Assignment 2

Useful information

- Poisson equation for a pn junction diode with depletion approximation:

  $\nabla^2 V(x) = -\frac{\rho(x)}{\epsilon_s}$, for $-x_p \leq x \leq x_n$

  Where,

  Abrupt junction $\rho(x) = \ qN_A \quad for -x_p \leq x \leq 0$

  $\qquad\qquad\qquad\quad = -qN_D \quad for\ 0 \leq x \leq x_n$

  Linearly graded $\rho(x) = -\frac{qx}{W}\left(N_D(x = x_n) - N_A\left(x = -x_p\right)\right),\ W = x_n + x_p$

- Gauss Law for the electric field in pn junction diode:

  $E(x) = \int \frac{\rho(x)}{\epsilon_s}\, dx$, for $-x_p \leq x \leq x_n$

- Charge neutrality equation:

  $N_D^+ - N_A^- = n - p$

  Where N_D^+ and N_A^- are the partially ionized donor and acceptor concentrations.

Consider these typical values for the following parameters

$N_D = 1e16\ cm^{-3}, N_A = 1e16\ cm^{-3}, T = 300K, N_c = 2.75e19\ cm^{-3}, N_v = 2e19\ cm^{-3}, E_g = 1.1eV$

Question 1.

Solve the following for abrupt and linearly graded pn junction diode.

(a) Plot the Electric field profile by solving the Gauss Law using numerical integration techniques such as Trapezoidal or Simpson's methods. Compare the result with the inbuilt MATLAB functions for integration. Check the accuracy of numerically integrated results by varying the grid spacing.

(b) Use central difference discretization scheme i.e.

$$\nabla^2 V_i = (V_{i-1} - 2V_i + V_{i+1})/h^2$$

to solve the Poisson equation with depletion approximation. For this calculation first compute the L and U matrices numerically. Use these matrices to solve the system of linear equations $[A]_{n\times n}[V]_{n\times 1} = [b]_{n\times 1}$ using LU decomposition method and compare the result with inbuilt MATLAB operator $A\backslash b$.

Question 2.

Consider a compensated semiconductor bar with doping concentrations $N_D = 1e16\ cm^{-3}, and\ N_A = 2e15\ cm^{-3}$. Use Newton Raphson method to solve the charge neutrality equation for finding the fermi energy E_F.