For my my final computational physics project, I will apply Monte Carlo methods to simulate an Ising model. In this proposal, I will briefly go over my goals for this project.

1. **Simple Ising Model**
   The Ising Model is a simple version of a ferromagnet. The overall magnetization of the material is determined by the number of dipoles that are aligned parallel to one-another. The Ising Model is a simulation of ferromagnetism in statistical mechanics and phase transitions. The Hamiltonian of Ising can be written as:
   $$H = -J \sum_{ij} S_i S_j$$
   where $J > 0$ is the strength of the interaction between adjacent lattice.

   The procedures simulate Ising model is as follows:

   (a) Start by randomly picking a lattice site and flip the spin.
   (b) Calculate the change in energy.
   (c) If $H \leq 0$ then permanently flip it, otherwise calculate the Boltzmann's probability p
   $$p = e^{-\beta H}$$
   where $\beta = \frac{1}{k_B T}$, where k_B is Boltzmann constant and T is temperature in Kelvin.
   (d) Generate a random variable x between $[0, 1]$.
   (e) If $x \leq p$, then flip the spin, otherwise flip back to its original state.
   (f) Repeat until it reaches a macro equilibrium.

   We can simulate this model for a variety of temperatures and see how energy, specific heat, magnization and magnetic susceptibility changes with temperature.

2. **Building on top of the simple Ising Model**
   Suppose there is an external field h, then the Hamilton should be adjusted as
   $$H = -J \sum_{ij} S_i S_j - h \sum_j s_j$$

   For this project I will implement some external magnetic field on the system to observe its behavior.

   Simulating Ising Model in higher dimension (3D).

   Try out with different values of J (antiferromagnet $J < 0$).

   Identify the temperature that phase transition happen, going from ferromagnet to paramagnet.

   Animate the ising model!

   Apply Wolff algorithm