PHY407: Lab 5

Date: October 15th. 2021

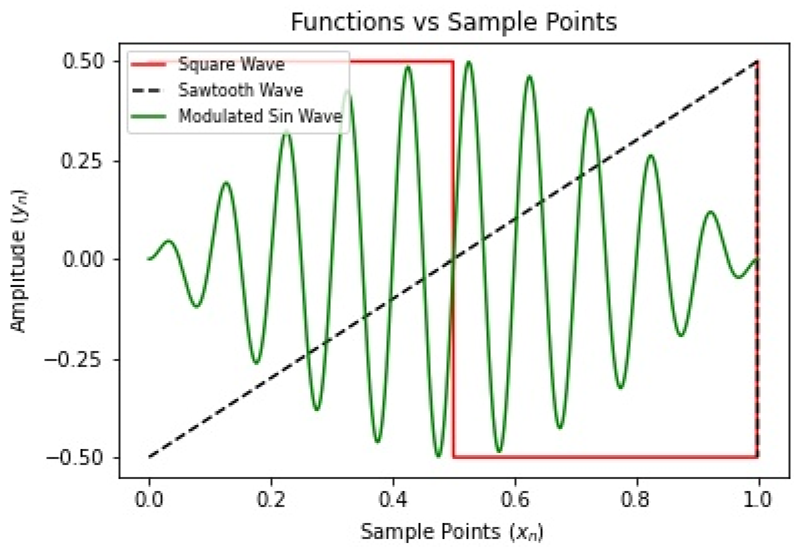
Lab Partners: Brendan Halliday and Nikolaos Rizos

Contributions:

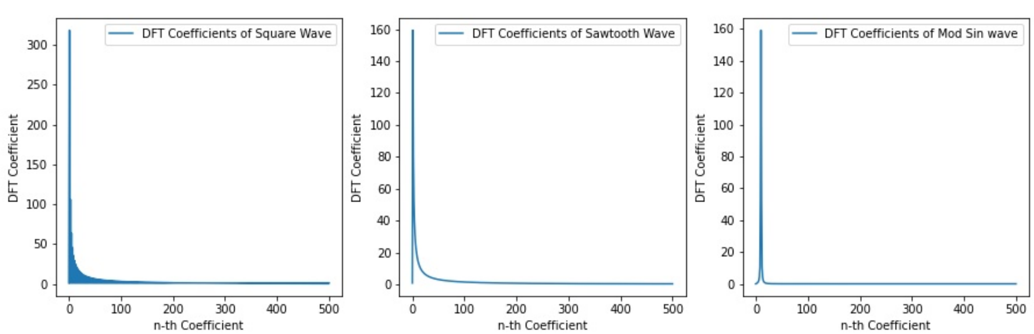
- Q1. Nikolaos Rizos
- Q2. Brendan Halliday
- Q3. Brendan
- Q4. Nick

Q1.a.

The functions described in Newmann Ex.7.1 are plotted below and appear on the same graph (They are all normalized by being plotted from 0 to 1, and having amplitude 1):

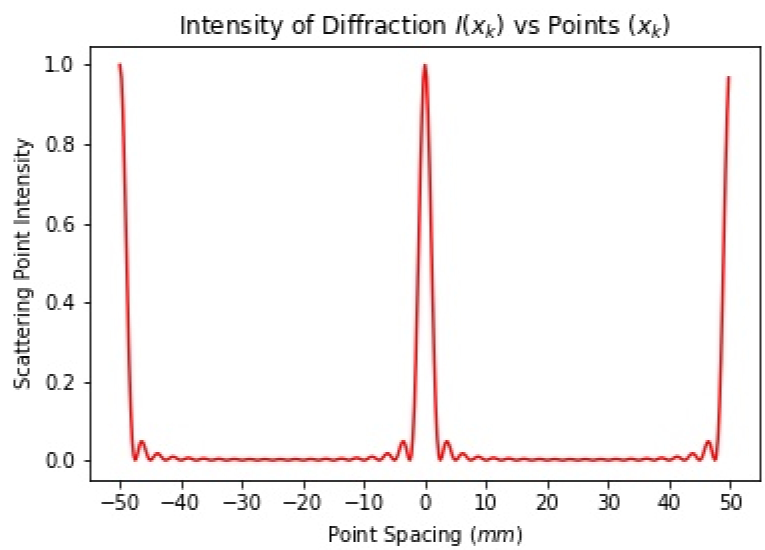


The Fourier coefficients of each of these functions, corresponding to their Fourier transforms, evaluated at N = 1000 equally spaced points appear below:



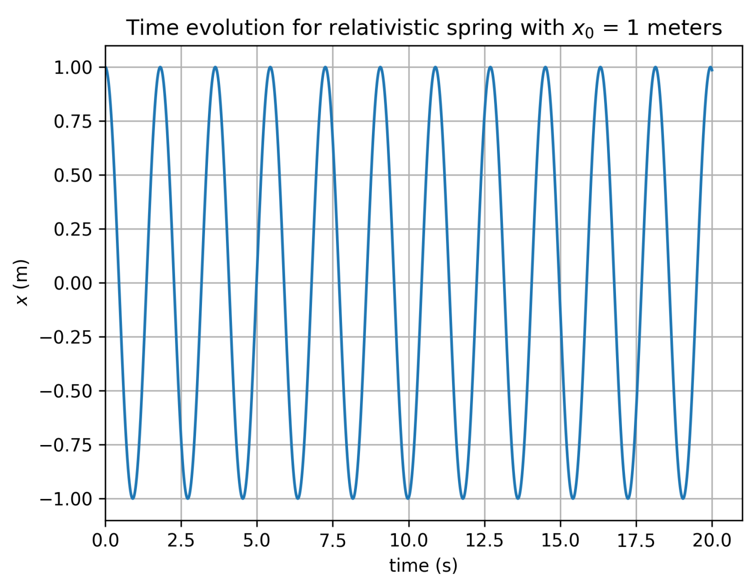
Q1.b.

The diffraction pattern for the given parameters appears below in the form of the intensity of the points where the light hits the wall, between -5cm and 5cm:

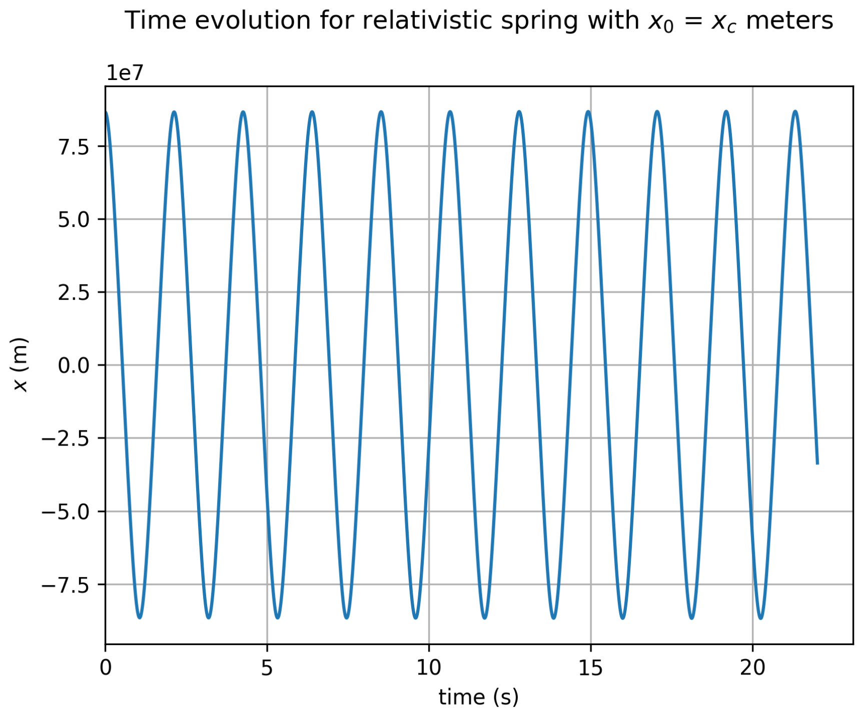


Q2.a.

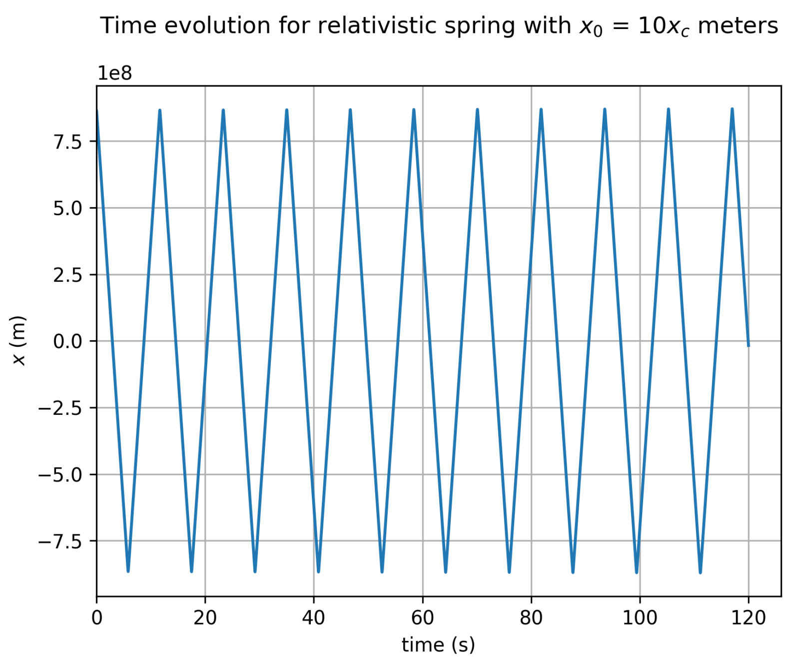
The following are the time evolution plots for the relativistic spring. The first plot is of the position as a function of time for an initial displacement of x_0 = 1m. The time increment used was 1.e-4 with a total number of steps being N = 200000. This gives approximately 10 periods:



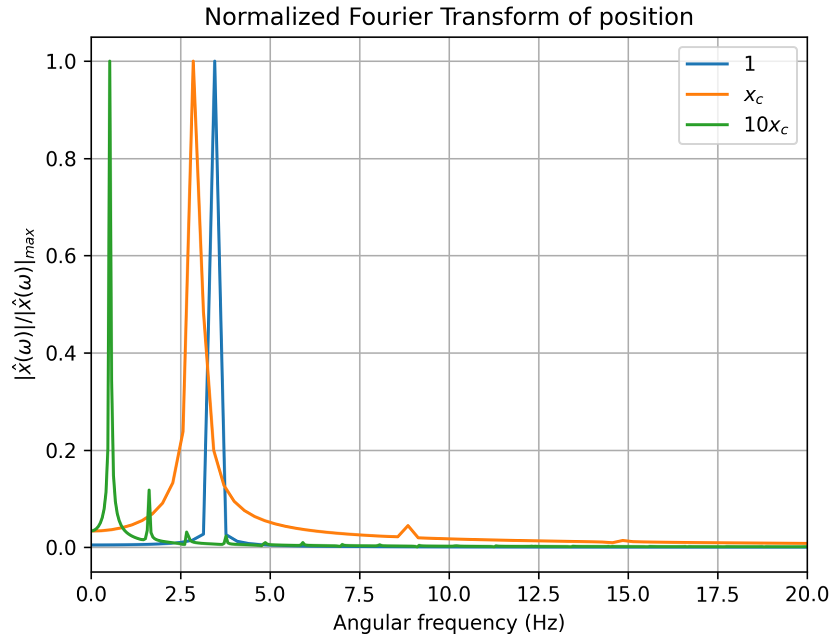
The second graph is that of x_0 = x_c where x_c is the displacement of the spring required for a max speed of c (the speed of light). The time increment used was 1.e-4 with a total number of steps being N = 220000:



The third graph is that of x_0 = 10x_c. The time increment used was 1.e-4 with a total number of steps being N = 1200000:

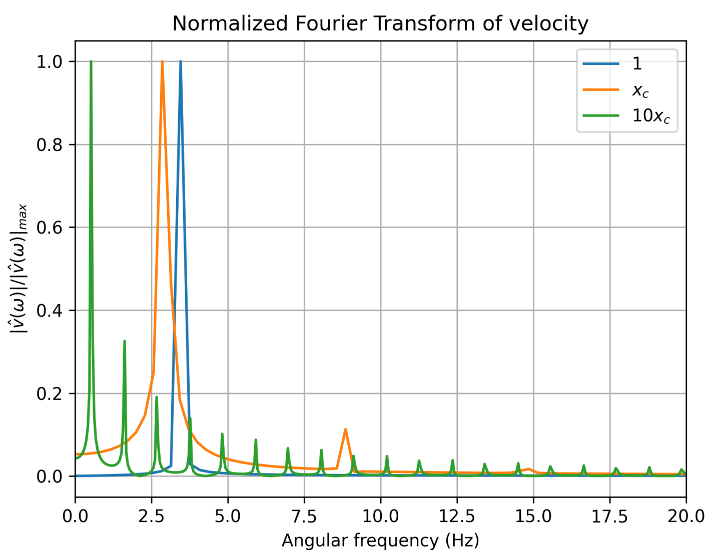


Below is the normalized fourier transform for position of the three simulations:



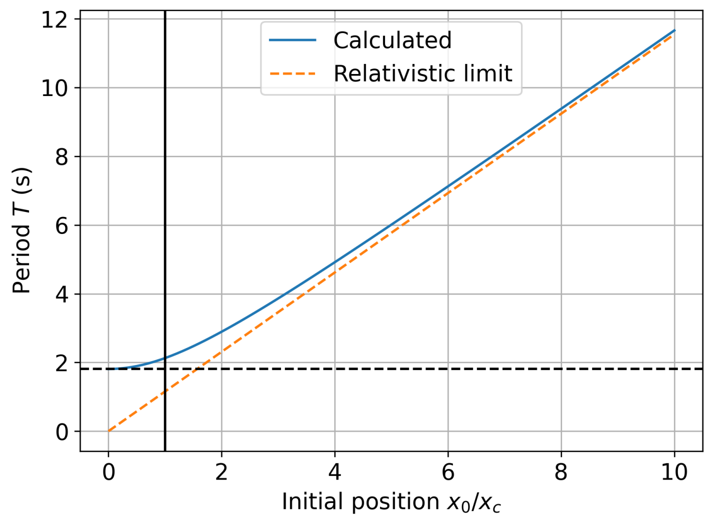
This plot makes sense since the x_0 = 1m has only one spike near omega = 3 which indicates that it behaves like a non relativistic spring composed of a single frequency. As the initial displacement increases and the speeds become relativistic, we notice a more complex spectrum. More spikes in 10x_c and x_c implies a more complex periodic function. This seems true since 10x_c is not sinusoidal at all.

Below is the normalized spectrum for the velocity of each simulation:

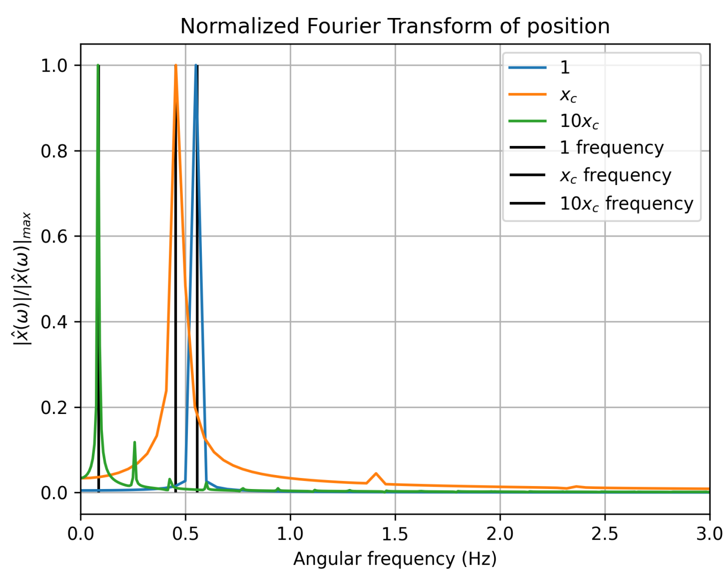


Here we notice that the spectrum has larger more visible spikes for x_c and 10x_c.

I did not have enough time to go through the quantitative details of computing the period for the relativistic spring in each simulation using Gaussian quadratures. However, I used this plot[1] from lab 3:



We can estimate the period of x_0 = 1m to be 1.8 seconds, x_0 = x_c to be about 2.2 seconds, and x_0 = 10x_c to be roughly 11.5 seconds. Plotting the vertical lines of 1/T in frequency space, we have:



Which nearly perfectly matches up with the main frequency from each simulation. This shows that both methods give similar approximations.

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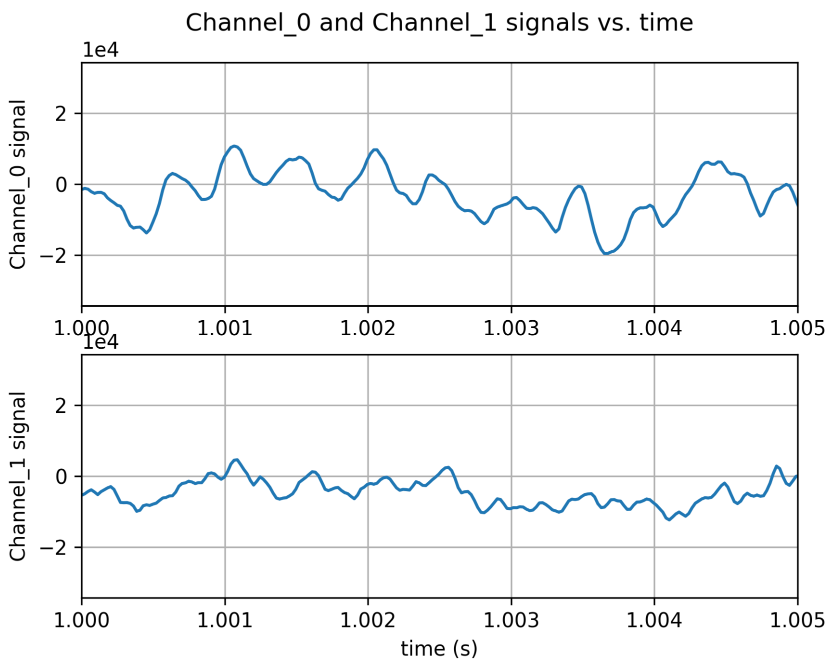
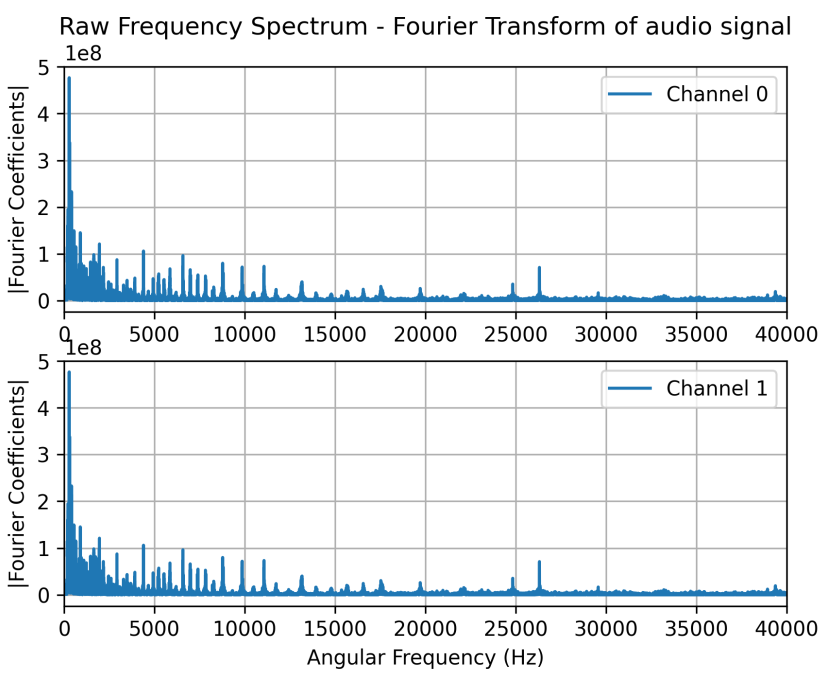
[1] This plot was created by Nicolas Grisouard

Q2.b.

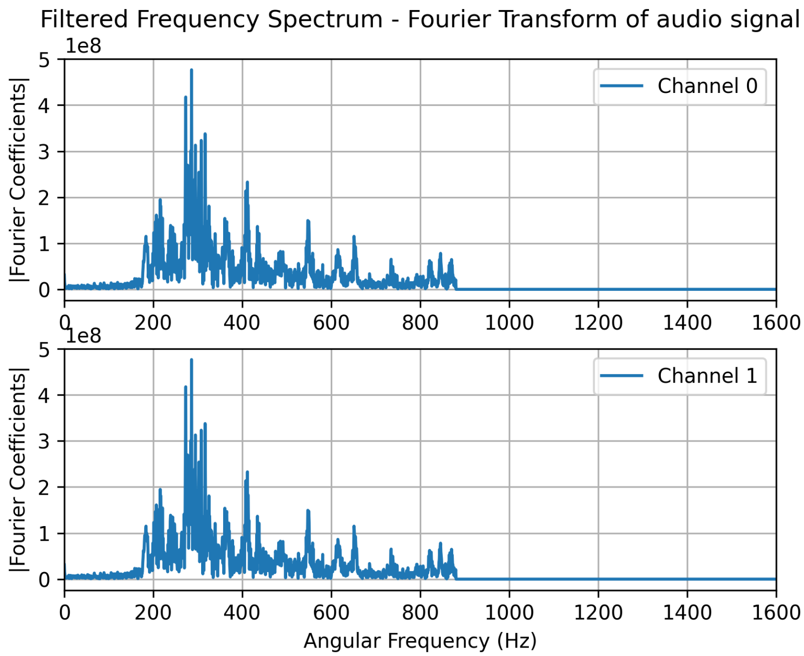
Below are the plots for the data in both channels from 1 to 1.005 seconds



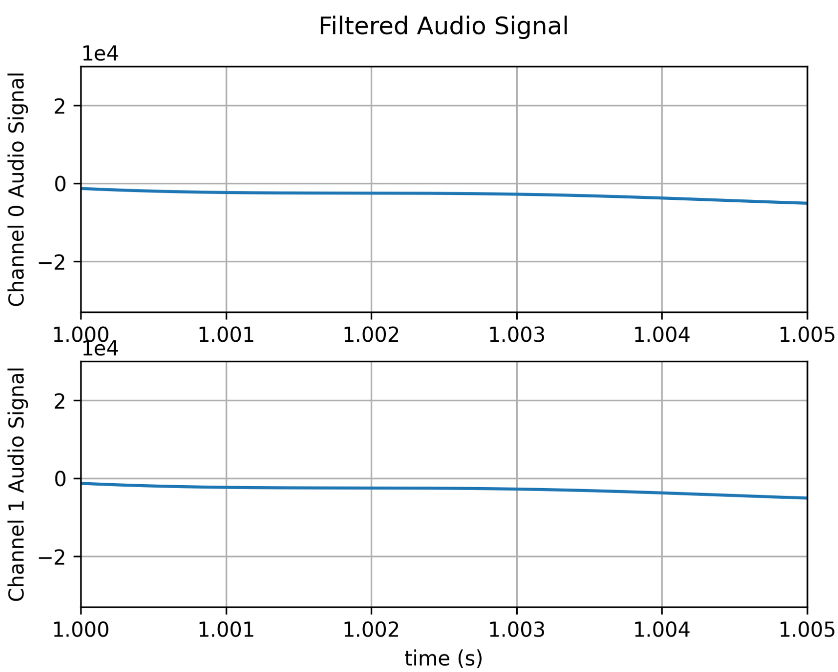
Below are the Fourier transforms of each signal:



Below are the same transforms with all frequencies greater than 880 Hz deleted:



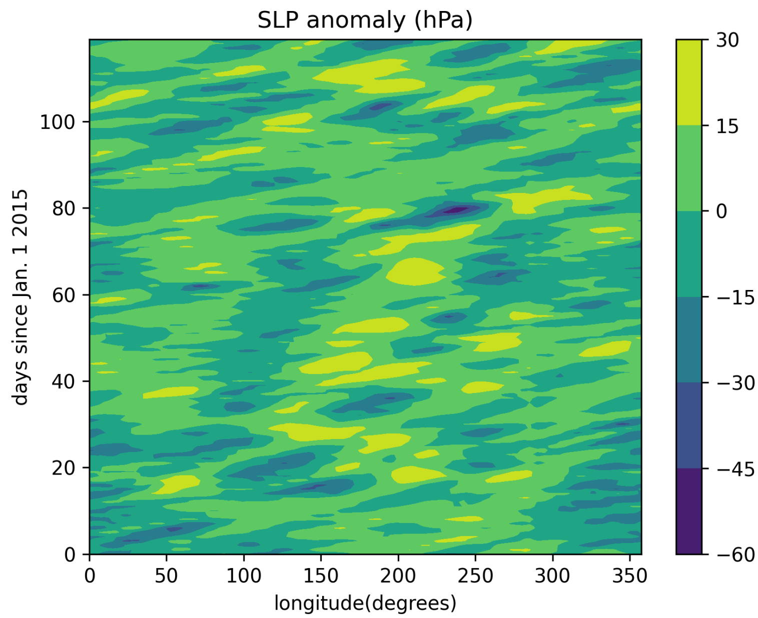
Below is the filtered signal after an inverse fourier transform was applied to the above transform:



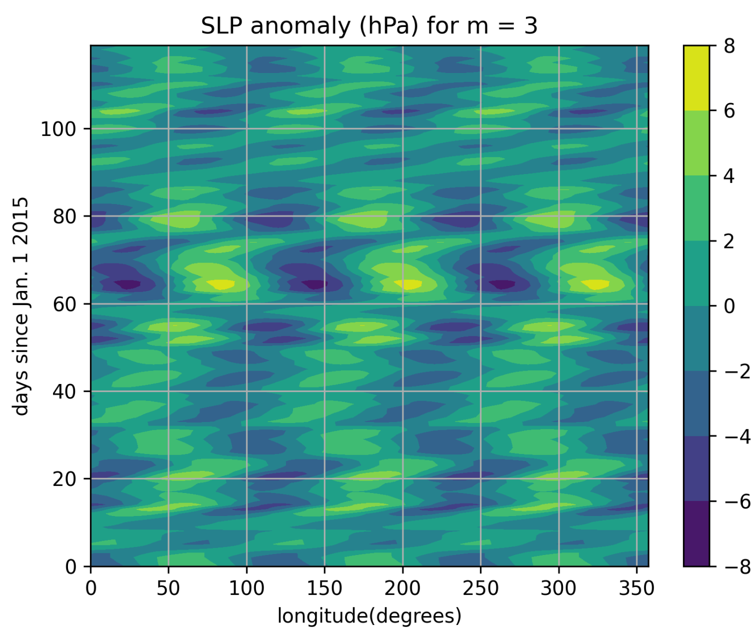
A copy of the song is included with this report.

Q3.a.

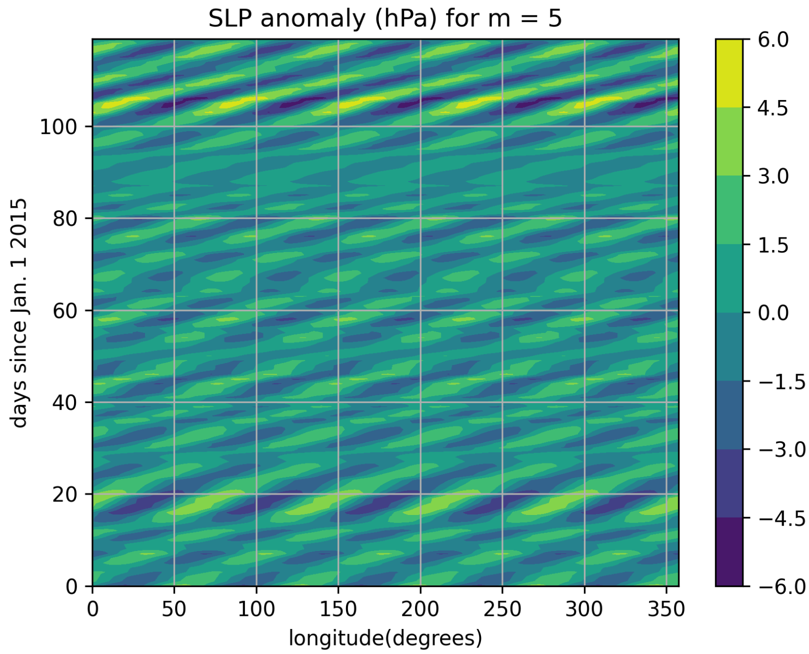
Here is the plain plot of SLP:



Here is the plot of SLP with only longitudinal wavenumber m = 3.



Here is the plot of SLP with only longitudinal wavenumber m = 5:



It is visible that for larger wavenumber and hence shorter wavelength, m=5 has a steeper gradient in the streaks of pressure as a function of time.

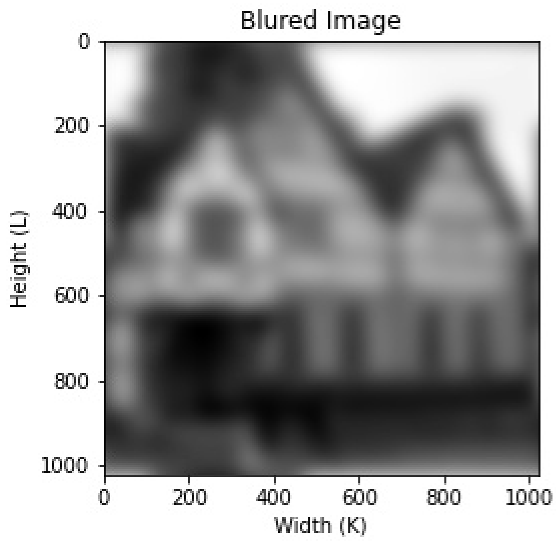
Q3.b.

Upon inspection, the plot shows diagonal streaks of propagation. As time evolves, areas of similar pressure move to the left.

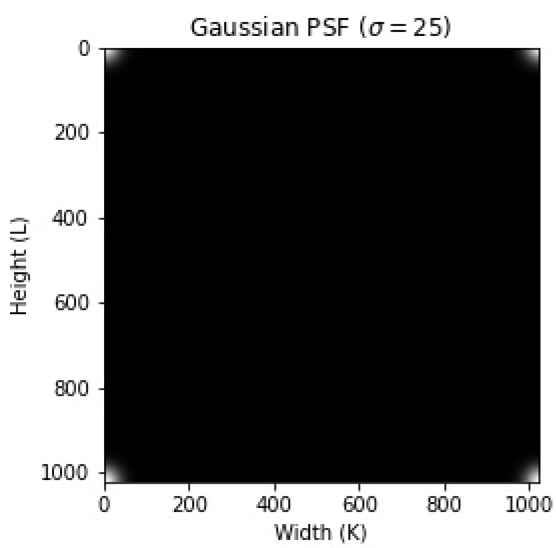
To estimate the speed of propagation, a graphical method was used. When the code is run, the contour plot for m = 5 is displayed. The streaks of propagation are essentially linear, estimate the end points of the streaks, the slope of longitude over time could be estimated. A function was written to then calculate the linear speed of the propagation based on the rise(longitude) and the run(time). A user input program was written to calculate the linear speed of propagation with end points of the line (L2, t2) and (L1, t1). For instance, we can calculate the slope of the long dark streaks at the top of the plot. Take (L2 = 200 degrees, t2 = 120 days) and (L1 = 0 degrees, t1 = 100 days) which gives an angular velocity of 5 degrees / day. Converting this to meters per second based on the latitude of observations, we get a speed of about 8.27 m/s. This user input function can be used for any (L2, t2) and (L1, t1) you desire.

Q4.

The blurry image was compiled from the “blur.txt” file and it appears below:

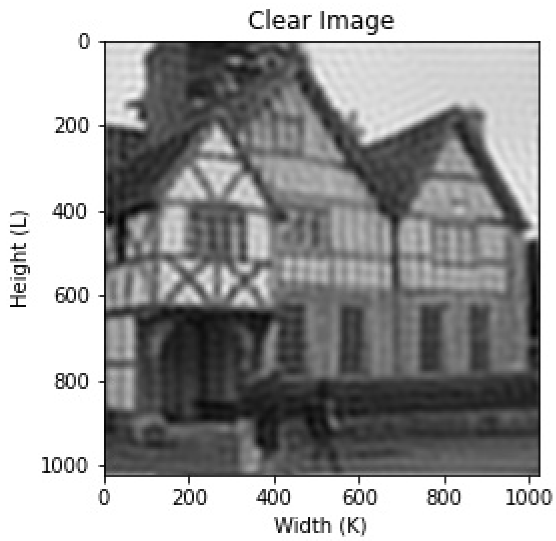


The sample of the Gaussian Point Spread Function which contributed to the blur of the above picture was created and its plot appears below:



As we can see from the bright spots in the corners, the function is periodic and thus consistent with what the exercise outlined.

After taking the Fourier transform of the Gaussian PSF function plotted above, the Fourier transform of the original blurry image data, dividing the two and then by the dimensions of the picture, and then taking the inverse transform of the result, we used the data resulting from this process in order to graph the now clear image. This image appears below.



The pattern in the picture can clearly be observed, although the picture is not completely clear (its resolution could be higher).