# Sound Representation



**CLNandi (Dr)**

# Key Concepts & Terms

**We will be looking at the following concepts:-**

**(1) Analogue Data**
**(2) Digital Representation**
**(3) Analogue to Digital Converter**

**(4) Sample**
**(5) Sampling Interval**
**(6) Sample Frequency or Rate**
**(7) Bit Rate**
**(8) File Size**

**(9) Quality**

**(10) Factors affecting the Quality of Sound**
**(11) Factors Affecting File Size**

**(12) How to identify a Sound File through the File Extensions**

# Introduction

(1) Sounds are produced by different sources, these are analogue in nature.

(2) The Source of the sound could be an instrument such as a piano, violin, drum, cello, trumpet or your voice or any number of things.

(3) The Sound Wave is an analogue signal.

(4) An analogue signal is continuous in nature

**Analogue to Digital Converter**

Original Sound Produced is an Analogue Signal

Digital Signal is the type of signal the computer understands

(5) Now, computers represent sound in a different way.

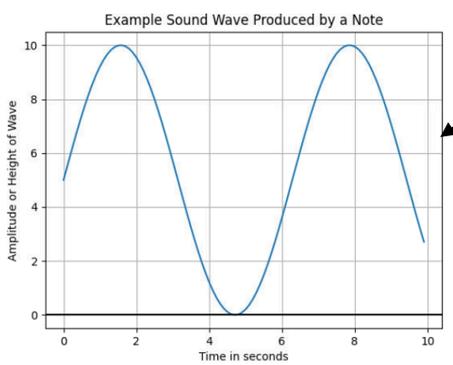
(6) Computers represent sound in a Digital fashion.

(7) So, the original sound wave whic
analogue in its nature must be conve
to
A digital form in order for the compu
to represent it.

(9) This conversion is performed by an analogue to digital converter.

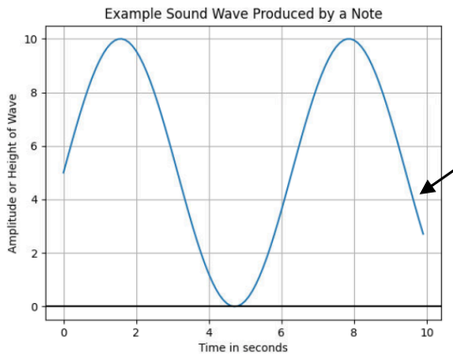
(10) Digital signals are discrete i.e. not continuous

**Analogue Wave**



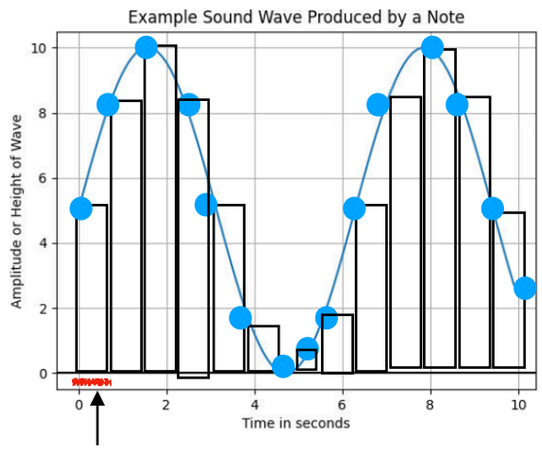
# Showing in Detail how Original Analogue Sounds are Converted to A Digital Form

## A Sound Wave Produced by a Note Played on the Piano




## Analogue Wave

## Analogue to Digital Conversion




Sample

- **(1) These Blue dots represent the amplitude of when samples taken**

**(2) The amplitude (or height) is measured at regular intervals**

**( 3)This is known as sampling and samples are produced.**

**(4) A sample is a measure of the amplitude at a point in time.**

**(5) The time gaps between samples are called the sample intervals**

**(6) This red line represents a sample interval.**

**(7) The values of the amplitudes are then stored as a series of binary numbers.**

**(8) Note, that the smaller the sample interval, the more accurately the original sound can be produced.**

# Samples, Sample frequency & Sample Size

**Samples - two aspects to samples Sample Frequency & Sample Size**

**Sample Frequency (or also called Sample Rate)**

**This is the number of samples taken per unit of time. i.e in each second.**

**The unit of sampling frequency is the Hz (Hertz) which is number of samples per second.**

**Increasing the Sample Frequency results in a better quality of sound,**

**Sample Size (unit bits/sample)**

**This is the number of bits associated with a sample (analogous to bit-depth in images)**

**The Unit of Sample Size is in bits/sample**

**Increasing the Sample Size results in a better quality of sound.**

**Samples Frequency (or Rate) * Sample Size = Bit Rate**

# The Idea of the Quality of a Sound or the idea of Forming an Accurate Representation of the Original Sound

**(1) So, you have the original sound.**

**(2) And when you sample at regular intervals, you want to sample it so that you have an accurate representation of the original sound.**

**(3)You want a faithful representation of the original sound.**

**(4) And we use the term 'Quality' we mean how close to the Original Sound is the Digital Representation (how faithful the representation is).**

**(5) In general, a sampling frequency of around 40,000 times per second (40Khz) is enough to create a reasonable sound reproduction.**
**If the sampling frequency is lower than that, the human ear hears distortions.**
**A higher sampling rate produces better-quality sound, but after a certain point the extra data is irrelevant as the human ear cannot hear the difference.**

# Factors Affecting the Quality of the Sound & File Size

**(1) By Quality we mean how close to the Original Sound is the Digital Representation.**

**(2) Increasing the Sample Frequency OR the Sample Size OR the Sampling Interval will result in:-**

**(i) Increase of the quality of the sound as *****

**(ii) Increase in the file size as there are more samples to store.**

**(3) Decreasing the Sample Frequency OR the Sample Size OR the Sampling Interval will result in:-**

**(i) Decrease of the quality of the sound as *****

**(ii) Decrease in the file size as there are fewer samples to store.**

**(4) An increased BIT RATE means:-**

**(ii) Increase in the quality,**

**(ii) Increase in the file size.**

# Factors Affecting the Size of a Sound File

File Size (in number of bits) =  Sampling frequency (or rate) * sample size* Time (in sec)

File Size (in number of bits) = Bit Rate * Time (in sec)

**http://www-users.math.umn.edu/~rogness/math1155/soundwaves/**

# Formulas Connected with Sound

**From this we get the concept of the Bit Rate which is the number of bits Per second of audio & it is calculated using the following formula:-**

**Formula 1**

Bit Rate = Sampling frequency (or rate) * sample size

Learn all of these 3 formulas

**The Units of Bit Rate = Bits /Second**

**Formula 2**

File Size (in number of bits) = Bit Rate * Time (in sec)

**The Units of Sampling Frequency = Number of Samples Taken /Second**

**The Units of Sample Size = No of Bits / Sample**

**Formula 3**

File Size (in number of bits) = Sampling frequency (or rate) * sample size* Time (in sec)

# Question 1

**(1) Calculate the file size in KiloBytes (KB) of a sound lasting 5 seconds, with a sample frequency of 44,100 Hz and a bit rate of 16 bits per sample.**

**Hint**

File Size (in number of bits) = Sampling frequency (or rate) * sample size* Time (in sec)

# Question & Answer 1

**(1) Calculate the file size in KiloBytes (KB) of a sound lasting 5 seconds, with a sample frequency of 44,100 Hz and a bit rate of 16 bits per sample.**

**Answer**

File Size (in number of bits) = Sampling frequency (or rate) * sample size* Time (in sec)

**= 44,100 * 16 * 5**

**= 3,528,000Bits**

**Now, as 8 bits make a byte**

**3,528,000 Bits =3,528,000/8 Bytes**

**= 441,000 Bytes**

**= 441 KB (as 1000 Bytes make a KiloBytes)**

# Question 2

**(1) Calculate the file size in KiloBytes of a sound lasting 10 seconds, with a sample frequency of 8000 Hz and a bit rate of 16 bits per sample.**

**Hint**

File Size (in number of bits) = Sampling frequency (or rate) * sample size* Time (in sec)

# Question & Answer 2

**(1) Calculate the file size in KiloBytes of a sound lasting 10 seconds, with a sample frequency of 8000 Hz and a bit rate of 16 bits per sample.**

**Answer**

File Size (in number of bits) = Sampling frequency (or rate) * sample size* Time (in sec)

**= 8000 * 16 * 10**

**= 1,280,000**

**Now, as 8 bits make a byte**

**1,280,000 Bits =1,280,000/8 Bytes**

**= 160,000 Bytes**

**= 160 KB** **(as 1000 Bytes make a KiloBytes)**

# Question 3

**(1) A TV Channel records an interview with a Mr. Gates using a computer and audio recording software. Explain how sampling is used to store audio recordings.**

**(2) Another interview is recorded with a Mr. Musket. Before this interview, the sampling frequency in the audio software is increased.**

**Define what is meant by the term sampling frequency.**

# Question & Answer 3

**(1) A TV Channel records an interview with a Mr. Gates using a computer and audio recording software.**
**Explain how sampling is used to store audio recordings.**

Answer

**The height (or amplitude) of a waveform is sampled/measured at regular intervals.**

**This is then converted to binary.**

**(2) Another interview is recorded with a Mr. Musket. Before this interview, the sampling frequency in the audio software is increased.**

**Define what is meant by the term sampling frequency.**

Answer

**The sampling frequency is the number of samples taken per second.**

**It is measured in Hertz.**

# Question 4

**Place a ‘Yes’ by two boxes to show the effects of increasing the sampling frequency.**

| Scenario | Place a ‘Yes’ Box if correct |
|---|---|
| The file size of the digital recording will be smaller | |
| The file size of the digital recording will be larger | |
| The quality of playback of the digital recording will be better. | |
| The quality of playback of the digital recording will be worse. | |

# Question and Answer 4

**Place a ‘Yes’ by two boxes to show the effects of increasing the sampling frequency.**

| Scenario | Place a ‘Yes’ Box if correct |
|---|---|
| **The file size of the digital recording will be smaller** | |
| **The file size of the digital recording will be larger** | Yes |
| **The quality of playback of the digital recording will be better.** | Yes |
| **The quality of playback of the digital recording will be worse.** | |

# Recognising a Sound File - Audio Formats

**Popular extensions of sound files are:-**

***.MP3**

***.WAV**

***That's all for now folks!!***

# Code which generated the Sound Wave in a Previous Slide

```
import numpy as np
import matplotlib.pyplot as plot

# Get x values of the sine wave
time       = np.arange(0, 10, 0.1);

# Amplitude of the sine wave is sine of a variable like time
amplitude   = np.sin(time)+1

# Plot a sine wave using time and amplitude obtained for the sine wave
plot.plot(time, amplitude*5)

# Give a title for the sine wave plot
plot.title('Example Sound Wave Produced by a Note')

# Give x axis label for the sine wave plot
plot.xlabel('Time in seconds')

# Give y axis label for the sine wave plot
plot.ylabel('Amplitude or Height of Wave')
plot.grid(True, which='both')
plot.axhline(y=0, color='k')
plot.show()
```