

Firstly, this is my Mathematica code that I used for part 3:

```

σ+ = {{0, 1}, {0, 0}}; σ- = {{0, 0}, {1, 0}};
c†j- := KroneckerProduct @@ N@ReplacePart[ReplacePart[Table[IdentityMatrix[2], 6], Table[{j - i}, {i, j - 1}] → -PauliMatrix[3]], j → σ+];
cj- := KroneckerProduct @@ N@ReplacePart[ReplacePart[Table[IdentityMatrix[2], 6], Table[{j - i}, {i, j - 1}] → -PauliMatrix[3]], j → σ-];

H = 1 ⎛⎝ ∑i=15 (c†i · ci+1) + c†6 · c1 ⎞⎟ + 2 ⎛⎝ ∑i=15 (c†i · c†i+1 · ci · ci+1) + c†6 · c†1 · c6 · c1 ⎞⎟;

ListPlot[Sort@Eigenvalues[H + ConjugateTranspose[H]], PlotStyle → Black, PlotMarkers → {Automatic, 3}]

```

Figure 1: Mathematica code used for parts 3

1 Plotting Eigenvalues for a Hamiltonian

$$H = 1 \sum_i^6 c_i^\dagger c_{i+1} + 2 \sum_i^6 c_i^\dagger c_{i+1}^\dagger c_i c_{i+1} + H.C.$$

Using the same system, these are the eigenvalues for above Hamiltonian:

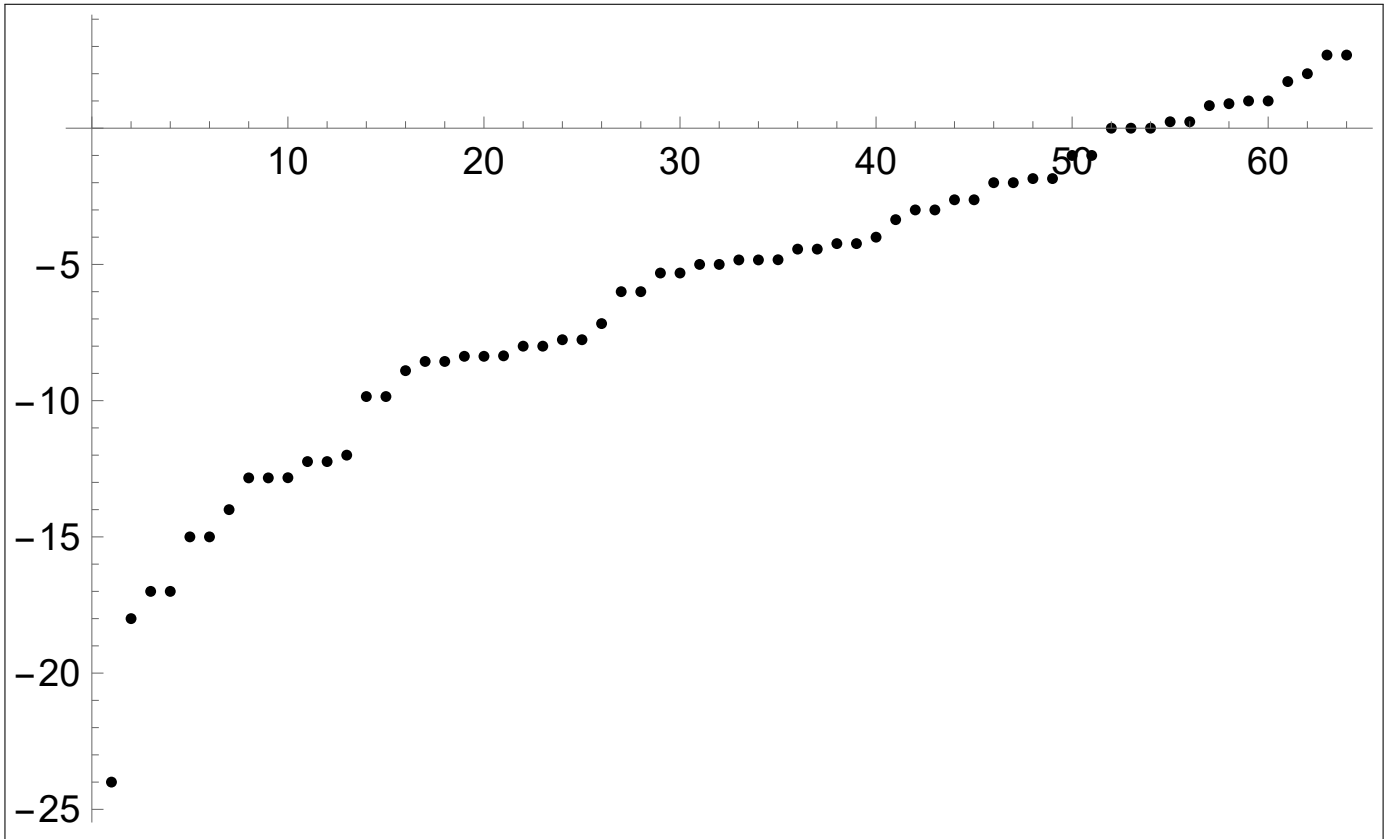


Figure 2: Sorted Eigenvalues of the Hamiltonian