http://www.ece.umd.edu/~pabshire/enee312h.htm due Thursday, March 7, 2002

1) Consider an abrupt *p*-*n* junction with $N_a = 5\text{x}10^{17}$ 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=-12V.
   d. The breakdown electric field in moderately doped silicon is approximately $5\text{x}10^5$ 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?

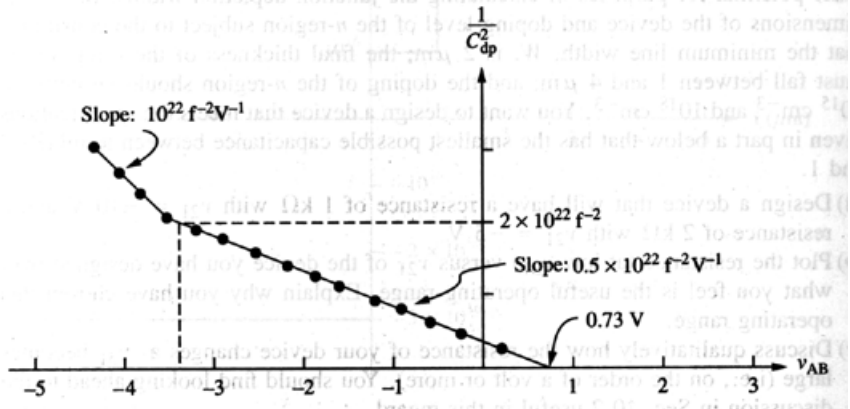

FIGURE P7.5

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

c. $J_h(x)$

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

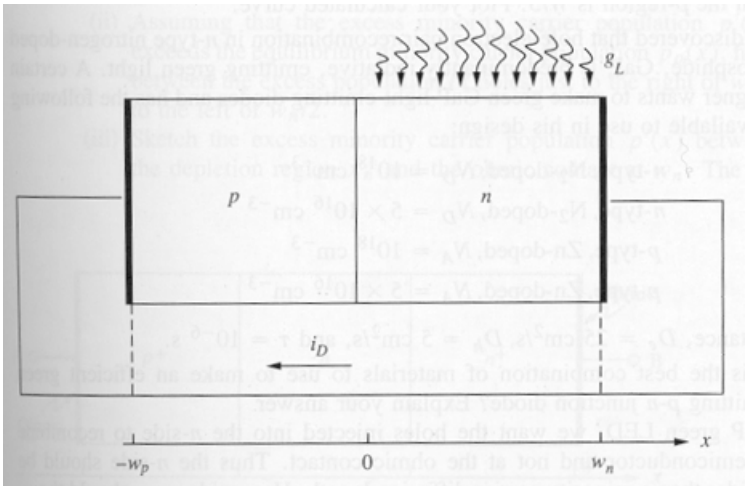

FIGURE P7.10

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

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