

MUS_TECH 450 Advanced Audio Signal Processing

Syllabus

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Please communicate by email!

Who Should Take This Class? This class is designed for students intending to implement music and audio technology. It is especially appropriate for students 1) who may work professionally in the music/audio technology industry, 2) who be involved in related research, or 3) who are interested in designing technology for use in the electronic arts.

Textbook: *Advanced Audio Signal Processing Readings*, course packet (available at Quartet)

Software: SuperCollider is a *free* downloadable program. The primary version that we will be using is available for the Mac OS X. There is also version for Windows that has different GUI programming. There is even a Linux version that doesn't have very good reviews. I strongly recommend using the Mac version. To download SuperCollider for Mac OS or Windows:

1. Go to <http://www.audiosynth.com/>
2. Click on "Download SuperCollider Server for MacOS X from here" (Windows people do this even though it doesn't make sense.)
3. Following the instructions and download where you want it.
4. Has to be decompressed before being installed where you put your applications.

SuperCollider is also installed on the Macs in the Listening Center/Computer Lab of the Deering Hall Music Library. The hours of the Music Library Lab are Monday - Thursday: 10:00 a.m. - 10:00 p.m., Friday: 10:00 a.m. - 5:00 p.m., Saturday: 1:00 p.m. - 5:00 p.m. and Sunday: 1:00 p.m. - 10:00 p.m. In order to start SuperCollider in the Music Library Lab:

1. Double-click on the Macintosh HD icon.
2. Double-click on the Home icon.
3. Double-click on the Applications folder.
4. Double-click on the SuperCollider_f folder.
5. Double-click on the SuperCollider application icon.

SuperCollider comes with a huge amount of built in documentation. It is your best source of helpful information. You will also be receiving copies of the lectures as SuperCollider documents that you can read.

Assignment: Audio Signal Processing Notebook

Over the span of the course, you will construct a notebook that reflects the knowledge you have acquired. The Notebook should both capture the evolution of your experience in the class and represent a summary of what you have learned.

Each person comes to this class with a unique background. One function of the Notebook is to be a vehicle for you to construct a representation of what you have gathered from this course in a way that is relevant to you. This assignment also puts the course's emphasis on your process of integrating information from lectures, albums, videos, etc. The Notebook ought to be an information resource you can keep after the class is over. The Notebook assignment also asks that you take time to reflect on the nature of your learning experience in the class and seek to relate the class to your everyday experience.

Work on the Notebook should be accumulative. This assignment preferences consistent day-by-day, week-by-week work. Don't even think about putting it off. Get started today.

Format. The Notebook must be created with a word processing program that enables the various sections to be expanded incrementally. For your own protection, be sure to make back-up copies of your computer files on separate disks!

Organization. Your Notebook must contain the following two sections:

I. Summary of Audio Signal Processing Theory as Presented in Lecture and Readings. Write a summary of the topics covered in the class. Nearly every topic is supported by class lectures and readings. Synthesize the information into a whole and construct an organized summary of the material. (Do not simply include your lecture notes! Do not forget the readings! Do not forget musical topics!) Organize your text by topics like the "Schedule of Topics" and use subject headings and subheadings to help organize the material. (Do not include lecture dates or general impressions of lectures!) Write full sentences and complete paragraphs. (Do not write sentence fragments and constantly make lists.)

II. Diary. Personal reflections (at least one for every week) that capture the evolution of your reactions to and ideas about the class topics. This is also the place to provide feedback (positive and negative) to the instructor on how well the course is serving you. Organize the Diary by the date of the entry.

Periodic Review by Instructor. The Notebook will be turned in for periodic review and comments by the instructor during the 3rd-4th and 6th-7th weeks. You may be requested to turn in Notebooks on additional dates.

Final Version. The Final Version is due on **Monday, June 5 at 9 am**. Don't be late and don't ask for an extension. Turn it in.

Turning In Your Notebook. Turn in your Notebook at room 112 of the Music Administration Building.

Signal Processing Assignments

Signal processing assignments will be given in class. The majority of these assignments will involve programming in SuperCollider and other assignments will require processing audio with other software packages. Coding style is not a consideration in grading. Assignments either fulfill the requirements and work or do not. Grades are either 100% or 0%.

Final Grade. The course grade will be based 80% on the notebook and 20% on Signal Processing assignments.

Schedule of Topics

Abbreviations for Cited Sources

CMJ	<i>Computer Music Journal</i> , MIT Press.
COOK	Perry Cook, <i>Music Cognition, and Computerized Sound :An Introduction to Psychoacoustics</i> , MIT Press, 1999.
JAES	<i>Journal of the Audio Engineering Society</i>
LYONS	Richard Lyons, <i>Understanding Digital Signal Processing</i> , Addison-Wesley, 1997.
MOORE	F Richard Moore, <i>Elements of Computer Music</i> , Prentice Hall, 1990.
MSP	<i>Musical Signal Processing</i> , ed. by Curtis Roads, Stephen Travis Pope, Aldo Piccialli, Giovanni De Poli., Swets & Zeitlinger, 1997.
ROADS	Curtis Roads, <i>The Computer Music Tutorial</i> , MIT Press, 1996.
POHLMANN	Ken Pohlmann, <i>Principles of Digital Audio</i> , 4 th Ed., McGraw-Hill, 2000.

STEIGLITZ Ken Steiglitz, *A Digital Signal Processing Primer*, Addison-Wesley, 1996.
STRAWN John Strawn, *Digital Audio Signal Processing: An Anthology*, A-R, 1985.

I. Introduction

Reading:

Fundamentals

“Discrete Sequences and Systems” [Chapter One, LYONS]

Appendix: Useful References to DSP Mathematics

“Tuning Forks, Phasors” [Chapter 1, STEIGLITZ]

“An Introduction to the Mathematics of Digital Signal Processing” by F. Richard Moore
[Chapter One, STRAWN]

II. Digital Filtering Revisited (Weeks 1-2)

Reading:

Basic Concepts

“Fundamentals of Digital Filter Theory” by Julius O. Smith [CMJ, 1985]

“Digital Filters” [MOORE, section 2.4]

Filter Examples

“Digital Filter Theory, Part III, Examples and Important Special Cases” Julius O. Smith [Chapter
2, STRAWN]

“Cookbook Formulae for audio EQ biquad filter coefficients” Robert Bristow-Johnson.
Posted to music-dsp list server.

III. Effects Revisited (Weeks 2-3)

Reading:

Dynamic Range Processing

“Dynamic Range Processing,” excerpt from Chapter 10, pp. 390-397, ROADS

“Compression/Limiting” Harmony Central web site.

Reverberation and Delay-based Effects

“Effect Design, Part 1: Reverberation and Other Filters” Jon Dattorro, [vol. 45, no. 9, JAES]

“Effect Design, Part 2: Delay-Line Modulation and Chorus” Jon Dattorro, [vol. 45, no. 10, JAES]

“Filters, Delays, Modulations and Demodulations: A Tutorial” Pierre Dutilleul. DAFX98
Workshop on Digital Audio Effects, Barcelona.

“Modulation and Delay Line-Based Digital Audio Effects” Sascha Disch and Udo Zölzer.
DAFX99 Workshop on Digital Audio Effects, Trondheim.

“A Hilbert-Transformer Frequency Shifter for Audio” Scott Wardle, DAFX98 Workshop on
Digital Audio Effects, Barcelona.

IV. The Fast Fourier Transform (Weeks 4-6)

Reading:

Using the FFT

“Fourier Analysis” Curtis Roads with Philip Greenspun [Appendix, ROADS]

“The Discrete Fourier Transform” [from Chapter 3, LYONS]

Convolution with FFTs

“Convolution,” [excerpt from Chapter 10, pp. 419-432, ROADS]

“A Generic Description of Discrete Convolution” [from Chapter 5 LYONS]

“Linear Convolution Using the Discrete Fourier Transform” from *Digital Signal Processing* by
Oppenheim and Schaffer.

Tricks of the Trade

“Digital Signal Processing Tricks” [Chapter 10, LYONS]

V. Spectral Processing (Weeks 6-8)

Reading:

“Time/Pitch Changing,” [excerpt from Chapter 11, pp. 440-448, ROADS]

“Sound transformation by convolution,” Curtis Roads [MSP]
“Introducing the phase vocoder” Marie-Helene Serra [MSP]
“Spectral Mutation in Soundhack” Larry Polansky and Tom Erbe [CMJ, 1966]

VI. Perceptual Coding and Its Applications (Weeks 9-10)

Reading:

“The Ear and How It Works” and “The Auditory Brain” by Max Mathews [Chapters 1 & 2, COOK]
“Perceptual Coding” [Chapter 10, POHLMANN]
“DVD” [Chapter 11, POHLMANN]
“Internet Audio” [Chapter 15, POHLMANN]