ECE 3040 Fall, 2000
Homework 3
Due Tuesday, September 19, 2000
Be sure to show all of your work!!!

1. A silicon sample with \( n_0 = 10^{17} \text{cm}^{-3} \) is optically excited by a laser which creates \( 10^{18} \text{EHP/cm}^3 \) every 1 ms. The sample has a carrier lifetime of \( \tau_n = \tau_p = 10 \mu\text{s} \).
   (a) What are the majority and minority carrier concentrations before the light is incident upon the sample?
   (b) What are the maximum majority and minority concentration after the light is incident upon the sample?
   (c) What is the maximum change in conductivity of the sample due to optical generation?
   (d) What is the maximum change in resistivity of the sample due to optical generation?

2. A 3 mW He:Ne laser (\( \lambda = 633 \text{ nm} \)) is incident upon a sample of GaAs with doping \( N_d = 10^{17} \text{cm}^{-3} \). The illuminated area is 1 cm X 1 cm.
   (a) Is this wavelength absorbed by the GaAs?
   (b) Assuming that the absorption coefficient of this wavelength of light is \( 10^4 \text{ cm}^{-1} \), and that the GaAs sample is 3 \( \mu \text{m} \) thick, how many excess carriers per second are created in the GaAs?
   (c) The minority carrier lifetime for GaAs is 10 ns. What is the steady state excess carrier concentration generated by the incident light?
   (d) What is the change in conductivity caused by the laser?
   If the laser is turned off at time \( t=0 \), what is the excess carrier concentration at:
   (e) time \( t=5 \text{ ns} \)?
   (f) time \( t=10 \text{ ns} \)?
   (g) time \( t=30 \text{ ns} \)?
   (h) time \( t=100 \text{ ns} \)?

3. Assume that an abrupt Si pn junction with area \( 10^{-4} \text{ cm}^2 \) has \( N_{a}=10^{17} \text{ cm}^{-3} \) on the p side and \( N_d=3 \times 10^{17} \text{ cm}^{-3} \) on the n side.
   (a) What is the built-in potential?
   (b) What is the depletion layer width?
   (c) What is the maximum electric field in the diode?

4. An abrupt Si pn junction has been doped \( N_a = 10^{17} \text{ cm}^{-3} \) on the p side of the junction and \( N_d = 10^{18} \text{ cm}^{-3} \) on the n side. You do not need to compute the numerical values for this questions, but draw to scale the diagrams.
   (a) Draw the band diagram, carefully showing the depletion region in both the p and n sides, and the built-in potential.
   (b) Draw, to scale, the ionized charge densities as a function position in the device.
   (c) Draw, to scale, the electric field as a function of position in the device.