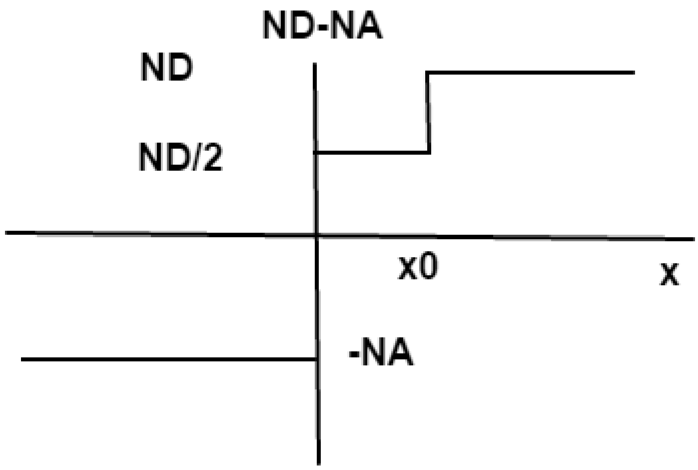
EE 207: Assignment 3

Submission deadline: 11:55 PM on 14th October, 2018 (Sunday)
Submission mode: Online Moodle interface.

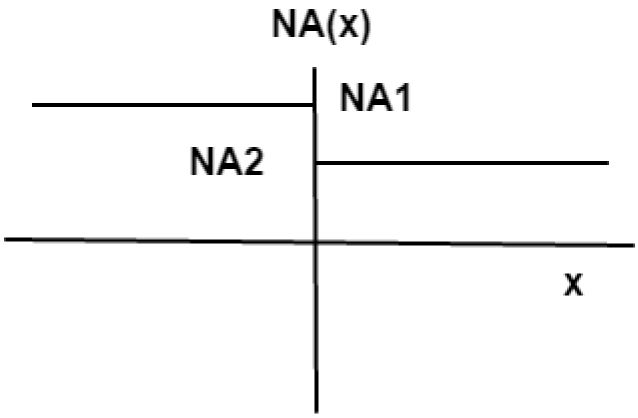
PN Junction Diode

1. A p-n junction has a doping profile shown, make assumption that xn>x0 (xn is the depletion width in n region) for all applied biases of interest.



(a) What is the built-in potential across the junction? Justify your answer. **(2 Marks)**
(b) Invoking the depletion approximation, sketch the charge density versus x inside the diode. **(2 Marks)**
(c) Obtain an analytical solution for the electric field, inside the depletion region. **(2 Marks)**

2. Consider a p1-p2 "isotype" step junction shown



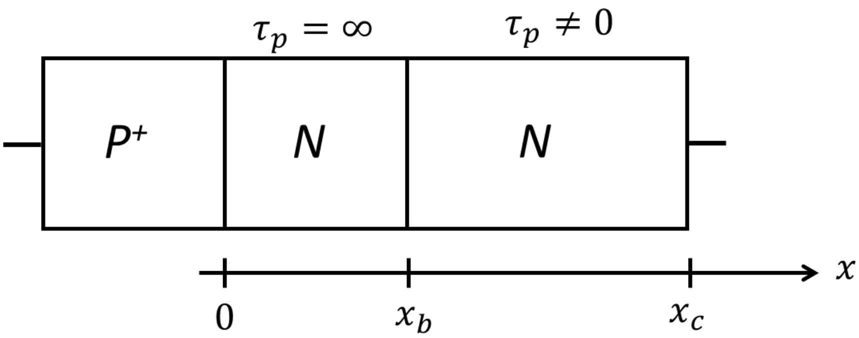
(a) Draw the equilibrium energy band diagram for the junction, taking doping to be non - degenerate and NA1>NA2. **(1 Marks)**
(b) Derive an expression for the built – in voltage that exists across the junction under the equilibrium condition. **(2 Marks)**
(c) Make rough sketches of potential, electric field, charge density. **(3 Marks)**

3. Consider an ideal p^+-*n* step junction diode where incident light is uniformly absorbed throughout the device producing a photogeneration rate of G_L electron-hole pairs per cm^3-sec. Assume that low-level injection prevails.

(a) What is the excess minority carrier concentration on the *n*-side a large distance ($x \to \infty$) from the metallurgical junction. [$\Delta p(x \to \infty) \neq 0$.] **(2 Marks)**

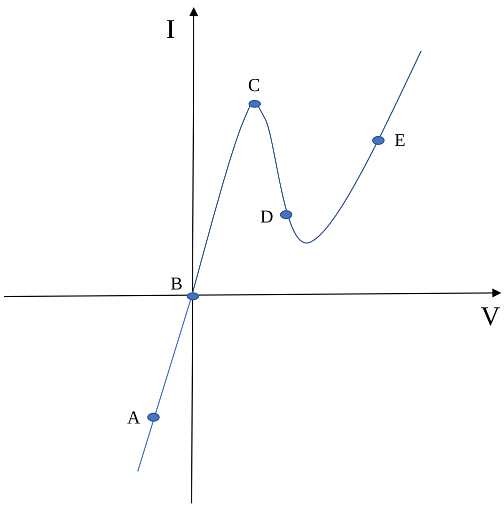
(b) The usual ideal diode boundary conditions (Eq. 1) still hold at the edges of the depletion region. Using the revised boundary condition established in part (a) and Eq. 1, derive an expression for the *I-V* characteristic of the p^+-n diode under the stated conditions of illumination. As in the derivation of the ideal diode equation, ignore all recombination-generation, including photogeneration, occurring in the depletion region. **(3 Marks)**

4. Consider the special silicon p^+-n junction shown in the figure below.



Take τ_p to be nonzero but sufficiently small so that $L_p \ll x_c - x_b$. Assuming the depletion width (W) never exceeds x_b for all biases of interest, and excluding biases that would cause high-level injection or breakdown, derive an expression for the room temperature *I-V* characteristic of the diode. **(4 Marks)**

5. Draw the band diagrams for the points indicated on the I-V characteristics of an Esaki diode. **(5 Marks)**



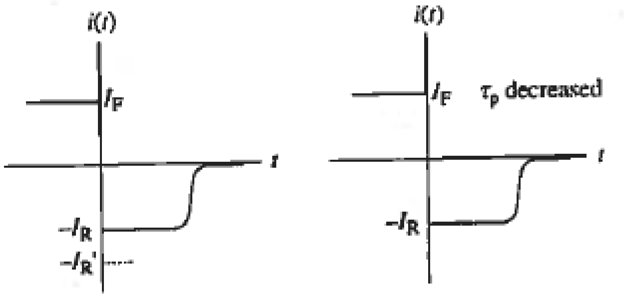
6. An n^+-p diode gives the following relation w.r.t its junction capacitance. Determine the p doping and the built-in voltage of the diode. A = 3.72 x 10^{-3} cm^2. **(2 Marks)**

$$\frac{1}{C_j^2} = (6.89 \times 10^{19}) - (9.78 \times 10^{19})V_A.$$

7. Qualitatively predict the effect of **(2 Marks)**

(i) an increased I_F
(ii) a reduced τ_p

on pn junction diode's $i - t$ transient. Sketch the expected modification using a dashed line.



8. Consider an ideal n⁺p abrupt pn junction diode with uniform doping N_d, N_a. The diode was carrying a steady-state forward current $I_F = I_0\left(e^{\frac{qV_F}{KT}} - 1\right) \sim I_0 e^{\frac{qV_F}{KT}}$. Here, V_F is the voltage drop across the junction. The supply voltage is suddenly switched off at $t = 0$. Calculate the voltage transient $v(t)$ across the diode for $t > 0$. Assume that the decay of stored charge is quasi-static. Let the electron and hole parameters be – mobility: μ_n, μ_p, minority carrier lifetime: τ_n, τ_p. **(5 Marks)**