Area: Solid State Devices

Problem 1

(a) Write down the drift-diffusion equation for electrons, i.e., the total current as a summation of the drift current and the diffusion current terms. (50%)

(b) Show that for a non-degenerate semiconductor, the total current density can be expressed as

\[ J_n = n \mu_n \frac{dF_n}{dx}, \]

where \( F_n \) is the quasi Fermi energy level, \( n \) is the electron density, and \( \mu_n \) is the electron mobility. (50%)

Problem 2:

Consider a particle in a box problem for which the potential is zero at \( 0 < x < W \) and is infinitely large otherwise. (a) Write down the normalized wave function for the lowest energy level. (70%)

You may find the following equations useful:

\[ \sin^2(x) = \frac{1 - \cos(2x)}{2} \quad \cos^2(x) = \frac{1 + \cos(2x)}{2} \]

\[ e^{ix} = \cos(x) + i \sin(x) \]

(b) Write down the electron density as a function of \( x \) in the unit of per length if the lowest energy level is filled by one electron. (30%)