\[ \frac{dE}{dx} = \frac{\rho}{\epsilon_0} \]

\[ \int_{x_0}^{x} d[\varepsilon E(x')] dx' = \varphi(x) \]

\[ \varphi(x) - \varphi(x_0) = \int_{x_0}^{x} -E(x) \, dx \]

\[ E(x) = -\frac{d\varphi(x)}{dx} \]

\[ \varepsilon \frac{d^2\varphi(x)}{dx^2} = \frac{dE(x)}{dx} = -\frac{\rho(x)}{\varepsilon} \]

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**Surface Charge and Electric Field**

Dept. of EECS 7

University of California at Berkeley
pn Junction

- Present in most IC structures
Junction in Thermal Equilibrium

- Mobile electrons and holes can cross junction (huge concentration difference)
- Process creates balanced +/- charge layers because the donors and acceptors are "stuck" in the lattice and can't move
- Limiting state with $V_D = 0$ V $\rightarrow$ thermal equilibrium
- "Built-in voltage" is about 1 V
\[ Q_p = 2Xdp \cdot Na \]
\[ Q_n = 2Xd_n \cdot Nd \]

\[ Xdp \cdot Na = Xdn \cdot Nd = \]

\[ \frac{Xdp}{Xd_n} = \frac{Nd}{Na} \]