

# ELECTRICAL AND COMPUTER ENGINEERING COURSE SYLLABUS

|                       |                                    |                    |                        |
|-----------------------|------------------------------------|--------------------|------------------------|
| <b>Instructor:</b>    | Prof. Henry Pfister                | <b>E-mail:</b>     | henry.pfister@duke.edu |
| <b>Office / Hour:</b> | 305 Gross Hall / Tu 3:00 - 4:00 PM | <b>Phone:</b>      | (919) 660-5288         |
| <b>Class Room:</b>    | Teer 106                           | <b>Class Time:</b> | MW 1:25 - 2:40 PM      |

**Course Name:** ECE 485

**Course Title:** Digital Audio Processing

**Prerequisite(s):** ECE 280 - Signals and Systems

**Required Text(s):** Course reader handouts

**Other Text(s):** *Discrete-Time Signal Processing* by Oppenheim and Schaffer, 3rd Ed. (DTSP-3)  
*Principles of Digital Audio* by Ken Pohlmann (PDA)  
*Digital Signal Processing* by Proakis and Manolakis, 4th Ed. (DSP-4)  
*Signals and Systems* by Oppenheim, Willsky, and Hamid, 2nd Ed. (SSOW)

## Course Objectives:

Digital audio signal processing (DASP) consists of the recording, storing, manipulation, transmission, and reproduction of high quality acoustic signals such as music. DASP is an extremely broad field spanning acoustics, hearing, signal processing, communications, music, and psychoacoustics. This course focuses on fundamental signal processing aspects of DASP. This course covers many of the principles behind commercial digital audio workstation (DAW) tools. However, it is **not** a course on how to use commercial software such as Pro Tools or Logic Studio.

At the end of the course, the student should be able to:

1. Describe basic elements of discrete-time signal processing including the discrete-time Fourier transform, the Z-transform, and discrete-time linear filtering.
2. Understand practical details of A/D and D/A conversion including quantization noise, dither, oversampling, and sigma-delta converters.
3. Implement sample rate conversion for audio processing and music synthesis.
4. Understand basic acoustics and implement digital reverberation and other effects.
5. Understand time-frequency analysis for audio applications including filter banks and the modified discrete-cosine transform.
6. Implement time and pitch scale modification of audio signals.
7. Understand perceptual models of human hearing and implement a simple form of perceptual-based audio coding.
8. Capture and process the spatial dimension of sound with microphone arrays.

## Student Evaluation:

|         |     |          |     |
|---------|-----|----------|-----|
| Midterm | 20% | Homework | 25% |
| Final   | 25% | Projects | 30% |

- Homework will include short MATLAB tasks. Projects will have longer MATLAB tasks.

## Rules and Guidelines:

The class shall follow all established policies of Duke University.

**Course Topics and Hours: (2.5 hours/week)**

| Unit | Topics  | Hours     |
|------|---|-----------|
| 1    | Review of Discrete-Time Signal Processing     | 6.25      |
| 2    | Waveform and Physical Synthesis               | 5         |
| 3    | Autocorrelation and Pitch Detection           | 2.5       |
| 4    | Digital Effects Processing                    | 3.75      |
| 5    | Filter Banks and the Phase Vocoder            | 5         |
| 6    | Perceptual Models of Hearing and Audio Coding | 2.5       |
| 7    | Sampling, Quantization, and Dither            | 5         |
| 8    | Array Processing of Audio Signals             | 5         |
|      | <b>Total Hours</b>                            | <b>35</b> |

**Tentative Schedule:**

| Week | Date | M  | W  | F  | Topics                                 | Notes             | Assignments        |
|------|------|----|----|----|--|-------------------|--------------------|
| 0    | 1/7  | X  | 1  |    | Introduction                           |                   | Lab 0 + MathReview |
| 1    | 1/14 | 2  | 3  | 4  | Corr/Conv - LCCDE - EigenDTFT          |                   | Lab 1 (rand)       |
| 2    | 1/21 | X  | 5  | 6  | Eigen+DTFT / Z-transform / DTFT        | MLK / W Last Drop | Homework 1         |
| 3    | 1/28 | 7  | 8  | 9  | WindowFIR - Up/Dn Sampling / Filtering |                   |                    |
| 4    | 2/4  | TA | 10 |    | Pole-Zero                              | Travel            | Homework 2         |
| 5    | 2/11 | TA | 11 |    | Filtering                              | Travel            | Homework 3         |
| 6    | 2/18 | TA | 12 |    | Guitar Effects                         | Travel            | Lab 2 (solo)       |
| 7    | 2/25 | 13 | 14 | TA | Physical Modeling / Filter Banks       |                   | Practice Midterm   |
| 8    | 3/4  | 15 | 16 |    | Phase Vocoder / Midterm                | Midterm Wednesday | Lab 3 (rand)       |
| 9    | 3/11 | X  | X  |    | —                                      | Spring Break      |                    |
| 10   | 3/18 | 17 | 18 | TA | Phase Vocoder / Demos                  | W Last Withdrawl  |                    |
| 11   | 3/25 | 19 | 20 |    | Least Squares / Probability            |                   |                    |
| 12   | 4/1  | 21 | 22 | TA | Random Processes / Quantization        |                   | Lab 4 (choose)     |
| 13   | 4/8  | 23 | 24 |    | Quantization / Quantization            |                   |                    |
| 14   | 4/15 | 25 | 26 | TA | Spatial / Spatial                      |                   | Lab 5 (solo)       |
| 15   | 4/22 | 27 | 28 |    | Spatial / LDOC                         |                   |                    |

**Final Exam: Thursday, May 2nd, 2:00 PM - 5:00 PM**