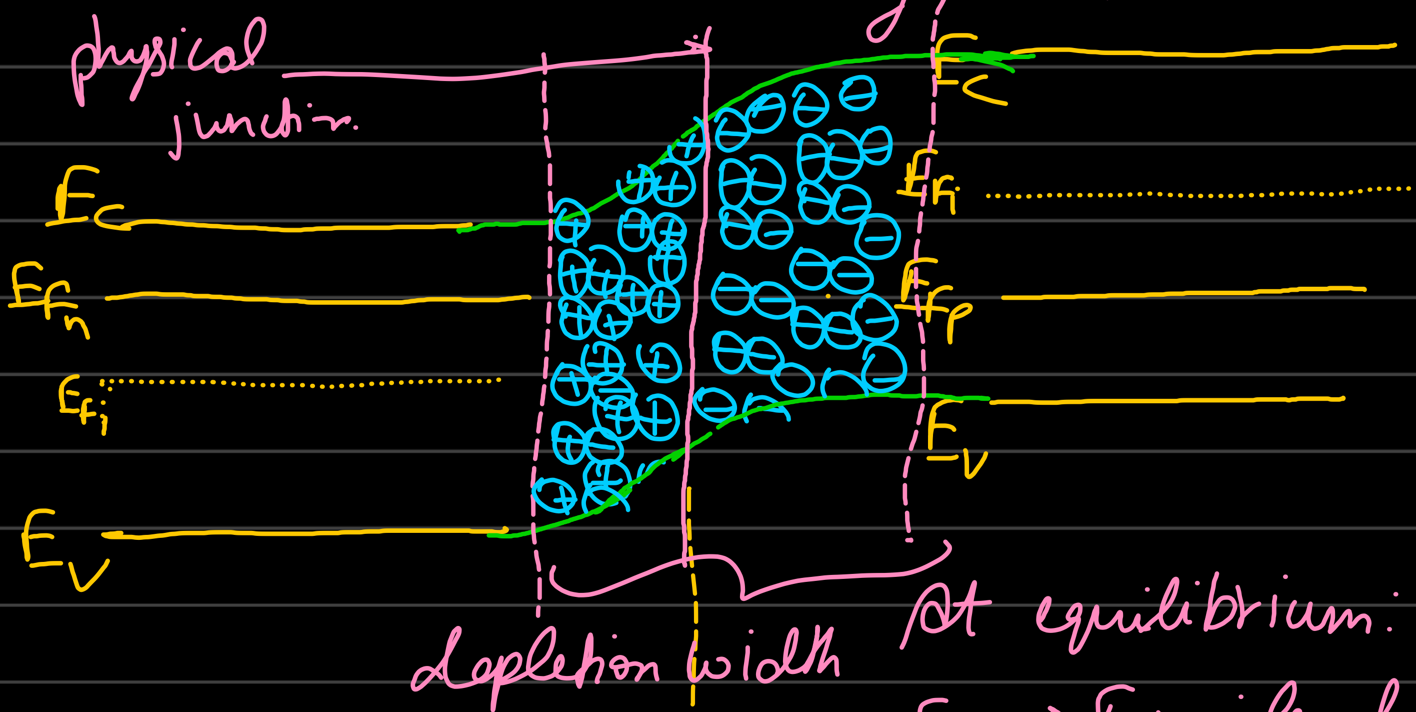
Lecture 19

Semiconducting Devices



At equilibrium:

$E_F \rightarrow$ Fermi level is flat

$J = 0$

$$n = N_c \, e^{-(E_c - E_F)/kT}$$

$$p = N_v \, e^{-(E_F - E_v)/kT}$$

Poisson's Equation: $-\nabla^2 \phi = \rho$

{Gauss Law}

$$-\nabla^2 V = \rho$$

$$-\frac{dV}{dx} = E \quad \Rightarrow \quad \frac{dE}{dx} = \rho$$

↳ charge density enclosed.

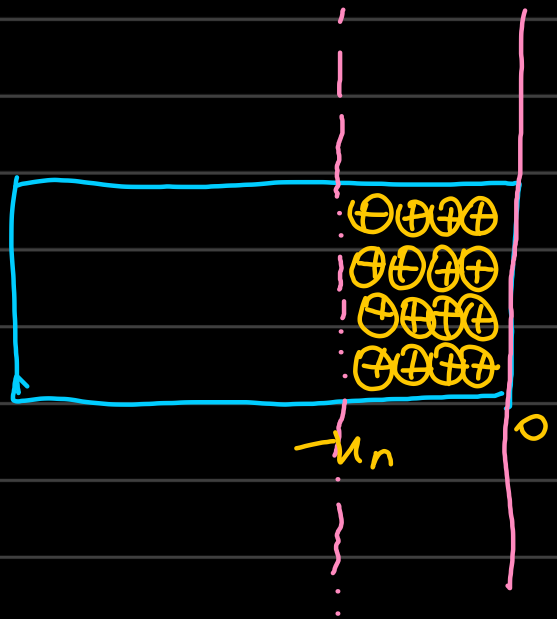
$\{\varepsilon_0 = 1$ in vaccuum$\}$ ↓ Gauss Law n - side : $N_D^{\oplus}$: no. of donors.

p - side : $N_A^{\ominus}$: total no. of acceptors.

+ve charged

$$\frac{dE}{dx} = q\left[p - n + N_D - N_A\right]$$

-ve charged

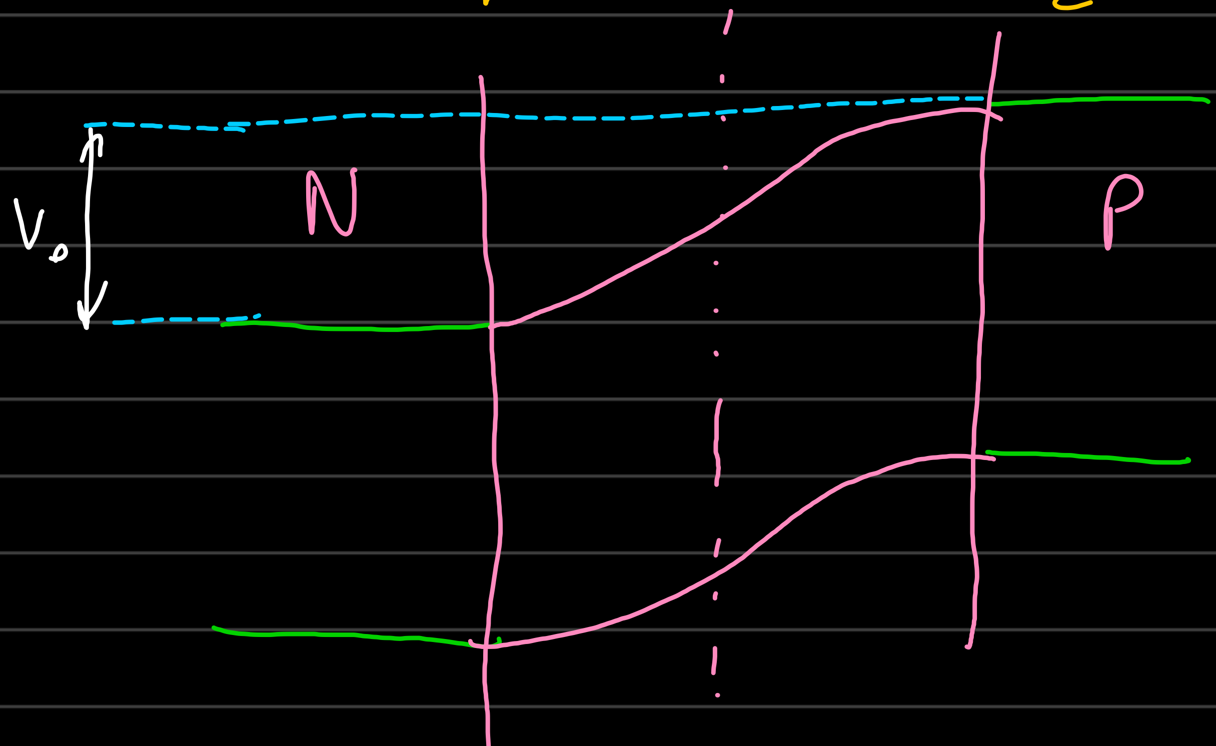


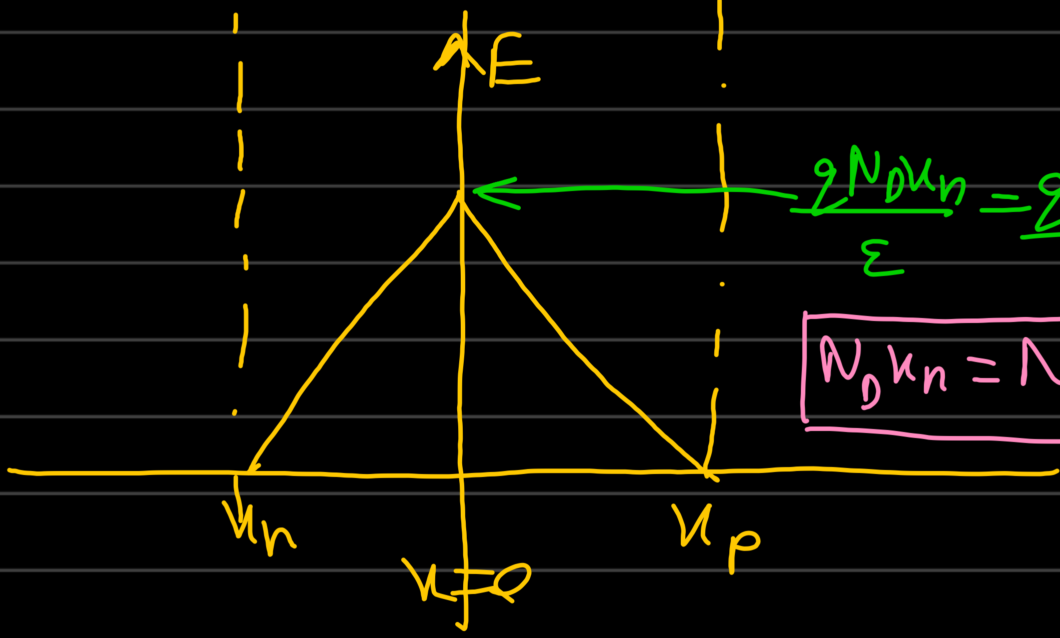
$$\frac{dE}{dx} = \frac{q[N_D]}{\varepsilon}$$

$p = n = 0$ {in depletion width}

$N_A = 0$ {n-type semi conductors}

$$E\Big|_{x=0} = \int_{-x_n}^{0} \frac{qN_D}{\varepsilon}\,dx = \frac{qN_D x_n}{\varepsilon}$$





$$\frac{qN_D x_n}{\varepsilon} = \frac{qN_A x_p}{\varepsilon}$$

$$\boxed{N_D x_n = N_A x_p}$$

Built-in Potential

V_0 = area under curve

$$= \frac{1}{2}\times(x_p+x_n)\times E_{max}$$

$$V_0 = \frac{(x_p+x_n)}{2}\,\frac{qN_D x_n}{\varepsilon}$$

extent of band bending

$$V_0 = \frac{1}{2} w E_{max}$$

$$w = x_p + x_n$$

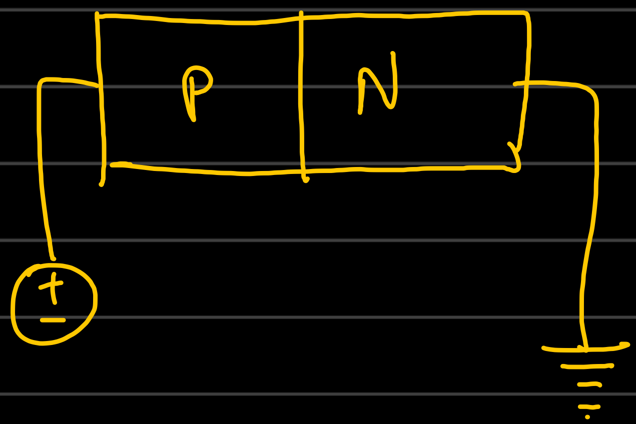
$$E_{max} = \frac{qN_D x_n}{\varepsilon}$$

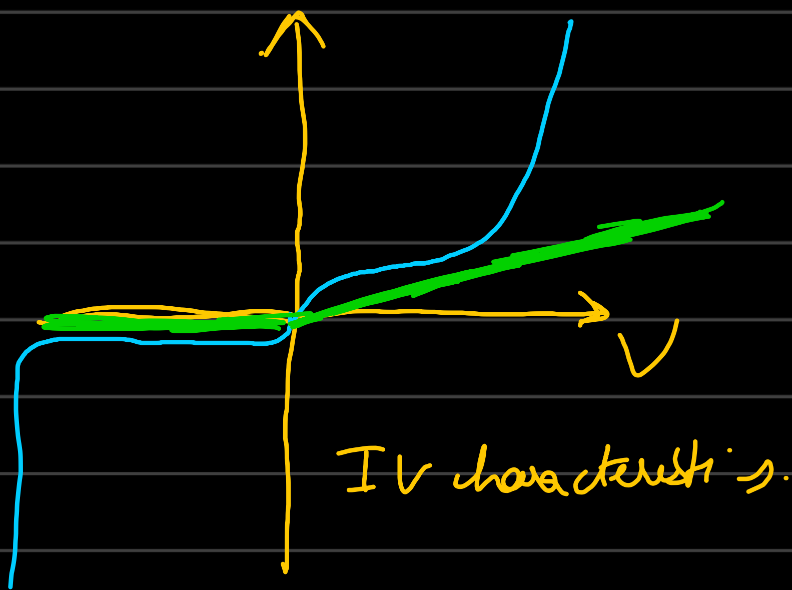
$$N_D x_n = N_A x_p$$

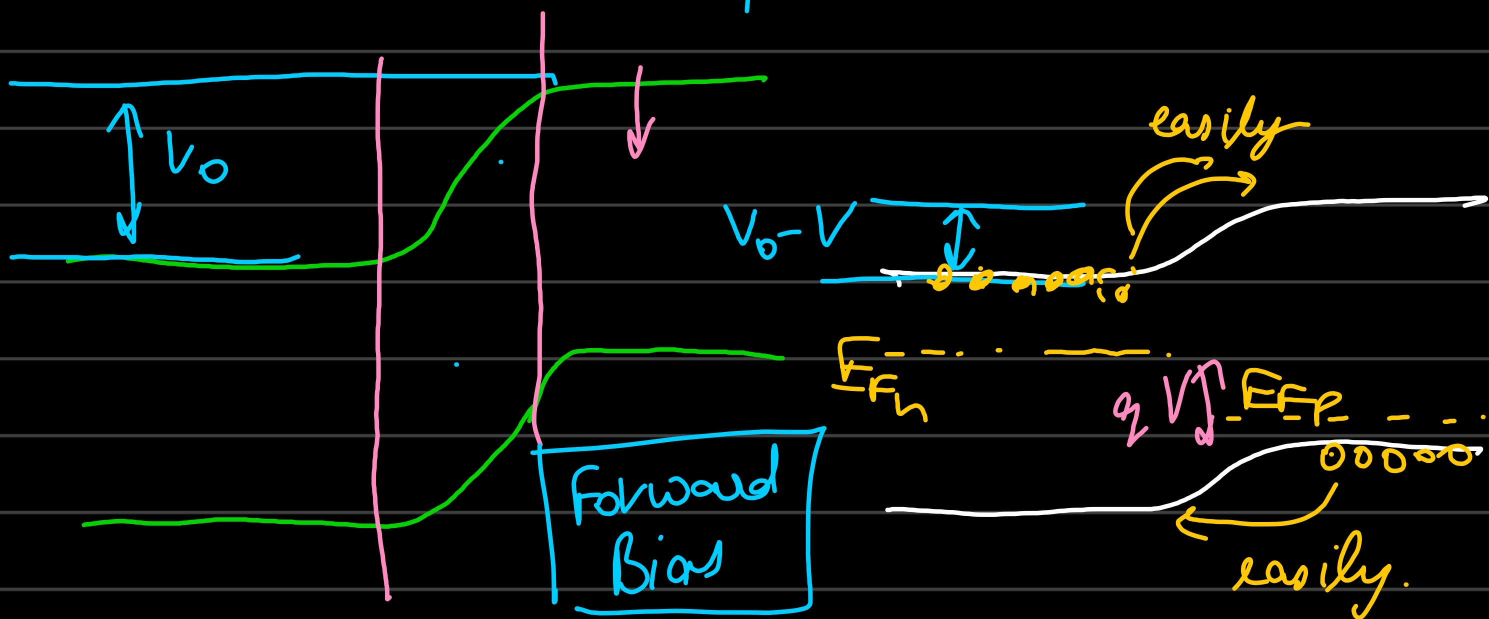
$$\boxed{V_0 = \frac{e N_A N_D w^2}{2\varepsilon(N_A+N_D)}}$$

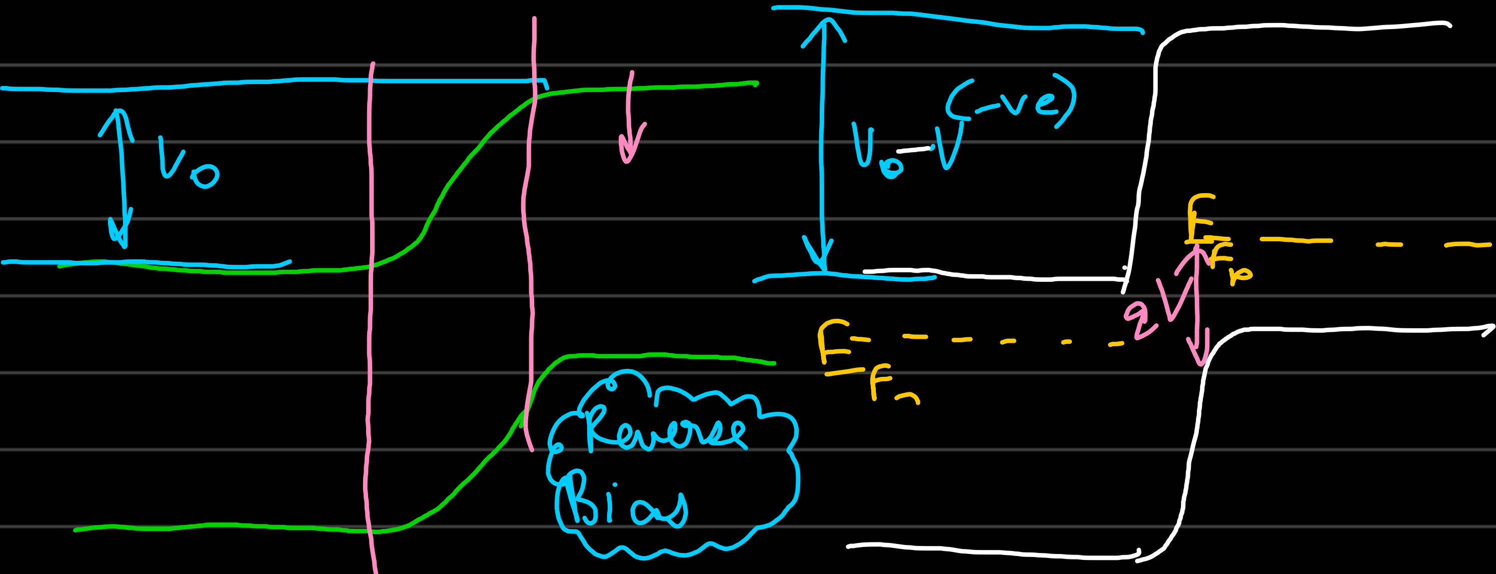
$$I = I_0\left[e^{(\beta V)} - 1\right] \qquad \beta = \frac{q}{kT}$$

I_0: due to diffusion









for $J=0$: $\underbrace{\frac{dE_F}{dx} \neq 0 \quad \frac{\Delta E_F}{\Delta x} \neq 0}$

during junction performance.

$\phi = E_{vac} - E_{Fermi}$ = work func

$\chi = E_{vac} - E_{conduction}$ = Electron affinity.