

Solid State Physics

Homework Ch2 No.1, Due on Mar 15th, Friday

1. Problem No.1 in Ch8 of “Solid State Physics” by Ashcroft/Mermin, “Periodic potential in One Dimension”. Questions (a)-(h).
2. Consider a one-dimensional lattice Hamiltonian $H = P_x^2/2m + U(x)$, with $U(x) = -V_a \cos^2(k_0 x)$, where the constant $V_a > 0$ denotes the amplitude of periodic lattice potential and k_0 denotes the periodicity. Assume that $V_a \ll E_R$, with $E_R = \hbar^2 k_0^2 / 2m$ called *recoil energy*.
 - (a) Find the momentum component of $U_{\mathbf{K}}$, with $\mathbf{K} = K \hat{e}_x$.
 - (b) Solve the energy \mathcal{E}_{k_x} of the Bloch states ψ_{k_x} of the “first band” with momentum $|k_x| \ll k_0$ up to the order of V_a^2 . The “first band” means that the energy of the states with momentum k_x without lattice potential (i.e. $V_a = 0$) should be $\mathcal{E}_{k_x}^{(0)} = \hbar^2 k_x^2 / 2m$.
 - (c) The gap between the first and the second bands is opened at $k_x = \pm k_0$. Solve the strength of the gap up to the first order of V_a .