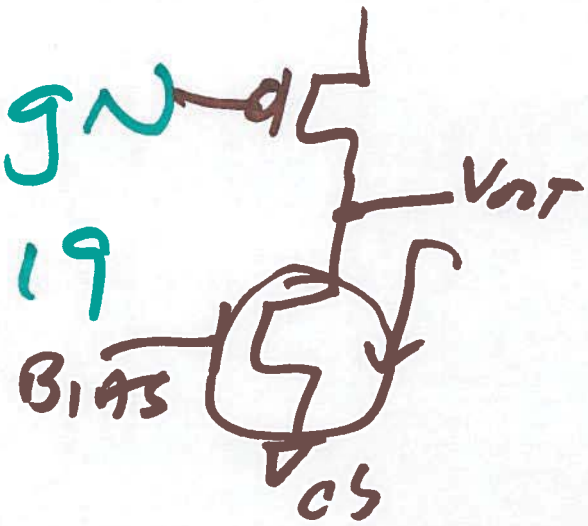
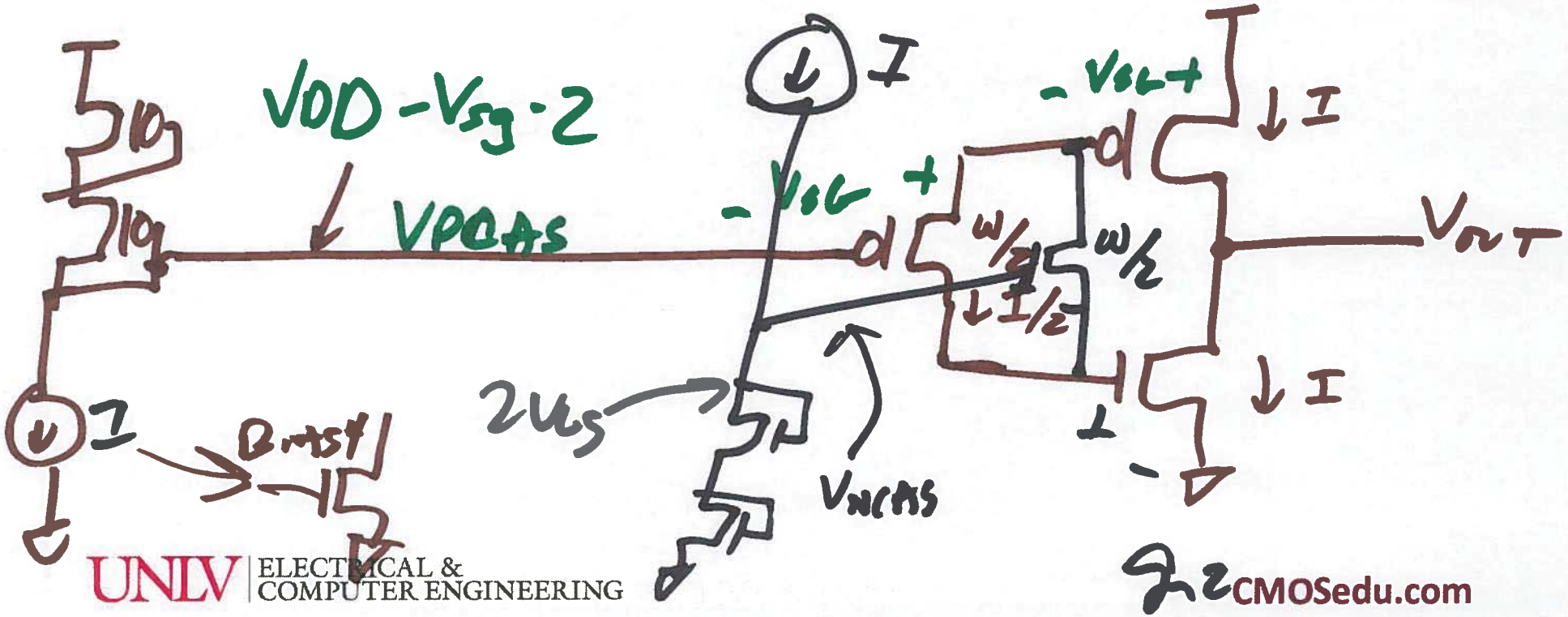
EE420/ECG 620
Analog IC Design
April 22, 2019
Lecture 21





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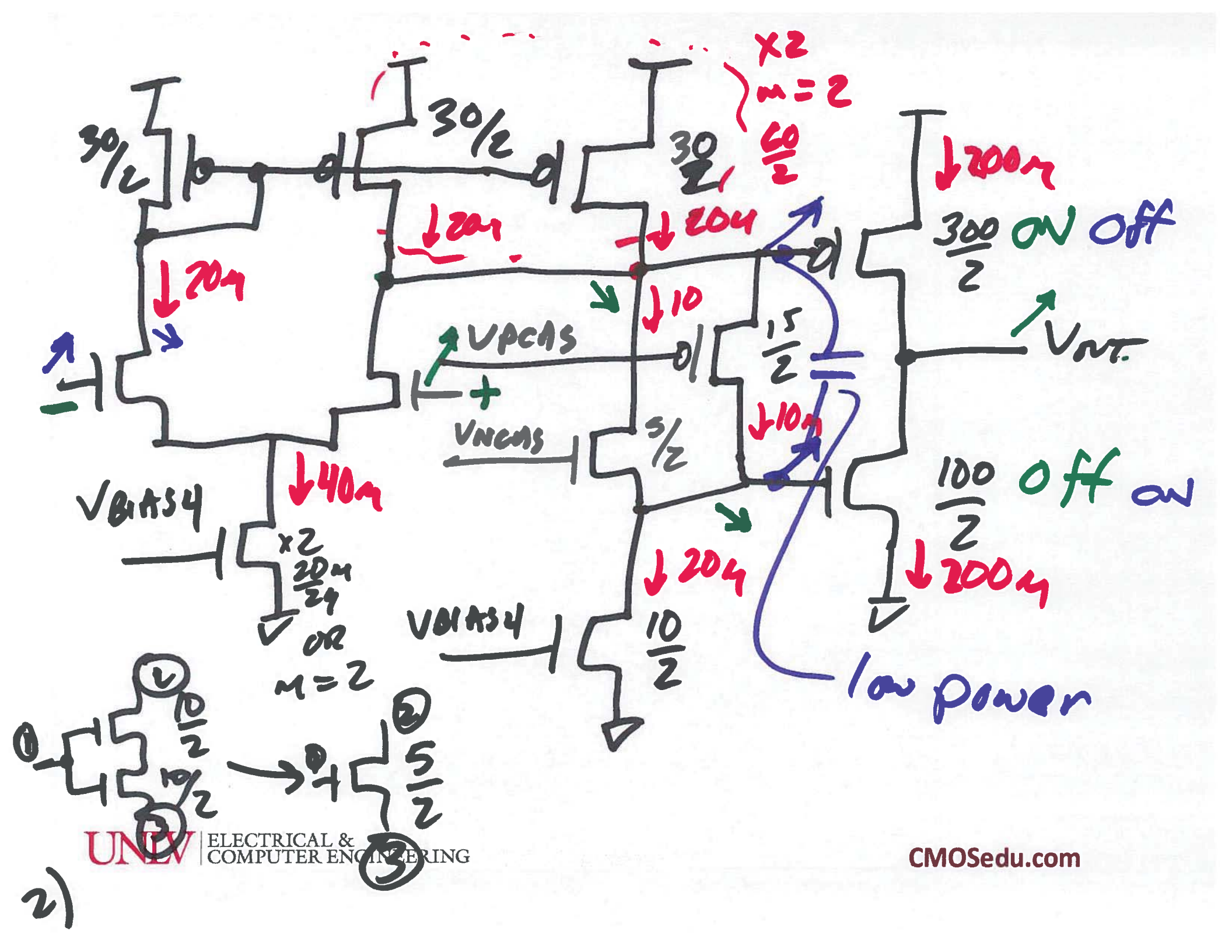
1)


30/2
30/2
30/2
x2
m=2
60/2
↓200n
↓20n
↓20n
↓20n
300/2
ON
OFF
↓10
VPCAS
15/2
VOUT
VNCAS
5/2
↓10n
VBIAS4
↓40n
100/2
OFF
ON
x2
20n/2
OR
m=2
↓20n
↓200n
VBIAS4
10/2
low power
10/2
5/2
1
2
3
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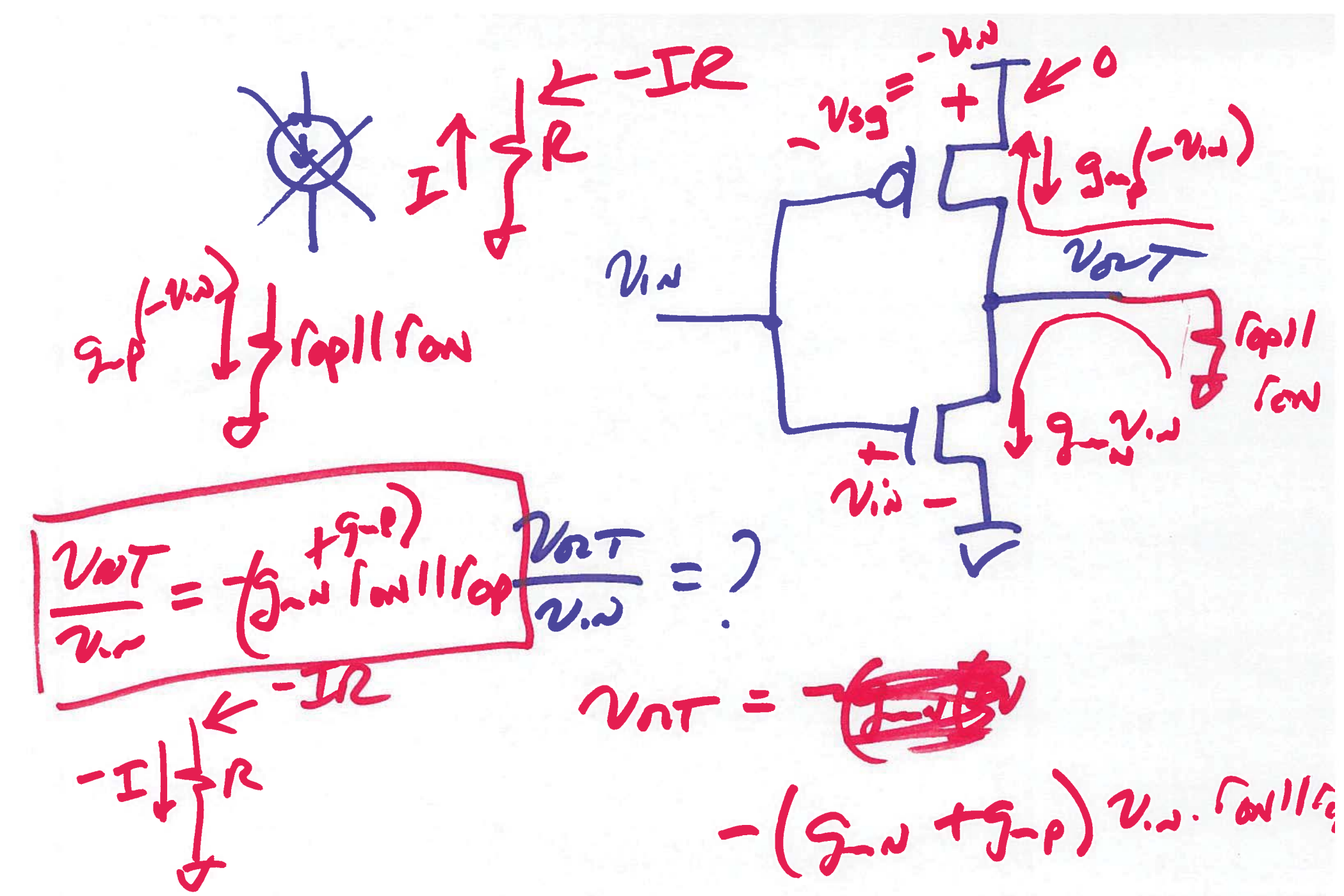
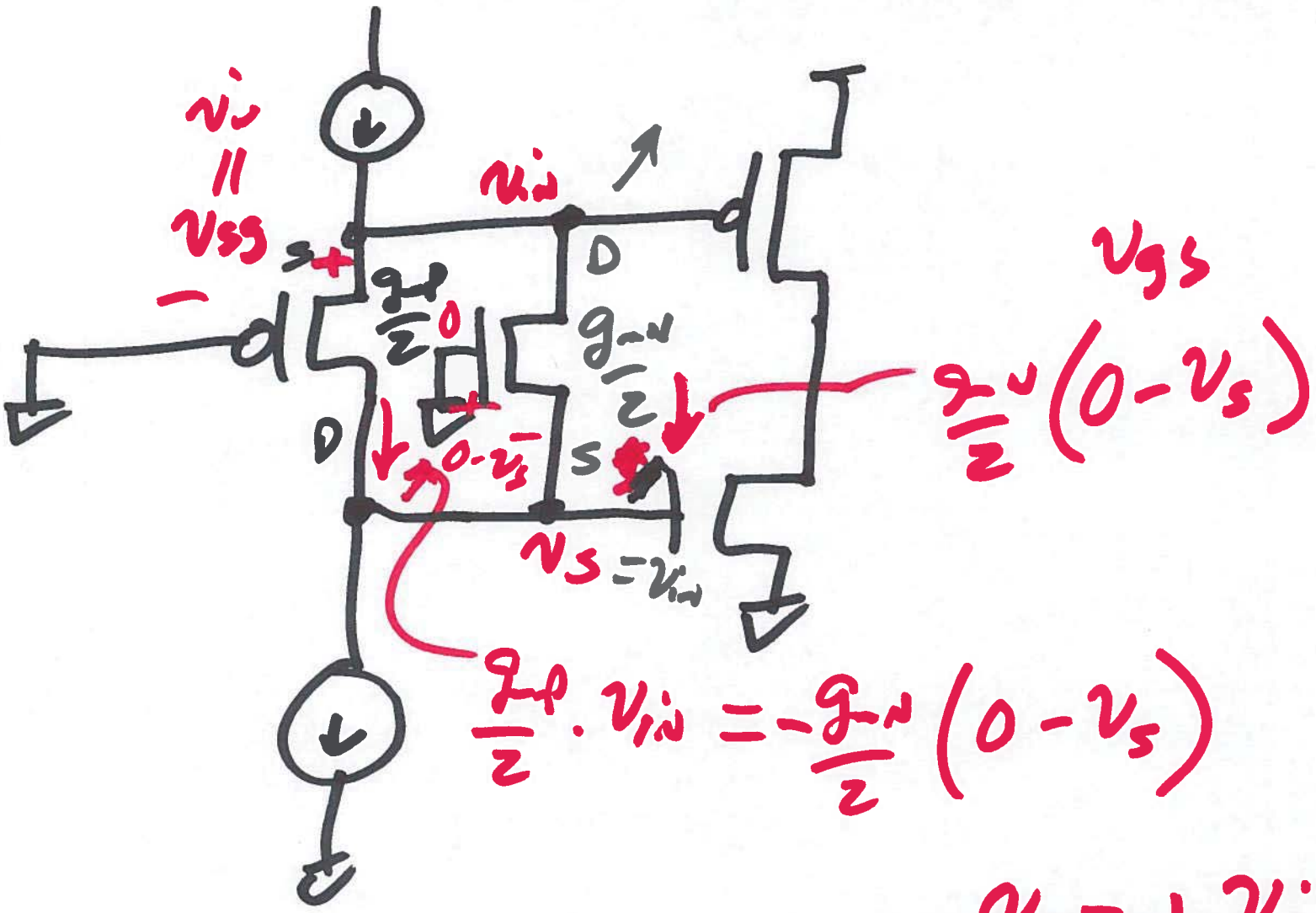
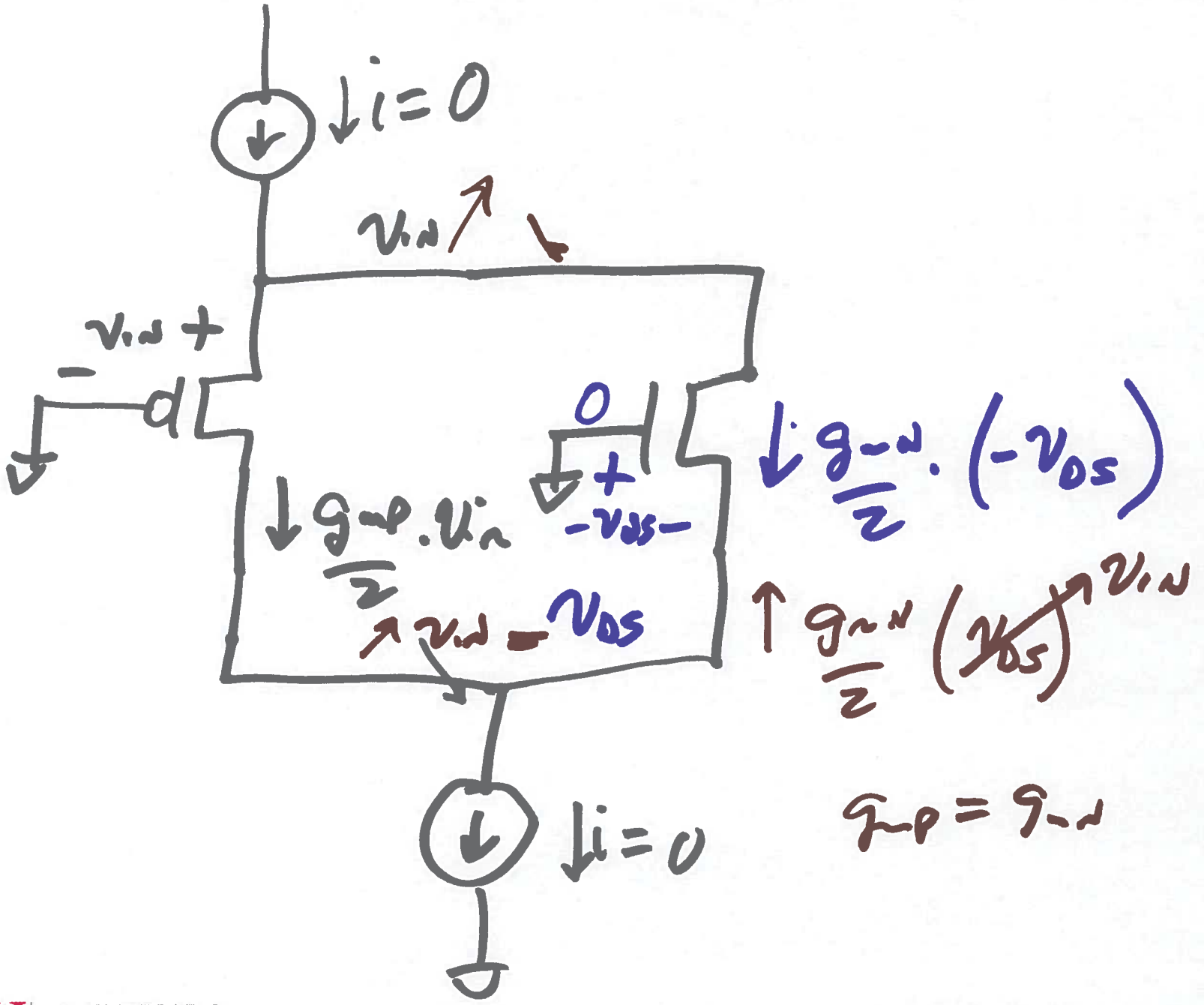
2)

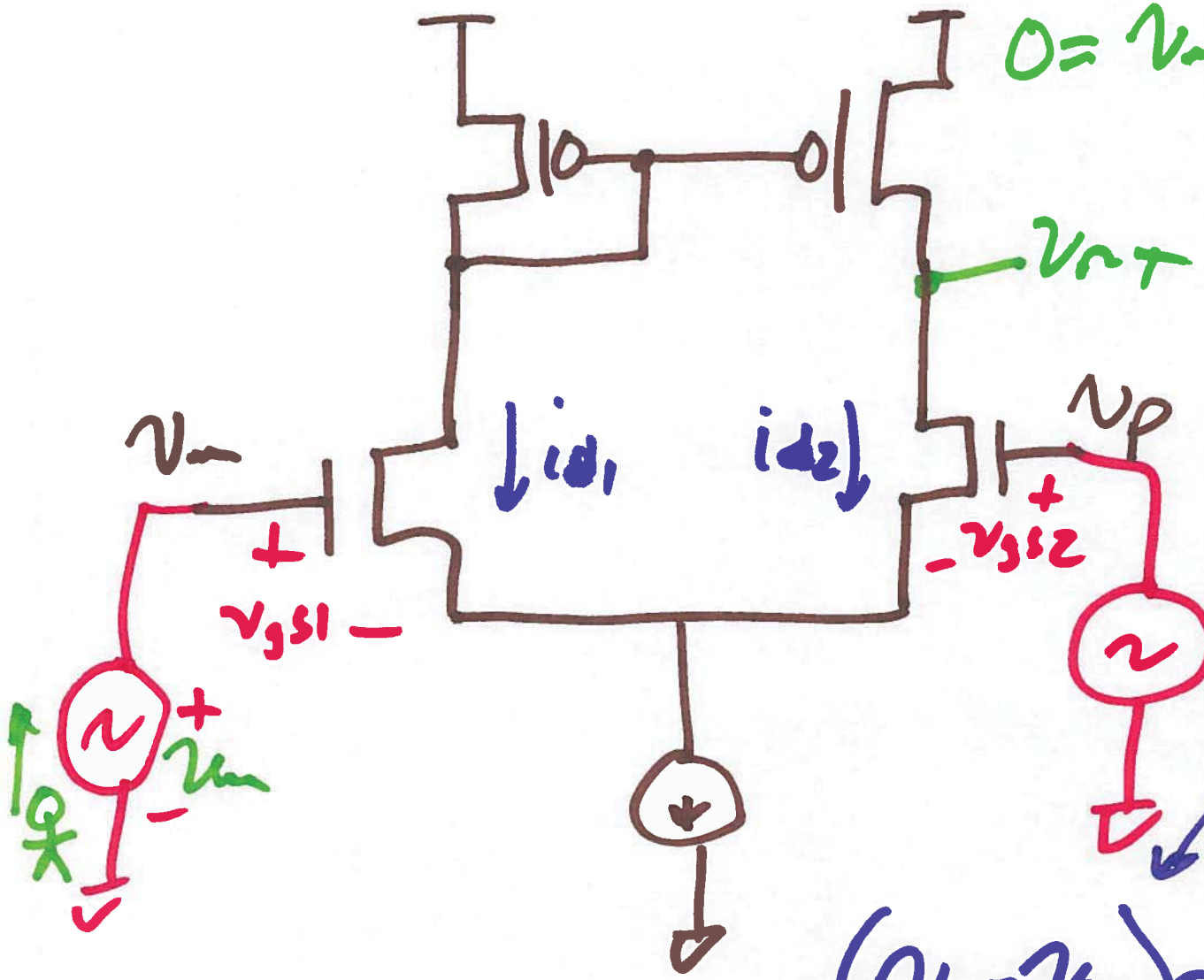

I
R
-IR
$g_{mp}(-v_{in})$
$r_{op} \| r_{on}$
v_{in}
$-v_{sg} = -v_{in}$
0
$g_{mp}(-v_{in})$
v_{out}
$r_{op} \| r_{on}$
$g_{mn} v_{in}$
v_{in}
$\frac{v_{out}}{v_{in}} = -(g_{mn} + g_{mp}) r_{on} \| r_{op}$
$\frac{v_{out}}{v_{in}} = ?$
$v_{out} = -(g_{mn} + g_{mp}) v_{in} \cdot r_{on} \| r_{op}$



$v_s = + v_{in}$

assuming $\frac{g_{-p}}{2} = \frac{g_{-n}}{2}$


i = 0
v_in
v_in +
−
d
0
+
−v_DS−
g_mp/2 · v_in
v_in − v_DS
g_mn/2 · (−v_DS)
g_mn/2 (v_DS)
v_in
i = 0
g_mp = g_mn



$$0 = v_{in} - v_{gs1} + v_{gs2} - v_p$$

$$i_{d1} = -i_{d2}$$

$$v_{gs1} = -v_{gs2}$$

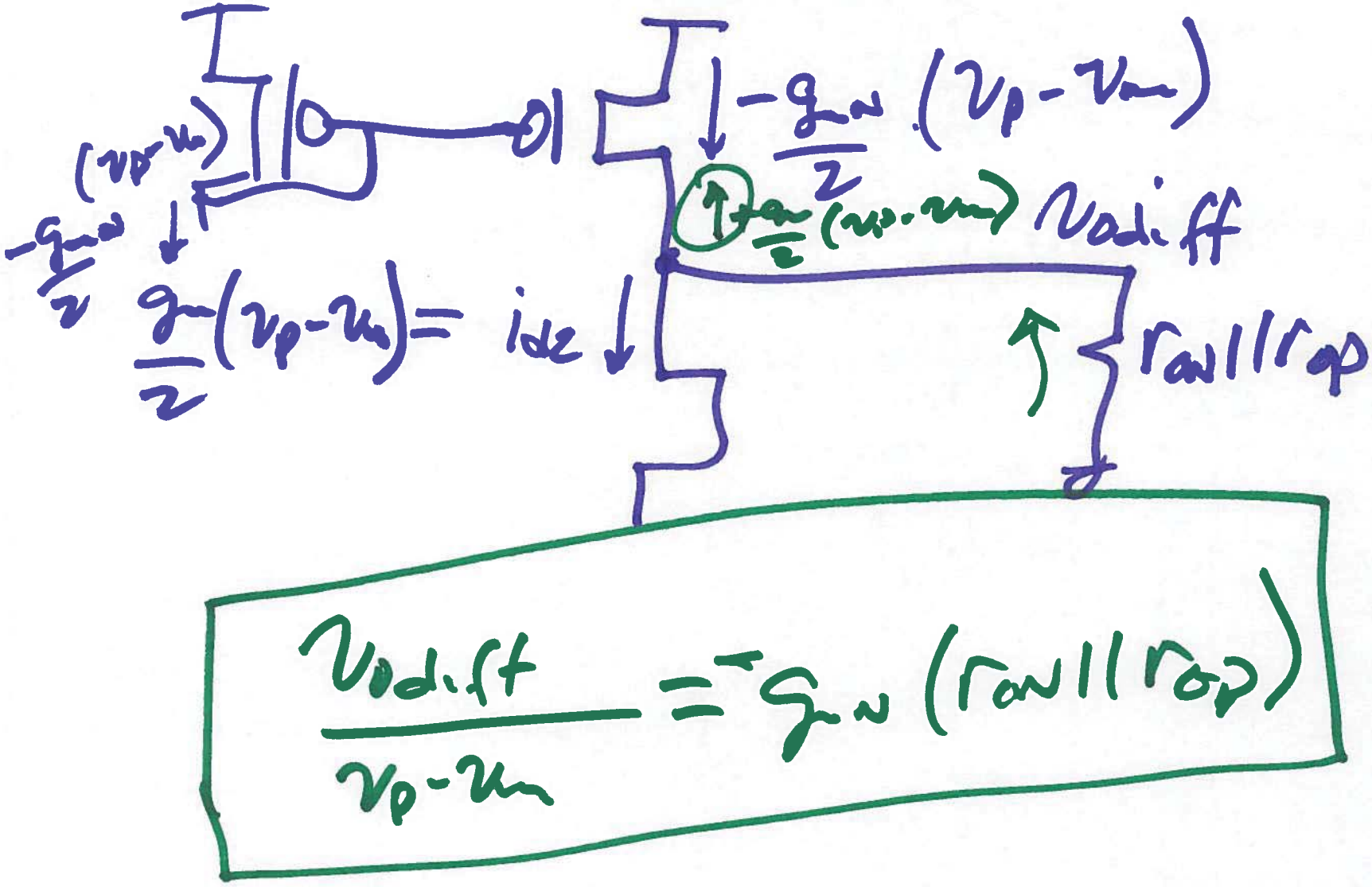
$$v_p - v_{in} = \frac{-i_{d1}}{g_{mN}} + \frac{i_{d}}{g_{}}$$

$$(v_p - v_{in}) \cdot \frac{g_{mN}}{2} = -i_{d1}$$

$$(v_p - v_{in}) g_{mN} = -i_{d1} - i_{d1}$$

$$= -2 i_{d1}$$

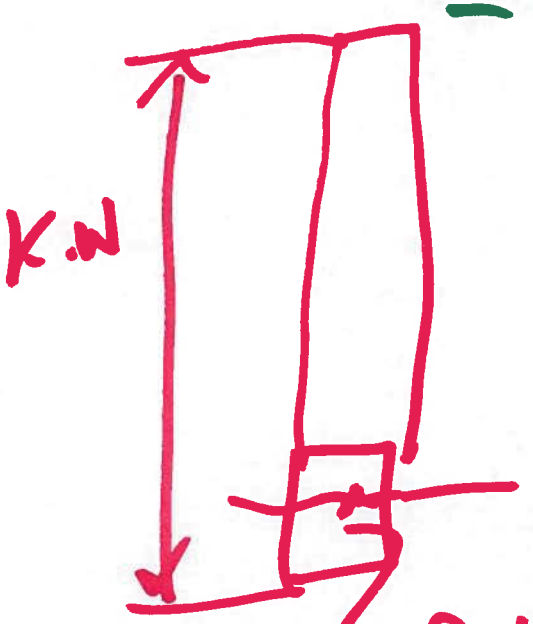
b)


$-\frac{g_m}{2}(v_p - v_m)$
$\frac{g_m}{2}(v_p - v_m) = i_{dc}$
$r_{ON} \| r_{op}$
$\frac{v_{odiff}}{v_p - v_m} = -g_m (r_{ON} \| r_{op})$

$$K \cdot g_m = \frac{KP}{\cancel{K}} \cdot \frac{W}{L} \cdot K V_{OV}$$

$$= KP \cdot \frac{W}{L} \cdot K \left(V_{OS,\,sat} \right) =$$

$$KP \cdot \frac{W}{L} \cdot K \left(V_{GS} - V_{T(th)} \right)$$

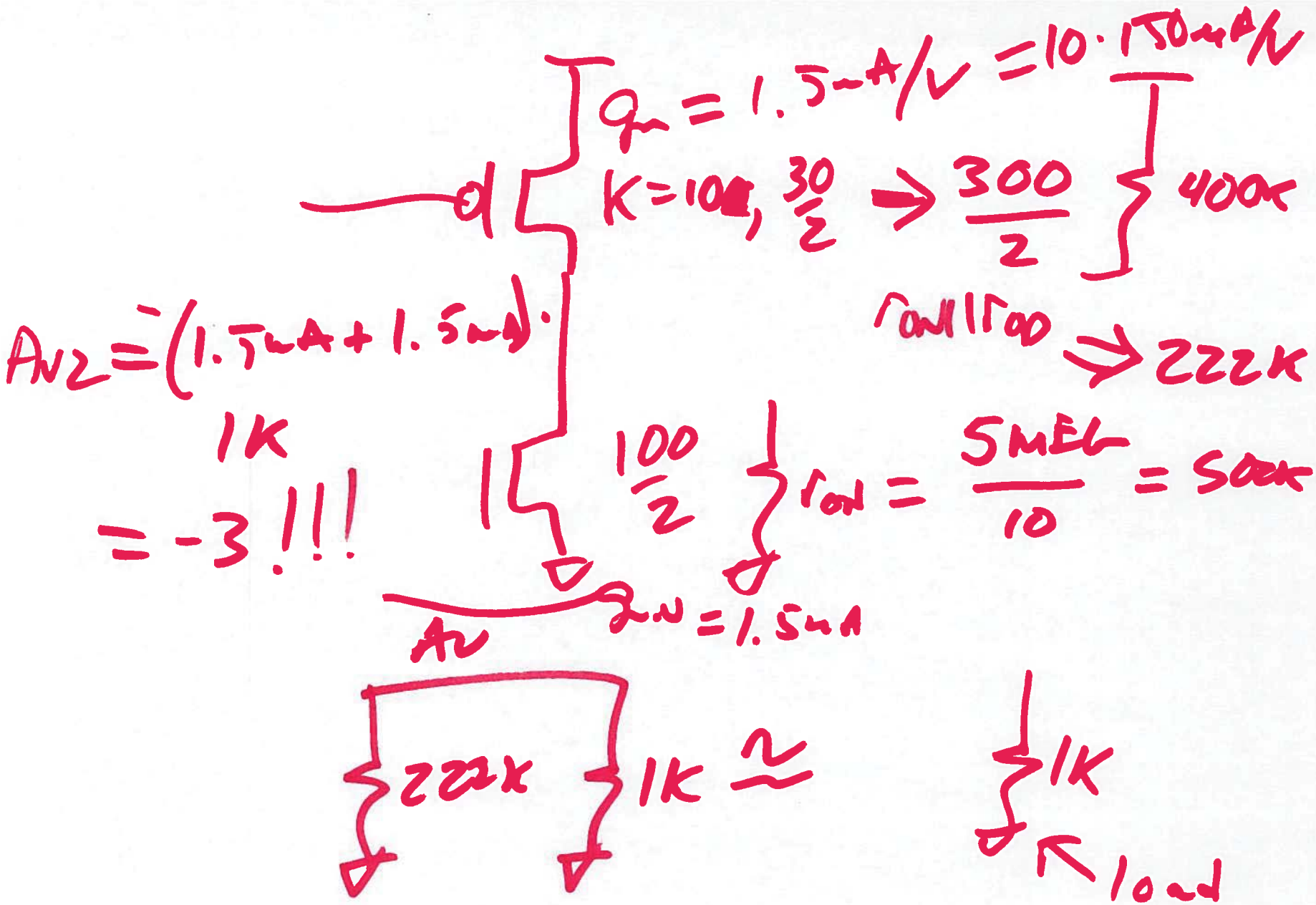


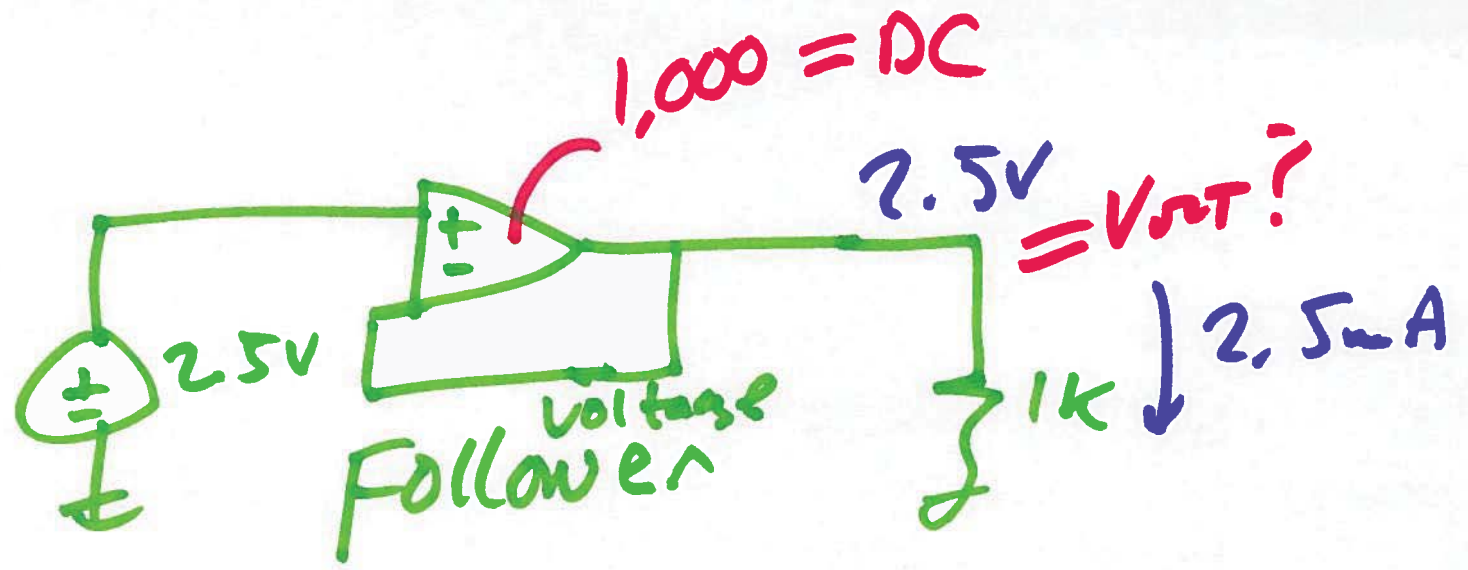
$$I_{D,new} = k \cdot I_{D,OLD}$$

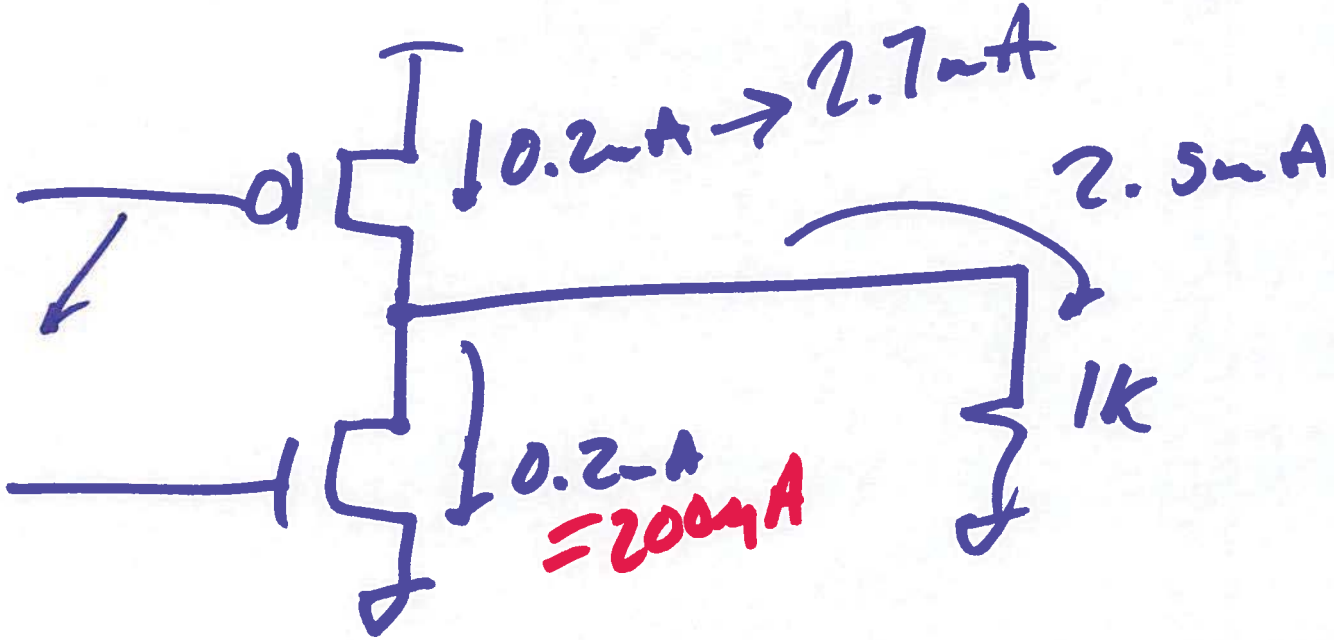
$g_m \cdot r_{ON} = \text{CONST.}$

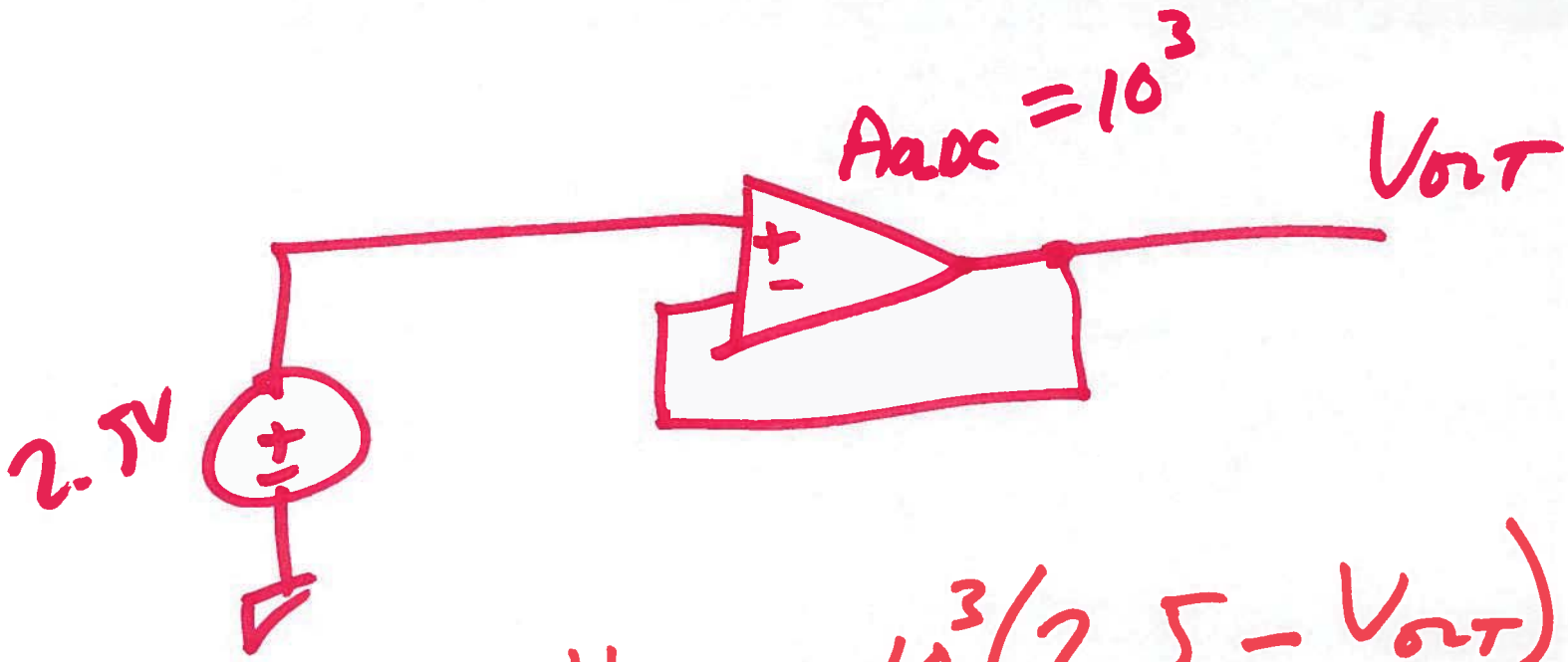
$$r_{ON} = \frac{1}{\lambda I_D}$$

$r_{ON} \downarrow$ as $K \uparrow$


$g_m = 1.5\,mA/V = 10 \cdot 150\,\mu A/V$
$K = 100, \frac{30}{2} \Rightarrow \frac{300}{2}$
400K
$A_{V2} = (1.5\,mA + 1.5\,mA) \cdot$
1K
$= -3$!!!
$r_{ON} \| r_{OP} \Rightarrow 222K$
$\frac{100}{2}$
$r_{ON} = \frac{5\,M\Omega}{10} = 500K$
$I_N = 1.5\,mA$
A_V
222K
1K $\cong$
1K
load


1,000 = DC
2.5V
= VOUT ?
2.5V
2.5mA
1k
Voltage
Follower


0.2mA → 2.7mA
2.5mA
1k
0.2mA
= 200μA



$$V_{OUT} = 10^3(2.5 - V_{OUT})$$

$$V_{OUT} = 2{,}500 - 1{,}000\,V_{OUT}$$

$$V_{OUT} = \frac{2{,}500}{1001} = 2.499\,V$$