1. [30 points] Below is a sketch not to scale of the minority carrier distribution across the quasi-neutral regions of a forward-biased p-n diode. For this diode, $W_p - x_p = 4 \, \mu m$, $W_n - x_n = 3 \, \mu m$, $D_n = 25 \, cm^2/s$, and $D_p = 10 \, cm^2/s$. The area of the junction is $10 \, \mu m^2$.

a) [5 points] Calculate the hole current injected into the n-side of the diode.

b) [5 points] Calculate the electron current injected into the p-side of the diode.

c) [5 points] Calculate the diffusion capacitance associated with carrier storage on the n-side of the diode.

d) [5 points] Calculate the diffusion capacitance associated with carrier storage on the p-side of the diode.

e) [5 points] How much should the voltage across the junction increase if we wish to double the total current through the diode?

f) [5 points] If we increase the voltage in the manner suggested in the previous question, what happens to the total diffusion capacitance of the diode?

g) [5 points] What is the ratio of the doping levels across the junction: $N_a/N_d$?
h) [5 points] In what direction should $N_a/N_d$ change if we wish to redesign the diode so as to get less diffusion capacitance at the same current level? (Assume that in redesigning the diode $D_n, D_p, W_n - x_n,$ and $W_p - x_p$ do not change).

Choose one: $N_a/N_d$ must increase. $N_a/N_d$ must decrease. Explain.

2. [40 points] Consider an abrupt asymmetric n$^+$-p junction diode with a junction area of $100 \mu m^2$. All the action in this device is dominated by the lowly-doped p-type region.

Due to processing reasons, the diffusion coefficient of holes across the quasi-neutral p-type region is not uniform. It suddenly changes half way down the n-QNR at location $x_1$. As a result, at a current level of 400 $\mu A$, the excess minority concentration in the quasi-neutral p-type region has a distribution as sketched below:

At this bias point:

a) Estimate the electron diffusion coefficient in both portions of the quasi-neutral region.

b) Estimate the total amount of excess minority carrier charge in the diode.

c) Estimate the diffusion capacitance of the diode.

d) Estimate the electron diffusion velocity at $x_1^-$ and $x_1^+$.

3. [30 points] Problem P6.14 of Howe & Sodini. Add one more part to this problem:

c) Plot the conductance of this diode as a function of the applied bias over this voltage range.