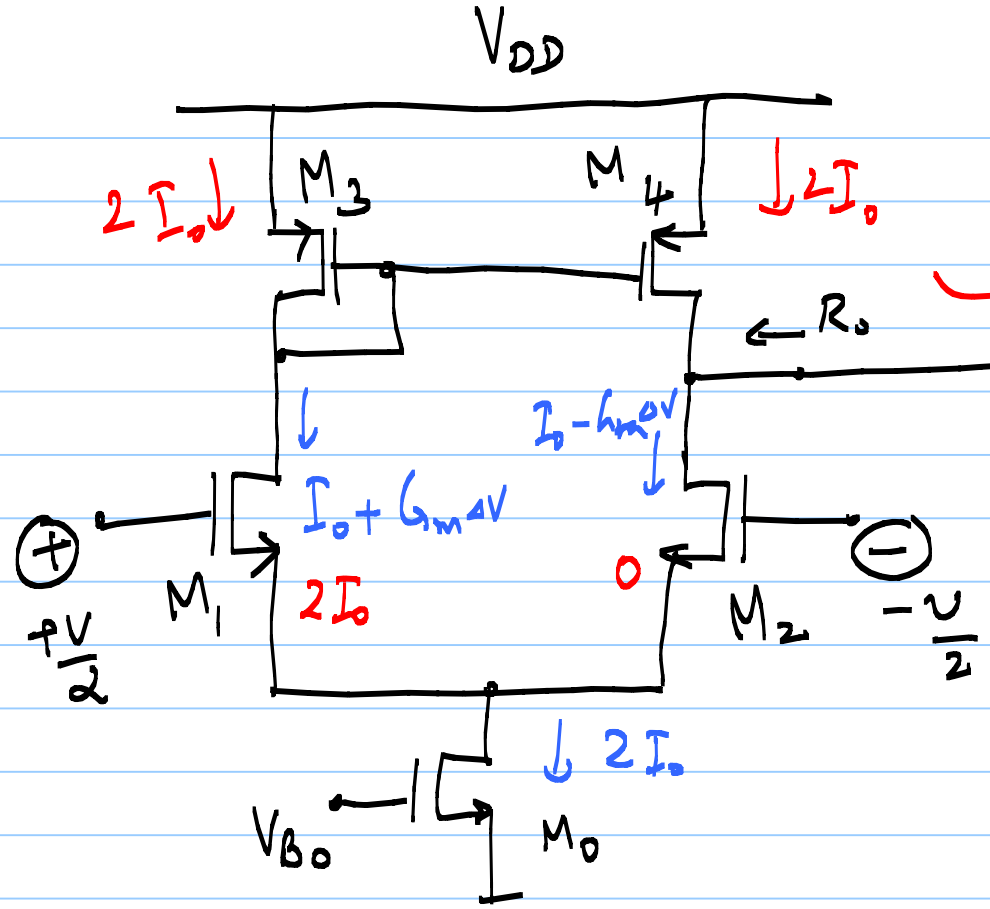
$$z = 2p_2 = \frac{2g_{m3}}{C_x}$$

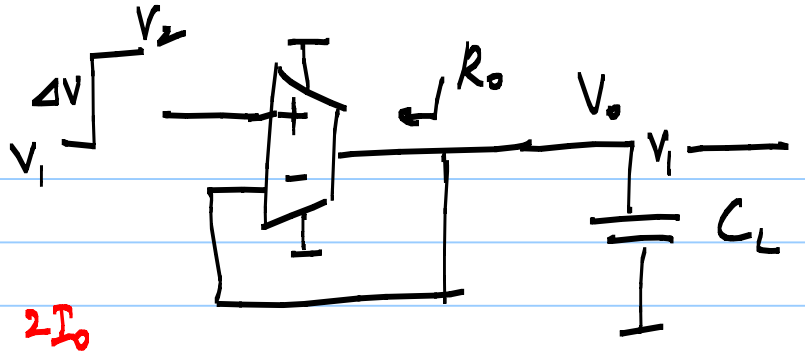
Ideal 1-stage opamp :

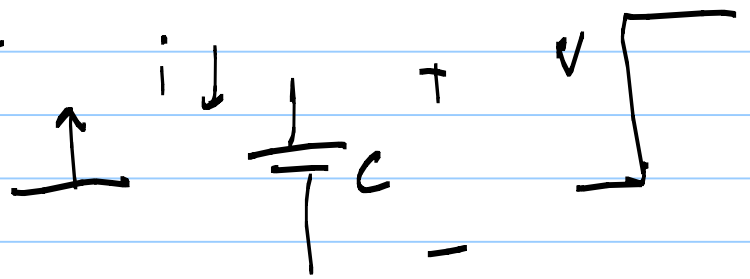


$$\omega_u = \frac{G_m}{C_L} = \frac{g_{m1}}{C_L}$$

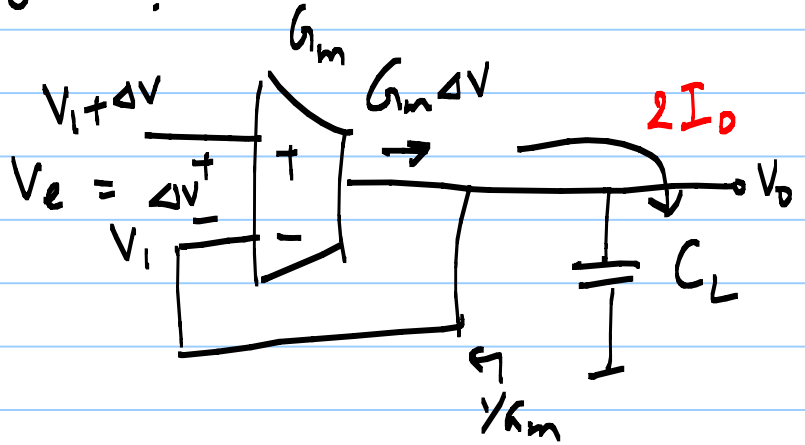
$$G_m = g_{m1} \; ; \; R_o = r_{ds2} \| r_{dsp} \; ; \; A_o = G_m R_o = g_{m1}(r_{ds2} \| r_{dsp})$$







@ $t = 0^+$:

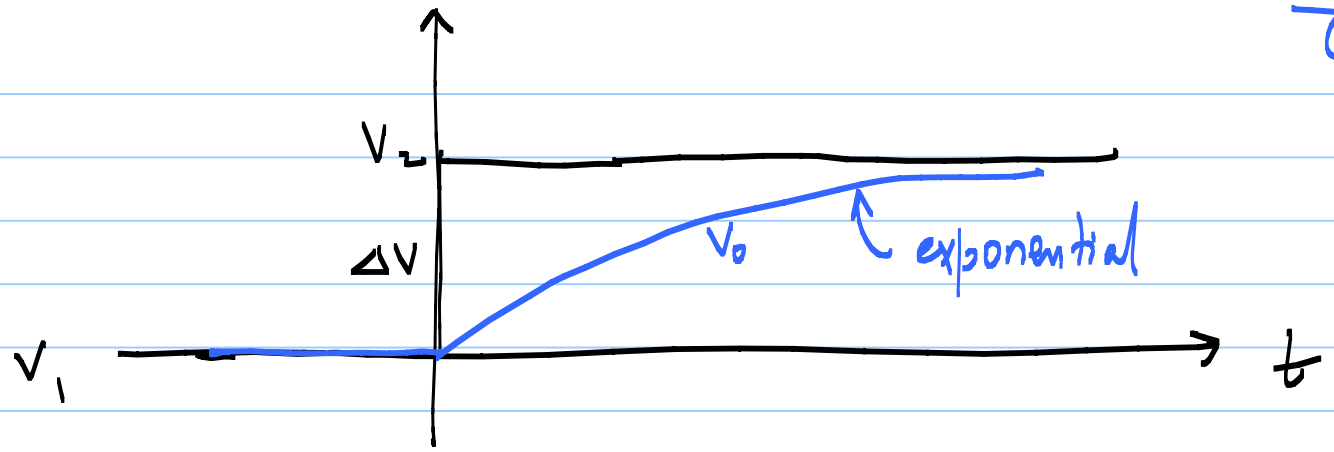


$V_e(t)$ approaches 0

as C_L charges towards

$V_1 + \Delta V$

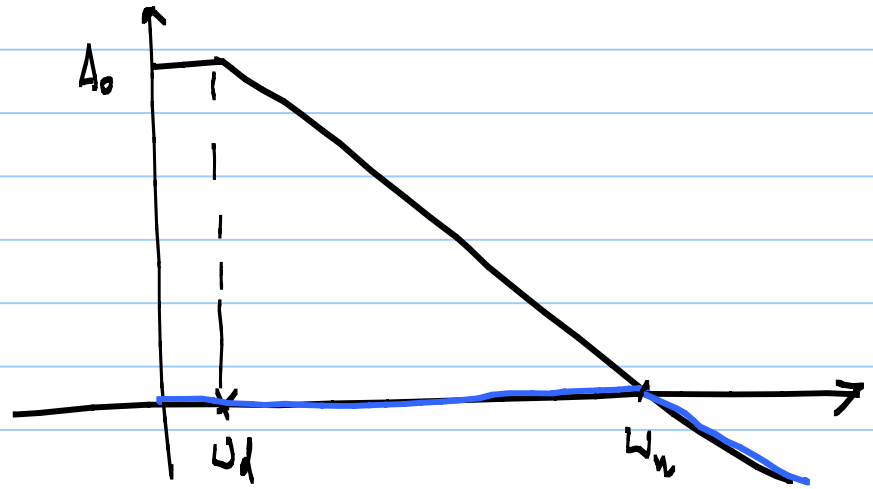
$$\tau = \frac{1}{\omega_u} = \frac{C_L}{G_m}$$



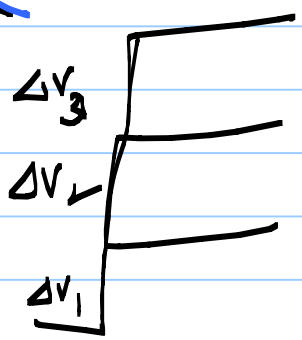
open loop

opamp

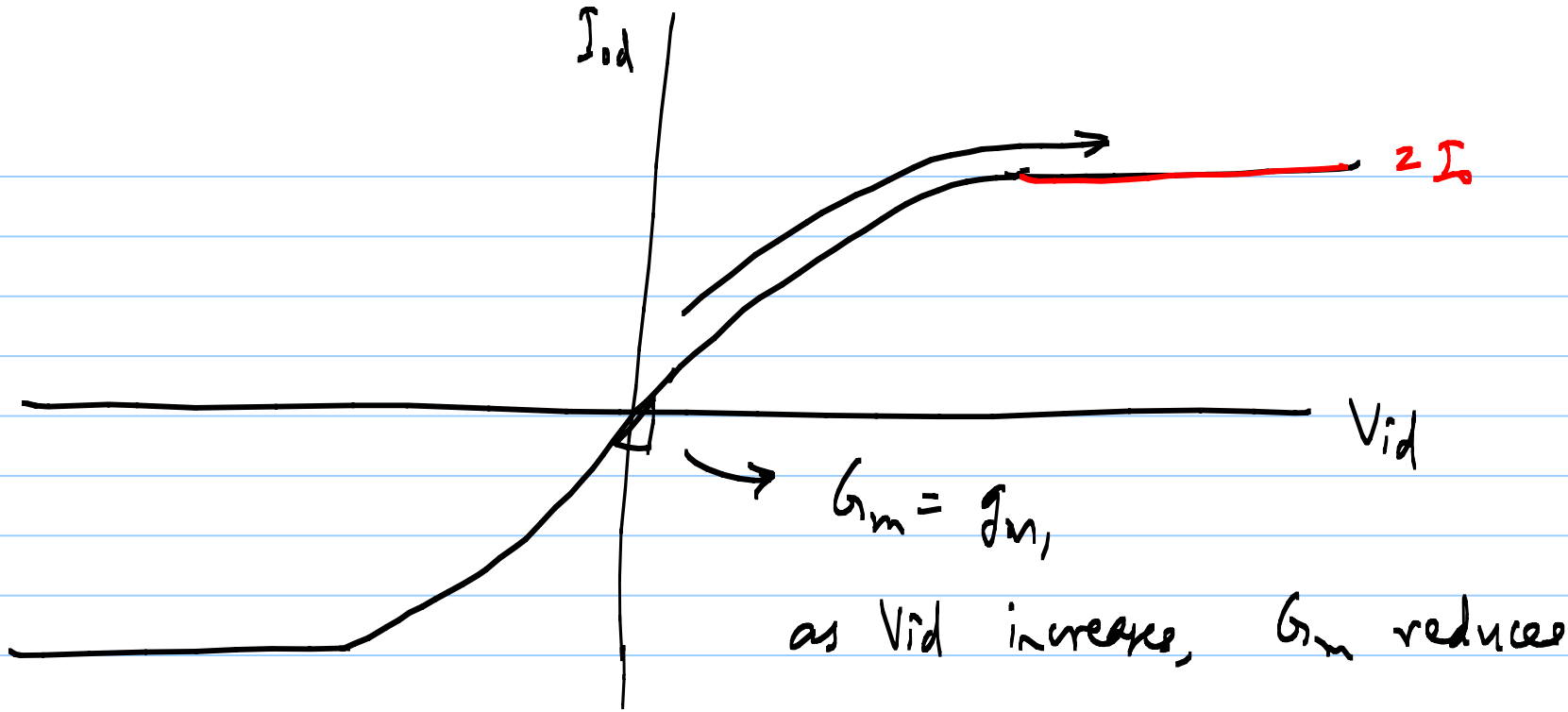
closed loop

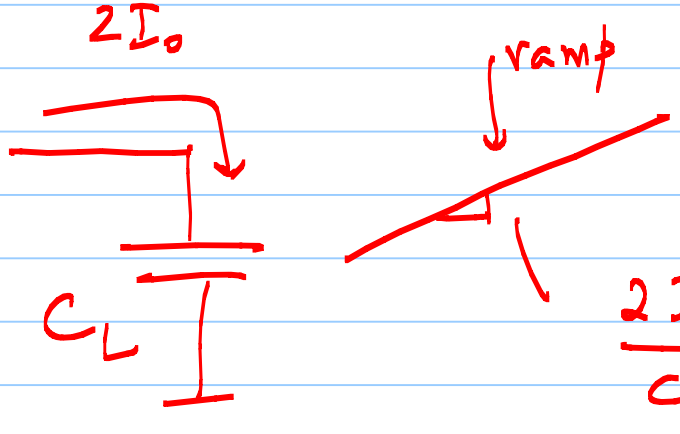


Now start ↑ ΔV



$$i_o\Big|_{t=0^+} = G_m \cdot \Delta V$$





"slew"

slew rate = $\pm \frac{2I_o}{C_L}$