PHY407H1 Lab4

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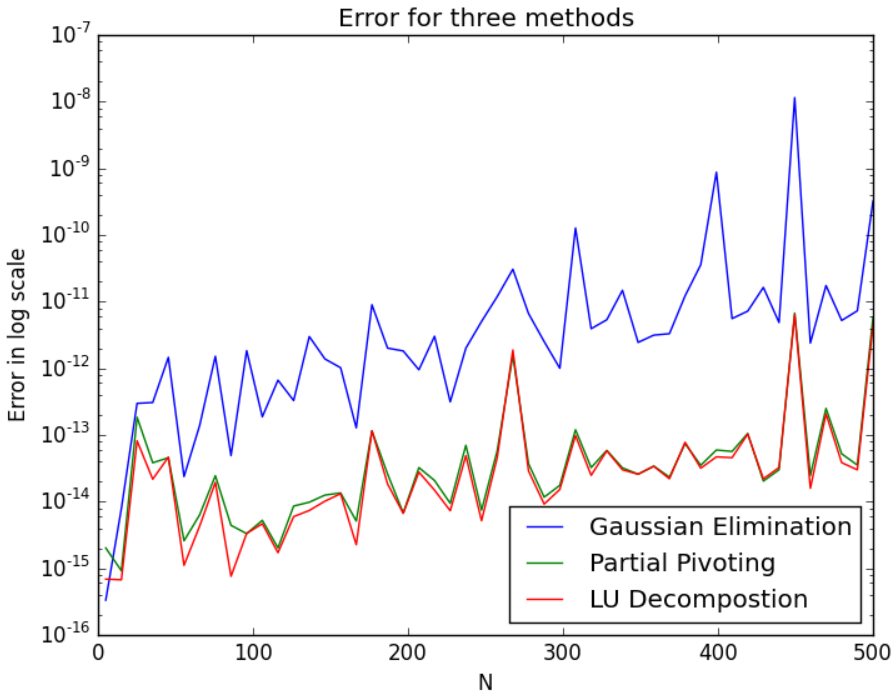
(Dated: October 9, 2015)

QUESTION 1

a) Not to be handed in.
b) See Lab4_q1b.py by Chi.
For the error, Gaussian Elimination is far worse than the other two methods. Partial Pivoting and LU Decomposition seems to be very close to one another. However, it seems like LU Decomposition is slightly better in terms of minimal error.



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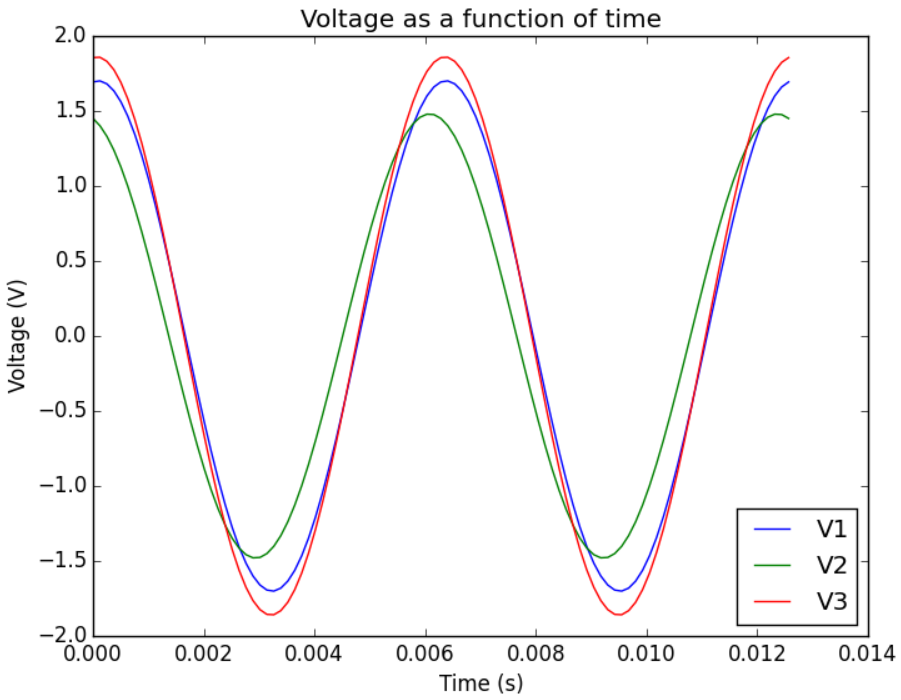
For the run time, LU Decomposition is far faster than the other two methods. Partial Pivoting and Gaussian Elimination seem to be very close to one another, but ultimately Partial Pivoting takes slightly longer to compile than Gaussian Elimination.

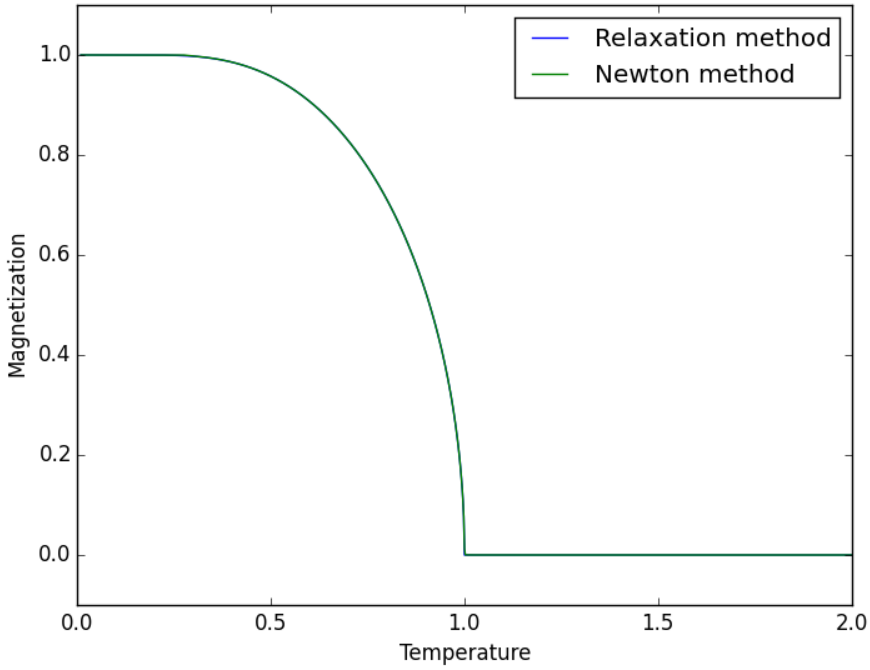
c) See Lab4_q1c.py by Chi.
The output of the program gave the voltage amplitudes and their respective phases in degrees.

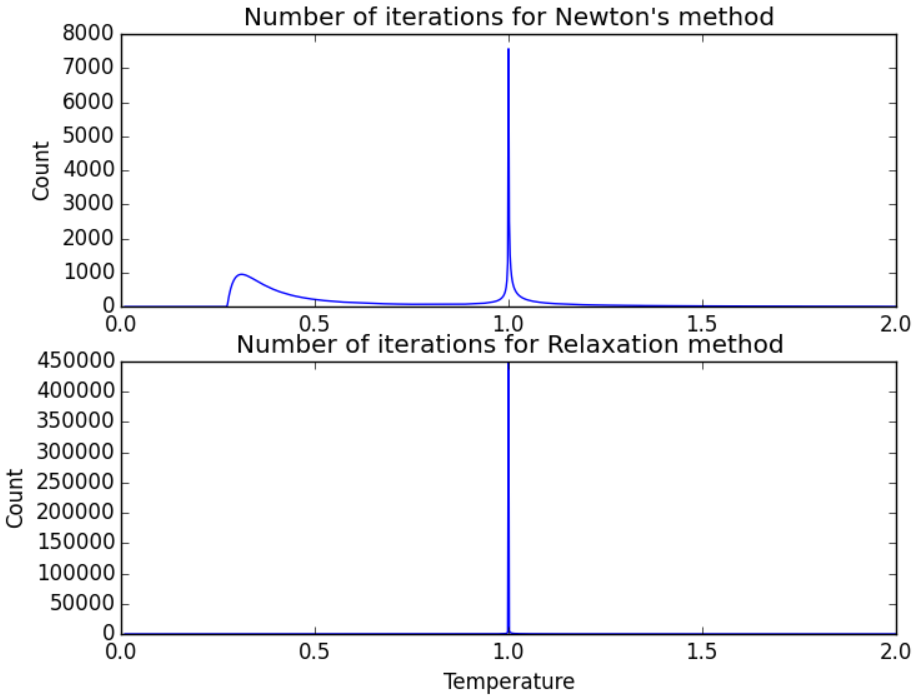
$$[1.69369369 - 0.16216216j 1.45045045 + 0.2972973j 1.85585586 - 0.13513514j]$$
$$0 : V1 = 1.70143906588, \text{ phase } = -5.46909497011$$
$$1 : V2 = 1.48060534654, \text{ phase } = 11.5834186047$$
$$2 : V3 = 1.86076932006, \text{ phase } = -4.16467265187$$

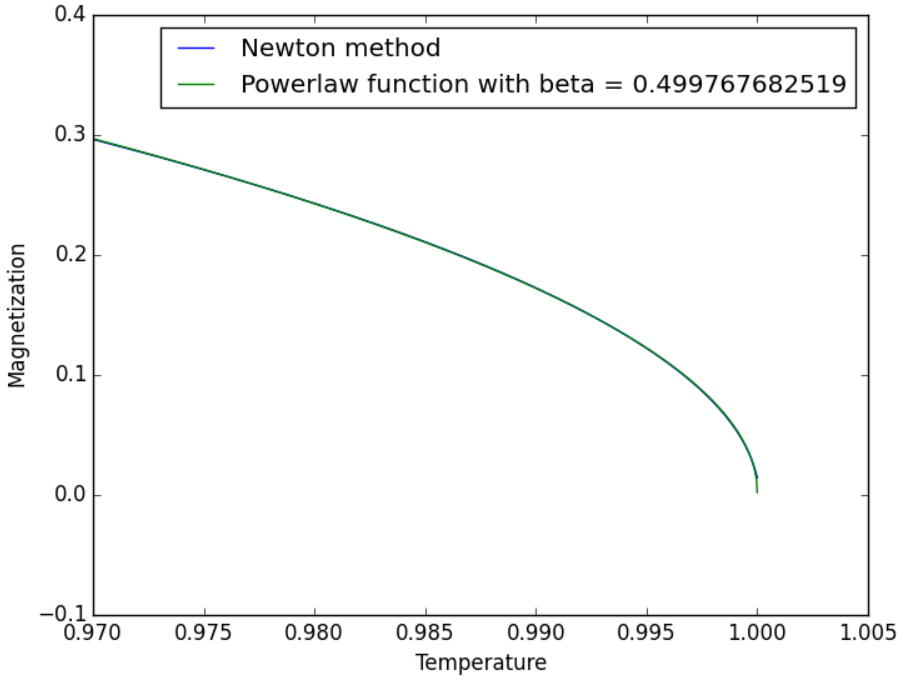


QUESTION 2

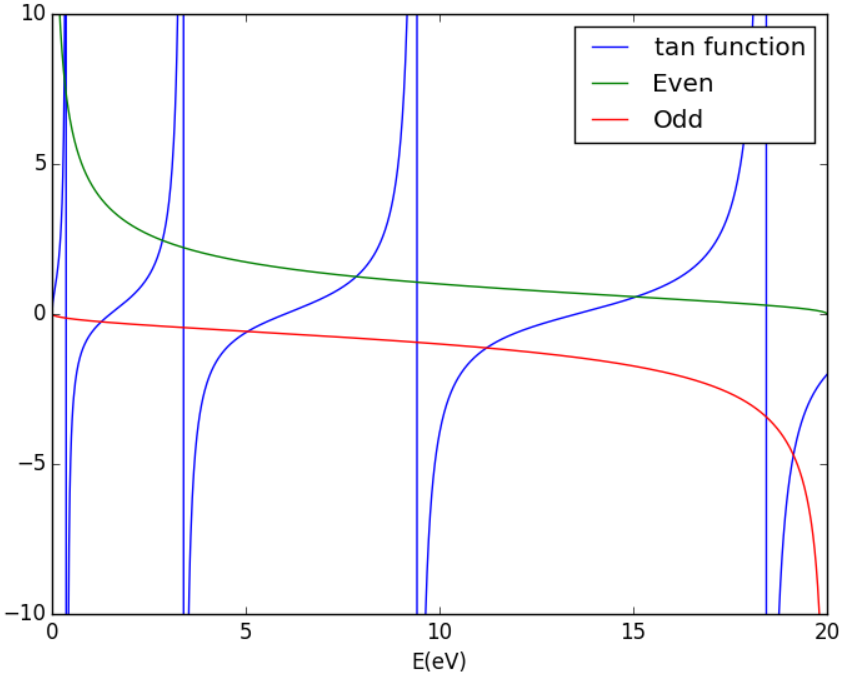
a) See Lab4_q2a.py by Chi.





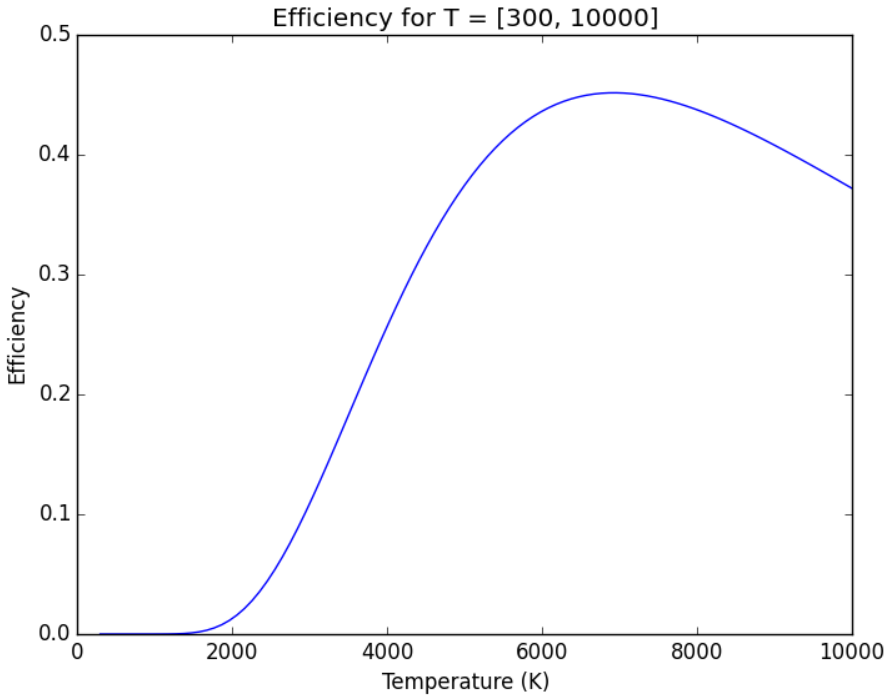

Newton method
Powerlaw function with beta = 0.499767682519
Magnetization
Temperature
0.4
0.3
0.2
0.1
0.0
−0.1
0.970
0.975
0.980
0.985
0.990
0.995
1.000
1.005

b) See Lab4_q2b_chi.py by Chi. The graph was provided by Paul Kushner.



Using binary search, I found that the first 6 roots, or energy levels are [0.31735, 2.85075, 7.849375, 1.2705, 5.051, 11.2159375 eV] in electron volts.

c) See Lab4_q2c.py by me. I plotted the efficiency vs temperature relationship. I found that the maximum efficiency 0.45169 occurs at 6928.58 K



QUESTION 3

c) See Lab4_q3c.py by me. First 10 energy levels are E_n = [9.35091324e-19 1.79140861e-18 2.99012273e-18 4.66941000e-18 6.83408718e-18 9.48250962e-18 1.26138143e-17 1.62276971e-17 2.03237987e-17 2.49226692e-17]
The Ground state is given as 9.35091324498e-19, which is 5.83684004752 eV. Which I know is correct.

d) See Lab4_q3c.py by me. Same file as above, I just changed nmax and mmax both to 100. The first 100 energy levels read E_n = [9.35091260e-19 1.79140840e-18 2.99012243e-18 4.66940859e-18 6.83408571e-18 9.48250120e-18 1.26138060e-17 1.62275961e-17 2.03236654e-17 2.49019013e-17 2.99622382e-17 3.55046359e-17 4.15290688e-17 4.80355198e-17 5.50239774e-17 6.24944335e-17 7.04468821e-17 7.88813189e-17 8.77977409e-17 9.71961454e-17 1.07076531e-16 1.17438895e-16 1.28283238e-16 1.39609558e-16 1.51417855e-16 1.63708127e-16 1.76480375e-16 1.89734598e-16 2.03470795e-16 2.17688967e-16 2.32389113e-16 2.47571233e-16 2.63235327e-16 2.79381395e-16 2.96009436e-16 3.13119450e-16 3.30711438e-16 3.48785398e-16 3.67341332e-16 3.86379240e-16 4.05899120e-16 4.25900973e-16 4.46384799e-16 4.67350598e-16 4.88798370e-16 5.10728114e-16 5.33139832e-16 5.56033522e-16 5.79409185e-16 6.03266821e-16 6.27606429e-16 6.52428011e-16 6.77731564e-16 7.03517091e-16 7.29784590e-16 7.56534062e-16 7.83765507e-16 8.11478924e-16 8.39674314e-16 8.68351676e-16 8.97511011e-16 9.27152319e-16 9.57275599e-16 9.87880852e-16 1.01896808e-15 1.05053728e-15 1.08258845e-15 1.11512159e-15 1.14813671e-15 1.18163379e-15 1.21561285e-15 1.25007389e-15 1.28501689e-15 1.32044187e-15 1.35634882e-15 1.39273775e-15 1.42960864e-15 1.46696151e-15 1.50479635e-15 1.54311317e-15 1.58191196e-15 1.62119271e-15 1.66095545e-15 1.70120015e-15 1.74192683e-15 1.78313548e-15 1.82482610e-15 1.86699869e-15 1.90965326e-15 1.95278980e-15 1.99640831e-15 2.04050879e-15 2.08509125e-15 2.13015568e-15 2.17570208e-15 2.22173046e-15 2.26824081e-15 2.31523313e-15 2.36270743e-15 2.41066587e-15] all in joules.

e) See Lab4_q3e.py by me. With nmax, mmax = 100, I took the eigenvectors from the previous file and created a wave function and integrated the modulus squared of the wave function.
I found the value of the integral to be A = 2.20022838115e-10, which is what I would expect for an un-normalized probability. I then found $\sqrt{A}$ = 1.48331668269e-05 and divided my probability density by $\sqrt{A}$ so that I would get

$$1 = \frac{1}{\sqrt{A}} \int_0^L |\psi(x)|^2 dx$$

The graphs with the probability densities of the ground state, 1st excited state, and 2nd excited state was shown on the same plot.