Elementary charge

$q_e := 1.602 \cdot 10^{-19}\ C$

Try to not using e because it's reserved as Euler number

For Si: $n_i = 1.5 * 10^{10} \frac{1}{cm^3}$, $\epsilon_r = 11.9$.

Vacuum permittivity

$\varepsilon_0 := 8.854 \cdot 10^{-12}\ \frac{F}{m}$

$ni := 1.5 \cdot 10^{10} \cdot \frac{1}{cm^3}$

$\varepsilon_r := 11.9$

Doping concentration on P-side

$Na := 8 \cdot 10^{15} \cdot \frac{1}{cm^3}$

Temperature :

$T := 300\ K$

Doping concentration on N-side

$Nd := 2 \cdot 10^{16} \cdot \frac{1}{cm^3}$

Boltzmann constant :

$kb := 1.38 \cdot 10^{-23}\ \frac{J}{K}$

SMath built in constants:

$\varepsilon_0 = 8.85418781762039 \cdot 10^{-12}\ \frac{F}{m}$

$k = 1.3807 \cdot 10^{-23}\ \frac{J}{K}$

Permittivity :

$\varepsilon := \varepsilon_0 \cdot \varepsilon_r = 1.0536 \cdot 10^{-10}\ \frac{F}{m}$

Built-in voltage, contact potential:

$$Vbi := \frac{kb \cdot T}{q_e} \cdot \ln\left(\frac{Nd \cdot Na}{ni^2}\right) = 0.7052\ V$$

Depletion width (no external bias)

$$W := \sqrt{\frac{2 \cdot \varepsilon \cdot (Nd + Na) \cdot Vbi}{q_e \cdot Nd \cdot Na}} = 4.0291872 \cdot 10^{-7}\ m$$

Depletion width in the p-region:

$$Wp := \frac{Nd \cdot W}{Nd + Na} = 2.8779908 \cdot 10^{-7}\ m$$

Depletion width in the n-region:

$$Wn := \frac{Na \cdot W}{Na + Nd} = 1.1511963 \cdot 10^{-7}\ m$$

From this point on, I don't know how to proceed.

$l := 0$ On figure 4, this is point x=0

Equation given:

$$\frac{d^2}{d x^2} y + \frac{Pnet}{qe \cdot e0} = 0$$

Boundary condition:

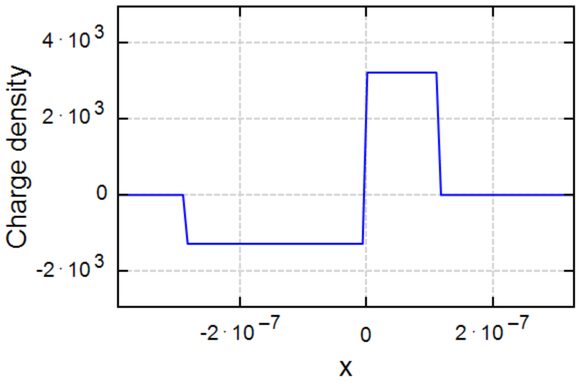
$$E = \frac{1}{\varepsilon} \cdot \int_{-Wp}^{Wn} \rho \, d x$$

$$Vo := \frac{q_e}{2 \cdot \varepsilon} \cdot (Wp + Wn)^2 \cdot \frac{Na \cdot Nd}{Na + Nd} = 0.7052\ \mathrm{V}$$

this is Vbi

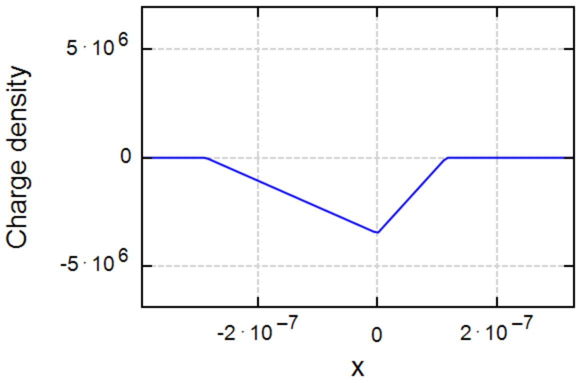
Charge density, electric field an potential

$$\rho(x) := \begin{cases} -q_e \cdot Na & \text{if} \quad -Wp < x < 0 \\ q_e \cdot Nd & \text{if} \quad 0 < x < Wn \\ 0 & \text{otherwise} \end{cases}$$



$\rho(x\ \mathrm{m})$

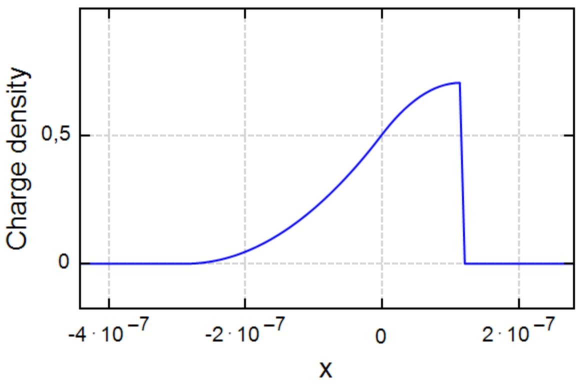
$$E(x) := \begin{cases} -\frac{q_e \cdot Na}{\varepsilon} \cdot (x + Wp) & \text{if} \quad -Wp < x < 0 \\ \frac{q_e \cdot Nd}{\varepsilon} \cdot (x - Wn) & \text{if} \quad 0 < x < Wn \\ 0 & \text{otherwise} \end{cases}$$



$E(x\ \mathrm{m})$

Here, I've removed the minus sign

$$V(x) := \begin{cases} \frac{q_e \cdot Na}{2 \cdot \varepsilon} \cdot (x + Wp)^2 & \text{if} \quad -Wp < x < 0 \\ Vbi - \frac{q_e \cdot Nd}{2 \cdot \varepsilon} \cdot (x - Wn)^2 & \text{if} \quad 0 < x < Wn \\ 0 & \text{otherwise} \end{cases}$$



$V(x\ \mathrm{m})$

Dimensions check:

$$\rho(1\ \mathrm{nm}) = 3204\ \frac{\mathrm{C}}{\mathrm{m}^3}$$

$$E(1\ \mathrm{nm}) = -3470294.9972\ \frac{\mathrm{V}}{\mathrm{m}}$$

$$V(1\ \mathrm{nm}) = 0.5072\ \mathrm{V}$$