1) Consider an abrupt $p$-$n$ junction with $N_a = 5 \times 10^{17}$ cm$^{-3}$ and $N_d = 10^{16}$ cm$^{-3}$ at room temperature.
   a. Find the ratio of the depletion region width on the $n$-side, $x_n$, to the width on the $p$-side, $x_p$.
   b. Find the total width of the depletion layer (in microns).
   c. Find the maximum electric field in this junction for applied biases of (i) $V_A=0$ and (ii) $V_A=-12$V.
   d. The breakdown electric field in moderately doped silicon is approximately $5 \times 10^5$ V/cm. At what reverse bias will the field reach this value, and what will the depletion region width be at that bias?

2) Data from a measurement of the small-signal capacitance of a silicon $p^+$$-n$ diode structure as a function of bias voltage is plotted below in the form $1/C_{dep}^2$ versus $V_{ab}$. The area of the junction is $10^{-5}$ cm$^2$.
   a. What is the built-in potential of this junction?
   b. What is the doping level of the more lightly doped side ($n$-side) of this diode in the vicinity of the junction?
   c. What is the doping level of the more heavily doped side?
   d. At some distance from the junction the doping level changes.
      i. At what distance does the change occur?
      ii. Does the doping level increase or decrease at this point, and what does it become?
   e. Suppose that in addition to the above structure there is a very heavily doped $n^+$-region 3 µm from the junction. How would you expect the plot of $1/C_{dep}^2$ versus $V_{ab}$ to look in this case?

3) The short-circuited, symmetrically doped p-n diode shown below is illuminated by a distributed source that generates $g(x) = g_0 \sin \left( \frac{2 \pi x}{w_n} \right)$ hole-electron pairs/cm$^3$ in the region $0 \leq x \leq w_n$. You may assume: low level injection, $w_n \ll L_h, w_p \ll L_e$, $\mu_e = 4 \mu_h$, $N_d = N_a$. Label sketches of the following over the range $-w_p \leq x \leq w_n$.
   a. $n'(x)$
   b. $J_e(x)$

---

http://www.ece.umd.edu/~pabshire/enee312h.htm
due Thursday, March 7, 2002
c. \( J_h(x) \)

d. Find the total short-circuit current of the diode.

4) – 7) Complete Sedra & Smith problems 3.47, 3.69, 3.71, 3.101

Design Question:
A photodiode has reverse saturation current \( I_S = 1 \text{pA} \). Upon illumination the short circuit reverse saturation current increases to about \( 1 \text{nA} \). Compute the optimum load so that maximum power is delivered from the diode.