1:Modify your 1D Ising code so that it works in 2 dimensions as described above. Furthermore, implement the Metropolis-Hastings accept/reject that was discussed in the lectures (in other words do NOT do a "brute-force" calculation like in the previous homework). Set your code up such that measurements are done after each "sweep" of the lattice, where a "sweep" constitutes looping over all sites on the lattice, and at each site flipping its spin and performing the Metropolis-Hastings accept/reject step. In other words, after each "sweep" of the lattice you will have performed Λ accept/reject tests .

The answer to that can be seen in the github repository, at the commitment #commitment

2:How does the numerical cost of the calculation of the energy (for a given spin configuration) scale with the system size Λ?

The numerical cost of measuring the energy of a given configuration is $N_x * N_y$ in or case $N_x = N_y = N$ so its N^2 because we require two nested loops of each range N.

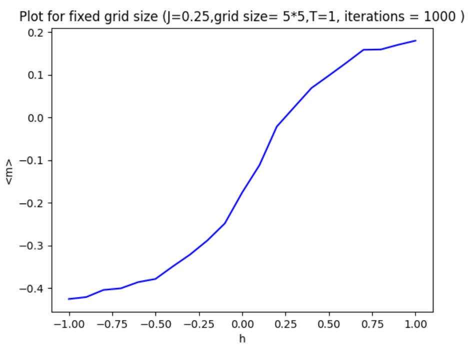
3:Assuming you've flipped one spin s_i, how does the numerical cost of the calculation of the change in energy ΔS scale with the system size Λ?

If we flip the spin the two measure the change in energy for initial and final configuration we need to measure the energy for each configuration, and numerical cost of measuring the energy of one configuration is N^2 ,So for two configurations it would be $2N^2$.

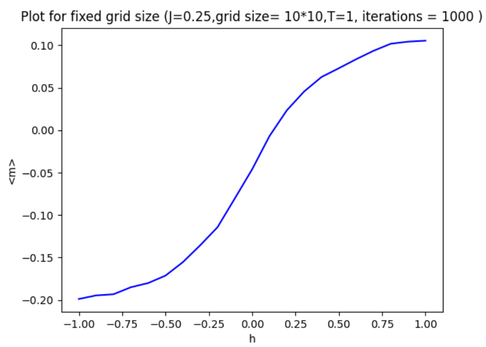
4:What is the significance of the critical coupling J_c?

Critical coupling constant decides the magnetization behavior of the material, if the coupling constant is less than or equal to this it would be zero.

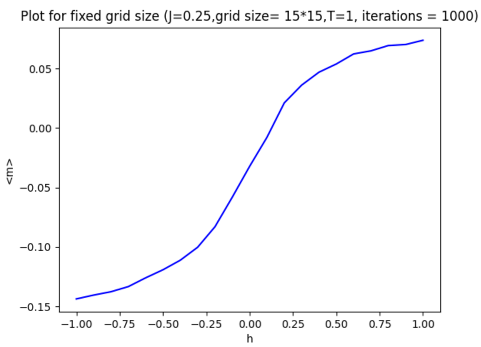
5:Use your algorithm to estimate $< m >$ as a function of $h \in [-1, 1]$ for some fixed $J < 1$ Use $N_x = N_y$ for a sample of values between 4 and 20.



(a)

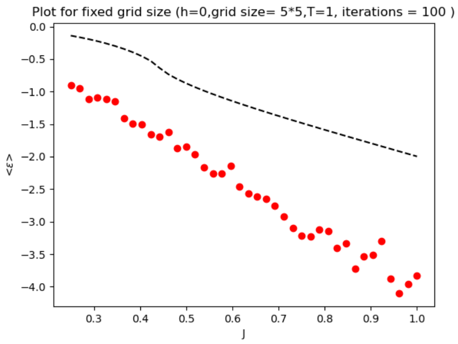


(b)

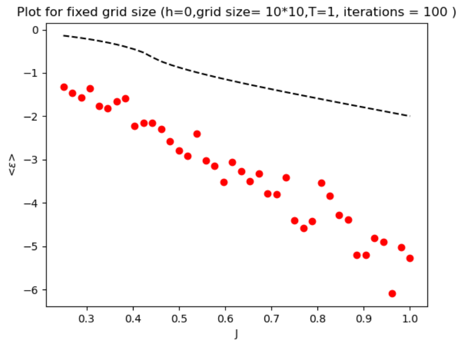


(c)

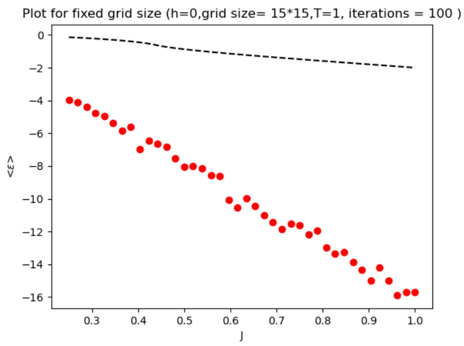
6:Use your algorithm to estimate $<\epsilon>$(average energy per cite) as a function of $J \in [.25, 2]$ for $h = 0$. Again use $N_x = N_y$ for various values between 4 and 20. Compare your result to the exact solution in the thermodynamic limit.



(a)



(b)

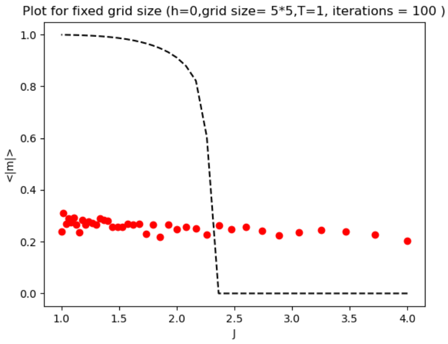


(c)

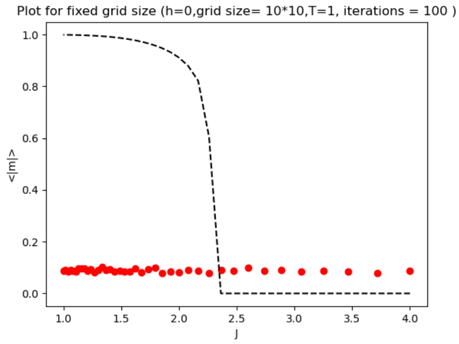
We see that the plots are not close to the exact calculations but they follow the same trend, and maybe this is the expected behavior. Although we are not sure, they could be completely wrong.

7:Use your algorithm to estimate $<|m|>$ (absolute value of the mean magnetization) as a function of $J \in [.25, 2]$ and h=0. Again use $N_x = N_y$ for various values between 4 and 20. Plot your results as a function of J^{-1} and compare your result to the exact solution in the thermodynamic limit. Explain the physical significance of what you find. What would you see if you instead plotted $<m>$ instead of $<|m|>$?

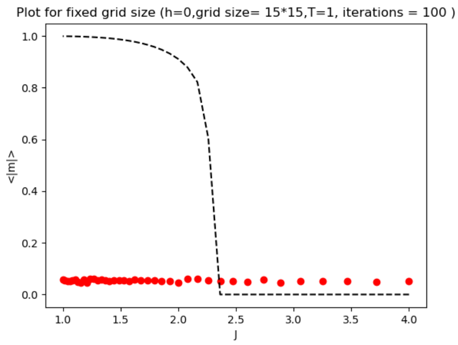
Probably the calculations here are wrong and we could figure out how to calculate the absolute value of the magnetization.


Plot for fixed grid size (h=0,grid size= 5*5,T=1, iterations = 100)
<|m|>
J

(a)


Plot for fixed grid size (h=0,grid size= 10*10,T=1, iterations = 100)
<|m|>
J

(b)


Plot for fixed grid size (h=0,grid size= 15*15,T=1, iterations = 100)
<|m|>
J

(c)