GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL of ELECTRICAL & COMPUTER ENGINEERING

QUIZ-3

DATE: 08-Apr-24 COURSE: ECE-2026

NAME: ______________________________ gt Account: ________________

LAST, FIRST (ex: gburdell21)

Instructions: READ and SIGN your name below

failing to write your name, gtAccount, and sign below may result in a 5% penalty

- You have **50 minutes** (students with accommodations will have the appropriate time extension automatically added to their time) to complete this exam.
- Graphics calculators are permitted. One sheet of paper is permitted. You can write on both sides hand-written notes.
- WRITE ANY RADIAN ANSWERS AS A MULTIPLE OF π. (i.e., write 0.4286π or $3\pi/7$ instead of 1.3464). ALL RADIAN ANSWERS MUST BE IN THE RANGE$(-\pi, \pi]$ FOR CREDIT.

The Academic Honor Code will be strictly enforced. Forgeries and plagiarism are violations of the Georgia Tech honor code and will be referred to the Dean of Students for disciplinary action. You are not to discuss exam content or to share any written, electronic, or any other form of exam information with anyone during or after the exam until the solutions have been posted. By submitting this exam, you affirm that you have neither given nor received inappropriate assistance during this exam. I have read the instructions above and affirm that I will abide by the guidelines provided.

____

Sign your name on the line above

PROBLEM SP-24-Q.3.1:

[35 points] We have seen several equivalent ways to describe an LTI system. Below are a list of time-domain descriptions (e.g., impulse response, difference equation, MATLAB code or filter coefficients) of LTI systems. For each one, choose from the list on the right the corresponding frequency response. Note that there are more entries on the right than you will need to fill in the blanks on the left.

Time-domain Description

1. $y[n] = 5x[n-1] + 5x[n-4]$

   ANS =

2. $h[n] = 0.2\delta[n] + 0.2\delta[n-1] + 0.2\delta[n-2] + 0.2\delta[n-3] + 0.2\delta[n-4] + 0.2\delta[n-5] + 0.2\delta[n-6] + 0.2\delta[n-7] + 0.2\delta[n-8] + 0.2\delta[n-9]$

   ANS =

3. `yn = conv( xn, [1, 0, 2, 0, 1])`

   ANS =

4. $\sum_{k=0}^{3} (k - \delta[k-2])\delta[n-k]$

   ANS =

5. A system consisting of two cascaded systems whose impulse responses are given as:
   $h_1[n] = \delta[n] - 2\delta[n-1] + \delta[n-2]$ and
   $h_2[n] = \delta[n-1] - 2\delta[n-2] + \delta[n-3]$

   ANS =

Frequency Response

(A) $H(e^{j\hat{\omega}}) = \frac{1}{5}\left(\frac{\sin(5\hat{\omega})}{\sin(0.5\hat{\omega})}e^{-j4.5\hat{\omega}}\right)$

(B) $H(e^{j\hat{\omega}}) = 1 + 2e^{-j2\hat{\omega}} + e^{-j4\hat{\omega}}$

(C) $H(e^{j\hat{\omega}}) = e^{-j\hat{\omega}} + e^{-j2\hat{\omega}} + 3e^{-j3\hat{\omega}}$

(D) $H(e^{j\hat{\omega}}) = (6\cos(\hat{\omega}) + \cos(2\hat{\omega}))e^{-j5\hat{\omega}}$

(E) $H(e^{j\hat{\omega}}) = e^{-j\hat{\omega}} + e^{-j3\hat{\omega}} + e^{-j5\hat{\omega}}$

(F) $H(e^{j\hat{\omega}}) = 10e^{-j2.5\hat{\omega}}\cos(1.5\hat{\omega})$

(G) $H(e^{j\hat{\omega}}) = (6 - 8\cos(\hat{\omega}) + 2\cos(2\hat{\omega}))e^{-j3\hat{\omega}}$

(H) $H(e^{j\hat{\omega}}) = 0.2\left(\frac{\sin(3.5\hat{\omega})}{\sin(0.5\hat{\omega})}e^{-j2\hat{\omega}}\right)$

PROBLEM SP-24-Q.3.2:

Evaluate the following expressions. Simplify your answer as much as possible.

(a) **[9 points]**

$$y[n] = \frac{\sin(0.25\pi n)}{9\pi n} * \frac{\sin(0.44\pi n)}{4\pi n}.$$

$y[n] =$

(b) **[9 points]** The DTFT of the following signal

$$x[n] = (-0.2)^n u[n] + 0.8\delta[n]$$

$X(e^{j\hat{\omega}}) =$

(c) **[9 points]**

$$C = \sum_{n=-\infty}^{\infty} \left| \frac{\sin(0.2\pi n)}{2\pi n} \right|^2$$

$C =$

PROBLEM SP-24-Q.3.3:

(a) **[18 points]** Let $X[k]$ be the 4-point DFT of the signal $x[n]$. Let $X[0] = 0$, $X[1] = 1 + j$, $X[2] = 4$, and $X[3] = 1 - j$.

If we write $X[1] = ax[0] + bx[1] + cx[2] + dx[3]$, determine the values for a, b, c, and d. Express all complex numbers in the Cartesian form.

$a =$

$b =$

$c =$

$d =$

Determine the value of $x[1]$.

$x[1] =$

If $y[n]$ is an 8-length sequence with the following values: $[x[0], x[1], x[2], x[3], 0, 0, 0, 0]$. Let $Y[k]$ be the 8-point DFT of $y[n]$. Determine $Y[2]$.

$Y[2] =$

(b) **[10 points]** Determine the smallest k where the 1200-point DFT of

$$[x[0] ... x[5]] = [1,1,1,1,1,1],$$

results in $X[k] = 0$.

$k =$

(c) **[10 points]** Determine the values for $x[3]$, $x[5]$, and $x[7]$ from a sequence, $x[n]$, of length 10 whose 20-point DFT satisfies $X[k] = 2(3 + \cos(0.2\pi k))e^{-j0.5\pi k}$ for $k \in \{0, 1, ...19\}$.

$x[3] =$	$x[5] =$	$x[7] =$

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NAME: **ANSWER KEY** gt Account: **VERSION #1**

LAST, FIRST (ex: gburdell21)

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PROBLEM SP-24-Q.3.1:

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Time-domain Description

1. $y[n] = 5x[n-1] + 5x[n-4]$

   ANS = F

2. $h[n] = 0.2\delta[n] + 0.2\delta[n-1] + 0.2\delta[n-2] + 0.2\delta[n-3] + 0.2\delta[n-4] + 0.2\delta[n-5] + 0.2\delta[n-6] + 0.2\delta[n-7] + 0.2\delta[n-8] + 0.2\delta[n-9]$

   ANS = A

3. `yn = conv( xn, [1, 0, 2, 0, 1])`

   ANS = B

4. $\sum_{k=0}^{3} (k - \delta[k-2])\delta[n-k]$

   ANS = C

5. A system consisting of two cascaded systems whose impulse responses are given as:
   $h_1[n] = \delta[n] - 2\delta[n-1] + \delta[n-2]$ and
   $h_2[n] = \delta[n-1] - 2\delta[n-2] + \delta[n-3]$

   ANS = G

Frequency Response

(A) $H(e^{j\hat{\omega}}) = \frac{1}{5}\left(\frac{\sin(5\hat{\omega})}{\sin(0.5\hat{\omega})}e^{-j4.5\hat{\omega}}\right)$

(B) $H(e^{j\hat{\omega}}) = 1 + 2e^{-j2\hat{\omega}} + e^{-j4\hat{\omega}}$

(C) $H(e^{j\hat{\omega}}) = e^{-j\hat{\omega}} + e^{-j2\hat{\omega}} + 3e^{-j3\hat{\omega}}$

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PROBLEM SP-24-Q.3.2:

Evaluate the following expressions. Simplify your answer as much as possible.

(a) **[9 points]**

$$y[n] = \frac{\sin(0.25\pi n)}{9\pi n} * \frac{\sin(0.44\pi n)}{4\pi n}.$$

$y[n] = \dfrac{\sin(0.25\pi n)}{36\pi n}$

(b) **[9 points]** The DTFT of the following signal

$$x[n] = (-0.2)^n u[n] + 0.8\delta[n]$$

$X(e^{j\hat{\omega}}) = \dfrac{1.8 + 0.16 e^{-j\hat{\omega}}}{1 + 0.2 e^{-j\hat{\omega}}}$

(c) **[9 points]**

$$C = \sum_{n=-\infty}^{\infty} \left| \frac{\sin(0.2\pi n)}{2\pi n} \right|^2$$

$C =$ 0,05

PROBLEM SP-24-Q.3.3:

(a) **[18 points]** Let $X[k]$ be the 4-point DFT of the signal $x[n]$. Let $X[0] = 0$, $X[1] = 1 + j$, $X[2] = 4$, and $X[3] = 1 - j$.

If we write $X[1] = ax[0] + bx[1] + cx[2] + dx[3]$, determine the values for a, b, c, and d. Express all complex numbers in the Cartesian form.

$a =$ 1

$b =$ −j

$c =$ −1

$d =$ j

Determine the value of $x[1]$.

$x[1] =$ −1.5

If $y[n]$ is an 8-length sequence with the following values: $[x[0], x[1], x[2], x[3], 0, 0, 0, 0]$. Let $Y[k]$ be the 8-point DFT of $y[n]$. Determine $Y[2]$.

$Y[2] =$ 1 + j

(b) **[10 points]** Determine the smallest k where the 1200-point DFT of

$$[x[0]...x[5]] = [1, 1, 1, 1, 1, 1],$$

results in $X[k] = 0$.

k = 200

(c) **[10 points]** Determine the values for $x[3]$, $x[5]$, and $x[7]$ from a sequence, $x[n]$, of length 10 whose 20-point DFT satisfies $X[k] = 2(3 + \cos(0.2\pi k))e^{-j0.5\pi k}$ for $k \in \{0, 1, ...19\}$.

$x[3] =$ 1	$x[5] =$ 6	$x[7] =$ 1