MUS115 Fundamentals of Music and Sound Design

Week 1: The Art of Sound Design and Digital Audio

- ***A Brief History of Music and Sound Design***
- ***Sound Design Terminology***
- ***Listening***
- ***The Development and Production of Animation, Live Action Film, and Game Soundtracks***
- ***FEZ: Game Audio Analysis***
- ***The Properties of Sound***
- ***The Process of Hearing Sound***
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A Brief History of Music and Sound Design

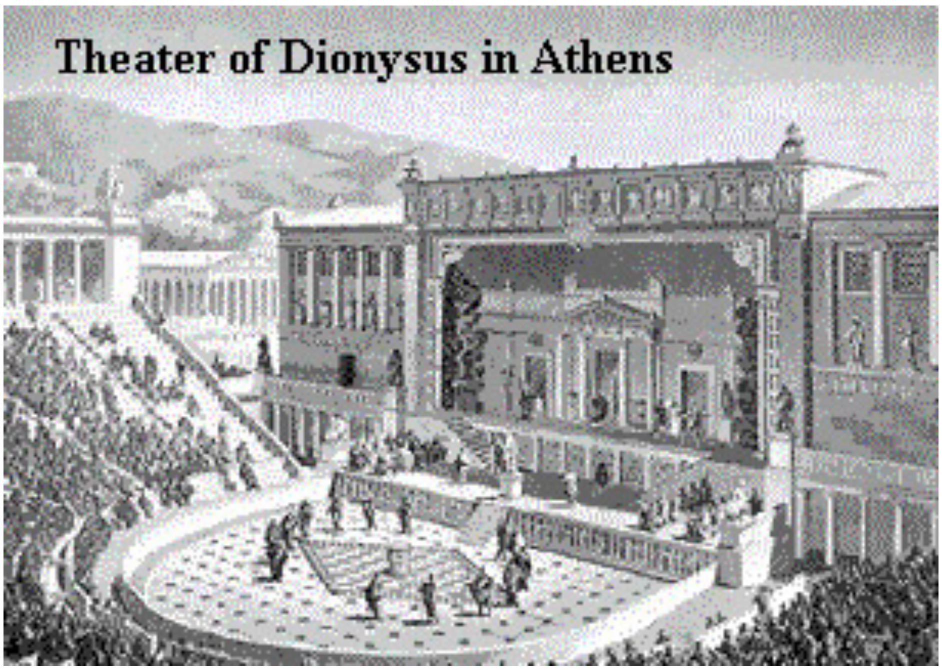
Prehistoric Times

Sound is an integral part of our daily lives. It envelops our physical and emotional states as we work, play, and celebrate life. For thousands of years, music and sound effects have been used to underscore and accentuate religious ceremonies, funerals, weddings, theatre, and social events found in a variety of cultures around the world.

Consider the chanting of a prehistoric man as he tells his dramatic story of a recent hunting expedition. His story was most likely enhanced by reenactments of the events using vocal effects that imitated wild animals, weapons, and the sounds of nature.

Early Civilized Societies

Even in early, civilized societies, such as those found in ancient Greece, Japan, China, and India; music and sound effects were essential components of popular and classic theatrical forms. For example, the plays of ancient Greek dramatists Aeschylus, Euripides, and Sophocles**,** often used music to accompany the delivery of an actor's lines. At the same time, there were off-stage sound 'technicians' who created a variety of sound effects such as shaking pebbles in bronze jars to imitate the sound of thunder.



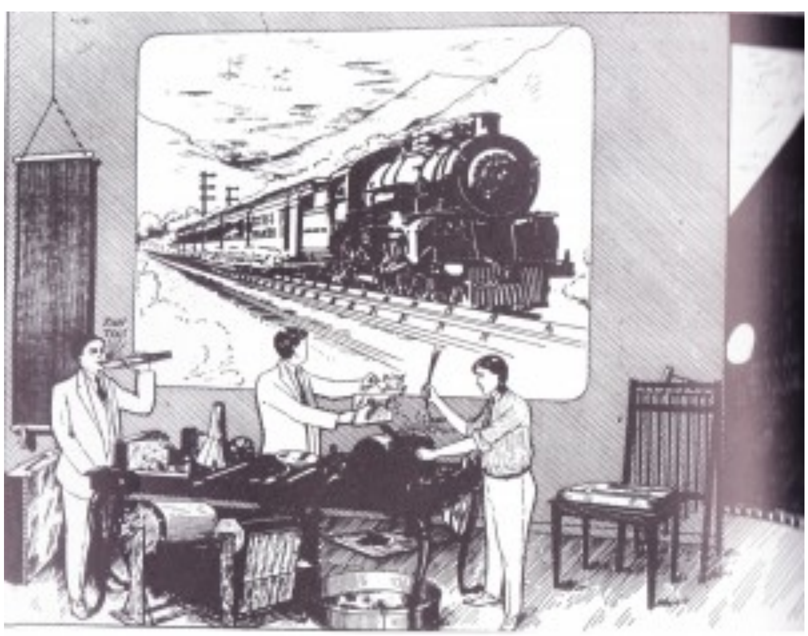
Musical and Non-Musical Dramatic Art

Operas and plays of the late Renaissance through the Romantic periods used music and off-stage sound effects to give the audience a more realistic, convincing, and emotional performance. Cues for the music and sound effects would be written in the script and used devices such as bells, whistles, horns, and miscellaneous musical instruments.

One popular sound effect of the 1800s was a windstorm used in many operas of the Romantic period (e.g., Rossini's *The Barber of Seville* and Strauss' *Don Quixote).* A 'wind machine' consisting of a wooden drum equipped with wooden rods and a weighted canvas was used to produce a swooshing sound similar to that of a storm's wind gusts.

Entertainment and Media

Stage productions and silent films of the late 1800’s and early 1900’s took advantage of the sound design possibilities offered by the early recording technology of gramophones and phonographs. The first documented use of a recorded sound effect was in an 1890’s London theatre production in which a phonograph played the sound of a baby crying. In the early 1900’s, during a London production of *Nero*, two recordings were used: one of a bugle fanfare and the other of the agonizing groans of tortured martyrs. Later, sound effects enhanced many silent films as well. Stage musicians who performed the musical accompaniments to these films would often serve as off-screen ‘sound effect technicians’.



The early 'talkies' (film with sound) of the late 1920's such as '*The Jazz Singer*' used Vitaphone technology. This technology, based on the phonograph record, was used to synchronize music, sound effects, and dialogue to film.

Early radio broadcasts from the 1920s and 1930s used stage personnel to create and play a variety of live and pre-recorded sound effects using simple props. These sound effects would enhance the mood and carry the action forward while, at the same time, create vivid visual images in the minds of its listeners.

From the 1940's throughout the 2000's, technology progressed through various stages from the phonograph, to magnetic tape, and finally to digital audio. At the same time, the craft of binding together recorded sound effects, music, and dialogue had also reached greater artistic achievements as represented in the films '*ShowBoat*' (Jack Foley); Disney Studio's full-feature length animations (Jimmy MacDonald); '*Apocalypse Now'* and '*The Conversation*' (Walter Murch); '*Star Wars'* (Ben Burt), 'Jurassic Park', '*Toy Story'* and '*Lord of the Rings*' (Gary Rydstrom).

The development of sound design for video games began in the early 1970's with the introduction of the simple bleeps and blips of basic wave forms that were hard coded into the game consoles' micro-chips. Continual developments in hardware specifications such as increased memory, more channel allocation for sound, improvements in sound cards, MIDI technology, increased sampling rate, and increased bit depth all contributed to the music composer and sound designer's creative freedom.

With the combination of demands from video gamers and movie goers, the requirements of video game play, the advancements in audio software/hardware tools, and a better understanding of the nature of dynamic audio and game composition techniques, today's sonic landscapes continue to reshape and enhance the world of sound around us.

Sound Design Terminology

Sound design is the process of recording, creating, editing, and manipulating dialogue, music, and sound effects to be used in television, sound recordings, live performances, live action films, animations, and video games.

Dialogue is a written or spoken conversational exchange between two or more people. Dialogue is the primary means in which a story can be told and the plot of the story propelled forward.

Music is a form of communication that uses the musical elements of melody, rhythm, harmony, texture, timbre, form, dynamics, and tempo to elicit emotions and responses from its listeners.

Sound effects are sounds that are produced either naturally or artificially that enhance or emphasize specific actions within a dramatic presentation, live action film, animation, or video game and are not specifically part of the dialogue or music soundtrack.

Music and Sound in Video Games

A ***soundtrack*** is a recording of the musical accompaniment to a movie or video game. Originally, the soundtrack was a segment on a filmstrip or magnetic, audiotape designated for embedded sound.

A ***nonlinear soundtrack*** is one in which the game music is conceived and composed with an *indefinite* beginning and end. Game music that changes in response to player input and game state is an example of a ***nonlinear soundtrack***.

Dynamic audio refers to the interactive and adaptive nature of video game audio. Music and sound effects of a game that are in a constant state of change due to player input or game state are said to be ***dynamic***.

Interactive audio means that the participant has a direct influence over the occurrence and characteristics of the music and sound effects during game play. Interactive audio refers to those sound events that react to the player's direct input. For example, depressing a controller button to make a character run or jump is an example of interactive audio.

Adaptive audio means that the sonic events react to a game state. In-game parameters such as time-ins, a player's health, and an enemy's health would be examples of ***adaptive audio***.

Generative audio consists of one or more unique sounds (either music or sound effects) whose sonic characteristics are different upon each occurrence in real time. These sounds' random behaviors are due to their settings and parameters through written code or through middleware.

Music and Sound in Animations and Live Action Films

A ***linear soundtrack*** is one in which the music and sound effects are conceived and composed with a *definite* beginning and end as in the case of a traditional music composition or a live action film/animation soundtrack.

Diegetic sound is sound whose source is visible on the screen or whose source is implied to be present by the action of the film. Voices of characters, sounds made by objects in the story, and music represented as coming from instruments in the story space (***source music***) would be examples of diegetic sound.

Non-diegetic sound is sound whose source is neither visible on the screen nor has been implied to be present in the action. A narrator's commentary, sound effects that are added for the dramatic effect, and mood/background music (***underscore***) that is represented as coming from a source outside the story space are good examples of non-diegetic sound.

Listening

Four Modes of General Listening

As an audience or gamer engages in a multi-media experience, they may find themselves listening to the music, sound effects, and dialogue in one or more modes depending on their own musical and technical understanding. Below are the four main types, or modes, of general listening that audiences or gamers might experience as they view animations, live action films, and video games:

1. ***Reduced listening:*** In a ***reduced listening*** mode the listener observes the sound itself without any regard to its meaning.

2. ***Casual listening***: In a ***casual listening*** mode the listener determines what type of space, object, or person is creating the sound.

3. ***Semantic listening*****:** In the ***semantic listening*** mode the listener analyzes a spoken language (dialogue) that symbolizes ideas, actions, and things.

4. ***Referential listening*****:** In a ***referential listening*** mode the listener is consciously aware of the sound's emotional affect and dramatic meaning.

Types of Music Listeners

Listening to music, in particular, also has its own levels and depths of aural participation. Musicians and sound designers, because of their special technical knowledge of the elements of music and sound, are able to listen to music at any of these levels while an average listener may only experience music at its most basic level. Regardless of the level of listening, music can be enjoyed by anyone who has an open mind and a general sense of appreciation for music's rich variety of elements (melody, rhythm, harmony, texture, timbre, form, dynamics, and tempo):

1. ***Sensuous:*** A ***sensuous*** listener is one who enjoys music as a background or delights in the presence of music and its ambient effect (Example: New Age compositions with ambient nature sounds).

2. ***Associative:*** An ***associative*** listener is one who associates the music with an experience from his/her past, a literary work, an idea, or a visual experience. (Examples: music from a folk, popular, or rock song; program music; a game; or animation).

3. ***Critical:*** A ***critical*** listener is one who listens for the quality of the performance. The quality of performance is evaluated by technical accuracy; intonation; balance of timbre and dynamic levels between the notes of the instrument or instrumentalists; stylistic interpretation; and stage presence.

4. ***Attentive:*** The ***attentive*** listener goes one step beyond the ***sensuous***, ***associative***, and ***critical*** listening skills by researching background information on the music of the performance, listening while reserving judgment until completion of the performance, and evaluating the performance after careful contemplation and consideration in regard to all of his/her knowledge base and experience.

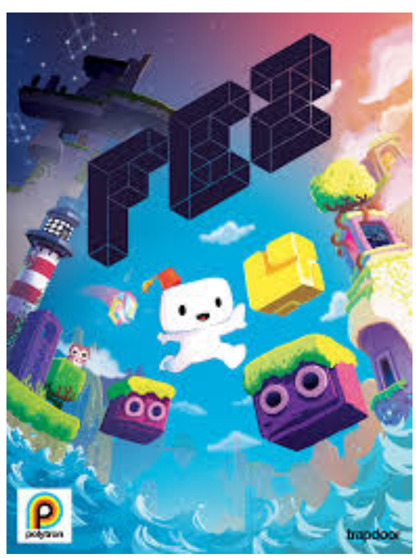
The Development and Production of Animation, Live Action Film, and Game Soundtracks

Creating high-quality audio for animations, live action films, and games begins with the organization of the processes and tasks into a production 'pipeline' that will assure a smooth work flow. There are many similarities, differences, and challenges unique to the individual production of animations, live action films, and games. However, there are many key steps that are common to the audio production of all types of media. These steps are outlined below with examples of the necessary types of steps, processes, and documents that facilitate the production pipeline:

1. ***Meet with the director, producer, and team members*** to discuss and propose sonic solutions in terms of style, mood, and character of the various scenes or levels.
2. ***Read a current script, story, or game document*** of the animation, live action film, or game.
3. ***Establish a production pipeline*** that will delegate the production's tasks, coordinate the workflow, set milestones, and ship dates.
4. ***Establish a format of final deliverables*** to determine how to prepare the tracks for the final mix and rendering: ***.MOV, .AVI, .WMV, .AIF, .WAV, .BWF, 16bit or 24 bit depth, 44Khz or 48Khz sample rate***.
5. ***View the film, animation, or screen captures of game play*** (if available).
6. ***'Listen' (with your eyes)*** for objects, actions, environments, emotions, and transitions. Write down nouns, verbs, and adjectives that correspond to the visual elements of the animation, live action film, or game.
7. ***Begin documentation of the audio assets*** using a combination of visual maps, music storyboards, spreadsheets, and/or cue sheets.
8. ***Begin a detailed journal*** of the tasks accomplished each day.

9. ***Create a Music Storyboard***: The process of creating music storyboards for mapping out musical ideas, music cues, and sound effects began in the early days of Disney studios with cartoon-music pioneer Carl Stalling. Stalling would frequently write the musical ideas directly onto a small storyboard so that the musical themes matched up to the correct scene.
10. ***Document the audio assets*** using a combination of spreadsheets and cue sheets.
11. ***Participate in the production*** for advice on reducing or removing shots, selection of locations, procurement/utilization of proper equipment/materials, recording of wild/unusual sounds on a location shoot, and all phases of editing the film, animation, or game audio.
12. ***Begin composing the music score*** through a proper choice of the musical elements (melody, harmony, rhythm, timbre, form, dynamics, texture, and tempo) in relation to the dialogue and sound effects.
13. ***Record and re-record music and dialogue*** through on-location dubbing, alternative production takes in the studio, and/or postproduction dubbing.
14. ***Add sound effects and sound*** to the soundtrack through sound libraries, Foley, wild (on location) track recordings, synthesizers, and samplers.
15. ***Experiment with the creative editing of music and sound effects*** through speed, pitch, and timbre.
16. ***Pre-mix sound effects, music, and dialogue*** into sub-groups for finer control over balance, screen placement, or game audio implementation.
17. ***Perform a final mix and mastering*** to achieve an artistic, sonic balance between the story, dialogue, music, and SFX.
18. ***Begin the final cue sheet preparation*** of spreadsheets, cue sheets, visual maps, music story boards including all music, sound effects, fades, cross fades, filters, EQ, reverb, pitch changes, and etc. for final documentation of the project.
19. ***Deliver*** the final animation, live-action film, or game.

FEZ: Game Audio Analysis



About the Game…

Polytron's indie puzzle/platform game, *FEZ,* was designed by Phil Fish and published by Polytron, Trapdoor, and Microsoft Studios for the *Xbox360* in 2012. In *FEZ,* the player maneuvers the character *Gomez* and the revelations of his fez, through four 2D views of a 3D game world with the objective of solving puzzles, collecting cubes and cube fragments, and restoring order to the universe. Interestingly, after *FEZ's* initial release, a number of secret images, QR codes (2-D bar codes), and dates were found hidden in individual music tracks.

About the Music…

FEZ's game chiptune-esque electronic soundtrack was composed by Rich Vreeland ('Disasterpiece'). In *FEZ,* Vreeland creates a trance-like atmosphere through simple, musical hypnotic patterns of shimmering electronic sounds through the use of soft synth pads, reverb, and 80s synth sounds. Rather than relying on traditional percussion in *FEZ*'s game score, Vreeland incorporated distortion techniques such as *bitcrushing* (a low-fidelity distortion effect that intentionally reduces audio quality to emulate early digital audio gear and create a grainy, gritty, metallic sound) and *wow* (frequency wobble caused by a sound file's speed fluctuation).

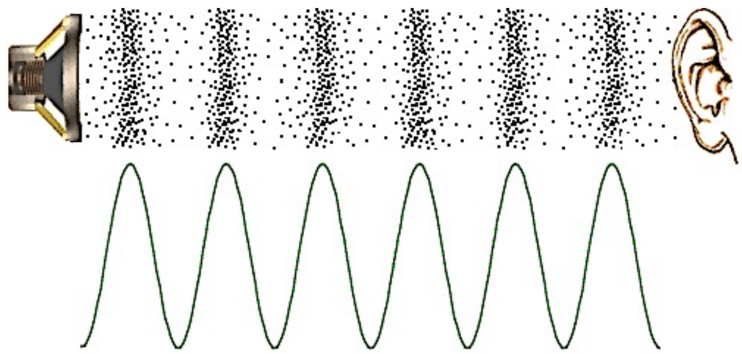
FEZ's music contains primarily slow-tempo musical passages with varying tempos that could "ebb, flow, and breathe with the player". Portions of the *FEZ*'s soundtrack dynamically changes between several dozen constituent elements and as they react to the game environment. For example, the changing of the puzzle track's elements key based on the in-game time of day would be an example of one of these reactions. Certain tracks were intended to imitate real-world sounds, such as those of bats, thunderstorms (taiko drums), and water falling from stalactites. Vreeland's musical inspirations were drawn from a variety of sources: the *Lord of the Rings' Shire Theme*, 1980s horror media, the soundtrack of game demo-scenes from *Jasper's Journeys*, the *Legend of Zelda's* dungeon music, the *Mass Effect* soundtrack, *Tangerine Dream*, and the music of Steve Reich. Vreeland's love of the Romantic piano literature inspired the music track '*Continuum*', a synthesized rendition of *Frédéric Chopin 's Prelude, Op. 28, No. 4.*

FEZ's sonic uniqueness is due to both its 'instrumentation' and compositional techniques. Unusual instruments used in *FEZ*'s soundtrack include the *Sonic Charge Synplant* (a software synthesizer), the MiniMoog, a 'synthetic flute', and a *Boomwhacker* (tuned percussion tubes). One notable level that exemplifies *FEZ*'s unique soundscape is the *Music Room*. In this level, the player synchronizes Gomez' jumps from one platform to another with the music's beat. One of Vreeland's favorite music forms commonly used for many of the individual music tracks is the *through-composed* form (this was an outcome of the improvisatory nature of many of *FEZ*'s music tracks).

The Properties of Sound

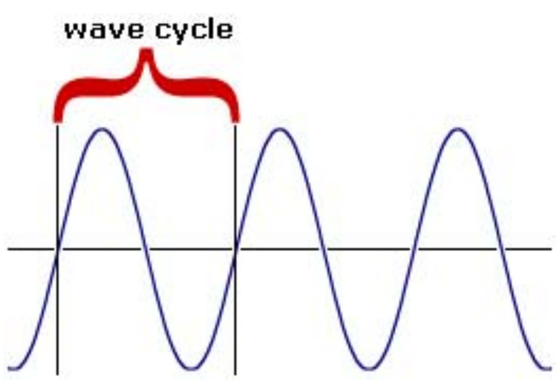
Sound Waves

When force is applied to a sound source it creates a change in atmospheric pressure. For example, if a guitarist plucks a guitar string, the vibration of the string causes changes in the atmospheric pressure in the form of vibrational disturbances. These vibrational disturbances are called ***sound waves*** and are transmitted as alternate compressions and rarefactions of the atmosphere's molecules.



Ex. 1

One single occurrence of the air molecules' compression and rarefaction is known as a ***cycle*** (or ***wave cycle***). A graphic representation of a cycle helps visualize how the oscillation of air molecules occurs both above and below the central axis of the sound wave. The example below shows how a waveform is graphically represented in a digital-audio wave-editing tool such as ***Audacity***:

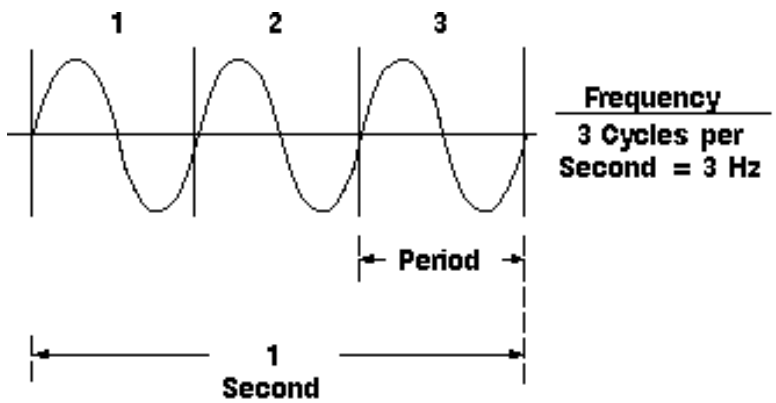


The Four Properties of Sound

The sounds we perceive in the world around us possess, in varying degrees, four unique properties. The variance of these four properties in one sound to the next is what makes, for example, a flute sound different from a violin.

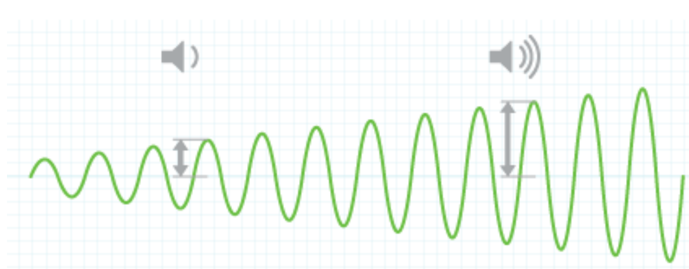
Pitch

There are a few important terms used when discussing the ‘highness’ or ‘lowness’ of a sound. ***Pitch*** is the term used to describe the ‘highness’ or ‘lowness’ of a sound. The pitch of each individual sound is measured by its number of wave cycles (or vibrations) per second. ***Frequency*** is the term used to describe the number of wave cycles that occur within one second. ***Hertz (Hz)***, a term named after the German physicist Heinrich Hertz, is the scientific unit of measurement for frequency vibration.



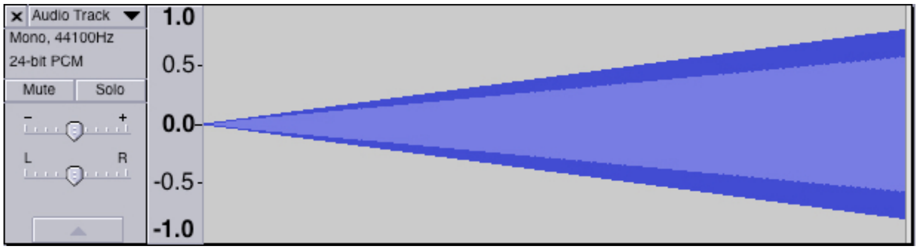
Intensity

Sound also has a perceived level of softness or loudness. ***Intensity*** is the term that describes the softness or loudness of a sound. When described in terms of a scientific measurement, a sound’s intensity is referred to as ***amplitude***. The ***amplitude*** of a sound is measured in decibels (***dB***). A ***decibel*** is a logarithmic unit named after the inventor Alexander Graham Bell. The decibel measurement labels the *relative* amplitude of a sound’s intensity.



Ex. 2

Wave Editor Representation of Amplitude in Decibels

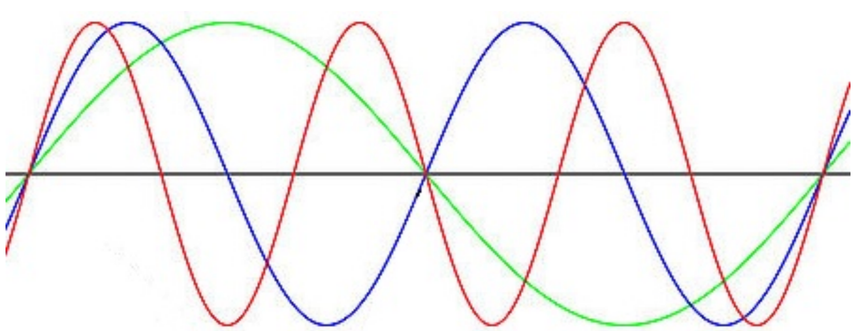


Timbre

The unique tone quality that distinguishes one sound from another is called ***timbre.*** Timbre is the 'brightness' or 'darkness' of a sound's tone quality. Timbre is a result of the number and intensity of a sound wave's secondary vibrations. To clearly understand timbre, we must take a closer look at a sound wave's secondary vibrations, or ***overtones***.

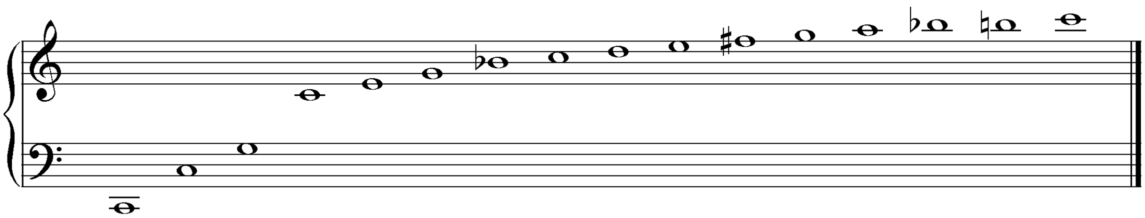
When energy is produced from a sound source, a sound wave is generated in the atmosphere. Because of the repercussions and 'spring-like' action of the sound wave's impact, secondary sound waves are generated. Imagine tossing a large stone into a still, standing pool of water. At first, you will notice that waves are generated outward from the point of impact. However, upon further observation, you will see many tiny ripples of water within the larger, original waveforms. This phenomenon is also true with sound waves. As we first listen to a sound, we will perceive the primary sound wave's frequency called the ***fundamental*** tone. However, there are also secondary vibrations that generate from the fundamental tone. These secondary vibrations are called ***harmonics*** or ***overtones***. ***Harmonics***, or ***overtones***, are a complex of pitches resulting from secondary vibrations along various points of the sound source's length.

A Fundamental (*green*) with Its Secondary Vibrations (*red* and *blue*)



The ***harmonic series*** is the number, distribution, and intensity of harmonics (***overtones or partials***) that occur above the fundamental tone. In the example below, the fundamental is the lowest note. Timbre is simply a result of the series of harmonics or overtones generated by the fundamental tone.

The Harmonic Series



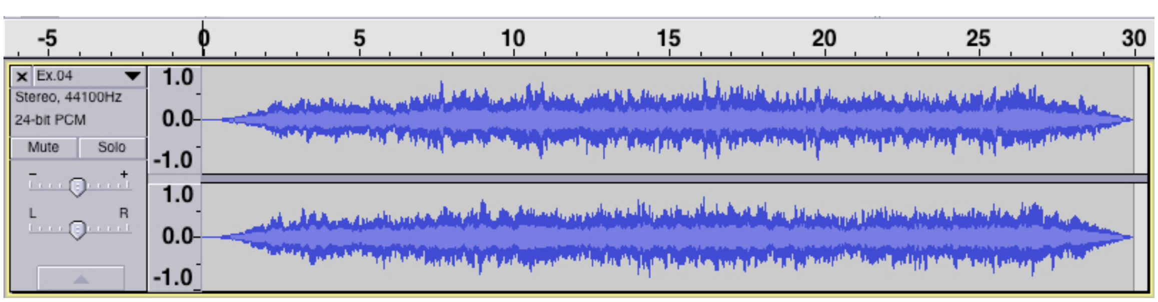
Ex. 3

In summary, a ***partial*** is any one of the harmonics generated by a primary or secondary vibration of the sound wave, the ***fundamental*** is the lowest partial in the harmonic series (i.e., the most prominent pitch as perceived by the listener), and an ***overtone*** or ***harmonic*** is any partial in the harmonic series except the fundamental.

Duration

A final sound property to be discussed is the ***duration*** of the sound. The duration of a sound is its length as measured in minutes, seconds, or any fraction thereof. All digital audio tools provide these various types measurements in their user interfaces.

A Sound Wave with Its Corresponding Timeline in Seconds

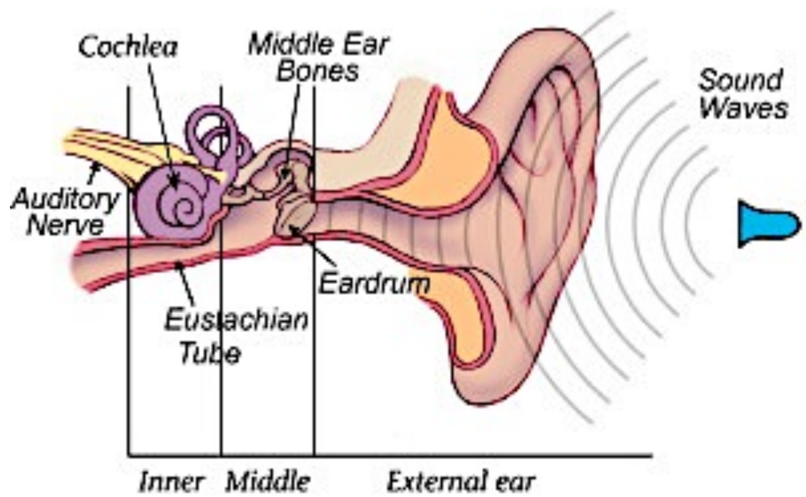


Ex. 4

The Process of Hearing Sound

To better understand some of the processes involved in digital audio, it is important to take a brief look at exactly how humans receive auditory information through the ears.

Anatomy of the Ear



When sound waves reach the ear, the ***eardrum*** (***tympanic membrane)*** begins to vibrate. This causes the three ***middle ear bones*** (the ***malleus, incus,*** and ***stapes)*** to pass the vibrations through a snail-shaped, fluid-filled structure in the inner ear called the ***cochlea*.** Then, the vibrations excite hair cells located on the basilar membrane of the cochlea. These vibrations generate a nerve impulse in the ***auditory nerve***. The nerve impulse is then sent to the brain and is perceived as pitch, intensity, timbre, and duration. It is important to remember that humans can only hear sound waves with frequencies between 20 and 20,000 Hz. Understanding this information allows musicians and sound designers to make important decisions during the audio production processes.

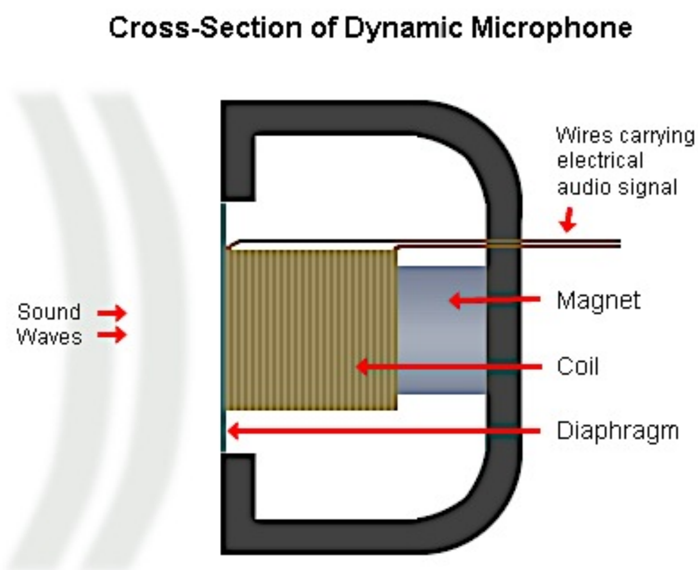
Analog to Digital Conversion

Musicians and sound designers employ a variety of methods to create soundtracks for animations, live action films, and games. One method may be running live recording sessions to capture the music and sound effects. Another method may be the manipulating and editing of pre-recorded sounds from a professional sound library. Regardless of the method used, a good, basic understanding of how live sound is captured and converted to digital audio is extremely important. So far, we have explored the fundamentals of the sound wave and its behavior in an acoustic environment. Now, it is time to delve into ***analog audio***, ***digital audio***, and the ***analog to digital conversion process*** (***A/D***) that allows musicians and sound designers to sculpt their custom sounds.

Analog and Digital Audio

When the sound waves travel through the atmosphere into a microphone and then, into a recording device, the sound waves are first captured as ***analog audio***. Analog audio is the representation of sound through electrical impulses that is *analogous* to a sound wave. The next step is to convert the analog audio to ***digital audio***. Digital audio is the reproduction and transmission of sound stored in a digital format consisting of binary code (ones and zeros). Therefore, ***analog to digital audio conversion*** is the process of capturing and converting sound energy from electrical impulses into a digital format. The following information outlines the lifecycle of the audio signal beginning with its generation from the initial sound source.

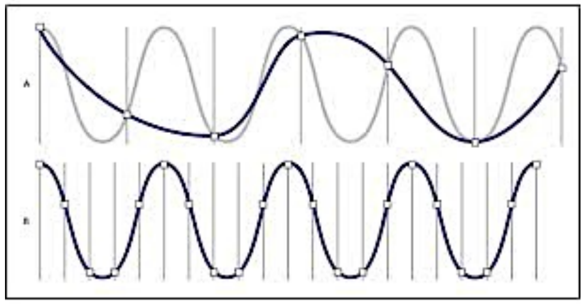
1) First, the sound source creates energy that travels as sound waves. The sound waves are then received through a microphone and converted into electrical energy:



2) Then, the electrical signal is processed with a ***low pass filter*** to eliminate any unwanted/unnatural high frequencies.

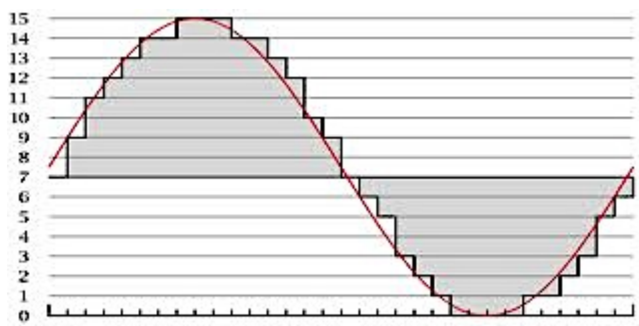
3) Next, the analog to digital converter (***A/D***) analyzes the analog signal and samples the sound wave. A ***sample*** is a 'sonic snapshot' of the audio signal being captured. The greater the number of samples captured (***sample rate),*** the more accurate the overall 'sonic snapshot' will be. The outcome of a larger sample rate will be a cleaner, more noiseless sound quality. The standard sample rate for CD quality is 44.1kHz or 44,100 times per second however, most professional musicians and sound designers work with a 48kHz sample rate (48,000 times per second).

Sample Rate
(low sample rate vs. high sample rate)



4) While the ***A/D*** converter is sampling the analog signal, it also analyzes the amplitude of the waveform (or its ***bit depth resolution***). The standard ***bit depth*** for CD quality is ***16-bit*** resolution (In professional audio production, 24-bit recording is the standard bit depth resolution). However, in final audio renderings, 16-bit is often the choice used in the final deliverable format. In summary, the greater the bit depth, the more accurate the conversion of the waveform's amplitude will be. Simply put, the larger the sample rate and bit depth resolution, the clearer and more noiseless the digital audio will be.

Bit Depth Resolution



5) Next, the digital information is then ***quantized*** (or 'rounded off') and stored as binary code.

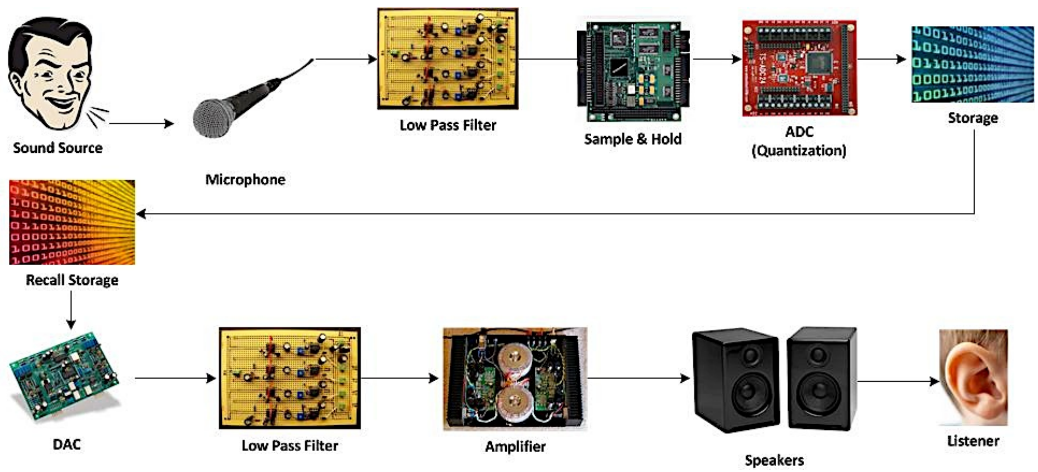
6) When the information is retrieved for playback, the ***A/D*** conversion process is reversed.

7) The binary code is processed, converted back to electrical impulses (***D/A***), receives additional processing through a low pass filter, and sent through the amplifier.

8) The audio signal receives a boost in amplitude by the ***amplifier*** that causes the electric impulses to vibrate the surface area of the ***speaker diaphragm***.

9) The vibrating speaker diaphragm creates alternate compressions and rarefactions of the molecules in the atmosphere. The oscillation of air molecules generates sound waves that are then sent to the listener's ears.

The Analog to Digital Audio Conversion Process

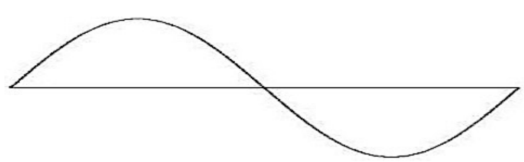


Types of Waveforms

Many of the sounds created in the early history of electronic music and video games used very basic waveforms. These waveforms were originally generated artificially through vacuum tube oscillators, transistors, and later by microprocessors. The following basic types of waveforms were among the first sounds heard in the early days of game audio and are still considered fundamental in crafting more sophisticated, modern-music compositions, and sound effects.

Sine (or Pure Tone) Wave

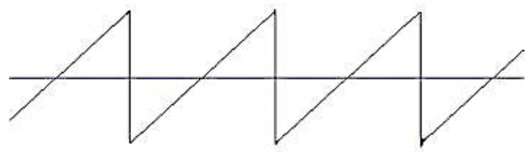
The ***sine wave (or pure tone)*** is a waveform with only one frequency (the fundamental) and no overtones. In early game music, sine waves were frequently used for sound effects such as lasers and alarms. Sine waves were also commonly used as flute-like sounds in upper or lower melodic passages.



Ex. 5

Sawtooth (or Ramp) Wave

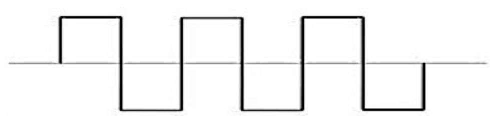
A ***sawtooth (or ramp) wave*** is a waveform that uses a combination of both odd and even overtones. Sawtooth waves are frequently used for melodic bass lines and have a mixture of raspy, warm, and round timbre qualities.



Ex. 6

Square (or Pulse) Wave

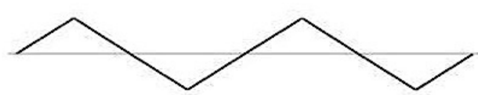
The ***square (or pulse) wave*** is a waveform with only odd overtones. Square waves are frequently used for a variety of melodic lines. Depending on the intensity of overtones, the square wave can sound fat, thin, raspy, or hollow.



Ex. 7

Triangle Wave

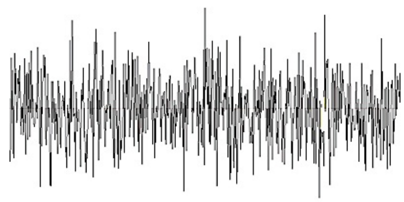
A ***triangle wave*** is a waveform with odd overtones that diminish faster than a square wave's overtones. Triangle waves are frequently used for a variety of melodic lines that require a smooth, round timbre quality.



Ex. 8

White Noise

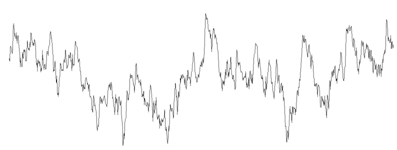
White Noise is a waveform that contains every frequency within the range of human hearing in equal amounts. White noise was often used as a percussive effect (e.g., the cymbal) in early game music. In traditional sound design, white noise has been used for sound effects such as radio static or windstorms.



Ex. 9

Pink Noise

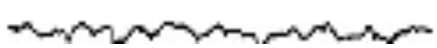
Pink Noise is a variation on white noise. Pink noise is filtered to reduce the amplitude of selected higher frequencies. In sound design, pink noise is sometimes used as a substitute for the sound of a waterfall. In early game music pink noise was also used as a percussive effect (e.g., the snare drum).



Ex. 10

Brown Noise

Brown Noise is a variation on white noise. Brown noise is filtered to reduce the amplitude of most of the higher frequencies. Brown noise is often used as an enhancement and reinforcement in explosive sound effects and percussive effects such as the kick drum.



Ex. 11

Generating and Editing Waveforms with a WAV Editor

The WAV Editor

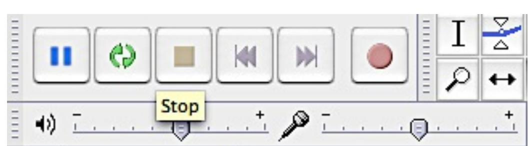
One of the most commonly used tools in audio production today is the ***WAV editor*** (or wave editor). With this tool, the composer/sound designer can manipulate and edit waveforms in an almost limitless number of ways. Because the WAV editor is the starting point for most audio production, it is important to understand its basic functionality and processes. Below is a description of the WAV editor's basic set of controls called the ***transport controls***. The transport controls may vary slightly in appearance and user interface (***UI***) from one wave editor to the next but, for the most part, all transport controls have the same functionality. For this course, we will be using a free, downloadable WAV editing tool known as ***Audacity***.

Transport Controls

- **Pause**

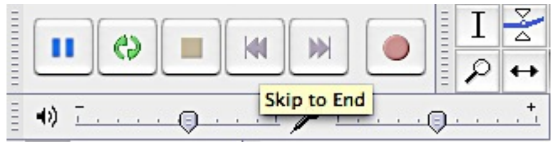
- **Play**

- **Stop**



- **Skip to Start**

- **Skip to End**

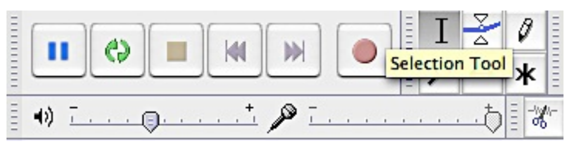


- **Record**

Editing Tools

Editing tools provide the composer/sound designer with a means of editing and manipulating the waveforms in a variety of ways:

- **Selection Tool**



- **Envelope Tool**

- **Draw Tool**

- **Zoom Tool**

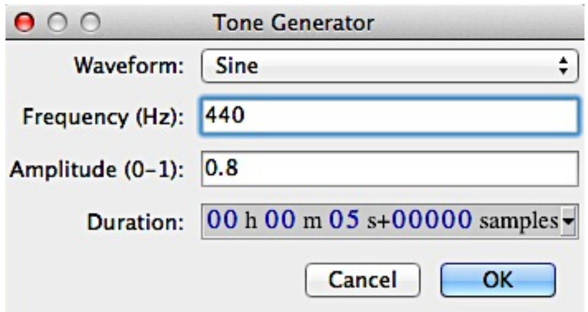
- **Time-Shift Tool**

- **Multi-Tool Mode**

Generating/Editing Waveforms and Melodies with a WAV Editor

Most wav editors allow the composer and sound designer to generate one or more of the basic waveforms. Remember that basic waveforms are the building blocks for more complex sounds in electronic music and sound effects. Therefore, is important to understand how to manipulate and edit waveforms for a variety of sonic situations. The next section shows how to generate and alter the waveform's four basic properties.

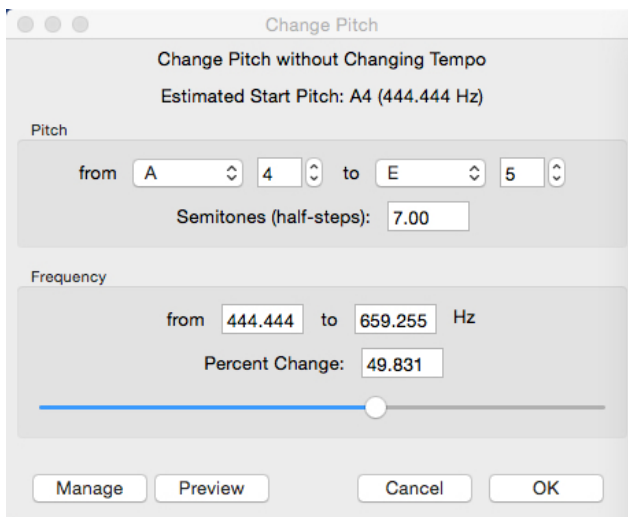
- Open ***Audacity.***
- Click on ***Generate*** in the ***Menu Bar.***
- *Click on **Tone…***
- Use the following default settings:
  Waveform: Sine, ***Frequency: 440Hz***, ***Amplitude: 0.8 dB***, ***Duration: 5 seconds.***
- Click ***OK.***
- Click on the ***Zoom In Tool*** and magnify the waveform 10X to see the shape of the sine wave.
- Click ***Play*** on the ***Transport Controls.***
- Click ***Stop*** on the ***Transport Controls.***



Ex. 12

Changing the Pitch of a Waveform (Method #1)

- Click on ***Effect*** in the ***Menu Bar.***
- Click on ***Change Pitch…***
- Under the drop down menu, ***Change Pitch***: ***From: A4 To: E5.***

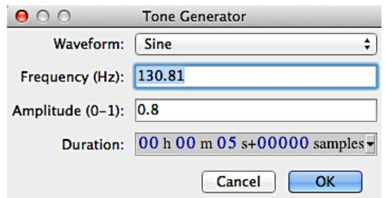


Ex. 13

- Click ***OK.***
- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***
- Delete the waveform by double-clicking on the waveform and depressing the ***Delete*** key.

Changing the Pitch of a Waveform (Method #2)

- Click on ***Generate/Tone*** in the ***Menu Bar.***
- Generate a *sine wave* at ***C_3* *130.81*** (use the ***Table of Frequencies Chart*** for referencing other pitches).
- Click ***OK.***

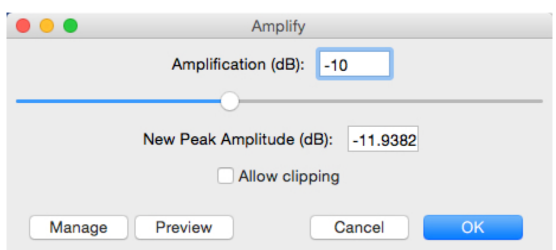


Ex. 14

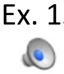
- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***
- Delete the waveform by double-clicking on the waveform and depressing the ***Delete*** key.

Changing the Intensity of a Waveform

- Generate a *sine wave* at ***A 440.***
- Click on ***Effect*** in the ***Menu Bar.***
- Click on ***Amplify…*** This will physically change the sound wave's ***amplitude***.
- Enter ***-10*** in the ***Amplification (dB)*** box and click ***OK***.



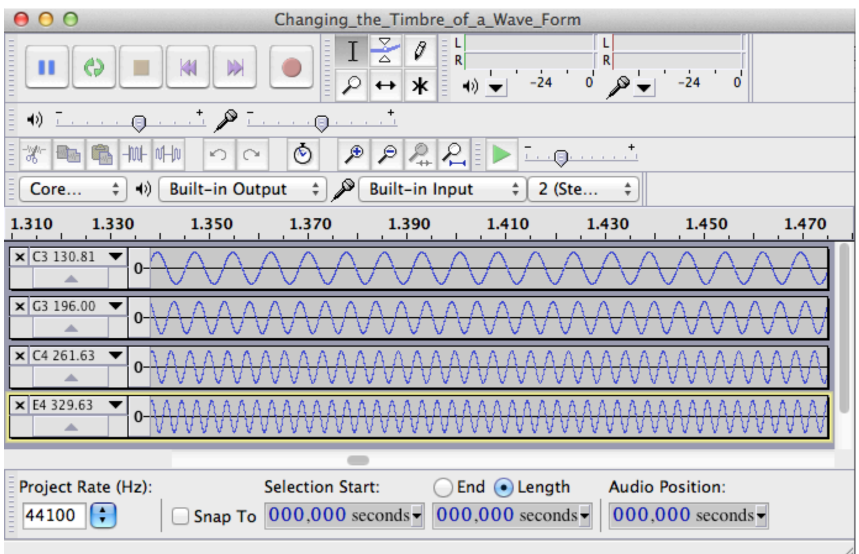
Ex. 15



- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***
- Delete the waveform by double-clicking on the waveform and depressing the ***Delete*** key.

Changing the Timbre of a Waveform

- Create a new 5-second *sine wave* at ***C_3* *130.81.***
- Create a new audio track: ***Tracks/Add New/Audio Track.***
- Create a 5-second *sine wave* at ***G_3* *196.00.***
- Create a new audio track: ***Tracks/Add New/Audio Track.***
- Create a 5-second *sine wave* at ***C_4* *261.63.***
- Create a new audio track: ***Tracks/Add New/Audio Track.***
- Create a 5-second *sine wave* at ***E_4* *329.63.***
- Click on ***Play*** on the ***Transport Controls.***
- Notice the change in ***timbre*** quality from the original ***C_3* *130.81*** sine wave.
- Adjust the ***Audio Track's Gain Faders*** in tracks 2, 3, and 4.
- Again, notice the change in timbre quality.
- A ***square wave*** has been created.
- Delete the waveform by double-clicking on the waveforms and depressing the ***Delete*** key.

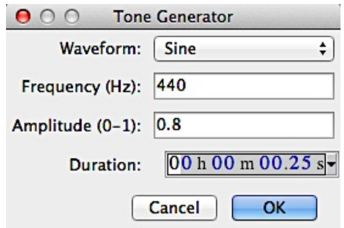


Ex. 16

Editing the Duration of a Waveform (Method #1)

- Create a ***sine wave*** at ***A 440.***
- Use the following settings: ***Waveform: Sine***, ***Frequency: 440Hz***, ***Amplitude: 0.8 dB***, and, using the drop-down menu for hundredths of a second (***hh:mm:ss: + hundredths),*** change the ***Duration*** to ***0.25 seconds***.

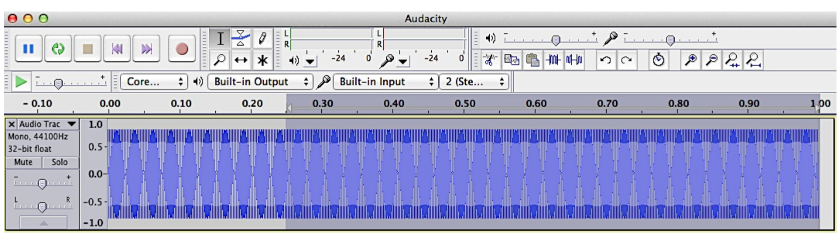
- Click ***OK.***
- Click ***Play*** on the ***Transport Controls.***
- Click ***Stop*** on the ***Transport Controls.***
- Delete the waveform by double-clicking on the waveform and depressing the ***Delete*** key.

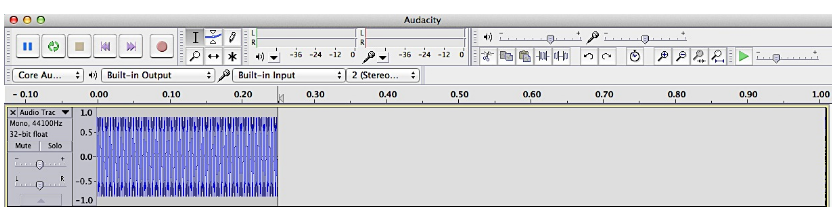


Ex. 17

Editing the Duration of a Waveform (Method #2)

- Generate a *sine wave* at ***A 440.***
- Use the following settings:
  Waveform: Sine, ***Frequency: 440Hz***, ***Amplitude: 0.8 dB***, ***Duration: 1 second.***
- Click on the ***Selection Tool*** in the toolbar.
- Click on the ***Zoom In Tool*** and magnify the waveform to see the tenths of a second.
- Using the ***Selection Tool***, ***click>drag>select*** from the extreme right end of the ***audio region***, trim (shorten) the wavelength to ***0.25*** seconds.





- Click on the ***Delete*** key.
- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***

Ex. 18

Creating a Scale with a Waveform

A ***scale*** is a preset, consecutive series of tones that ascend and descend in pitch. In this next exercise, we will create an ascending scale using the various wave-editing tools available in our wav editor.

- Generate a new 1.00" *sine wave* at ***C_4 261.63.***
- Create a ***scale*** using pitches from the ***Table of Frequencies*** chart. Generate the pitches, one at a time, in the following order:

 D_4 293.66
 E_4 329.63
 F_4 349.23
 G_4 392
 A_4 440
 B_4 493.88
 C_5 523.25

- You have now created a ***C major scale***.
- Click on the ***Skip to Start*** button on the ***Transport Controls.***
- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***

Ex. 19

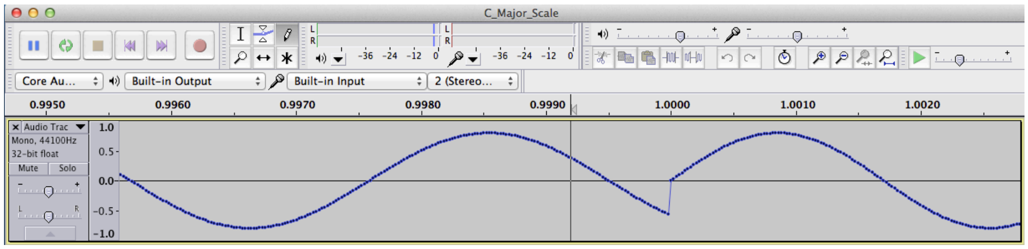
Editing the Waveform to Remove Sonic Artifacts

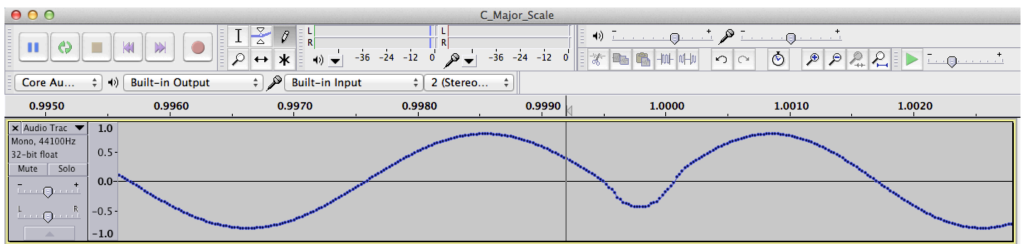
As you played the C major scale, you may have noticed clicking, popping, or percussive sounds when transitioning from tone to tone. These are known as ***sonic artifacts***. Composers and sound designers use various methods to remove these unwanted sonic artifacts.

Sonic Artifact Removal: Method #1

a) Zoom in 13X, ***Select All***, click on ***Edit>Clip Boundaries>Join***. This will join all of the audio regions together into one complete audio region. As you generated a new waveform for each pitch, you were also simultaneously creating new audio regions. These audio regions must be joined together before any editing takes place.

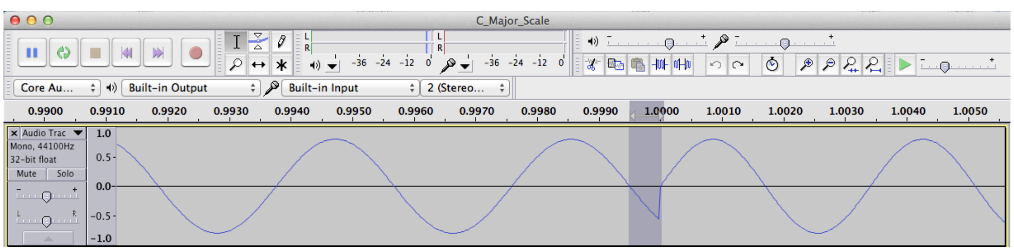
b) Scroll through the waveform until you locate the ending and beginning of each pitch. The sonic artifact will appear as a disconnected ('broken') line. This disconnection in the waveform is what is causing the sonic artifact. Using the ***Pencil Tool***, restore the waveform by connecting the 'dots' (control points) in a smooth a curve as possible.



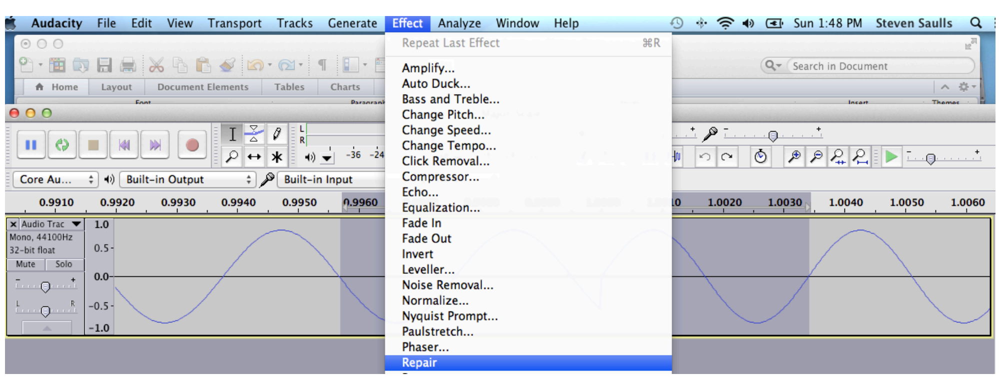


Sonic Artifact Removal: Method #2

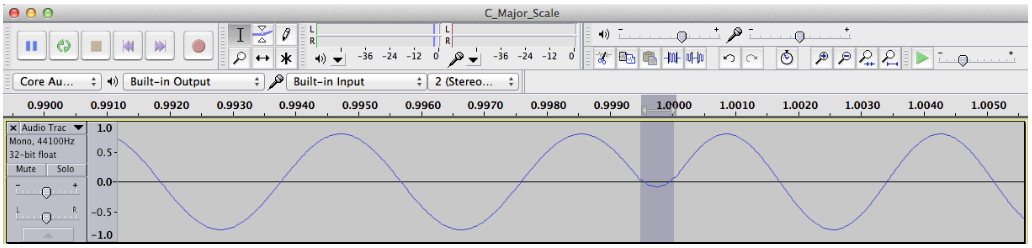
a) Locate the waveform's 'broken' area and, using the ***Selection Tool***, select the damaged area**.**



b) Click on ***Effect,*** and ***Repair.***

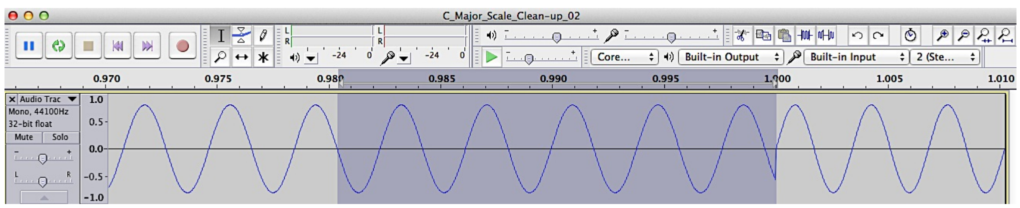


c) The disconnection between the two pitches is now repaired and is represented by the smooth curve in the waveform**.**

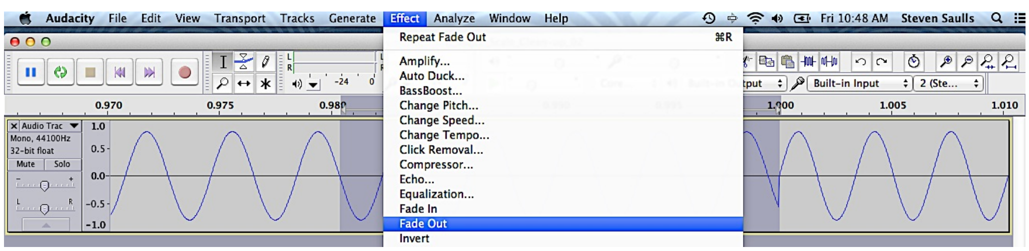


Sonic Artifact Removal: Method #3

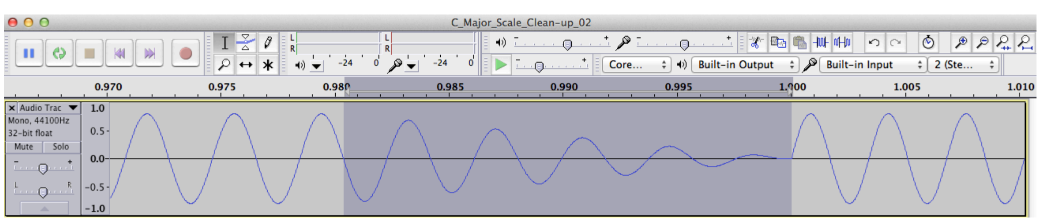
a) Select a few milliseconds (***ms***) of the damaged area starting at the ***beginning*** of the undamaged wave cycle and ending with the damaged area's wave cycle.



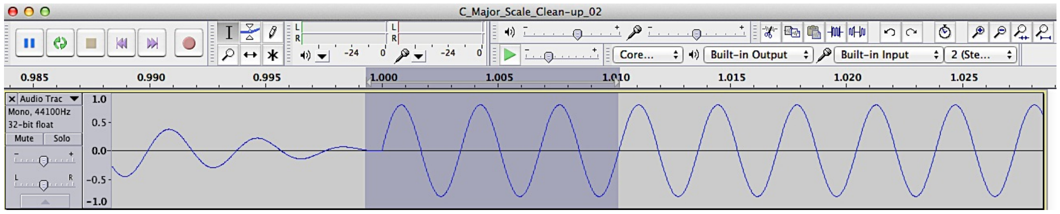
b) Select ***Effects/Fade Out.***



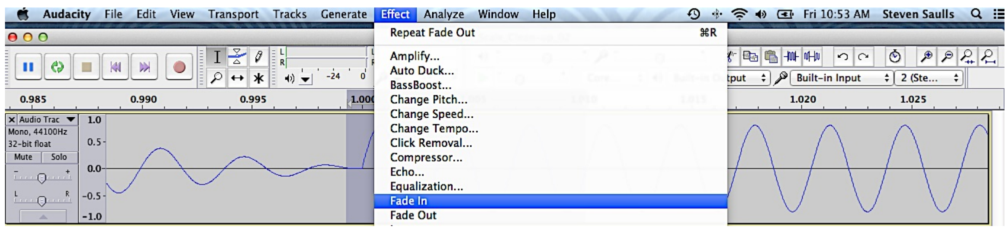
c) The amplitude of the waveform will be reduced to an inaudible level as it approaches the damaged area.



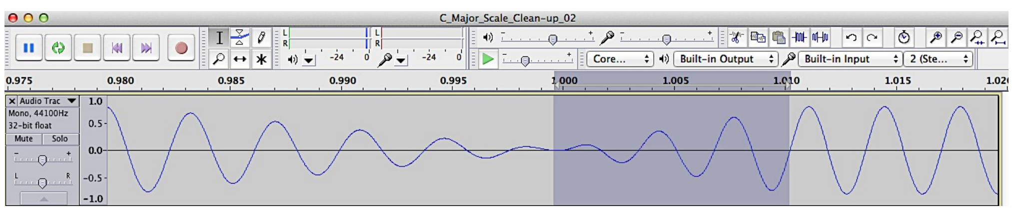
d) Select a few milliseconds (***ms***) after the damaged area of the wave cycle.



e) Select ***Effects/Fade In.***



f) The amplitude of the waveform will be increase from an inaudible level to an audible level as it leaves the damaged area.

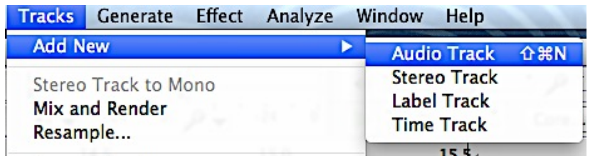


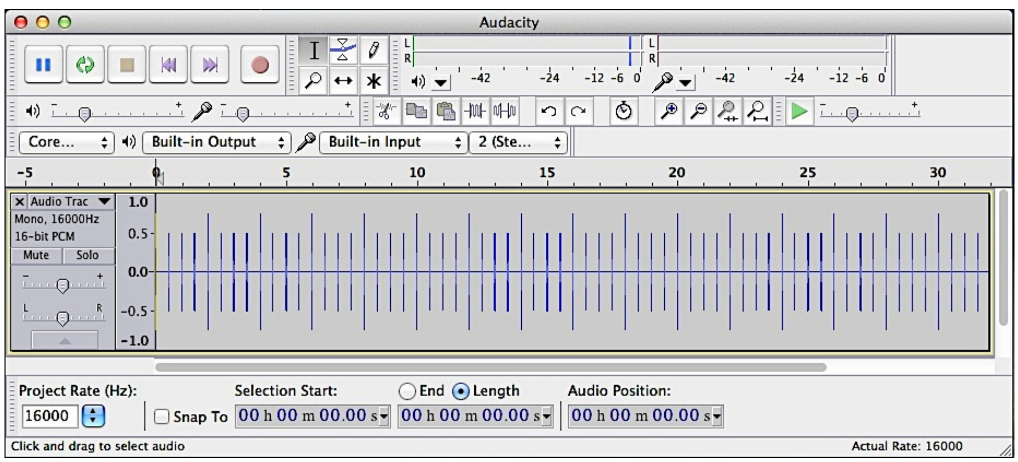
Creating a Melody with a Waveform

A ***melody*** is a linear succession of musical tones using a combination of the four properties of sound: pitch, intensity, duration, and timbre. It is often the foreground of any musical composition. Melodies are created using a variety of pitches and durations with distinct patterns called ***rhythm.*** Rhythm is the temporal organization in which patterns of long and short durations of sound are used to create motion and energy within a musical composition. In this next exercise, we will create a short melody using the various wave-editing tools available in our wav editor.

Before creating a melody using waveforms, we must assure an even alignment of all the pitches to a steady ***beat*** and ***tempo***. A ***beat*** is a regular, recurring pulse that divides a period of time within the music. ***Tempo*** is the rate of speed at which one beat progresses to another within one minute. Creating a ***click track*** will provide an even, steady beat and tempo against which we may align the pitches of the melody. By aligning the pitches of the melody with the beat or fraction of a beat, your various durations (rhythm) of pitch will have a sense of balance and evenness. The alignment process will first occur when the pitches are generated. Use the ***Time Shift Tool*** for finer adjustment and alignment of an audio region.

- To generate a ***Click Track,*** click on ***Tracks/Add New/Audio Track*** and then ***Generate/Click Track/OK***).



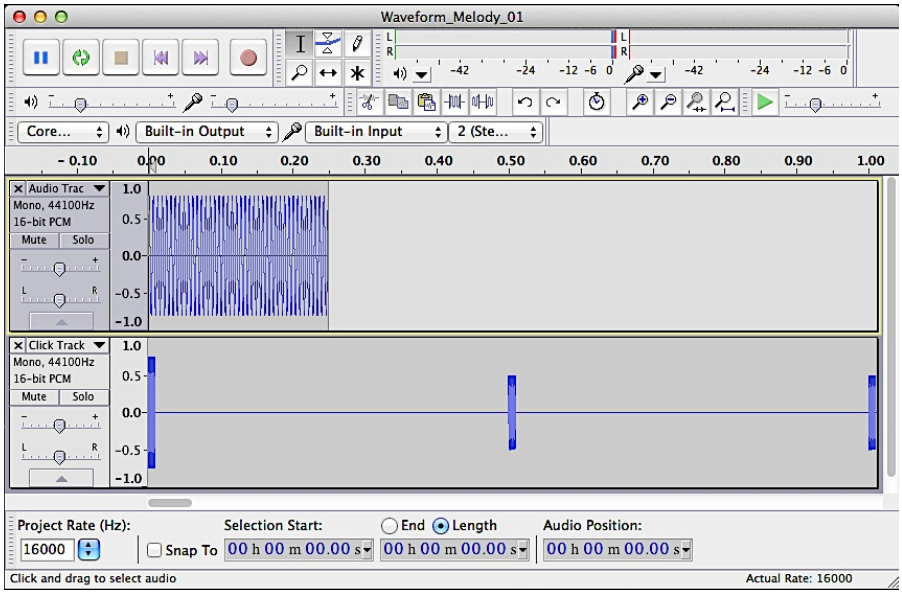


- To preview the click track, click on the ***Skip to Start*** button on the ***Transport Controls.***
- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***

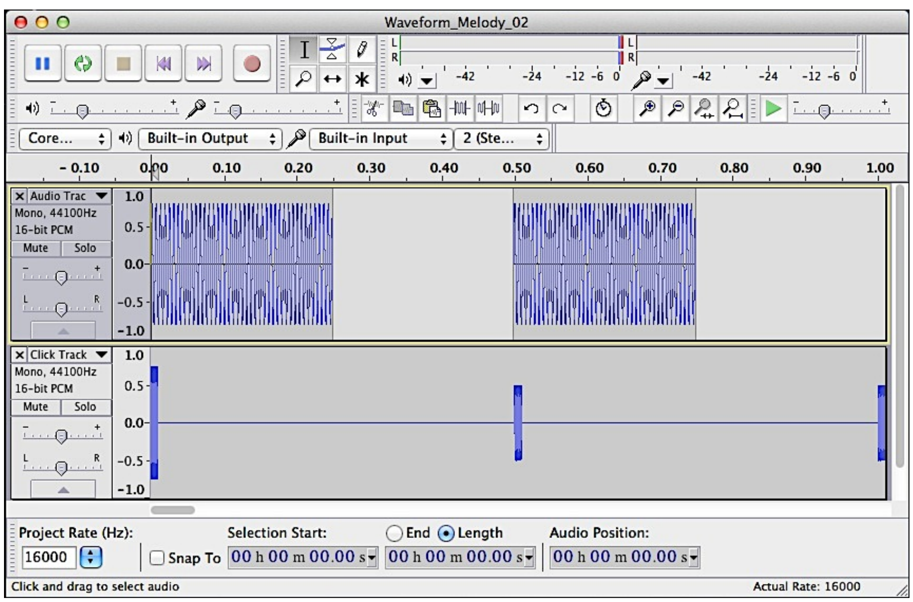
To create a melody using a wave editor, generate various combinations of contrasting pitches using the ***Table of Frequencies Chart.*** To create rhythm, use a variety of long and short durations ranging from 4.00" - 0.25" wavelengths***.***

- The following is a step-by-step guide in creating a melody from a well-known children's song ***'Twinkle, Twinkle, Little Star'***:

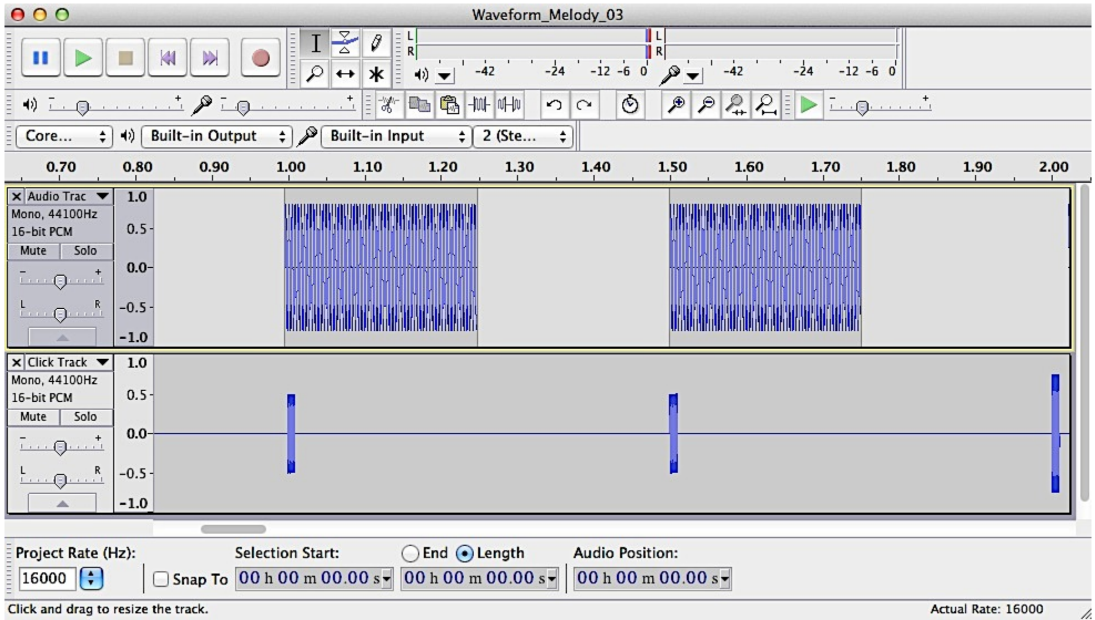
  1) Create a .25" ***Sine Wave*** on ***E_3 164.81.***



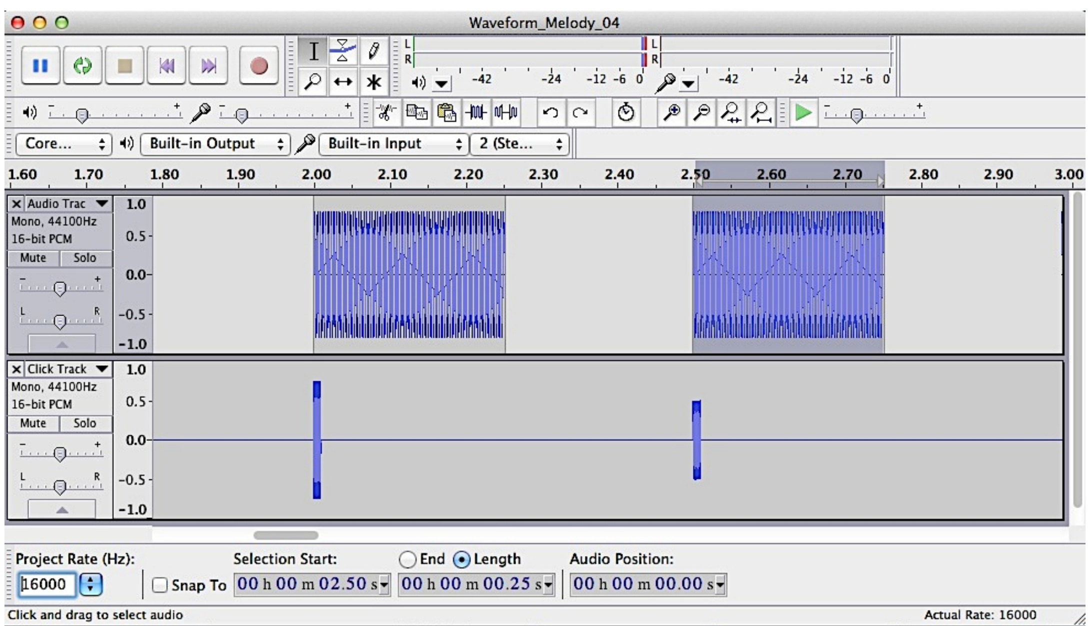
2) Select, copy, and paste this audio region at 0.50” along the timeline.



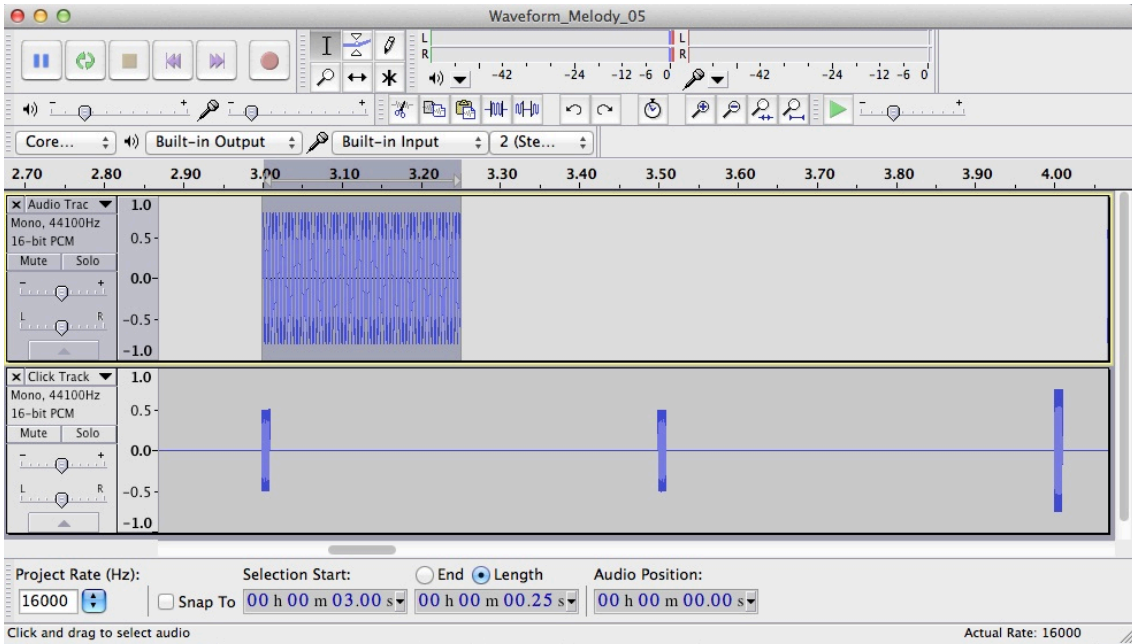
3) Create a .25” ***Sine Wave*** on ***B***$_3$ ***246.94*** at 1.00” along the timeline. Select, copy, and paste this new region at 1.50” along the timeline.



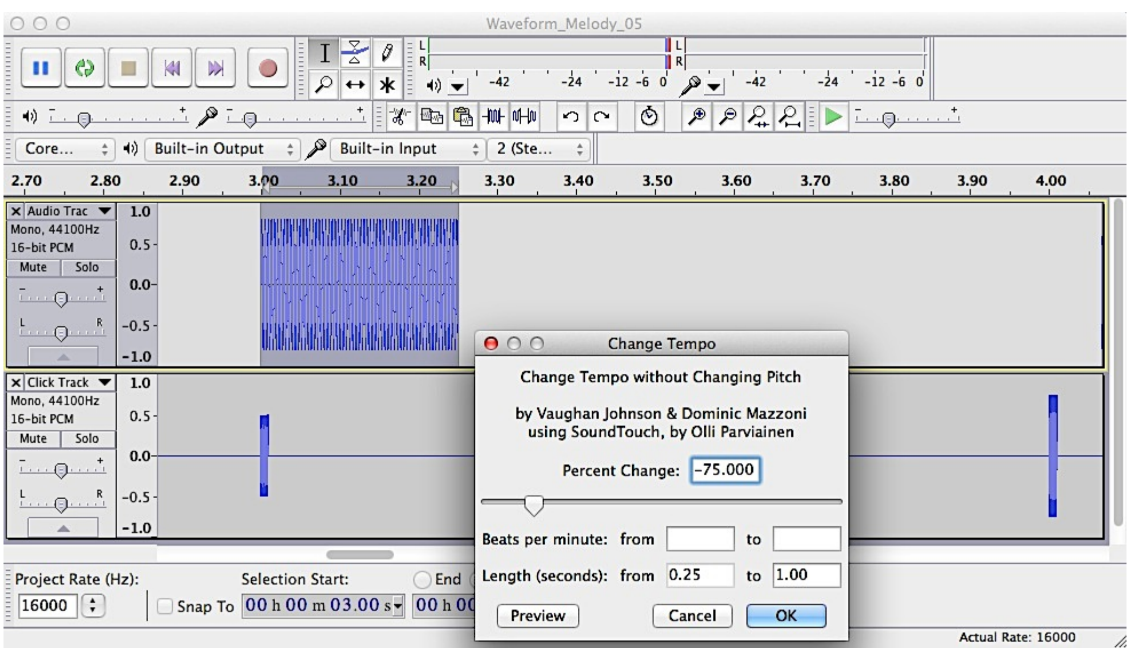
4) Create a .25” ***Sine Wave*** on ***C#$_3$ 277.18*** at 2.00” along the timeline. Select, copy, and paste this new region at 2.50” along the timeline.



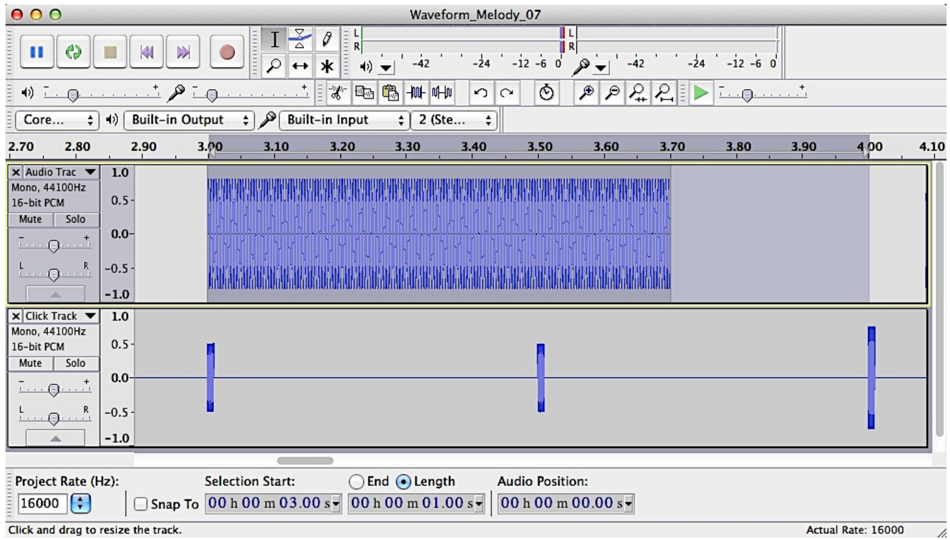
5) Select and copy the region at 1.50” to 3.00” along the timeline.



6) Lengthen the duration of this region by using the ***Change Tempo*** function under ***Effects***. We can increase the duration of the pitch by decreasing its tempo (i.e., its rate of beats per minute. Slow the tempo down by moving the ***Percent Change*** slider to ***-75.000***.

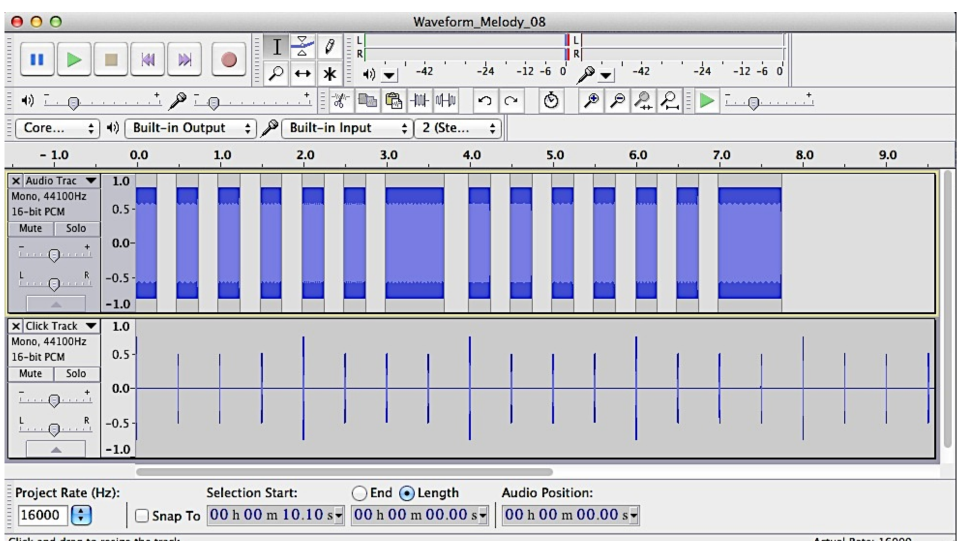


7) This will increase the audio region's duration.

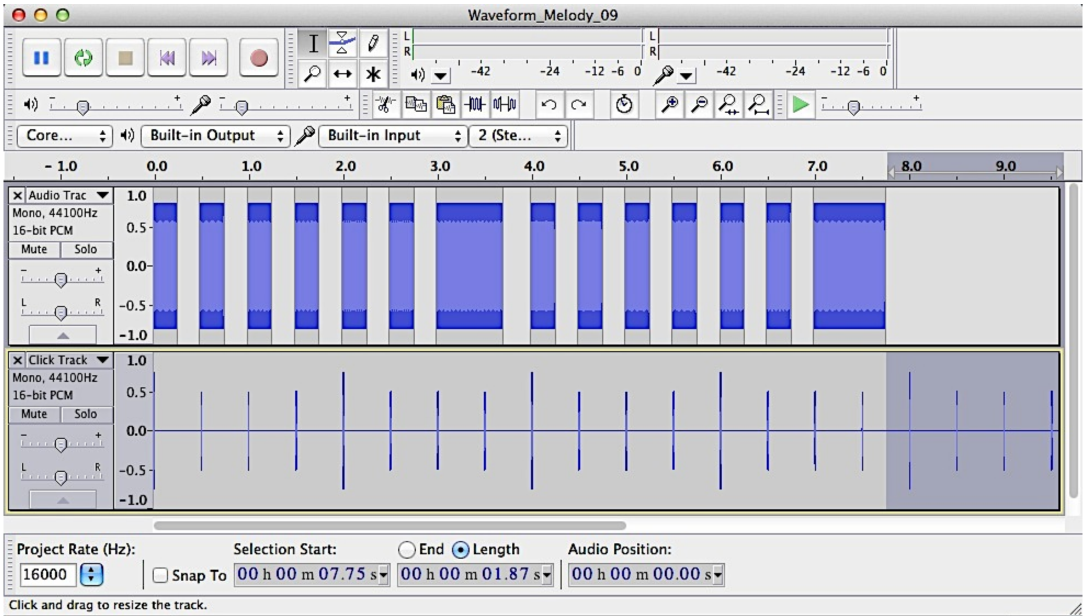


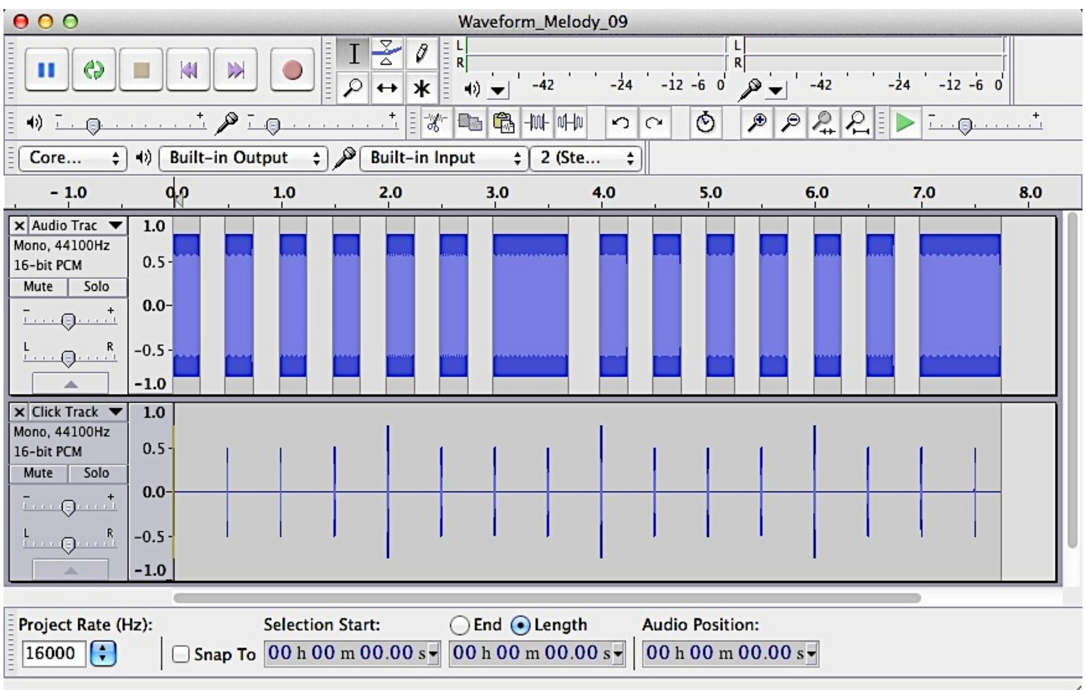
8) To finish the first part of the melody, complete the following steps:

* Create a .25" ***Sine Wave*** on ***A_3 220*** at 4.00" along the timeline.
* Select, copy, and paste this new region at 4.50" along the timeline.
* Create a .25" ***Sine Wave*** on ***$G\#_3$ 207.65*** at 5.00" along the timeline.
* Select, copy, and paste this new region at 5.50" along the timeline.
* Create a .25" ***Sine Wave*** on ***$F\#_3$ 185*** at 6.00" along the timeline.
* Select, copy, and paste this new region at 6.50" along the timeline.
* Create a .75" ***Sine Wave*** on ***$F\#_3$ 185*** at 7.00" along the timeline.



9) Click, select, and delete the click track from the end of the ***Audio Track's*** region.

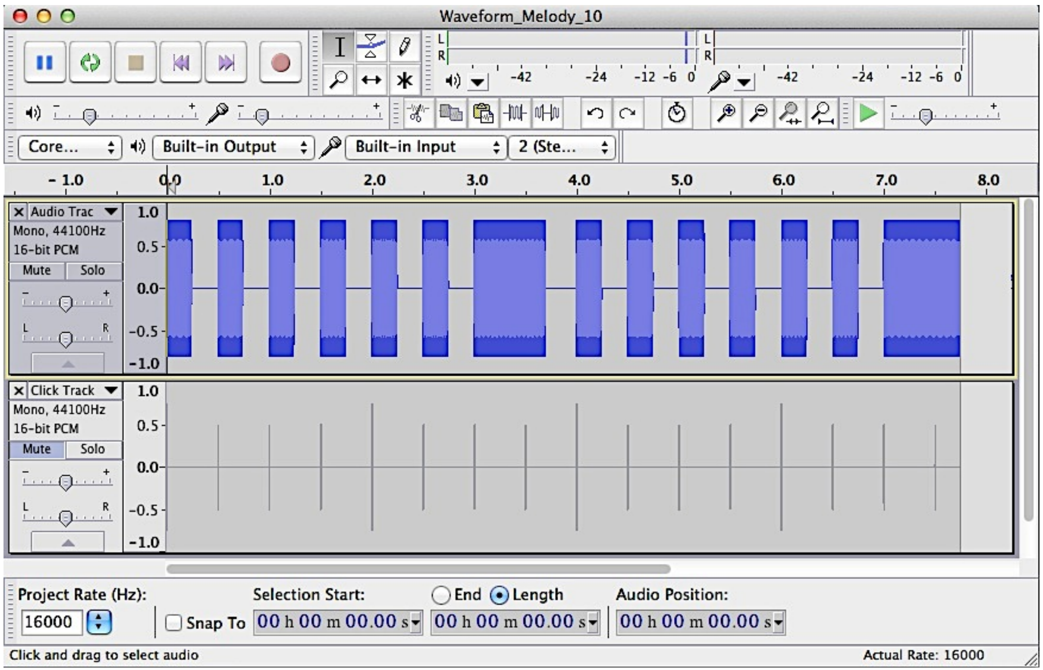




- Click on the ***Mute*** button located on the ***Click Track.***
- Click on the ***Skip to Start*** button on the ***Transport Controls.***
- Click on ***Play*** on the ***Transport Controls.***
- Click on ***Stop*** on the ***Transport Controls.***

As you play the melody, you will notice the many sonic artifacts. These artifacts need to be eliminated before you export the project into an audio file.

- ***Select All***, click on ***Edit>Clip Boundaries>Join***. This will join all of the audio regions together into one complete audio region. Then, use any one of the ***Sonic Artifact Removal Methods*** to 'clean up' the new audio region.



Ex. 20

Exporting Your Project to Digital Audio

The final rendering of an audio file is the last step in the audio production process. The terms ***export***, ***bounce***, and ***export as*** all mean that the final audio file is converted to a specific digital-audio file type to be listened to through any audio or media player. The following steps for exporting audio are for the ***Audacity*** wav editor. However, this basic process is relevant to all wav editors and ***DAWs*** (***Digital Audio Workstations***).

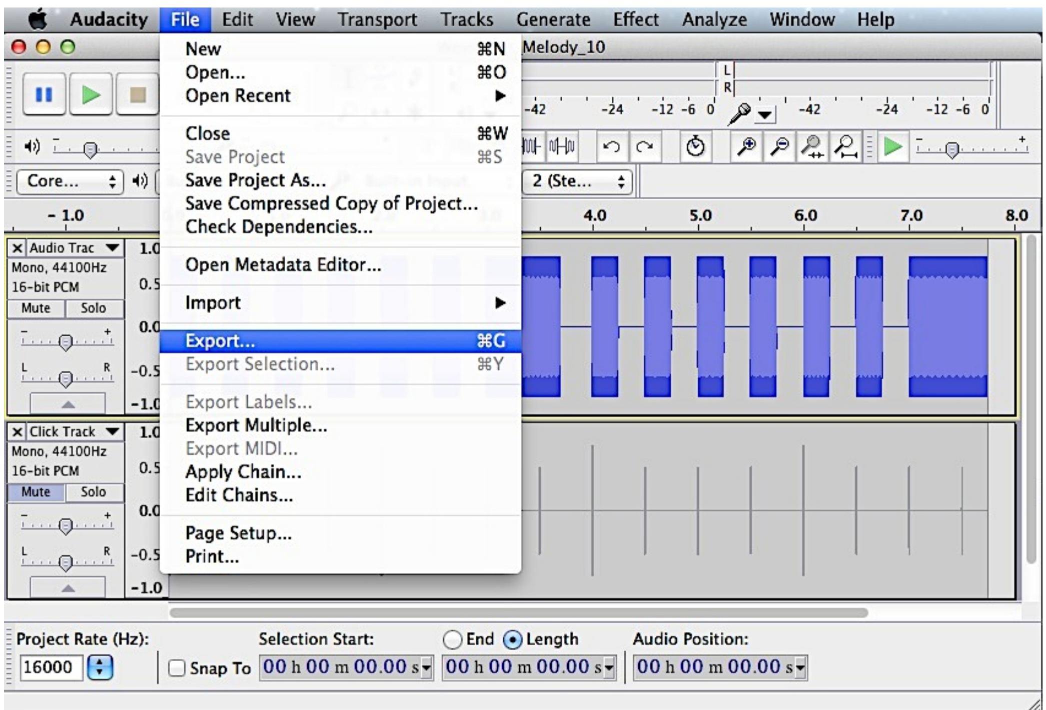
About Audio File Types…

There are a variety of file types to choose from depending on the usage of the final product. The two most common choices are the WAV files (***Waveform Audio File Format***) and MP3s (***Moving Picture Experts Group Layer-3 Audio***).

When exporting your final mix, you must consider the desired quality, the purpose, usage of the audio file, and the device on which the file is to be stored. Greater audio quality means a greater file size and the need for a larger storage space. So, you must make a choice between different sizes of sample rates (44.1 kHz or 48kH) and bit depths (16 bit or 24 bit) for your final WAV file exportation (use 44.1kHz and 16-bit for CD-quality).

Remember, ***bit depth*** is directly related to the audio's dynamic range resolution. The greater the bit depth, the more accurate the conversion of the wave form's amplitude. ***Sample rate*** is the number of audio 'snapshots' that are sampled every second. The continuous audio stream is digitally encoded many times per second. Therefore, the higher the sample rate, the more accurate frequencies can be represented.

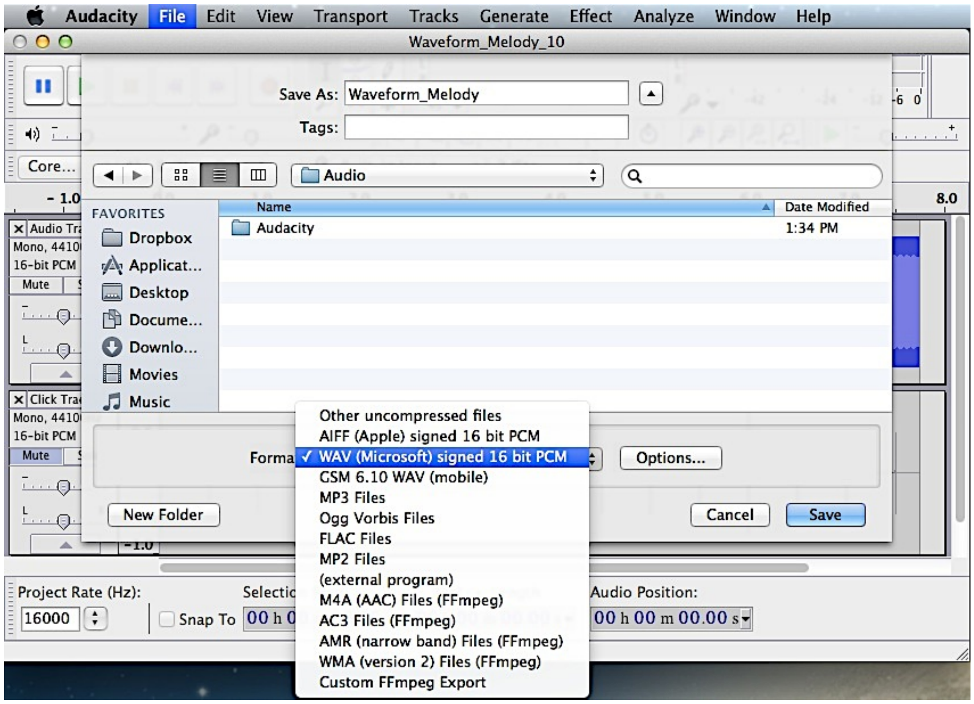
To begin the audio exportation process, click on ***File/Export***.



Choose your file type and destination (for example: ***WAV (Microsoft) signed 16bit PCM***).

Note: Many people use the MP3 file type for digital music because MP3s use smaller files sizes than those created using CD-quality audio WAV files. An MP3 takes up about 10% of the space of a CD-quality audio WAV file. MP3s achieve this space savings by compressing the data that makes up the file. This is accomplished by removing some of the redundant frequencies from the original audio.

However, because some data has been removed from the file, an MP3 doesn't sound identical to CD-quality audio.



Click ***OK*** in the ***Edit Metadata*** window.