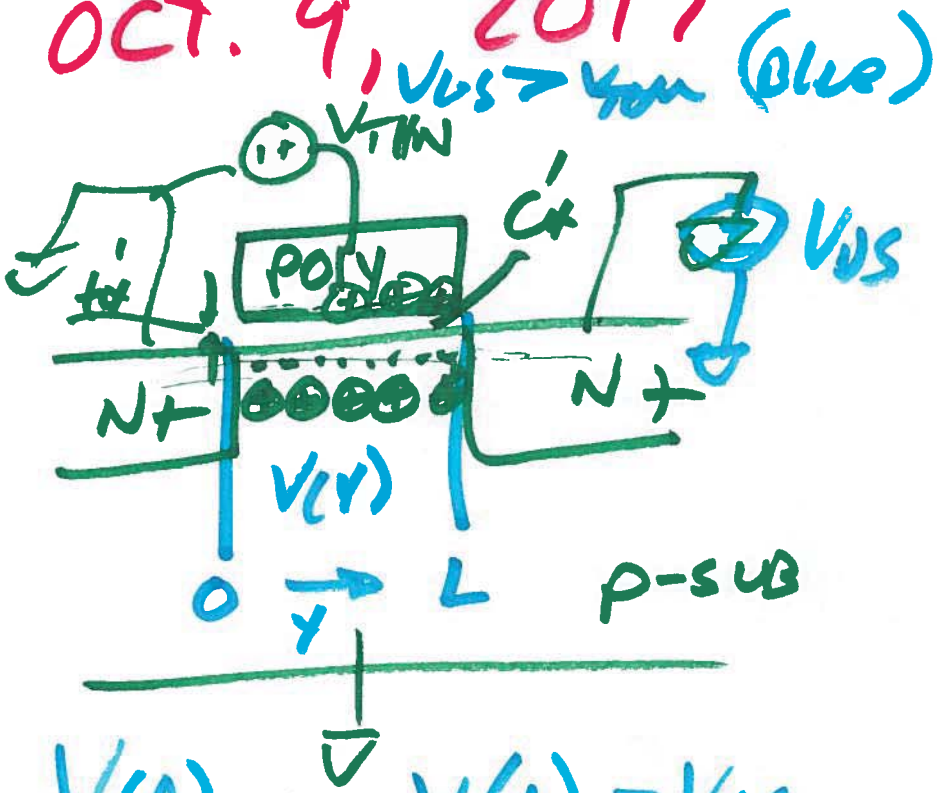
EE 421/ECE 621
Digital IC Design
Lecture 12
OCT. 9, 2017

$Q'_{CH} =$

$Q'_b = V_{THN} \cdot C'_{ox}$

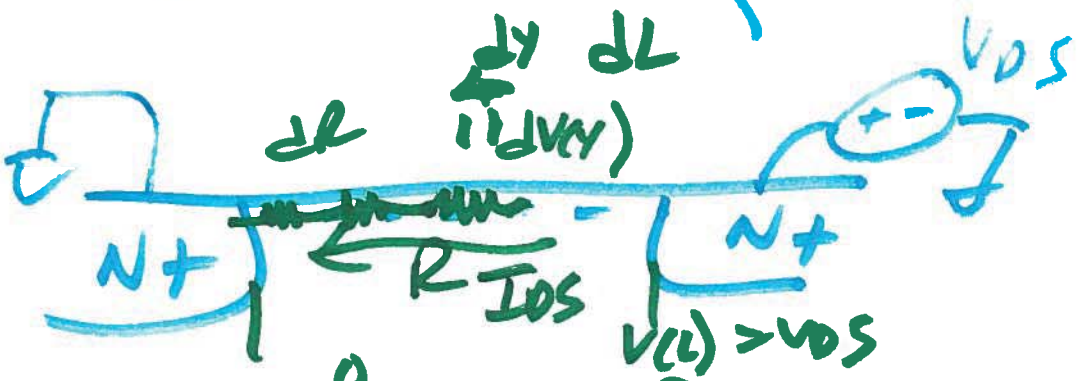
$Q'_I =$



$Q'_{CH} = C'_{ox}(V_{GS} - V(y))$

$Q'_I = C'_{ox}(V_{GS} - V(y)) - V_{THN} \cdot C'_{ox}$

$$Q_I'(y) = C_{ox}'\left(V_{GS} - V(y) - V_{THN}\right)$$



$$V(0) = \sum_0 dR = R$$

velocity: $\frac{cm/s}{V/cm}$ → $\vec{\mathcal{E}}$

μ_n: $\frac{cm^2}{V \cdot s}$

$$dR = \frac{dy}{W} \cdot \frac{1}{Q_I'(y) \cdot \mu_N}$$

sheet R

$$dV(y) = I \cdot dR = I \cdot \frac{dy}{W} \cdot \frac{1}{Q_I'(y) \cdot \mu_N}$$

$$dV(y) \cdot Q_I'(y) \cdot \mu_n \cdot W = I \cdot dy$$

$$I \int_0^L dy = \int_0^{V_{DS}} dV(y) \cdot \mu_n \cdot W \left(V_{GS} - V(y) - V_{TH_n}\right) \cdot C'_{ox}$$

$$KP_N = C'_{ox} \cdot \mu_n$$

$$I \cdot L = W \cdot KP_N \left[\int_0^{V_{DS}} V_{GS}\, dV(y) + \int_0^{V_{DS} - \frac{1}{2}V_{DS}^2} \left(-V(y)\right) dV(y) \right]$$

$V_{DS} \le V_{GS} - V_{TH_N}$

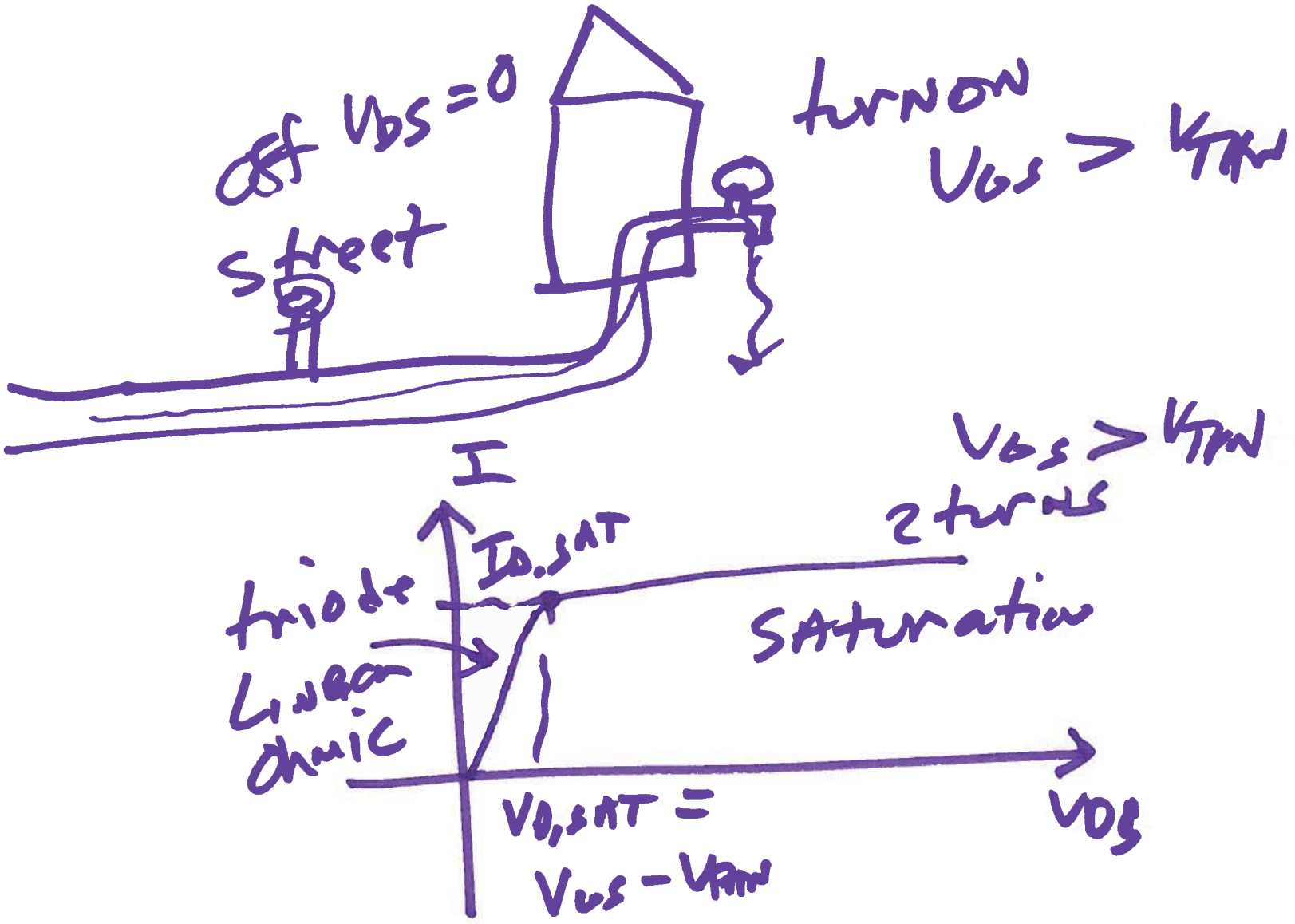
$V_{GS} \ge V_{TH_N}$

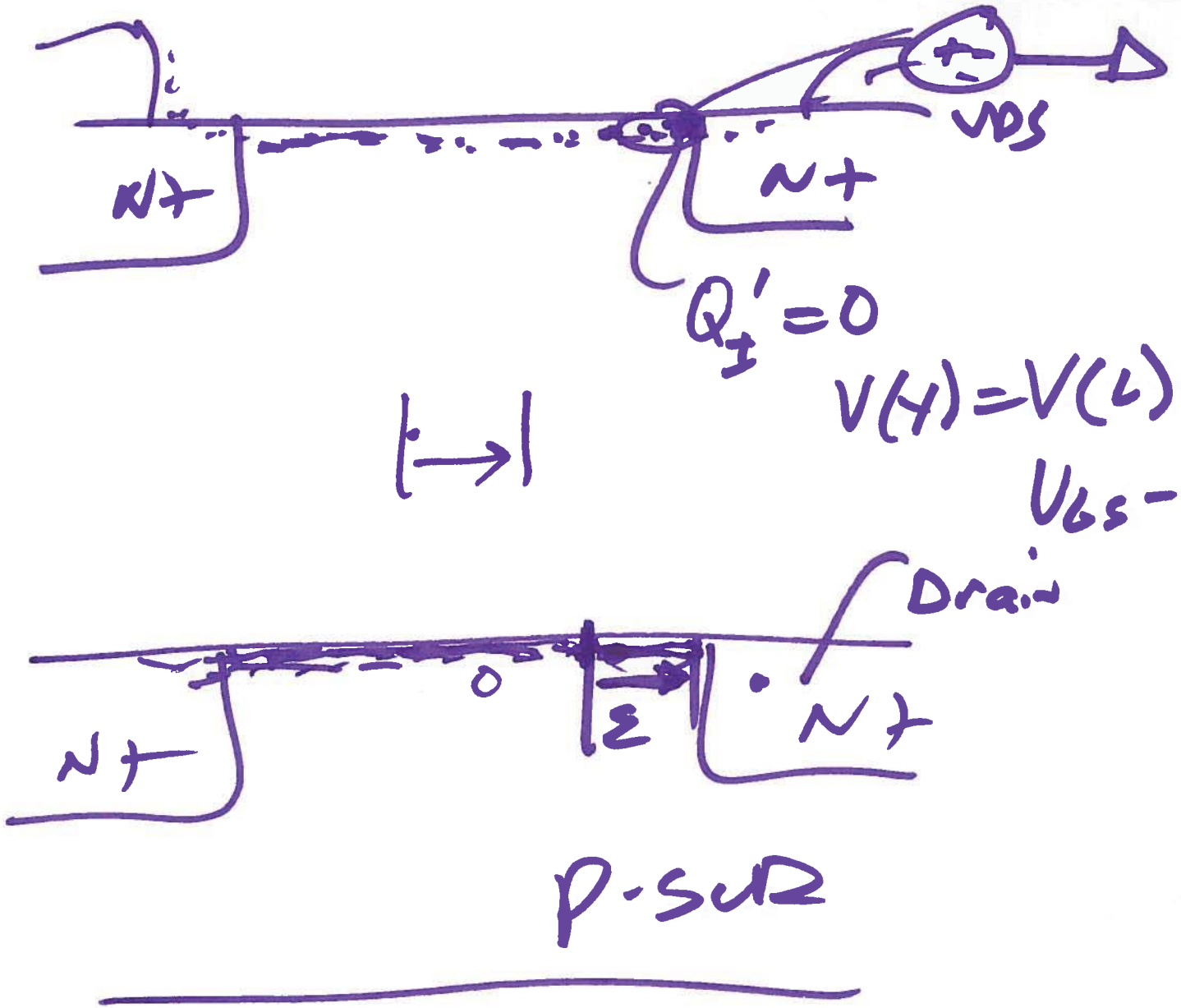
$$+ \int_0^{V_{DS} - V_{TH_N} \cdot V_{DS}} \left(-V_{TH_N}\right) \cdot dV(y) \Bigg]$$

$$= W \cdot KP_N \cdot \left(\left(V_{GS} - V_{TH_N}\right) V_{DS} - \frac{1}{2} V_{DS}^2 \right)$$

$$I = \frac{W}{L} KP_N \left(\left(V_{GS} - V_{TH_N}\right) V_{DS} - \frac{1}{2} V_{DS}^2 \right)$$

3)


off $V_{DS}=0$
turnON
$V_{GS} > V_{TH}$
street
I
$V_{GS} > V_{TH}$
2 turns
$I_{D,SAT}$
triode
Linear
ohmic
saturation
$V_{D,SAT} =$
$V_{GS} - V_{TH}$
V_{DS}


VDS
N+
N+
$Q_I' = 0$
$V(Y) = V(L) =$
$V_{GS} - V_{TN}$
Drain
N+
N+
P-SUB

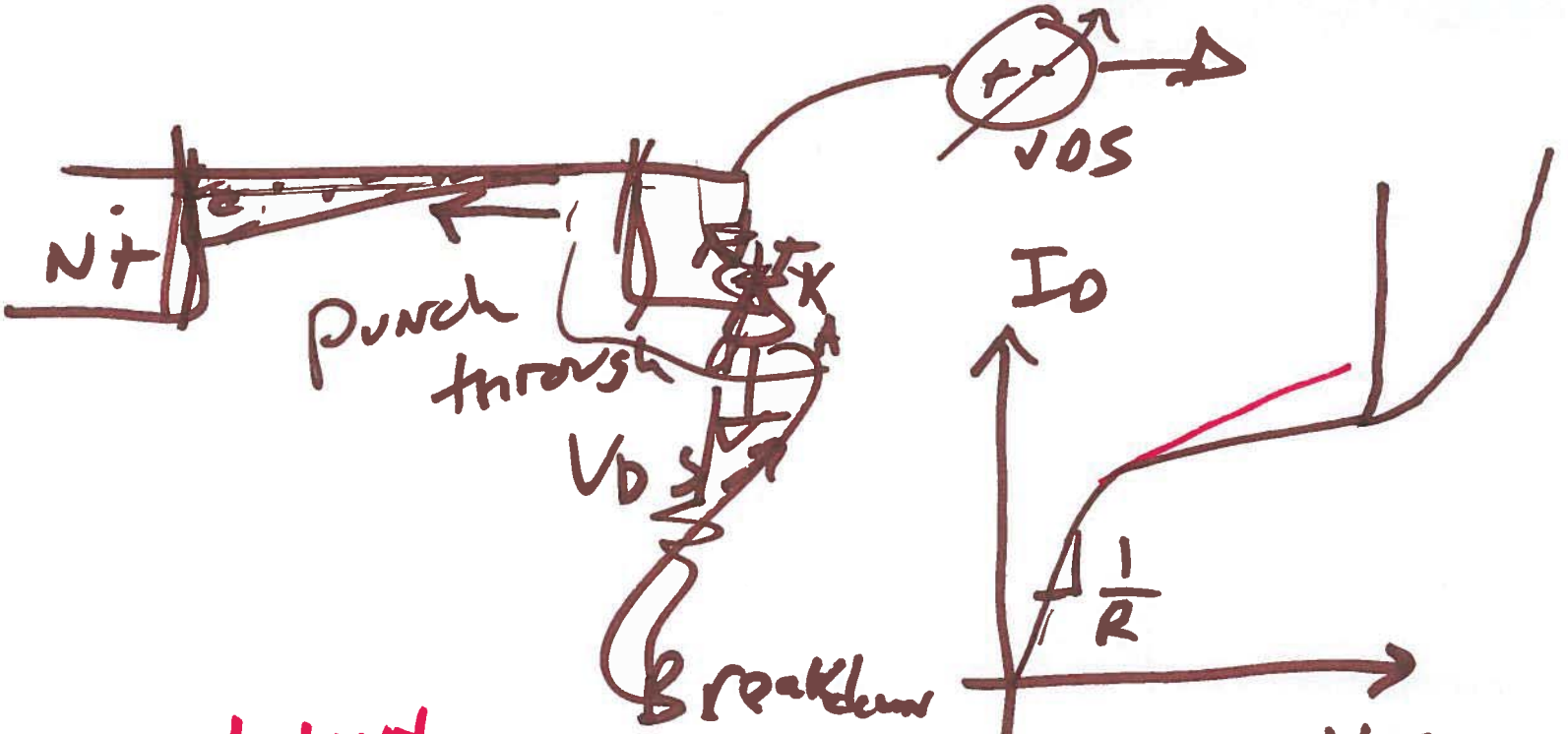
$$I = \frac{W}{L} K_{P_n}\left((V_{DS} - V_{T_{0n}})(V_{GS} - V_{T_{0n}}) - \frac{1}{2}(V_{GS} - V_{T_{0n}})^2\right)$$

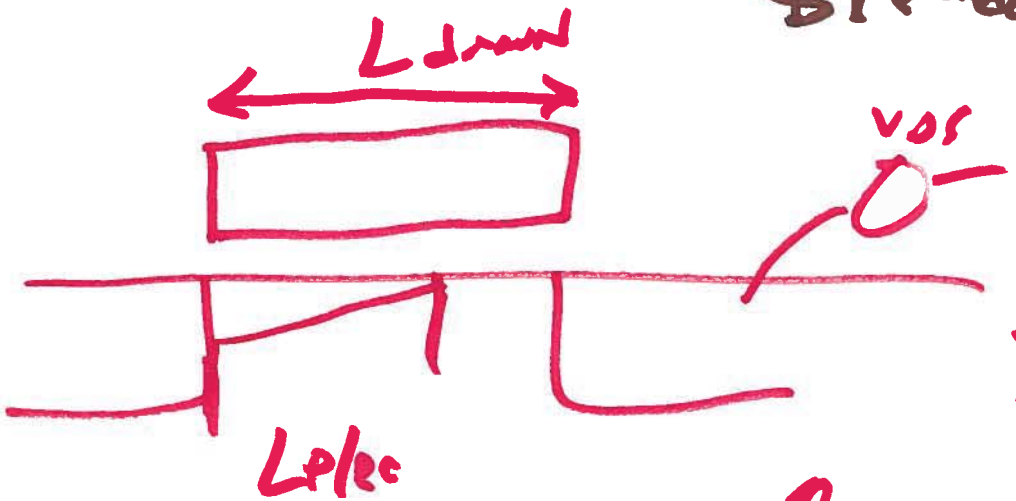
$$= \frac{W}{L} K_{P_n}\left((V_{GS} - V_{T_{0n}})^2 - \frac{1}{2}(V_{GS} - V_{T_{0n}})^2\right)$$

$$\boxed{I = \frac{K_{P_n}}{2}\frac{W}{L}(V_{GS} - V_{T_{0n}})^2}$$

$$V_{GS} \geq V_{T_{0n}}$$

$$V_{DS} \geq V_{GS} - V_{T_{0n}}$$

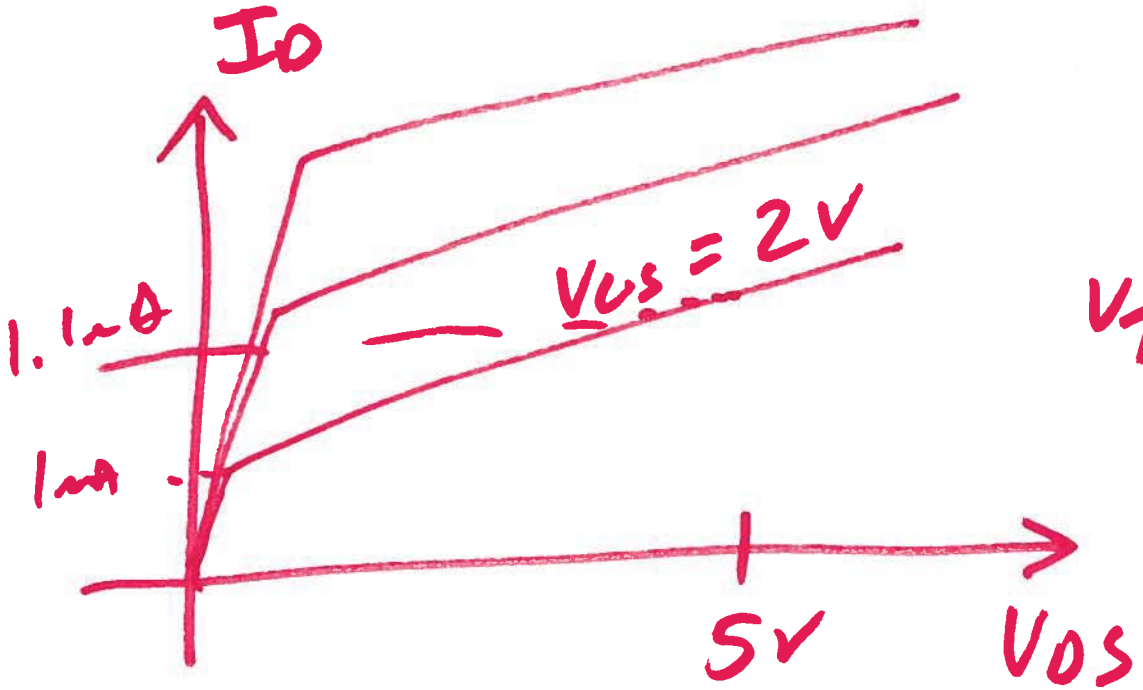




$$I = \frac{K'_n}{2}\frac{W}{L_{eff}}(V_{GS} - V_{TH})$$

$V_{DS} \uparrow$

$L_{eff} \downarrow$



$V_{THN} = 1V$

$$1mA = KP \cdot \frac{W}{L}(2-1)$$

$$KP \cdot \frac{W}{L}^{10u} = 1mA$$

$$KP = 1mA/V^2$$

.model MyNMOS NMOS

VTO = 1 KP = 1m Lambda = 0.05

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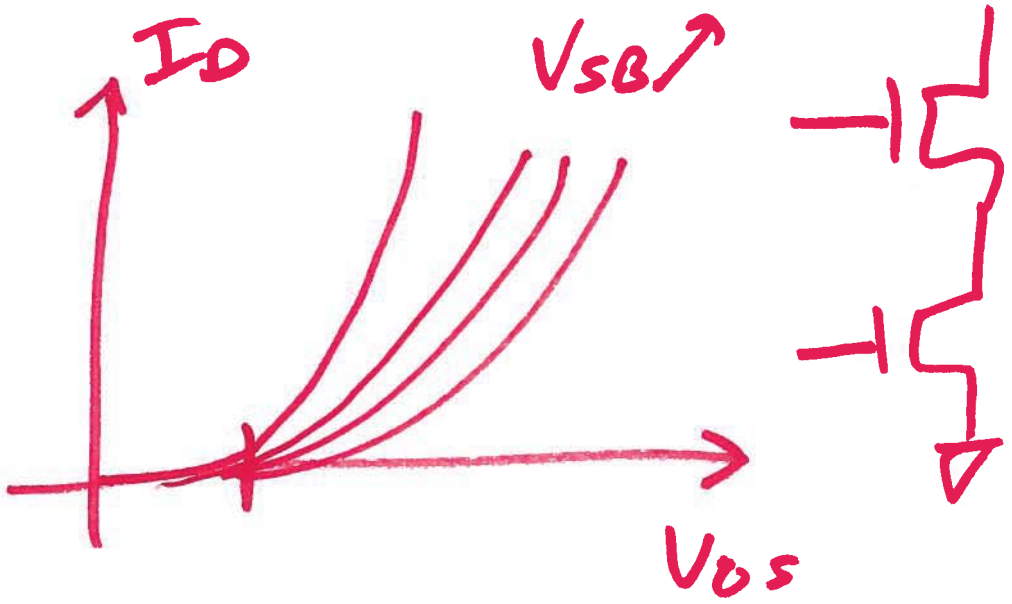
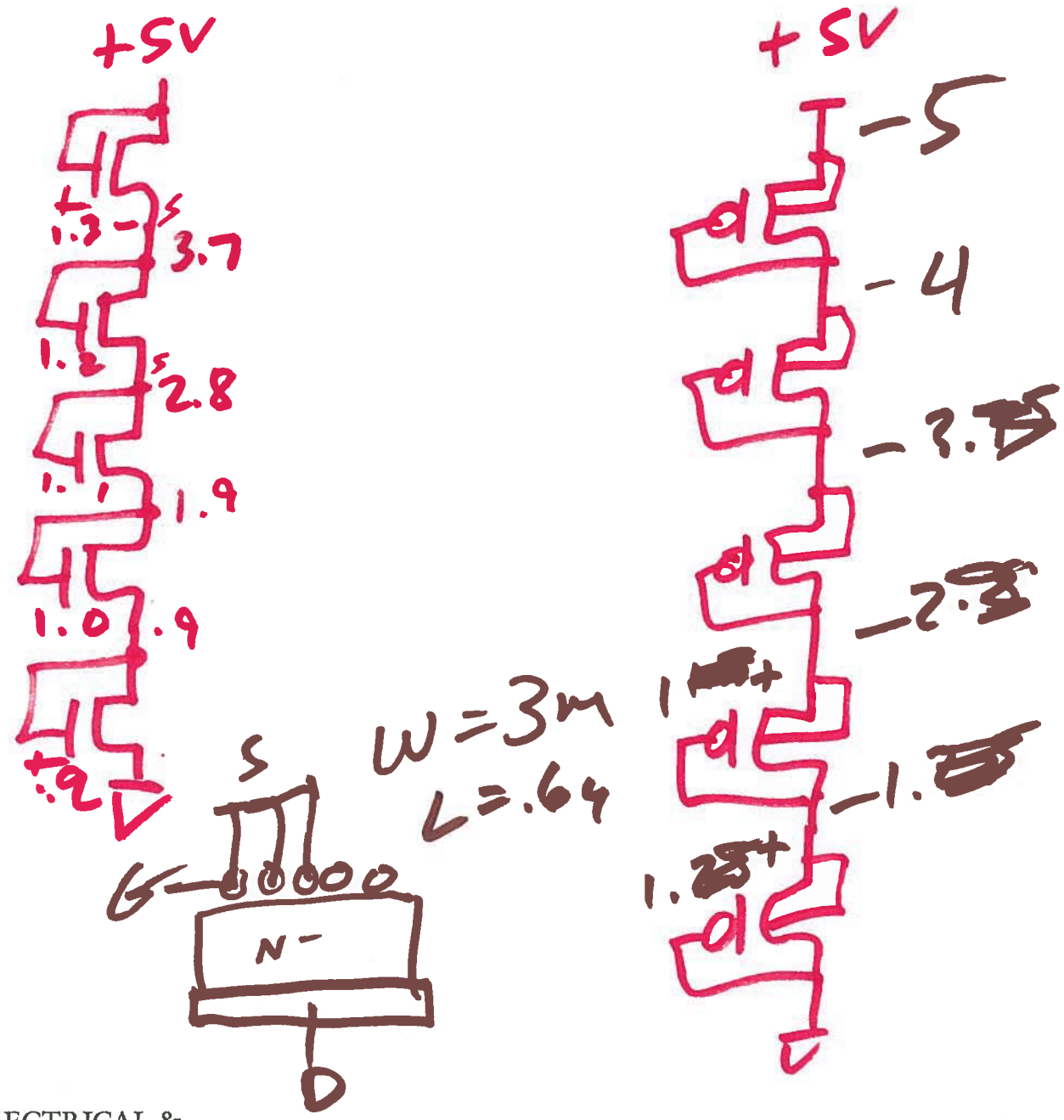
Body effect




+5V
+5V
-5
-4
S
W=3m
L=.64
N-