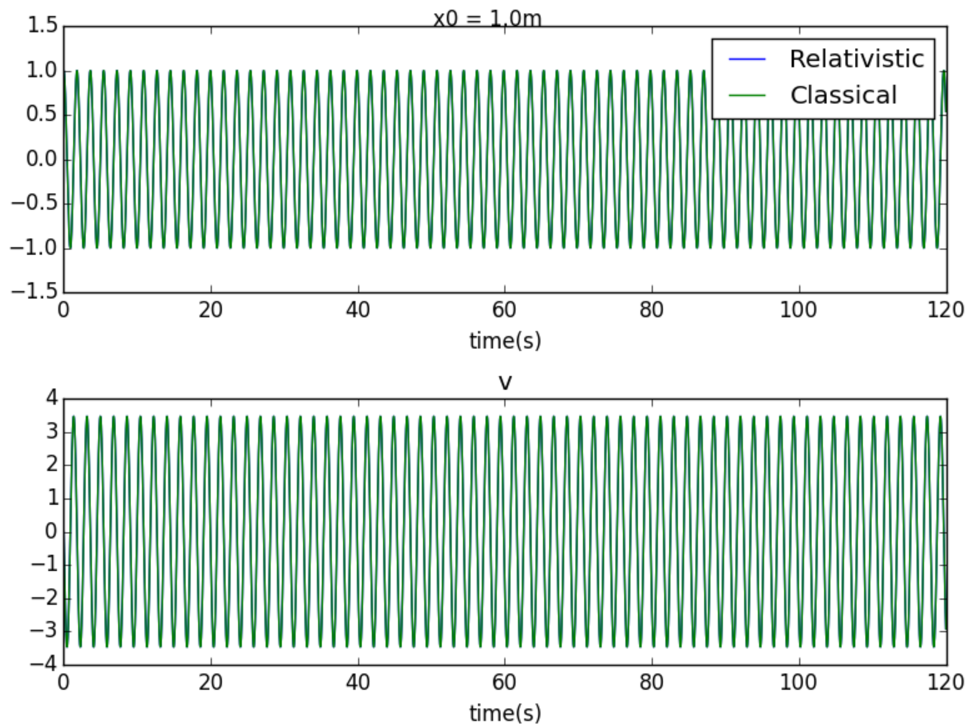
# PHY407H1 Lab5

Eric Yeung*
*Department of Physical Sciences, University of Toronto, Toronto M1C 1A4, Canada*
(Dated: October 16, 2015)

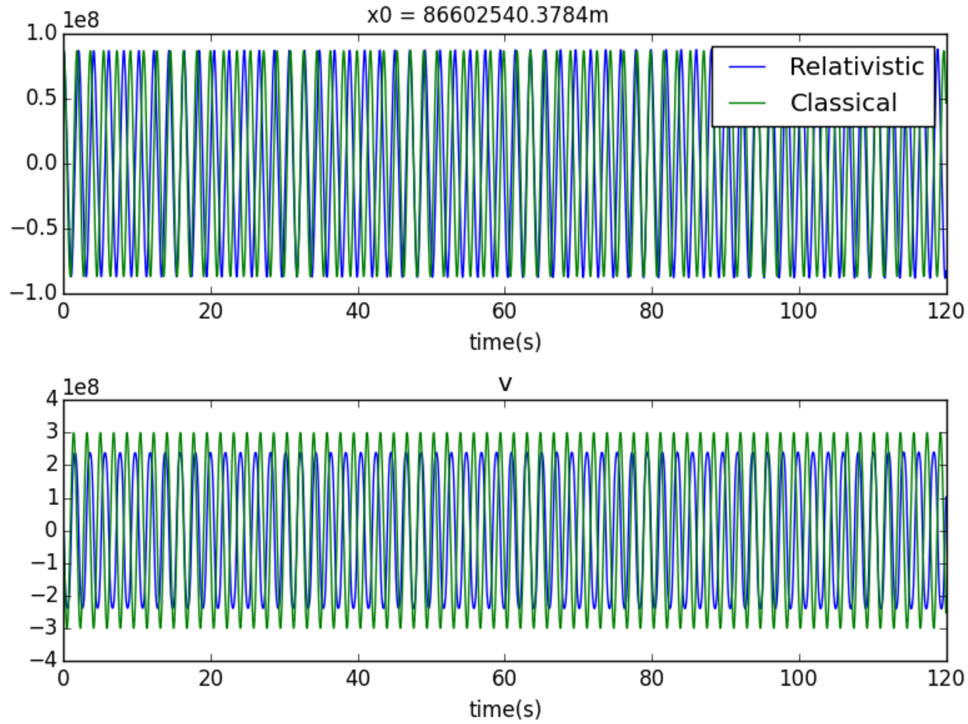
## QUESTION 1

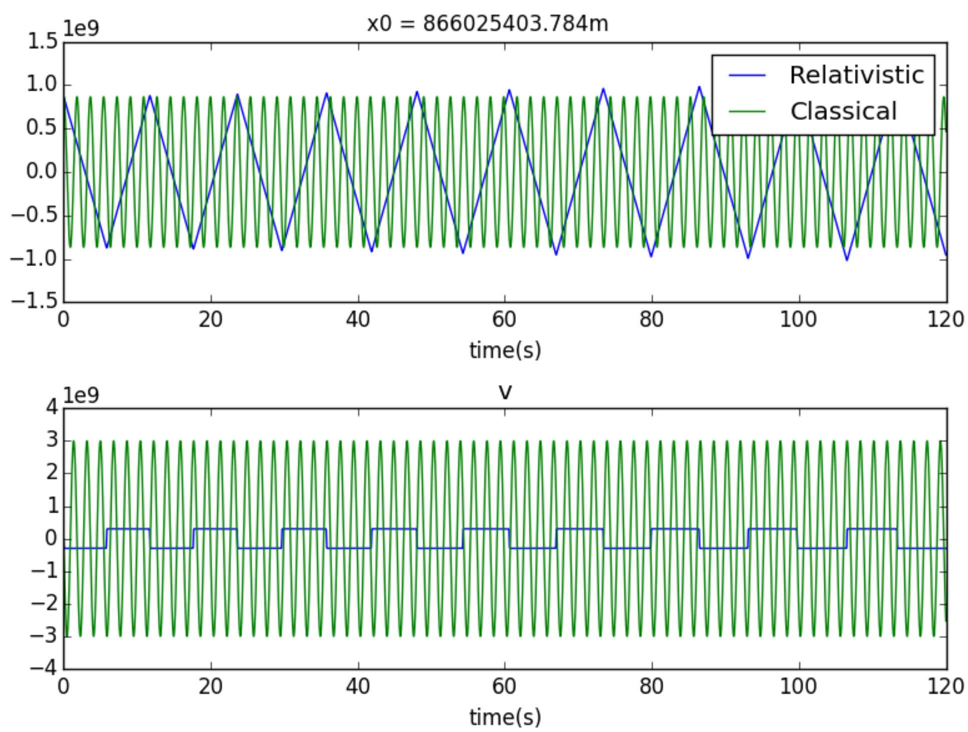
a) See Lab5_q2a.py by Chi.

Here is the simulation of the relativistic spring system that were in Lab 1. The time series is very long, looks way more than 10 periods. The following 3 graphs are for $x_0 = 1$, $x_0 = x_c$, $x_0 = 10x_c$ metres respectively.

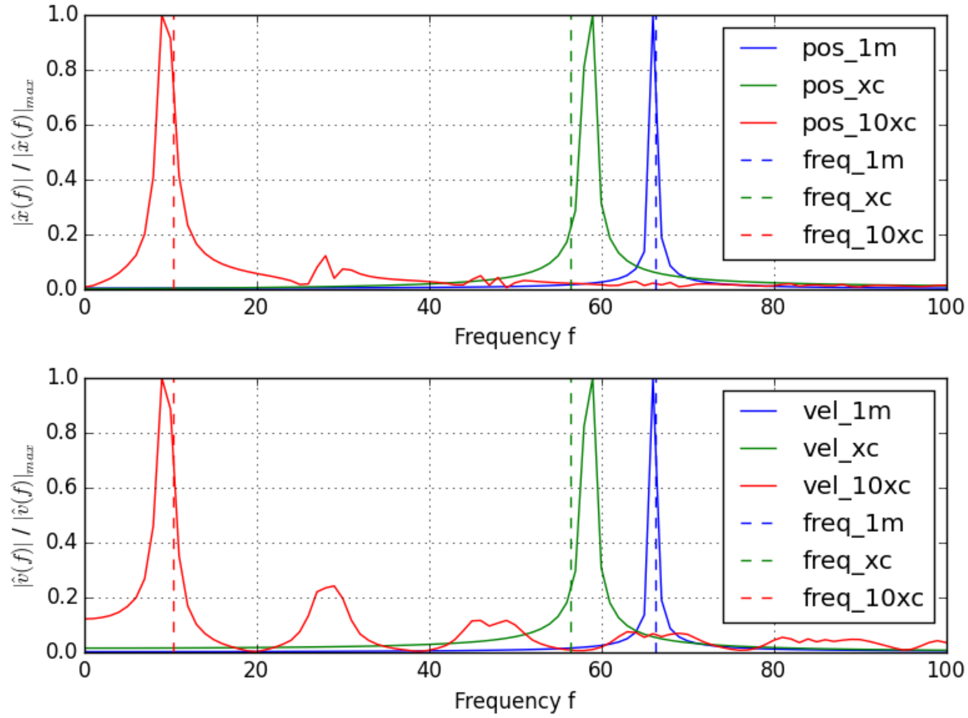



* eric.yeung@mail.utoronto.ca


x0 = 86602540.3784m
Relativistic
Classical
time(s)
v
time(s)


x0 = 866025403.784m
Relativistic
Classical
time(s)
v
time(s)

Now we find the Fourier transform of x(t) with Fourier coefficients $\hat{x}(f)$. The plot below shows the scaled quantity $|\hat{x}(f)|/|\hat{x}(f)|_{max}$. As one can see, the frequency of the $10x_c$ case is around 10, where the ones for 1 and $x_c$ are low 60s and high 50s respectively. This makes sense and it is reflected in the time series graphs. The lower the initial condition, the more frequent the oscillations for the relativistic case.



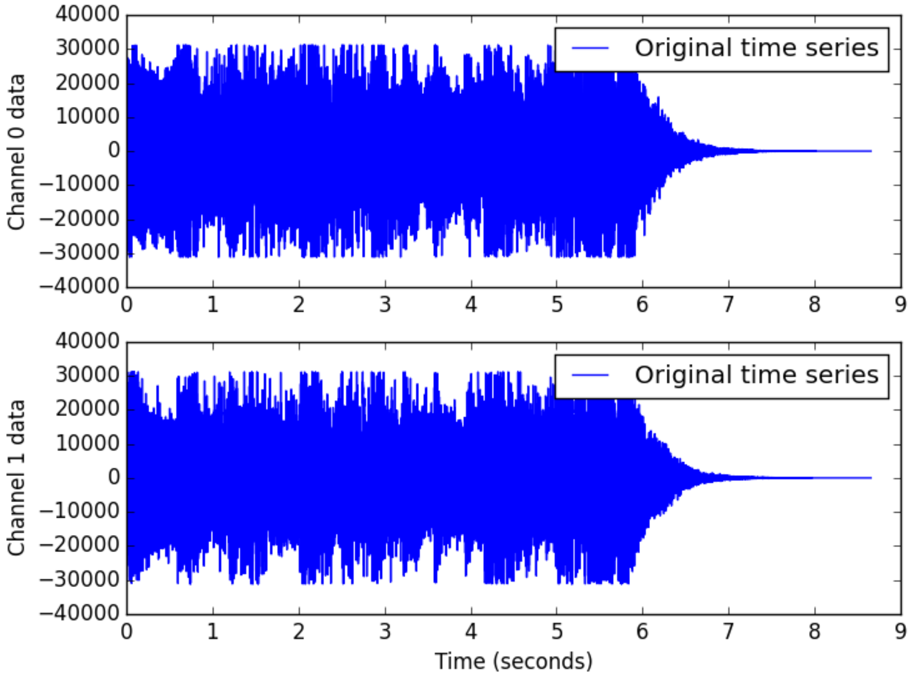

Now we do it for velocity instead of position. The main difference I see between the position and velocity spectra is that the velocity for $10x_c$ graph has bigger "bumps" around 30, 50, 70, and 90 Hz. The characteristic frequencies seem to have stayed the same.

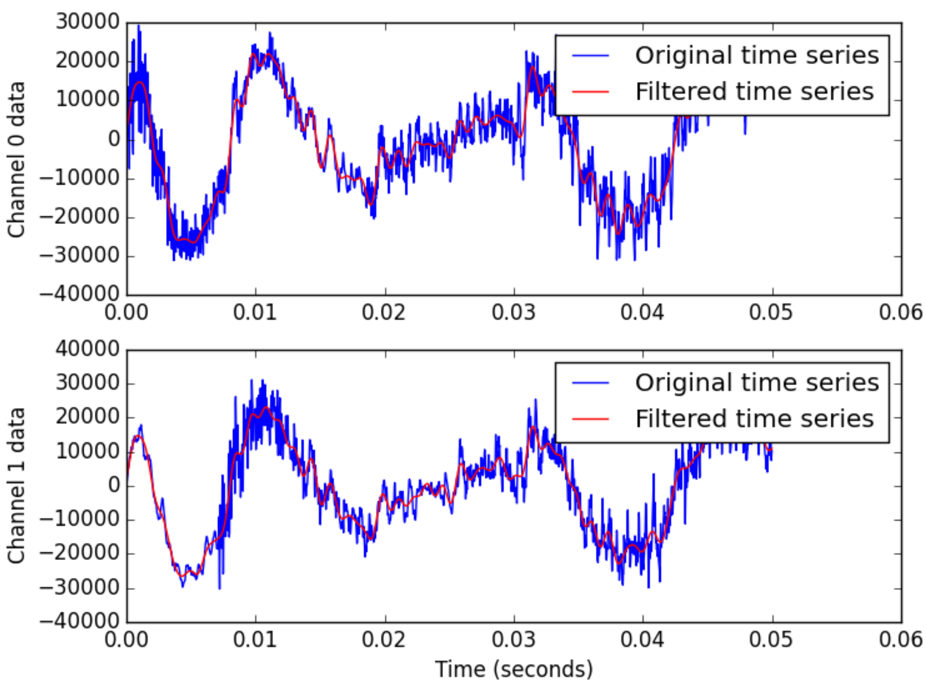
In Lab 3, Equation (4) gives the period estimate:

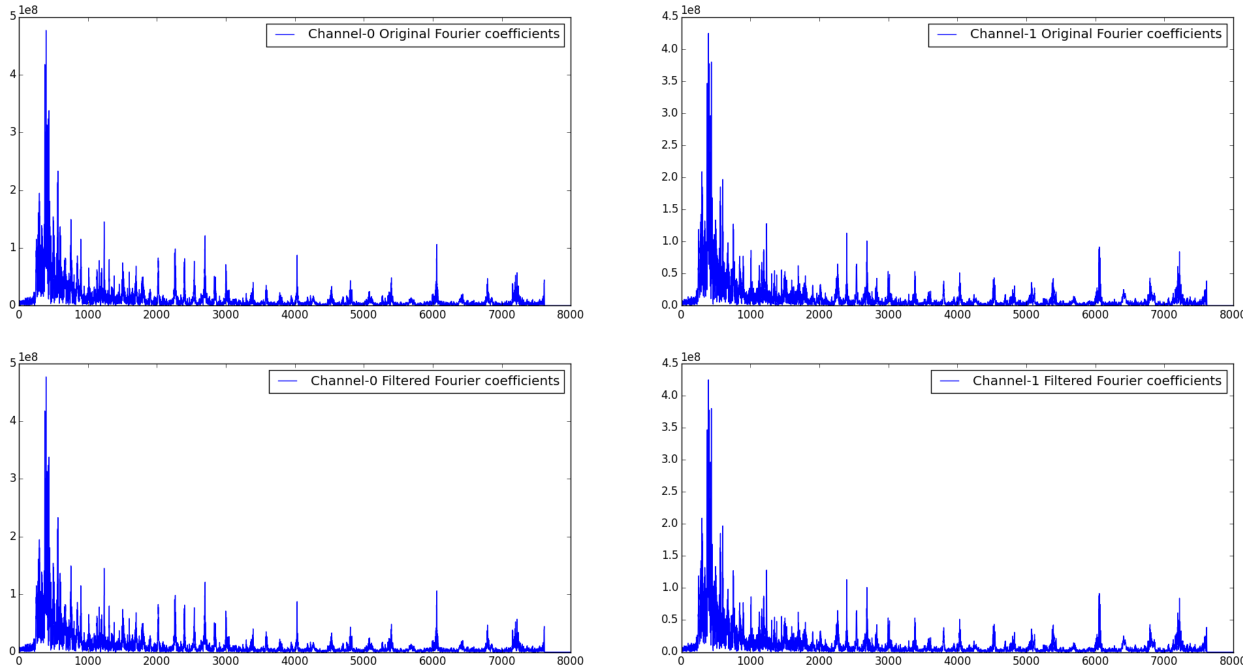
$$T = 4\int_0^{x_0} \frac{dx'}{g(x')}$$

From the frequencies obtained from the spectrum, the periods when $x_0 = 1, x_c$, and $10x_c$ are computed to be 1.810253652, , 2.12766797679, 11.6608876365 seconds respectively. This is pretty close to what we found in Lab 3.

b) See Lab5_q2b.py by Chi.

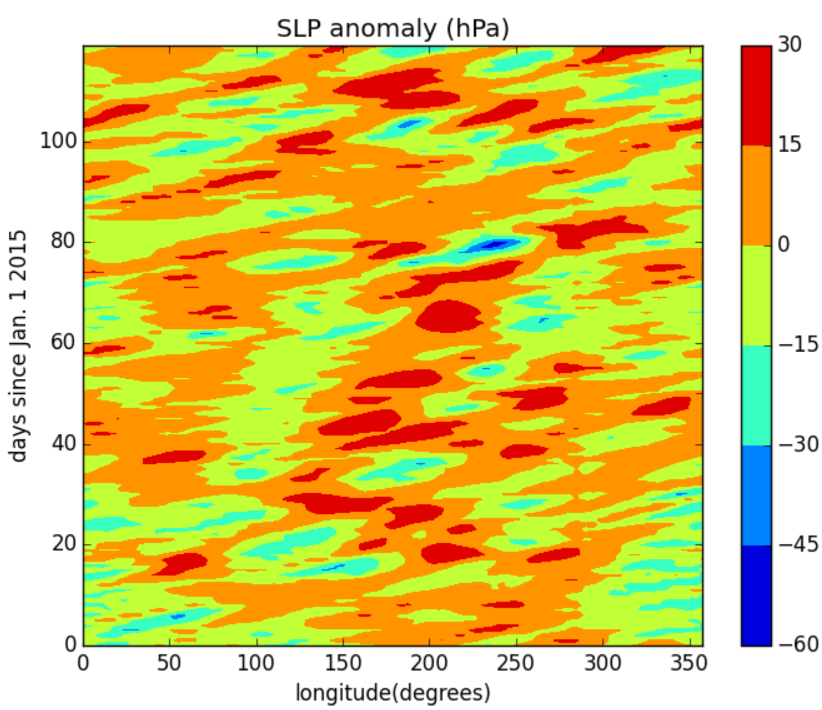


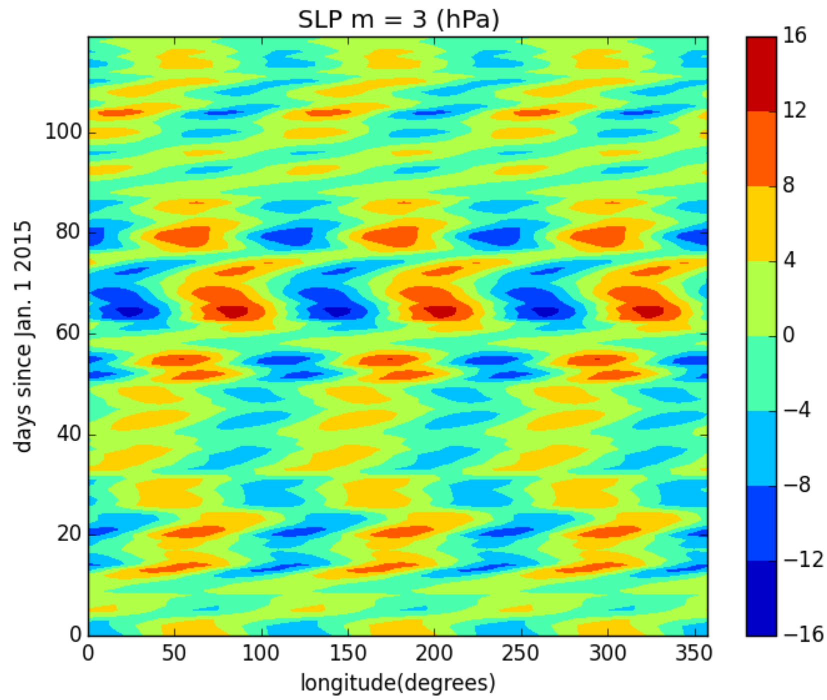



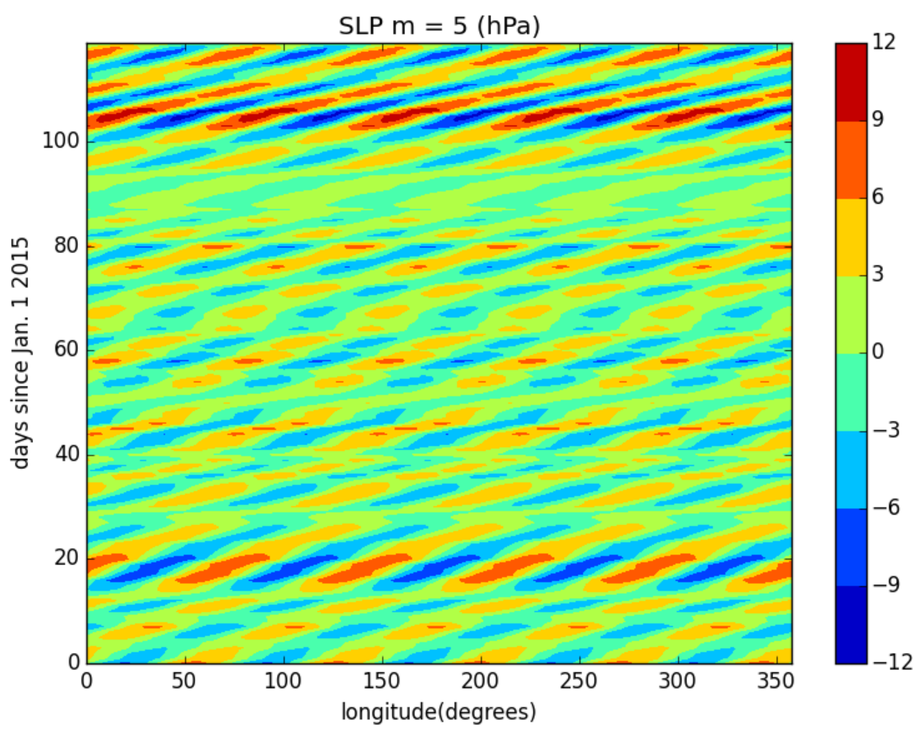



## QUESTION 2

b) See Lab5_q2a.py by me. This file covers both (a) and (b).





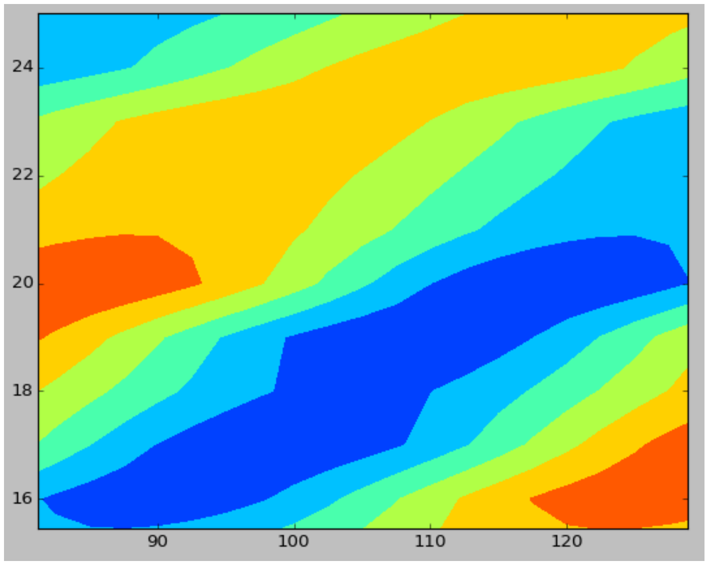




From the plots, we can see that there are 5 troughs when we isolate the m = 5 component of SLP, and only 3 troughs when we look at the m = 3 case. The waves of the m = 5 case also seem to longer. To clarify, there are 3 "red areas" and 3 "blue areas" that can fit horizontally in the m = 3 case. This is what the Fourier wavenumber corresponds to. Likewise, there are 5 red and blue areas that can fit in the m = 5 component. The troughs in the m = 5 case are a lot

less slanted than in the m = 3 case. As time is our y-axis, less slanted slopes of areas of similar pressure indicate slow movement of the "low pressure centres". The higher the slope, the faster the pressure changes as shown by the rapid change in colour when the days increase in our density plot. Therefore, the theory of atmospheric wave propagation is roughly consistent with what I see.

c) See Lab5_q2c.py by me.

I zoomed in on the m = 5 case. I look at the slope of one of the troughs.

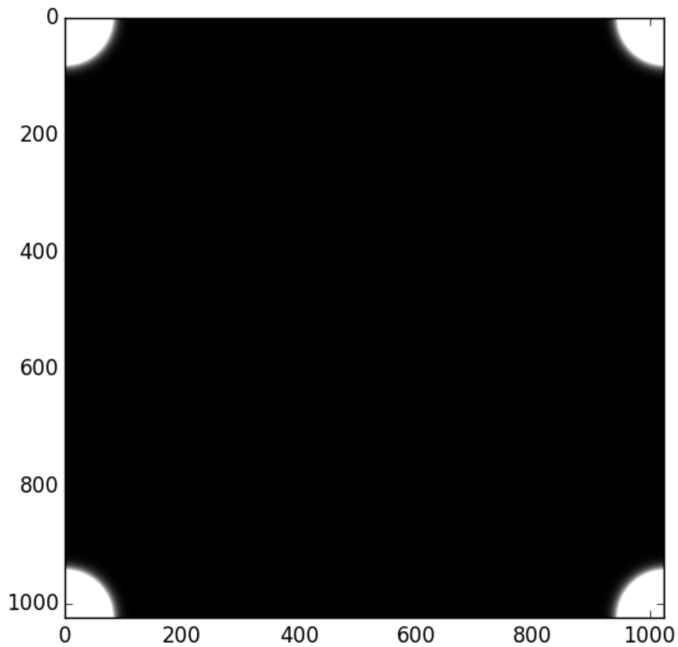



The circumference of the latitude is 25730899.60 metres or 25730.90 kilometres. I would find the velocity by looking at the slope of my zoomed-in trough. Using the latitude-longitude relationship $DLat = DLong \times \cos(Lat)$, I get a new array. And after converting the days into seconds, I use the generic velocity formula $v = \Delta d/\Delta t =$ 2.23502733488e-05 m/s. And of course, the waves are propagating east.

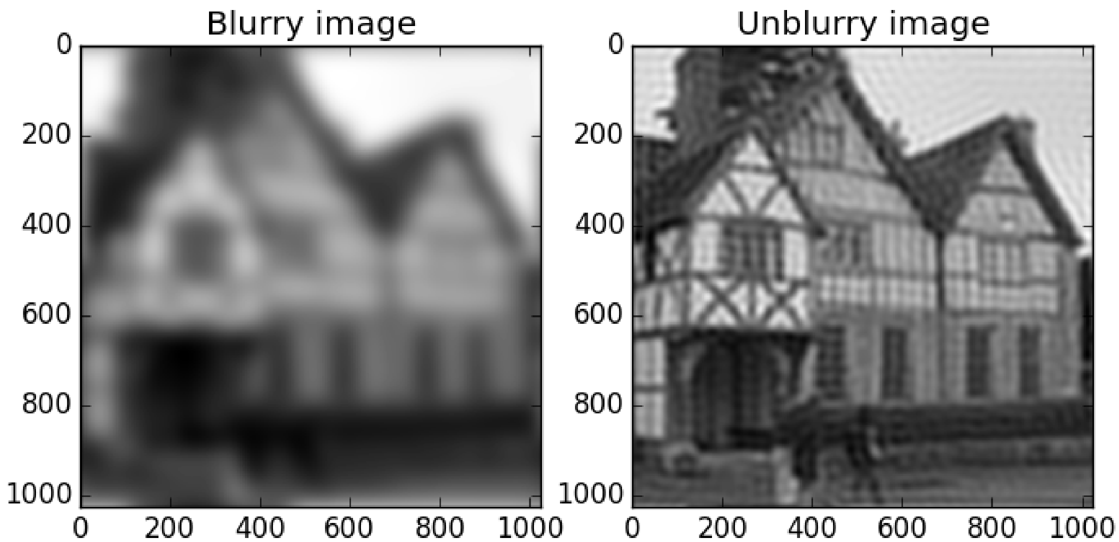
Therefore, I estimate that the velocity of propagation is around $2.23 \times 10^{-5}$ m/s [East].

**QUESTION 3**

All the parts in the question are in Lab5_q3c.py by me.
The Gaussian f(x, y) was plotted below.




Now we want to combine the two programs a) and b) and essentially sharpens the blurry photo. It turns out that the photo was a picture of people walking by a house. As seen by the comparison below, the program did a pretty good job.


Blurry image
Unblurry image
0
200
400
600
800
1000