ECE 2026 Exam 3
Fall 2022

Name _____

General Instructions:

- Exam is closed book / closed notes other than the one-page of handwritten notes.
- Choose the best possible answer available in all cases.
- Blank scratch paper is allowed

_____ Part I: Objective Questions

_____ Part II: Open Response Question

_____ Final Score

Part I: Objective Questions

These questions have straight-forward answers. Make sure to put your answer in the line required as that is the part that will be graded for the answer given. Only the final answers, as indicated by the question, will be considered correct for each question. Each question is worth 4 points (total of 80 points)

Matching:

1. _____ DFT Transform

2. _____ Symmetric DFT Transform

3. _____ Inverse DFT Transform

a. $$x[n] = \frac{1}{N} \sum_{n=0}^{N-1} X[k] e^{-j\hat{\omega}_o kn}$$

b. $$X[k] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x[n] e^{\hat{\omega}_o kn}$$

c. $$x[n] = \frac{1}{N} \sum_{n=0}^{N-1} X[k] e^{j\hat{\omega}_o kn}$$

d. $$X[k] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x[n] e^{-\hat{\omega}_o kn}$$

e. $$X[k] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x[n] e^{\hat{\omega}_o kn}$$

f. $$x[n] = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} X[k] e^{j\hat{\omega}_o kn}$$

g. $$X[k] = \sum_{n=0}^{N-1} x[n] e^{-\hat{\omega}_o kn}$$

4. _____ (True / False) The symmetric DFT operation is a Unitary Matrix operation.

5. _____ (True / False) The symmetric DFT matrix is the same as the inverse DFT matrix.

6. _____ What is the fundamental frequency (variable and expression) for an N-point DFT?

7. _____ (T/F) All Fourier Transforms transform a form of convolution into a product in Frequency space.

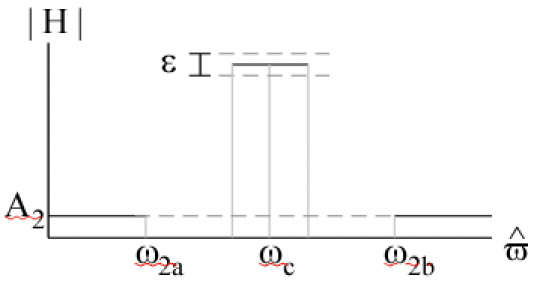
8 & 9: y[n] =_____ Find the step response for

$$y[n] = 0.9y[n-1] + x[n] + x[n-1]$$ (x[n]=u[n]).

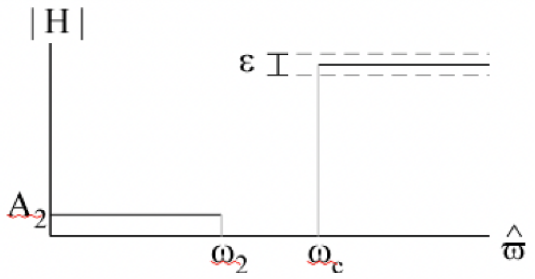
10. _____ (True / False) Periodicity in time or sampled time leads to sampled periodicity in frequency.

Matching

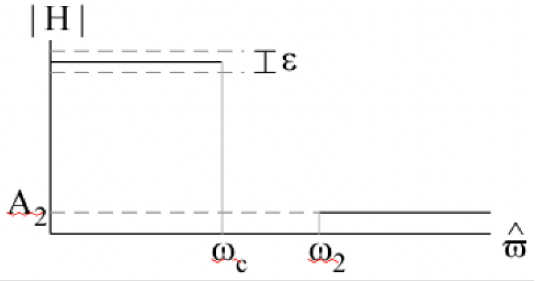
11. _____ Highpass Filter



12. _____ Lowpass Filter



13. _____ Bandpass filter



14. What is ε from the above matching? _____

15. What is A_2 from the above matching? _____

16. What is ω_2 (as well as ω_{2a}) from the above matching? _____

17. _____ Write the 2-point DFT matrix (rectangular form)

Your company needs a filter, and they want it to be a digital FIR filter so that the filter has a constant delay. The incoming speech signal is sampled at 20kHz and one does not expect any significant aliasing of this signal. You know that your maximum delay must be no more than roughly 1.6ms. The sample rate is low compared to your processor computations, so the delay of 100-200 operations per sample will not affect your delay; focus on the other signal processing operations.

A few short questions:

18. _____ What is the maximum number of taps based on the samples that you can use for your filter design?

19. _____ What is the FIR filter delay for this problem?

20. _____ How big an DFT can you use as your filter structure?

Part II: Open Response Question (20 points)

This question will build digital FIR filters using a 4-point DFT matrix.

Write down the 4-point DFT matrix with all terms in rectangular form.

Draw the filter structure using a DFT matrix-vector multiplication for all four outputs of the DFT matrix. Each output should be a function of [n], as the input signal, x[n], is a function of [n].

Using the four outputs that are functions of [n], construct three filters, a low-pass filter, a bandpass filter, and a high-pass filter. One expects real values as the outputs since x[n] is real.

What is the transfer functions H(z) for the three filters (low-pass, bandpass, and high-pass)?

What is the frequency response for these three filters and sketch the frequency response for all three filters?