1.6. Beyond 1-D

1.6a. To ensure that the dispersion relation for the 2D tight-binding model for a square lattice shown matches the relation

\[ E(k) = E_c + \frac{\hbar^2}{2m} (k_x^2 + k_y^2) \]

for small values of \( k_x a \) and \( k_y a \), we should choose

(a) \( E_c = +2t \), and \( t = \frac{\hbar^2}{2ma^2} \)

(b) \( E_c = 2t \), and \( t = \frac{\hbar^2}{2ma^2} \)

(c) \( E_c = +2t \), and \( t = \frac{\hbar^2}{2ma^2} \)

(d) \( E_c = +4t \), and \( t = \frac{\hbar^2}{2ma^2} \)

(e) \( E_c = +4t \), and \( t = \frac{\hbar^2}{2ma^2} \)

1.6b. Suppose each site of the square lattice shown has additional coupling \( T \) with each of the four neighbors that are diagonally across from it.

(a) \( E = \varepsilon + 2t \cos k_x a + 2t \cos k_y a \)
(b) \( E = \varepsilon + 2t \cos k_x a + 2t \cos k_y a + 4T \cos k_x a \cos k_y a \)
(c) \( E = \varepsilon + 2T \cos k_x a + 2t \cos k_y a \)
(d) \( E = \varepsilon + 2t \cos k_x a + 2T \cos k_y a \)
(e) \( E = \varepsilon + (2t \cos k_x a + 2t \cos k_y a) T \cos k_x a \cos k_y a \)