# ECE 4750/6750: Digital Signal Processing

Spring 2018

## Logistics

Instructor: Daniel Weller
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Office Hours: Mondays, 3-5 PM

Lecture: Date/time: Mondays, Wednesdays, 5:00 PM – 6:15 PM
Room: Thornton Hall ~~E303~~ E316

Textbook: A. V. Oppenheim and R. W. Schafer. *Discrete-Time Signal Processing, 3/E*. Prentice-Hall, 2010. [required; UVA bookstore or buy online] (Earlier editions generally are not acceptable.)

## Course Description

How do phones know which way is up, or to turn off the display when we hold them up to our ears? A hallmark of the digital revolution is how our devices interact, not only with their users, but also with their surroundings. Digital Signal Processing (DSP) is an enabling technology of this revolution, allowing our smartphones, appliances, and even buildings to interact intelligently with their environment.

However, DSP is about so much more. How can we create spectacular images with tiny cameras? How does Siri (or Google or Cortana) know what I am asking? Can we program a computer to focus on a voice in a crowd or pick an instrument out of an orchestra? The common component in all these questions is signal processing – sampling, filtering, and analyzing measurements of the real world. This course will explore and apply these concepts in digital systems all around us.

## Course Structure

In this course, students learn DSP concepts via readings, in-class activities, and periodic homework and lab reports. Having completed preparatory readings before class, students will work together discussing the concepts and completing exercises using MATLAB and LabVIEW software. This course does not teach MATLAB or LabVIEW; *students should already have background from prerequisite courses*. A number of these activities will feature as "labs", with pre-lab activities to complete beforehand and a report due as homework. These lab activities will supplant many of the book-based homework problems from previous years. In addition to two midterm exams, students work in small teams over the semester to design a real DSP system of their own choosing (see project handout for details). Project presentations will take the place of a final exam, and will occur during the assigned final exam time.

## Learning Goals and Objectives

This course is aimed at 3rd/4th year undergraduates and graduate students (who have not previously taken a DSP course) interested in understanding how (1) to analyze digital signals and design digital systems and (2) to apply DSP to complex real-world problems. By the end of this course, students should be able to:

1. Describe digital systems using frequency-domain and time-domain representations
2. Deduce and evaluate the behavior of digital systems using these representations
3. Analyze real signals using digital systems
4. Associate digital signal processing with other engineering disciplines and everyday life
5. Create a real digital system that fits the criteria of a given application or problem
6. Divide a complex real world problem into component problems and work as a team to manage the construction and integration of the solutions to those problems

## Evaluation

**Team Project** (30%): Students work in **teams of three or four** to complete a semester-long design project applying the concepts of digital signal processing covered in this class. Each team (1) selects a project (see separate project handout for examples from previous years), (2) subdivides the project into milestones, (3) implements solutions to each milestone, and (4) integrates those solutions into a real system. As a critical part of this project, students need to analyze and verify the functionality of the design, using real world signals or data. Grades are based on the team proposal, reporting on milestones, a final (group) presentation, and a final (individual) written report. This experience provides valuable experience working in groups, tackling real-world problems, and designing and analyzing a multi-component system. **The final presentations will take place during the scheduled final exam period**.

**Homework and Labs** (50%): In addition to the assigned readings in preparation for class, students must complete a range of individual and group exercises, "lab" activities, and homework assignments related to the concepts taught in class. Beyond reinforcing foundational knowledge, these activities involve creative or practical thinking through (1) peer instruction/problem solving (e.g., specifying and implementing filters) and (2) strategic problem solving (e.g., designing multi-stage systems). Many activities involve MATLAB or LabVIEW, **so bringing a laptop running MATLAB and LabVIEW to class is highly recommended.** Students enrolled in ECE 6750 will complete additional homework problems.

**Midterms** (20% total): Two graded exams given in class test the concepts covered in the course. Test problems are similar to the written components of homework/lab activities. Students enrolled in ECE 6750 will answer additional questions as part of each midterm exam.

## Tips for Success in DSP

*Active and consistent participation* is the single-most important contributor to effective learning in this course. This way, you place yourself in the best position to succeed. Teaching and learning are *social*

*activities*, so take advantage of office hours, group work, and your team project to support your learning and gain a more thorough understanding of the ideas underlying this course.

*Be creative and explore*! Past projects often integrated ideas from signal processing and a wide variety of projects, some obvious and conventional, and others more exploratory and highly creative. Both approaches carry the reward of producing a significant design experience. But, the process likely will be more satisfying and agreeable if your project incorporates something that interests you. Take your time considering project ideas and talk to your friends, classmates, as well as the course staff, as you seek inspiration.

## Course Policies and Grading

*Cheating:* All students must by the UVA honor code policy. If you are unfamiliar with this policy or have questions, please contact me. In particular, you must do your own work and not provide assistance to others on individual activities. Plagiarism or copying code or solutions, *even with attribution*, is cheating. Do not share or distribute course materials outside this class.

*Attendance:* Students are expected to attend all lectures and complete all in-class activities. Absence from a class does not excuse you from making up the work. Please notify Prof. Weller to make arrangements in advance if possible.

*Late Policy:* Late assignments are not graded unless arrangements have been made with Prof. Weller. Please be proactive about requesting an extension; generally, requests after the deadline will be denied. Missing a class does not excuse you from submitting assignments due that day.

*Assessment Forms (ECE 6750 only):* If you will submit a skill assessment form for this course, you must give a hard copy of the desired skill assessment to Prof. Weller before the last lecture. **No skill assessments will be completed after the semester concludes**. These are graduation requirements for some graduate degrees, so consider in advance which course to use for each skill assessment.

*Disabilities:* Students who need to make arrangements for disabilities should work with the Student Disability Access Center or other appropriate office and provide me with documentation detailing the accommodations requested. All reasonable efforts will be made to ensure these needs are met.

*Grading:* Grades will be assigned according to this scale: 93=A / 90=A- / 87=B+ / 83=B / 80=B- / 77=C+ / 73=C / 70=C- / 67=D+ / 63=D / 60=D- / below=F. I may adjust these thresholds downward to reflect the actual difficulty of the class, but I will not set these thresholds above what are listed here.

Course Calendar and Important Dates (**Tentative**)

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| 1/17 – 1/24 | Review of analog and digital signals and systems |
| 1/29 – 2/7 | Discrete Fourier and z-transforms |
| *1/31* | *SEAS Add Deadline* |
| 2/12 – 2/19 | Sampling theory |
| 2/21 – 2/28 | Quantization of signals |
| **2/26** | **Midterm exam #1** |
| *2/28* | *SEAS Drop Deadline (no penalty)* |
| 3/5 – 3/7 | No class (spring recess) |
| 3/12 – 3/14 | Properties of LTI systems |
| *3/14* | *SEAS Withdrawal Deadline ("W" on transcript)* |
| 3/19 – 4/2 | IIR and FIR filter design |
| **4/4** | **Midterm exam #2** |
| 4/9 – 4/11 | Filter structures |
| 4/16 – 4/18 | Discrete Fourier Transform |
| 4/23 – 4/30 | Spectral analysis |
| **5/11** | **Final presentations (during final exam, 2-5 PM)** |