Section 3b. Statement of Teaching

I thoroughly enjoy engaging students inside and outside the classroom. In both settings, it is exciting to facilitate intellectual growth, including professional development, in students and in myself. Below, I describe teaching an upper division undergraduate course in general terms, both inside (Section 1) and outside (Section 2) the classroom. The course meets for three hours/week of lecture and three hours/week of laboratory. Section 3 discusses specific course content. Section 4 describes university service to support teaching. Underlined text indicates a hyperlink.

1. Making Lecture Rigorous and Relevant

Motivate Every Lecture. Showing students how material is relevant to them helps motivate them in devoting the time outside of class to study and internalize the material. In lecture, I show how the material fits into the course and electives. Integrating industry trends, current events, and research results into the course helps students plan their career path after graduation in terms of companies to join, products to design and topics to research. Section 3b-3 gives examples.

Multiple Views. In lecture, I give multiple views into the material, including text, formulas, graphs and images, as well as animations and video demos. For fall 2015, I have created several audio demos in response to student requests. Please see Multiple Views in Section 3b-3.

Lecture Style. Before lecture, I play a short video. Some videos relate to the lecture topic; others are for fun. I start lecture by asking “Are there any questions?” and field student questions [1]. Then, I review how the lecture topic fits into the course, electives, graduate study and industrial practice. Then, we discuss recent events and research results (see Section 3b-3). After that, my style will go back-and-forth between presenting slides, deriving mathematical relationships, and giving demos by computer, while asking questions and fielding student questions along the way.

Flipped Fridays. The eight homework assignments require the student to perform quantitative analysis, validate the analysis by computer simulation, and interpret results. Homework helps students prepare for laboratory work. When students submit homework, I hand them the solution set and flip the classroom to discuss the solutions. The problems are very fresh in students’ minds when they turn in homework vs. waiting until a later class period to discuss solutions. For midterm #1, which is on a Friday, I return the graded exams on Monday and flip the classroom.

Electronic Note Taking. Each semester, I have provided a course reader with slides, handouts, and recent midterm exams. In spring 2013, students asked to take notes in the course reader on their tablets/laptops. Since then, I have made the reader available for free download. Students may print the reader as well. Students may use the reader on midterm exams (see next).

Midterm Examinations. On both midterms, students may access notes, books and laptops, but laptops cannot have network access. The idea is to give students as much of the problem-solving environment that they had been using as possible. Questions test understanding of fundamental principles and come from in-class discussions. Problem #1 is similar to homework problems. Problems #2 and #3 require students to apply critical thinking in deriving new equations and inferring relationships. In problem #4, students defend their answers in an argumentative essay.
2. Making the Best of the Learning Opportunities Outside of Lecture

**Rapid Feedback.** When a student submits a homework assignment on Friday, they receive the solution set immediately, which is also available online. Each homework is graded with feedback and returned by the next lecture (Monday). Midterm #1 is given on a Friday, and I grade and return them by the next lecture (Monday) with the solution set.

**Hands-on Learning.** In homework assignments, students perform analysis and design by writing computer simulations [2]. Assignments are constructed to give immediate sensory feedback in the form of visualizations and/or sound. So, too, are weekly laboratory tasks [2]. The immediate sensory feedback really helps students in refining their designs until they give the desired visible and/or audible responses. Lab concepts are tightly integrated with lecture and homework.

**Finish All Lab Work during Lab Time.** To encourage students to be prepared for laboratory, students take an online pre-lab quiz based on assigned reading for each new lab assignment. For the lab section each week, the TA would review material and provide a document detailing lab procedures and deliverables. Most students are able to finish all lab work during the weekly lab time, which allows them to better plan their time for studying for this course and others.

**Open Courseware to Facilitate Self-Study.** I created open courseware based on the spring 2014 offering of the course to facilitate self-study [3]. In an on-campus studio, staff recorded the spring 2014 lecture discussions using simultaneous views of a smart board and the instructor. The smart board captured projected content and my annotations. The video recordings included discussions of homework and midterm #1 solutions. I posted the videos on YouTube for free worldwide access, and the videos had 22,516 views as of November 10, 2015. Any student can watch the videos to review or preview material. I also put online all of the course materials (slides, handouts, demonstrations, homework solutions, etc.).

**Decoupled Office Hours and Advising Hours.** By decoupling class office hours and drop-in advising hours, students enrolled in my course are not blocked from asking course-related questions due to students seeking non-course advice, and vice-versa. I hold office hours immediately after lecture to allow a natural continuation of the discussion, and office hours immediately before lecture to field questions from the last lecture and current homework assignment. Separate from office hours, I have been holding weekly drop-in advising hours for students and alumni at a local café on the edge of campus for more than ten years. We discuss career plans and what to do to fulfill those plans, including courses and internships to consider.

**Extensive Course Alumni Network.** Of the 1547 students in this course since 1997, 673 have given permission to be on the course alumni Web page. After I submit grades, I ask students if they would like to be listed. Many students who give permission will also send their job or graduate school upon graduation. I keep up with career changes via LinkedIn. The course alumni serve as a massive referral base to help current and previous students land positions. Of 185,000 full-time hires analyzed in 2012, current employees filled 42%, referrals from current employees filled 25%, and applicants through job Web sites filled 18% of the positions [4]. Course alumni in graduate school can provide helpful advice about graduate studies. Successful placements of course alumni in companies and graduate schools also help to motivate students.
3. Discipline-Specific Content of the Course

The above undergraduate course is **EE 445S Real-Time Digital Signal Processing Laboratory** in the Department of Electrical & Computer Engineering (ECE). It is required for certain BS ECE students, and elective for BS Biomedical Engineering and other BS ECE students. I created the course from scratch upon joining UT Austin in fall 1996, and its first offering was in fall 1997.

Digital signals convey information for human consumption, e.g. video streaming over the Internet, or for computer consumption, e.g. sending bits from a handheld platform to support a wireless Internet connection. Digital signal processing algorithms attempt to improve the quality of the information in the digital signal. Many possible algorithms exist for a particular task. In the course, students evaluate candidate algorithms in terms of signal quality vs. implementation complexity tradeoffs. This is the kind of tradeoff analysis for deciding what algorithms to include in a product. In the course, the primary application is communication systems. Secondary applications are digital audio, image/video processing and biomedical instrumentation.

**Reviewing Pre-Requisite Material.** Students enter this course with varying familiarity with the pre-requisite material; in fact, some students took the pre-requisite courses 1-2 years ago. With student Jean Farias, I created a handout to review the Fourier transform, which is a fundamental mathematical tool in the course. I also created handouts on other pre-requisite topics such as convolution, modulation, and linear time-invariant systems, as well as the co-requisite topic of random variables. The first four weeks of lecture and the first two homework assignments review pre-requisite material while covering new applications to give a larger context for the material.

**Bridging Application Theory and Software Implementation.** In the lecture component, students model digital signals (data) and signal processing algorithms (tasks) as equations, convert equations into computer simulations in the Matlab programming language, and validate and interpret results. In the laboratory component, students convert the Matlab implementations to a lower-level implementation in the C programming language, compile and run the C program on a standalone electronics board, and validate and interpret results. Students quantify design tradeoffs in signal quality vs. implementation complexity in their Matlab and C programs. This is a prototyping cycle commonly used in industry and graduate study. Through implementation, students gain new insights into application theory, and use the insights to develop theory for more efficient algorithms in implementation. Students improve in theory and implementation.

**Multiple Views.** The course combines computer science, engineering and mathematics. I give multiple views into the material, including text, formulas, graphs, images, animations and video demos. For example, I show an animation of a wheel spinning faster and faster in one direction. Eventually, the wheel spins too fast for our eyes to follow— the wheel appears to slow down, then rotate the other direction, then speed up, then slow down, then rotate the original direction, etc. Another example is a sampling demonstration (starts at the 47:39 mark).

On the spring 2015 course surveys, students asked for more demos of communication concepts. For fall 2015, I created audio demonstrations for modulation, which is used in communicating a message. Modulation shifts content to higher frequencies, and demodulation shifts it back. The audio demo plays a track, a modulated version shifted by an octave, and a demodulated version.
**Bringing Research into the Class.** In [lecture 4 on sampling and aliasing](#), I play videos of handshake distortion when recording video on smart phones and show the videos after applying our methods to correct for handshake [2]. In [lecture 12 on channel modeling](#), I visualize challenges in communicating data through air, wires, and water [2]. Based on research results, I give expected improvements in data rates and coverage over the next 2-5 years. I announced in class that on October 22nd, the [FCC announced plans](#) to make new frequency bands available to enable 5G cellular systems to achieve 10x the data rate of today’s 4G systems.

**Austin or Bust.** I let the students know that the course is a natural extension of why I came to Austin. I watched Austin City Limits growing up. Then, in 1983, Stevie Ray Vaughan burst onto the national scene from Austin and reinvigorated R&B. In 1996, I joined the ECE faculty at UT to strengthen the communications area, and that’s why I developed the course. The connection to the Austin music scene is why I play music videos before class and use audio demos in class.

### 4. University Service to Support Teaching

In fall 1999, my Department Chair appointed me to chair the first [major overhaul of the undergraduate curriculum](#) in more than 20 years. After two years of discussions, we removed redundancy and artificial pre-requisites in our courses, and gave students more choices. For the 2002-2004 catalog, we changed 60 of 90 course abstracts, increased ECE electives from 5 to 8, reduced the degree by five credit hours, and made finishing the degree in four years realistic.

To implement 2002-2004 BS ECE curriculum, my Department Chair asked me to chair the ECE committee for instructor assignments, course scheduling and TA allocations.

In 2009, my Department Chair called on me to take a leadership role in curriculum reform discussions. The co-chairs had resigned after discussions had fallen apart. To accommodate the extra courses in the Core Curriculum without increasing hours, we shifted from a two-tier system with required and elective courses to a three-tier system with required, mezzanine and elective courses. Mezzanine courses are required for the two specializations that students selected.

Since 2008, as mentioned in the curriculum vitae, I have served on several university committees that support teaching, from safeguarding academic freedom to giving faculty orientations to improving TA/AI salaries to improving faculty input on budgets to evaluating new degrees.

### 5. References


