EECS312-HW8:

Semiconductors

1. What is the concentration of free electrons and holes [#/cm^3] of intrinsic silicon at 100K and 310K?

@100K: $p = n = ni = 7.3x10^{15} (100^{3/2}) \exp(-1.12/(2*8.62x10^{-5}*100)) = 4.4596x10^{-10}$ (essentially zero)
@310K: $p = n = ni = 7.3x10^{15} (310^{3/2}) \exp(-1.12/(2*8.62x10^{-5}*310)) = 3.15x10^{10}$ [#/cm^3]

2. What is the conductivity and resistivity of intrinsic silicon at 100K and 310K?

@100K: σ = essentially zero, ρ = infinity [Ω cm]
@310K: σ = 9.24x10-6 [1/(Ω cm)], $\rho = 1.082x10^5$ [Ω cm]

3. A cylindrical resistor is constructed from intrinsic silicon at 310K having dimensions of radius=0.1cm and length 0.5cm. What is the value of the resistor?

@310K: $R = 0.5*1.082x10^5/(\pi 0.1^2) = 1.72$ MΩ

4. Repeat 1-3 with doped silicon $N_D = 1x10^{16}$ [#/cm^3]. (just for 310K)

@310K: $n=1x10^{16}$ [#/cm^3], $p=1x10^4$ [#/cm^3], $\sigma = 2.16$ [1/(Ω cm)], $\rho = 0.46$ [Ω cm], $R = 7.36\ \Omega$

5. Repeat 1-3 with doped P-type silicon $N_A = 1x10^{16}$ [#/cm^3]. (just for 310K)

@310K: $p=1x10^{16}$ [#/cm^3], $n=1x10^4$ [#/cm^3], $\sigma = 0.77$ [1/(Ω cm)], $\rho = 1.30$ [Ω cm], $R = 20.72\ \Omega$

6. The distribution of free electrons in a N-type Silicon with at room temperature is given by the equation (use free electron mobility=2000 cm^2/Vs and V_T=0.025V).

$$n(x)|_{t=0} = 1x10^{16}(\cos(2\pi 100x) + 1)\ [\#/cm^3]\text{, where x is in units of cm.}$$

What is the diffusion current density as a function of position (x) at t=0?

$D_n = 2000*0.025 = 50\ cm^2/s$

$J_n = q \cdot D_n \cdot n'(x) = 1.6x10^{-19}[\text{Coulombs}] \cdot 50[cm^2/s] \cdot (d/dx)1x10^{16}(\cos(2\pi 100x) + 1)\ [\#/cm^3][1/cm]$

$J_n = 1.6x10^{-19} \cdot 50 \cdot 2\pi 100x10^{16} \cdot (-\sin(2\pi 100)\ [\text{Coulombs}][cm^2/s][\#/cm^3][1/cm]$

$J_n = -16\pi \sin(2\pi 100)\ [\text{Coulombs}/cm^2 \cdot s]$ or $[\text{Amps}/cm^2]$