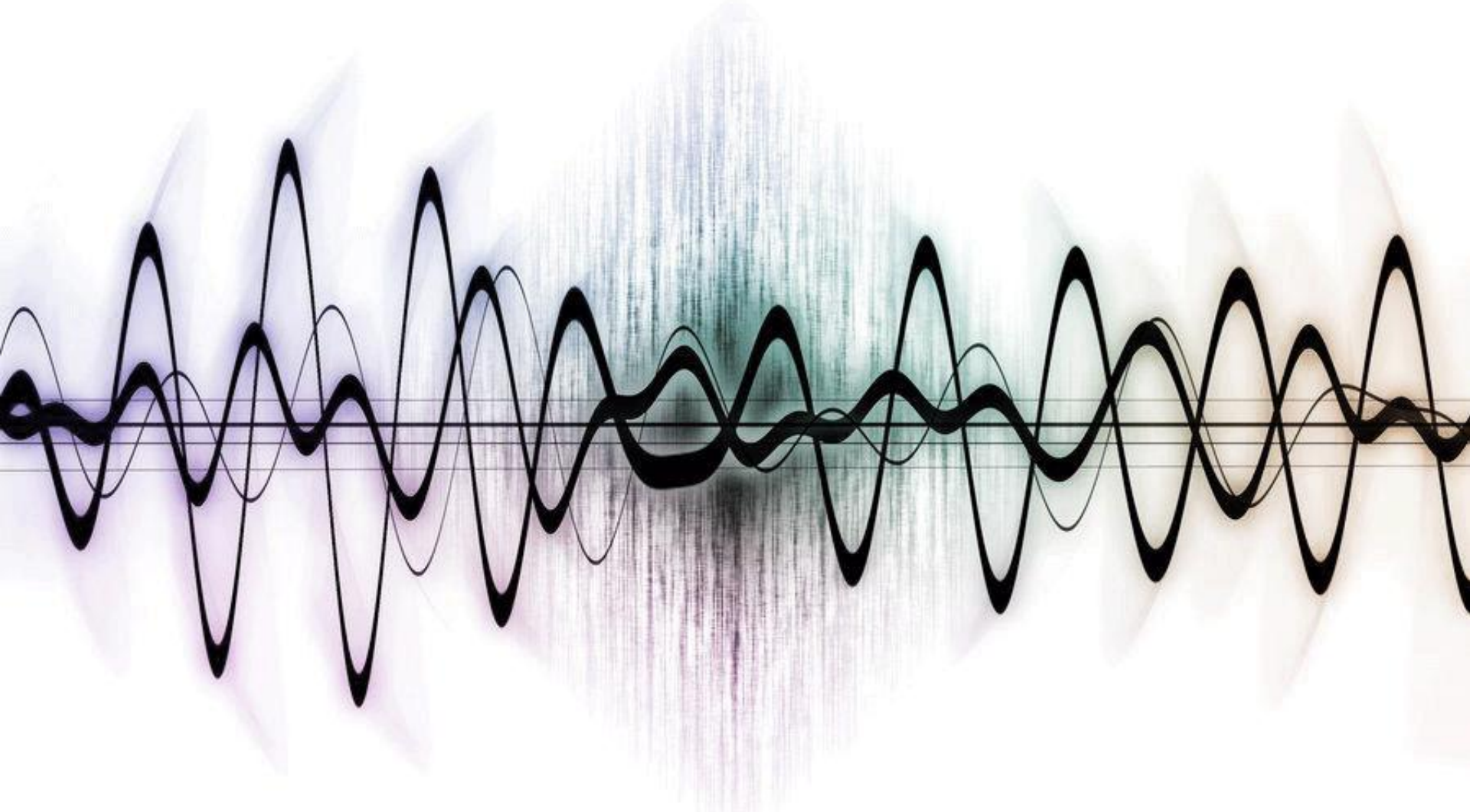
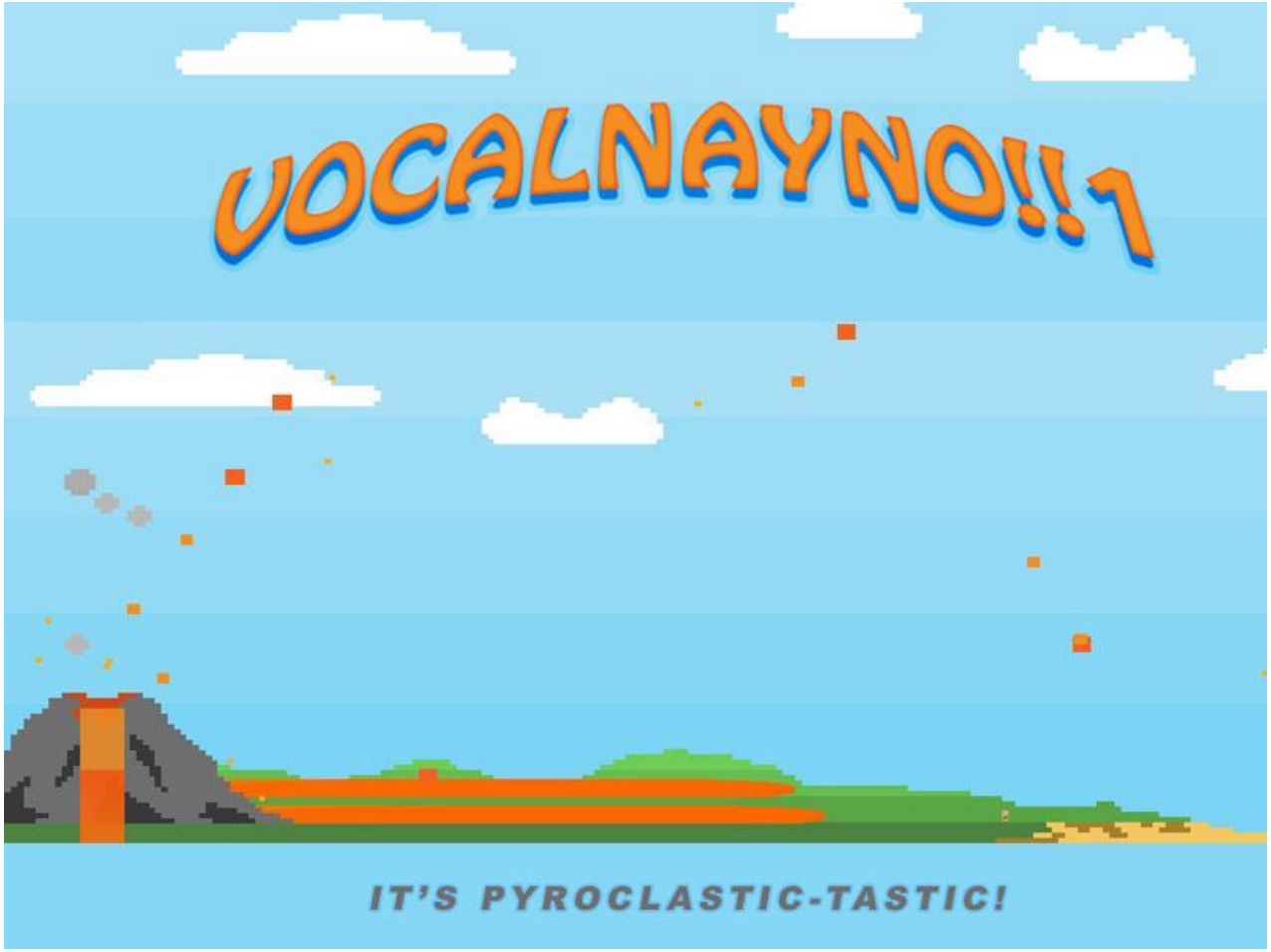


An Introduction to Digital Sound

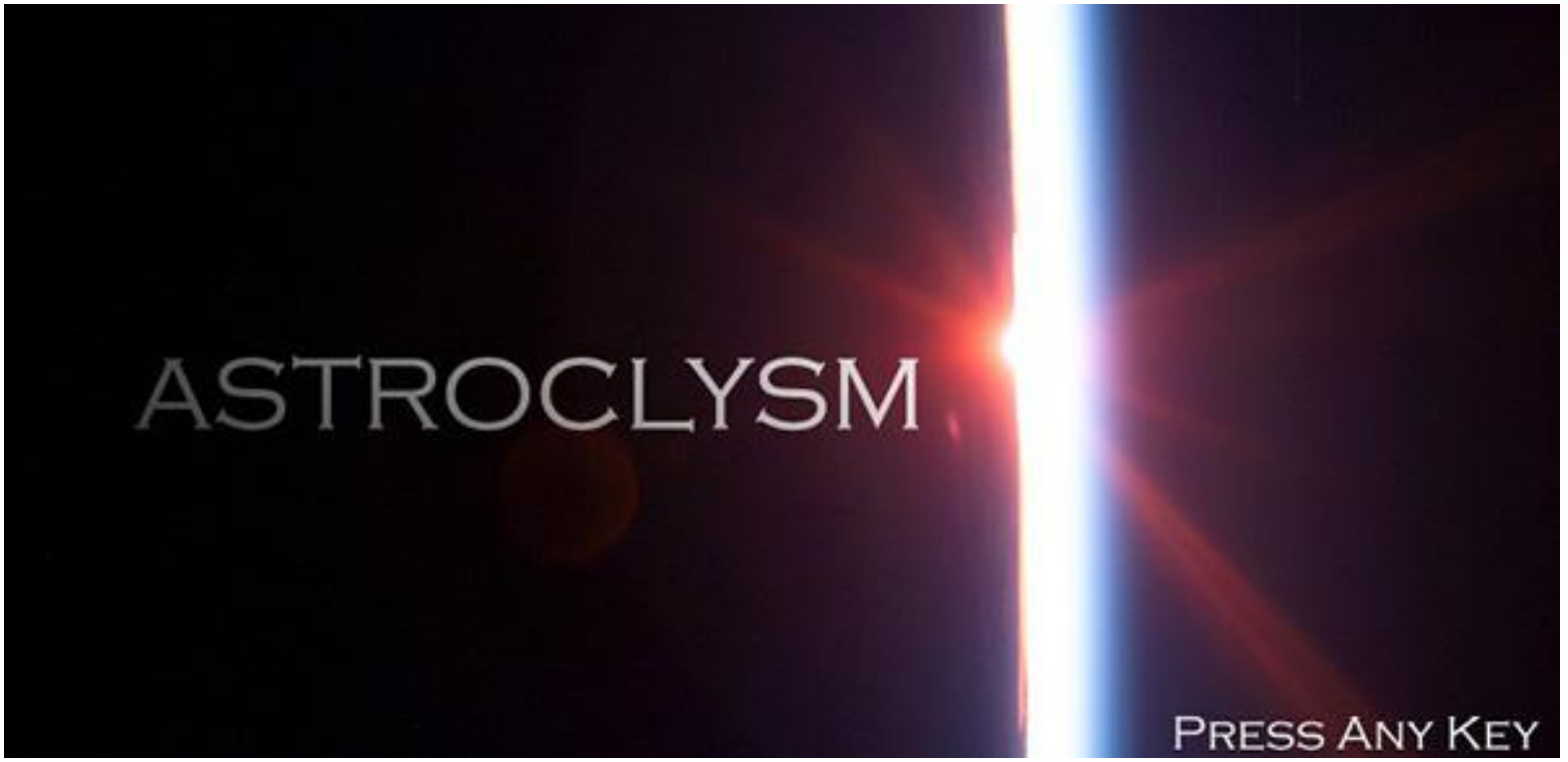
Creative Computing: Tinkering – Session 8 – Michael Scott

Introduction

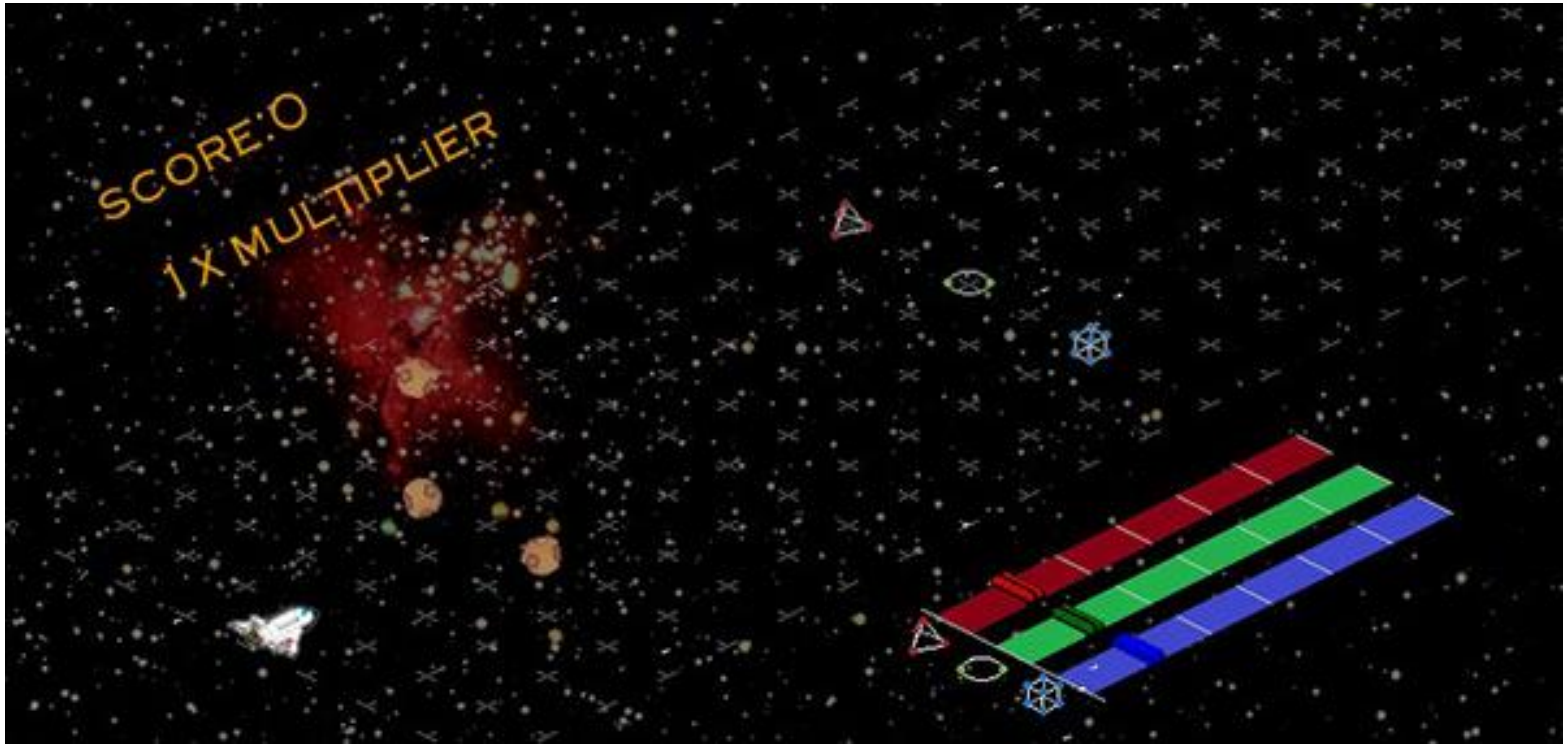


Introduction

Introduction



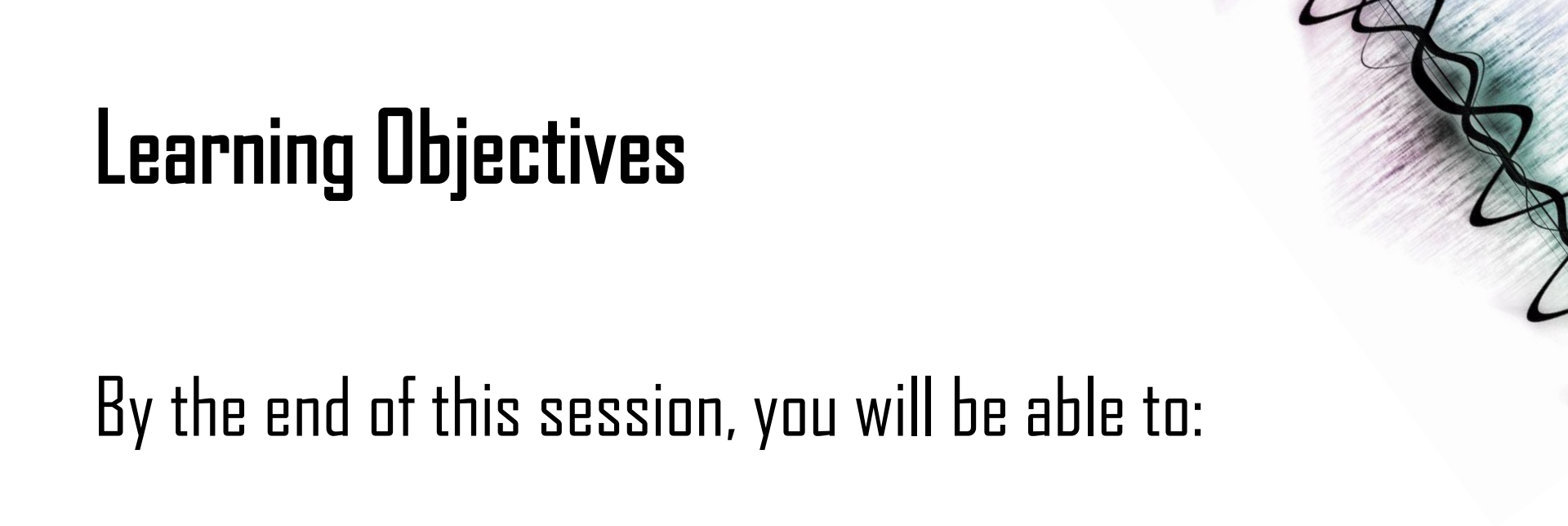
Introduction



Introduction

https://www.youtube.com/watch?v=oF7POPv1GyQ

Learning Objectives



By the end of this session, you will be able to:

- **Recognise** several ways how sound is used in games
- **Explain** what sound **and** waves are
- **Describe** how sound can be represented digitally
- **Write** a program that will create a sound

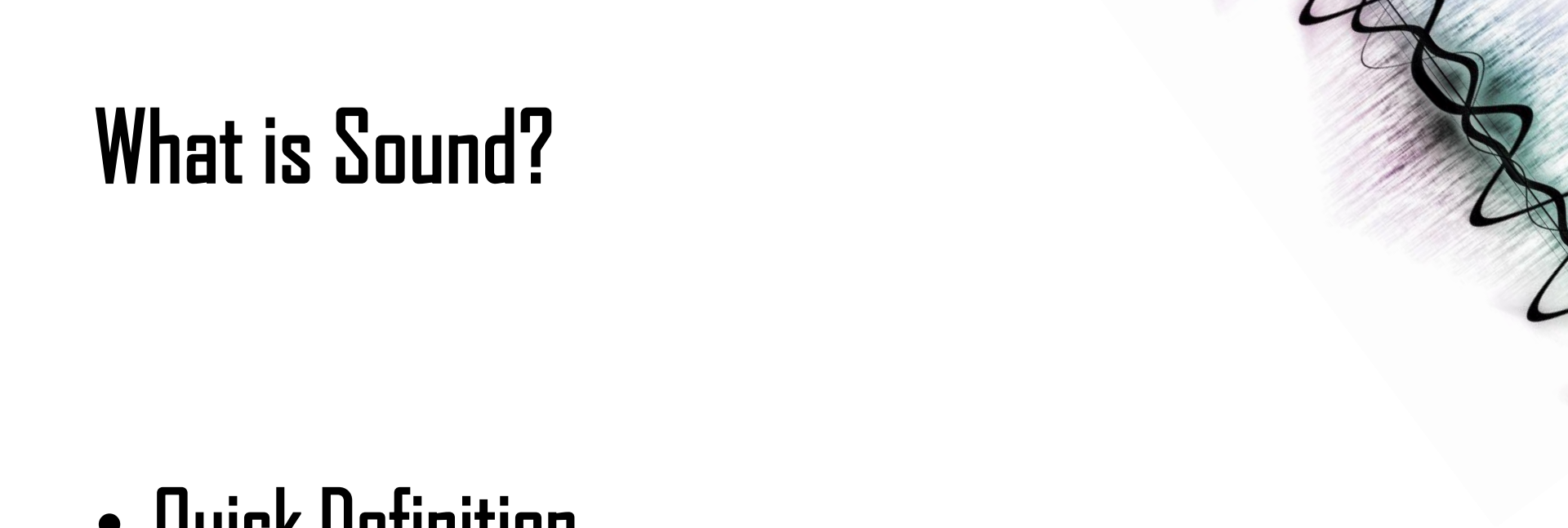
An Introduction to Digital Sound

HOW ARE SOUNDS USED IN GAMES?

An Introduction to Digital Sound

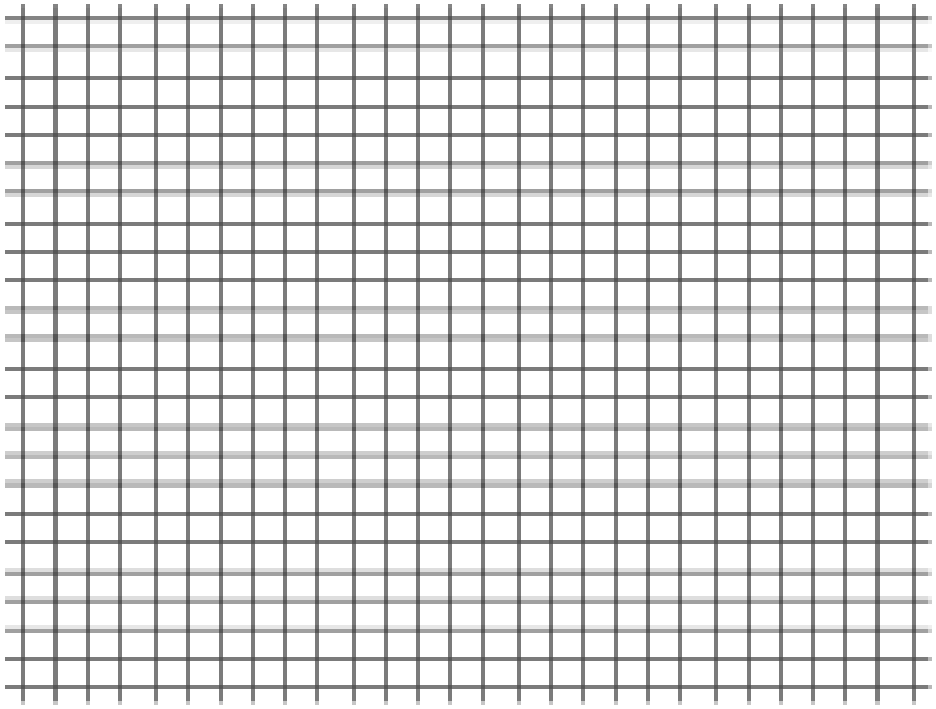
WHAT IS SOUND? WHAT IS A WAVE?

What is Sound?

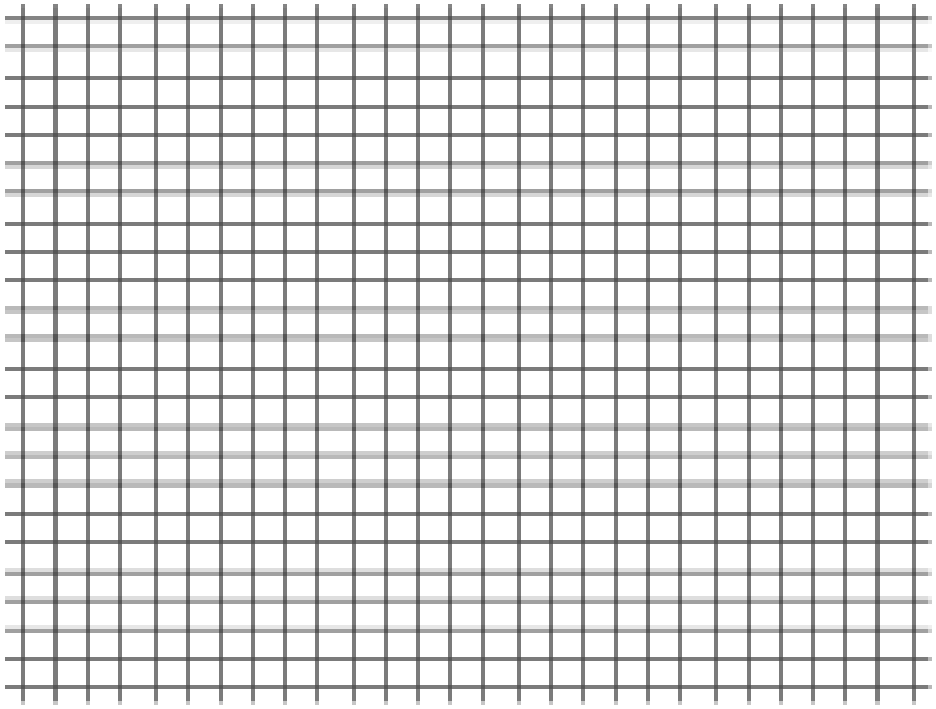


- **Quick Definition**
  A wave of compression and rarefaction in an elastic medium, such as air, which can be detected by an animal's sense of hearing

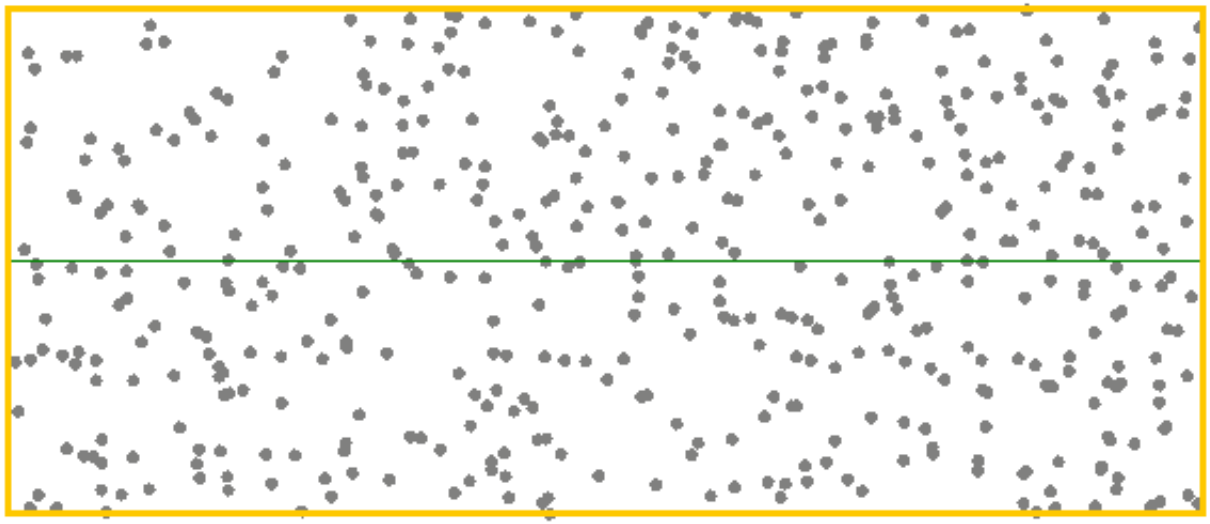
What is Sound?



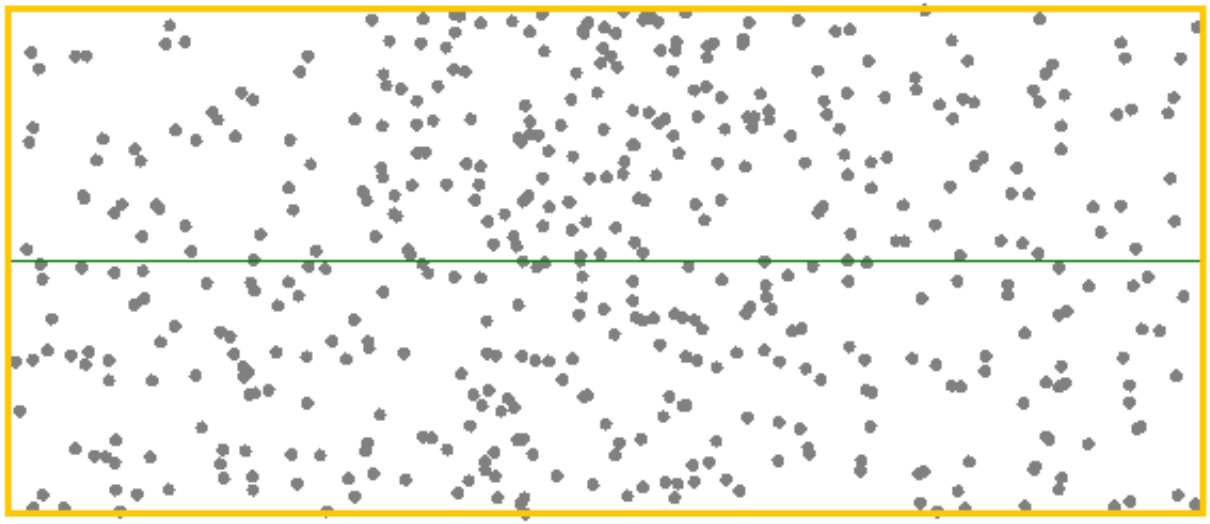
What is Sound?



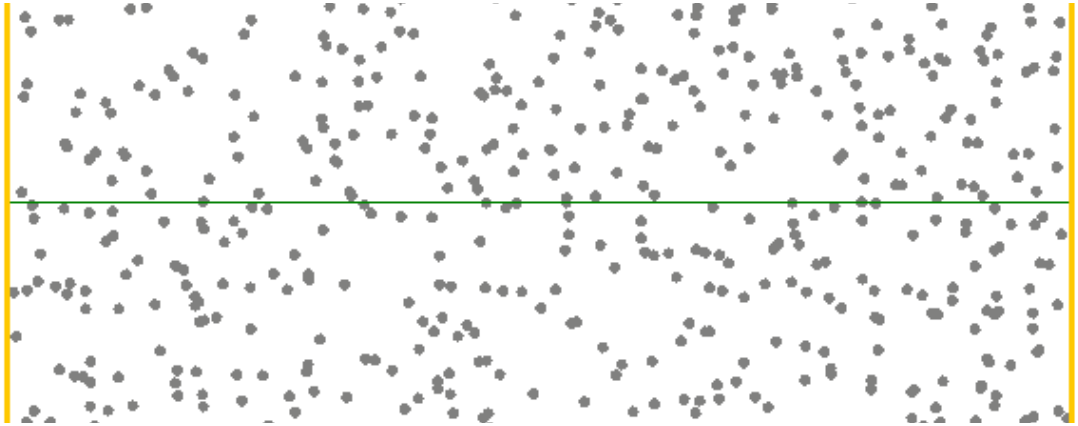
What is Sound?

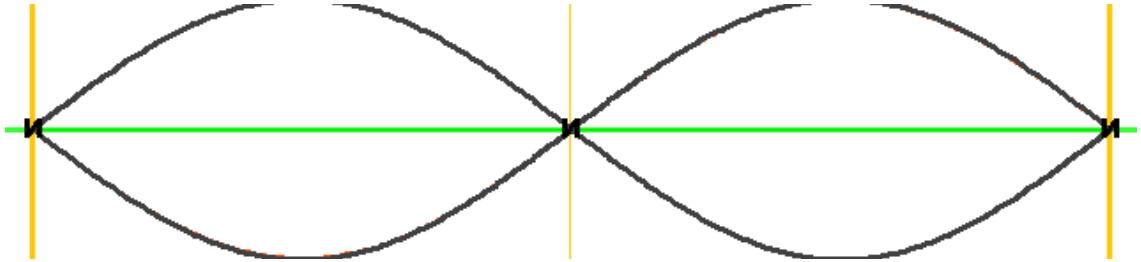


What is Sound?

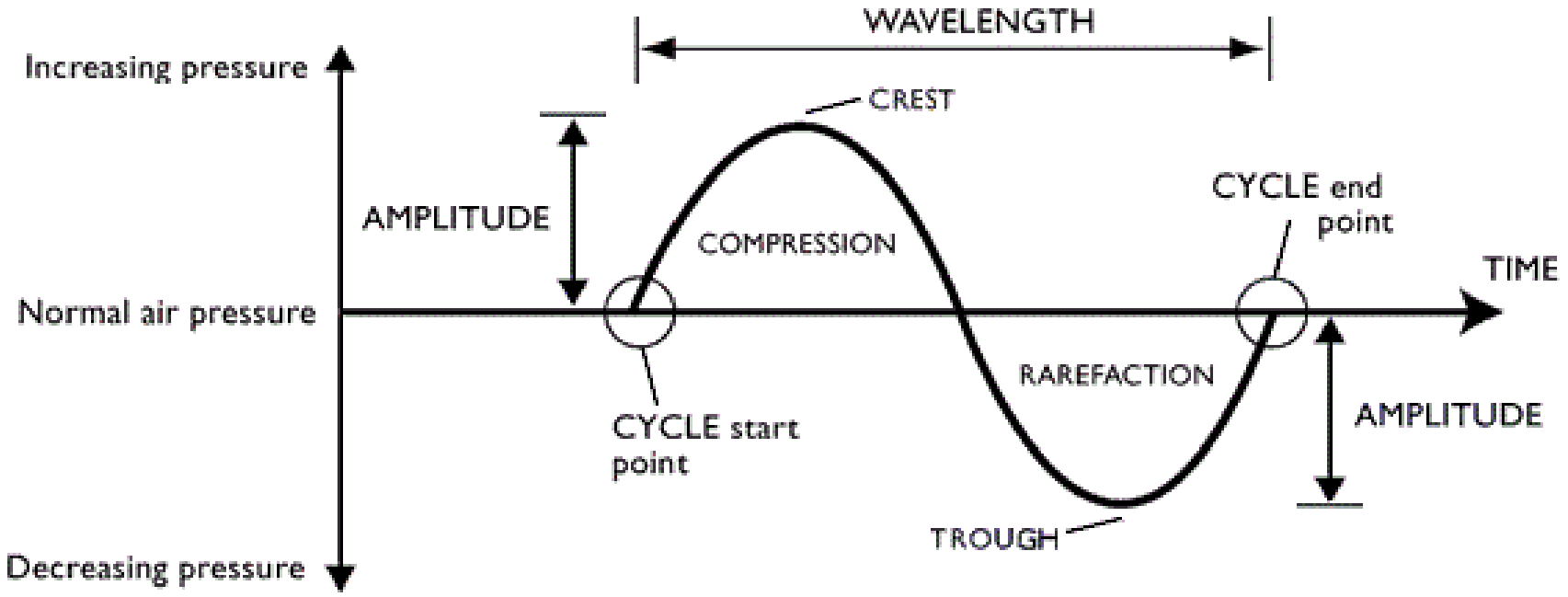


What is a Wave?





What is a Wave?



What is a Wave?

What is Sound?

- Many animals are able to sense sound in two key ways: **volume** and **pitch**.

- **Volume**
  The intensity of the change in pressure, as signified by the amplitude of a wave
- **Pitch**
  The frequency of the change, as signified by the length of the wave and its velocity (i.e., "the speed of sound")

What is a Wave?

Introduction to Digital Sound

HOW CAN SOUND BE REPRESENTED DIGITALLY?

How Can Sound Be Represented Digitally?

- One method is to represent the wave itself and one approach to do this is **L**inear **P**ulse **C**ode **M**odulation (LPCM).
  - An array of integers is created
  - The value of these integers represents the amplitude of the wave
    - With linear coding, the way how bytes correspond to real-world measures - called *quantisation* - is uniform across the range
  - The positions in the array represent time, and so each element contains a sample of the wave amplitude

How Can Sound Be Represented Digitally?

How Can Sound Be Represented Digitally?

- **Sample Rate**
  How many samples are taken per second (consequently, how much time is represented by each element in the array)?

- **Bit Depth**
  How many bits are available to represent the value?

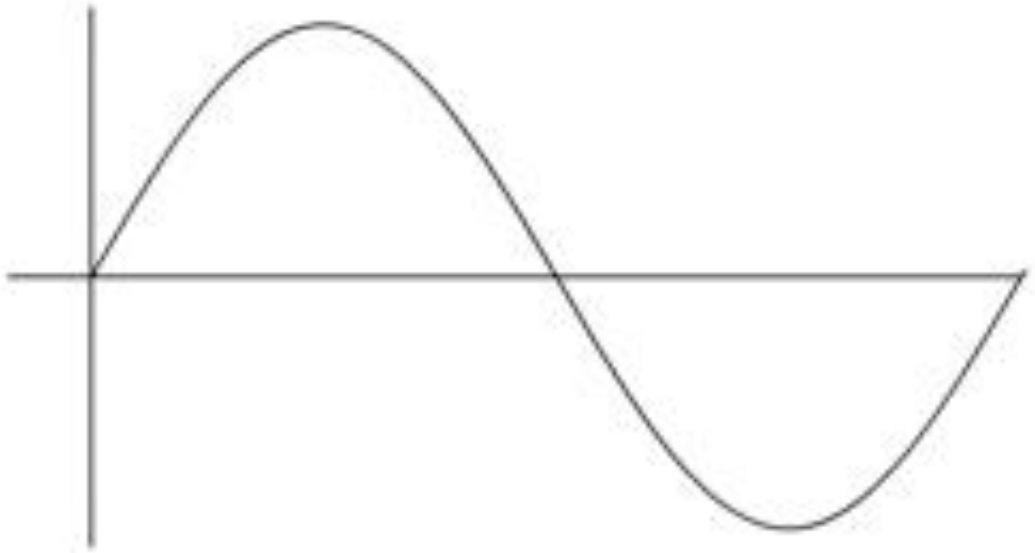
How Can Sound Be Represented Digitally?

- **Sample Rate**
  i.e., range of frequencies which can be recorded

- **Bit Depth**
  i.e., the number of amplitude levels which can be represented

How Can Sound Be Represented Digitally?

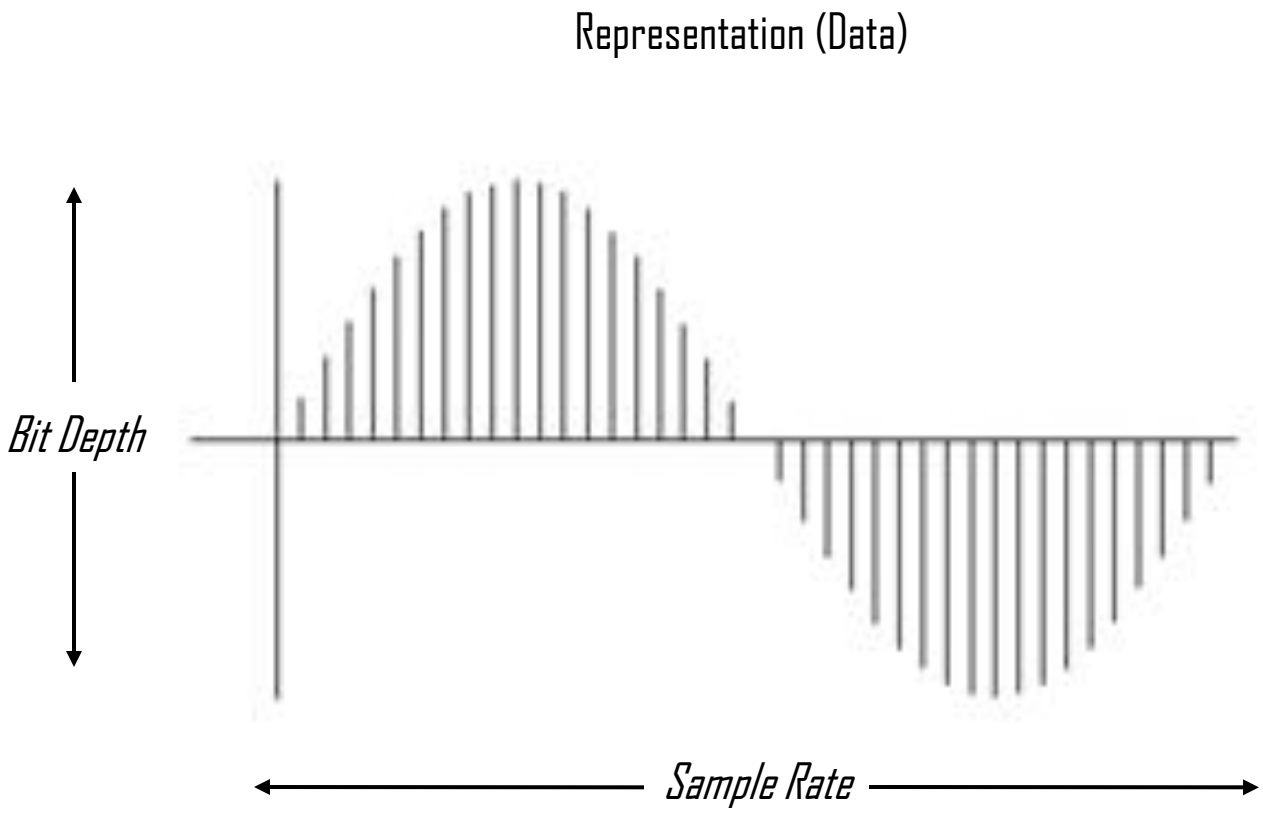
Source



How Can Sound Be Represented Digitally?

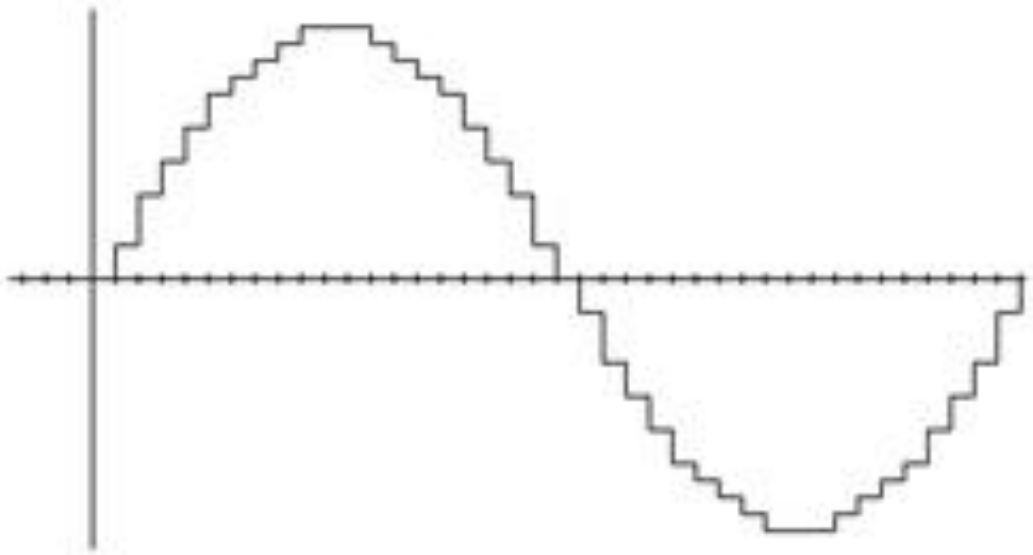
Representation (Data)

How Can Sound Be Represented Digitally?



How Can Sound Be Represented Digitally?

Reconstructed Output



Introduction to Digital Sound

CAN I WRITE A PROGRAM TO CREATE SOUND?

Example

- >>> filename=pickAFile()
- >>> print filename
- /Users/guzdial/mediasources/preamble.wav
- >>> sound=makeSound(filename)
- >>> print sound
- Sound of length 421109
- >>> samples=getSamples(sound)
- >>> print samples
- Samples, length 421109
- >>> print getSampleValueAt(sound,1)
- 36
- >>> print getSampleValueAt(sound,2)
- 29
- >>> explore(sound)

- Open the Jython Environment for Students (JES)
- Find an Wav File
- Explore the Sound Functions in JES
- Ask Questions on Slack

Example

- >>> print getLength(sound)
- 220568
- >>> print getSamplingRate(sound)
- 22050.0
- >>> print getSampleValueAt(sound,220568)
- 68
- >>> print getSampleValueAt(sound,220570)
- I wasn't able to do what you wanted.
- The error java.lang.ArrayIndexOutOfBoundsException has occurred
- Please check line 0 of
- >>> print getSampleValueAt(sound,1)
- 36
- >>> setSampleValueAt(sound,1,12)
- >>> print getSampleValueAt(sound,1)
- 12

- Open JES
- Find an Wav File
- Explore the Sound Functions in JES
- Ask Questions on Slack

Example

- >>> print getLength(sound)
- 220568
- >>> print getSamplingRate(sound)
- 22050.0
- >>> print getSampleValueAt(sound,220568)
- 68
- >>> print getSampleValueAt(sound,220570)
- I wasn't able to do what you wanted.
- The error java.lang.ArrayIndexOutOfBoundsException has occurred
- Please check line 0 of
- >>> print getSampleValueAt(sound,1)
- 36
- >>> setSampleValueAt(sound,1,12)
- >>> print getSampleValueAt(sound,1)
- 12

- Open JES
- Find an Wav File
- Explore the Sound Functions in JES
- Ask Questions on Slack

Samples

- In this notation, the samples define the position of the components within the speaker
- By changing the position of the speaker rapidly waves rapidly enough, sound is produced
- But, of course, there are thousands of samples…!

"But there are thousands of these samples!"

- How do we do something to these samples to manipulate them, when there are thousands of them per second?
- We use a loop and get the computer to iterate in order to do something to each sample.
- An example loop:

```
for sample in getSamples(sound):
    value = getSample(sample)
    setSample(sample,value)
```

Activity

- Download the file "mystery.wav" from Slack
- Read the following documentation:

  https://docs.python.org/2/library/wave.html
  https://docs.python.org/2/library/struct.html

- **Write** an algorithm to unpack the file

Activity

- Investigate the **volume** and **frequency** of the tone contained within the file and type it into Slack (along with your code) once you have discovered them.
- There is no convenient function for this in the wave module.
- Hints: the file uses 16-bit unsigned little-endian values (i.e., `'<h'`); other parameters can be found using `getparams()`; write helper functions to scan the data to aid your investigation (e.g., max(), count_sign_changes(), etc.)

Increasing the Volume

```
def increaseVolume(sound):
  for sample in getSamples(sound):
    value = getSampleValue(sample)
    setSampleValue(sample,value * 2)
```

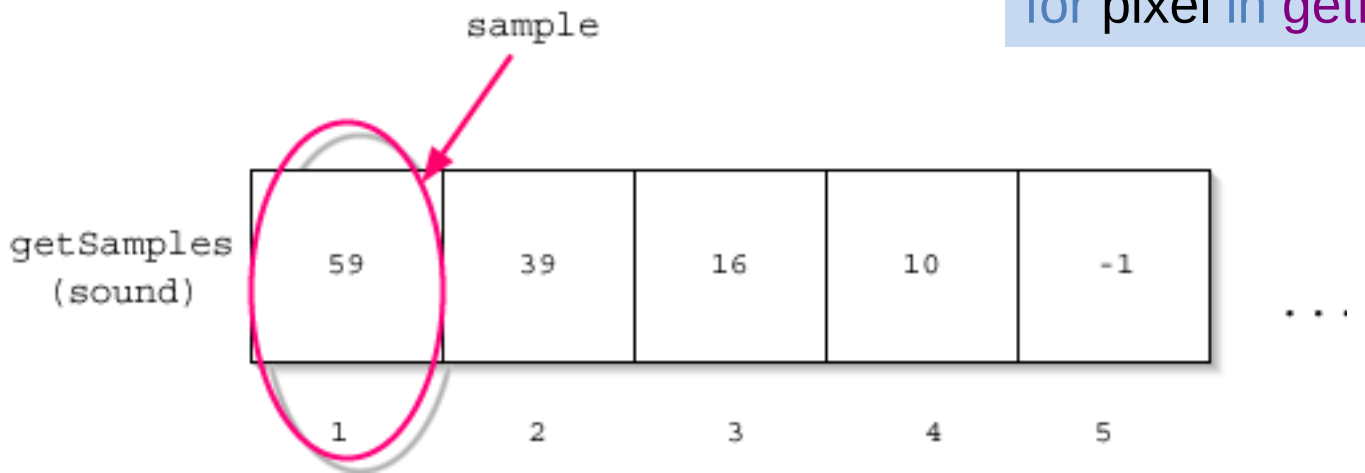
Starting the loop

- **getSamples(sound)** returns a sequence of all the sample objects in the **sound**.
- The **for** loop makes **sample** be the first sample as the block is started.

```
def increaseVolume(sound):
  for sample in getSamples(sound):
    value = getSampleValue(sample)
    setSampleValue(sample,value * 2)
```

Compare:

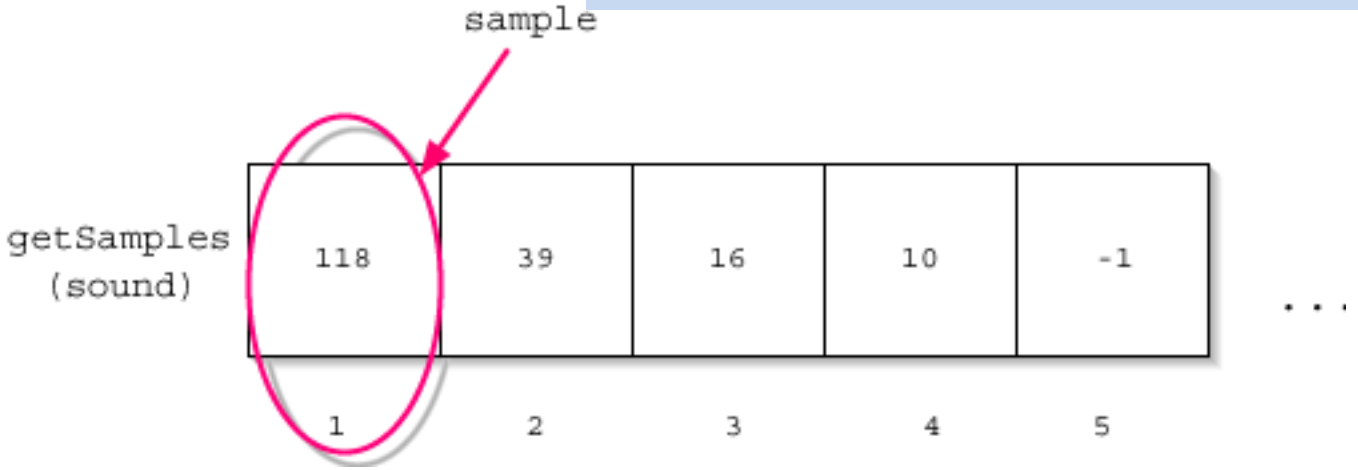
```
for pixel in getPixels(picture):
```



Executing the block

- We get the value of the sample named sample.
- We set the value of the sample to be the current value (variable value) times 2

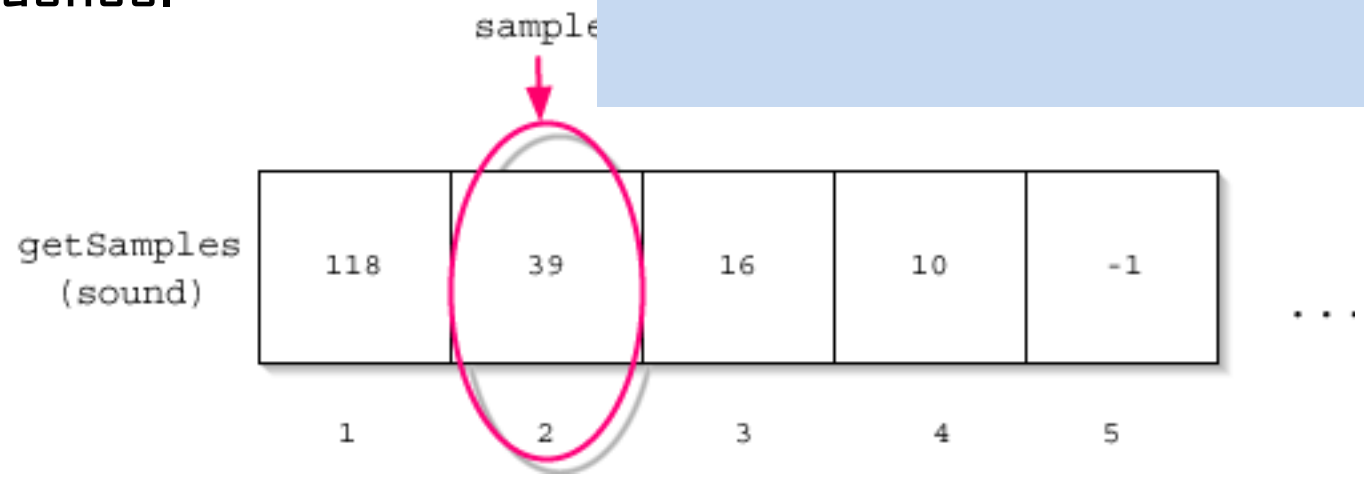
```
def increaseVolume(sound):
  for sample in getSamples(sound):
    value = getSampleValue(sample)
    setSampleValue(sample,value * 2)
```



Next sample

- Back to the top of the loop, and sample will now be the second sample in the sequence.

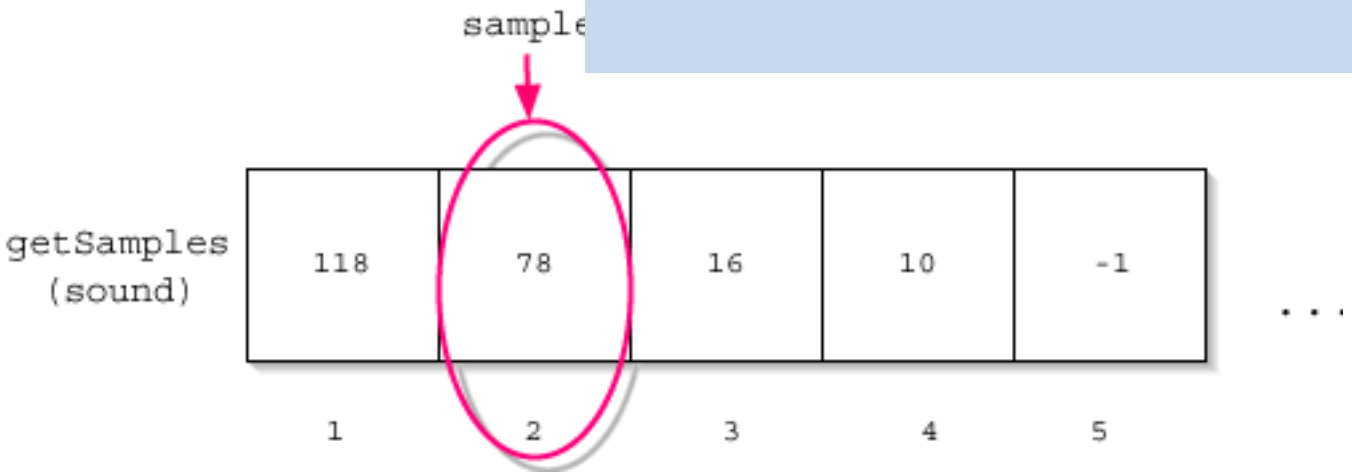
```
def increaseVolume(sound):
  for sample in getSamples(sound):
    value = getSampleValue(sample)
    setSampleValue(sample,value * 2)
```



And increase that next sample

- We set the value of *this* sample to be the current value (variable value) times 2.

```
def increaseVolume(sound):
  for sample in getSamples(sound):
    value = getSampleValue(sample)
    setSampleValue(sample,value * 2)
```



And on through the sequence

- The loop keeps repeating until *all* the samples are doubled

```
def increaseVolume(sound):
  for sample in getSamples(sound):
    value = getSampleValue(sample)
    setSampleValue(sample,value * 2)
```

Activity

- **Write** an algorithm to increase the volume of the sound and to save a new file

Stretch Goal

- Generate a tone using the sin() maths function

Introduction to Digital Sound

TINKERING AUDIO ASSIGNMENT

Coursework

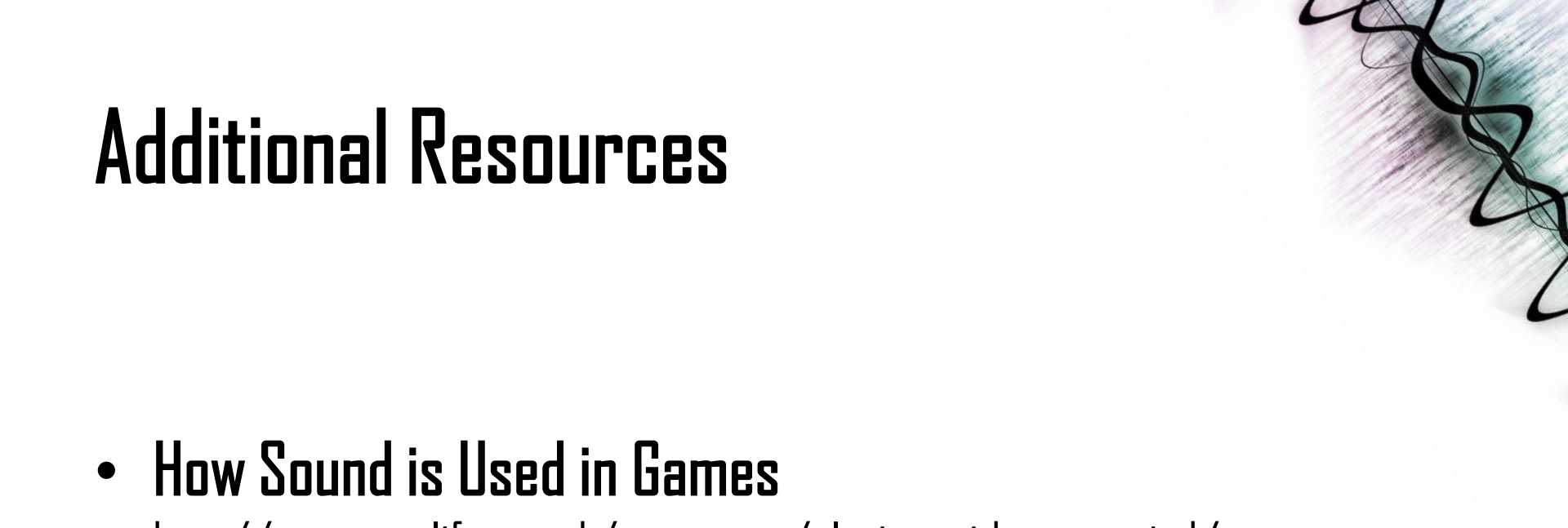
- Write **six** algorithms (*not* six sound effects)
- Use the algorithms to create 'melodies' and `sound effects` for your pre-production project
- New pairs --- as announced

Assignment Brief Demo

Introduction to Digital Sound

FINAL REMARKS

Additional Resources

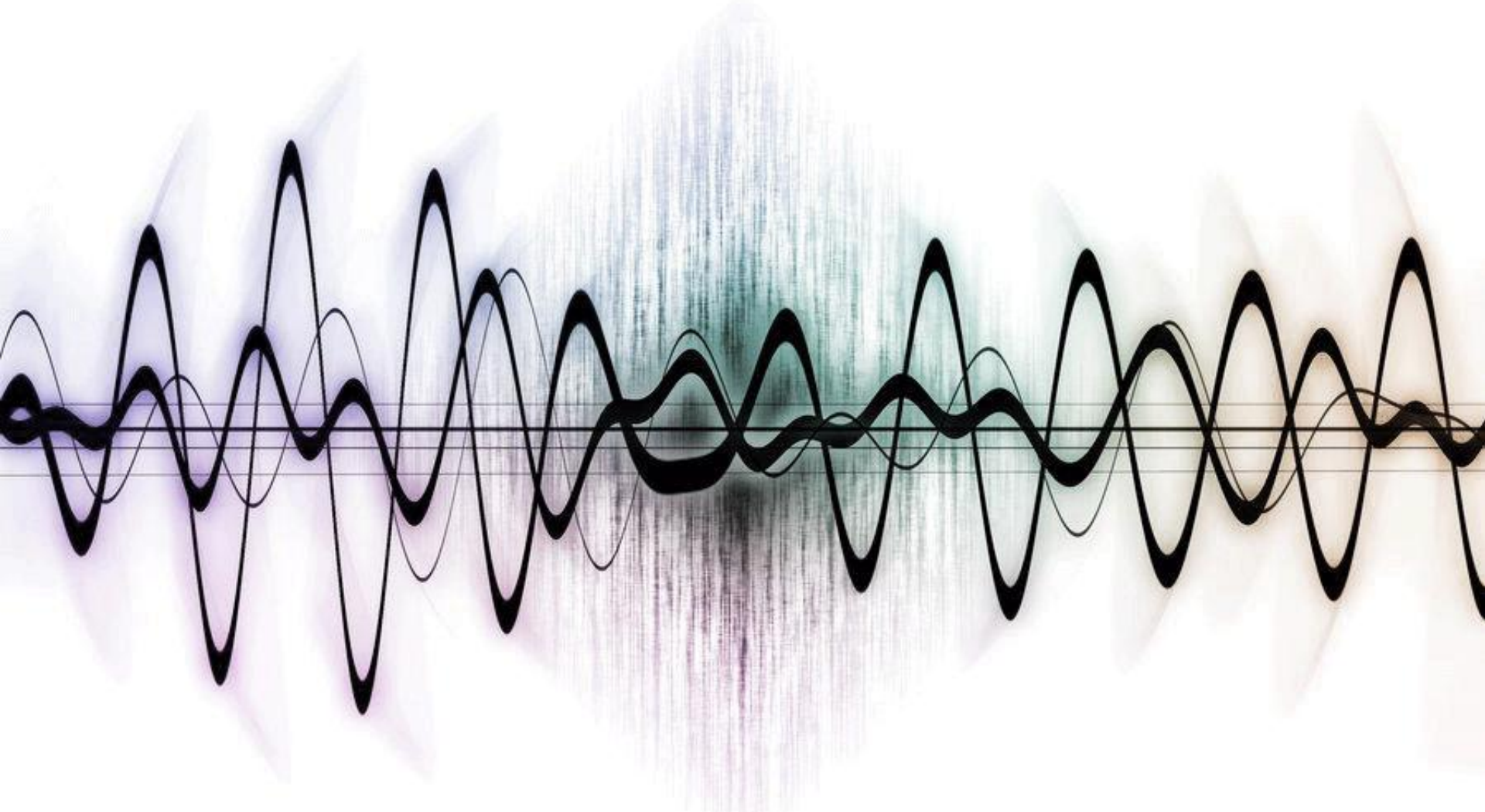


- **How Sound is Used in Games**
  http://www.amplifon.co.uk/resources/playing-with-your-mind/
- **How Sound Works**
  http://www.educationscotland.gov.uk/resources/s/sound/amplitude.asp
- **Digital Representation of Sound**
  http://www.jiscdigitalmedia.ac.uk/guide/an-introduction-to-digital-audio

Additional Resources

- **Frequently Asked Questions**
  http://www.sciforums.com/threads/speakers-how-do-they-produce-different-sounds-simultaneously.97540/

- **Any Other Questions or Concerns -- Please Email**
  michael.scott@falmouth.ac.uk



Thank You For Listening

Michael Scott