1 Results

1.1 2×2 lattice, analytical expressions

If we scale the value of β from $1/k_BT$ to $1/J$ (Scaling factor k_BT/J) in the analytical expression from section **??**, we will get a good benchmark for computer computations to come. These values are listed in table 1 below. Note that all values are divided by four, since we want the values per bond, and not for the entire lattice.

Mean energy, $\langle \mathbf{E} \rangle$	-1.9960
Mean absolute magnetization, $\langle \lvert \mathcal{M} \rvert \rangle$	0.9987
Specific heat capacity, $\mathbf{C_V}$	0.0321
Susceptibility, χ	3.9933

Table 1: Benchmark for material characteristics per bond for a 2×2 lattice

1.2 Ising model: simulation over temperature

We ran the program for different amounts of Monte Carlo cycles and plotted the error (analytical − simulated) in figure 1 below. Using 10^7 Monte Carlo cycles, we seem to be getting pretty accurate results.

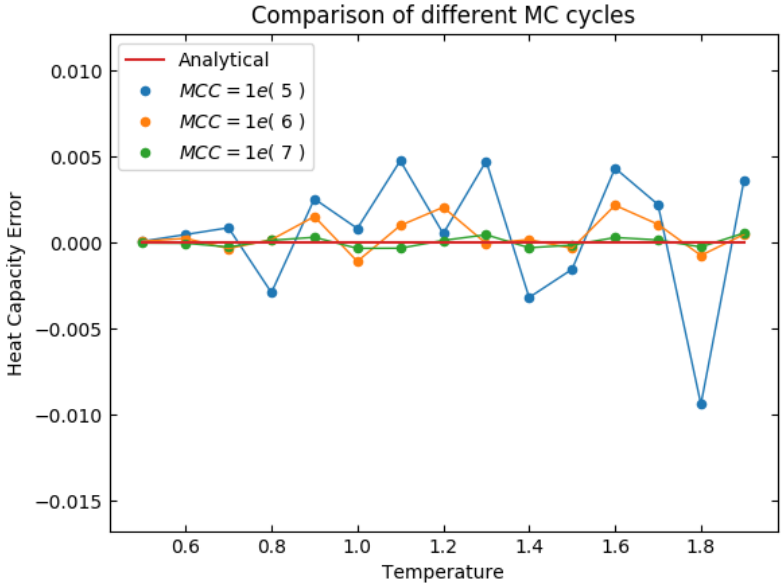

Figure 1: Shows the accuracy of different amount of MC cycles over temperature.

1.3 20×20 lattice

Ordered spin orientation

Initializing the spin structure, we first set every spin up for $T < 1.5$ and every spin down for $T \geq 1.5$. In figure 2, the computed values for the mean magnetization and energy are plotted against the number of MC cycles, at $T = 1.0$ and $T = 2.4$:

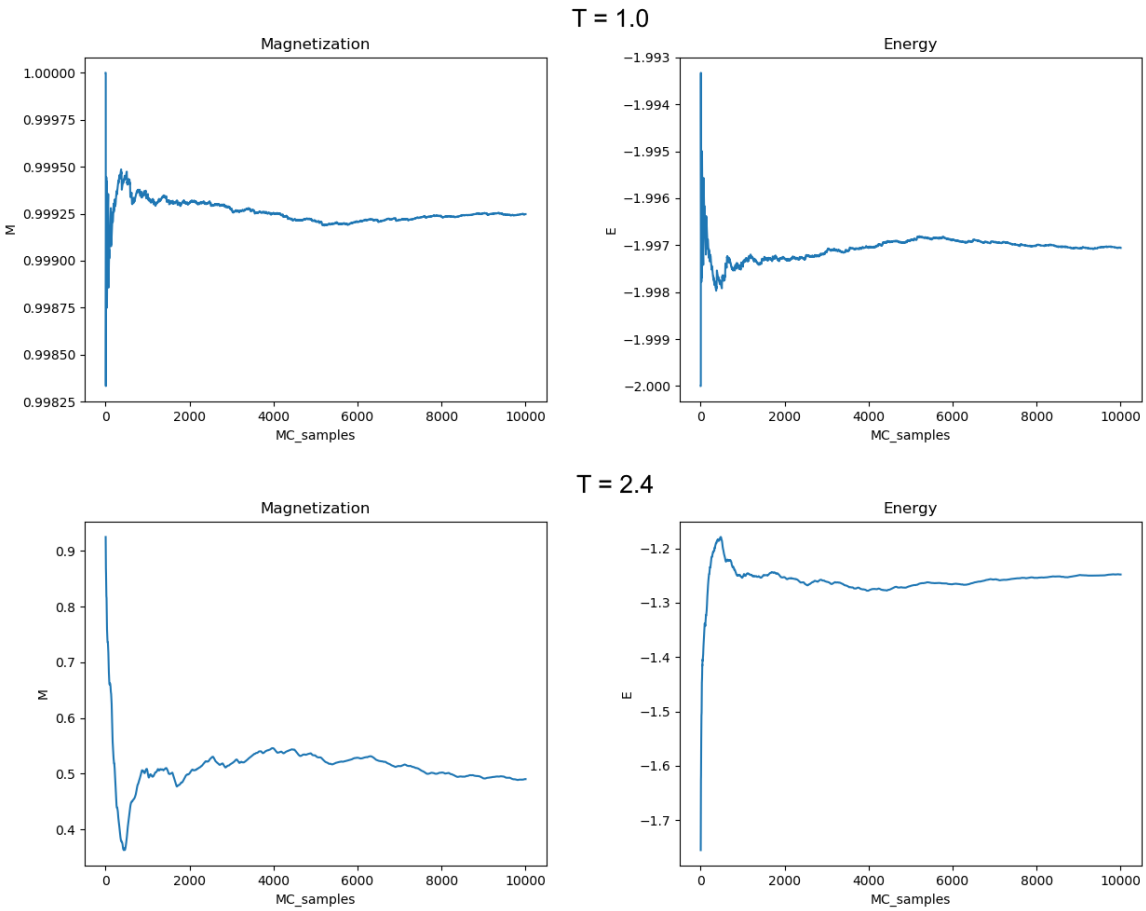

Figure 2: Shows the computed value for the mean magnetization and energy, with ordered initialization, against the number of MC cycles. The scaled temperature is $T = 1.0$ and $T = 2.4$ respectively.

All the plots pretty much stabilize into a value after 8000-1000 MC cycles. For $T = 1.0$, the magnetization stabilizes around the value 0.99950 and the energy around the value -1.997. This corresponds pretty good with the analytically calculated values. For $T = 2.4$, the magnetization stabilizes around the

value 0.5 and the energy around the value -1.25.

Random spin orientation

Following the ordered initialisation, we also initialized the crystal randomly. In figure 4, the computed values for the mean magnetization and energy are plotted against the number of MC cycles, at $T = 1.0$ and $T = 2.4$:

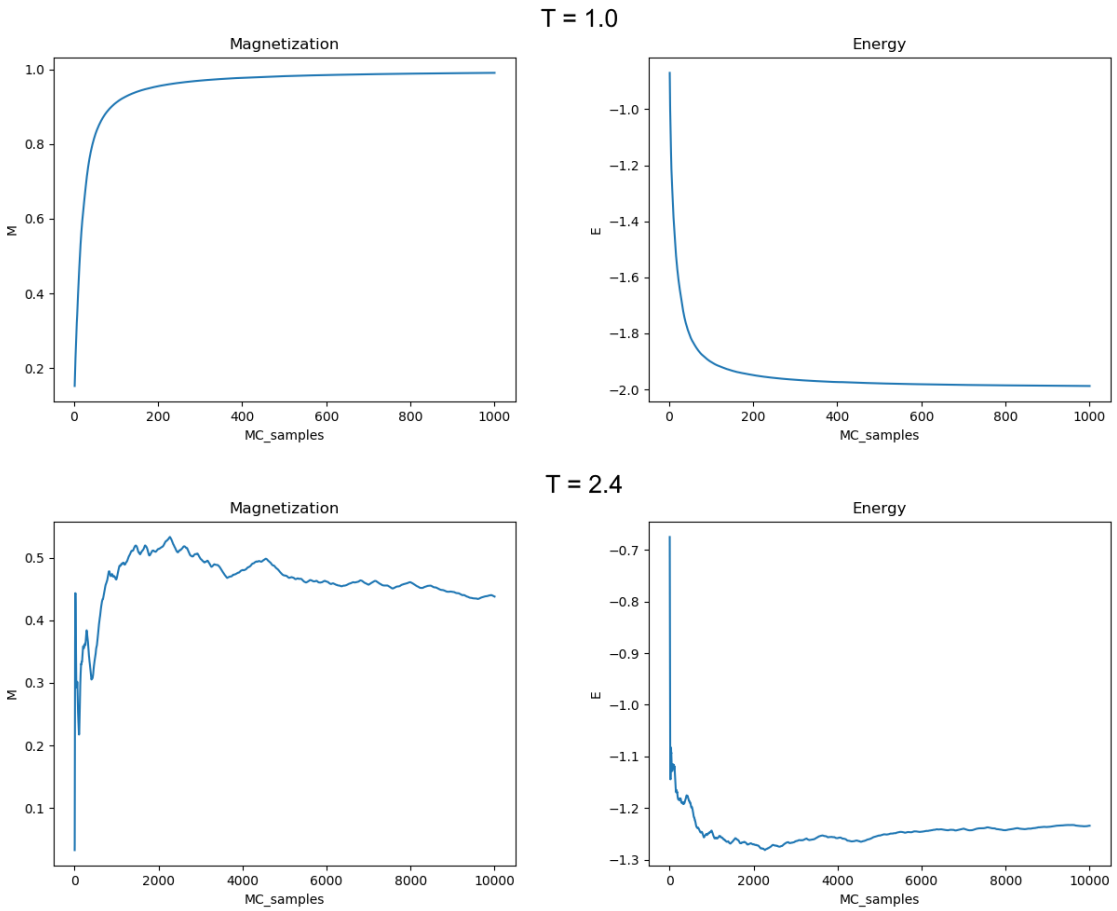

Figure 3: Shows the computed value for the mean magnetization and energy, with random initialization, against the number of MC cycles. The scaled temperature is $T = 1.0$ and $T = 2.4$ respectively.

The plots for $T = 1.0$ follow a clean exponential curve, while the other plots pretty much stabilize after 8000-1000 MC cycles - like the previous ones. For $T = 1.0$, the magnetization ends on the value 1.0 and the energy on the value -2.0. This is similar to the analytical values, but does not have the same

accuracy. For $T = 2.4$, the magnetization stabilizes around the value 0.45 and the energy around the value -1.25.