Lab 9 Report

Habiba Zaghloul, Augustine Tai

November 22, 2022

Q1 b

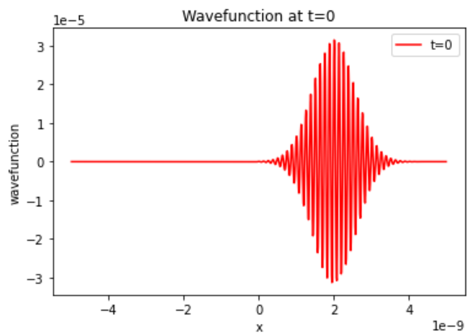


Figure 1: The real part of ψ (x) at t=0

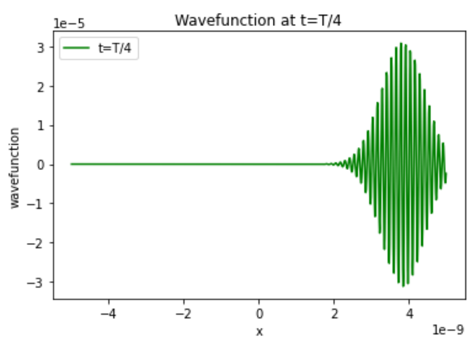


Figure 2: The real part of ψ (x) at t=T/4

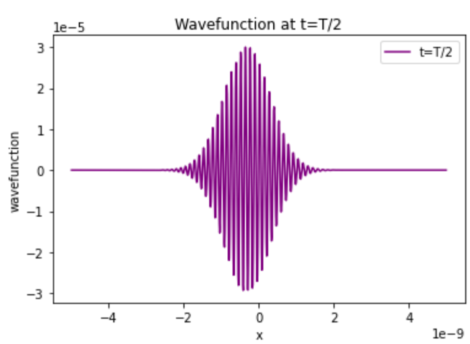


Figure 3: The real part of ψ (x) at t=T/2

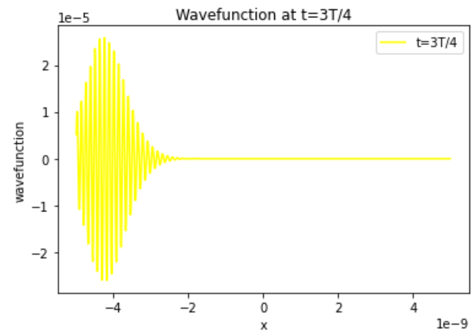


Figure 4: The real part of ψ (x) at t=3T/4

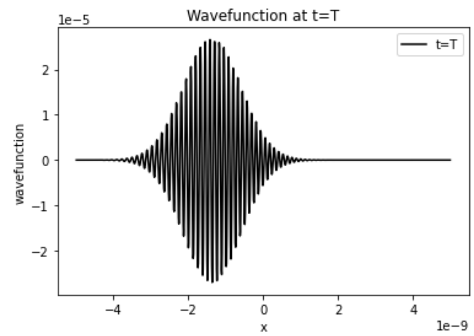


Figure 5: The real part of ψ (x) at t=T

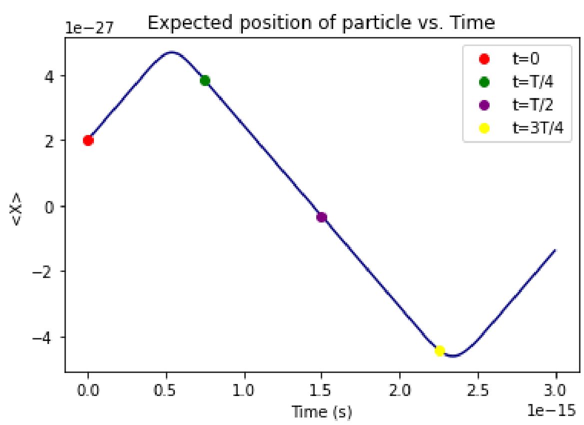
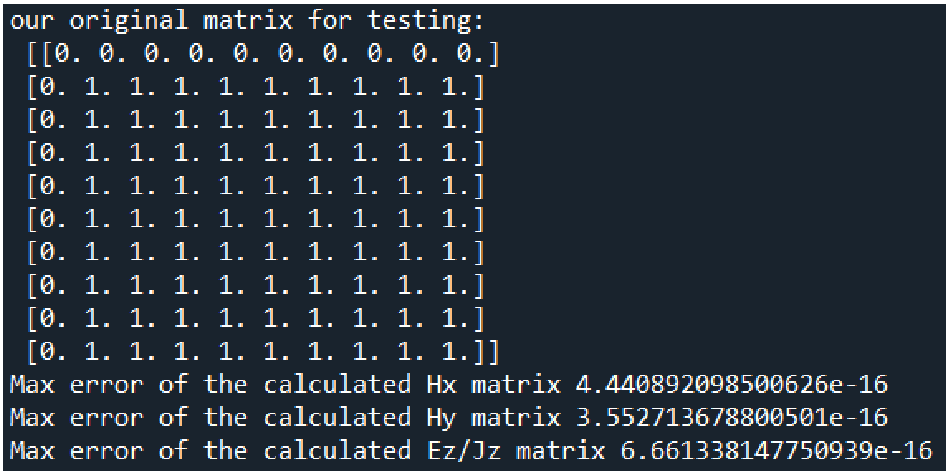


Figure 6: This plot shows the particles expected trajectory from t=0 till t=T

Q2 a

In order to test whether our 2D Fourier transforms and their inverses are working correctly, we created a matrix f, and Fourier transformed it and then inverse transformed it to see whether the resulting matrix was still the same. We then subtracted our original matrix with our transformed matrix to determine the difference/error between them. To measure the error and the amount of difference between the two matrices, the maximum difference between them is provided in Figure 1 to determine the severity of the difference. The original matrix being transformed is a 10x10 matrix with its first column and rows set to 0, as the functions in the dcst.py code sets the first elements of each row and columns to 0. Note that the actual value of the 10x10 matrix that underwent Fourier transform and inverse transform is outputted in the code, the printout of it is omitted here as the 10x10 matrix is quite big, so only the max difference between the original and the transformed matrix is outputted in Figure 7. As a result, the max difference between the original matrix and the transformed matrix will serve as a measure to see whether the 2 are equal.



```
our original matrix for testing:
 [[0. 0. 0. 0. 0. 0. 0. 0. 0. 0.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]
 [0. 1. 1. 1. 1. 1. 1. 1. 1. 1.]]
Max error of the calculated Hx matrix 4.440892098500626e-16
Max error of the calculated Hy matrix 3.552713678800501e-16
Max error of the calculated Ez/Jz matrix 6.661338147750939e-16
```

Figure 7: The Figure above shows the printout, checking whether the transforms and inverses transforms work as intended. Additionally, the original 10x10 matrix was shown. In the code the resulting matrices after transforming will also be outputted

By observing Figure 7, the maximum difference in values between the transformed and original matrix for Hz, Hy, and Ez respectively, are both on the order of 1e-16, indicating a very small difference between the two matrices. The difference might be due to floating points in the matrix/array when transforming because of machine precision. As a result, based on the small 1e-16 differences between the original and the transformed matrices, the 2D Fourier transform functions seems to be working as intended.

Q2 b

*Note that i separated the plots as Hx and Hy are exactly the same.

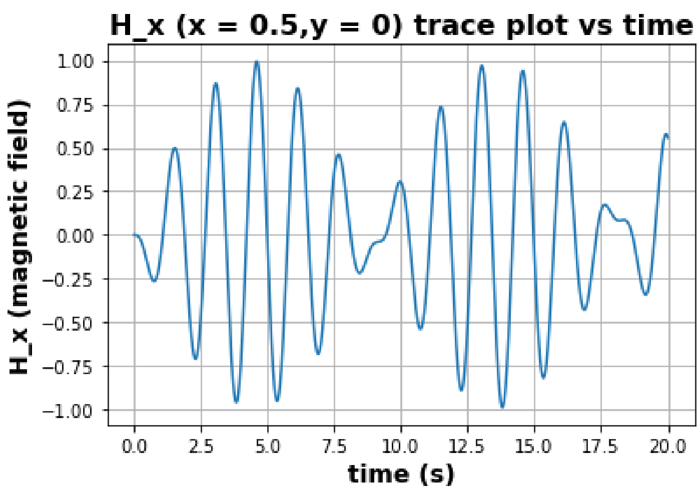


Figure 8: The above plot shows the trace for Hz at x = 0.5 and y = 0 as a function of time. Lx and Ly are partitioned into 32 cells/points.

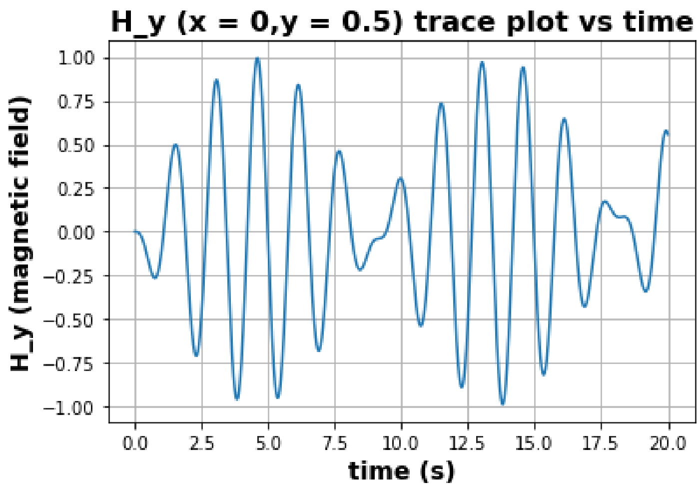


Figure 9: The above plot shows the trace for Hy at x = 0 and y = 0.5 as a function of time. Lx and Ly are partitioned into 32 cells/points.

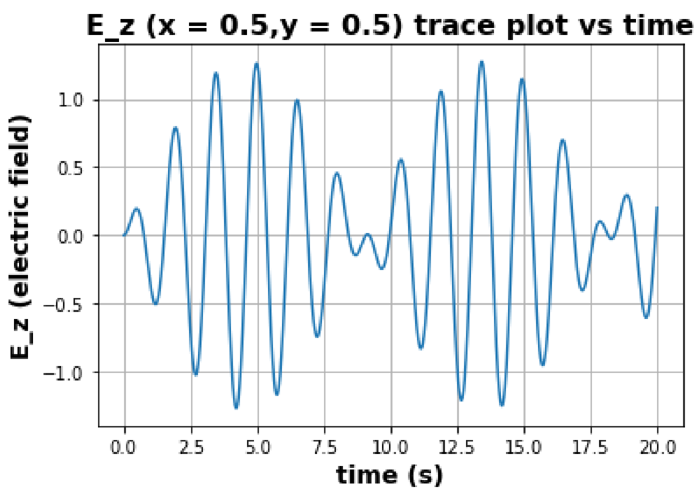


Figure 10: The above plot shows the trace for Ez at x = 0.5 and y = 0.5 as a function of time. Lx and Ly are partitioned into 32 cells/points.

Q2 c

Firstly, based on Figure 9 and 10, the trace of Hx at (0.5,0) and Hy at (0,0.5) are exactly the same. Indicating that Hx and Hy are equal to each other from t = 0-20s. Secondly, although the trace of Ez is different from Hx and Hy, these 3 plots share some similarities. By comparing Figure 11 to either Figure 9 or 10, at t = 0s, they start with a low amplitude and reach their respective maximum amplitudes close to t = 5s. After reaching their first max amplitude the traces (Hx,Hy,Ez) they reach a minimum around t = 8-9 s. Afterwards, the amplitude of the traces grow and reaches another maximum at around t = 13-14s, and proceed to get smaller in amplitude at t = 18-19s. Based on the available information, the oscillatory motion of the traces seems to be due to the alternating Jz current with driving frequency w = 3.75, causing the oscillating behaviour in the traces.