UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Electrical and Computer Engineering

ECE 417 Multimedia Signal Processing
Spring 2016

# EXAM 1

Thursday, February 25, 2016

- This is a CLOSED BOOK exam. You may use one sheet (front and back) of hand-written notes.
- No calculators are permitted. You need not simplify explicit numerical expressions.
- There are a total of 100 points in the exam. Each problem specifies its point total. Plan your work accordingly.
- You must SHOW YOUR WORK to get full credit.

| Problem | Score |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| Total | |

**Name:** _____

# Possibly Useful Formulas

### Z transform/DTFT

$$X(z) = \mathcal{Z}\{x[n]\} = \sum_{n=-\infty}^{\infty} x[n]z^{-n}, \qquad x[n] = \mathcal{Z}^{-1}\{X(z)\} = \frac{1}{2\pi}\int_{-\pi}^{\pi} X\left(e^{j\omega}\right)e^{j\omega n}d\omega$$

### Convolution

$$x[n] * h[n] = \sum_{m=-\infty}^{\infty} x[m]h[n-m]$$

### DFT

$$X[k] = \mathrm{DFT}\{x[n]\} = \sum_{n=0}^{N-1} x[n]e^{-j2\pi kn/N}, \qquad x[n] = \mathrm{DFT}^{-1}\{X[k]\} = \frac{1}{N}\sum_{k=0}^{N-1} X[k]e^{j2\pi kn/N}$$

### Frequency Conversion: Hertz ($f$) to Mel ($m$)

$$m = G\ln(1 + f/700), \quad G \equiv \frac{1000}{\ln(1 + 1000/700)}$$

| **Z-Transform/DTFT Pairs** | |
|---|---|
| $h[n]$ | $H(e^{j\omega})$ |
| $\frac{\sin\omega_c n}{\pi n}$ | $H(\omega) = \begin{cases} 1 & \lvert\omega\rvert < \omega_c \\ 0 & \text{otherwise} \end{cases}$ |
| $u[n] - u[n-N]$ | $e^{-j\frac{\omega(N-1)}{2}}\frac{\sin(\omega N/2)}{\sin(\omega/2)}$ |
| $\delta[n-\tau]$ | $e^{-j\omega\tau}$ |
| $e^{j\alpha n}$ | $2\pi\delta(\omega-\alpha)$ |
| $\sum_{\ell=-\infty}^{\infty}\delta[n-\ell T_0]$ | $\left(\frac{2\pi}{T_0}\right)\sum_{k=1}^{T_0-1}\delta\left(\omega - \frac{2\pi k}{T_0}\right)$ |

| **Useful Angles** | | | |
|---|---|---|---|
| $\theta$ | $\cos\theta$ | $\sin\theta$ | $e^{j\theta}$ |
| 0 | 1 | 0 | 1 |
| $\pi/6$ | $\sqrt{3}/2$ | $1/2$ | $\sqrt{3}/2 + j/2$ |
| $\pi/4$ | $\sqrt{2}/2$ | $\sqrt{2}/2$ | $\sqrt{2}/2 + j\sqrt{2}/2$ |
| $\pi/3$ | $1/2$ | $\sqrt{3}/2$ | $1/2 + j\sqrt{3}/2$ |
| $\pi/2$ | 0 | 1 | $j$ |
| $\pi$ | -1 | 0 | -1 |
| $3\pi/2$ | 1 | -1 | $-j$ |
| $2\pi$ | 1 | 0 | 1 |