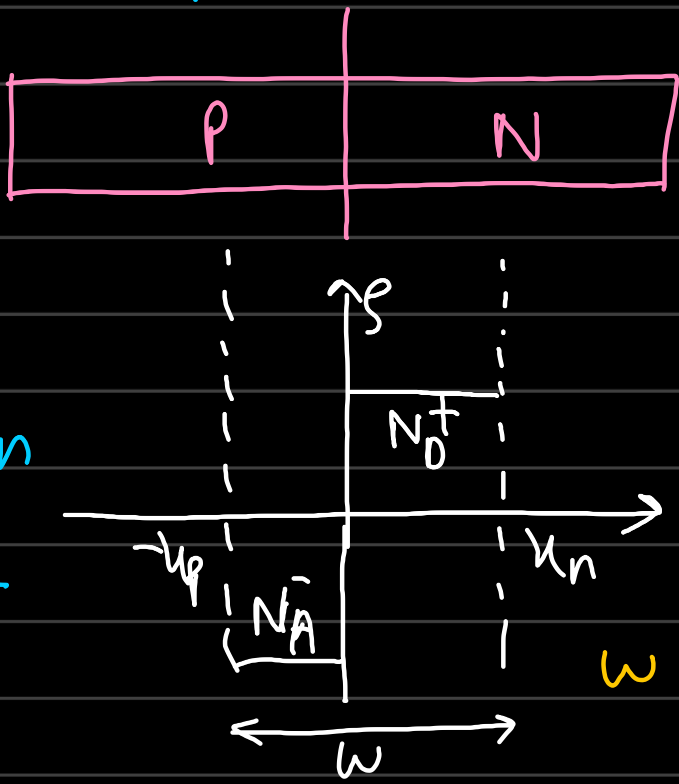
Lecture 20

$$I = I_0\left[e^{qV/kT} - 1\right]$$

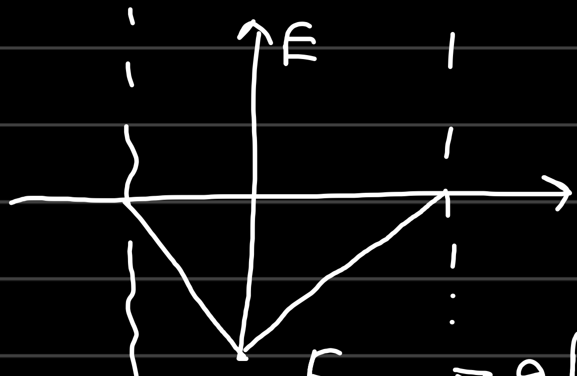


Poisson's Eqn

$$\frac{d^2V}{dx^2} = \frac{\rho}{\epsilon}$$

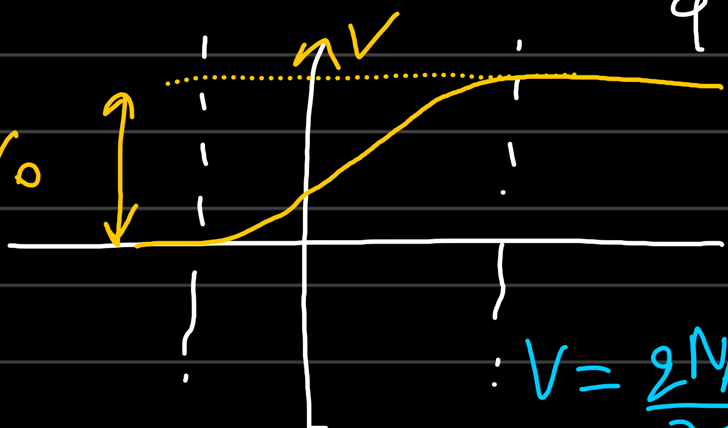
$$w = x_n + x_p$$

$$-\frac{dE}{dx} = \frac{\rho}{\epsilon}$$



$E =$

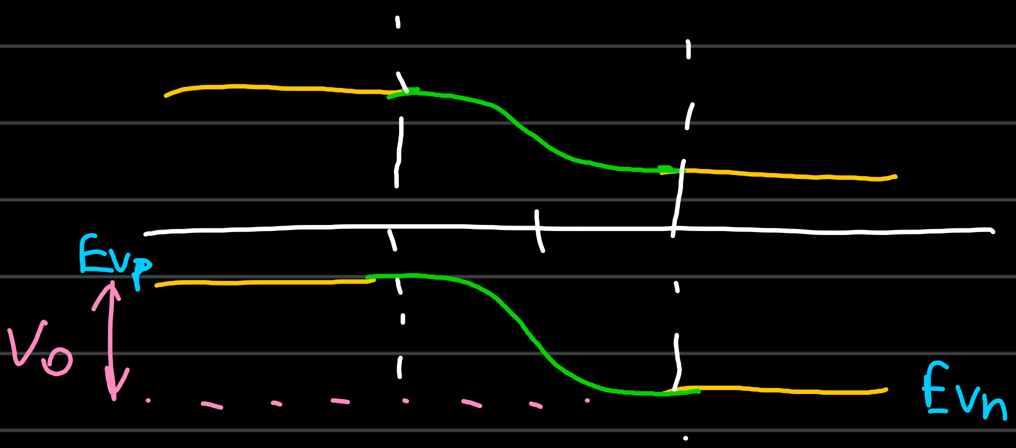
$$E_{max} = \frac{q N_A x_p}{\epsilon} = \frac{q N_D x_n}{\epsilon}$$

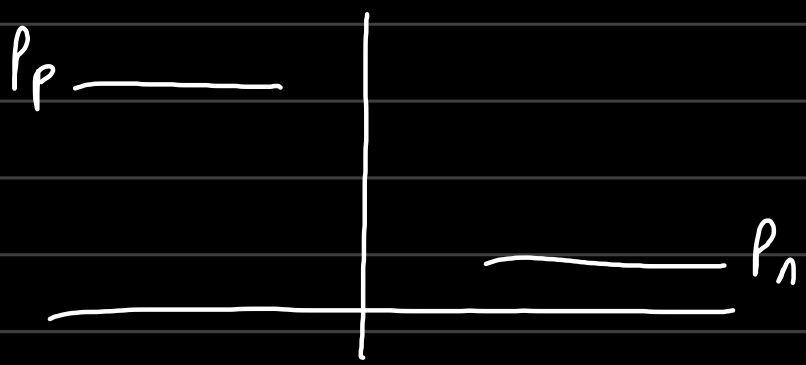


Built-in potential ← V_0

$$V = \frac{q N_A x_p^2}{2\epsilon} = \frac{q N_D x_n^2}{2\epsilon}$$

→ Constant dopant density
→ Fixed rigid depletion.
→ All above formulation at equilibrium.





$$P_p = N_v e^{-[E_f - E_{vp}]\beta} \qquad P_n = N_v e^{-[E_f - E_{vn}]\beta}$$

$$P_n = N_v e^{-[E_f - E_{vp} + V_0]\beta}$$

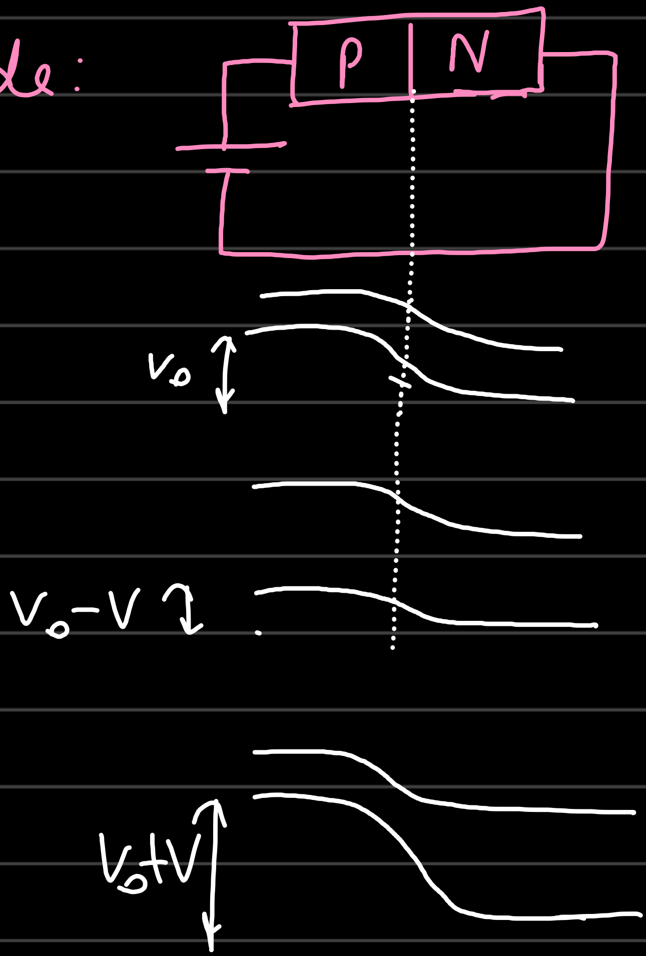
$$P_n = P_p e^{-\beta V_0}$$

$$n_p = n_n e^{-\beta V_0}$$

minority charge carriers

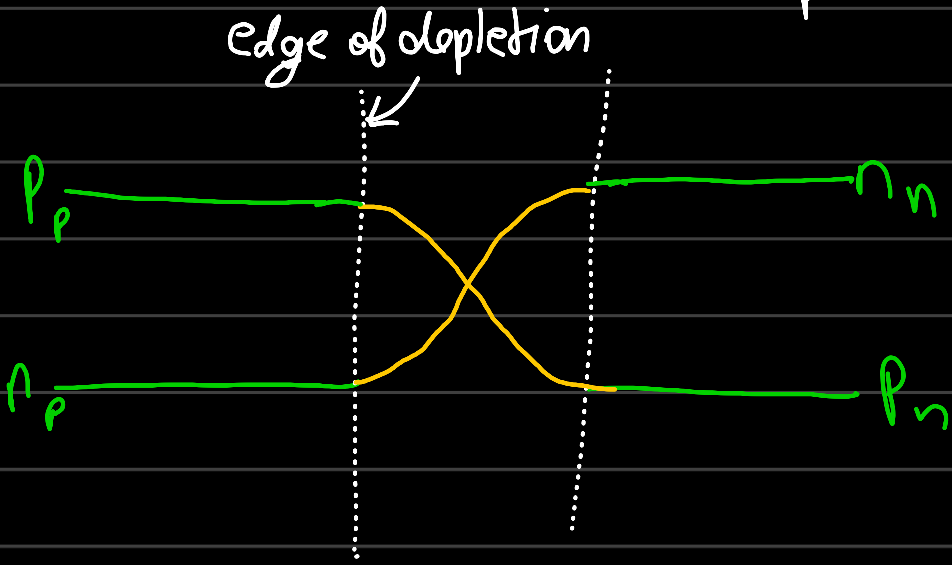
Law of Junctions

Forward bias a diode:



Forward bias

Reverse bias.



$n_p = n_n e^{-\beta V_o}$ @ equilibrium

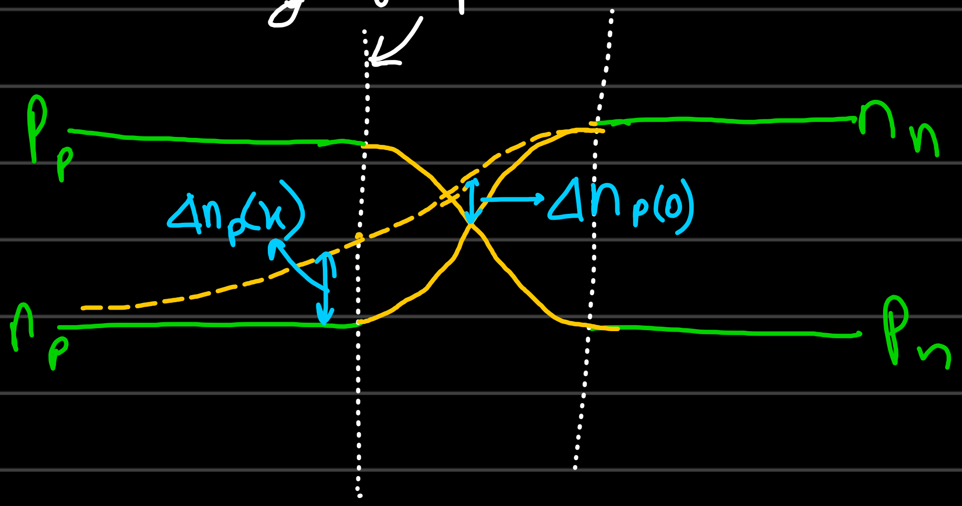
$n_p = n_n e^{-\beta(V_o - V)}$ @ forward bias.

$= n_n e^{-\beta(V_o + V)}$ @ reverse bias.

$$n_p = n_n e^{-\beta V_o} e^{\beta V} = \underline{\underline{n_{p_o} e^{\beta V}}}$$

$$\Delta n_p = \Delta n_{p_0} e^{-x/L_p}$$ → diffusion length.

$$\Delta n_p = n_p - n_p(0)$$



$$n_p(0) = n_n(0)\, e^{-\beta V_p}$$

$$n_p = n_n e^{-\beta(V_0 - V)} = n_p(0)\, e^{\beta V}$$

$$\Delta n_p(x) = \Delta n_p(0)\, e^{-x/L_n}$$

$$J = e D_n \frac{d}{dx} \Delta n_p \qquad \{\text{Fick's Law}\}$$

$$J_n(x) = +\frac{e D_n}{L_n} \Delta n_p(0)\, e^{-x/L_n}$$

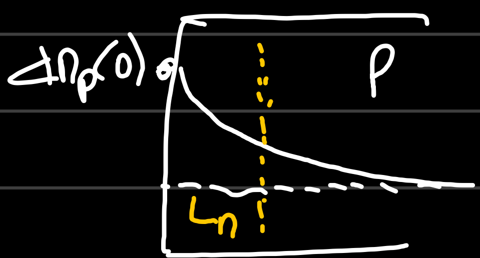
$$J_p(x) = \frac{e D_p}{L_p} \Delta p_n(0)\, e^{-x/L_p}$$

$$J = J_n(0) + J_p(0) = \frac{e D_n}{L_n} \Delta n_p(0) + \frac{e D_p}{L_p} \Delta p_n(0)$$

$$\boxed{J = \frac{eD_n n_{p0}}{L_n}\left(e^{\beta V} - 1\right) + \frac{eD_p p_{n0}}{L_p}\left(e^{\beta V} - 1\right)}$$

Shockley Equation.

"The total current in a p-n junction has to do with diffusion of minority charge carriers from p to n & vice versa".



diffusion length L_n : length at which Δn_p drops by value e.