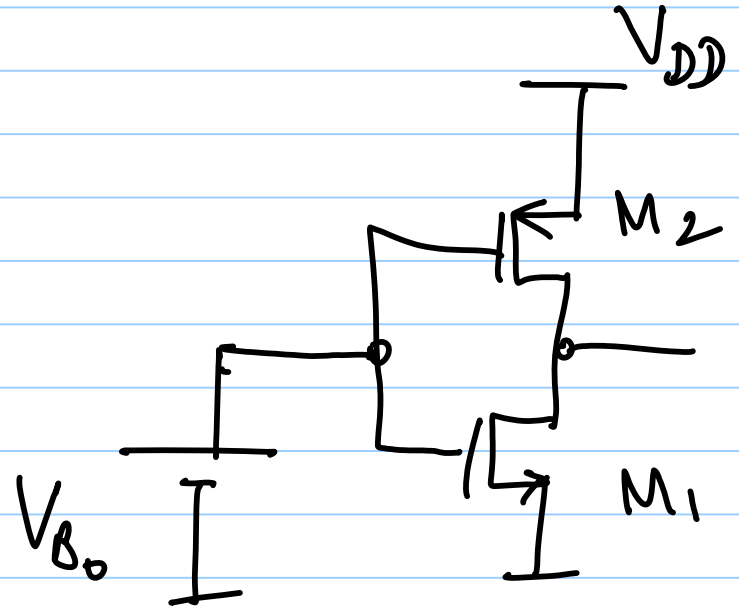
17/09/2019

Lec 21



M_1 & M_2 are in sat.

$$I_{D_1} = I_{D_2}$$

$$\frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_n = \beta_n$$

$$\frac{1}{2}\mu_p C_{ox}\left(\frac{W}{L}\right)_p = \beta_p$$

$$\beta_n \left(V_{B_0} - V_{T_n} \right)^2 = \beta_p \left(V_{DD} - V_{B_0} - V_{T_p} \right)^2$$

$$V_{B_0} - V_{T_n} = \left(V_{DD} - V_{T_p} \right) \sqrt{\left(\beta_p / \beta_n \right)} - V_{B_0} \sqrt{\frac{\beta_p}{\beta_n}}$$

$$V_{B_0} \left[1 + \sqrt{\frac{\beta_p}{\beta_n}} \right] = V_{T_n} + \left(V_{DD} - V_{T_p} \right) \sqrt{\frac{\beta_p}{\beta_n}}$$

$$V_{Bo} = \frac{V_{Tn} + (V_{DD} - V_{Tp})\sqrt{\frac{\beta_p}{\beta_n}}}{1 + \sqrt{\frac{\beta_p}{\beta_n}}}$$

If $\left(\frac{W}{L}\right)_n \gg \left(\frac{W}{L}\right)_p \Rightarrow \beta_n \gg \beta_p$

$$V_{Bo} \simeq V_{Tn}$$

If $\beta_p \gg \beta_n \Rightarrow V_{Bo} \simeq V_{DD} - V_{Tp}$

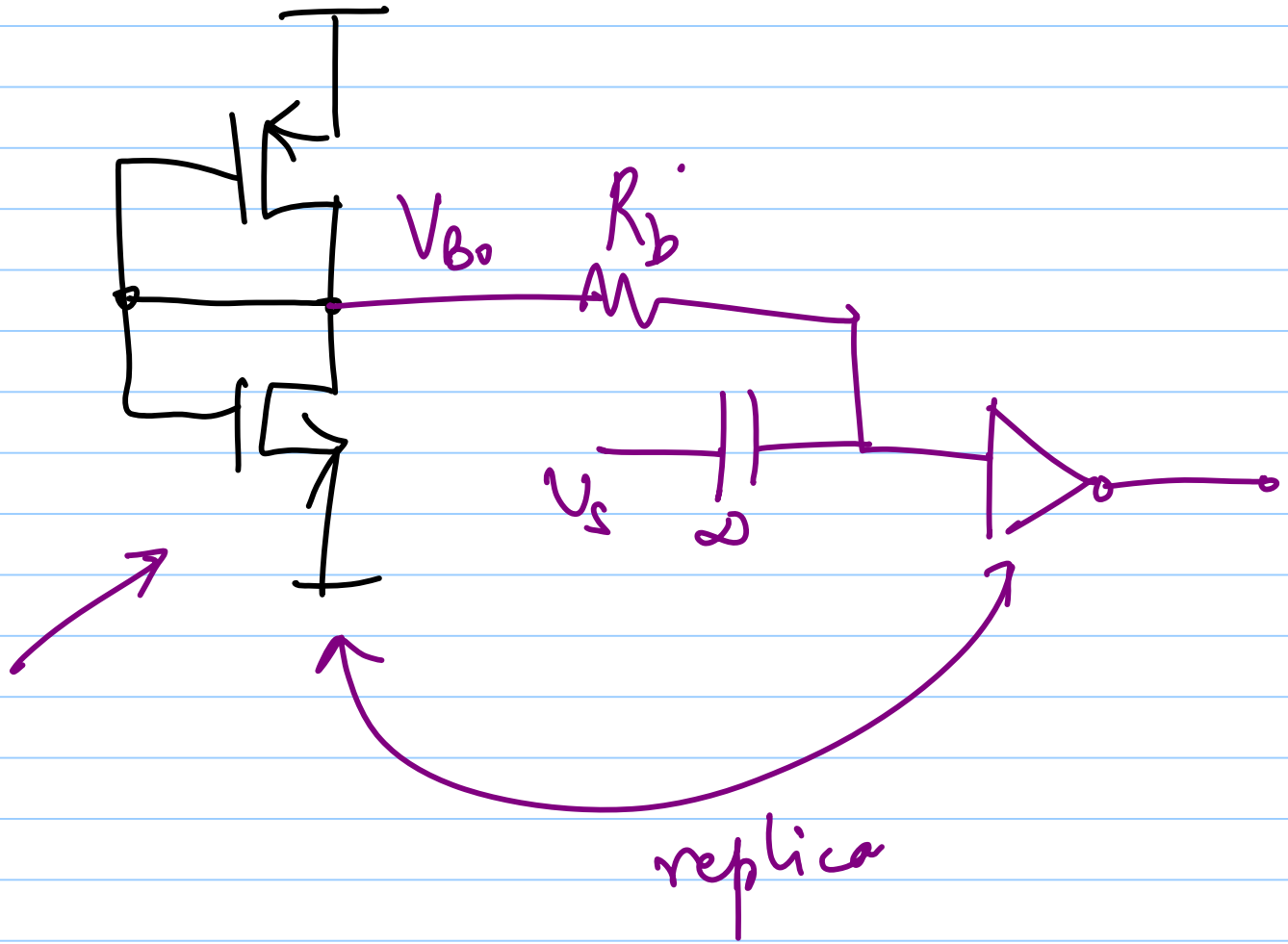
set $\left(\frac{W}{L}\right)_p = \frac{\mu_n}{\mu_p}\left(\frac{W}{L}\right)_n$ typically

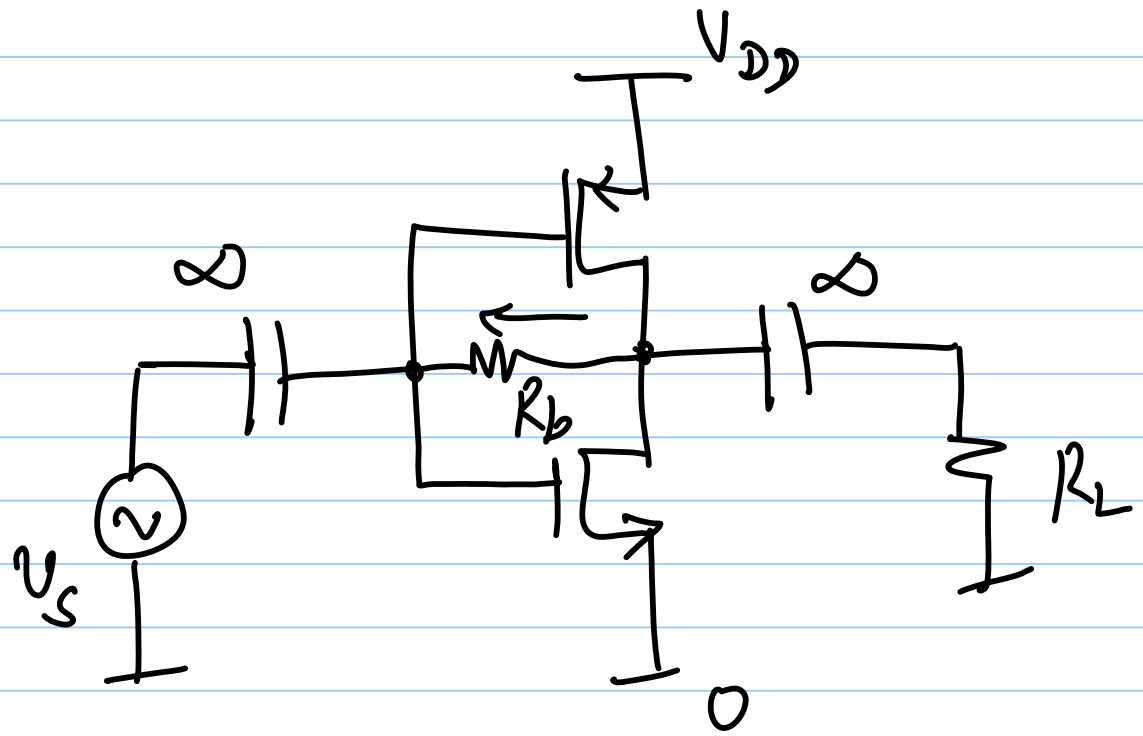
$\mu_n \approx 2\text{-}3 \times \mu_p$

So that $\beta_n = \beta_p$ $\{ g_{mn} \approx g_{mp} \}$

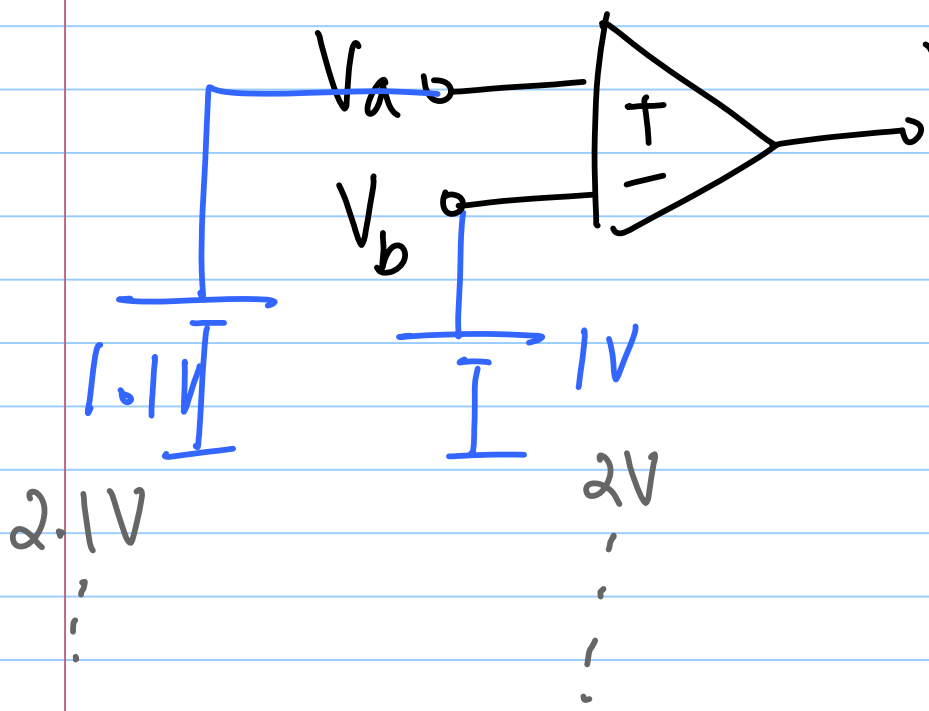
$$V_{B_0} = \frac{V_{Tn} + V_{DD} - V_{Tp}}{2}$$

$$\approx \frac{V_{DD}}{2} \quad \text{if} \quad V_{Tn} \cong V_{Tp}$$

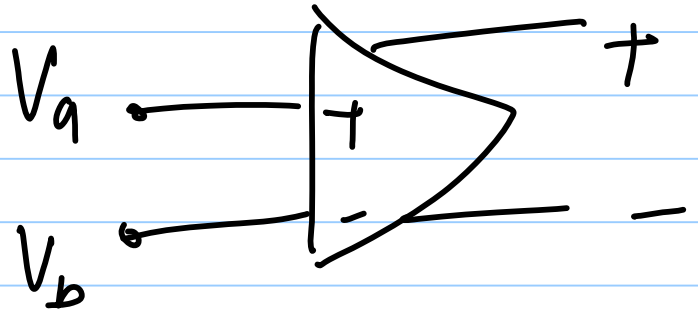

V_{Bo}
R_b
V_s
replica


V_{DD}
∞
∞
R_b
R_L
v_s
0

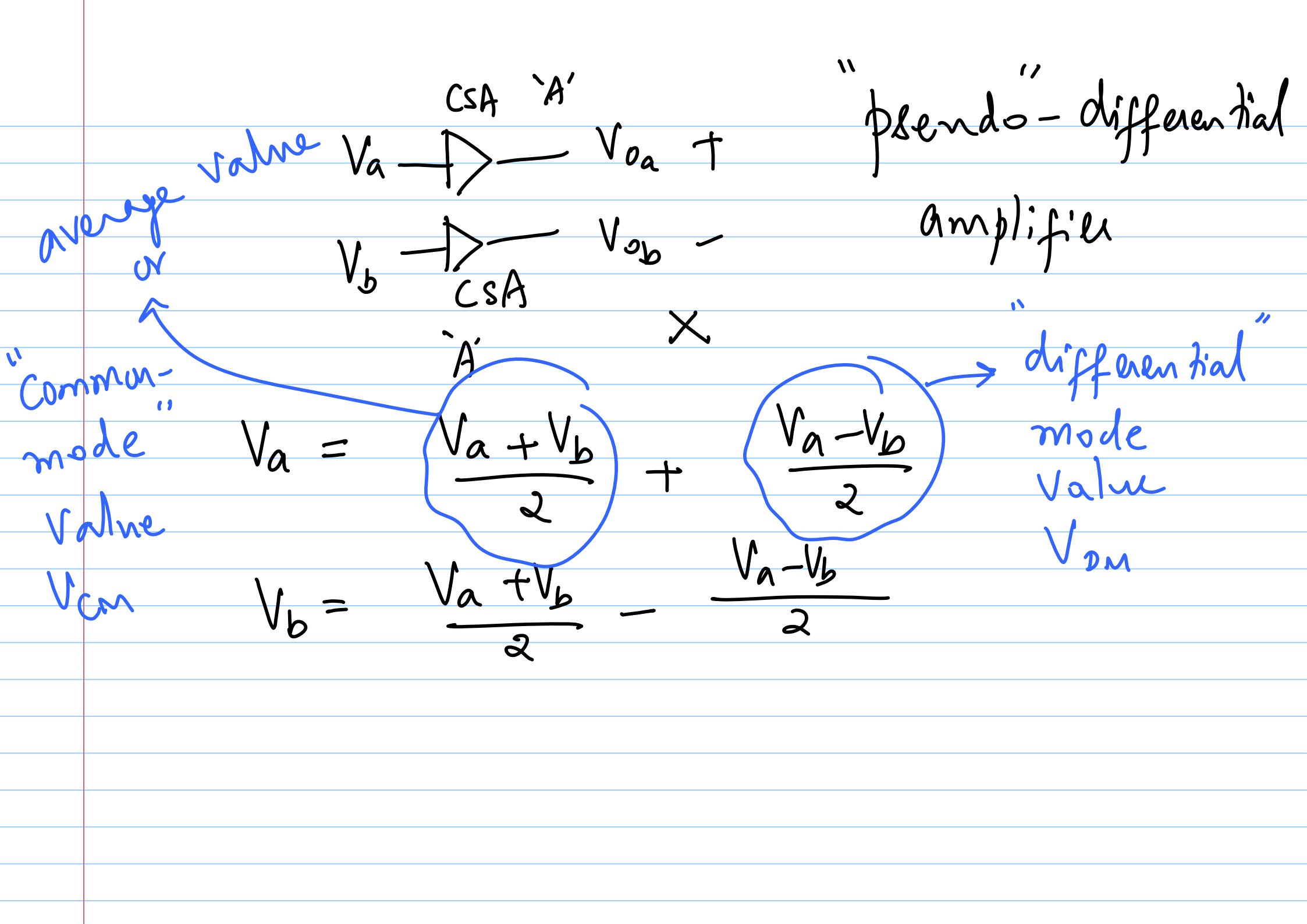
Differential Amplifiers



$$V_o = A(V_a - V_b)$$



$$V_o = A(V_a - V_b)$$

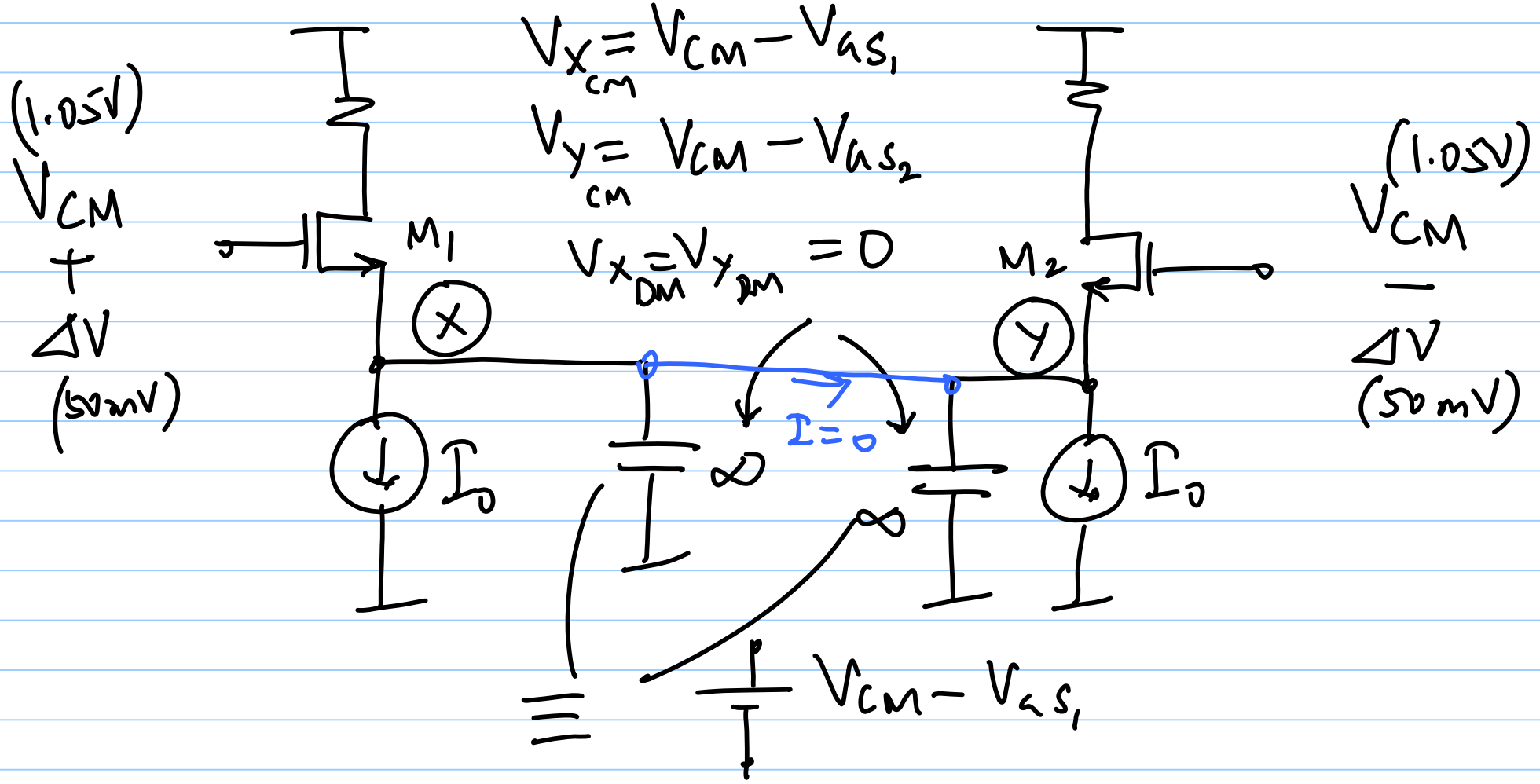

"pseudo" - differential amplifier
CSA 'A'
V_a
V_{oa} +
V_b
V_{ob} -
CSA
'A'
X
"common-mode" value or average value
V_{CM}
$V_a = \frac{V_a + V_b}{2} + \frac{V_a - V_b}{2}$
$V_b = \frac{V_a + V_b}{2} - \frac{V_a - V_b}{2}$
"differential mode value"
V_{DM}

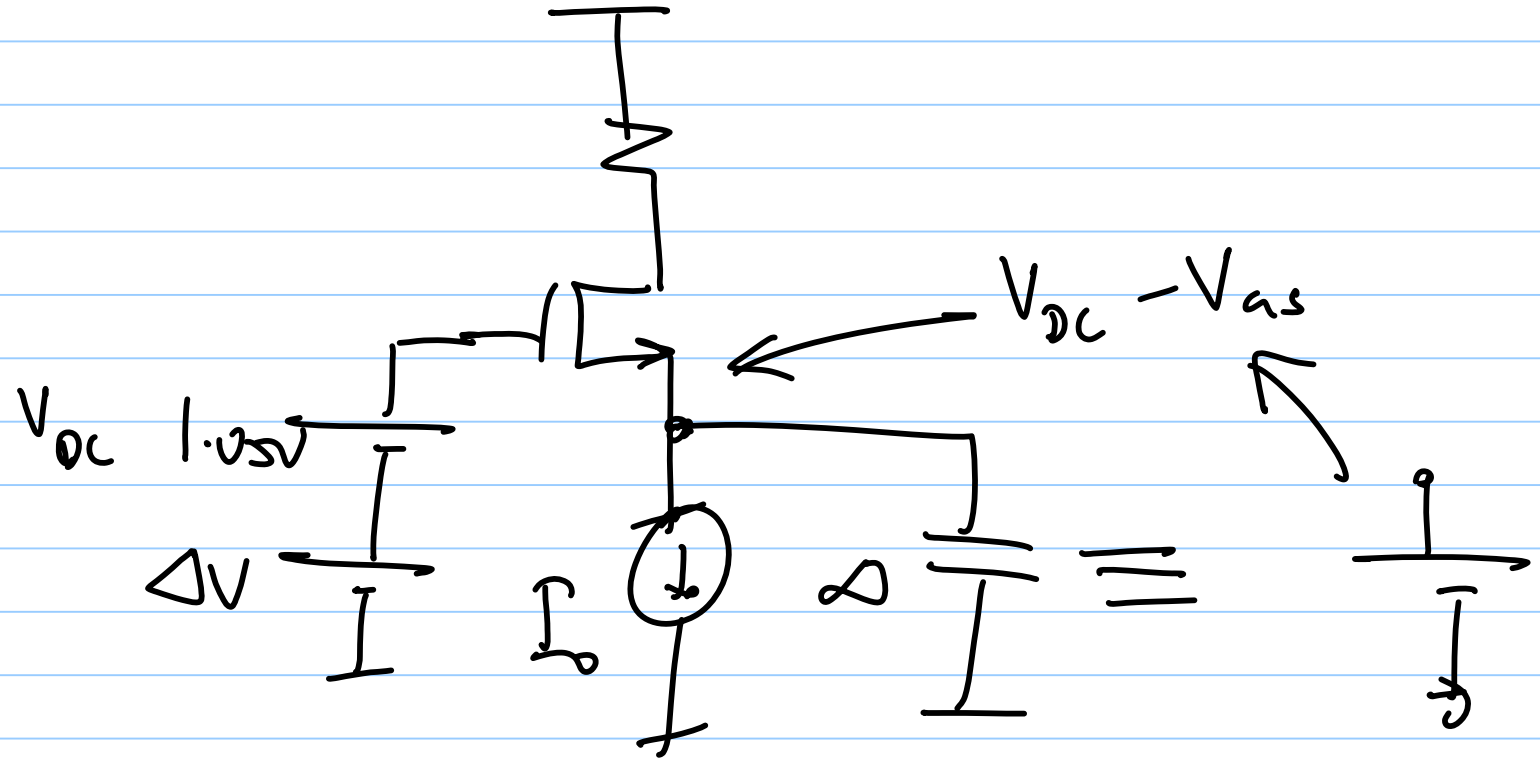
e.g. $V_A = 1.1V$, $V_B = 1V$

$V_{CM} = 1.05V$

$V_{DM} = 50mV$ ⟵ we want to amplify this quantity

$M_1 \equiv M_2$


$V_{x_{cm}} = V_{CM} - V_{GS_1}$
$V_{y_{cm}} = V_{CM} - V_{GS_2}$
$V_{x_{DM}} = V_{y_{DM}} = 0$
(1.05V)
V_{CM}
+
ΔV
(50mV)
M_1
M_2
X
Y
I_D
I_D
∞
∞
$I = 0$
$V_{CM} - V_{GS_1}$
(1.05V)
V_{CM}
—
ΔV
(50mV)


V_{DC} 1.05V
ΔV
I_o
$V_{DC} - V_{as}$
∞