

# ECE402 Lecture Topics

Electronic Music Survey Course – Haken and Cheng

Introduction to Lecture, Introduction to Lab, Choose Lab Teams and Times [Lect 1]

An Incomplete History of Electronic Music Technology since 1900 [Lect 2]

Telharmonium, Theremin, Reproducing Piano, Ondes Martenot  
Trautonium, Hammond Organ, RCA Synthesizer [Lect 3, Quiz]  
Musique Concrète, Pierre Schaeffer, Classic Studio, Edgar Varèse  
Hugh LeCaine, Robert Moog, Don Buchla, Mellotron, Walter Carlos, Isao Tomita [Lect 4]  
Lejaren Hiller, Max Mathews, Iannis Xenakis  
Phase Oscillator and Wavetable Synthesis, FM [Lect 5]  
Samson Box, Dartmouth Synthesizer, Fairlight CMI, Yamaha DX7 [Lect 6]  
IMS Synthesizer, Platypus  
Midi, Midi Sequencers and Timbre Editors, Digital Control of Analog Synthesizers  
Software Synthesis, Physical Models, DSPs – CPUs – GPUs [Lect 7]

Music Encoding

Kyma, Max, Reaktor  
Music Typesetting  
MusicXML  
Automated Music Transcription  
Optical Music Recognition (OMR)  
Braille Music [Lect 8]  
MusicN  
Midi Hardware Interface  
Midi Encoding, Running Mode, 14-bit Controller Fail, Control-Rate Aliasing [Lect 9]

Four Aspects of Music: Pitch, Loudness, Timing, Timbre

Note Name, Pitch Class, Note Number, Cents, Frequency Ratios  
Equal Tempered Scale, Just Tuning, Perfect Triads, Commas [Lect 10]  
JND, Frequency, Accuracy Requirements for Phase Oscillator  
Equal Loudness, Sones, Phons, Total Loudness, Musical Dynamic Markings [Lect 11]  
Accelerando Formulae

Time-varying Spectral Analysis/Synthesis [Lect 12; Lect 13 Midterm]

Pitch-tracking Analysis (Short Windows)  
McAulay-Quatieri Analysis (Long Windows) [Lect 14]  
Quadratic Phase Synthesis  
Noise Representation  
Phase Representation  
Time-Frequency Reassignment [Lect 15]

Psychoacoustics and Signal Processing

Outer ear - Middle Ear - Inner Ear  
Shoulder, Head, and Pinna Effects  
Place Principle  
Otoacoustic Emissions  
Critical Band, Masking Pattern, Temporal Masking Effects [Lect 16]  
Barks  
Total Excitation Pattern

Fixed Waveform Synthesis

No quasi-harmonic components  
Avoiding Aliasing  
Variable Duty-cycle Pulse Oscillator, Window Pulse Waveform  
Bandlimited Impulse Train, Bipolar BLIT, Leaky Integration [Lect 17]  
Phase Oscillator, Discrete Summation Formulae  
Engineer's Sawtooth, Musician's Sawtooth

# ECE402 Lecture Topics (continued)

## Additive Synthesis with Complex Basis Functions [Lect 18]

Spectral Matching with Fixed Wavetables, Genetic Search  
Properties of Group Additive Synthesis, Morphing Implementation

## Sound Morphing and Cross Synthesis [Lect 19]

Additive Sound Morphing, Additive Cross Synthesis  
Convolution  
Talking Guitar Effect  
Vocoder: Bandpass Filters, Amplitude Followers, Multipliers  
LPC: Transfer Function, Number of Poles, Frame Rate, Stability, Error Function  
Types of Inputs Useful for Vocoder and LPC

## Pitch Processing [Lect 20]

Zero Crossings, Peak Detection  
Comb Filter, 2nd Derivative  
Autocorrelation  
Cepstral Pitch Detection, Quefrency  
Spectral Peak Labeling, String Inharmonicity Formula  
How Not to Pitch Shift [Lect 21]  
Pitch Shifting Using Lent's Algorithm

## Synchronous Granular Synthesis

Serialized Lent's algorithm, Time Stretching and Pitch Shifting  
Grain Spectra, Mixing, Morphing, Formant Preservation, Spectral Envelope Dilation

## Asynchronous Granular Synthesis [Lect 22]

Sampled Grains, Granulated Sinusoids

## IRCAM Chant Synthesis

Jenny Oscillator

## Physical Models

Kinetic Model, Modeled Noise vs Filtered White Noise  
Karplus-Strong (Simple Waveguide Model), Fractional Sample Delay (All Pass vs. Lagrange)  
Models using Multiple Waveguides, Nonlinear Elements, Banded Waveguides, FDN [Lect 23]  
Modal Synthesis, Nonlinear Feedback

## Waveshaping (aka Nonlinear Filtering, or Memoryless Harmonic Distortion Synthesis) [Lect 24]

Clip, Soft Clip, etc.  
Feedback Impedance Functions for Physical Models  
Polynomial Table Function, Brightness and RMS Matching

## Modulation Synthesis [Lect 25]

AM, RM, Single-sideband  
FM, Spectral Frequencies and Amplitudes, FM Recipes  
Multi-operator FM, Formant FM

## Musician's Filters [Lect 26]

Musician's Low Pass Filter, Half-power Excursion, Transparency  
Control Issues: Parameter Decoupling, Stability  
All-pass Lattice, Regalia-Mitra Topology, Chamberlin Filter

## AES3 Standard [Lect 27]

Biphase Encoding, Differential (Balanced) Signals  
Block, Frame, Subframe, Time Slot, Channel Status

## Lab Demos [Lect 28 & 29]