# MUS421A/EE367B Overview: Administrative Info

Center for Computer Research in Music and Acoustics (CCRMA)  
Department of Music, Stanford University  
Stanford, California 94305  
Spring Quarter, 2015-2016

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Music 421A (EE 367B)
Spectral Audio Signal Processing

1 Course Description

Music 421A covers applications of the Fast Fourier Transform (FFT) arising in digital audio research. The main topics addressed are practical time-frequency analysis using the FFT, spectral foundations for Music Information Retrieval (MIR) and Audio Machine Learning, sound synthesis by means of spectral models, and FFT-based signal processing.

1.1 Prerequisites

The only prerequisite for Music 421 is Music 320 or equivalent (prior exposure to complex numbers, sinusoids, Fourier theory, linear systems theory, digital filters, and z-transform analysis). In Electrical Engineering (EE), more than adequate coverage of Fourier theory is provided by EE 261 (Fourier Transform and its Applications). The EE Digital Filtering course, EE 264 covers prerequisite background pertaining to sampling and digital filtering, and there is some overlap of topics. Matlab or Octave is required for homework assignments, and is recommended for programming project work.

1.2 When, Where, Who

Term: Spring Quarter, every other year
Location: Main CCRMA Classroom (Knoll 217)
Time: Tuesdays and Thursdays, 4:30-5:45 PM
Instructor: Julius Smith (jos@ccrma.stanford.edu)
TA: Kitty Shi (kittyshi@ccrma.stanford.edu)
TA Office Hours: Wednesdays 3:30-5:30 pm in the CCRMA Ballroom
JOS Office Hours: after class on Tu, Th afternoons, up to half-hour appointments typical
Website: https://ccrma.stanford.edu/courses/421/

1 http://ccrma.stanford.edu/courses/320/
2 http://www.stanford.edu/class/ee261/
3 http://www.stanford.edu/class/ee264/
4 http://www.mathworks.com/
5 http://www.octave.org/
2 Administrative Information

2.1 Announcements

Class announcements are often made via email. For this we are presently using Piazza:

https://piazza.com/stanford/spring2016/music421a/home

You should have received an invitation from Piazza to join the class after you signed up for it in axess (using the email address known to axess). Otherwise, please join by visiting the above URL and entering your preferred email address.

2.2 Weekly Homework

There will typically be weekly to bi-weekly assignments consisting of reading, working theory problems, and carrying out lab exercises. The lab portions typically require programming in matlab.

The theory and lab assignments are normally assigned together on Thursdays. The theory part is normally due the following Thursday at 4:30 pm in the 421A mailbox (located in the Knoll Ballroom with the other mailboxes). The lab part is due on Friday at midnight, the day after the theory problems are due.

For lab assignments, we will be using the Coursework website. To sign up, go to the Coursework website and find Music421A. Once you are enrolled in the class, you can upload your matlab files in the “drop box” on the left menu.

See §2.5 below regarding obtaining help with theory and lab assignments.

Regarding late homeworks, 7 free late days are allowed (with hours rounded up to the nearest day). Late homeworks beyond this will not be accepted. Only up to 3 late days can be used for any one assignment. When using late days, students are required to write the number of late days used at the top of the assignment (date and time).

Students are encouraged to discuss the homework assignments with each other. It is fine to learn from a classmate how to solve any of the homework problems, but each student is responsible for carrying out and writing up the assignments individually. It is an honor code violation to copy the work of others.

2.3 Exams

The final examination will be held in the CCRMA Classroom (Knoll 217) on the University-assigned date, also listed for convenience in the class schedule (§ on page 4).

2.4 Grading

Grades are based on the homeworks/labs (60%), and the final exam (40%). There are also bonus points available based on general participation. The weightings may be changed as we see fit.

https://coursework.stanford.edu
2.5 Office Hours and Getting Help

We will be using Piazza\footnote{https://www.piazza.com} for sharing answers to posted questions with the whole class. To sign up, see the 421A Piazza site\footnote{https://piazza.com/stanford/spring2016/music421a/home}. It is free and allows you to view past questions from other students, and discuss questions together. Try it first for any homework questions you may have. You are also welcome, of course, to catch us whenever you see us at CCRMA, such as during office hours, etc.

TA weekly office hours will be announced in class and via email to the class. Meetings with JOS are arranged via email for half-hour slots before or after class, or other times when necessary.

2.6 Computer Usage

Lab exercises will be computer based. All students may obtain a computer account at CCRMA in order to use the computer facilities. It is also possible to work entirely on your own computer, as long as you have the necessary software. However, note that some course materials are restricted to on-campus access, so you should have at least one Stanford computer account from which you access those.

Here is how to obtain a CCRMA computer account:

\url{https://cm-knoll.stanford.edu/usersignup}

Note: This link only works at CCRMA.

Once you have your account, please log in at CCRMA and take a look at the User’s guides\footnote{http://ccrma.stanford.edu/guides/} tab in the left-frame menu of the main CCRMA website to learn more about computer usage and other facilities at CCRMA.

2.7 Units

You may sign up for 3 or 4 units. Three units involves only in-class time, assigned reading, any assigned videos, and homework/lab problems, and final exam. A fourth unit adds an independent project and report, which can be based on reading and/or lab work.

2.8 Final Project (Optional 4th Unit)

The purpose of the final project is to go beyond the content of the lectures and assigned reading in the direction most interesting to you. Your project can be on any topic related to lectures and assignments. A one-page project specification/proposal is due by the 4th class meeting, and the final written report is due by the end of finals week. You are also invited to present your project results during the last class. There are two primary project types:

- Outside reading and report
- Programming project and report

Your project can consist of any combination of the above components. A research-oriented project typically consists of the following main phases:

\footnote{https://www.piazza.com} \footnote{https://piazza.com/stanford/spring2016/music421a/home} \footnote{http://ccrma.stanford.edu/guides/}
Phase I: Outside reading (explore the topic)
Phase II: Software project (implement your best ideas from Phase I)
Phase III: Write-up

It is normal to iterate the above phases to some extent, rather than to perform them entirely sequentially.

2.9 Required Software

Laboratory assignments in this course will require programming in the matlab language. You can get by fine with Octave\(^\text{10}\), a free-software version of basic matlab. The student version of Matlab\(^\text{11}\) is priced well below other versions.

2.10 Important Pointers

The course schedule and outline\(^\text{12}\) in \(^\text{[1]}\) (also reachable from the class home page\(^\text{13}\)) lists the following information:

- Assignments!
- Schedule of lectures
- Pointers to all lecture overheads and the online text.

The class home page further contains pointers to sound examples and related items of interest online.

3 Reading

The text for this course is Spectral Audio Signal Processing\(^\text{14}\) by JOS. It is available online in HTML format, and the printed book\(^\text{15}\) can be ordered if desired. All reading assignments will be specified in the course schedule and outline\(^\text{4}\).

4 Schedule and Assignments

Below is our master schedule, with pointers to all reading assignments, lecture overheads\(^\text{17}\) and homework/lab assignments for the course.

Please bookmark this page\(^\text{16}\) (reachable from the class home page\(^\text{19}\)) and consult it each week for assignment specifications.

\(^{10}\)\url{http://www.octave.org/}
\(^{11}\)\url{http://www.mathworks.com/products/studentversion/}
\(^{12}\)\url{http://ccrma.stanford.edu/~jos/intro421/Schedule_Assignments.html}
\(^{13}\)\url{http://ccrma.stanford.edu/courses/421/}
\(^{14}\)\url{https://ccrma.stanford.edu/~jos/sasp/}
\(^{15}\)\url{https://www.createspace.com/3751411}
\(^{16}\)Older (2010 Draft) hardcopies of the text, which are nearly the same as the published version, may be obtained for $10 from a TA or JOS, while they last.
\(^{17}\)Links to the on-line lecture overheads appear only in the week titles in the Web version of this page.
To obtain printable versions of the assignments and solutions from off-campus locations, you can use commands such as

scp you@ccrma-gate.stanford.edu:/usr/ccrma/web/html/courses/421/hw/hw1/hw1.pdf .
scp you@ccrma-gate.stanford.edu:/usr/ccrma/web/html/courses/421/hw/hw1/hw1sol.pdf .

- **Week 1 - Course Intro**

  - **Reading**
    - Music 421 Overview (this document)
    - Verify that you have had adequate prior exposure to elementary spectrum analysis\(^{20}\), digital filter analysis\(^{21}\), and signal modeling\(^{22}\).
    - First 25 pages of Chapter 5 of *Spectral Audio Signal Processing (SASP)*\(^{23}\) entitled “Spectrum Analysis of Sinusoids”\(^{24}\) (through “The Rectangular Window”)

  - **Demos (supplementary)**
    - Demos\(^{25}\)

  - **HW#1**\(^{26}\)
• Week 2 - Fourier Review, Spectrum Analysis Windows

  – Reading
    * First three sections of Chapter 2 of [SASP](http://ccrma.stanford.edu/~jos/sasp/Fourier_Transforms_Continuous_Discrete_Time_Frequency.html) entitled “Fourier Transforms and Theorems”

  – Demos (supplementary)
    * DFT Visualizations ([be sure to check out the spectrum analyzer on Page 39 — built up starting on page 30](https://acko.net/files/gltalks/toolsforthought/))

• Week 3 - Spectrum Analysis Windows
  Optimal Window Design by Linear Programming
  – Reading
    * Chapter 3 of SASP entitled “Spectrum Analysis Windows”
    * First section of Appendix G of SASP entitled “Examples in Matlab and Octave”
  – HW#3

• Week 4 - FIR Digital Filter Design
  – Reading
    * Chapter 4 of SASP entitled “FIR Digital Filter Design”
  – HW#4

• Week 5 - Sinusoidal Spectrum Analysis
  – Reading
    * Finish Chapter 5 of Spectral Audio Signal Processing (SASP)\textsuperscript{30} entitled “Spectrum Analysis of Sinusoids.”
  – HW#5
    * Supplementary: Appendix C of SASP entitled “Statistical Signal Processing”

• Week 6 - Noise Spectrum Analysis
  – Reading
    * Chapter 6 of SASP entitled “Spectrum Analysis of Noise”
  – HW#6

• Week 7 - Time-Frequency Displays
  – Reading
    * Chapter 7 of SASP entitled “Time-Frequency Displays”
    * Chapter 8 of SASP entitled “Overlap-Add (OLA) STFT Processing”
  – HW#7

• Week 8 - Overlap-Add FFT Processors, Filter-Bank Summation (FBS) and Overlap-Add (OLA) Duality
  – Reading
    * First 4 sections of Chapter 10 (“Applications of the STFT”) on STFT spectral modeling
    * Start Chapter 9 of SASP entitled “Filter Bank View of the STFT”
    * Supplementary Handout: Frequency Domain Interpretation of COLA\textsuperscript{31}
  – HW#8

\textsuperscript{30}\textsuperscript{31}http://ccrma.stanford.edu/~jos/sasp/
http://www.stanford.edu/~wonghoi/mystuff/COLA.pdf
• Week 9 - Filter-Bank Summation (FBS)
  – Reading
    * Finish Chapter 9 of SASP entitled “Filter Bank View of the STFT”
    * Chapter 10 of SASP entitled “Applications of the STFT”

• Week 10 - Project Presentations