EE 464: Digital Signal Processing (Fall 2018)

Catalog Description: (3 credits) Discrete and fast Fourier transforms; Z-transform; sampling; discrete convolution; digital filter design; effects of quantization. (Prereq. EE 341)

Instructor: T. Fischer e-mail: thomas_fischer@wsu.edu
Tel: 509 335 4960
Office Hours: MWF 10:15-11:15 a.m., MW 2:15-3:15 pm, or by appointment (EME 404)
Lecture Hours: MWF 9:10 –10:00 a.m. (Spark 333 in Pullman and TBD in Everett and Bremerton)

Best way to reach me outside office hours: Via e-mail.

Teaching Assistant: TBA

Course Webpage: http://eecs.wsu.edu/~fischer

This will serve as a repository for:
- Syllabus and other course handouts
- Homework, homework solutions, project
- Links to online resources

Textbook:

Matlab supplement:
DSP Companion Software, Student Resources – available from the Cengage Learning website.

Additional References:

Course Outline:
The objective of this course is to gain an understanding of the analysis and design of discrete-time, linear time-invariant systems (sometimes referred to as digital filters). The major topics covered include discrete-time signals and systems; the Z-transform; Fourier representation of sequences and frequency response of linear, time-invariant systems; digital filter design and implementation; and the discrete Fourier transform, including applications such as spectral analysis and fast algorithms.

Prerequisites:
By course: EE 341.

Student Learning Outcomes and Assessment

Lectures present the theory and application of the course topics. Out-of-class work includes reading from the textbook and provided notes, homework exercises, and a course project. The project requires application of digital signal processing to solve a design problem, and summarizing the work in a technical report. Students should expect to invest at least 2 hours of work outside of class for every hour of lecture.

Specific goals for the course and means of assessment

a. specific outcomes of instruction (ABET outcomes covered are in parenthesis)

At the end of this course, students must be able to

- Analyze discrete-time linear time-invariant systems in time- and frequency-domains (1). Assessed through homework, project, and exams.
- Compute the spectrum of a sampled signal and its reconstruction from the samples, based on the spectrum of a continuous-time signal (1). Assessed using homework, project, and exams.
• Obtain the spectrum of a continuous time signal based on its samples (1). Assessed using homework, project, and exams.
• Design frequency selective digital filters with finite impulse response (FIR) (1,2,6). Assessed using homework, project, and exams.
• Design frequency selective digital filters with infinite impulse response (IIR) (1,2,6). Assessed using homework, project, and exams.

b. explicitly indicate which of the student outcomes listed in ABET Criterion 3 or any other outcomes are addressed by the course.

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

Brief list of topics to be covered and approximate number of lecture hours

• Review of Sampling; Quantization (3 hrs)
• Discrete-Time Signals and Systems (4 hrs)
• Z-Transform (3 hrs)
• Inverse Z-Transform; Analysis in Z-Domain. (5 hrs)
• Frequency Analysis of Discrete-Time Signals. (3 hrs)
• Frequency-Domain Analysis of LTI Systems. (6 hrs)
• Discrete Fourier Transform. (3 hrs)
• Fast Fourier Transform. (2 hrs)
• Applications of the DFT (3 hrs)
• Digital Filter Design. (7 hrs)
• Digital Filter Implementation (3 hrs)
• Exams and review (3 hrs)

Grading:
The grades in this course will be based on:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homework</td>
<td>15%</td>
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<tr>
<td>Project</td>
<td>15%</td>
</tr>
<tr>
<td>Midterm tests:</td>
<td>20% each</td>
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<tr>
<td>Final exam:</td>
<td>30%</td>
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Final numerical averages will be rounded to the nearest integer value, and grades assigned as follows:

- 100 – 93: A
- 92 – 90: A-
- 89 – 87: B+
- 86 – 83: B
- 82 – 80: B-
- 79 – 77: C+
- 76 – 73: C
- 72 – 70: C-
- 69 – 60: D
- <=59: F

General Course Policies:

1. **Homework**: Homework will be assigned roughly every two weeks and normally due one week after it is assigned. The lowest two homework scores for each student will be dropped before computing the final weighted score. This is intended to compensate for occasional conflicts with other commitments.

* Dates are tentative and will be finalized 1-2 weeks before the actual date.
2. **Submission of Homework**: All homework is to be submitted on the day it is due. Except in very unusual circumstances, late submissions will **not** be accepted.  
   **Pullman Students**: Submit a “hard copy” of your homework either in class, or slide it under my office door.  
   **Everett and Bremerton Students**: Scan your HW as a pdf file and submit as an e-mail attachment.

3. **Midterm Exams**: There will be two midterm exams. You will be allowed two 8.5” by 11” single-sided study sheets for each midterm exam. It is your responsibility to include all relevant formulae, tables, etc. in this sheet. Besides the problems, I will not be providing anything else during the exam.

4. **Office hours**: If you cannot see me during regular office hours (or even otherwise), you are encouraged to send me course messages via e-mail and/or setup another mutually convenient meeting time. I will try to answer queries as soon as possible (within a few hours in most cases, if I am in town).

5. **Academic honesty**: I encourage discussion of class material and, to a limited extent, homework problems among students. However, each student must turn in original work. No copying will be accepted. It is not permitted, under any circumstances, to consult or plagiarize past homework solutions. Cheating during an exam is considered to be a serious violation of ethical integrity. Any material you turn in for a grade must be your own work. Cases of academic dishonesty shall be dealt with in accordance with Academic Integrity Policy for the School of Electrical Engineering and Computer Science found at [http://www.eecs.wsu.edu/~schneidj/Misc/academic-integrity.html](http://www.eecs.wsu.edu/~schneidj/Misc/academic-integrity.html). Academic sanctions will range from receiving no credit for the assignment to failing the course and decertification from the degree program. If you are aware of any incidents of cheating by fellow students, please bring it to my attention, as soon as possible.

6. **Attendance**: I do not intend to impose regular lecture attendance. However, I don’t expect anyone to be habitually absent. If you miss a class, it is your responsibility to make-up the material covered in class (see me before or after the class or ask one of your classmates). You are responsible for all announcements made during that class.

7. **Make-up Exams**: Absence from an exam will be excused only for very serious medical or personal emergencies. Please let me know as soon as possible, preferably before the exam, if you would be unable to take an exam. In such cases, a make-up test will be given, at a time to be arranged.

8. **Computer accounts**: All students registered for this course are encouraged to get an account on the EECS computer systems. Contact the systems staff about this (let me know if you still have difficulties).

9. **Holidays**: There will be no class on the following days: Labor Day --- Monday, Sept. 3, 2018; Veteran’s Day -- - Monday, Nov. 12, 2018; Thanksgiving Break --- Nov. 19-23, 2018.

10. We will use Matlab in many HW exercises and the Project. Students who wish to have MATLAB on their own personal computers can purchase MATLAB & Simulink Student Version for around $99 from either of the following: Campus book store or [www.mathworks.com/store](http://www.mathworks.com/store). However, note the recent announcement of Matlab availability at WSU. An alternative to Matlab is Octave, an open-source resource that can be downloaded from the gnu.org website. Many of the Matlab functions have Octave equivalents. (However, some modifications may be necessary. Caveat emptor.)

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**WSU Reasonable Accommodation Statement**

“Students with Disabilities: Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center at **Pullman or WSU Online**: 509-335-3417, Washington Building 217; [http://accesscenter.wsu.edu](http://accesscenter.wsu.edu), [Access.Center@wsu.edu](mailto:Access.Center@wsu.edu) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center. For more information contact a Disability Specialist on your home campus.”

**WSU Academic Integrity Statement**

“Academic integrity is the cornerstone of higher education. As such, all members of the university community share responsibility for maintaining and promoting the principles of integrity in all activities, including academic integrity and honest scholarship. Academic integrity will be strongly enforced in this course. Students who violate WSU’s Academic Integrity Policy (identified in Washington Administrative Code (WAC) 504-26-010(3) and -404) will receive a grade of F for the course, will not have the option to withdraw from the course pending an appeal, and will be reported to the Office of Student Conduct.”
Cheating includes, but is not limited to, plagiarism and unauthorized collaboration as defined in the Standards of Conduct for Students, WAC 504-26-010(3). You need to read and understand all of the definitions of cheating: [http://app.leg.wa.gov/WAC/default.aspx?cite=504-26-010](http://app.leg.wa.gov/WAC/default.aspx?cite=504-26-010). If you have any questions about what is and is not allowed in this course, you should ask course instructors before proceeding.

If you wish to appeal a faculty member's decision relating to academic integrity, please use the form available at [conduct.wsu.edu](http://conduct.wsu.edu).”

Safety and Emergency Notification

“Classroom and campus safety are of paramount importance at Washington State University, and are the shared responsibility of the entire campus population. WSU urges students to follow the “Alert, Assess, Act,” protocol for all types of emergencies and the “Run, Hide, Fight” response for an active shooter incident. Remain ALERT (through direct observation or emergency notification), ASSESS your specific situation, and ACT in the most appropriate way to assure your own safety (and the safety of others if you are able).

Please sign up for emergency alerts on your account at MyWSU. For more information on this subject, campus safety, and related topics, please view the FBI’s Run, Hide, Fight video and visit the [WSU safety portal](http://wsu.edu).”

Week-To-Week Course Outline

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<thead>
<tr>
<th>Week no.</th>
<th>Dates</th>
<th>Topic (sections from text) and approximate order of coverage</th>
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<tbody>
<tr>
<td>1</td>
<td>Aug 20-24</td>
<td>Chapter 1, Notes on sampling, notes on quantization</td>
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<td>2</td>
<td>Aug 27-31</td>
<td>Chapter 2: 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7</td>
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<td>3</td>
<td>Sept 5-7</td>
<td>No class Sept 3 (Labor Day)</td>
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<td>Chapter 2: 2.8, 2.9</td>
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<td>Chapter 3: 3.1, 3.2</td>
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<td>4</td>
<td>Sept 10-14</td>
<td>Chapter 3: 3.2, 3.3, 3.4</td>
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<td>5</td>
<td>Sept 17-21</td>
<td>Chapter 3: 3.4, 3.5, 3.6, 3.7</td>
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<td>6</td>
<td>Sept 24-28</td>
<td>Chapter 3: 3.7, 3.8, 3.9 (browse), notes</td>
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<td>7</td>
<td>Oct 1-5</td>
<td>Chapter 3: 3.8, 3.9</td>
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<td>Exam 1 on Wed, Oct. 3</td>
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<td>Chapter 4: 4.1</td>
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<td>8</td>
<td>Oct 8-12</td>
<td>Chapter 4: 4.1, 4.2</td>
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<td>Oct 15-19</td>
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<td>Oct 22-26</td>
<td>Chapter 4: 4.4, 4.5, 4.6, 4.7, 4.8</td>
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<td>11</td>
<td>Oct 29-Nov2</td>
<td>Chapter 4: 4.8, 4.9</td>
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<td>Chapter 5: 5.1, 5.2, 5.3, 5.4</td>
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<td>Nov 5-9</td>
<td>Chapter 5: 5.4, 5.5, 5.6 5.7</td>
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<td>Chapter 6: 6.1, 6.2</td>
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<td>13</td>
<td>Nov 14-16</td>
<td>No class Nov 12 (Veteran’s Day)</td>
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<td>Exam 2 on Wed, Nov 14</td>
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<td>Chapter 6: 6.3, 6.4-6.7 (browse), 6.8</td>
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<td>Nov 19-23</td>
<td>Thanksgiving Break: no class</td>
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<td>14</td>
<td>Nov 26-30</td>
<td>Chapter 7: 7.1, 7.2, 7.3, 7.4, 7.5</td>
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<td>15</td>
<td>Dec 3-7</td>
<td>Chapter 7: 7.7, 7.7 7.8 (browse)</td>
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<td>Course Review</td>
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<td>Final Exam on Wed. Dec. 12, 8:00-10:00 am</td>
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