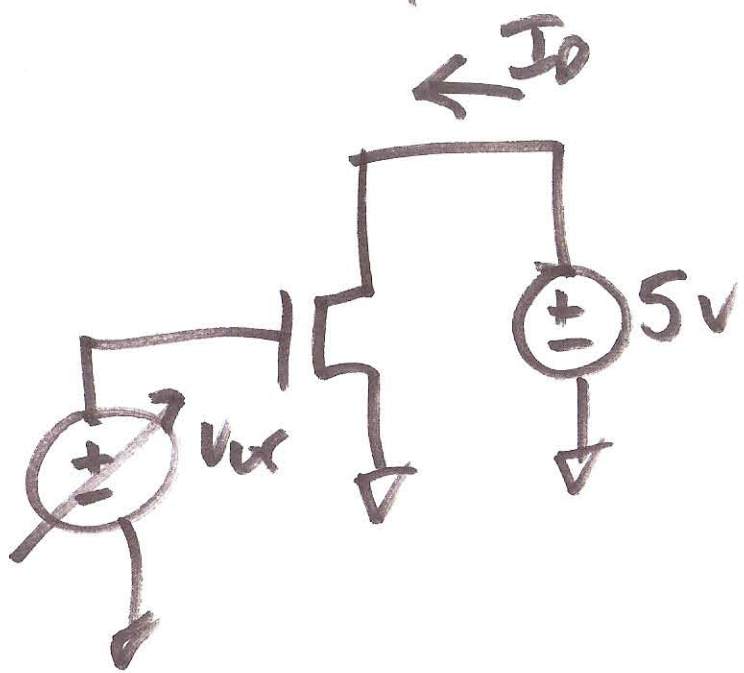
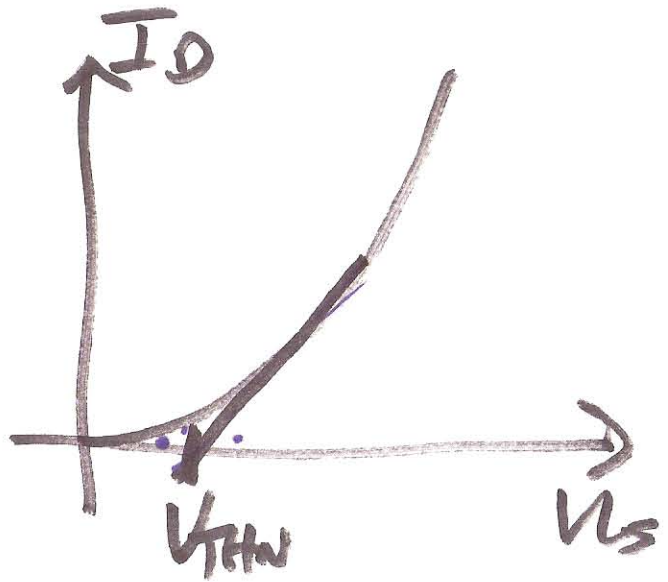
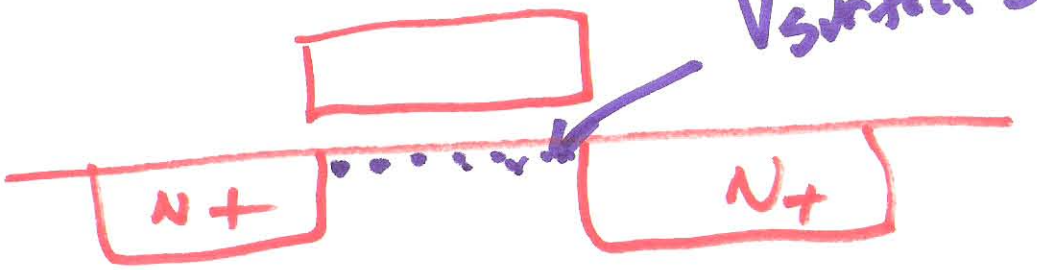
ECG 621 / EE 421

Lecture 11

9/30/2015







$V_{surface} = V_S = N_A = P$

Before apply a potential

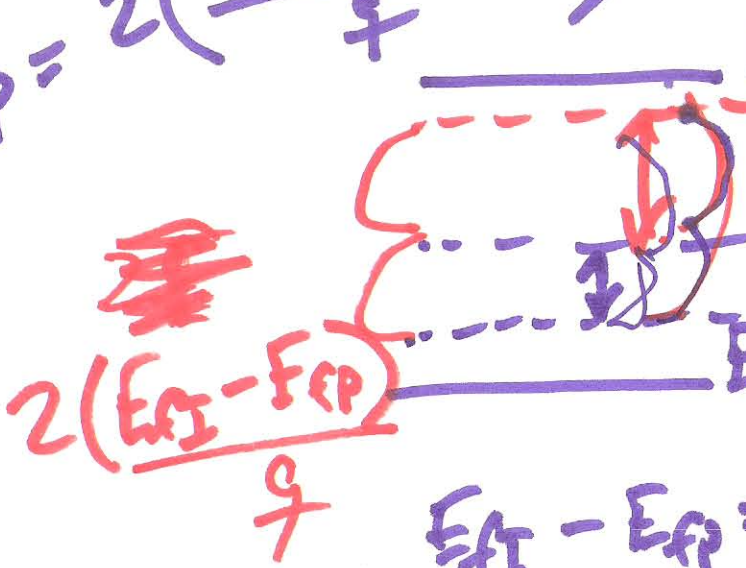
P-SUB

NA

$2V_{fp} = 2\left(\frac{E_{Fi} - E_{fp}}{q}\right)$

N_A = doping density of substrate

$\frac{Atoms}{cm^3}$



$P = N_A$ = # of holes in the substrate

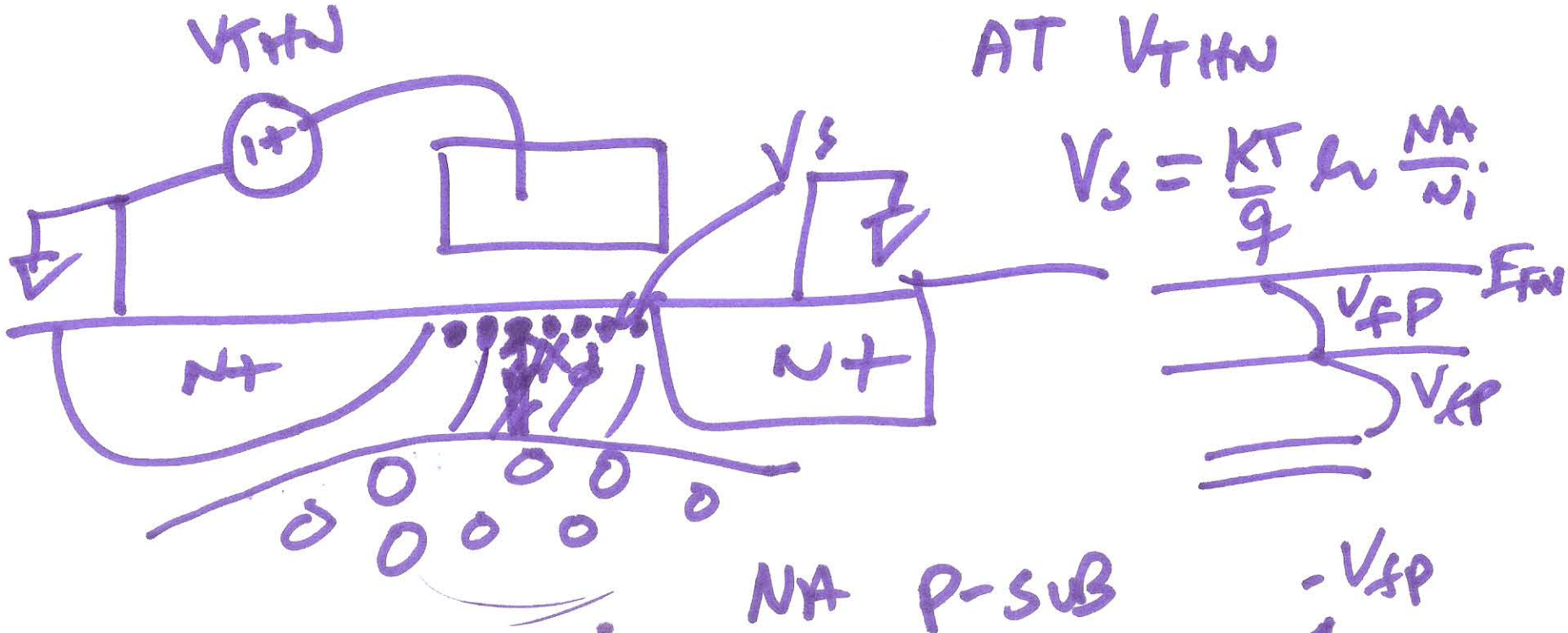
$2\left(\frac{E_{FI} - E_{fp}}{q}\right)$

$E_{FI} - E_{fp} =$

$N = \frac{n_i^2}{P}$

$V_{ff} = \frac{E_{FI} - E_{fp}}{q}$

$\frac{KT}{q} \ln \frac{n_i}{N_A} = -\frac{KT}{q} \ln \frac{N_A}{n_i}$



3)

$$Q_b' = qX_d \cdot N_A = \sqrt{2\epsilon_{si} \cdot q \cdot N_A |V_s - V_{fp}|}$$

$V_s = V_{SB}$ ↑

$V_{SB} = V_{THN}$

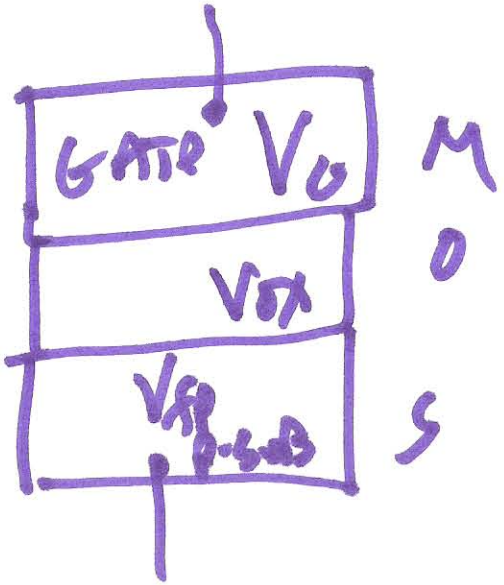
$$V_{fp} = -\frac{kT}{q} \ln \frac{N_A}{n_i}$$

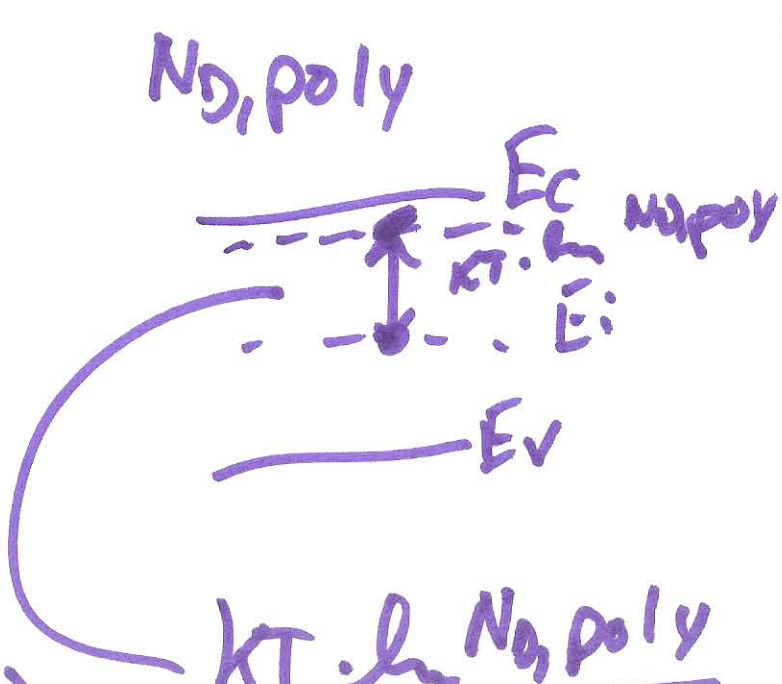
$$-V_{fp} = \frac{kT}{q} \ln \frac{N_A}{n_i}$$

positive

$$(6.8)\quad Q_{b0}' = \sqrt{2\epsilon_{si} q N_A |-2V_{fp}|}$$

Q_{b0}' ← Body is shorted to the source



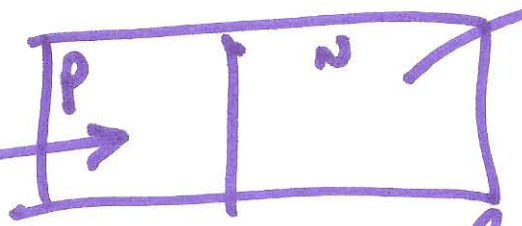


$$\frac{KT}{q} \ln \frac{N_A N_D}{n_i^2}$$

$$V_{ms} = (V_G - V_{ox}) + (V_{ox} - V_{fp})$$

↑ Contact potential

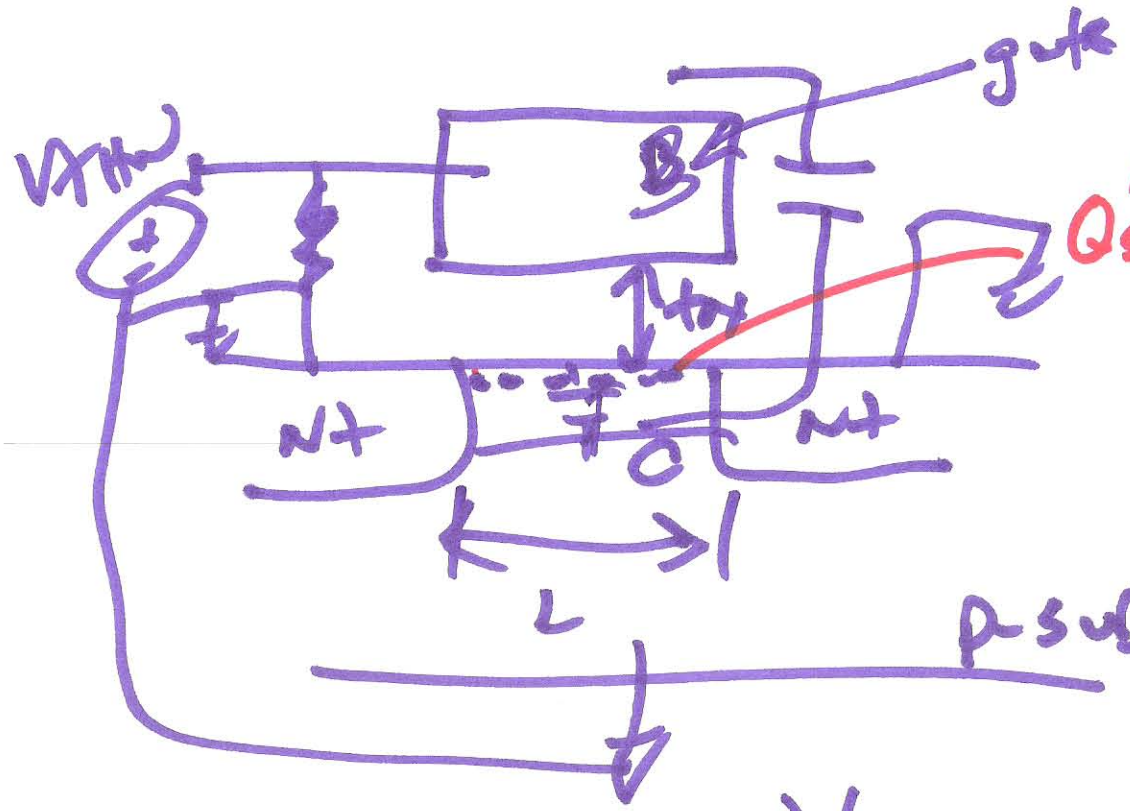
$$V_{fp} = -\frac{KT}{q} \ln \frac{N_A}{N_i}$$



$$\frac{KT}{q} \ln \frac{N_D}{N_i}$$

$$\frac{KT}{q} \cdot \ln \frac{N_D}{N_i} - \left(-\frac{KT}{q} \ln \frac{N_A}{N_i}\right)$$

5)



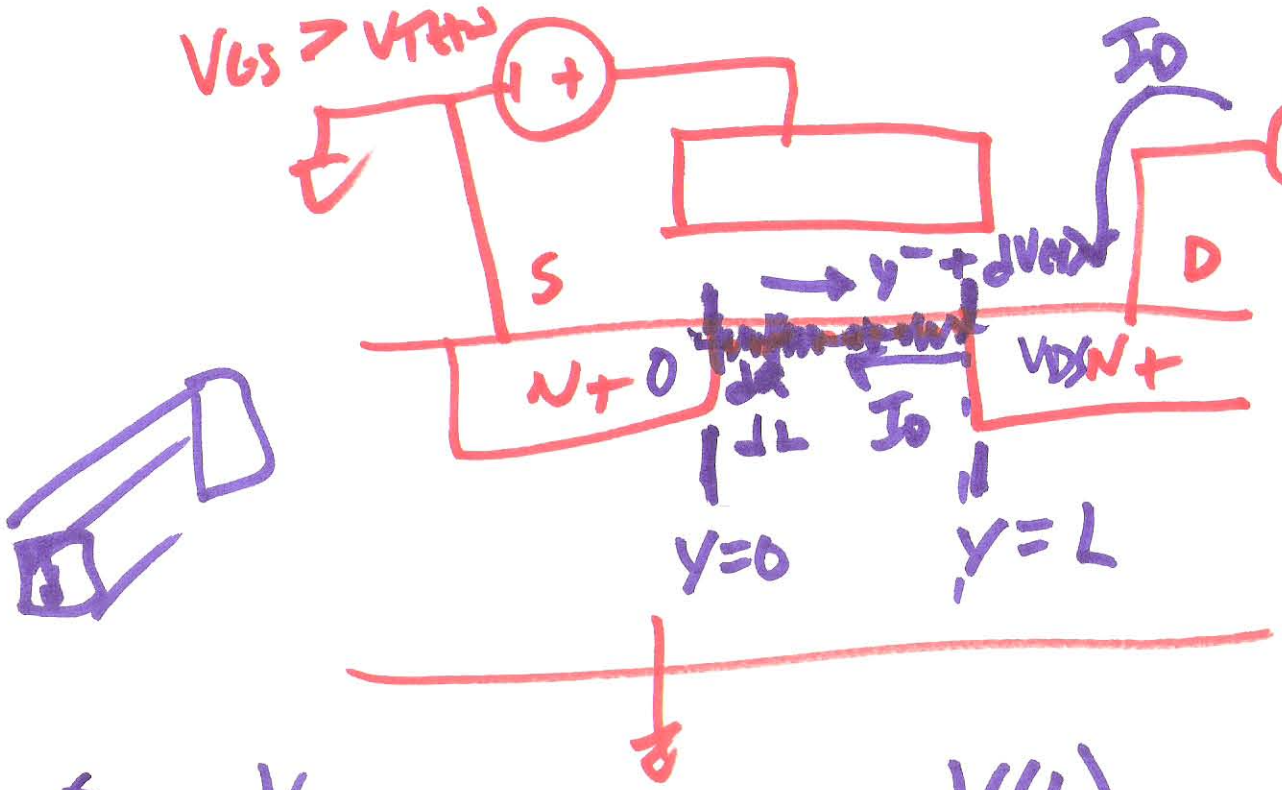
model trapped surface states (charge)

$$V_{BC} = \frac{Q_b'}{C_{ox}'}$$

$$V_B = \frac{Q_b' - Q_{ss}'}{C_{ox}'} - 2V_{fp}$$

$$V_{THN} = \frac{Q_b' - Q_{ss}'}{C_{ox}'} - 2V_{fp} - V_{ms}$$

6)



$\mu = \frac{s}{\varepsilon}$ $\frac{cm^2}{V \cdot s}$

$V(0) = 0$

$V(L) = V_{DS}$

$Q_I = K_{THN}$ $V(0)$ $V(L)$

$dV(y) = I \cdot dR$

$R = \frac{\rho}{t} \cdot \frac{L}{W}$

Q_I

Total Charge in inverted Channel

$dR = \frac{1}{Q_I' \cdot \mu_N} \frac{dL}{W}$

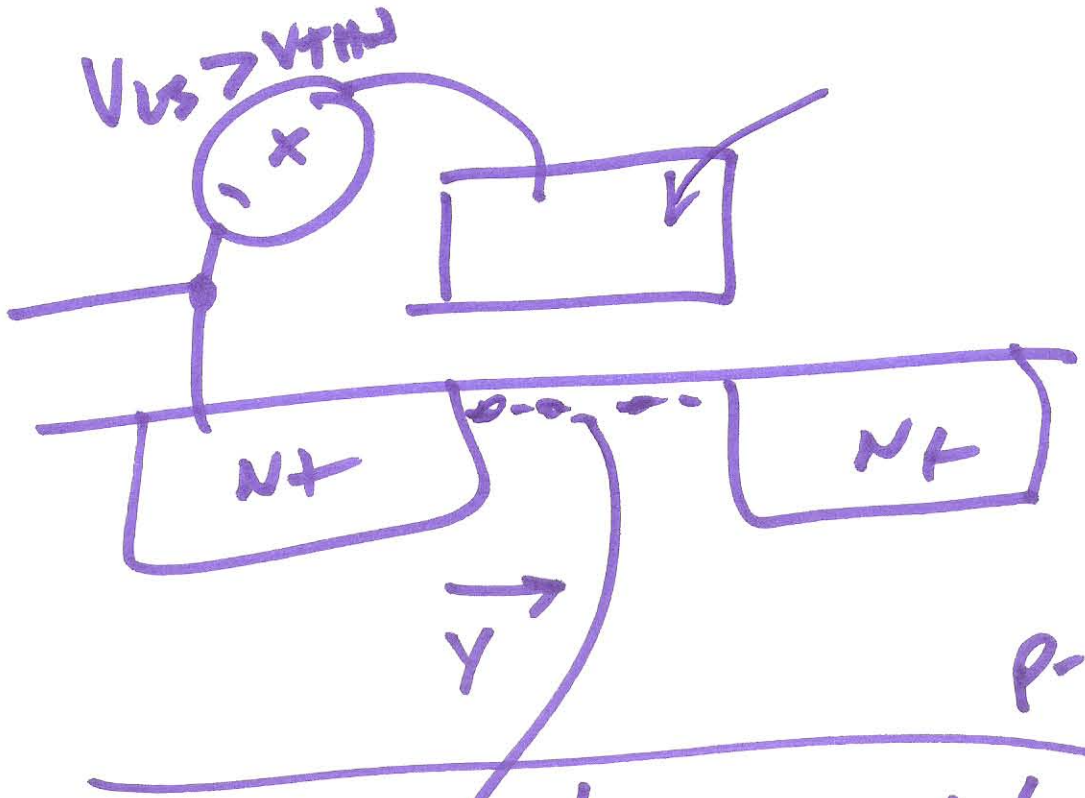
μ_N ← sheet resistance

$\frac{\rho}{t}$ ← sheet resistance

$$dV(y) = I_D \cdot \frac{1}{Q_I'(y) \cdot \mu_n} \cdot \frac{dL}{W}$$

$$dR = \frac{I_D}{\mu_n ($$

Return



$V_{DS} \leq V_{GS} - V_{THN}$ / triode

V_{DS}

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

$$dV(y) = \frac{I_D}{Q_I'(y) \cdot \mu_n} \cdot \frac{dL}{W}$$

$dL \Rightarrow dy$

$$\int_0^L I_D \cdot dy = \int_0^{V_{DS}} W \mu_n C_{ox} \left(V_{GS} - V(y) - V_{THN}\right) dV(y)$$

$$KP_N = \mu_n \cdot C_{ox}' \quad , \quad \beta_N = KP_N \cdot \frac{W}{L}$$

$$C_{ox}' = \frac{\varepsilon_{ox}}{t_{ox}}$$

$$I_D \cdot L = W \mu_n C_{ox}' \left(V_{DS} \cdot V_{GS} - \frac{1}{2} V_{DS}^2 - V_{THN} V_{DS} \right)$$

$V_{DS} \leq V_{GS} - V_{THN}$

$$I_D = \mu_n C_{ox}' \cdot \frac{W}{L} \left((V_{GS} - V_{THN}) V_{DS} - \frac{V_{DS}^2}{2} \right)$$

$V_{GS} > V_{THN}$ triode

10)