ELEC 315 - Assignment 3 **Due Dec. 5, 2025**
Winter 2025-26 Term 1

1. An abrupt Si PN junction with an area of 1 mm^2 has a constant donor density of N_D = 10^{15} cm^{-3} and an acceptor density of N_A = 10^{17} cm^{-3}, and the lifetime of minority electrons is τ_n = 1 ns and that of minority holes is τ_n = 0.2 ns (n_i = 10^{10} cm^{-3} and $\mu_n = 2 \times \mu_p$ =1000 cm^2/Vs at room temperature). Assume that the thickness of both n-type and p-type regions are 10 μm.

(a) What are the Fermi levels E_{Fp} and E_{Fn} for the p and n regions with respect to the middle of the band gap (E_i) at room temperature?
(b) Draw the junction band diagram for the PN junction at the equilibrium condition.
(c) Find the built-in potential V_0, the maximum electric field E_0, and the depletion width W_0 at equilibrium (dielectric constant of silicon is ε_{Si} = 11.7 ε_0 F/cm).
(d) Find the forward current and the depletion width at V = 0.5 V. Draw the band diagram for this applied voltage. Find the storage capacitance associated to both neutral n and p regions at this bias voltage.
(e) Calculate the reverse current and the depletion width at V = -0.5 V. Draw the junction band diagram for this applied voltage. Find the junction capacitance.
(f) If the breakdown field is 0.4 MV/cm, at what reverse voltage does the junction breaks down?

2. Using nanoHub PN junction simulation (https://nanohub.org/tools/pnjunctionlab), draw graphs for the PN Junction of question 1 showing:

(a) At equilibrium: Band diagram, potential, electric field and electron and hole densities.
(b) For positive voltages of 0.3 and 0.5 V: Band diagram, electric field, electron and hole currents, excess carrier densities, and recombination rate as a function of location in the junction.
(c) Plot similar graphs for negative voltages up to -0.3, and -0.5 V.
(d) Plot current-voltage and capacitance-voltage characteristics from -0.5 to 0.5 V.
(e) In each section, comment on the differences that you observe in your NanoHUB simulation vs calculations that you made in question 1 and explain the reason behind the observed differences in the simulation and your initial model.