ECE 137A Quiz #1 Solution
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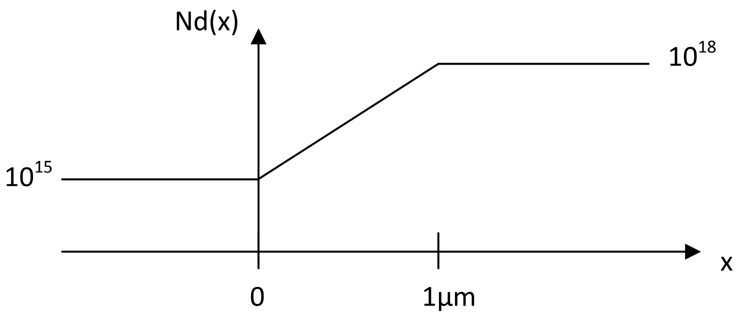
Given doping profile



Assuming that n(x) = Nd(x). Initially, because of the charge gradient, carriers diffuse from right to left, leaving behind positively charged ions. This in turn establishes an electric field E(x), which tends to pull charges back in the form of a drift current. Under equilibrium, no net current flows inside the semiconductor, hence diffusion current equals drift current.

$$I_{diff} + I_{drift} = 0$$

$$-qD_n \frac{dn(x)}{dx} = q\mu_n n(x) E(x)$$

$$So\ E(x) = -\frac{D_n}{\mu_n}\frac{1}{n(x)}\frac{dn(x)}{dx}$$

$$n(x) = Nd(x) = \begin{cases} 10^{15}\ cm^{-3}, & x < 0 \\ 10^{\left(15+\frac{3x}{\mu m}\right)} cm^{-3}, & 0 \le x \le 1um \\ 10^{18}\ cm^{-3}, & x > 1um \end{cases}$$

$$x < 0: \quad E(x) = 0$$

$$x > 1\mu m: \quad E(x) = 0$$

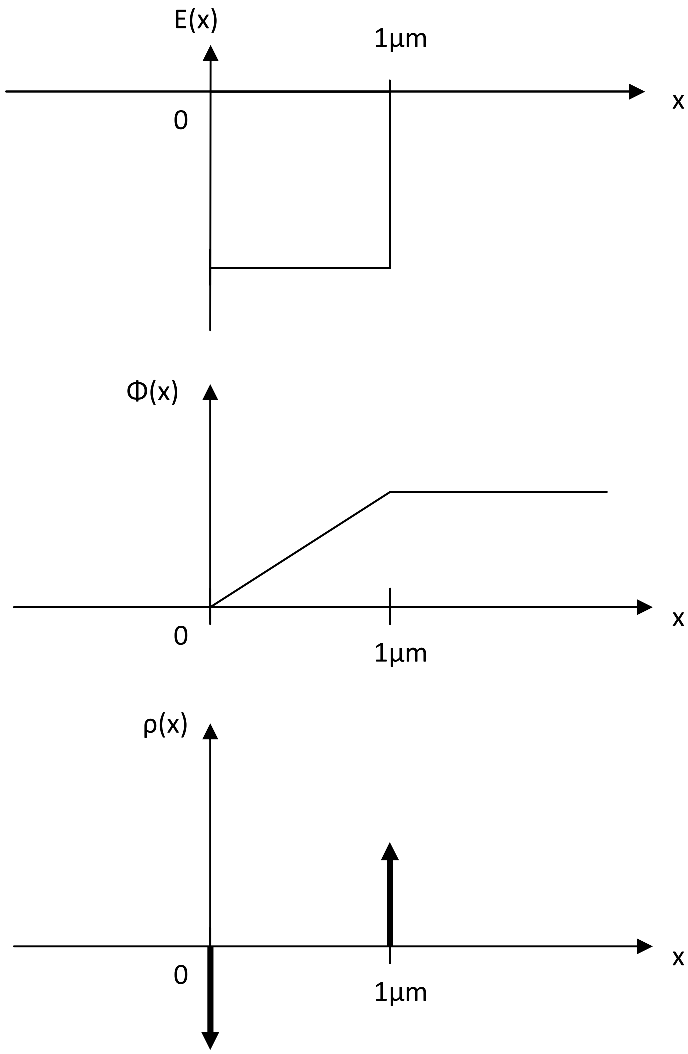
$$0 \le x \le 1\mu m: \quad E(x) = -\frac{D_n}{\mu_n}\frac{1}{10^{\left(15+\frac{3x}{\mu m}\right)}}\frac{d\left(10^{\left(15+\frac{3x}{\mu m}\right)}\right)}{dx}$$

$$E(x) = -\frac{kT}{q}\frac{1}{10^{\left(15+\frac{3x}{\mu m}\right)}} \cdot 3\ln(10) \cdot 10^{\left(15+\frac{3x}{\mu m}\right)}$$

$$E(x) = -3\ln(10)\frac{kT}{q}$$

$$\rho(x) = \epsilon\frac{dE(x)}{dx} \quad (Charge)$$

$$\Phi(x) = -\int E(x)dx \ \ (Potential)$$


E(x)
1μm
x
0
Φ(x)
x
0
1μm
ρ(x)
x
0
1μm