PHY407H1 Lab11

Eric Yeung*
Department of Physical Sciences, University of Toronto, Toronto M1C 1A4, Canada
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QUESTION 1

See Lab11_q1.py by me.

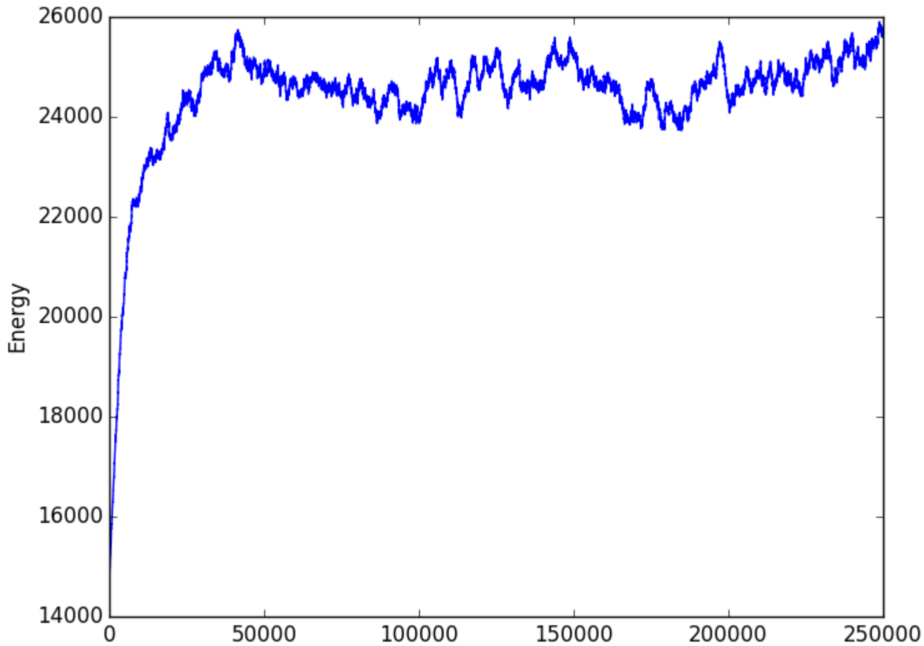


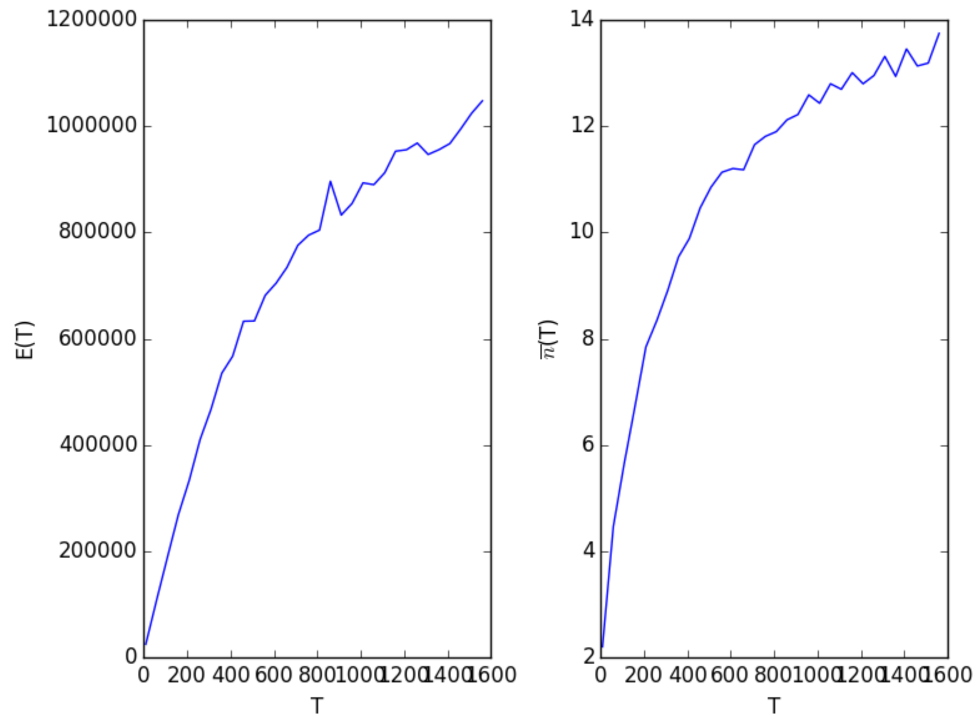
FIG. 1: Equilibrium as given in mcsim.py (250,000 steps)

Over this range [10, 1600]T, the heat capacity is computed to be 660.13. I just took the last element of the energy and subtracted it from the first to get ΔE. Same with the temperature ΔT(1600-10 = 1500). Then the heat capacity at constant volume,

$$C_v = \frac{\Delta E}{\Delta T}$$

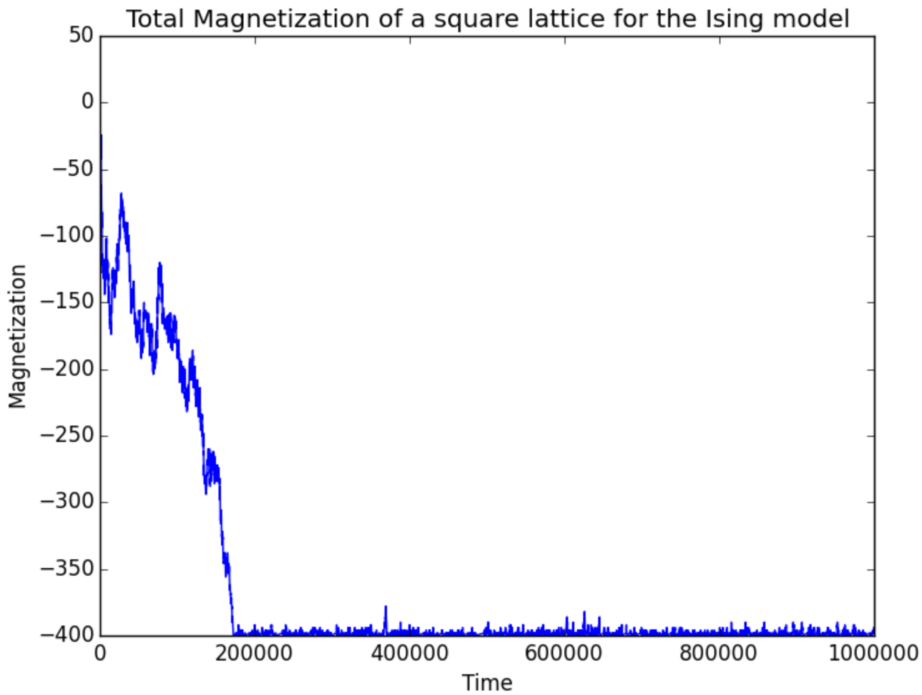
* eric.yeung@mail.utoronto.ca

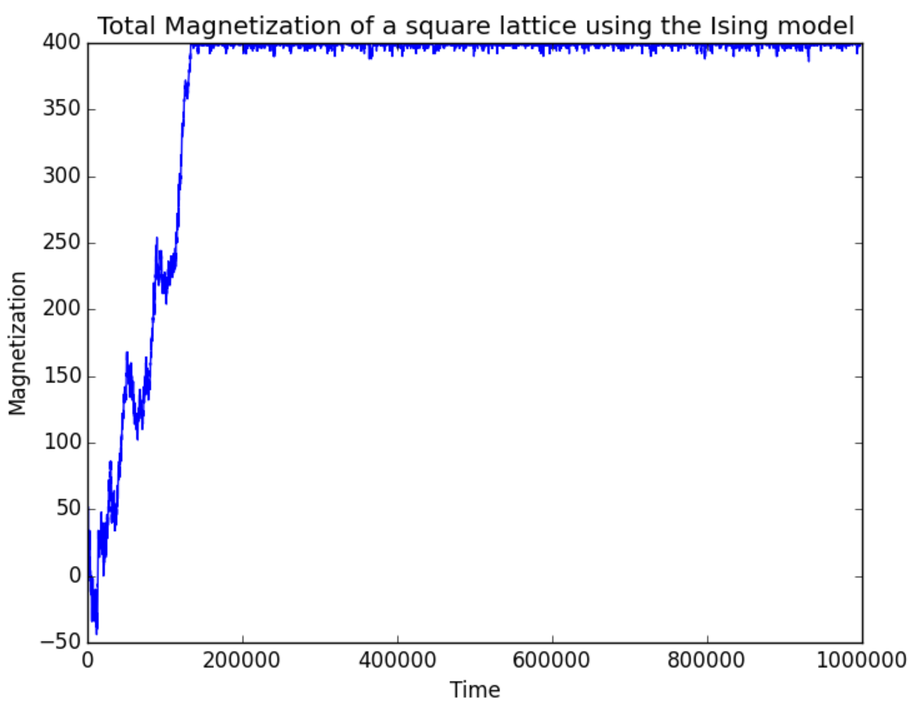
I wasn't sure how to do this question, since it asks for a discrete spectrum of temperature [10.0, 40.0,100.0, 400.0, 1200.0, 1600.0], but I found that this was too little data points. So I used a more continuous spectrum for temperature (more points). I found that the number of steps given in mcsim.py (250,000) was sufficient for equilibrium for the energy and $\overline{n}$. Equilibrium since it converges to the correct boltzmann distribution.



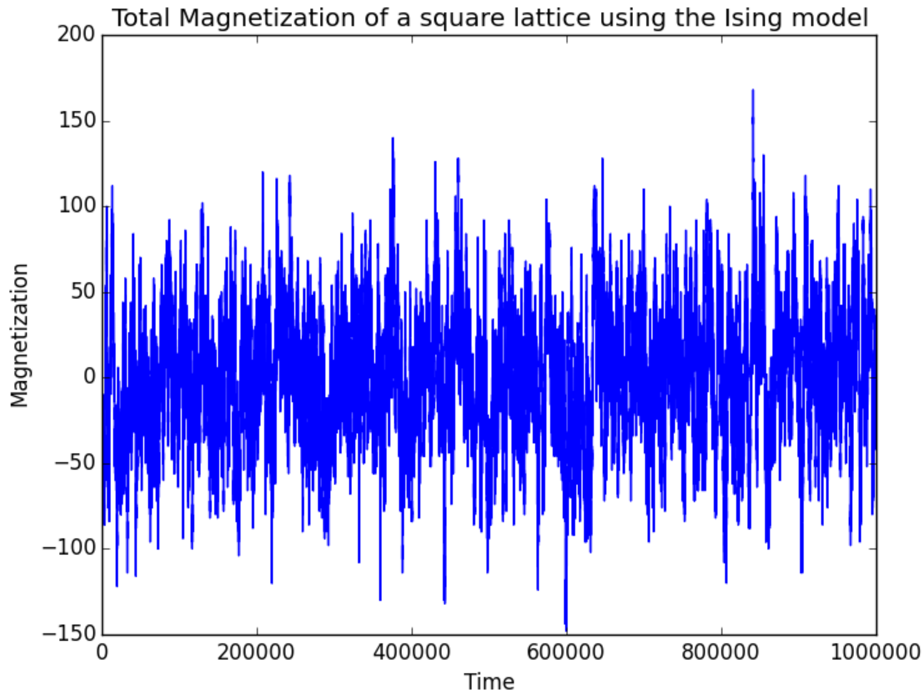
QUESTION 2

a) b) c) See Lab11_q2abc.py by me. This question isn't required but I plotted magnetisation anyways. Two different runs, plus one at the Curie temperature T_c.





At the curie temperature Tc = 4*J/k_b was also plotted. Note the amount of fluctuation, and almost an absence of magnetisation.



d) After running the program several times, the trend seems to be that it starts off near 0 magnetisation since, at the start, there is a fair probability of each dipole being in spin +1 or spin -1. Then, as the system evolves, the spins start to get magnetised. Resulting in a monotonic increasing or monotonic decreasing magnetisation(t).

e) See Lab11_q2e.py by me.

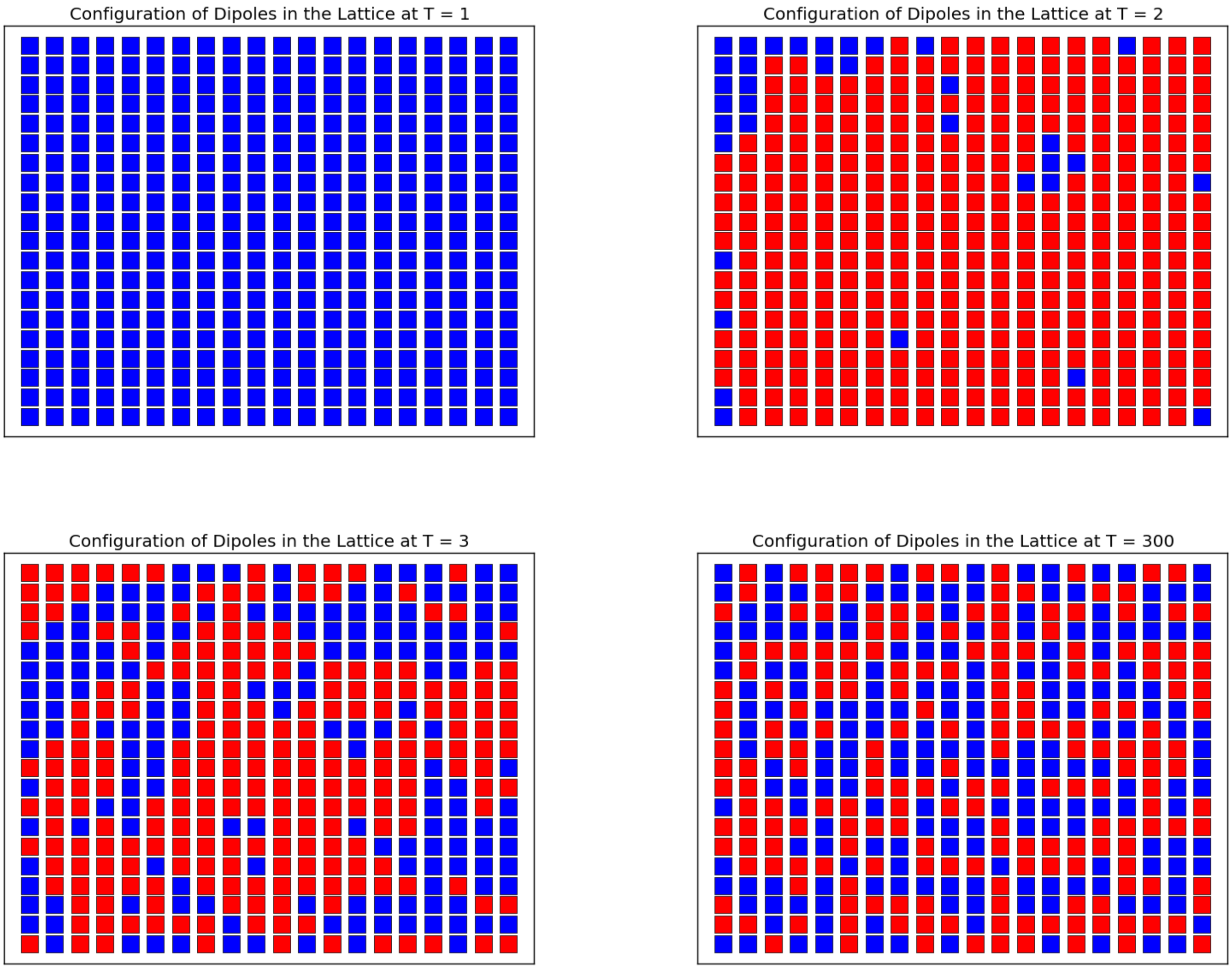
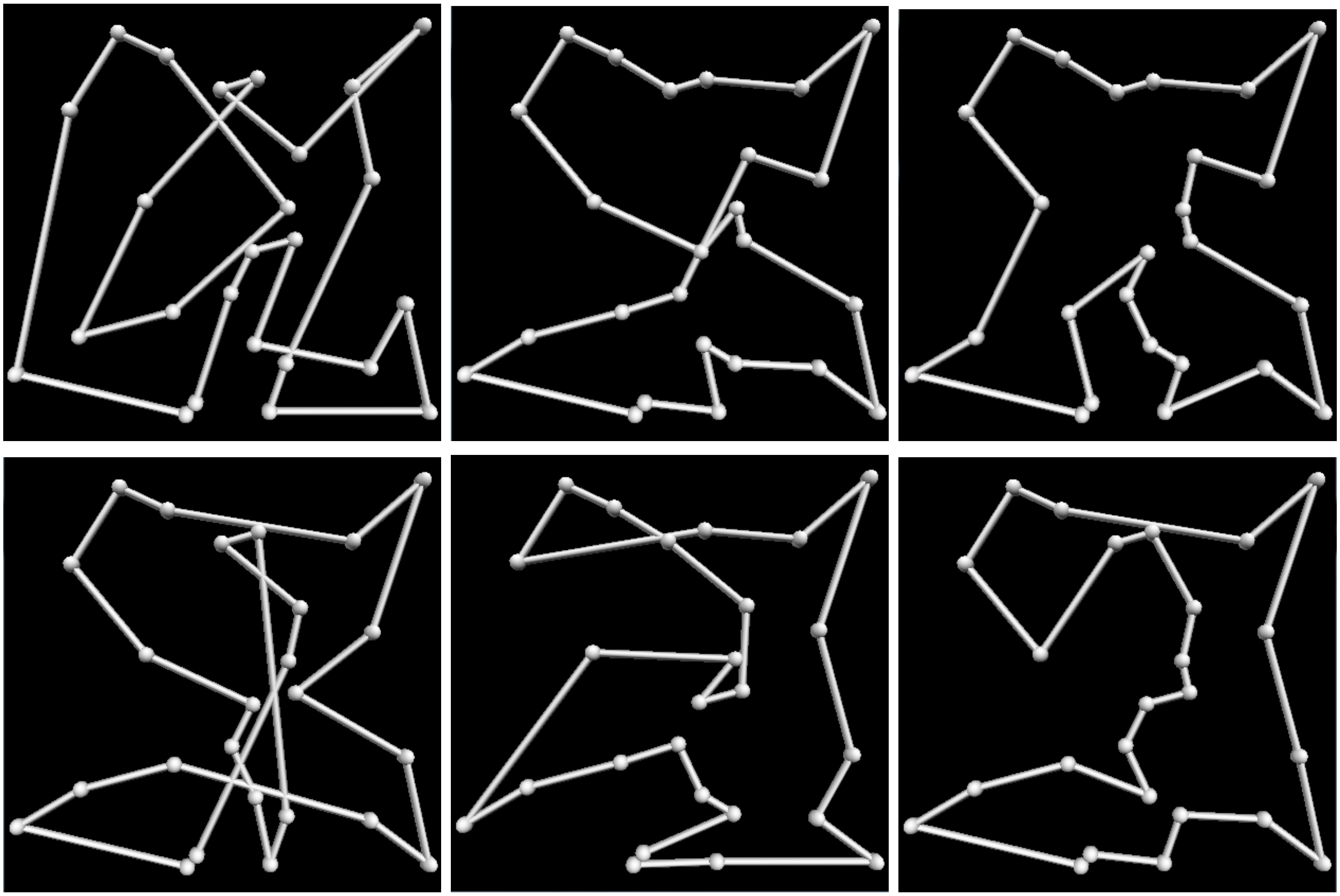


FIG. 2: Red means spin up, blue means spin down

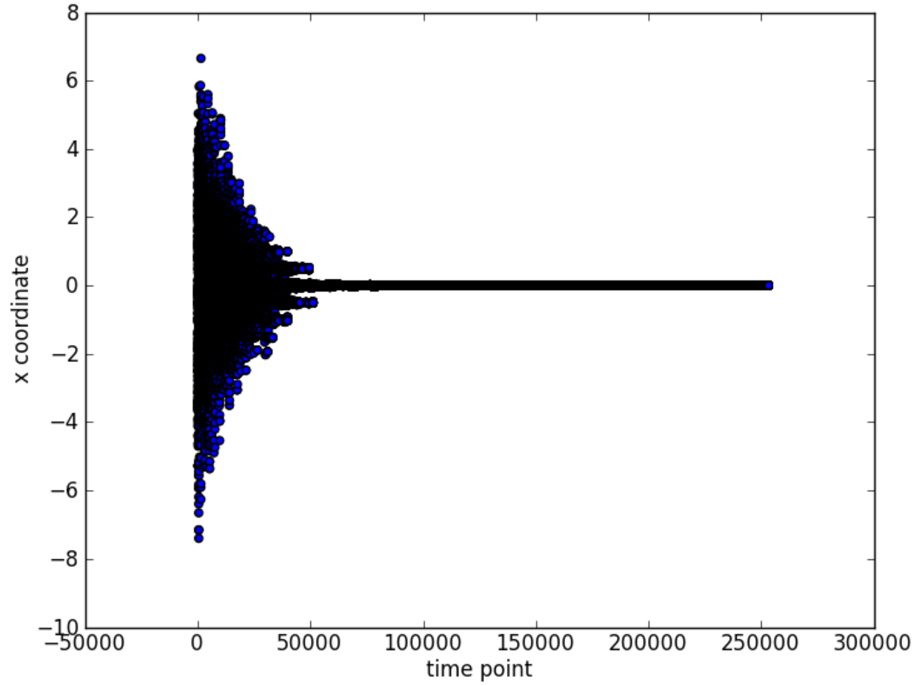
As one can see, at higher temperatures we have more variation in the spins. This is because at higher temperatures, the total energy of the system is higher. Which means that the dipoles will be in the position of highest energy configuration which is anti-parallel. Therefore we would expect an almost equal distribution of up/down spins which is what we see when T = 3.

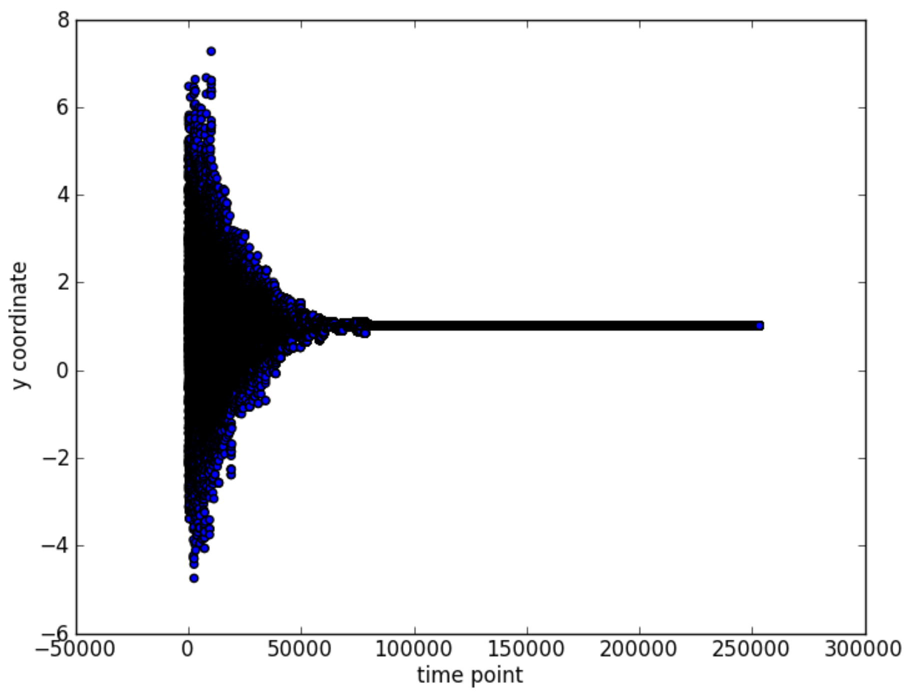
QUESTION 3

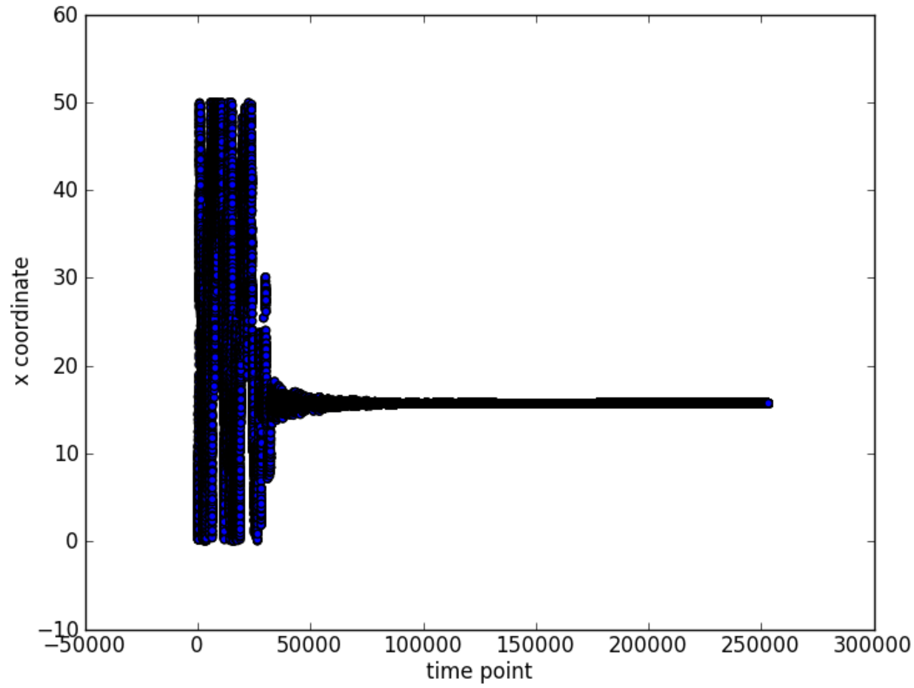
a) This was done by Chi. Here are some different paths taken:



b) See lab11_q3b.py by Chi.



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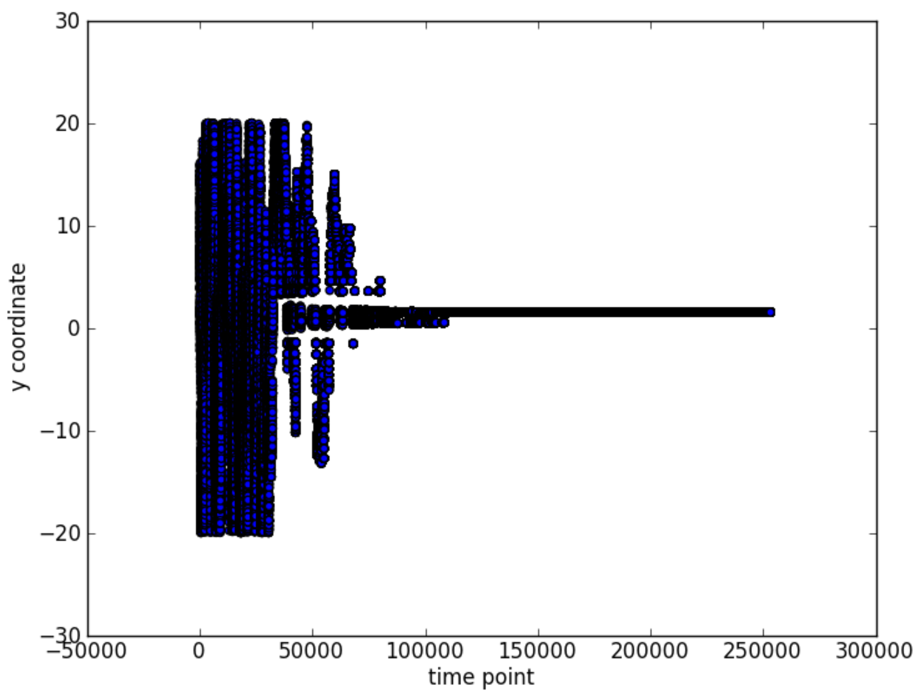
40
30
20
10
0
−10
−50000
0
50000
100000
150000
200000
250000
300000


y coordinate
time point
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−10
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−30
−50000
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100000
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