Homework #1 - February 16, 2001

Due: February 23, 2001 at recitation
(late homework will not be accepted)

Please write your recitation session time on your problem set solution.

1. *[25 points]* Consider an n-Si sample with a resistivity of 0.1 $\Omega \cdot cm$. The doping level is uniform throughout. In a certain portion of this sample, there is an electric field of a magnitude 1000 V/cm. Estimate the magnitude of:

a) *[5 points]* the electron drift velocity,

b) *[5 points]* the hole drift velocity,

c) *[5 points]* the electron drift current density,

d) *[5 points]* the hole drift current density,

e) *[5 points]* the total drift current density.

2. *[15 points]* In a certain region of a semiconductor characterized by $0 \leq x\ (\mu m) \leq 1$, there is an electron concentration that follows a profile:

$$n(x) = 10^{17}(1 + 10^5 x)\ cm^{-3} \qquad \text{with } x \text{ in } cm$$

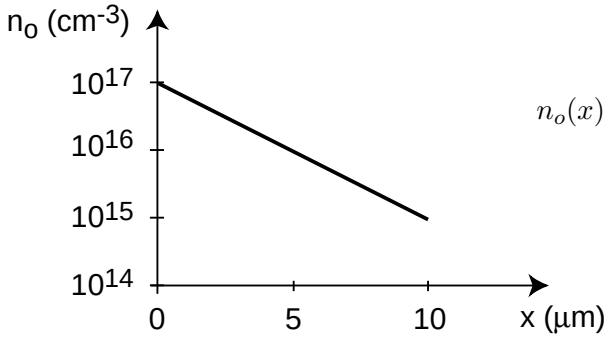
Assume an electron diffusion coefficient of 10 cm^2/s. Derive analytical expressions and sketch from $x = 0$ to $x = 1\ \mu m$:

a) *[5 points]* the electron diffusion flux,

b) *[5 points]* the electron diffusion current density,

c) *[5 points]* the electron diffusion velocity.

3. *[30 points]* Consider a piece of n-type Si in thermal equilibrium at room temperature. In a region defined by $0 \leq x\ (\mu m) \leq 10$, there is a spatially varying electron concentration as sketched below.



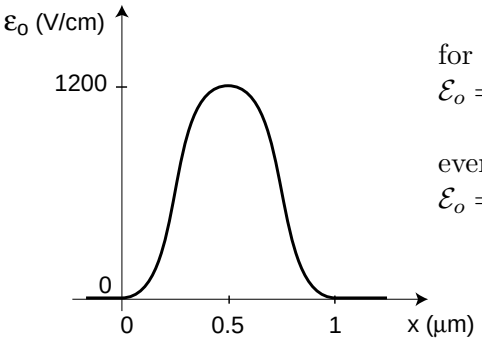
$n_o(x) = 10^{17} \times 10^{-2\times 10^3 x}\ cm^{-3}$ with x in cm

a) *[10 points]* Derive an analytical equation for the minority carrier concentration in space. *Quantitatively* sketch the result in a suitable diagram.

b) *[10 points]* Derive an analytical equation for the electrostatic potential in space. *Quantitatively* sketch the result in a suitable diagram.

c) *[10 points]* Derive an analytical equation for the electric field in space. *Quantitatively* sketch the result in a suitable diagram.

4. *[30 points]* In a certain region of n-type Silicon in thermal equilibrium at room temperature, there is an electric field distribution in space as sketched below.



for $0 < x < 1\ \mu m$:
$\mathcal{E}_o = 600\{1 + \cos[10^4\pi(2x - 10^{-4})]\}\ V/cm$ with x in cm

everywhere else:
$\mathcal{E}_o = 0$

a) *[10 points]* Derive an analytical expression and sketch the electrostatic potential distribution in this region.

b) *[10 points]* Derive an analytical expression and sketch the net volume charge density in this region.

c) *[5 points]* If you are told that the equilibrium electron concentration at $x = 0$ is $n_o = 10^{17}\ cm^{-3}$, compute the equilibrium electron and hole concentrations at $x = 1\ \mu m$?

d) *[5 points]* Can this region be considered quasi-neutral?