Midterm Examination 2
ECE 438
Fall 2011
Instructor: Prof. Mimi Boutin

Instructions:

1. Wait for the "BEGIN" signal before opening this booklet. In the meantime, read the instructions below and fill out the requested info.

2. You have 50 minutes to complete the 5 questions contained in this exam. **When the end of the exam is announced, you must stop writing immediately**. Anyone caught writing after the exam is over will get a grade of zero.

3. This exam contains 8 pages. Pages 6 contains a table of formulas and properties. The last 2 pages can be used as scratch paper. You may tear out the table and the scratch paper **once the exam begins**. If you use a non-trivial fact/property that is not contained in the table or in the cheat sheet, you must justify it (i.e., **prove it**!) in order to get full credit.

4. This is a closed book exam. The use of calculators is prohibited. Cell phones, pagers, and all other electronic communication device are strictly forbidden. Ipods and PDAs are not allowed either.

Name:_____

Email:_____

Signature:_____

Itemized Scores
Problem 1:
Problem 2:
Problem 3:
Problem 4:
Problem 5:
Total:

(15 pts) **1.** What is the CSFT of the signal $f(x, y) = \frac{\sin(\pi x)\sin(\pi y)}{xy}$? (Justify your answer.)

(20 pts) **2.** A DT signal $x[n]$ is the input of an LTI system with unit impulse response $h[n]$. The duration of $x[n]$ is 5, and the duration of $h[n]$ is 10. We denote the system's response to $x[n]$ by $y[n]$.

a) What is the relationship between $y_{14}[n] = \sum_{k=-\infty}^{\infty} y[n+14k]$ and $x[n] \circledast_{14} h[n]$? (No justification needed; just state the relationship.)

b) What is the relationship between y[n] and $x[n] \circledast_{14} h[n]$? (No justification needed; just state the relationship.)

c) What is the relationship between the 14-point DFT $X_{14}[k]$, the 14-point DFT $H_{14}[k]$, and $x[n] \circledast_{14} h[n]$? (No justification needed; just state the relationship.)

d) What is the relationship between the CTFT $Y(\omega)$ and the 14-point DFT of $x[n] \circledast_{14} h[n]$? (No justification needed; just state the relationship.)

3. (10 pts) Briefly explain how formants of female speech differ from formants of male speech.

4. (10 pts) Draw a complete diagram describing the computation of a 3-point DFT. Count the number of complex operations that your computation entails.

5. (15 pts) Consider the discrete-space system defined by the equation $g[m,n] = h[m,n] * *f[m,n]$, where $h[m,n]$ is

$$h[m,n] = \frac{1}{16} \begin{array}{c|ccc} & -1 & 0 & 1 \\ \hline 1 & 1 & 2 & 1 \\ 0 & 2 & 4 & 2 \\ -1 & 1 & 2 & 1 \end{array} \quad \begin{array}{c} n \\ \\ \\ \\ \end{array}$$

$$m$$

What is the system's response to the following input (using symmetric boundary conditions)?

1	1	1	0	0	0
1	1	1	0	0	0
1	1	1	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

Answer (no justification needed):

Table

CT Fourier Transform

$$\text{F.T. : } X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt \tag{1}$$

$$\text{Inverse F.T.: } x(t) = \int_{-\infty}^{\infty} X(f)e^{j2\pi ft}df \tag{2}$$

CS Fourier Transform

$$\text{C.S.F.T. : } F(u,v) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)e^{-j2\pi(ux+vy)}dxdy \tag{3}$$

$$\text{Inverse C.S.F.T.: } f(x,y) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F(u,v)e^{j2\pi(ux+vy)}dudv \tag{4}$$

DT Fourier Transform

Let $x[n]$ be a discrete-time signal and denote by $X(\omega)$ its Fourier transform.

$$\text{F.T.:}\mathcal{X}(\omega) = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n} \tag{5}$$

$$\text{Inverse F.T.: } x[n] = \frac{1}{2\pi}\int_{2\pi} \mathcal{X}(\omega)e^{j\omega n}d\omega \tag{6}$$

Discrete Fourier Transform

Let $x[n]$ be a periodic discrete-time signal with period N

$$\text{D.F.T.: } X_N[k] = \sum_{n=0}^{N-1} x[n]e^{-j\frac{2\pi}{N}kn} \tag{7}$$

$$\text{Inverse D.F.T.: } x[n] = \frac{1}{N}\sum_{k=0}^{N-1} X_N[k]e^{j\frac{2\pi}{N}kn} \tag{8}$$

z-Transform

$$X(z) = \sum_{n=-\infty}^{\infty} x[n]z^{-n} \tag{9}$$

-SCRATCH -
(will not be graded)

-SCRATCH -
(will not be graded)