

**ECE 305 Exam 1 Formula Sheet (Fall 2015)**

Physical Constants	Silicon parameters ( $T = 300$ K)
$\hbar = 1.055 \times 10^{-34}$ J·s	$N_C = 3.23 \times 10^{19}$ cm <sup>-3</sup>
$m_0 = 9.109 \times 10^{-31}$ kg	$N_V = 1.83 \times 10^{19}$ cm <sup>-3</sup>
$k_B = 1.38 \times 10^{-23}$ J/K	$n_i = 1.1 \times 10^{10}$ cm <sup>-3</sup>
$q = 1.602 \times 10^{-19}$ C	$K_s = 11.8$
$\epsilon_0 = 8.854 \times 10^{-12}$ F/m	

**Miller Indices:** (hkl) {hkl} [hkl] <hkl>

**Density of states**  $g_C(E) = \frac{(m_n^*)^{3/2} \sqrt{2(E-E_C)}}{\pi^2 \hbar^3}$

**Fermi function**  $f(E) = \frac{1}{1+e^{(E-E_F)/kT}}$

**Intrinsic carrier concentration**  $n_i = \sqrt{N_C N_V} e^{-E_g/2kT}$

**Equilibrium carrier densities:**  $N_C = \frac{1}{4} \left( \frac{2m_n^* kT}{\pi \hbar^2} \right)^{3/2}$

$N_V = \frac{1}{4} \left( \frac{2m_p^* kT}{\pi \hbar^2} \right)^{3/2}$

$n_0 = N_C e^{(E_F-E_C)/kT} = n_i e^{(E_F-E_i)/kT}$

$p_0 = N_V e^{(E_V-E_F)/kT} = n_i e^{(E_F-E_i)/kT}$

**Space charge neutrality:**  $p - n + N_D^+ - N_A^- = 0$

**Law of Mass Action:**  $n_0 p_0 = n_i^2$

**Conductivity/resistivity:**  $\sigma = \sigma_n + \sigma_p = q(n\mu_n + p\mu_p) = 1/\rho$

**Drift-diffusion current equations:**  $J_n = nq\mu_n \mathcal{E}_x + qD_n \frac{dn}{dx}$        $\frac{D_n}{\mu_n} = \frac{kT}{q}$

$J_p = pq\mu_p \mathcal{E}_x - qD_p \frac{dp}{dx}$        $\frac{D_p}{\mu_p} = \frac{kT}{q}$

**Carrier conservation equations:**  $\frac{\partial n}{\partial t} = +\nabla \cdot \left( \frac{J_n}{q} \right) + G_n - R_n$

$\frac{\partial p}{\partial t} = -\nabla \cdot \left( \frac{J_p}{q} \right) + G_p - R_p$

**Poisson's equation:**

$\nabla \cdot (\epsilon \mathcal{E}) = \rho$