

# Harmonize Your Code

An Introduction to Audio Programming

Lloyd Seo

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# Check-in Code

\_\_\_\_\_ for \_\_\_\_\_

Harmonize Your Code: Intro to Audio ...

audiO

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[members.acmucsd.com](https://members.acmucsd.com)

# Agenda

1

## What is Audio Programming?

What it is and its applications

2

## Basics of Digital Audio

Fundamental concepts and techniques

3

## Tools & Knowledge

Programming languages, frameworks, etc.

4

## Live Demo

Create sound with code!

5

## The Future

Challenges and future developments

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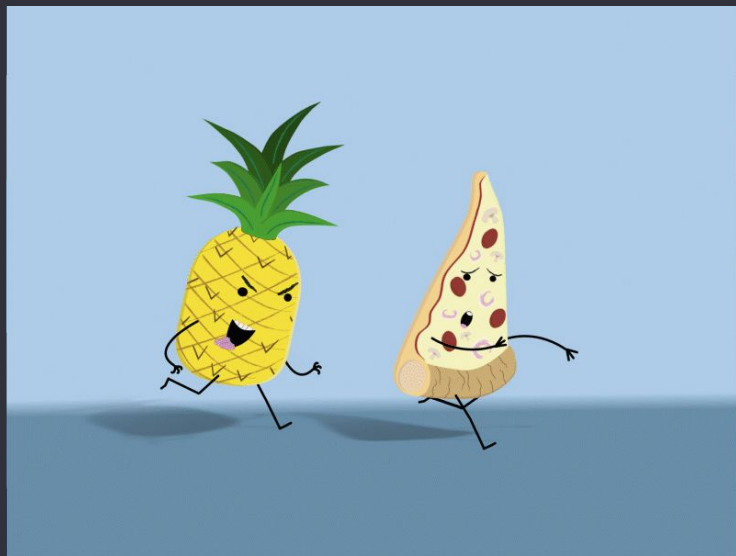
# Icebreaker

Introduce yourself to the people around you!

Q1. Is pineapple on pizza valid?

Q2. Is it ok to fold pizza??

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# What is Audio Programming?

Writing programs to create and  
manipulate digital audio

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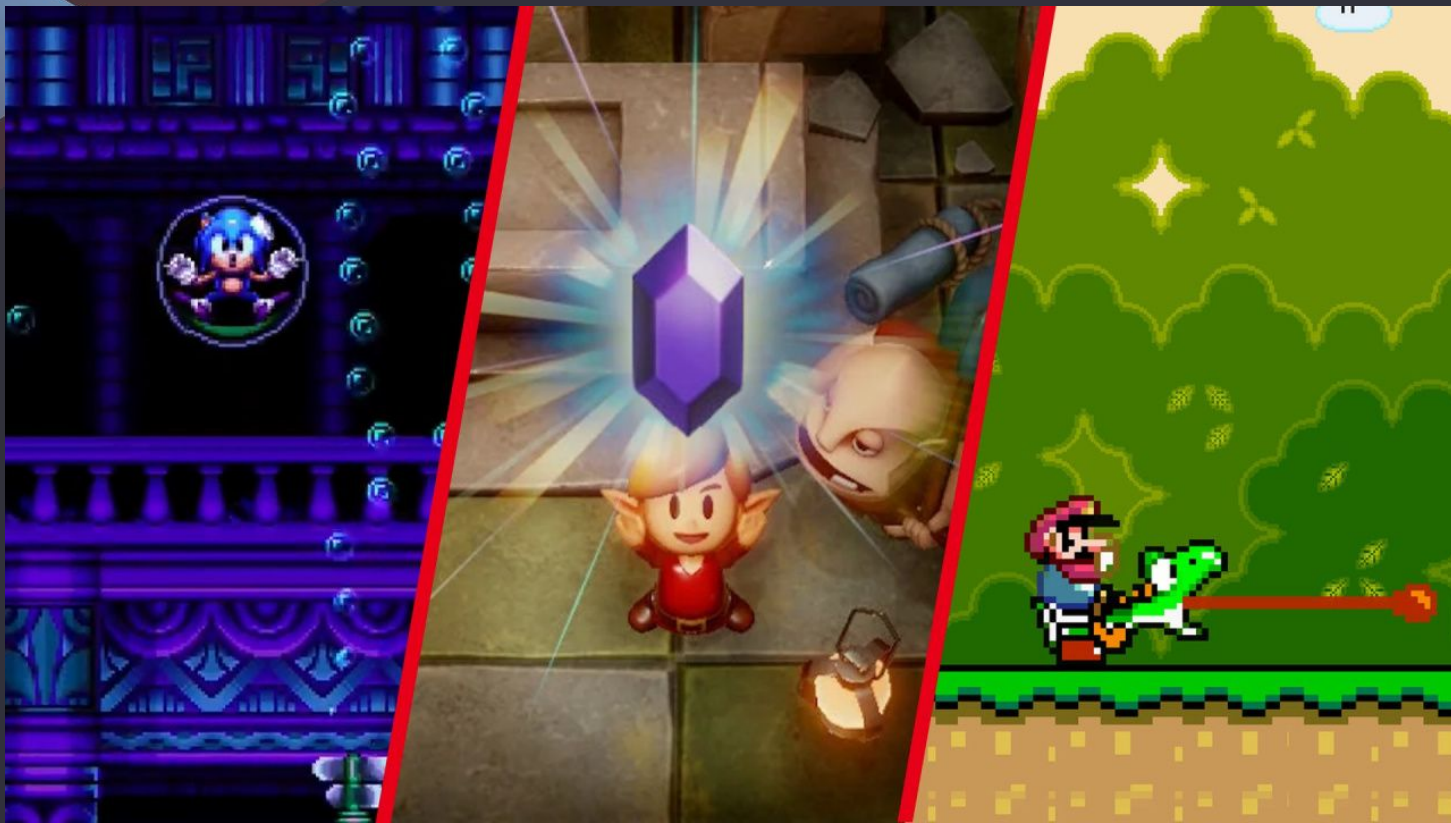




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pandora®

deezer

Apple Music

Spotify®

YouTube Music

amazon music

TIDAL

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# Other Applications Include...

- Speech/music recognition algorithms (i.e. automatic subtitles on YouTube, Shazam, voice assistants)
- Hearing-aids
- Telecommunications
- Microphones and speakers

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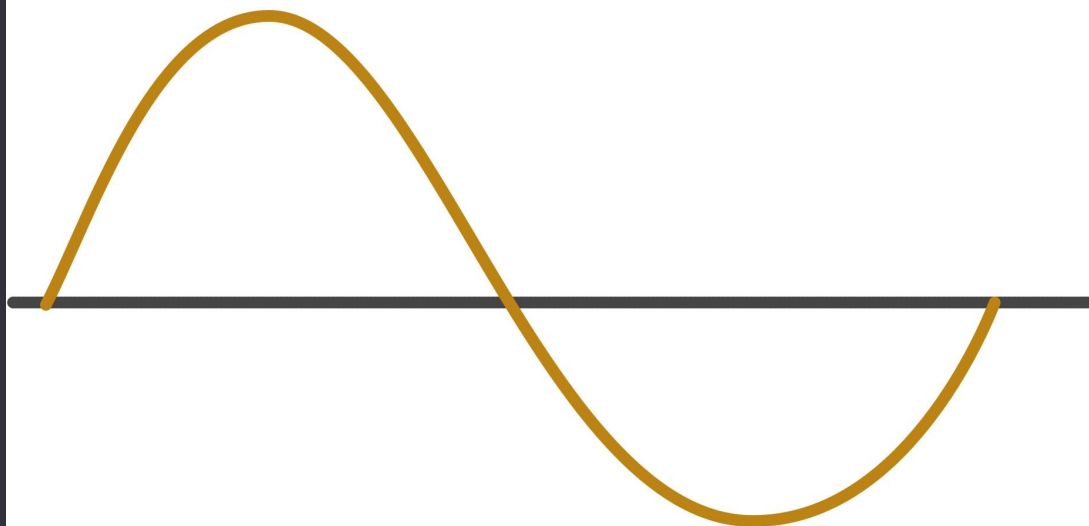
Challenges and future developments

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# Original Sound Wave



Analog Signal

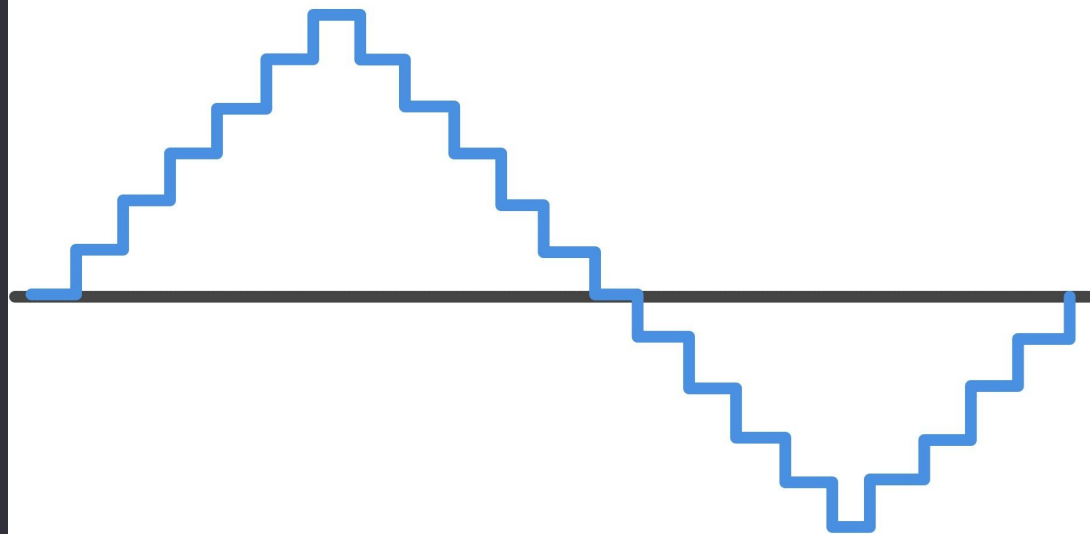
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# Digital Sound Wave



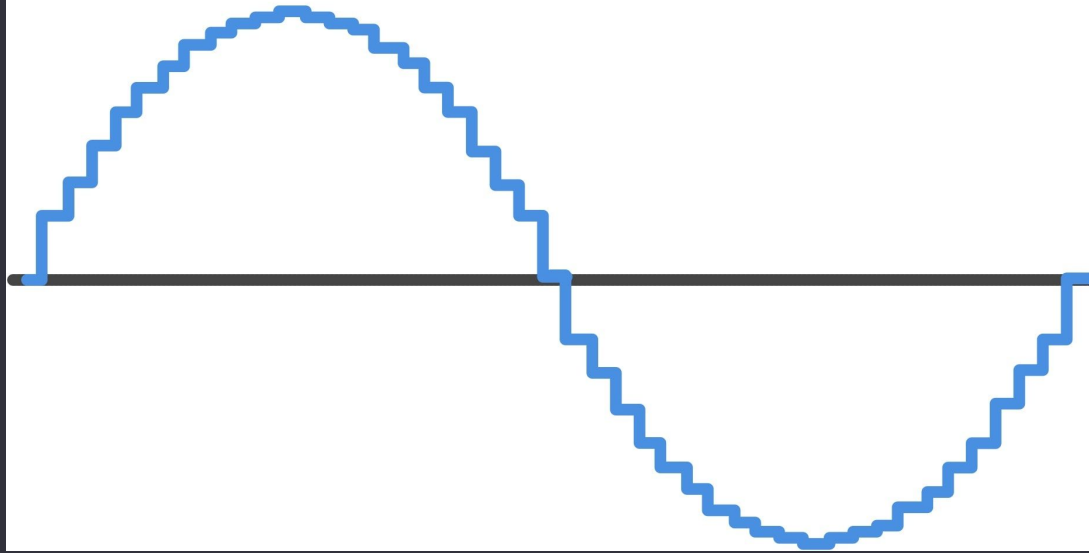
Digital Signal

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# Digital Sound Wave



Better Digital Signal?

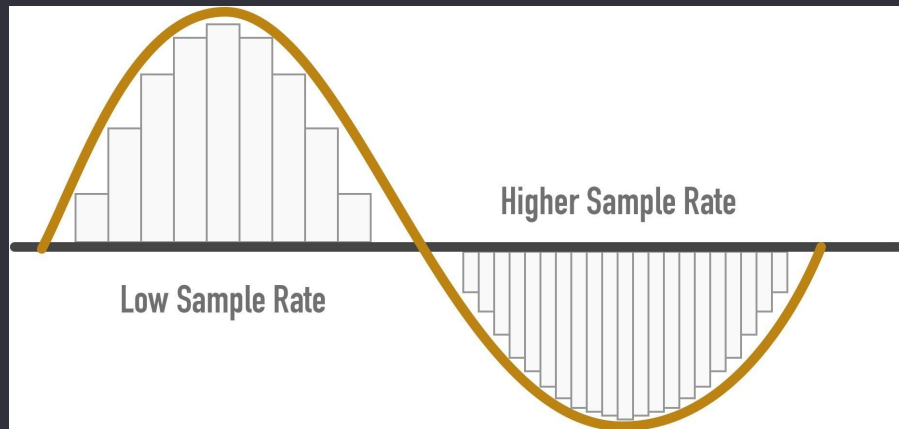
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# Characteristics of Digital Audio

Sample Rate: Number of waveform samples taken per second



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**Version 2 (of 3)**  
**Sample Rate = 22.05 kHz**  
**Nyquist = 11.025 kHz**  
**Not bad overall**

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# Characteristics of Digital Audio

Bit Depth: Number of possible amplitude values that can be stored as bits



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4 bits

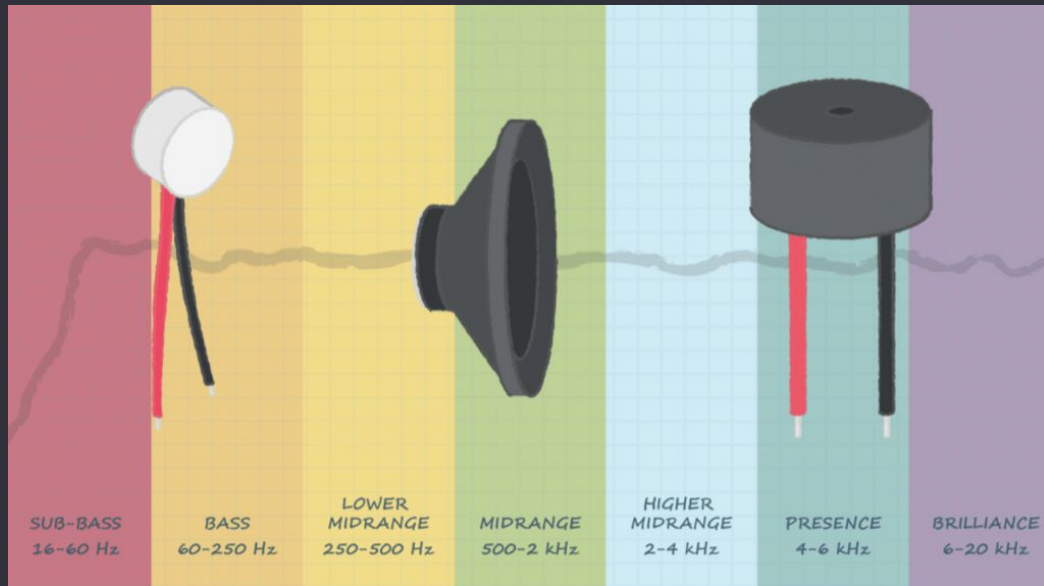
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# Audio Frequency Spectrum

- Average human hearing range is 20Hz-20kHz



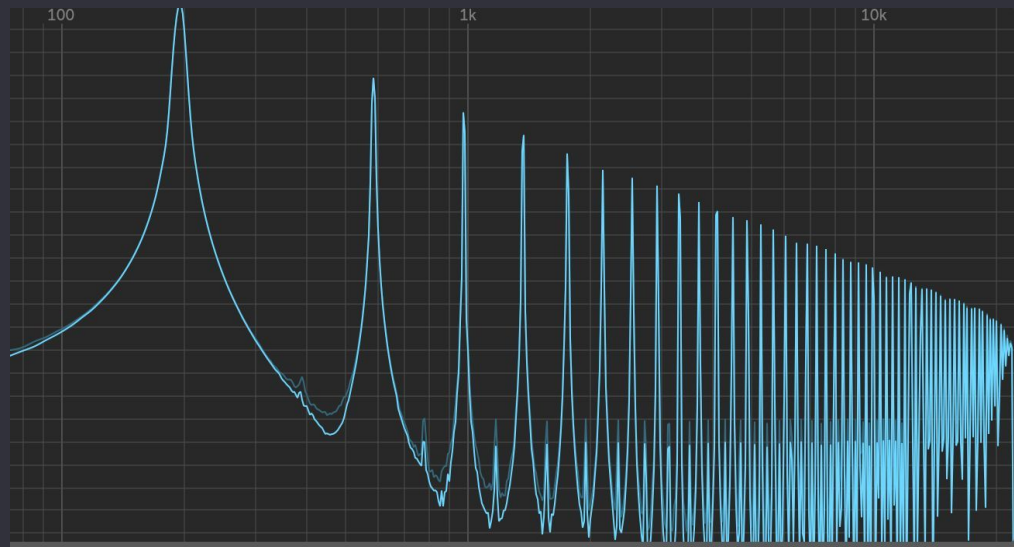
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# Harmonics

- The pitch of an instrument is its **fundamental frequency** and it has higher **harmonic frequencies**



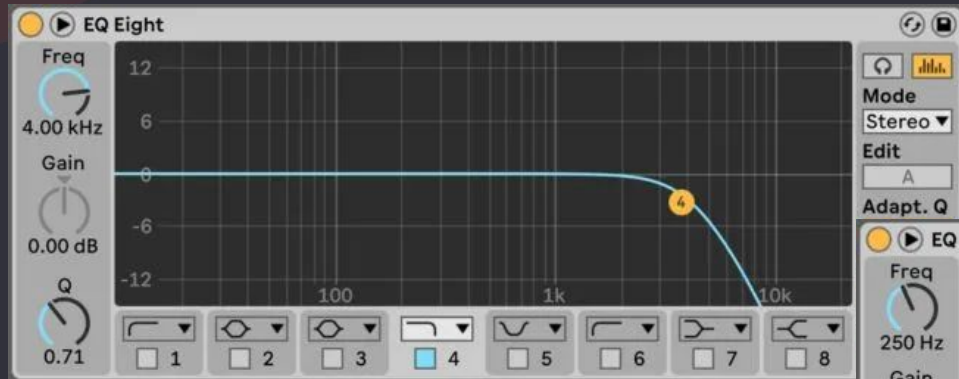
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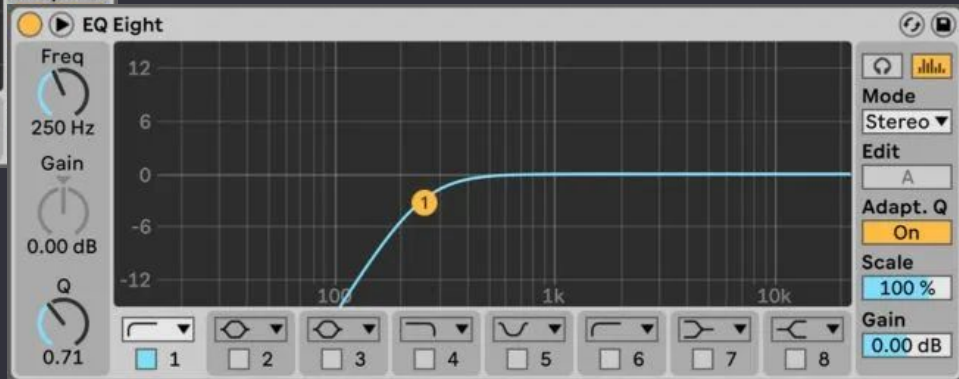


# Equalization



Low-pass Filter

High-pass Filter



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# Equalization: Low-Pass Filter

Low-pass filter:  
Underwater effect



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# Equalization: High-Pass Filter

High-pass filter: “Storm while indoors” effect



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# Audio Quiz



## Possible Modifications:

- Low Sample Rate
- Low Bit Depth
- Low-Pass Filter
- High-Pass Filter

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# Audio Quiz: Q1



## Answer Choices

- A. Low Sample Rate
- B. Low Bit Depth
- C. Low-Pass Filter
- D. High-Pass Filter

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# Audio Quiz: Q1



## Answer Choices

- A. Low Sample Rate
- B. ~~Low Bit Depth~~
- C. ~~Low Pass Filter~~
- D. ~~High Pass Filter~~

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# Audio Quiz: Q2



## Answer Choices

- A. Low Sample Rate
- B. Low Bit Depth
- C. Low-Pass Filter
- D. High-Pass Filter

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# Audio Quiz: Q2



## Answer Choices

- ~~A. Low Sample Rate~~
- ~~B. Low Bit Depth~~
- C. Low-Pass Filter**
- ~~D. High Pass Filter~~

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# Audio Quiz: Q3



## Answer Choices

- A. Low Sample Rate
- B. Low Bit Depth
- C. Low-Pass Filter
- D. High-Pass Filter

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# Audio Quiz: Q3



## Answer Choices

- ~~A. Low Sample Rate~~
- B. Low Bit Depth**
- ~~C. Low Pass Filter~~
- ~~D. High Pass Filter~~

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# Audio Quiz: Q4



## Answer Choices

- A. Low Sample Rate
- B. Low Bit Depth
- C. Low-Pass Filter
- D. High-Pass Filter

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# Audio Quiz: Q4



## Answer Choices

- ~~A. Low Sample Rate~~
- ~~B. Low Bit Depth~~
- ~~C. Low Pass Filter~~
- D. High-Pass Filter**

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# Languages & Frameworks

- Languages: C++
  - Prototyping Languages: Max/MSP, Pure Data, Python, MATLAB
- Frameworks: JUCE, PortAudio, AudioKit, FMOD

JUCE Tutorials: <https://juce.com/learn/tutorials/>

# Other Useful Skills

- Digital signal processing (DSP)
- Instrument design
- Familiarity with a digital audio workstation (DAW)
- UI design

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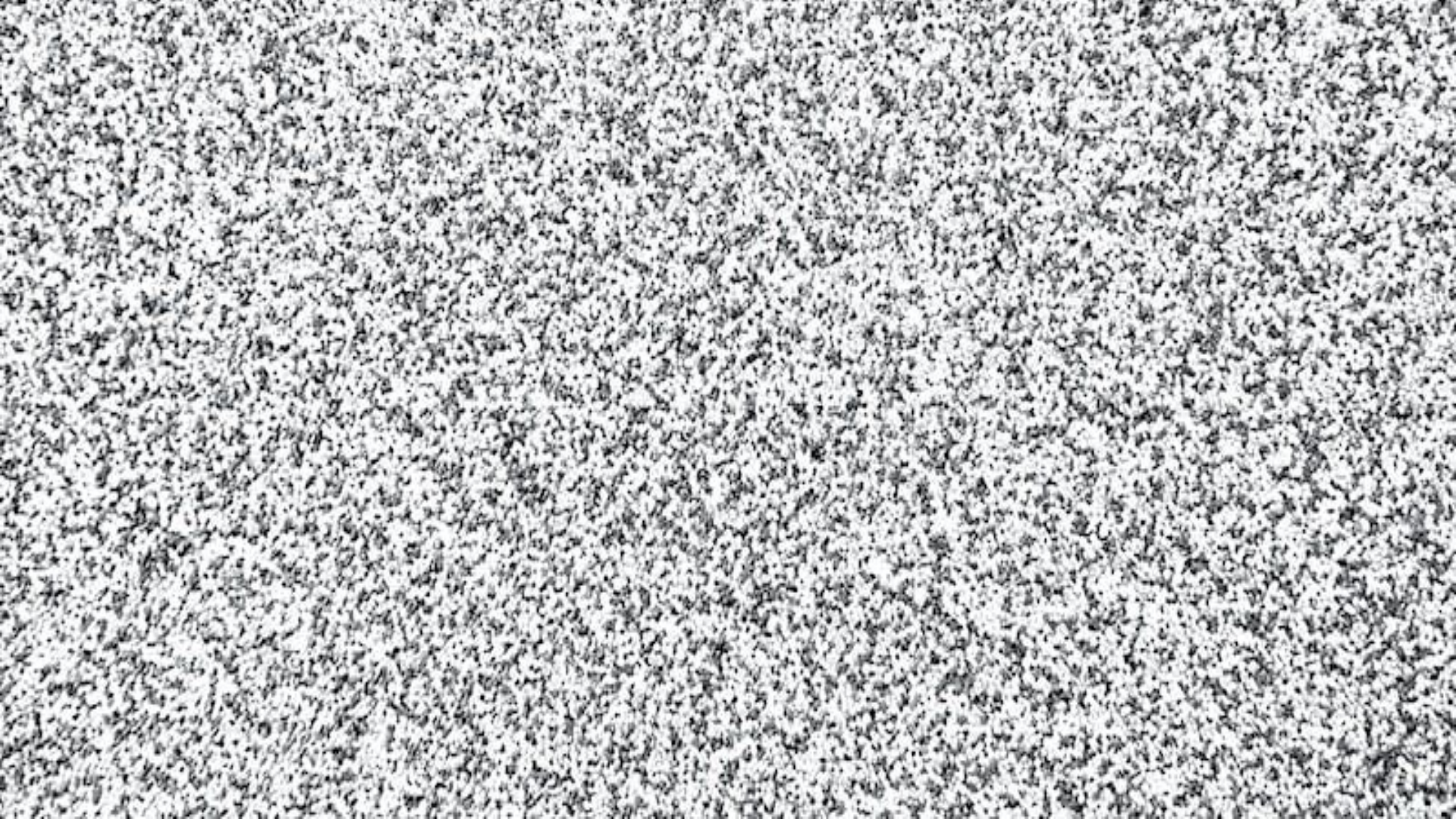
# White Noise Synthesizer

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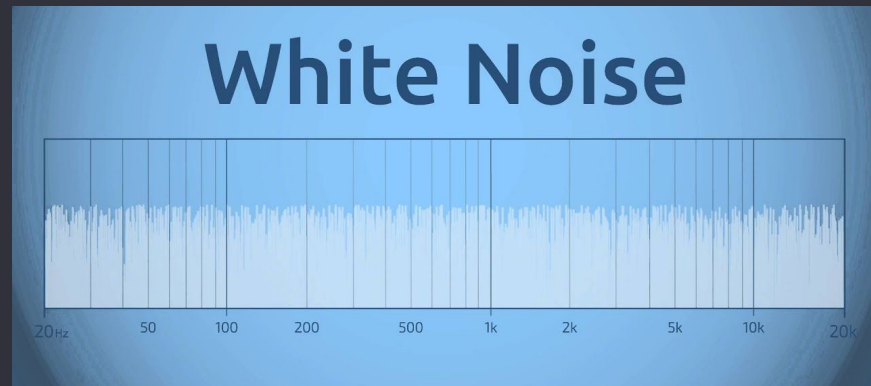






# White Noise

The combination of all audible sound frequencies played at equal levels



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# White Noise

The combination of all audible sound frequencies played at equal levels



**White Noise**  
**Black Screen**

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# Synthesizer

Electronic musical instrument that create and shape digital waveforms to generate sound



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# Getting Started With JUCE

1. Go to [juce.com/download/](https://juce.com/download/)
2. Scroll to “Download from this website” and download the correct version for your laptop’s operating system
3. Unzip the file and move the JUCE folder to your home directory
4. Go to [tinyurl.com/JUCEDemos](https://tinyurl.com/JUCEDemos) and download all three files
5. Open Projucer and click “Open Existing Project”
6. Make sure you have the correct exporter at the top of the window
7. Open “SimpleNoiseTutorial.h”

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# Demo Projects: Sine & MIDI Synth

1. Click on “Files” –> “New Project”
2. Go to “Open Existing Project” again and load up whichever .h file you want to! (SineSynthTutorial.h & SynthUsingMidiInputTutorial.h)

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# Spatial Audio



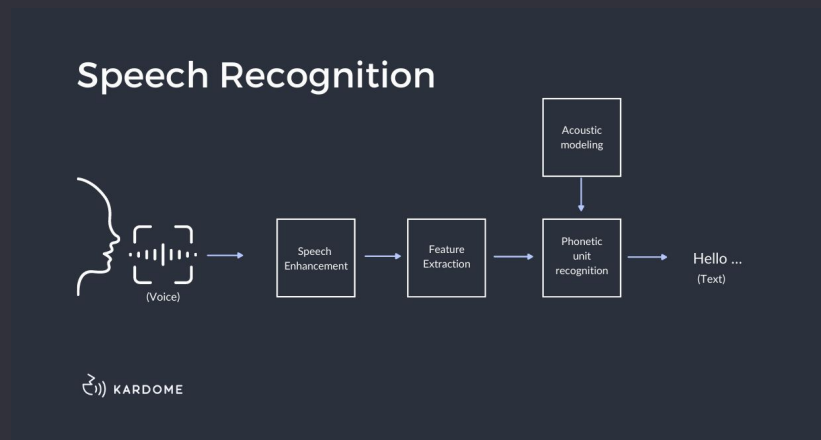
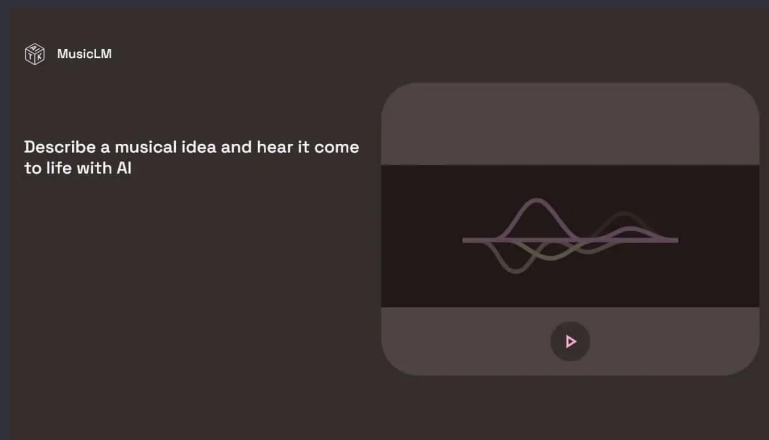
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# Machine Learning



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# Thank You

Do you have any questions?



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