

Introduction to Micro-Structural Composition and Sound Synthesis

MUS 109IA / MAT 276IA | Fall 2025

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Class meetings: Monday and Wednesday, 10:00-11:50

Location: Elings 2003

Course description

This course introduces computer music composition through the relationship between sound synthesis, code, and listening. Using C++ and AlloLib, students work with provided synthesis instruments and note-list scores to shape pitch, timbre, amplitude, and musical time. Exercises move from envelopes and waveforms through frequency modulation, amplitude modulation, additive and subtractive synthesis, and physical modeling.

Creative coding is developed through an iterative process: read and modify code or score data, listen to the result, identify a compositional problem, and revise. Historical listening and readings connect these technical decisions to musical form and perception. The course culminates in an original composition and an explanation of the choices that produced it.

Learning outcomes

By the end of the course, students will be able to:

L01 Explain how sampling, quantization, signal flow, and basic psychoacoustic principles affect digitally generated sound.

L02 Read and modify provided C++/AlloLib instrument code and note-list parameters to control sound and organize musical events.

L03 Apply envelopes, modulation, and synthesis techniques to create intentional changes in timbre and temporal structure.

L04 Test and revise a coded composition through listening, troubleshooting, and comparison of successive versions.

L05 Analyze computer music examples and explain relationships between synthesis processes, perception, and compositional choices.

L06 Present a composition with understandable code or score documentation, attribution of reused materials, and a reflection on its development.

Learning activities

Lectures, guided coding exercises, listening and analysis, assignment presentations, and individual project meetings connect technical practice with composition. Early troubleshooting sessions support students in working with the shared instruments before developing individual pieces.

Assignments and course assessment

Four composition studies build toward the final project. Each study asks students to make audible choices with the instrument or synthesis process introduced in class. The final project proposal prepares students for the final presentation and completed composition.

Component	Focus	Course grade
Assignment 1	Sine instrument and envelope composition	10%
Assignment 2	Waveforms and vibrato composition	15%
Assignment 3	Audio frequency modulation composition	15%
Assignment 4	Amplitude modulation and additive synthesis composition	15%
Assignment 5	Final project presentation	10%
Final assignment	Final composition and written description	25%
Classroom and lab participation	Exercises, discussion, presentations, and project development	10%
Total		100%

Composition studies

Assignment 1: Shape a composition with the sine instrument and amplitude envelopes. Explore how the timing and contour of individual events affect the larger musical form. Due October 13.

Assignment 2: Create a short composition with Synth 3, combining waveforms and vibrato. Use changes in modulation and event organization to develop a musical idea. Due October 29.

Assignment 3: Develop a composition using audio frequency modulation. Relate changes in synthesis parameters to the timbral behavior heard in the piece. Due November 5.

Assignment 4: Create a composition using amplitude modulation and additive synthesis. Explore how spectral relationships and changes over time contribute to form. Due November 17.

Assessment of the composition studies

The studies are assessed for understanding of the assigned synthesis process, intentional organization of sound, evidence of experimentation and revision, and the ability to explain technical and musical choices. A successful study makes the relationship between the code or score and the audible result clear. Technical complexity alone does not determine quality.

Final project sequence

Present a proposal on November 24, develop the piece through the scheduled individual meetings, and present the final work on December 3. Assignment 5 refers to the final presentation, worth 10%. The completed composition and written description form the separate final assignment, worth 25%. The proposal is a preparation stage rather than an additional grading category.

Final composition assignment

Proposal presentation: November 24 | Final presentation and submission: December 3

Prompt

Using one or more instruments introduced in class, compose an original piece in which the behavior of synthesized sound contributes to the musical form. Begin with a question you can investigate through code and listening: for example, how might an envelope change the perceived continuity of a phrase, or how might a changing modulation relationship create a transition between contrasting textures?

Develop your idea by editing instrument code, note-list data, or both, as appropriate to the instruments you choose. Work with the supplied instruments as a starting point and identify your own changes. The duration should follow the density of events, tempo, and development of the musical idea; there is no fixed duration requirement.

Process

1. Define your idea. Identify the intended listening experience, the instrument or synthesis process you will use, and the parameters you expect to explore.
2. Build a study. Make a small test that isolates a relationship between a parameter change and an audible result. Explain why that relationship matters to your composition.
3. Develop and revise. Expand the study into a piece with an intentional temporal structure. Compare versions and document at least one substantial revision made after listening or feedback.
4. Prepare the presentation. Show the connection between a short code or score excerpt and the sound it produces. Explain which decisions became central to the final piece.

What to submit

- The C++ source files and note-list or score files needed to reproduce the piece, with brief instructions identifying the entry point and any required dependencies.
- A written description of approximately 500-750 words explaining the compositional idea, instruments and synthesis techniques used, the relationship between selected parameters and audible results, and the development of the piece.
- Evidence of one meaningful revision, such as two short audio excerpts, annotated code or score excerpts, or a clearly described before-and-after comparison. This may be included in the written description.
- Attribution of provided instruments, borrowed code, and other reused materials, with a clear account of your own contribution.

Relevant materials and learning outcomes

Use the AlloLib instrument examples and note-list exercises developed in class. Consult Roads on oscillators and envelopes (pp. 87-107), modulation (pp. 215-239), or subtractive synthesis (pp. 184-197), and Moore on the corresponding techniques listed in the schedule. Select the readings relevant to your chosen process. This assignment assesses LO2, LO3, LO4, LO5, and LO6.

Final project assessment criteria

The following rubric makes the expanded final assignment expectations explicit. It applies to the composition, submitted materials, and written description, which together account for 25% of the course grade. The final presentation is assessed separately for 10%.

Criterion	Weight within final assignment	Evidence of successful work
Synthesis and code understanding	30%	The code and score materials reproduce the intended result. The explanation accurately connects the chosen synthesis process and parameter changes to audible effects.
Compositional development	30%	The piece develops a clear musical idea through intentional treatment of timbre, time, texture, or density. Its duration and organization support that idea.
Experimentation and revision	20%	The submission compares an earlier and later approach, identifies a specific problem or discovery, and explains how listening or feedback informed a meaningful change.
Documentation and reflection	20%	Files and instructions are understandable; reused materials are attributed. The written description connects technical decisions to listening and evaluates the result with concrete examples.

How the rubric is applied

For each criterion, strong work provides clear evidence and precise explanation. Satisfactory work meets the main requirement with minor gaps. Developing work shows partial understanding or incomplete evidence. Work requiring substantial revision does not yet demonstrate the outcome. Feedback identifies evidence and a next step for improvement.

Final presentation assessment

The final presentation is assessed for clarity of artistic intention, an accurate demonstration of the relationship between code and sound, and thoughtful discussion of the process. Identify one technical decision and one revision, and explain their effects. Presentation assessment focuses on communicating the work; the submitted composition is assessed through the rubric above.

Proposal and formative feedback

The November 24 proposal should explain the compositional question, planned instruments, and development plan, with a short sound or code study where available. Proposal discussion and individual meetings help students refine scope, troubleshoot, and revise before submission.

Classroom and lab participation

Participation is assessed through preparation, coding and listening exercises, constructive responses to classmates, and continued project development. Questions and troubleshooting contributions provide evidence of engagement, alongside the use of feedback.

Course schedule for weeks 1 through 5

Readings are assigned for preparation and continued work after the listed class. Roads and Moore refer to the core texts on page 7; page ranges are retained from the original course reading assignments.

Week and date	Class topics and activities	Reading and work for the next class
1 Sep 29	Course and instructor introduction; AlloSphere Research Group; history of computer music; review of syllabus; AlloLib installation.	Sound representation: Roads pp. 14-44; Moore pp. 27-56.
1 Oct 1	Acoustic and electronic music; how computers make music; science of sound; sound and noise; elements of sound; Synth 1; installation troubleshooting.	Roads pp. 14-44; Moore pp. 27-56. Acoustics: Dodge pp. 25-61. Psychoacoustics: Roads Part VII; Moore pp. 17-23.
2 Oct 6	Digital audio: ADC/DAC, sampling, Nyquist frequency, anti-aliasing, quantization, bit depth, and audio buffers; acoustics and psychoacoustics.	Oscillators, amplifiers, envelopes: Moore pp. 150-175; Roads pp. 87-107. AlloLib documentation. Begin Assignment 1.
2 Oct 8	Digital signal flow; note lists and composition methods; listening to Varèse (Octandre) and Schoenberg (Farben); AlloLib exercise.	Format scores for Synth 1; continue envelope composition. AlloLib documentation. Sub-audio FM: Moore pp. 198-203.
3 Oct 13	Assignment 1 due and presentations. Introduce Synth 2 and waveforms.	Study Synth 2 and AlloLib documentation; continue Moore pp. 198-203.
3 Oct 15	Sub-audio FM; Synth 3 combines waveforms with vibrato; instrument design; parametric note-list input.	Study Synth 3 and experiment with vibrato. Audio FM: Roads pp. 224-239; Moore pp. 316-329.
4 Oct 20	Signal flow; sub-audio FM; composition with AlloLib; listening to Ligeti; exercises and troubleshooting.	Begin Assignment 2 with Synth 3. Audio FM: Roads pp. 224-239; Moore pp. 316-329. AM: Moore pp. 185-189; Roads pp. 215-224.
4 Oct 22	Review of modulation; FM synthesis; Synth 3; AlloLib and note-list exercises.	Continue Assignment 2 using waveforms and vibrato.
5 Oct 27	Review; listening to Penderecki and Gérard Grisey; note-list syntax and modification.	Begin Assignment 3 using audio FM.
5 Oct 29	Assignment 2 due and presentations. Audio FM in detail.	Continue Assignment 3. AM: Moore pp. 185-189; Roads pp. 215-224.

Course schedule for weeks 6 through 10

Week and date	Class topics and activities	Reading and work for the next class
6 Nov 3	FM in detail; Synth 4 (FMVib_Wavetable); listening to John Chowning and Tristan Murail; tremolo and Synth 5; integrated instruments; compositional process.	Continue Assignment 3 and the assigned modulation readings.
6 Nov 5	Assignment 3 due and presentations. Instrument design; sub-audio and audio amplitude modulation.	Begin Assignment 4. AM: Moore pp. 185-189; Roads pp. 215-224. Read Moore on additive synthesis.
7 Nov 10	Amplitude modulation and its implementation; Synth 6 (AM); Fourier synthesis.	Explore additive synthesis and AM instruments for Assignment 4.
7 Nov 12	Review; Synth 7 (AddSyn); listening to Jean-Claude Risset (Mutations).	Continue Assignment 4 using AM and additive synthesis.
8 Nov 17	Assignment 4 due and presentations. Subtractive synthesis, filters, noise, and complex waveforms.	Begin final projects. Roads pp. 184-197; Moore pp. 263-278.
8 Nov 19	Synth 8 (SubSyn); reverb, delay, effects, and filters; physical modeling and Synth 9 (Pluck); listening to Risset (Sud).	Roads pp. 432-440. Prepare the final project proposal.
9 Nov 24	Final project proposal presentations and discussion.	Roads pp. 451-486; Moore pp. 340-353, 359-360, 369-376, 377-380. Continue project development.
9 Nov 26	Individual meetings.	Continue composing, listening, troubleshooting, and revising.
10 Dec 1	Individual meetings.	Refine the piece and prepare the final presentation and documentation.
10 Dec 3	Final project presentations at Alloportal (Assignment 5). Final composition and written description due.	Submit the final assignment materials described on page 3.

Software and working materials

The class uses C++ and AlloLib, the provided Synth 1-9 instrument examples, and note-list or score files. Installation, debugging, and code modification are introduced through the scheduled labs and exercises.

[AlloLib Playground and setup instructions](#)

[C++ language tutorial](#)

Course readings and reference materials

Readings are distributed in class or assigned from the following texts. The schedule identifies the required excerpts; the additional books and articles provide reference material for synthesis, composition, and project development. Use the assigned excerpts for the listed page ranges, which may differ across editions.

Core texts

Roads, Curtis. *The Computer Music Tutorial*.

Moore, F. R. *Elements of Computer Music*.

[Publisher reference for The Computer Music Tutorial](#)

Additional books

Bateman, Wayne. *Introduction to Computer Music*.

Dodge, Charles. *Computer Music: Synthesis, Composition, and Performance*.

Howe, Hubert. *Electronic Music Synthesis*.

Mathews, Max. *The Technology of Computer Music*.

Strange, Allen. *Electronic Music: Systems, Techniques, and Controls*.

Trythall, Gilbert. *Principles and Practices of Electronic Music*.

Roads, Curtis. *Composing Electronic Music: A New Aesthetic*.

Articles and technical readings

Chowning, John. *The Synthesis of Complex Audio Spectra by Means of Frequency Modulation*.

Chowning, John. *The Simulation of Moving Sound Sources*.

Moore, F. R. *An Introduction to the Mathematics of Digital Signal Processing, Parts I and II*.

Moore, F. R. *Music Signal Processing in a Unix Environment*.

Moorer, J. A. *How Do Computers Make Music?*

Moorer, J. A. *Signal Processing Aspects of Computer Music*.

Moorer, J. A. *About This Reverberation Business*.

Moorer and Grey. *Lexicon of Analyzed Tones, Part I: Violin Tone*.

Moorer. *Lexicon of Analyzed Tones, Part II: Clarinet and Oboe Tones*.

Truax, B. *Organizational Techniques for C:M Ratios*.

Schottstaedt, B. *The Simulation of Natural Tones Using Frequency Modulation with a Complex Modulating Wave*.

Truax, B. *Timbral Construction in Arrays as a Stochastic Process*.

Listening and analysis

Scheduled listening includes Varèse, Schoenberg, Ligeti, Penderecki, Grisey, Chowning, Murail, and Risset. The historical repertoire on the next page provides a wider reference for listening and discussion. Students are encouraged to relate audible structure and timbral development to the processes explored in their own work.

Historical listening repertoire

Reference works retained from the original course list. Selections support discussion of electronic sound, compositional form, and the historical development of computer music.

Composer	Works
Albright, W.	Last Rites
Arel, Bulent	Mimiana II: Frieze
Appleton, Jon	Chef d'Oeuvre; Of a Tonga
Babbitt, Milton	Ensembles for Synthesizer; Composition for Synthesizer
Berio, Luciano	Omaggio a Joyce; Visage
Boretz, Ben	Group Variations
Chowning, J.	Phonee; Stria; Turenas
Davidovsky, M.	Electronic Study I; Synchronism 6
Dodge, Charles	The Earth's Magnetic Field
Druckman, Jacob	Synapse; Animus II
Leedy, Douglas	Entropical Paradise
Ligeti, György	Artikulation
Lucier, Alvin	North American Time Capsule
McLean, Prisc.	Dance of Dawn
McLean, Bart	Spirals
Martirano, S.	Underworld
Oliveros, P.	I of IV
Randall, J. K.	Lyric Variations
Reich, Steve	Come Out
Risset, Jean-Claude	Mutations
Rudin, Andrew	Trageodia
Stockhausen, Kh.	Gesang der Jünglinge; Hymnen; Kontakte; Kurzwellen; Mikrophonie I/II; Telemusik
Subotnick, M.	Sidewinder; Silver Apples; Touch
Varèse, Edgard	Poème électronique
Vercoe, Barry	Synthesizm
Wuorinen, Ch.	Time's Encomium
Wilson, George	Exigencies
Xenakis, I.	Orient-Occident