# Announcements

OH TODAY – Prof. Niknejad 5-6pm

OH TOMORROW – Andrew 2-3:30 400 Cory

OH THURSDAY – Prof. Muller 10-12pm

MIDTERM THURSDAY IN LECTURE

HW 8 POSTED FRIDAY – DUE IN 2 WEEKS

a)


same

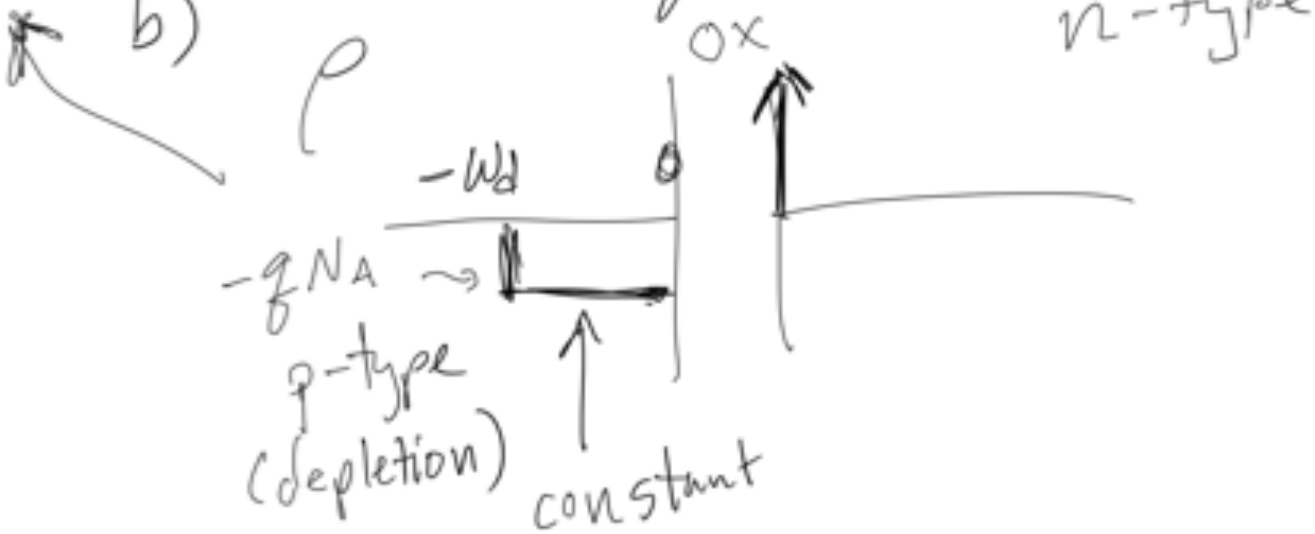
$$\phi_{bi} = \phi_n - \phi_p$$

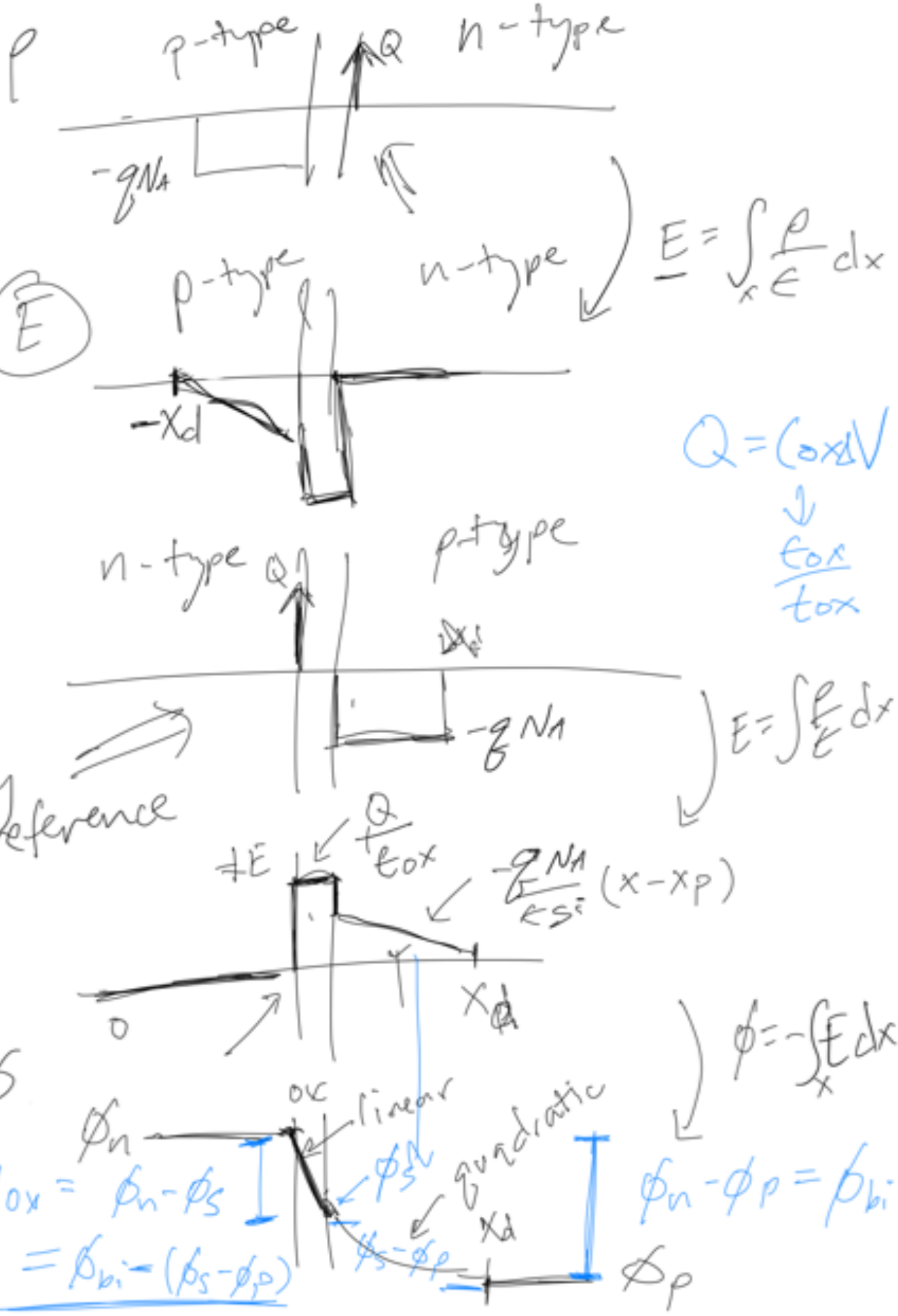
$$\phi_n = \frac{kT}{q} \ln\left(\frac{N_D}{n_i}\right)$$

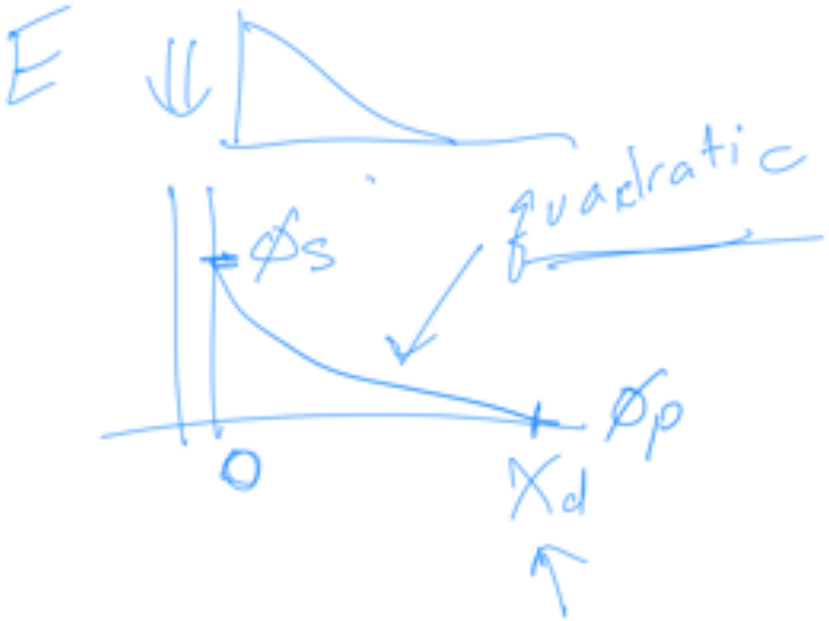
$$\phi_p = -\frac{kT}{q} \ln\left(\frac{N_A}{n_i}\right)$$

$$\phi_{bi} = \frac{kT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right)$$

b)




ρ
p-type
Q
n-type
$-qN_A$
$\underline{E} = \int_x \frac{\rho}{\epsilon} dx$
E
p-type
n-type
$-x_d$
$Q = C_{ox} \Delta V$
$\downarrow$
$\frac{\epsilon_{ox}}{t_{ox}}$
n-type
Q
p-type
$x_d$
$-qN_A$
$E = \int \frac{\rho}{\epsilon} dx$
my preference
$+\bar{E}$
$\frac{Q}{\epsilon_{ox}}$
$\frac{-qN_A}{\epsilon_{Si}}(x - x_p)$
0
$x_d$
$\phi = -\int_x E dx$
$\phi$
$\phi_n$
oc
linear
quadratic
$\phi_s$
$V_{ox} = \phi_n - \phi_s$
$V_{ox} = \phi_{bi} - (\phi_s - \phi_p)$
$\phi_s - \phi_p$
$x_d$
$\phi_p$
$\phi_n - \phi_p = \phi_{bi}$




$$\phi(x) \frac{q N_A}{2\varepsilon_s}(x - x_d)^2 + \phi_p$$

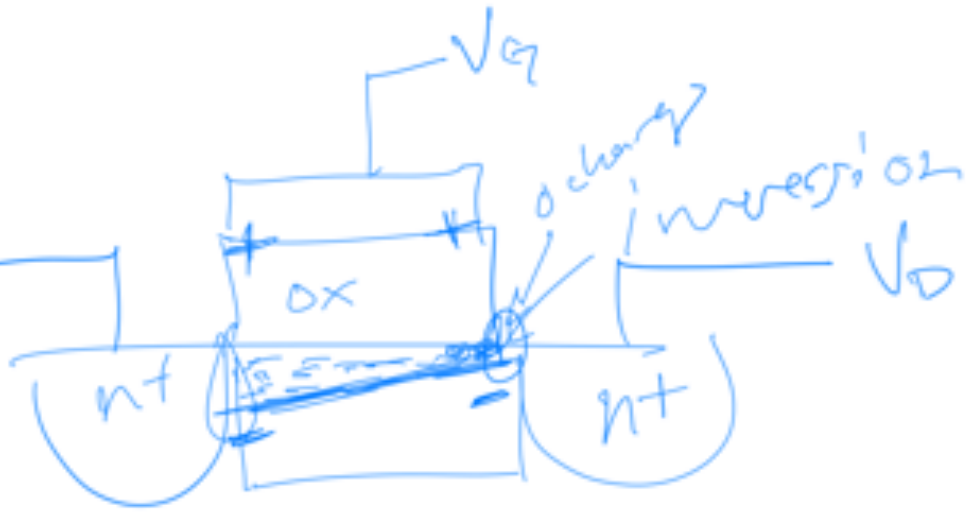
$$\phi(0) = \frac{q N_A}{2\varepsilon_s}(-x_d)^2 + \phi_p = \phi_s$$

$$\phi(x_d) = \frac{q N_A}{2\varepsilon_s}(0) + \phi_p$$

$$\underline{W_p} = \sqrt{\frac{2\varepsilon_s}{q N_A}(\phi_s - \phi_p)}$$

$$V_{ox} = \phi_{bi} - (\phi_s - \phi_p)$$

when add bias?

a) 


$$\mathcal{E} = \frac{V_{DS}}{L}$$

$$E = 1\,V/\mu m = \frac{V_{DS}}{L} = \frac{V_{DS}}{.1\,\mu m}$$

$$\boxed{V_{DS} = 0.1V}$$

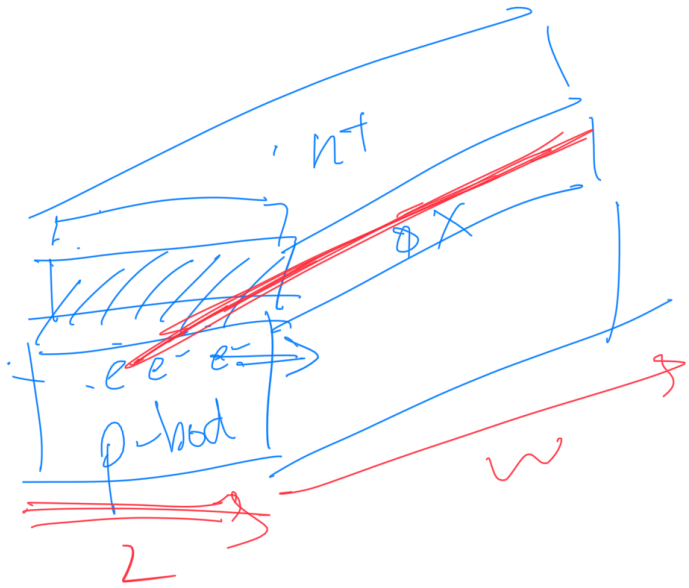
b) channel charge

$Q_{av}$ = charge@source + charge@drain

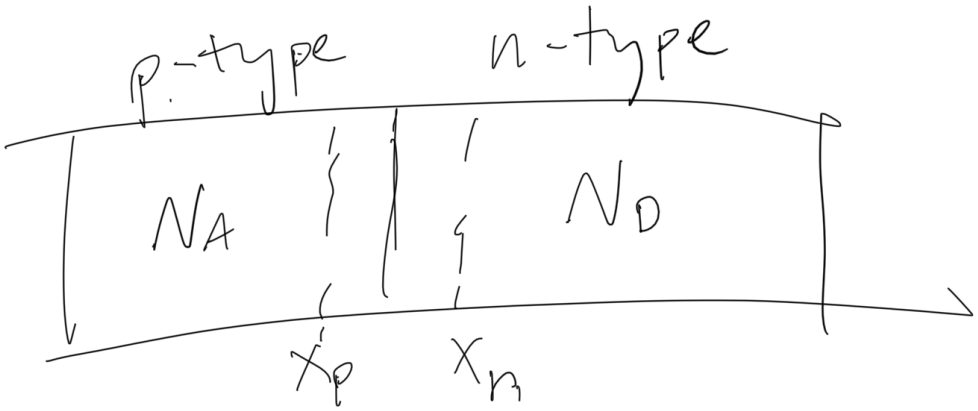
$$= \frac{C_{ox} \cdot WL}{2}\left[(V_{GS}-V_T) + (\underbrace{V_{GS}-V_T-V_{DS}}_{V_{GD}-V_T})\right] = 4.75fC$$

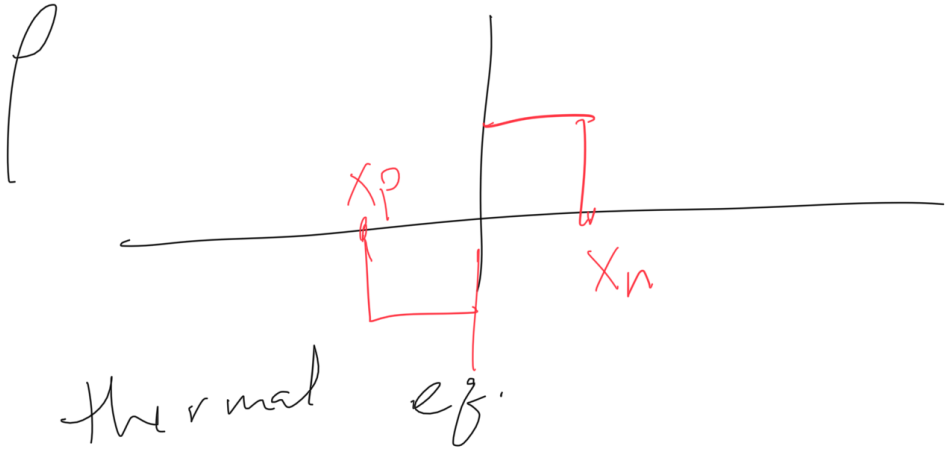
($V_{GS} = 1V$, $V_{DS} = .1V$, $V_{GD}-V_T = .9V$)

$v = 10^{11}\mu m/s$ $\quad I_D = \frac{Q_{av}}{\frac{L}{v}}$

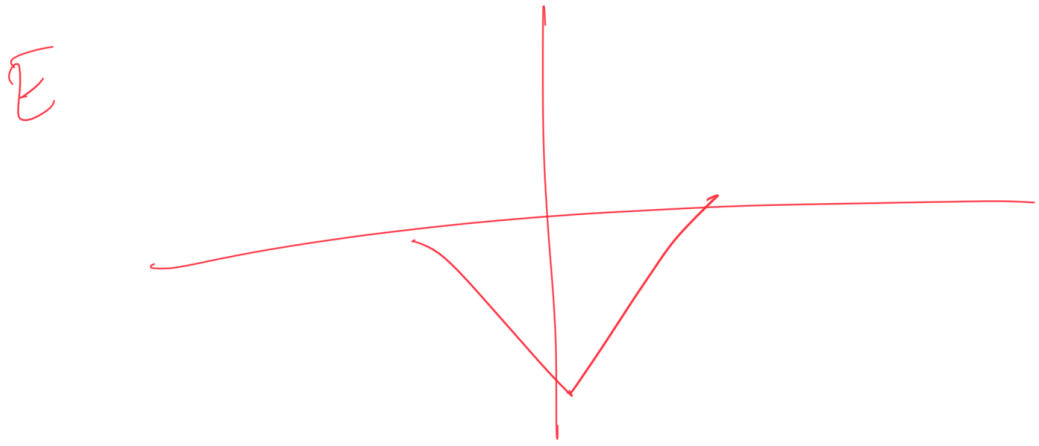

n+
p-bod
W
L

#1



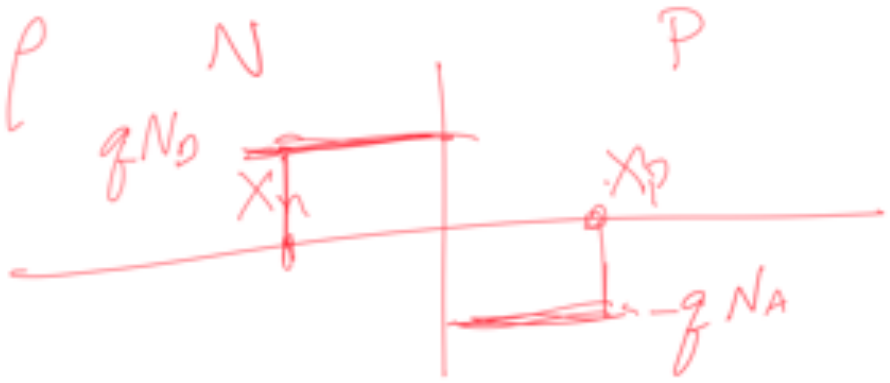

thermal eq.

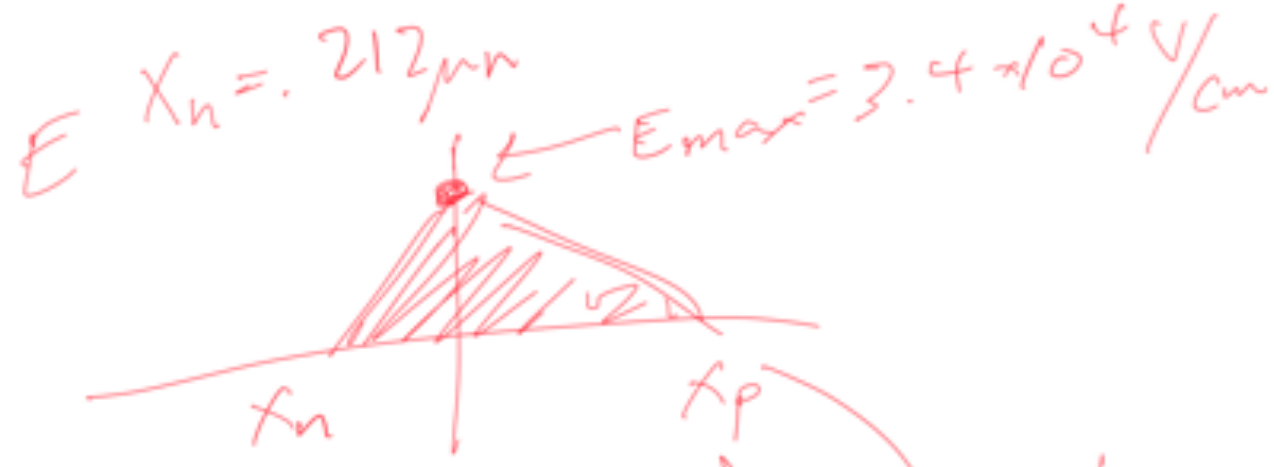



b) $x_n = .212 \mu m$

$\phi_{bi} = .72\ V$

$E_{max} = 3.4 \times 10^4\ V/cm$




$\phi_{bi} = .72\,V$

potential $= V_D$

$$E = \int \frac{\rho}{\epsilon_{Si}}$$

$$\phi = -\int E\,dx$$

$$E_{max} = \frac{qN_D x_n}{\epsilon_{Si}} = 3.4\times10^4\ V/cm$$

$$N_D = \frac{\epsilon E_{max}}{q x_n} \Rightarrow 10^{16}$$

$$\phi_{bi} = V_D = \frac{kT}{q}\ln\left(\frac{N_A N_D}{n_i^2}\right)$$