EE 471: Transport Phenomena in Solid State Devices

HW 2

Due: 2/16/18

Please show all working (including equations you use to calculate your answers).

All numerical answers should include units

Calculate numerical answers to 3 sig. figs.

1. A silicon sample is 120 μm in length and has a cross-section of 10 μm x 15 μm. It has been uniformly doped with phosphorous with a doping density of 4 x 10^{15} cm^{-3}. Assume the temperature is 300°K and mobilities are μ_n = 1250 cm^2/Vs and μ_p = 430 cm^2/Vs.

    a. What are the majority and minority carrier concentrations? *(3 points)*
    b. What is the resistivity of the sample? *(3 points)*
    c. What is the resistance (end-to-end) of the sample? *(3 points)*
    d. If one end of the sample is connected to ground and the other end is connected to a +5V supply, what will be the current through the sample? *(2 points)*
    e. Calculate the percentage of current due to minority carriers? *(3 points)*
    f. What will be the average drift velocity of the majority carriers? *(3 points)*
    g. Using the chart in slide 16 of Lecture 3, at approximately what voltage would you expect to see some reduction in mobility (the early effects of velocity saturation)? *(3 points)*

2. Suppose we have a silicon sample in which the density of conduction electrons is given by $n(x) = n_0 e^{-2x/\lambda}$.
    a. Find a formula for the velocity of these electrons due to diffusion (assume electric field is zero) *(4 points)*
    b. What would be the electric field that would lead to an electron drift velocity equal to that of the diffusion velocity in part (a) *(4 points)*
    At $300^{\circ}K$, what value of λ would make the field in part (b) equal to 1800 V/cm.