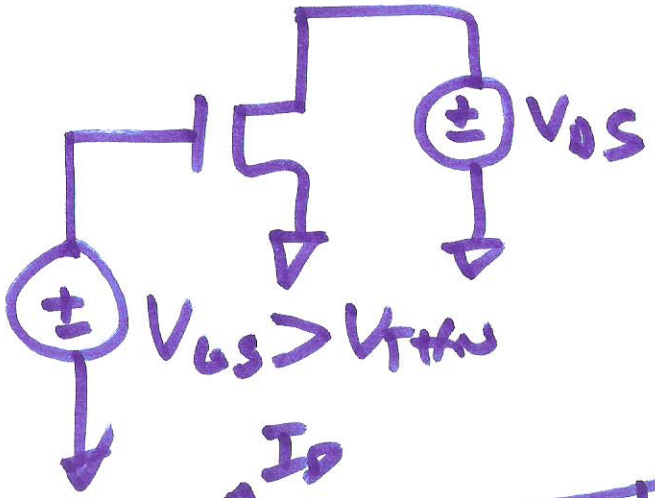
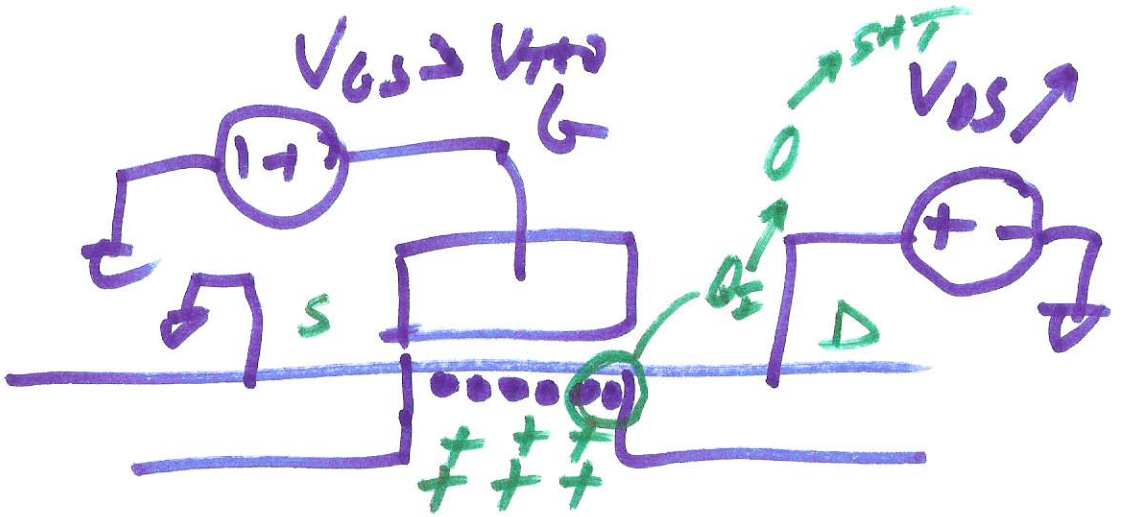
IE 421 / ECG 621
Digital IC Design
Oct. 14, 2013
Lecture 14
TEST A week from today.

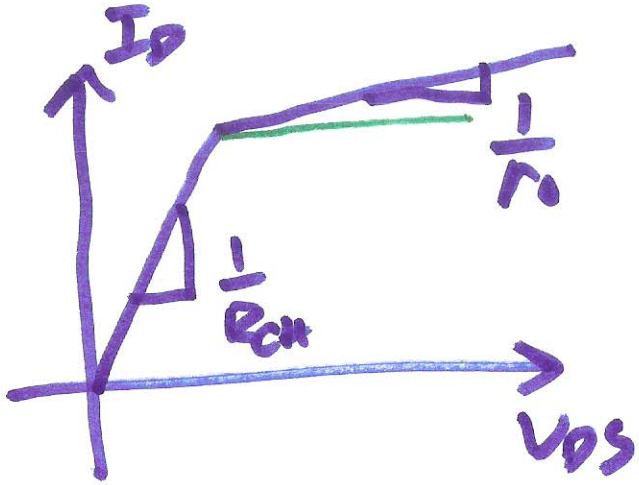
$$I_D = \frac{K_P}{2} \cdot \frac{W}{L}(V_{GS} - V_{TN})^2$$

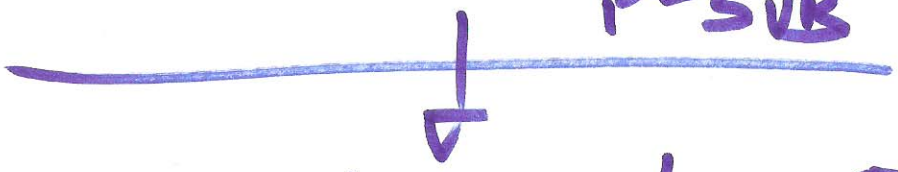
$V_{TN} \downarrow$

$I_D \uparrow$







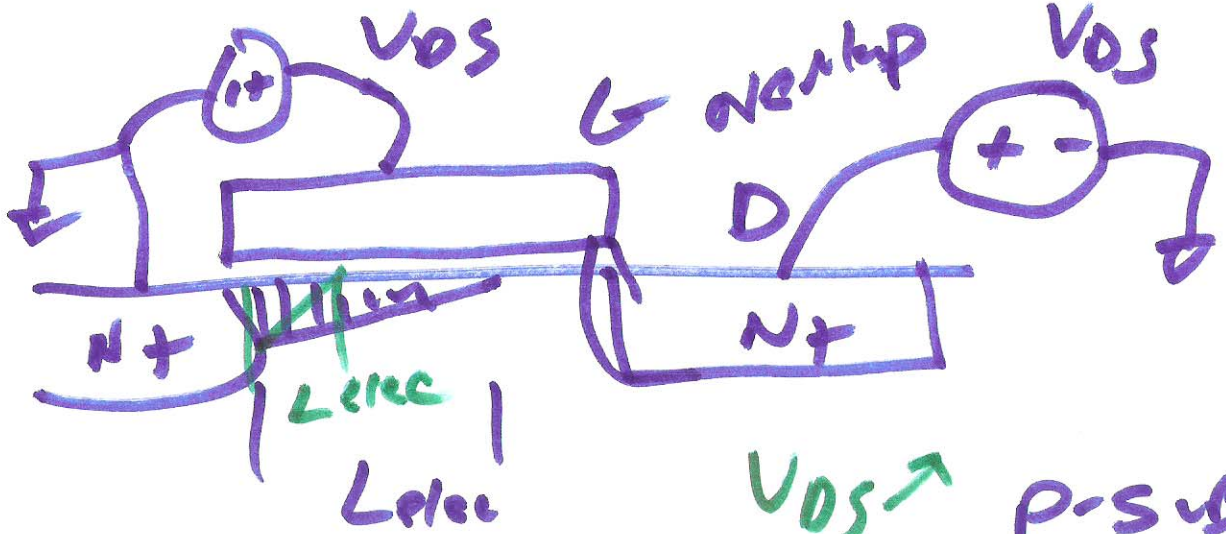


Q_B = charge to get to V_{THN}

$Q_B + Q_I = Q_{CH}$ = total Charge in Channel

Q_I = charge to conduct current

CLM - Channel Length Modulation



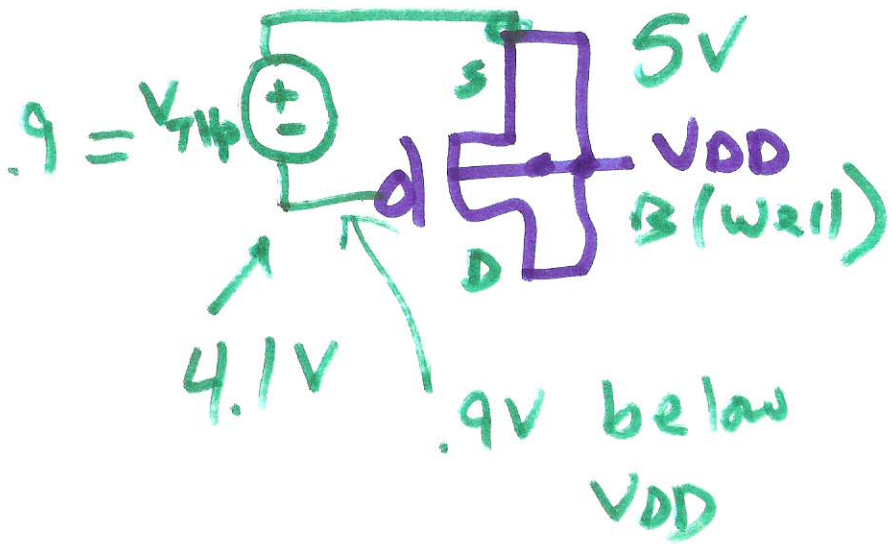
$V_{DS}\uparrow$ p-sub

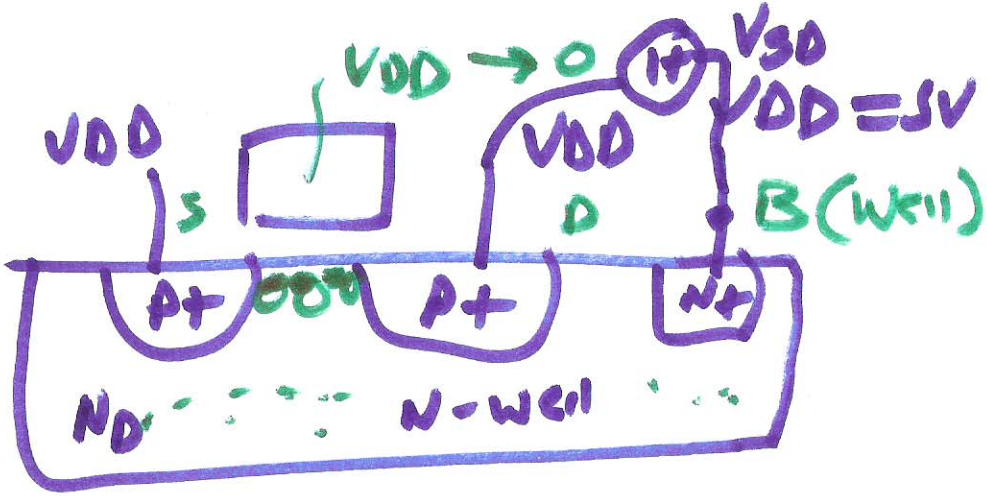
$L_{eff}\downarrow$

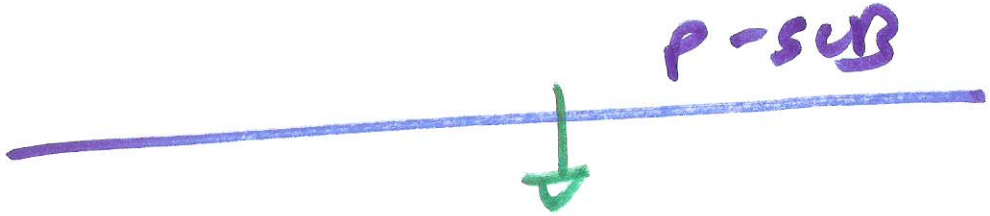
$$I_D = \frac{KP}{2} \cdot \frac{W}{L_{eff}} (V_{GS} - V_{THN})^2$$

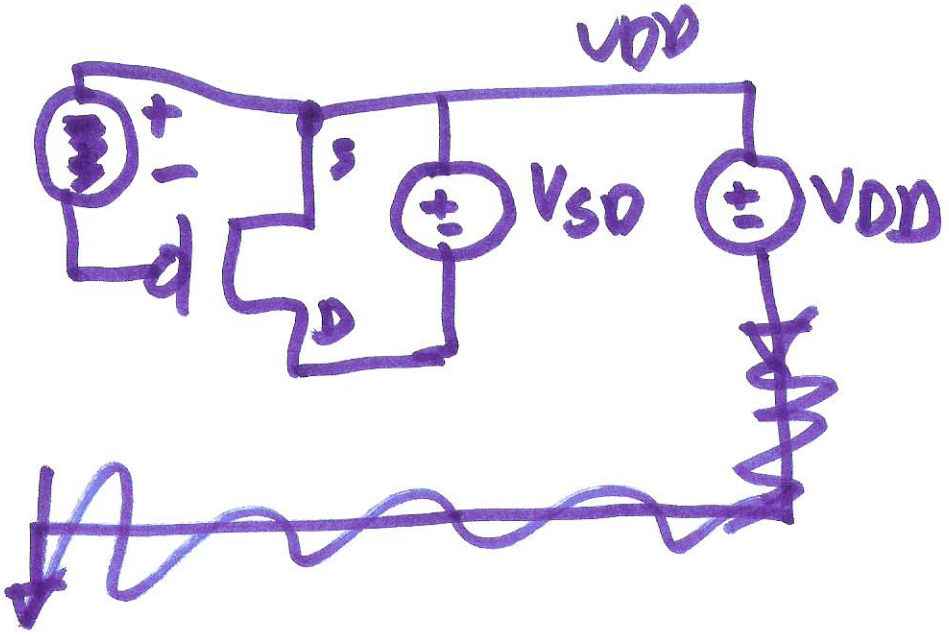
$L_{eff}\downarrow$

$I_D\uparrow$


.9 = VTHp
5V
S
VDD
d
B(well)
D
4.1V
.9V below VDD

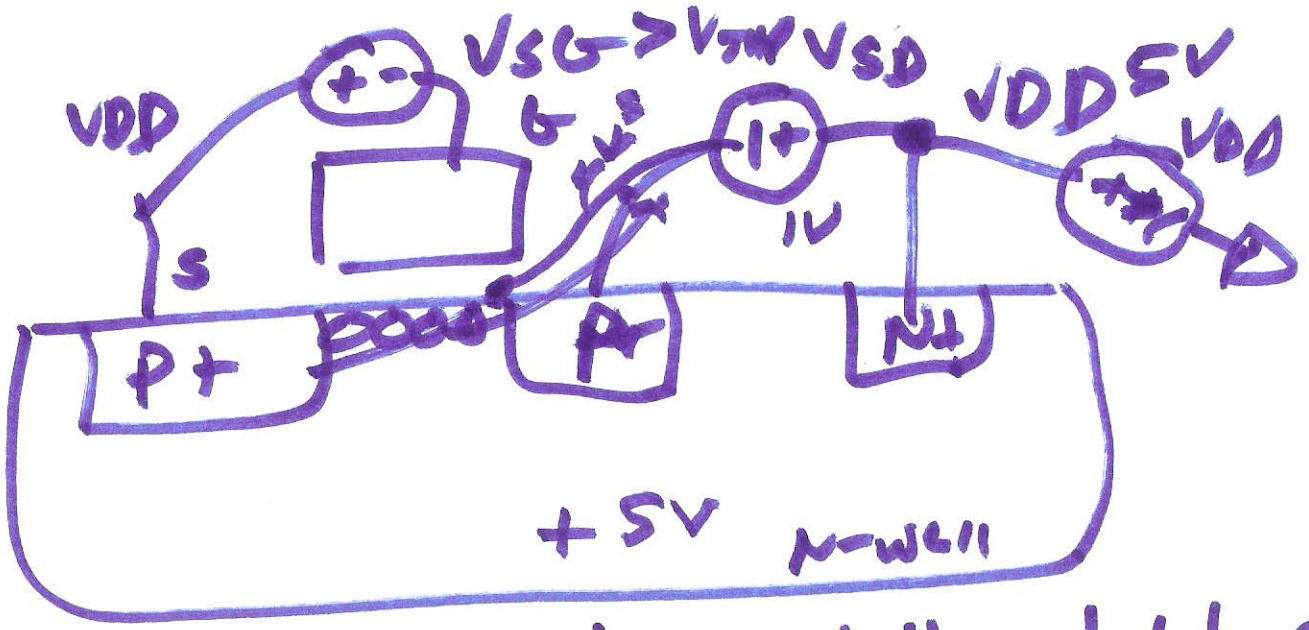

VDD → 0
VSD
VDD = 5V
VDD
VDD
S
D
B(well)
P+
P+
N+
ND
N-well


P-SUB

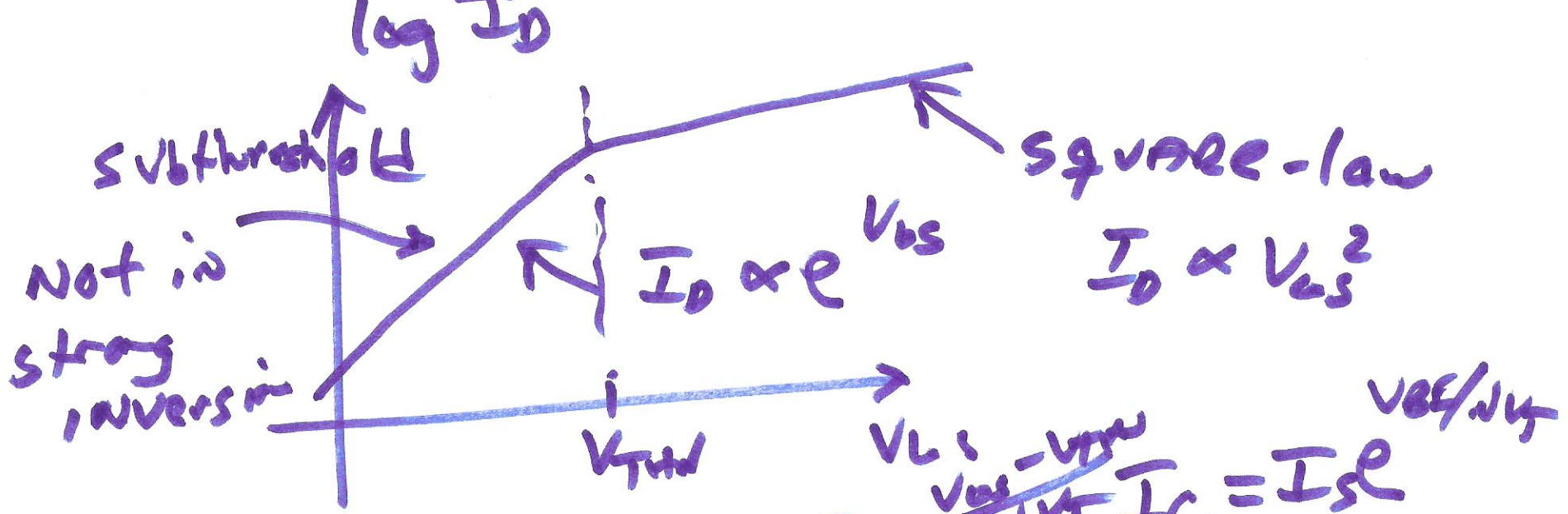

VDD
S
VSD
VDD
d
D

V_{SD} ↗

$V_{SD} = 1V$



off current & subthreshold current



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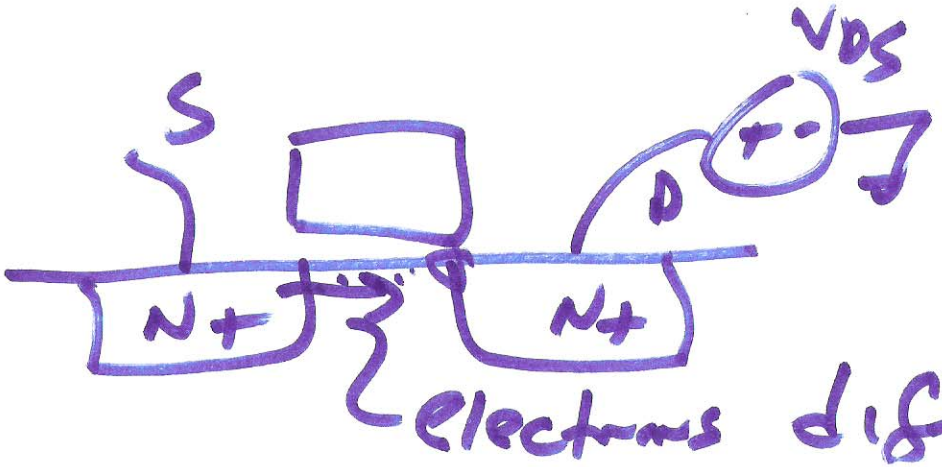
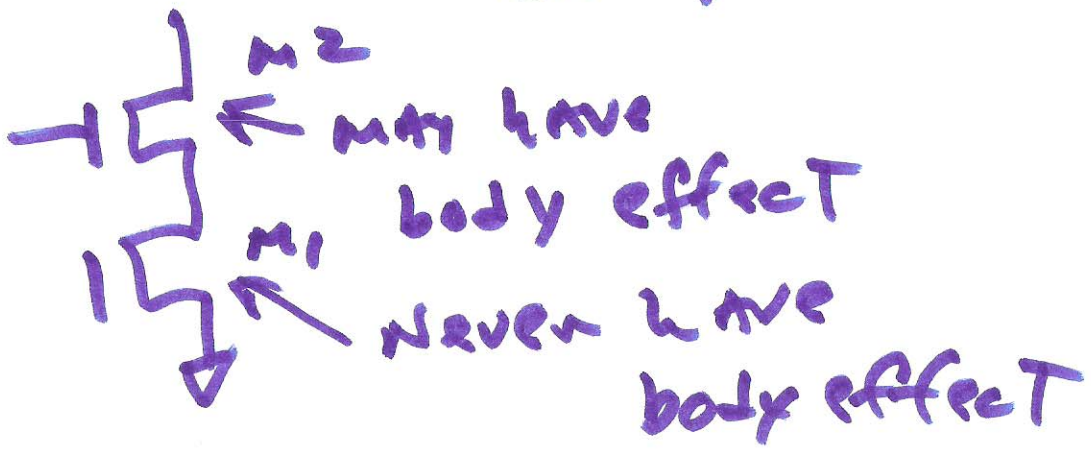
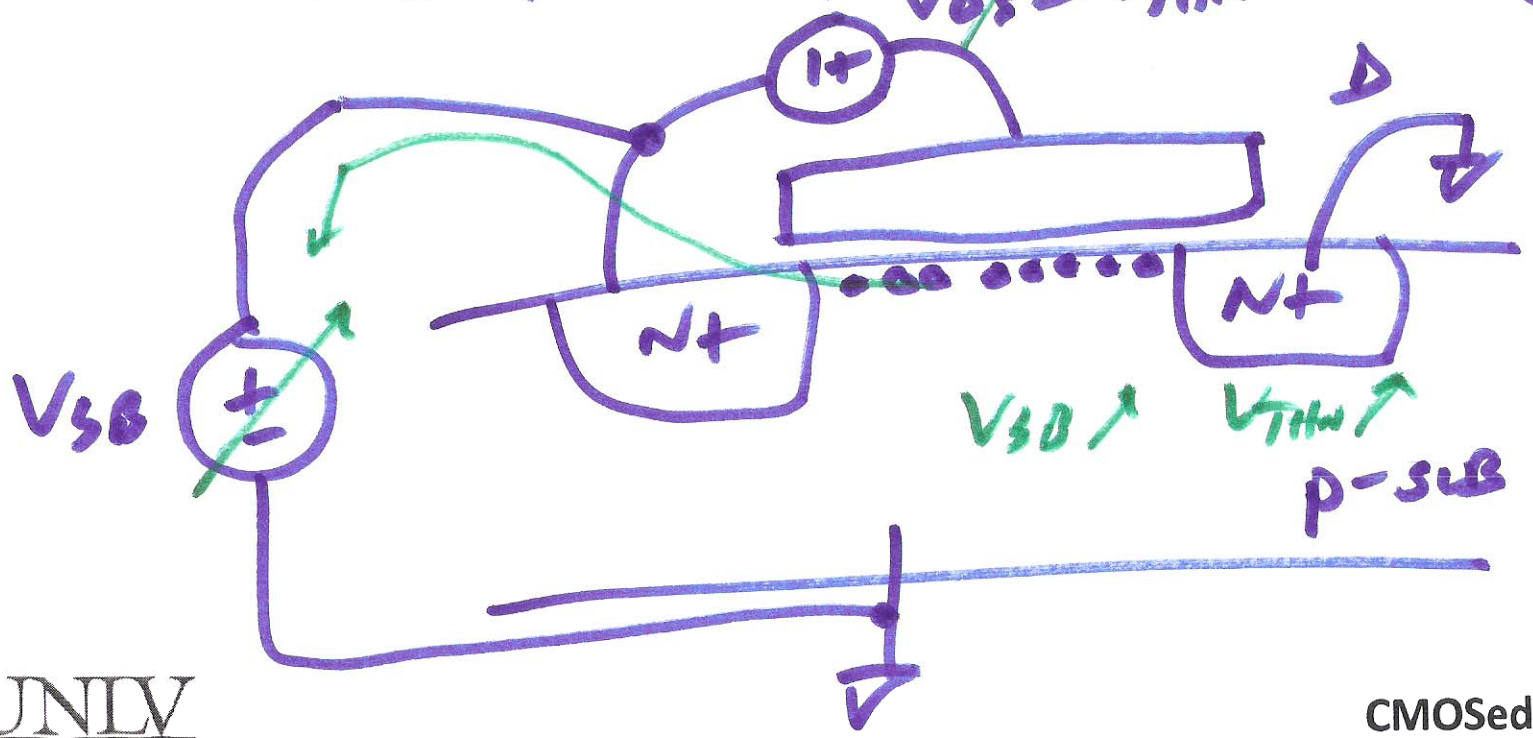
5)


S
D
V_{DS}
+
-
N+
N+
electrons diffuse from
S → D
drift → E field

Body effect



$V_{SB} \neq 0$ you have body effect.



$$I_{D,SAT} = \frac{\beta}{2}(V_{GS} - V_{THN})^2 \cdot (1 + \lambda(V_{DS,SAT} - V_{DS,SAT}))$$

$$I_D\Big|_{triode} = \beta\left[(V_{GS} - V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

$$V_{DS,SAT} = V_{GS} - V_{THN}$$

$$I_{D,SAT} = \frac{\beta}{2}(V_{GS} - V_{THN})^2 \cdot (1 + \lambda V_{DS})$$

$$(1 + \lambda V_{DS})$$

Level

8)

$C_{gs} \Rightarrow$ saturation

$$C_{GS} = \frac{2}{3} C_{ox}' \cdot W \cdot L$$

$$Q_I|_{total} = \int_0^L W \cdot Q_I'(y) \cdot dy$$

$$= W C_{ox}' \int_0^L (V_{GS} - V(y) - V_{THN}) \cdot dy$$

$$Q_I = \frac{(W C_{ox}')^2 \cdot \mu_N}{I_D} \cdot \int_0^{V_{GS}-V_{THN}} (V_{GS} - V_{THN} - V(y)) \, dV(y)$$

$$Q_I = \frac{2}{3} \cdot W \cdot L \cdot C_{ox}' (V_{GS} - V_{THN})$$

$$C_{GS} = \frac{\delta Q_I}{\delta V_{GS}} = \frac{2}{3} C_{ox} \cdot W \cdot L$$