2110233 Com Eng Math Lab - (1/2024) Take Home Quiz

Submission: (1) pdf file and (2) ipynb before 23:59, 19 September 2024

Instructions:

- This exam is an open book exam.
- You are also allowed to open online resources, but you will have to answer in your own words and understanding. You must provide all references at the end of this document.
- The exam must be taken completely alone. You cannot share your answers or code with anyone.
- You can ask questions on discord in **#labexam1**, further announcement will be posted on **#announcement**
- You must complete the exam within this exam paper and submit in PDF file. The PDF file will be primarily scored, while the IPYNB file will be used as a reference for validating the PDF file. Make sure you provide **clear** and **original answers** to all questions **in your own words**.
- **Any student who does not obey the regulations listed above will receive punishment under the Faculty of Engineering Official Announcement on July 27, 2017 regarding the exam regulations.**

a) With implicit evidence or showing intention for cheating, student will receive an F in that subject and will receive a lower ethical behavior score.

b) With explicit evidence for cheating, student will force to withdraw from Chulalongkorn University, or students will an F in that subject during that semester and will be required to withdraw all subjects and receive a lower ethical behavior score.

I acknowledge all instructions above. This exam represents **only my own work**. I did not give or receive help on this exam.

Signature .....วรินธร จันทร์สว่าง.....

Date .....13 September 2024.....

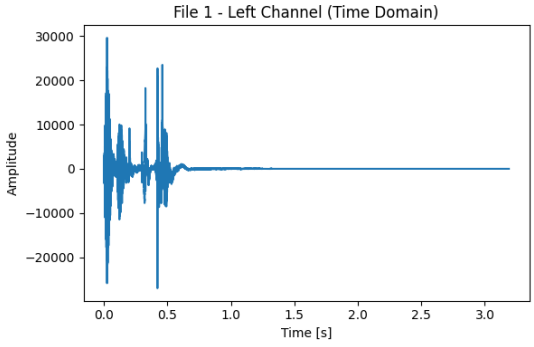
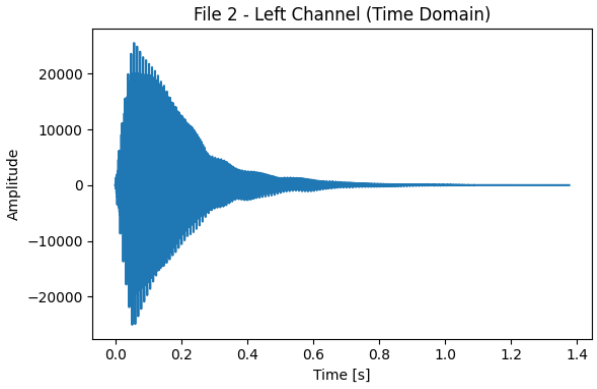
All required files and parameters have been sent to your Chula email.

1. (15 points) Audio Analysis

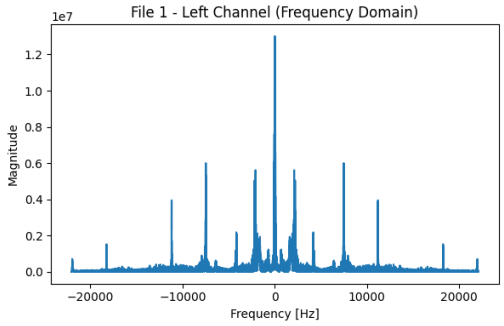
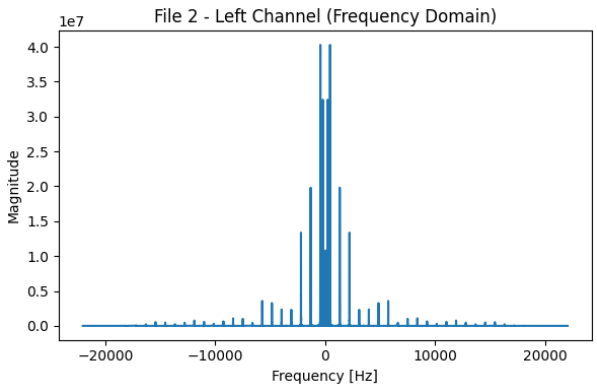
Download **`file1.wav`** and **`file2.wav`** from the links provided in your email. Perform a DFT to analyze and compare the signals.

1.1) Plot the **`file1`** and **`file2`** signals in time domain and its frequency spectrum (low frequency at the center)

`file1`:

Time domain	Frequency domain
	

`file2`:

Time domain	Frequency domain
	

1.2) Determine top three dominant frequencies of each signal in Hz. EXCLUDING the dc component and those that are the consequence of the **complex conjugate symmetry** property. Explain how you obtain these values.

Note: The 1st, 2nd, and 3rd dominant frequencies are those with the highest, second highest, and third highest magnitudes in the spectrum.

`File1`:

1st dominant frequency: 22.884 Hz

2nd dominant frequency: 23.197 Hz

3rd dominant frequency: 22.570 Hz

`file2:`

1st dominant frequency: 439.706 Hz

2nd dominant frequency: 440.433 Hz

3rd dominant frequency: 438.980 Hz

Explanation:

จากที่โจทย์บอกว่า EXCLUDING the dc component and those that are the consequence of the complex conjugate symmetry property.

จึงทำการเอา dc component ออกก่อน โดยการลบค่าเฉลี่ยของสัญญาณ

จากนั้นหาค่า magnitude ของแต่ละค่าความถี่ โดยการใช้ np.abs()

ในส่วนของ complex conjugate symmetry คือเอาเฉพาะสัญญาณที่อยู่ในฝั่งที่เป็นบวกเท่านั้น เพราะฉะนั้นตัดค่าของฝั่งที่เป็นลบออก

จากนั้นทำการเรียงลำดับหา dominant frequency ซึ่งคือการหาค่าที่มี magnitude สูงสุดจากมากไปน้อย 3 อันดับแรก โดยการใช้ np.argsort() แล้วนำค่า magnitude มาหาค่า dominant frequency

1.3) Analyze and compare the frequencies of the two signals and their corresponding sounds in your own words.

File 1 มีลักษณะตรงกับกราฟที่ plot ออกมา คือเสียงที่เด่นชัดอยู่ 2 จังหวะและมีความถี่ที่ต่ำเป็นส่วนใหญ่ ซึ่งสอดคล้องกับเสียงที่ได้ยิน คาดว่าจะเป็นเสียงคล้ายน้ำหยด

File 2 มีลักษณะตรงกับกราฟที่ plot ออกมา คือไล่ตั้งแต่เสียงดังแล้วค่อยๆ เบา และความถี่กลางจนถึงสูง ซึ่งสอดคล้องกับเสียงที่ได้ยิน

Note:

-If you use python, you can use “scipy.io.wavfile.read” for reading WAV file,

see https://docs.scipy.org/doc/scipy/reference/generated/scipy.io.wavfile.read.html

2) (15 points)

Hamtaro plans to design a system where the relationship between the input $x[n]$ and the output $y[n]$ is defined as follows:

$$y[n] = a_1 x[n] + a_2 x[n + n_1] + a_3 x[n + n_2]$$

The parameters a_1, a_2, a_3, n_1, and n_2 are defined in params.json. Provide the values below:

$a_1 =$	-3	$a_2 =$	2	$a_3 =$	-1	$n_1 =$	-1	$n_2 =$	1

2.1) Determine the impulse response $h[n]$ and frequency response $H(e^{j\omega})$ of the system and demonstrate the solution steps in your own words.

แทนค่าแล้วจะได้

$$y[n] = -3x[n] + 2x[n-1] - 1x[n+1]$$

Impulse Response: $h[n] = -3\delta[n] + 2\delta[n-1] - \delta[n+1]$

จาก DTFT of $\delta[n] = 1$

DTFT of $3\delta[n-k] = e^{-j\omega}$

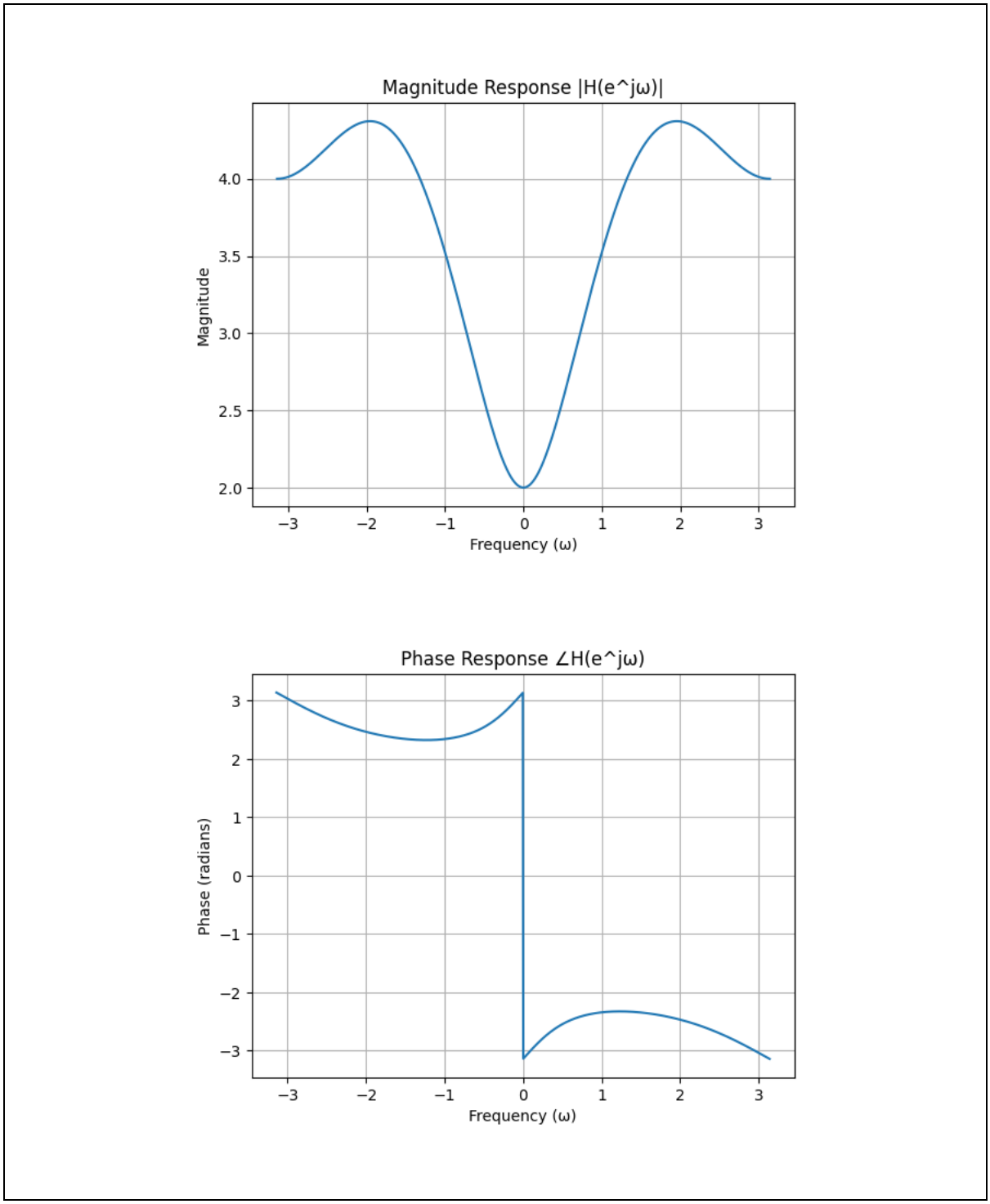
จะได้

Frequency Response:

$$H(e^{j\omega}) = -3 \cdot 1 + 2 \cdot e^{-j\omega} - 1 \cdot e^{j\omega}$$

$$H(e^{j\omega}) = -3 + 2e^{-j\omega} - e^{j\omega}$$

2.2) Plot magnitude and phase of the frequency response.



2.3) Determine and plot the DFT of the system output using your student id as the input sequence $x[n]$ to the system. For example, if your student ID is 6432154921, the input sequence $x[n] = \{6,4,3,2,1,5,4,9,2,1\}$. Finally, show the solution steps in your own words.

แทนค่าแล้วจะได้

n	x[n]	x[n-1]	x[n+1]	$y[n]=-3x[n]+2x[n-1]-x[n+1]$
0	6	0	4	y[0]=−3(6)+2(0)−4=−18−4=−22
1	4	6	3	y[1]=−3(4)+2(6)−3=−12+12−3=−3
2	3	4	2	y[2]=−3(3)+2(4)−2=−9+8−2=−3
3	2	3	1	y[3]=−3(2)+2(3)−1=−6+6−1=−1
4	1	2	5	y[4]=−3(1)+2(2)−5=−3+4−5=−4
5	5	1	4	y[5]=−3(5)+2(1)−4=−15+2−4=−17
6	4	5	9	y[6]=−3(4)+2(5)−9=−12+10−9=−11
7	9	4	2	y[7]=−3(9)+2(4)−2=−27+8−2=−21
8	2	9	1	y[8]=−3(2)+2(9)−1=−6+18−1=11
9	1	2	0	y[9]=−3(1)+2(2)−0=−3+4=1

จะได้ y[n] = $\{-22,-3,-3,-1,-4,-17,-11,-21,11,1\}$

จากนั้นคำนวณหา

$$Y[k] = \sum_{n=0}^{N-1} y[n] e^{-j\frac{2\pi}{N}kn}$$

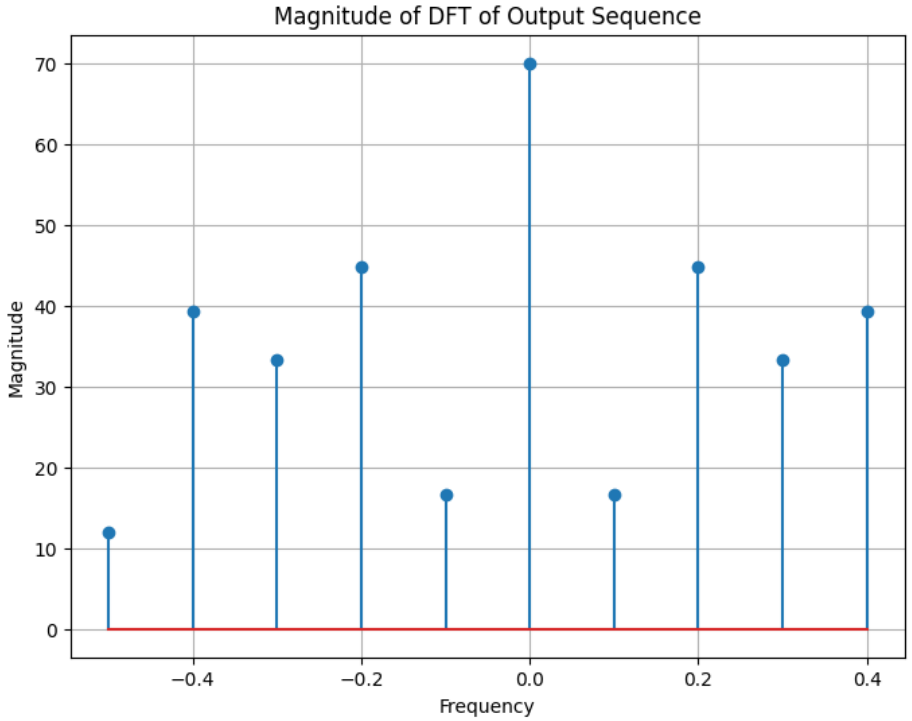
เช่น k = 0

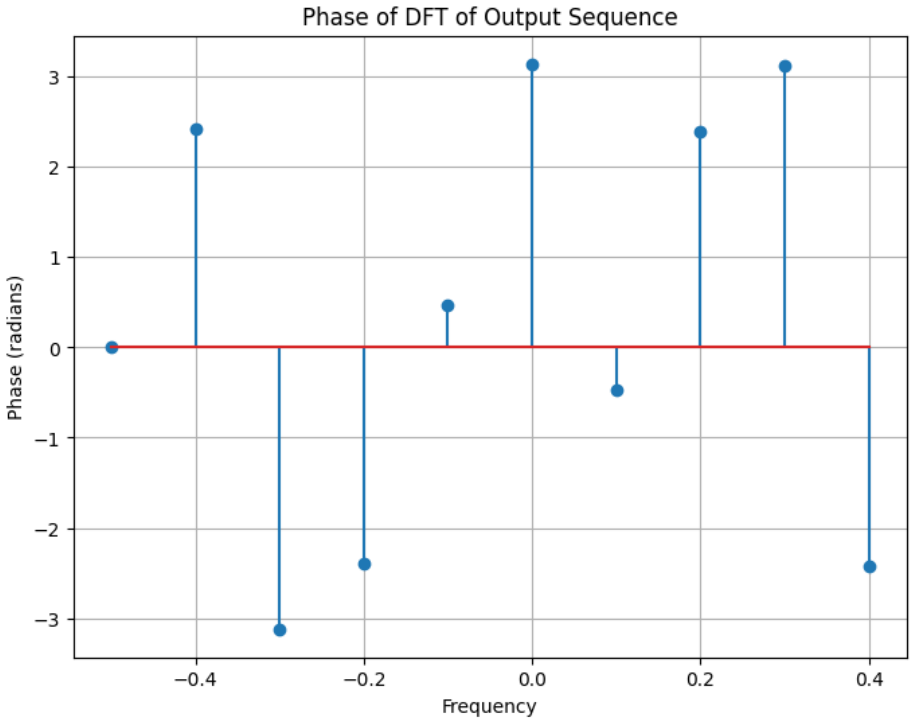
$$Y[0] = \sum_{n=0}^{9} y[n] \cdot e^{-j\frac{2\pi}{10}0n} = \sum_{n=0}^{9} y[n] \cdot 1$$

$$Y[0] = (-22) + (-3) + (-3) + (-1) + (-4) + (-17) + (-11) + (-21) + 11 + 1 = -70$$

ใช้คำสั่ง Y = np.fft.fft(y)

เมื่อ Plot กราฟ แล้วจะได้ (หน้าต่อไป...)


Magnitude of DFT of Output Sequence
Magnitude
Frequency
70
60
50
40
30
20
10
0
−0.4
−0.2
0.0
0.2
0.4


Phase of DFT of Output Sequence
Phase (radians)
Frequency
3
2
1
0
−1
−2
−3
−0.4
−0.2
0.0
0.2
0.4

References

Audio Analysis

- https://stackoverflow.com/a/23157189/9956949
- https://stackoverflow.com/a/18249362/9956949
- https://numpy.org/doc/stable/reference/generated/numpy.fft.fftshift.html
- https://discuss.python.org/t/dc-offset-in-python/5667
- https://chatgpt.com/share/66e83607-121c-800f-be1f-a74bf226480d

Hamtaro

- https://dsp.stackexchange.com/questions/62634/what-is-the-meaning-of-the-dtft-of-the-unit-impulse-sequence
- https://chatgpt.com/share/66ea85f3-bfa0-800f-801d-c66f9be89635