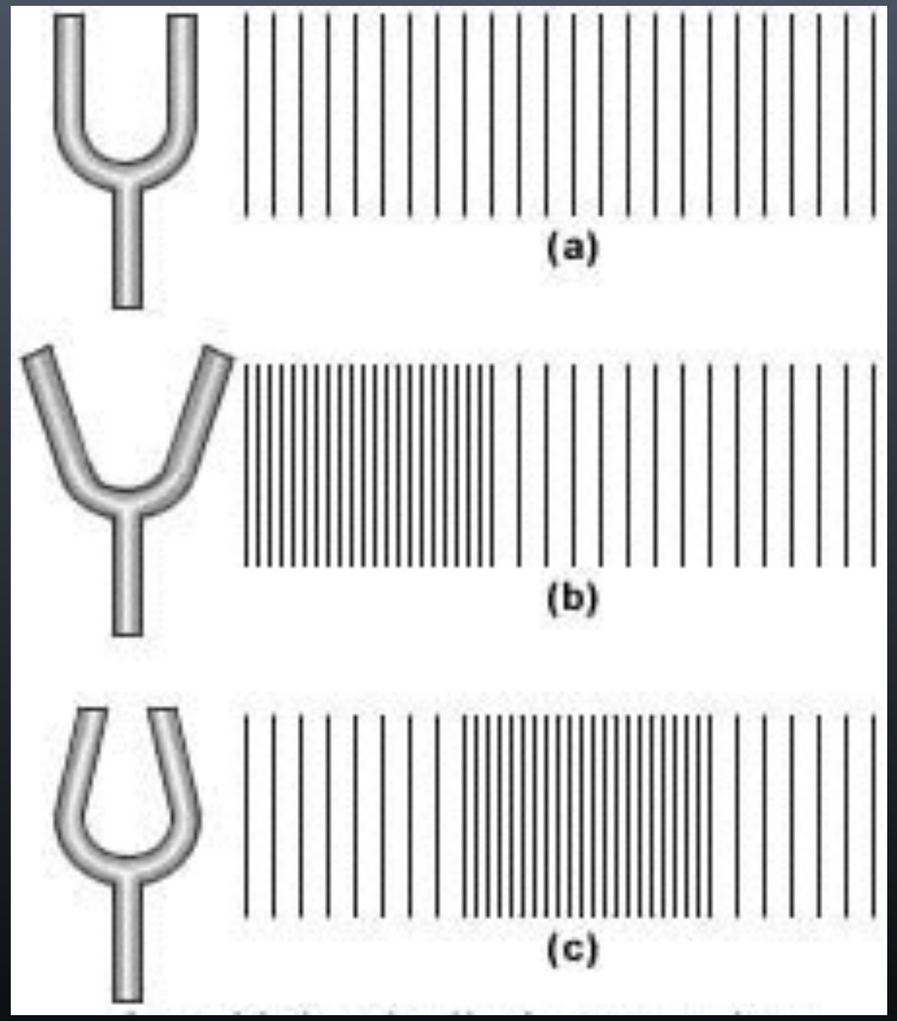
# Playing sound.

# How sound works.


(a)
(b)
(c)

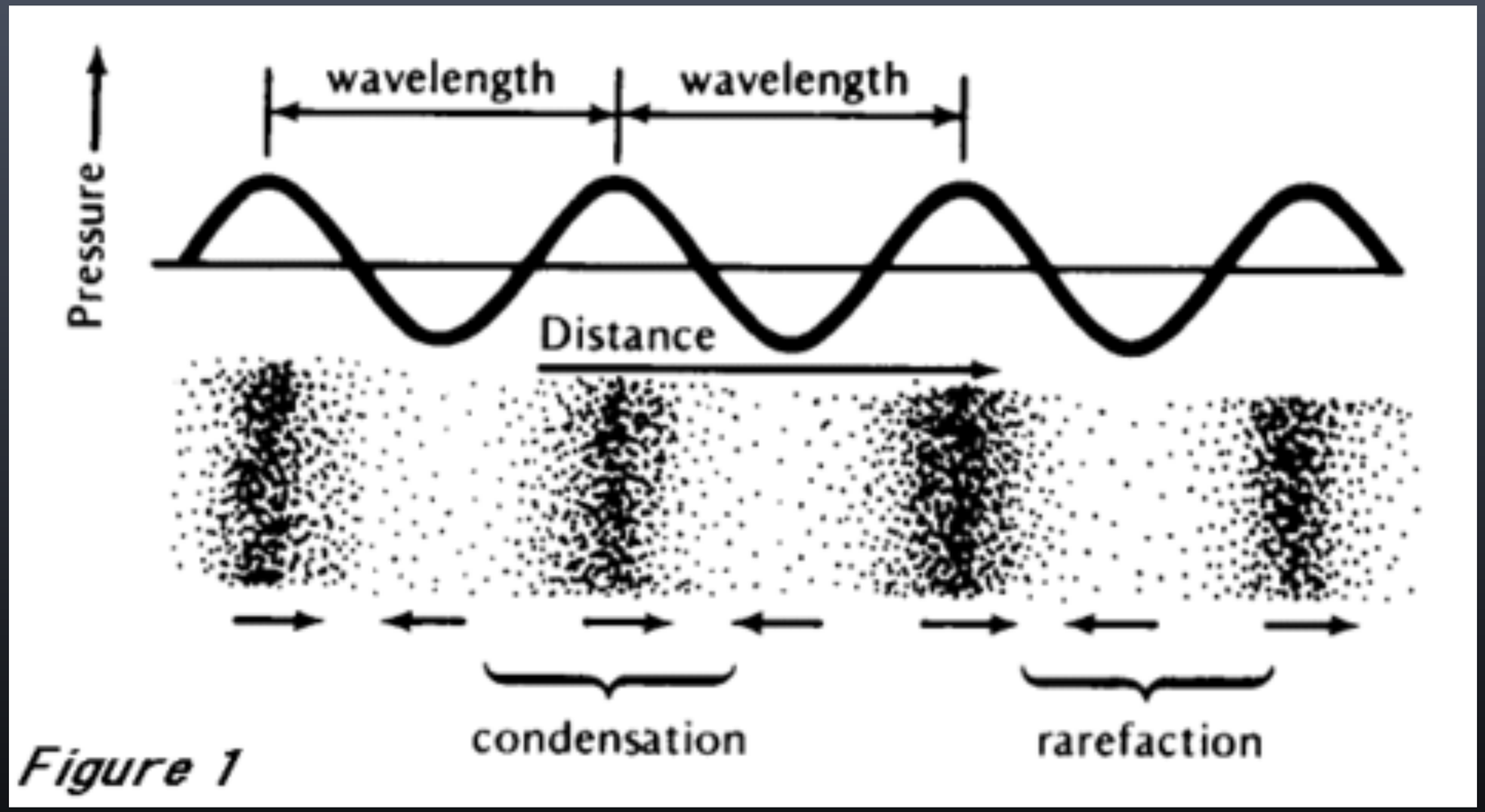
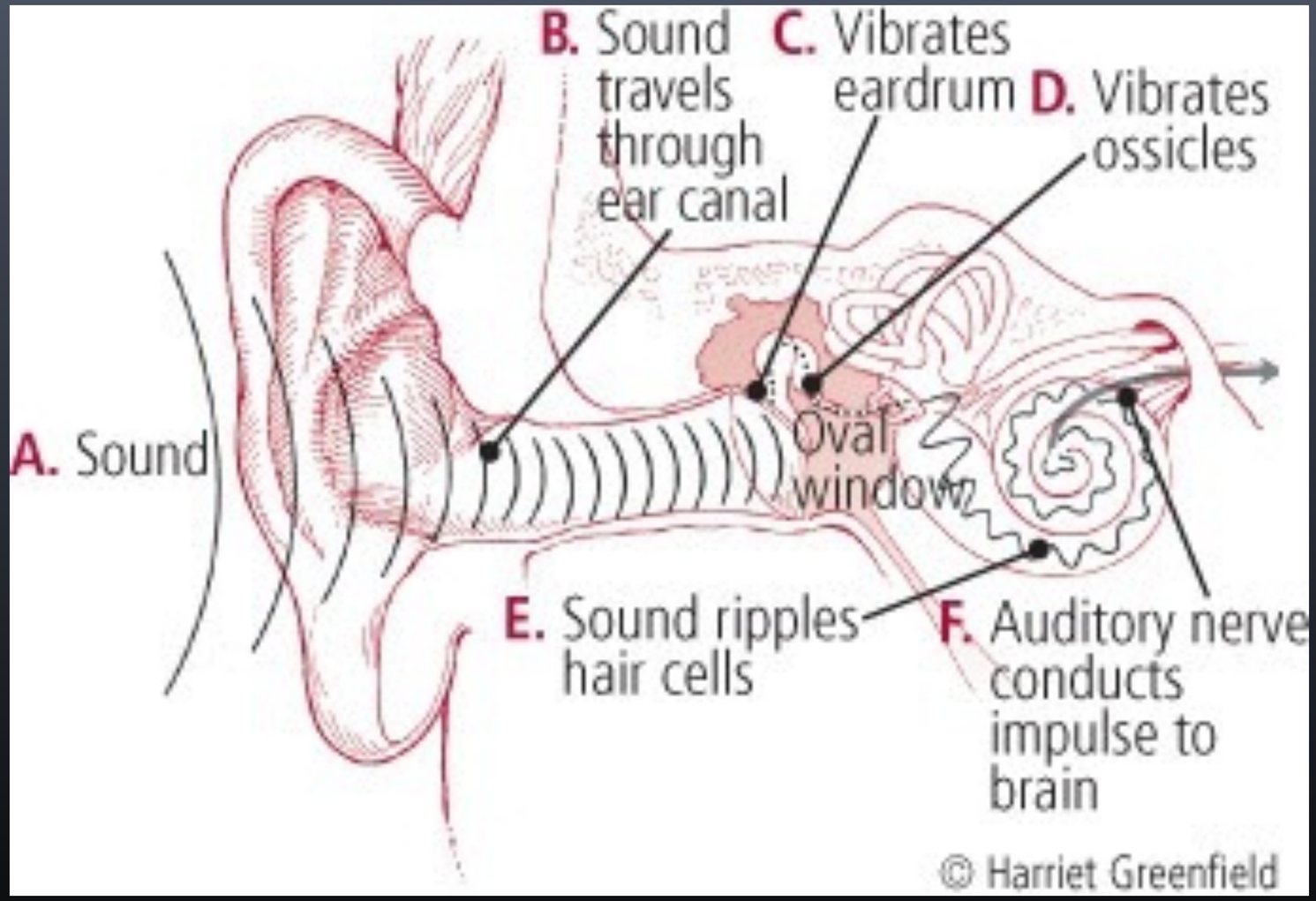
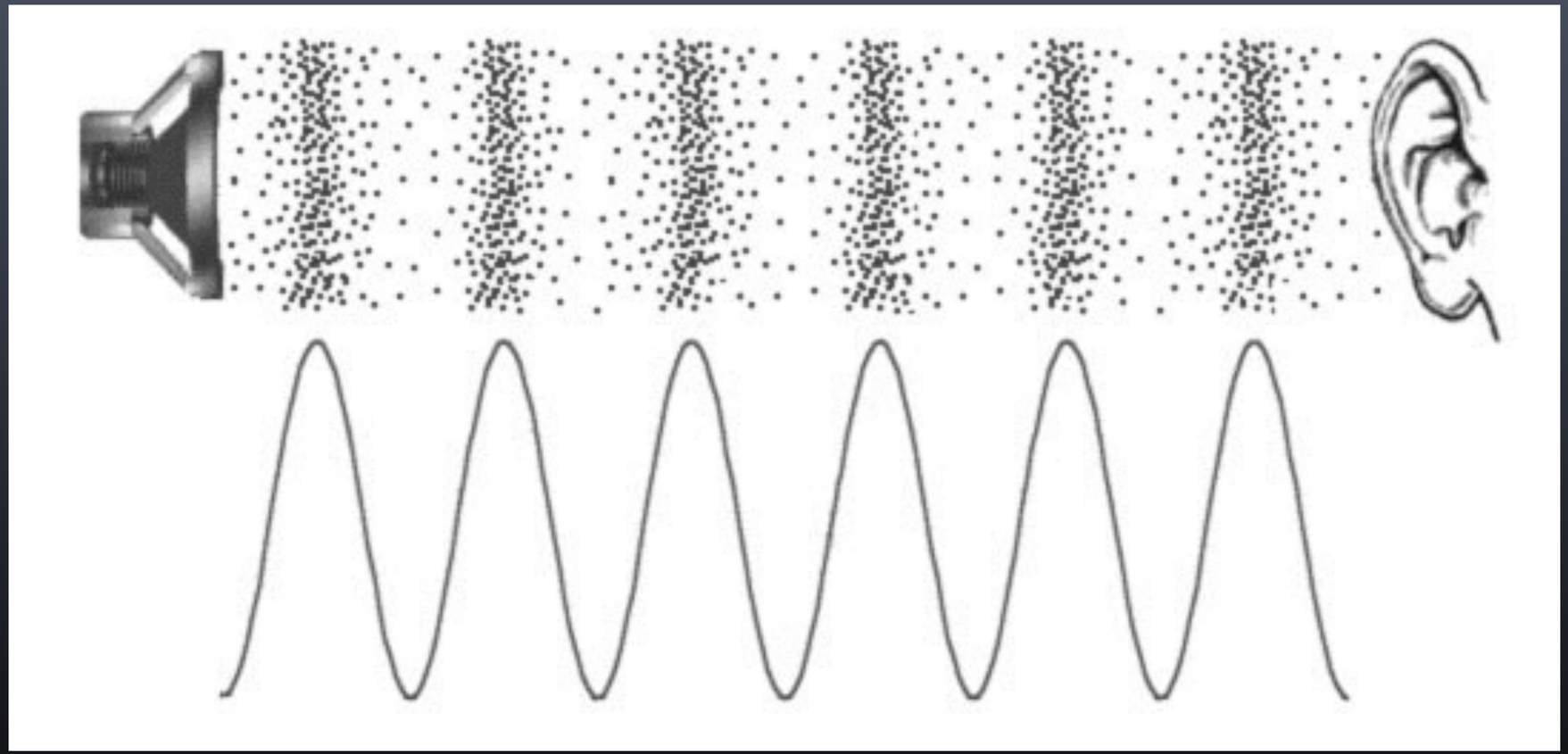
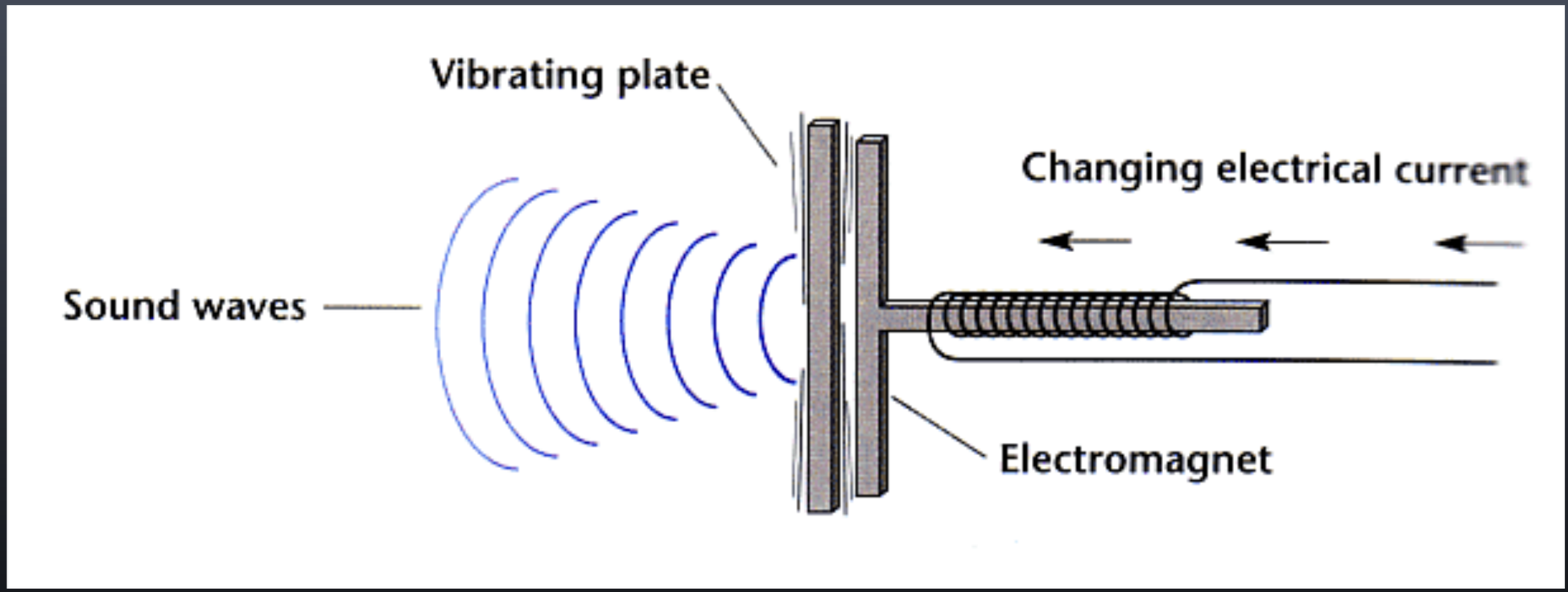

wavelength
wavelength
Pressure
Distance
condensation
rarefaction

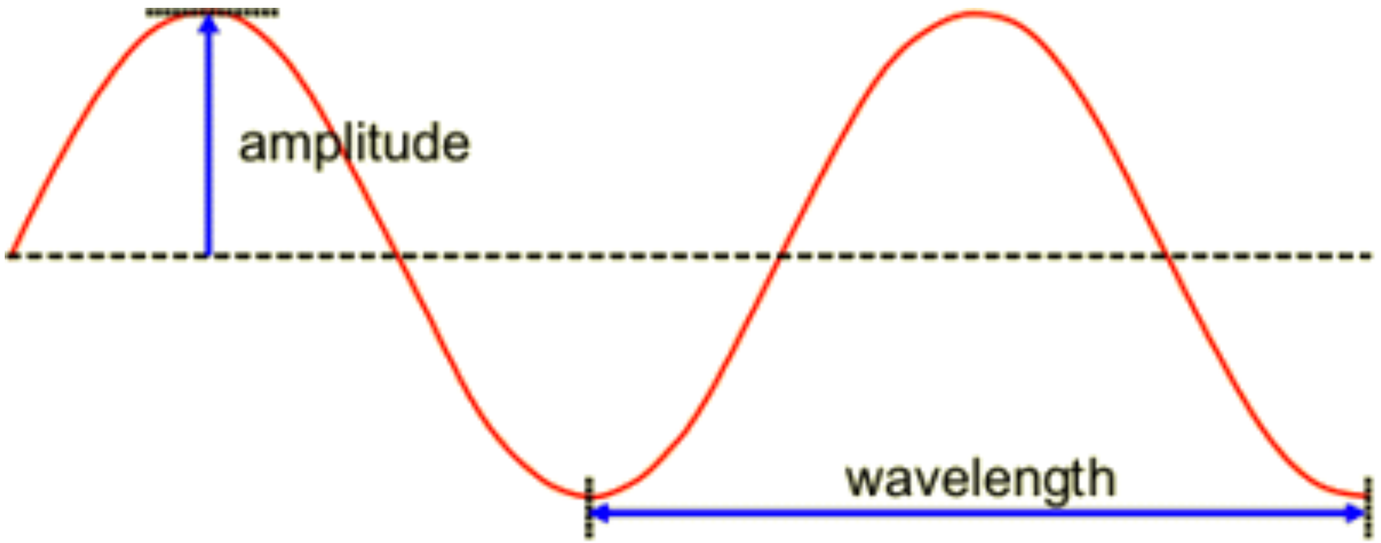
*Figure 1*

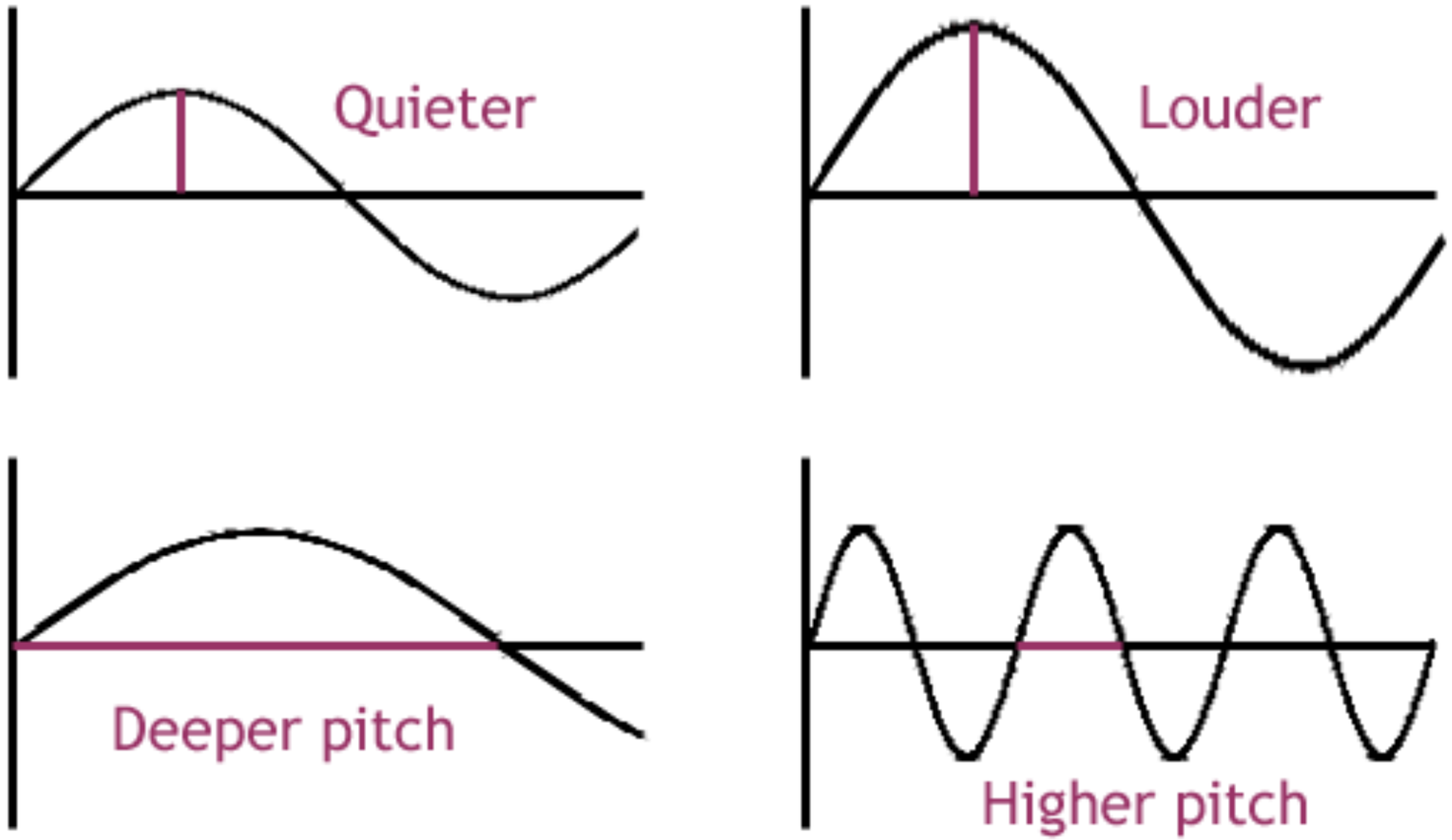

B. Sound travels through ear canal
C. Vibrates eardrum
D. Vibrates ossicles
A. Sound
Oval window
E. Sound ripples hair cells
F. Auditory nerve conducts impulse to brain
© Harriet Greenfield




Vibrating plate
Changing electrical current
Sound waves
Electromagnet

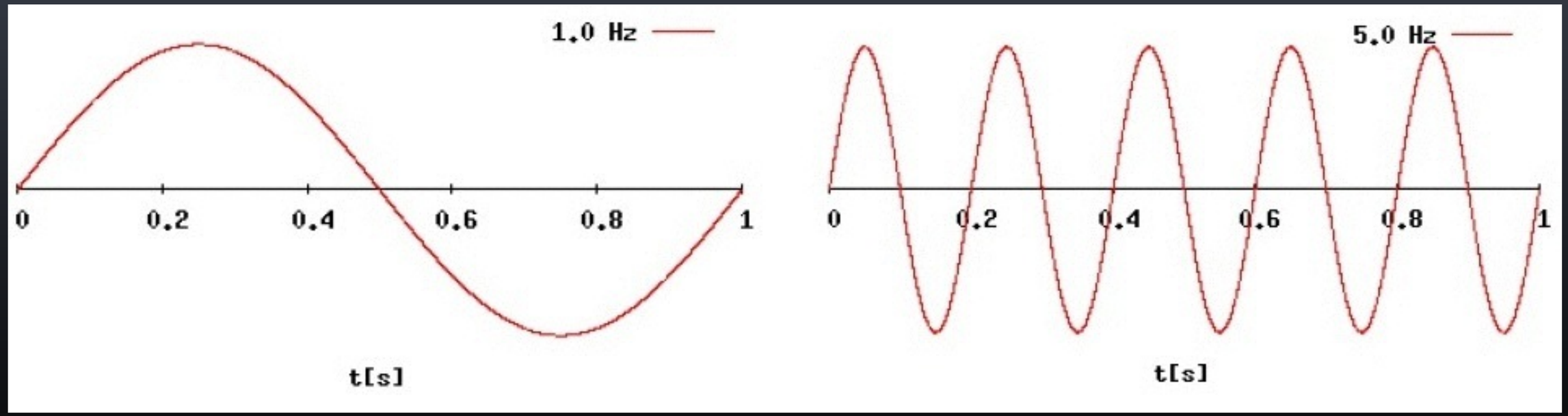
# Sound wave properties.


amplitude
wavelength

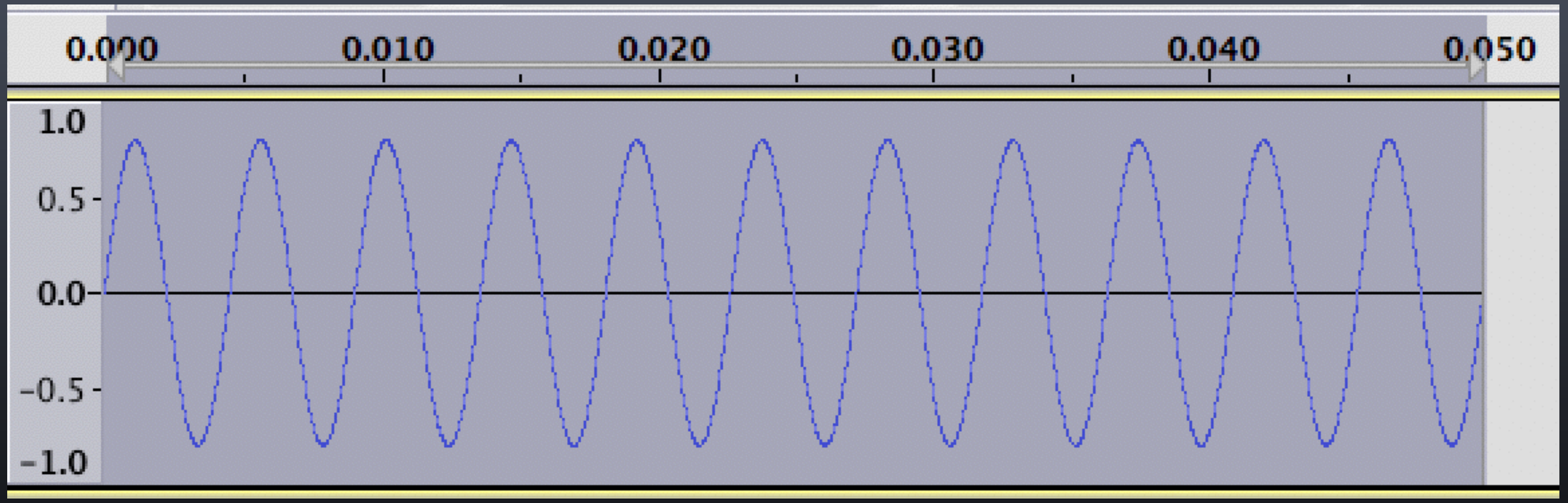


# Sound frequency.

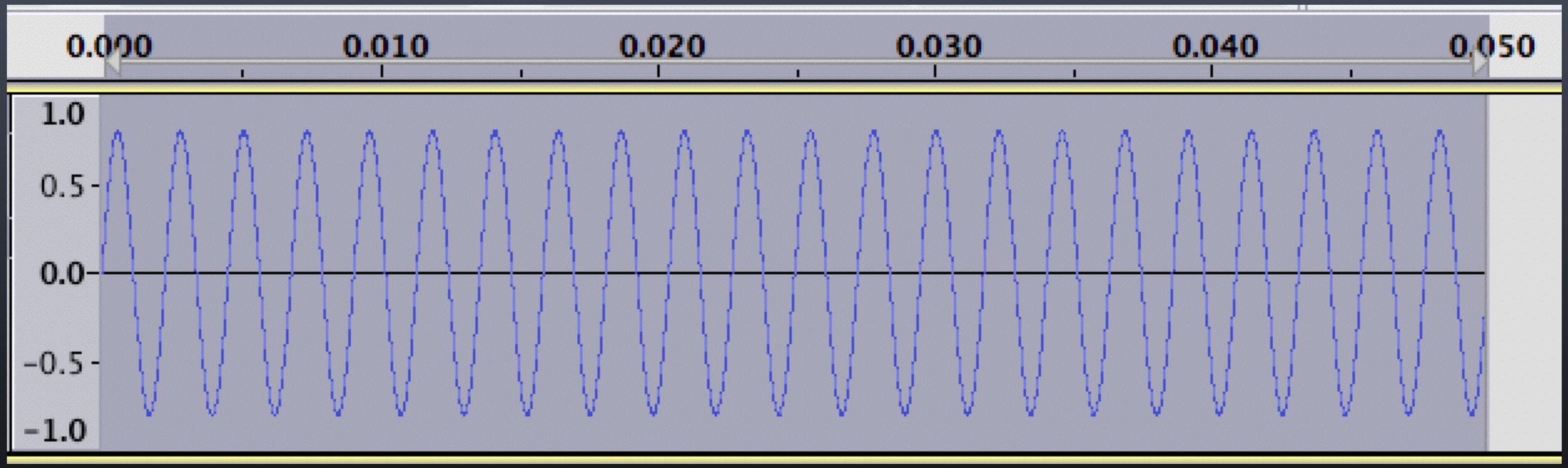
# hertz (Hz) = 1 cycle per second.



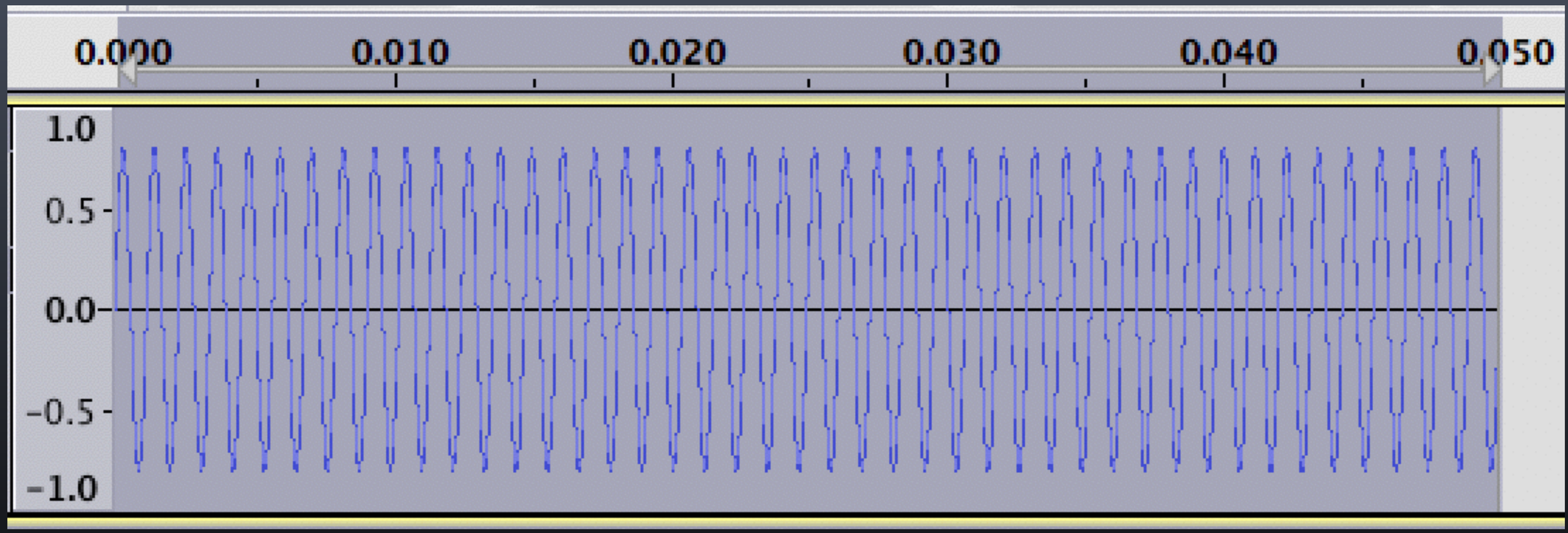
# 220 Hz



# 440 Hz

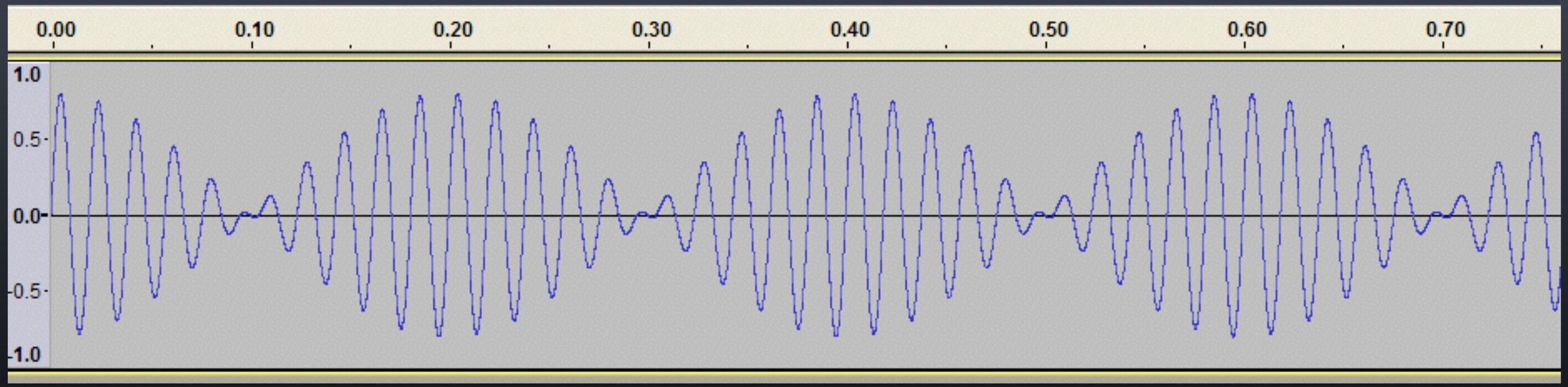


# 880 Hz

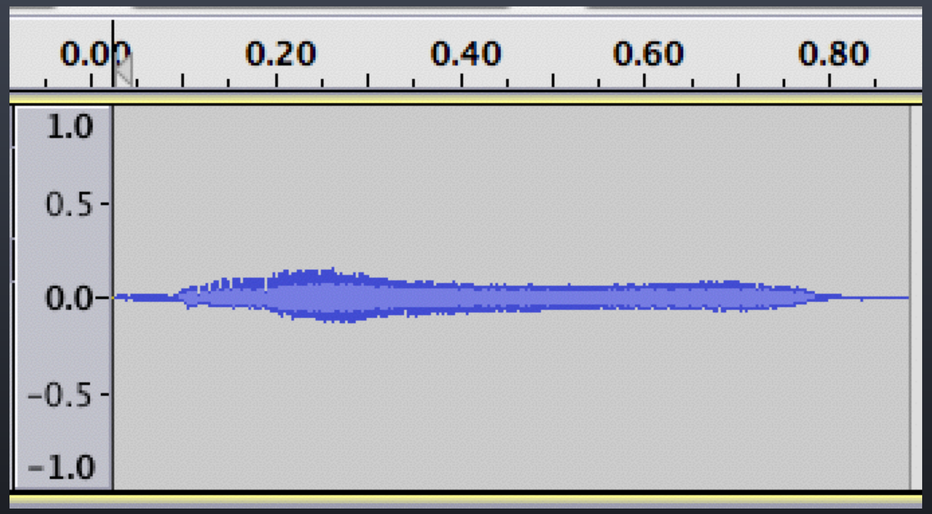


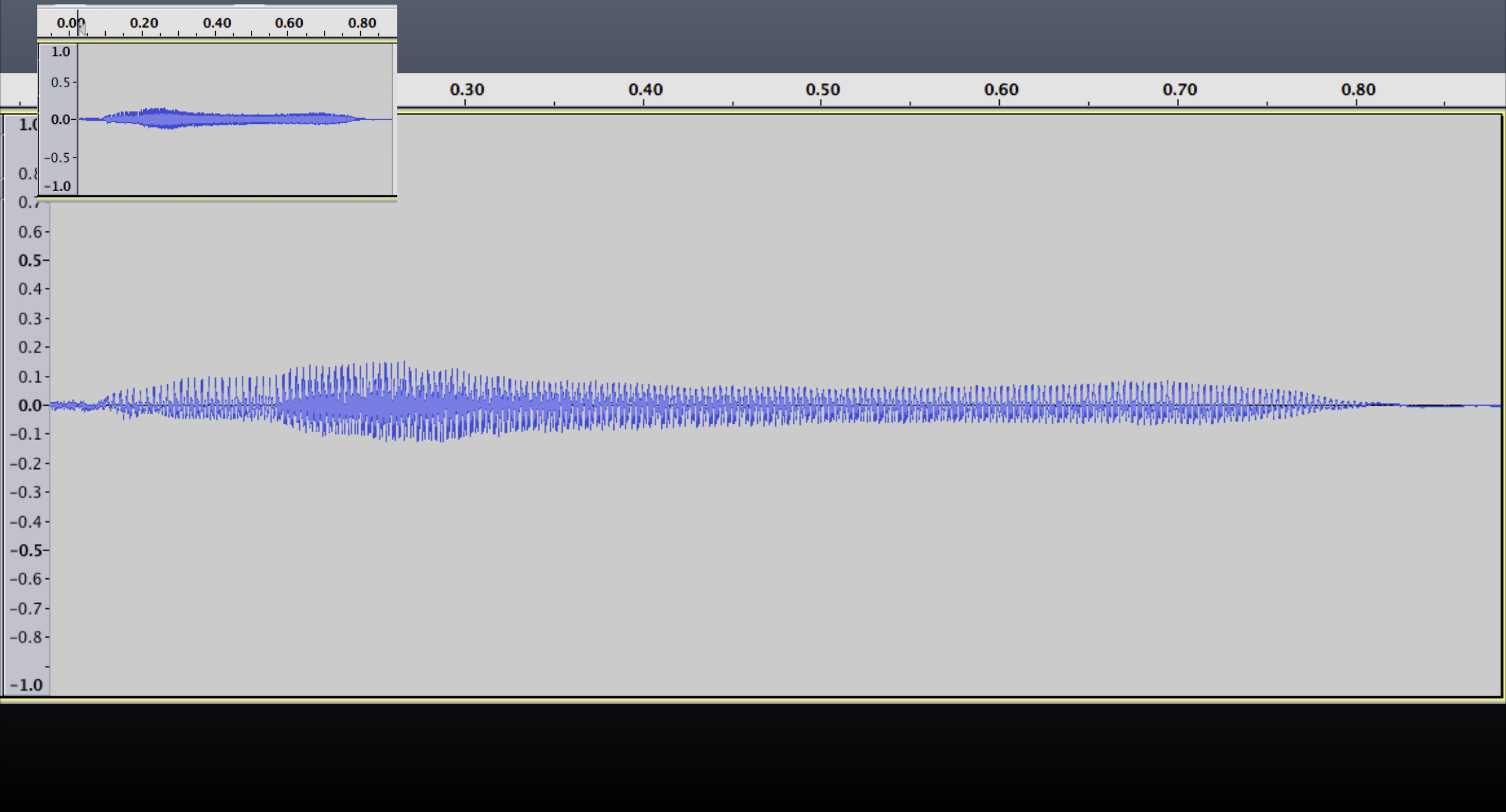
# Complex waveforms.

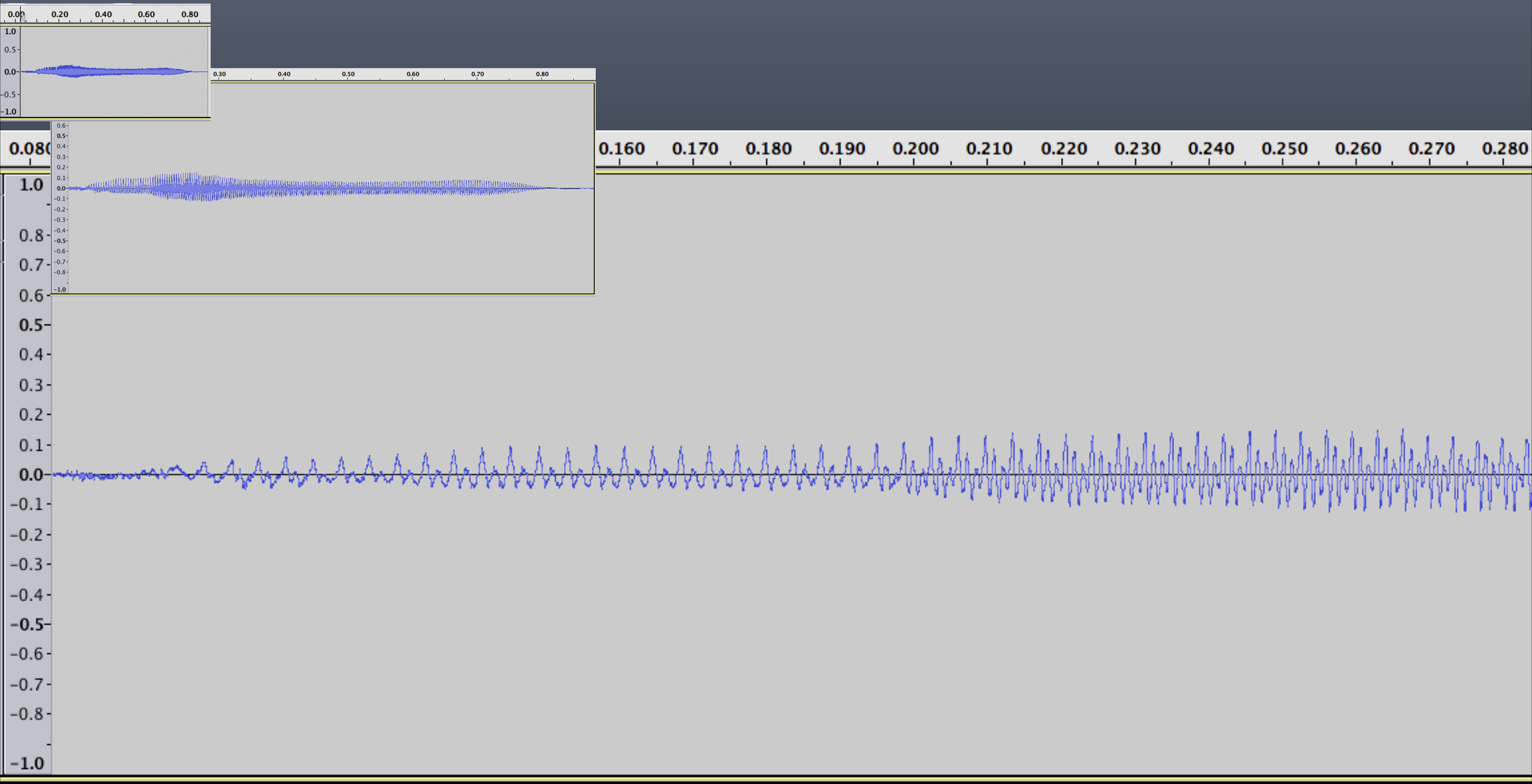
# Modulating frequency.

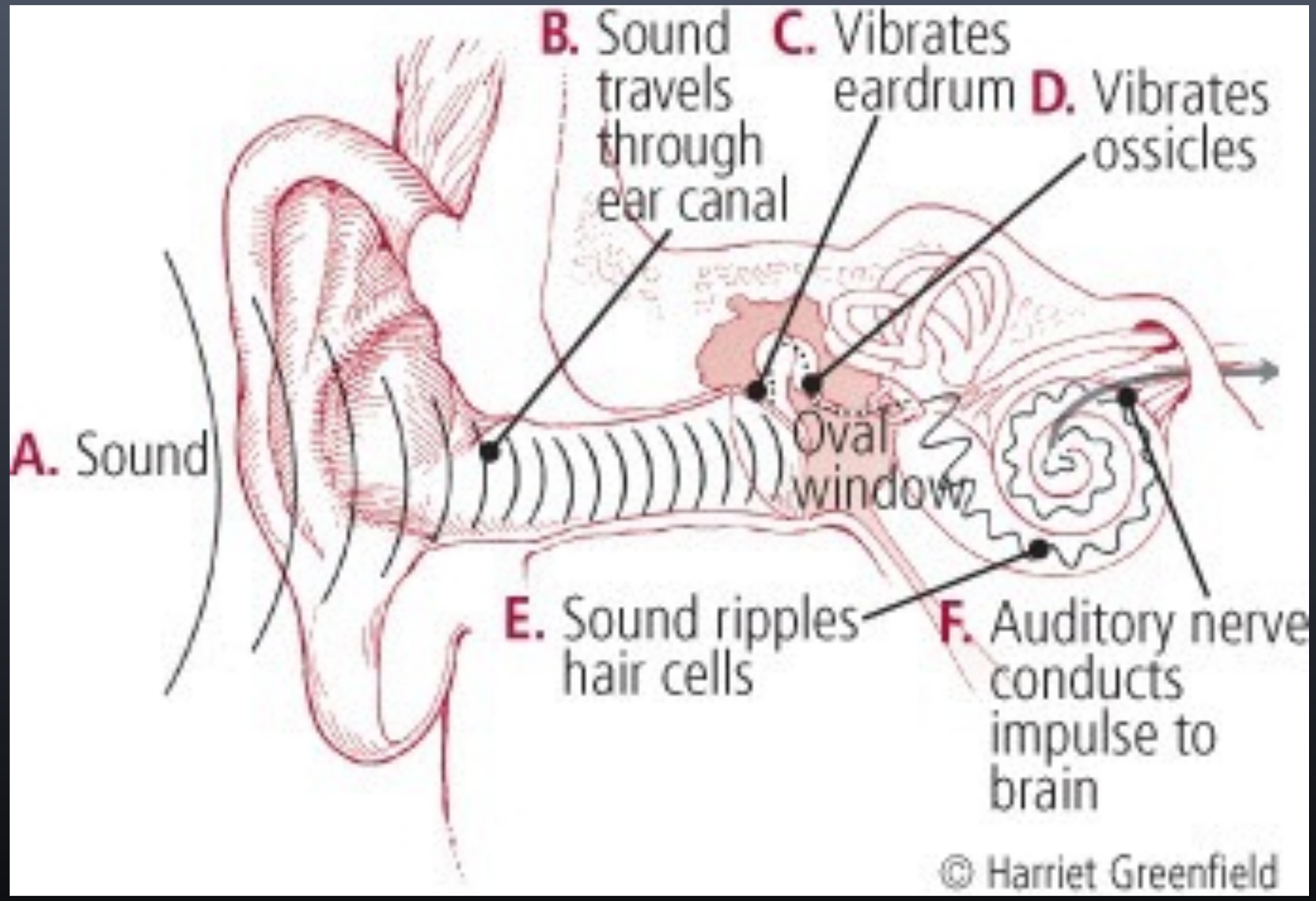


# “Hello”



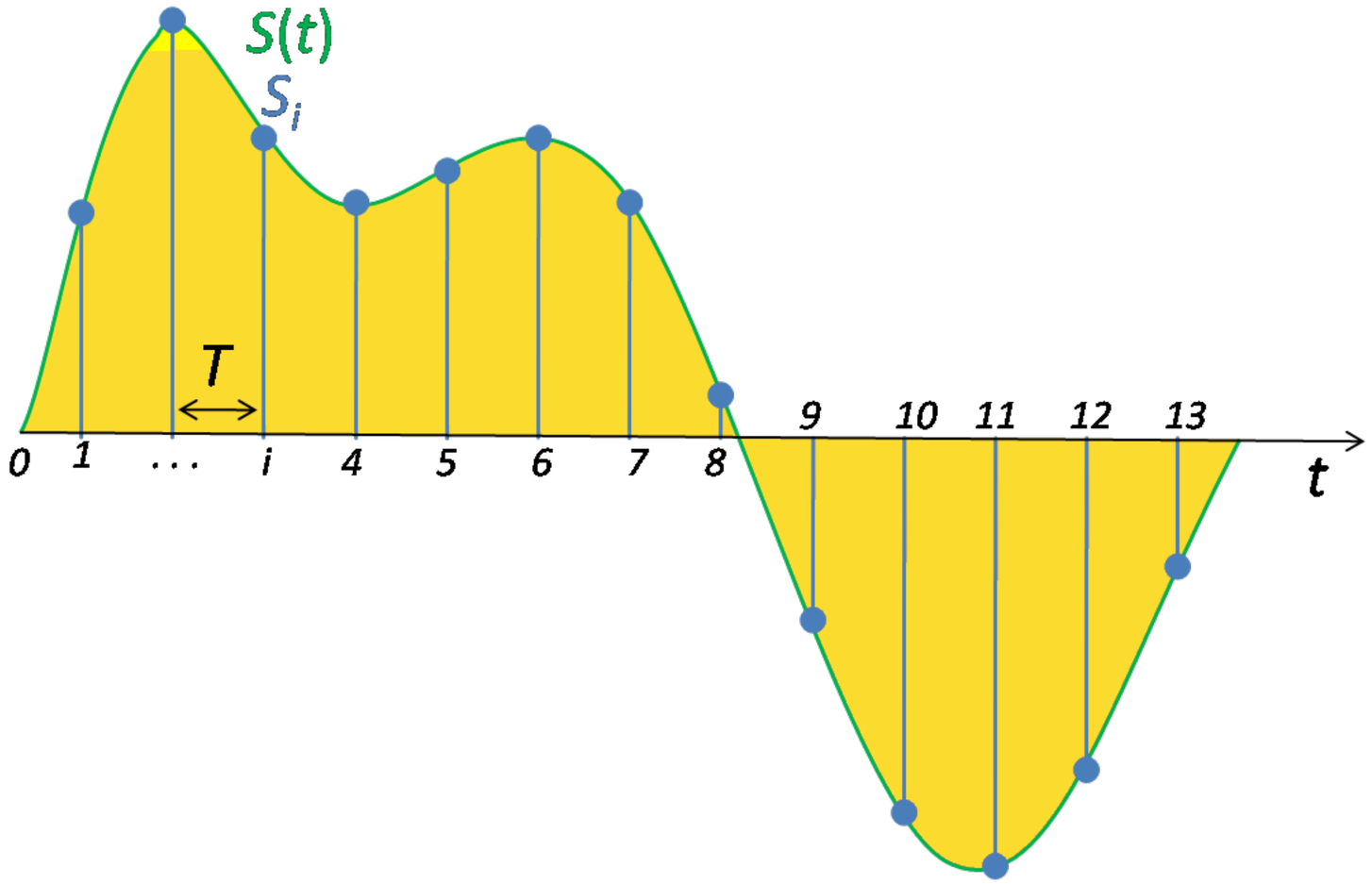

0.00
0.20
0.40
0.60
0.80
1.0
0.5
0.0
-0.5
-1.0
0.30
0.40
0.50
0.60
0.70
0.80
1.0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-1.0


0.00
0.20
0.40
0.60
0.80
1.0
0.5
0.0
-0.5
-1.0
0.30
0.40
0.50
0.60
0.70
0.80
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-1.0
0.080
0.160
0.170
0.180
0.190
0.200
0.210
0.220
0.230
0.240
0.250
0.260
0.270
0.280
1.0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-1.0


B. Sound travels through ear canal
C. Vibrates eardrum
D. Vibrates ossicles
A. Sound
Oval window
E. Sound ripples hair cells
F. Auditory nerve conducts impulse to brain
© Harriet Greenfield

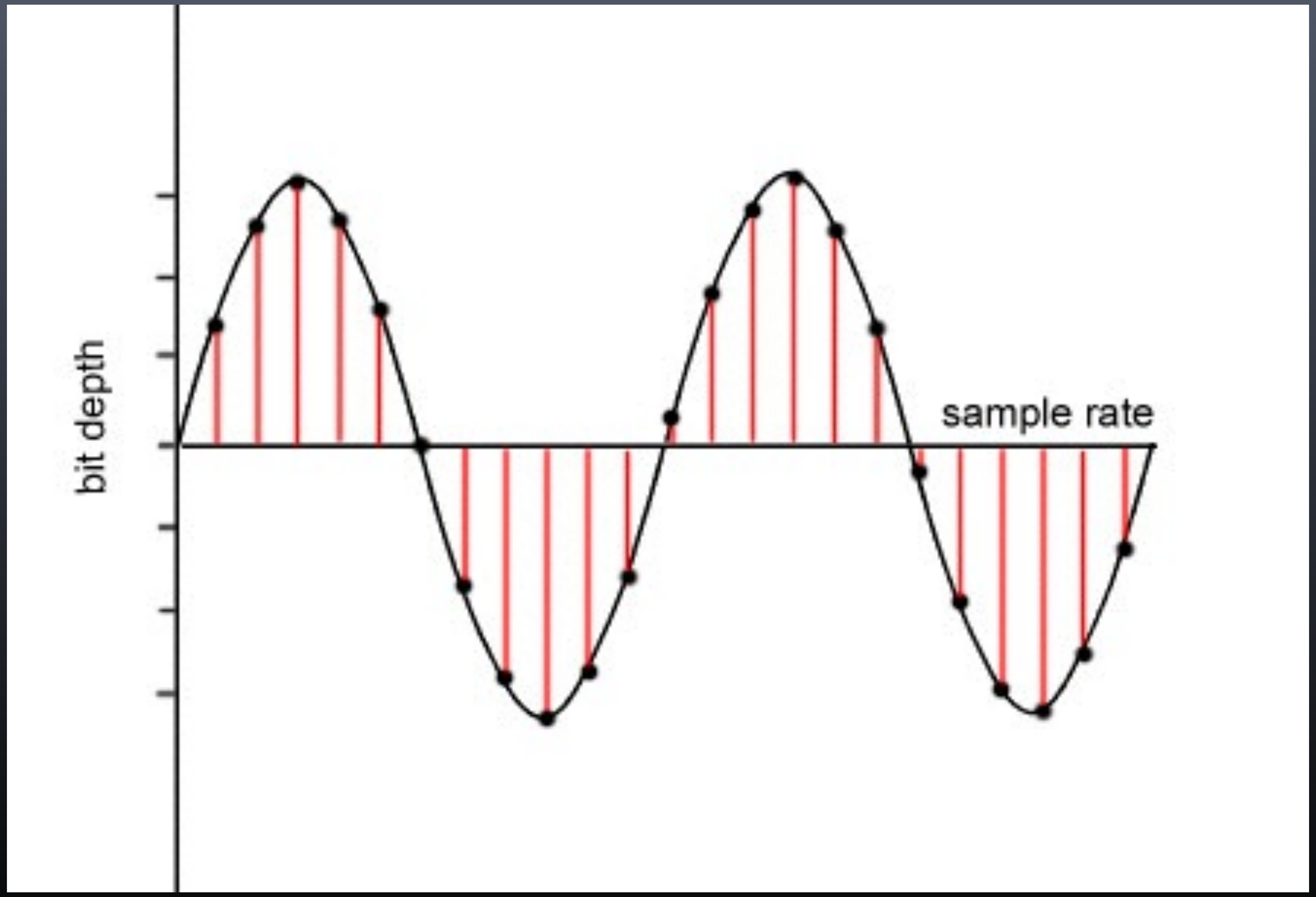
# How digital sound works.

# Digital sampling.


S(t)
$S_i$
T
0
1
. . .
i
4
5
6
7
8
9
10
11
12
13
t

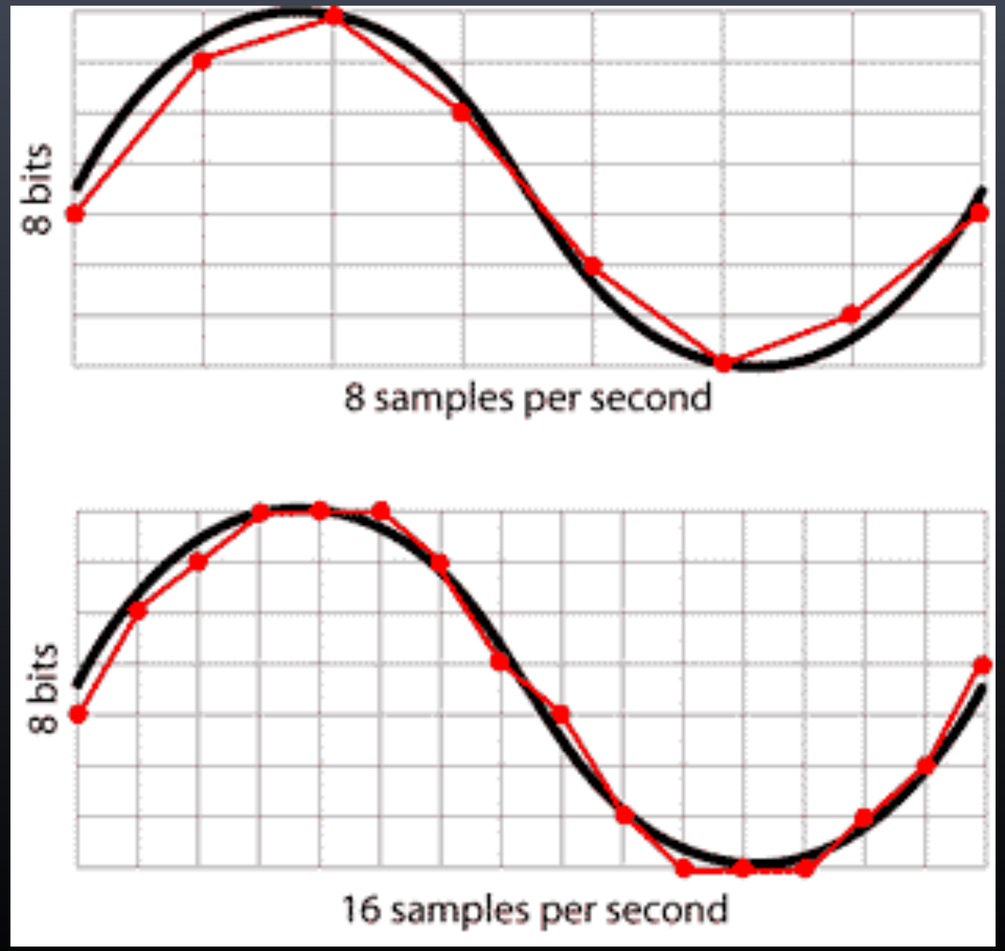
# Sampling quality.

Sample rate and bits per sample.


bit depth
sample rate

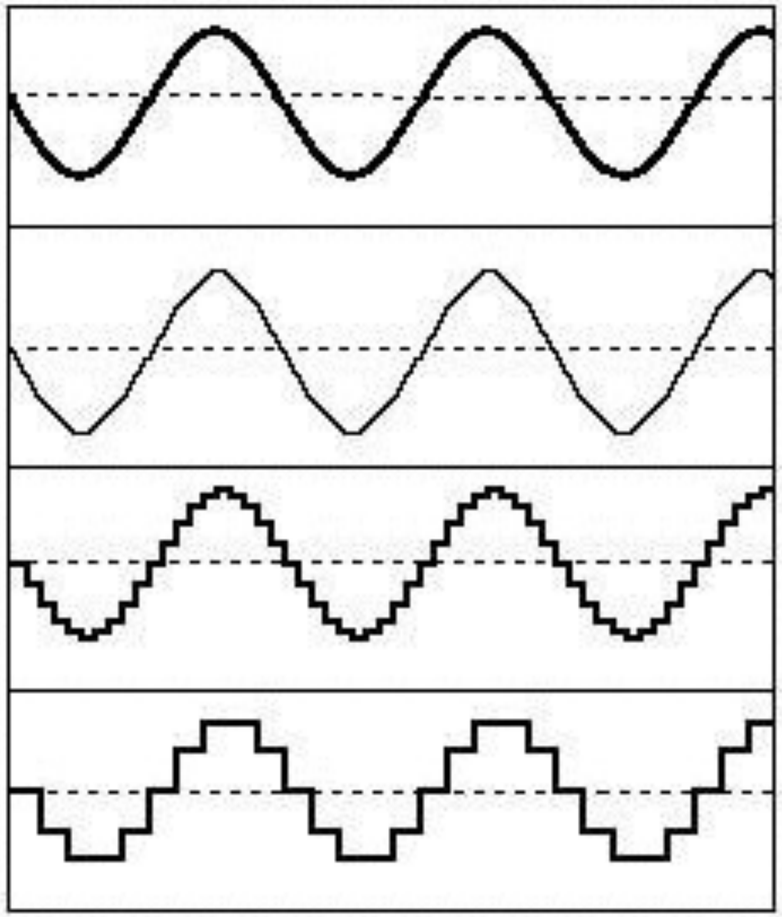
# Sample rate.

# How many discrete samples each second (measured in Hz).



Bits per sample.

**Sound quality and bits.**



Audio waveform

Waveform sampled at 22 bits.

Wavefrom sampled at 16 bits.

Waveform sampled at 8 bits.

# Bitrate.

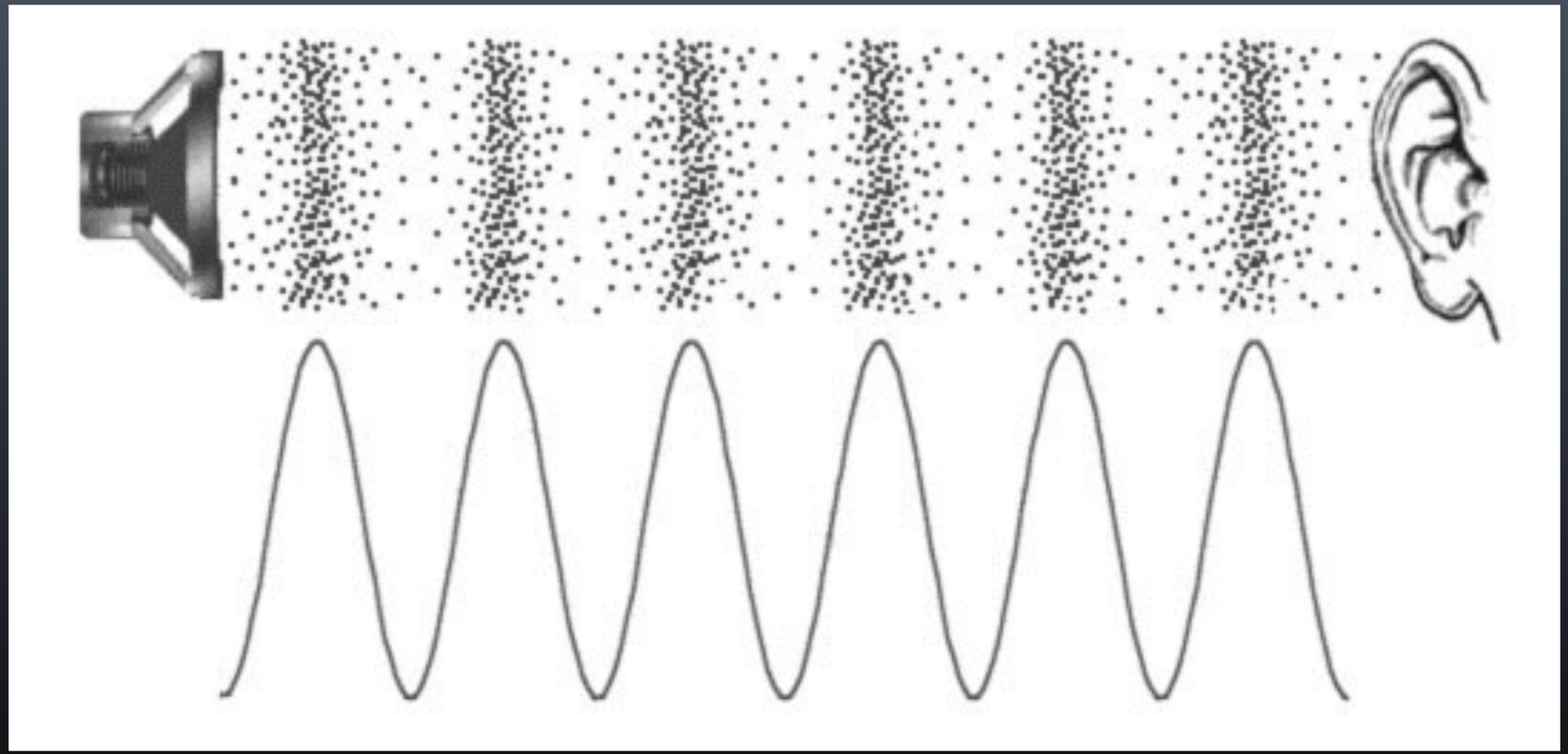
# Bitrate.

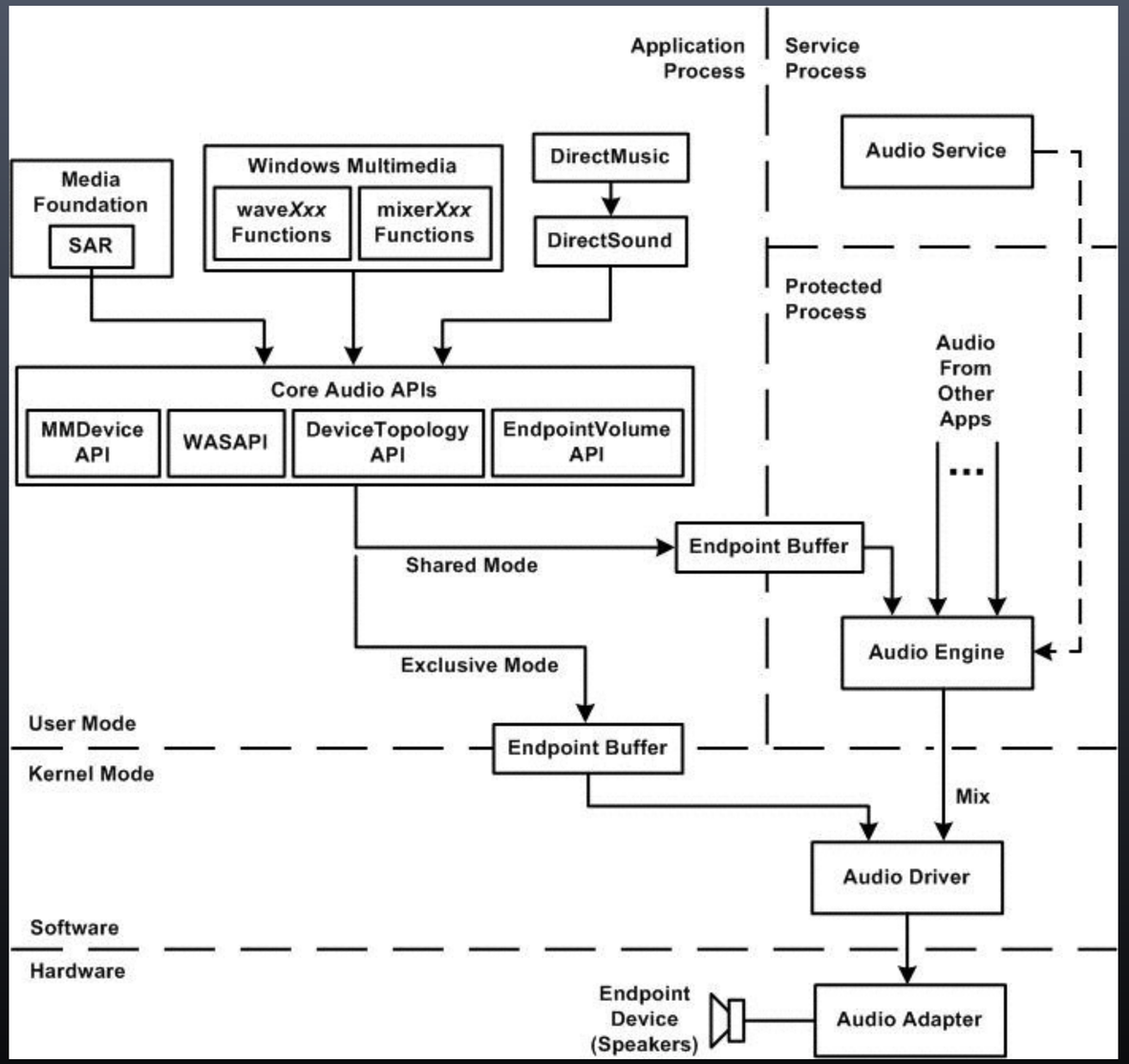
Sampling rate combined with bit depth.

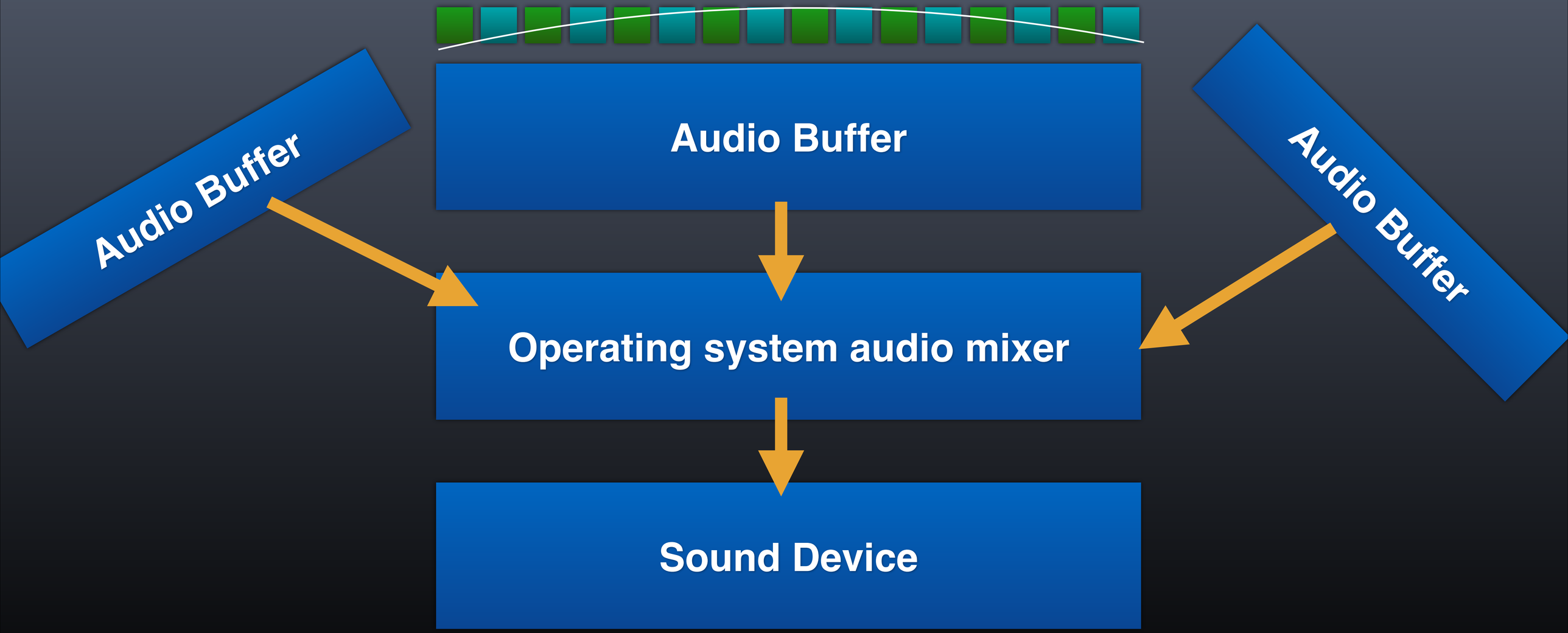
Reflects the total bit count processed per second.

Measured in bits per second or bit/s (or bps)

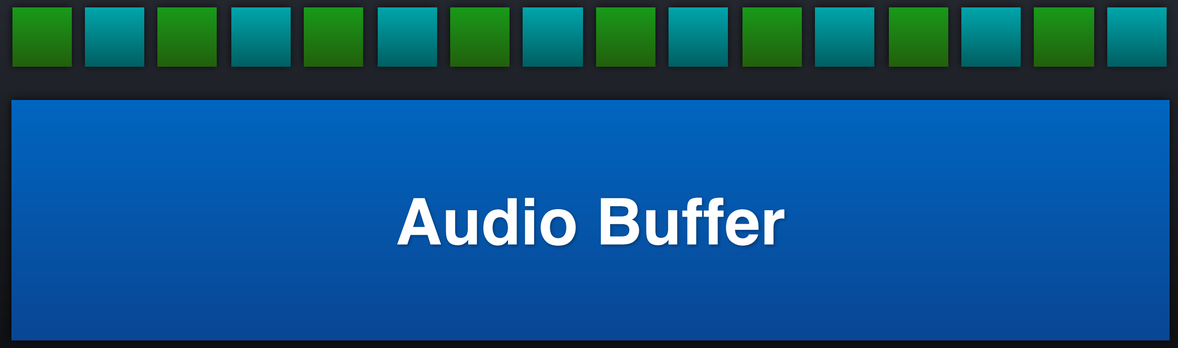
# Playing digital audio.




Application Process
Service Process
Audio Service
DirectMusic
Windows Multimedia
waveXxx Functions
mixerXxx Functions
Media Foundation
SAR
DirectSound
Protected Process
Audio From Other Apps
...
Core Audio APIs
MMDevice API
WASAPI
DeviceTopology API
EndpointVolume API
Endpoint Buffer
Shared Mode
Audio Engine
Exclusive Mode
User Mode
Endpoint Buffer
Kernel Mode
Mix
Audio Driver
Software
Hardware
Endpoint Device (Speakers)
Audio Adapter


Audio Buffer
Audio Buffer
Audio Buffer
Operating system audio mixer
Sound Device

Playing digital sound involves filling an audio buffer with audio data on demand.



# Playing audio with SDL2

# SDL_mixer (the easy way).

# Download SDL_mixer.

http://www.libsdl.org/projects/SDL_mixer/

**Development Libraries:**

Windows

SDL2_mixer-devel-2.0.0-VC.zip (Visual C++ 32/64-bit)

SDL2_mixer-devel-2.0.0-mingw.tar.gz (MinGW 32/64-bit)

Mac OS X

SDL2_mixer-2.0.0.dmg (Intel 10.5+)

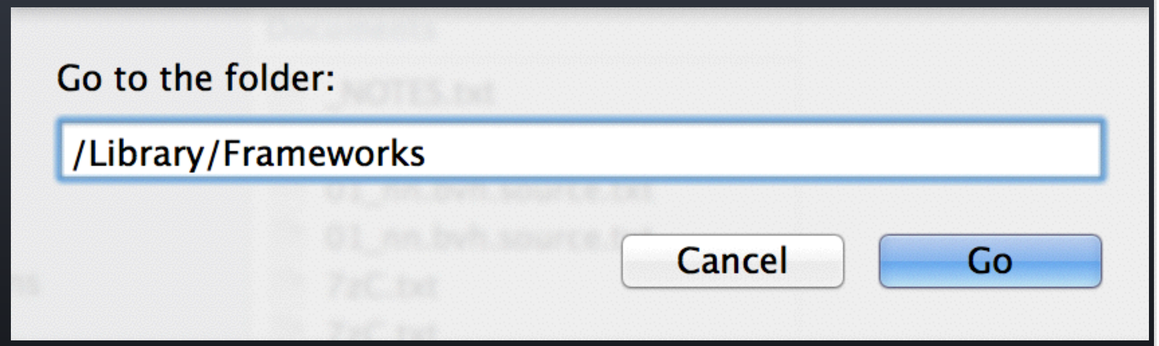
Linux

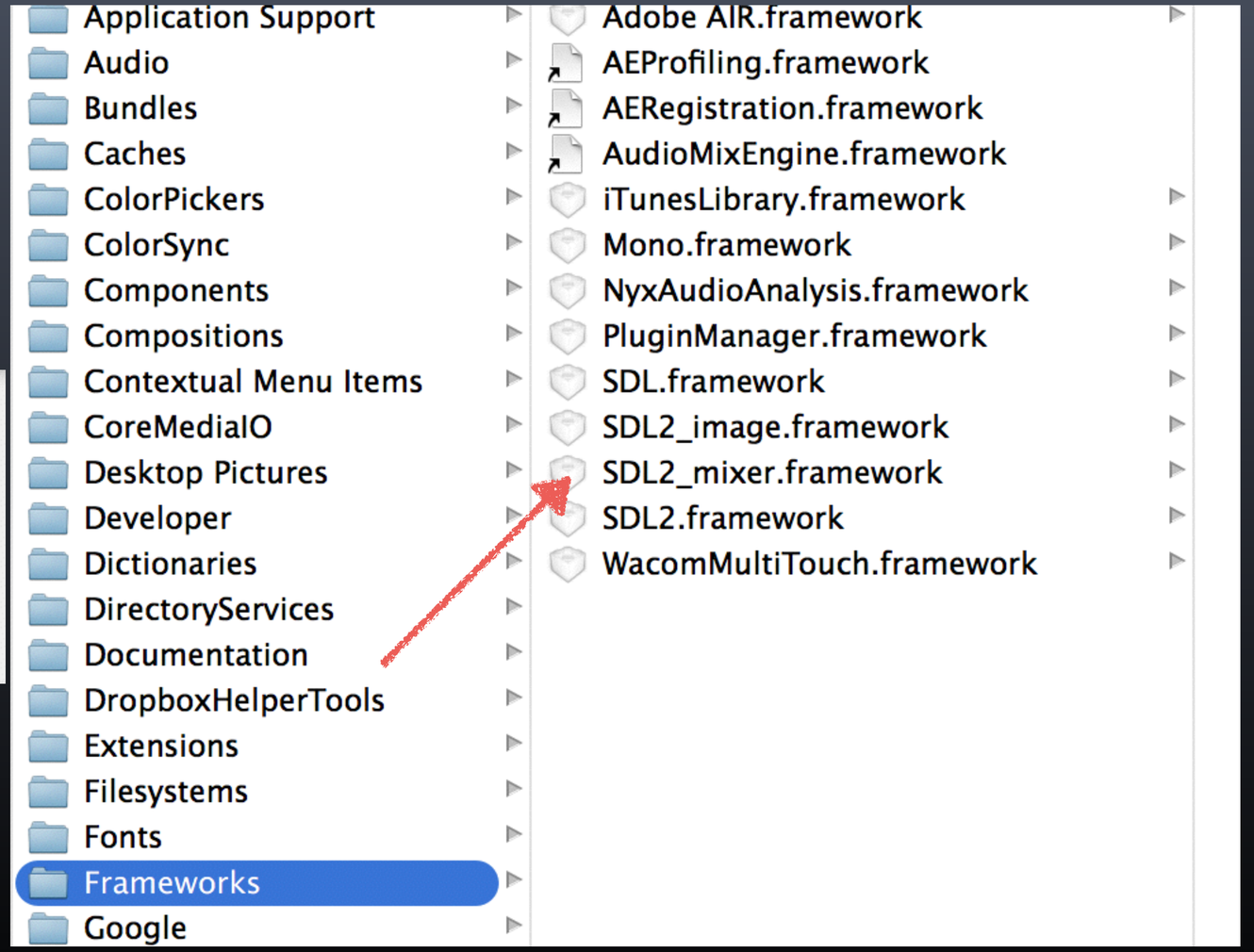
Please contact your distribution maintainer for updates.

iOS & Android

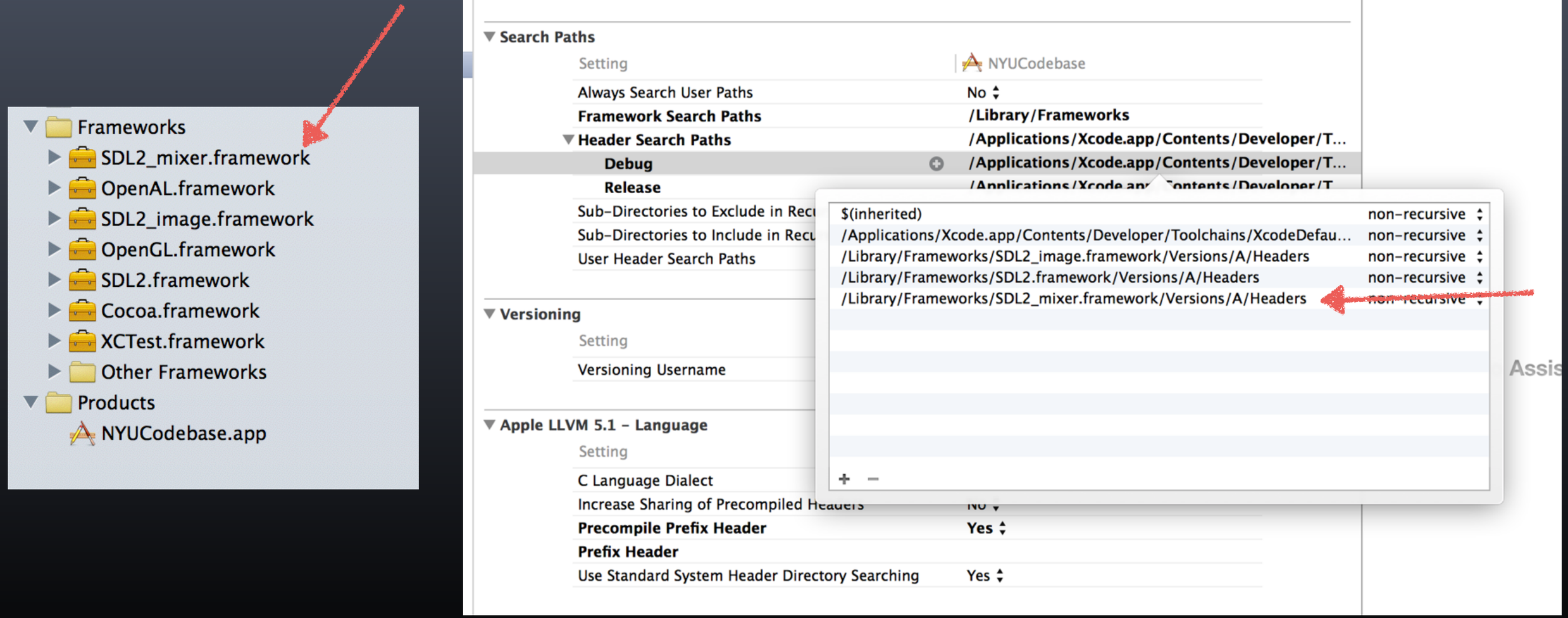
Projects for these platforms are included with the source.

# On Mac

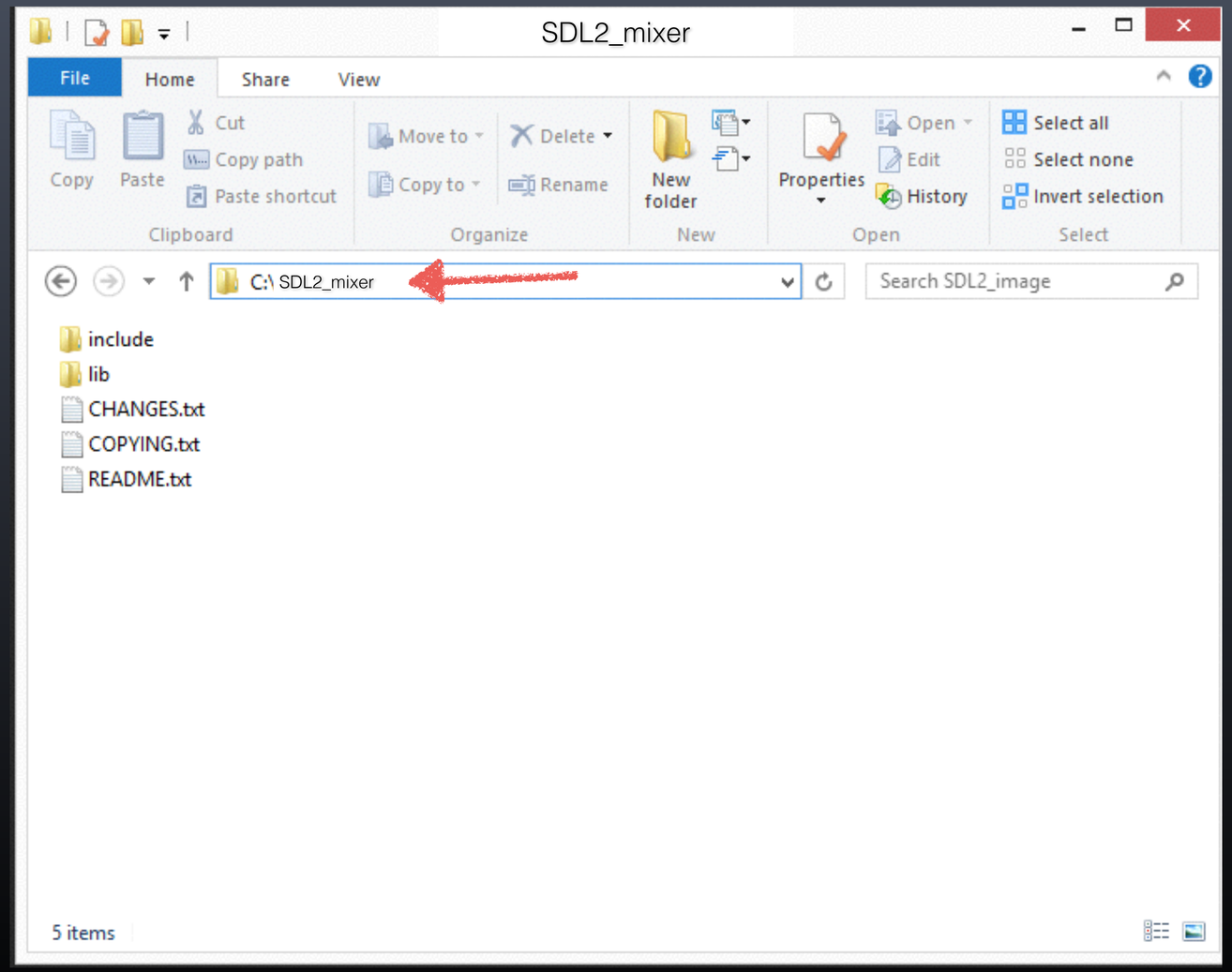

Go to the folder:
/Library/Frameworks
Cancel
Go


Application Support
Audio
Bundles
Caches
ColorPickers
ColorSync
Components
Compositions
Contextual Menu Items
CoreMediaIO
Desktop Pictures
Developer
Dictionaries
DirectoryServices
Documentation
DropboxHelperTools
Extensions
Filesystems
Fonts
Frameworks
Google
Adobe AIR.framework
AEProfiling.framework
AERegistration.framework
AudioMixEngine.framework
iTunesLibrary.framework
Mono.framework
NyxAudioAnalysis.framework
PluginManager.framework
SDL.framework
SDL2_image.framework
SDL2_mixer.framework
SDL2.framework
WacomMultiTouch.framework

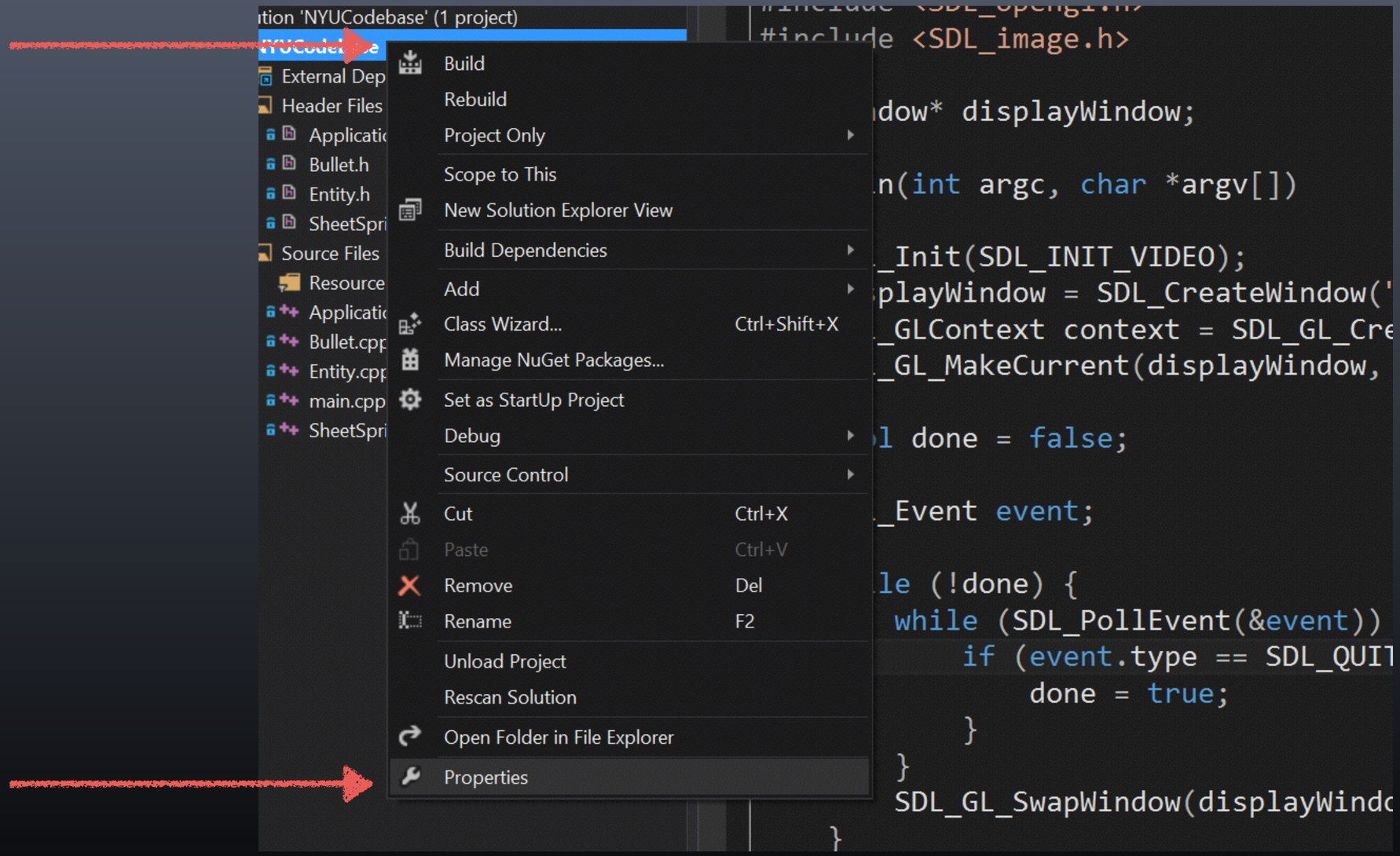
# DRAG FROM FINDER



# On Windows

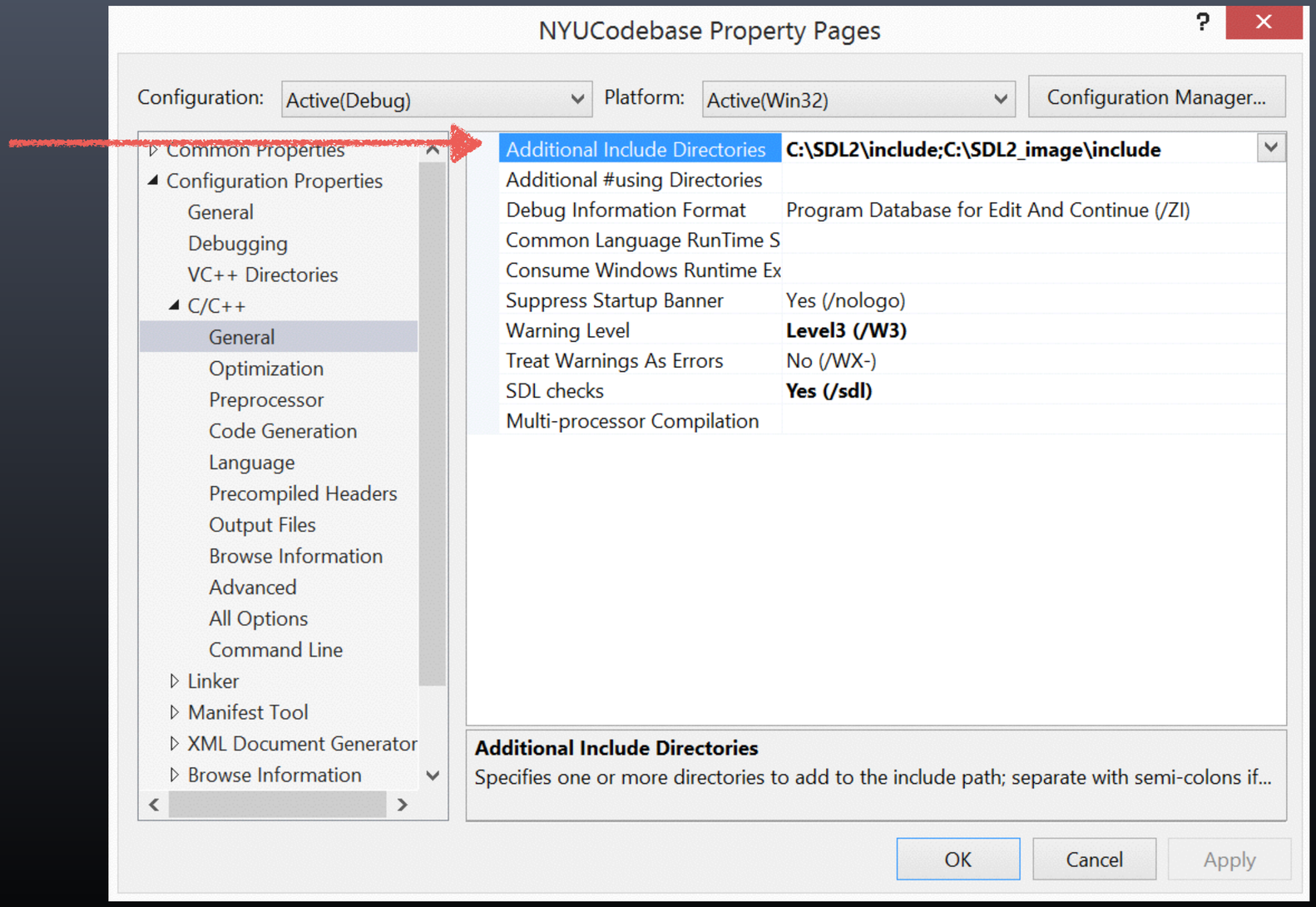

SDL2_mixer
File
Home
Share
View
Cut
Copy path
Paste shortcut
Copy
Paste
Move to
Copy to
Delete
Rename
New folder
Properties
Open
Edit
History
Select all
Select none
Invert selection
Clipboard
Organize
New
Open
Select
C:\ SDL2_mixer
Search SDL2_image
include
lib
CHANGES.txt
COPYING.txt
README.txt
5 items

# RIGHT CLICK PROJECT

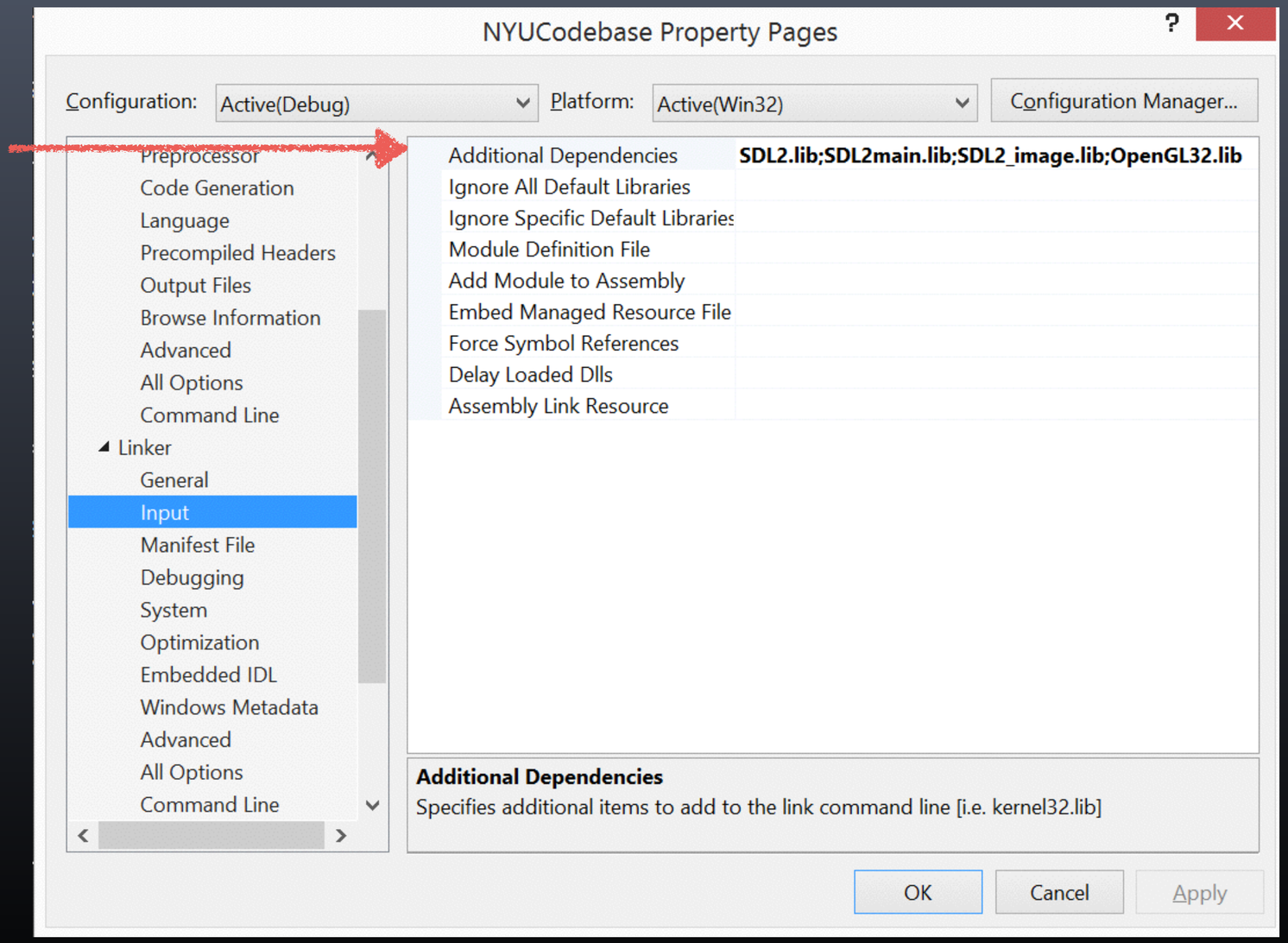



# GO TO PROPERTIES

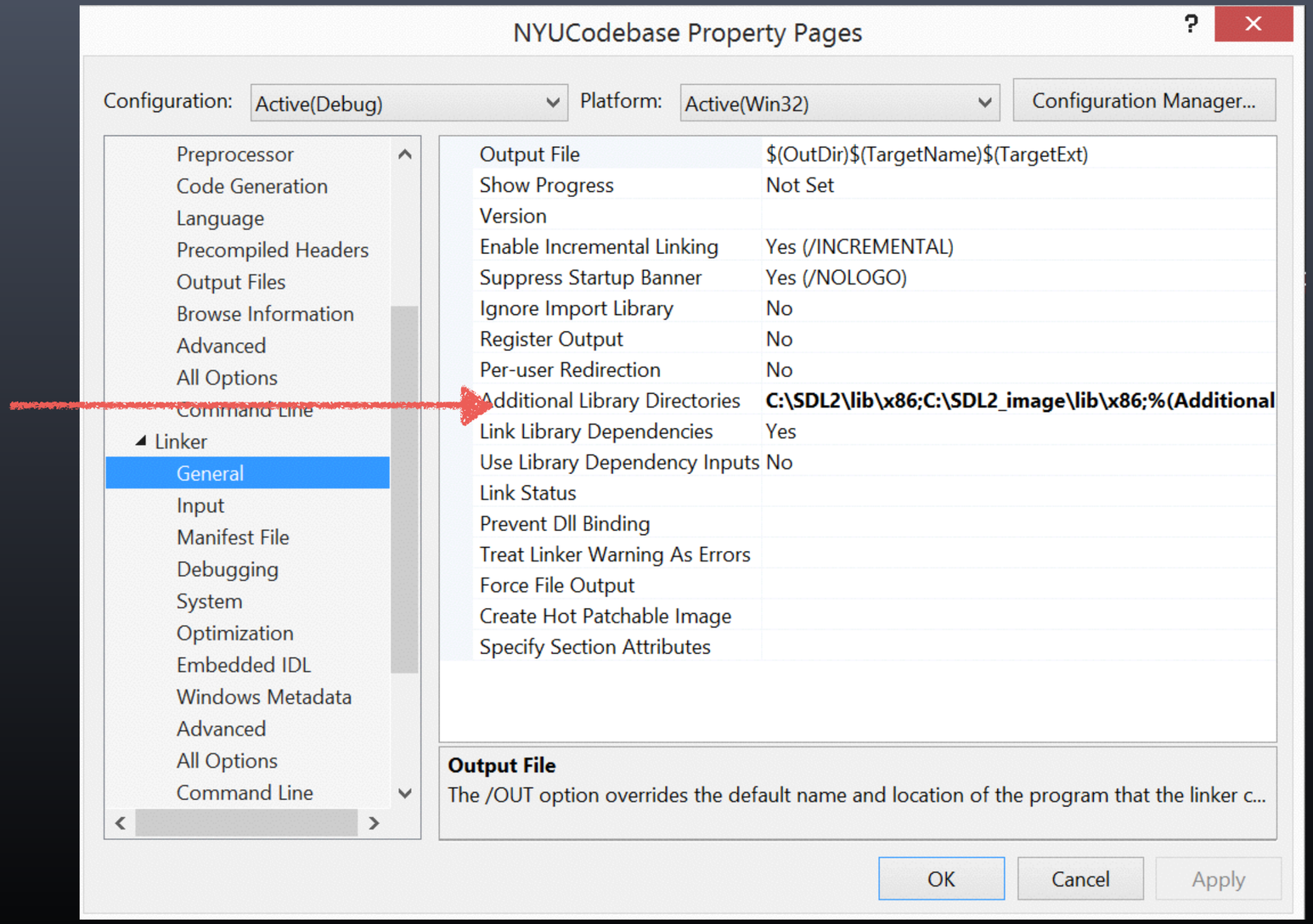
# Add C:\SDL_mixer\include to additional library directories



# ADD SDL2_mixer.lib to additional dependencies



# Add C:\SDL_mixer\lib\x64 to additional library directories



Do the same thing for both Release and Debug configurations.

Copy all DLL files from C:\SDL_mixer\lib\x64 to where all the other DLL files are in your project.

# Initializing SDL_mixer

# Include SDL_mixer header.

```
#include <SDL_mixer.h>
```

```
int Mix_OpenAudio(int frequency, Uint16 format, int channels,
int chunksize);
```

Initializes SDL_mixer with frequency, format, channel and buffer size.

```
Mix_OpenAudio( 44100, MIX_DEFAULT_FORMAT, 2, 4096 );
```

# Loading and playing sounds.

# Loading a sound.

```
Mix_Chunk *someSound;
someSound = Mix_LoadWAV(“some_sound.wav");
```

# Playing a sound.

```
int Mix_PlayChannel(int channel, Mix_Chunk *chunk, int loops);
```

Plays a sound on specified channel. You can pass -1 for “channel” to use the first available channel. Loops can be -1 to loop forever.

```
Mix_PlayChannel( -1, someSound, 0);
```

# Loading and playing music.

# Loading music.

```
Mix_Music *music;
music = Mix_LoadMUS( "music.mp3" );
```

# Playing music.

```
int Mix_PlayMusic(Mix_Music *music, int loops);
```

Plays specified music. Loops can be -1 to loop forever.

```
Mix_PlayMusic(music, -1);
```

# Cleaning up.

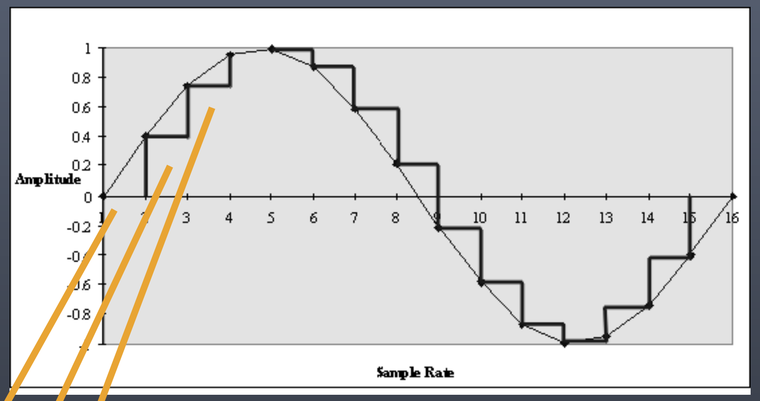
# Need to clean up music and sounds on quit.

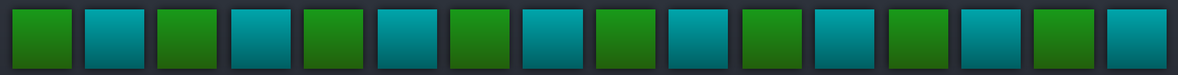
```
DemoApp::~DemoApp() {

    Mix_FreeChunk(someSound);
    Mix_FreeMusic(music);

    SDL_Quit();
}
```

# Pure audio buffer (the hard way).



Audio Buffer

Operating system audio mixer

Need to add SDL_INIT_AUDIO to SDL_Init flags.

```
SDL_Init(SDL_INIT_VIDEO|SDL_INIT_AUDIO);
```

# Define your audio callback function.

```
void myAudioCallback(void *userdata, Uint8 *stream, int len) {
}
```

Open an audio device with your callback and desired settings.

```
    SDL_AudioSpec deviceSpec;
    deviceSpec.freq = 44100; // sampling rate (samples a second)
    deviceSpec.format = AUDIO_F32; // audio format
    deviceSpec.channels = 1; // how many channels (1 = mono, 2 = stereo)
    deviceSpec.samples = 512; // audio buffer size in samples (power of 2)
    deviceSpec.callback = myAudioCallback; // our callback function

    // open new audio device with our requested settings
    SDL_AudioDeviceID dev = SDL_OpenAudioDevice(NULL, 0, &deviceSpec, 0,
SDL_AUDIO_ALLOW_FORMAT_CHANGE);
    SDL_PauseAudioDevice(dev, 0); // start playback on this device
```

# The audio callback function will be called by SDL every time it needs us to refill the audio buffer.

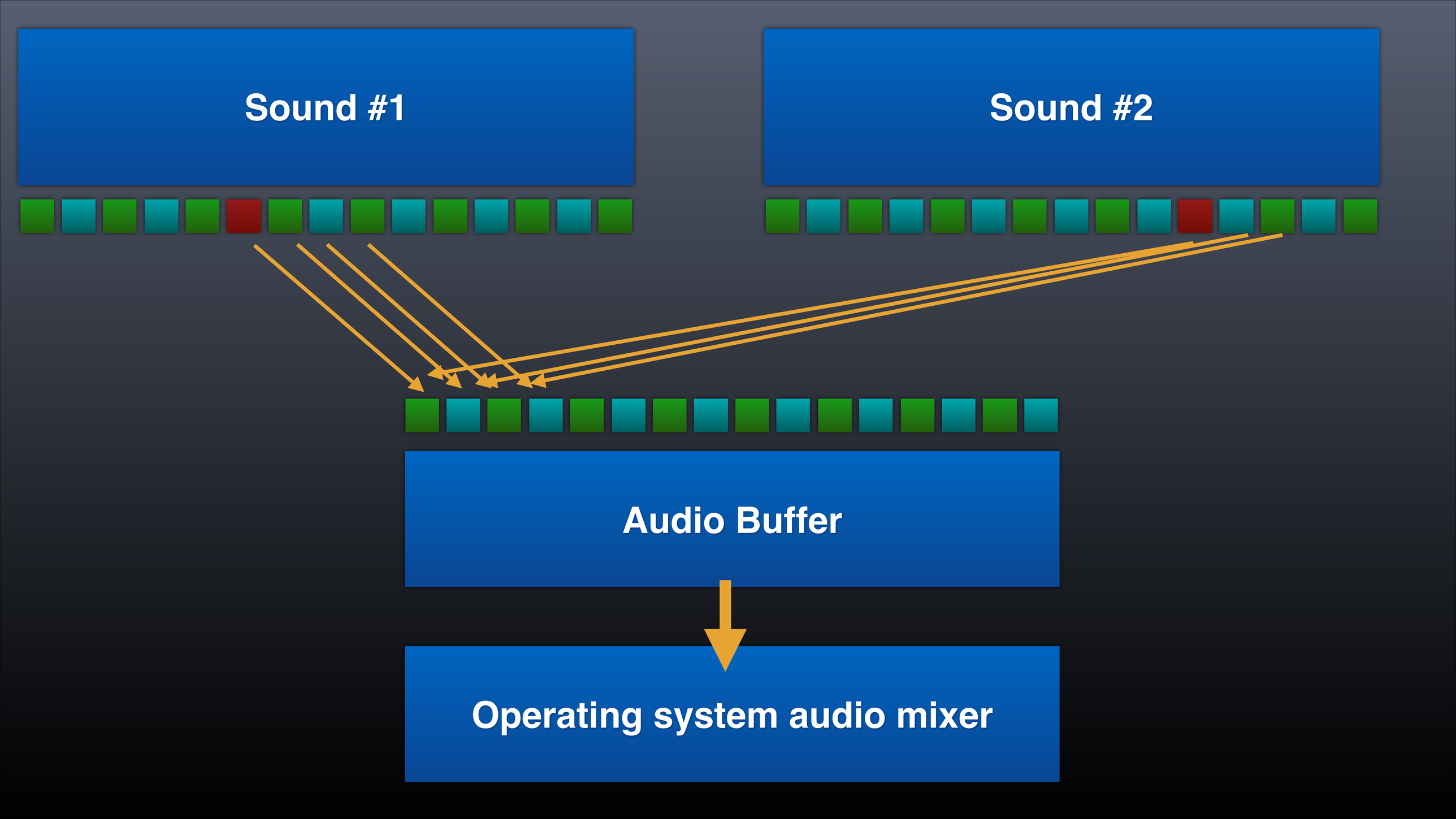
Here is an example of an audio callback function that's generating a 440Hz tone at 48000 sample frequency in a one channel float buffer.

```
unsigned int numSamples = 0;

float getAudioForTime(long numSamples) {
    double elapsed = ((double)numSamples)/44100.0;
    return sin(elapsed * 2.0 * M_PI * 440.0);
}

void myAudioCallback(void *userdata, Uint8 *stream, int len) {
    for(int i=0; i < len/4;  i++) {
        ((float*)stream)[i] = getAudioForTime(numSamples);
        numSamples++;
    }
}
```

# Writing a simple mixer.


Sound #1
Sound #2
Audio Buffer
Operating system audio mixer

```
class MixerSound {
public:
    Uint32 offset;
    Uint32 length;
    Uint8 *buffer;
    float volume;
    SDL_AudioFormat format;
    bool loaded;
    bool playing;
    bool loop;
};

class DemoApp {
    public:

        std::vector<MixerSound> mixSounds;
};
```

Create a class for storing loaded sound buffers and some basic sound information. Our app will keep these in a vector.

```
int DemoApp::loadSound(const char *soundFile) {

    Uint8 *buffer;
    SDL_AudioSpec spec;
    Uint32 bufferSize;

    if(SDL_LoadWAV(soundFile, &spec, &buffer, &bufferSize) == NULL) {
        return -1;
    }

    SDL_AudioCVT cvt;
    SDL_BuildAudioCVT(&cvt, spec.format, spec.channels, spec.freq,
deviceSpec.format, deviceSpec.channels, deviceSpec.freq);
    cvt.len = bufferSize;
    cvt.buf = new Uint8[bufferSize * cvt.len_mult];
    memcpy(cvt.buf, buffer, bufferSize);

    SDL_ConvertAudio(&cvt);
    SDL_FreeWAV(buffer);

    MixerSound sound;
    sound.buffer = cvt.buf;
    sound.length = cvt.len_cvt;
    sound.loaded = true;
    sound.offset = 0;
    sound.format = deviceSpec.format;
    sound.volume = 1.0;
    sound.playing = false;
    mixerSounds.push_back(sound);

    return mixerSounds.size()-1;
}
```

SDL_LoadWAV can only load .wav files.

```
someSound = loadSound("some_wave_file.wav");
```

```
void DemoApp::appAudioCallback(void *userdata, Uint8 *stream, int len) {
    DemoApp *app = (ClassDemoApp*) userdata;
    float *mixBuffer = new float[len/4];

    memset(stream, 0, len);
    memset(mixBuffer, 0, len);
    int numSoundsMixed = 0;
    for(int i=0; i < app->mixerSounds.size(); i++) {
        MixerSound *sound = &app->mixerSounds[i];

        if(sound->loaded && sound->playing) {
            for(int s=0; s < len/4; s++) {
                float *sourceBuffer = (float*) (sound->buffer+sound->offset);
                mixBuffer[s] += (sourceBuffer[s] * sound->volume);
            }
            numSoundsMixed++;

            sound->offset += len;
            if(sound->offset >= sound->length-len) {
                if(sound->loop) {
                    sound->offset = 0;
                } else {
                    sound->playing = false;
                }
            }
        }
    }
    if(numSoundsMixed > 0) {
        for(int s=0; s < len/4; s++) {
            ((float*)stream)[s] = mixBuffer[s] / (float)numSoundsMixed;
        }
    }
    free(mixBuffer);
}
```

```
deviceSpec.callback = DemoApp::appAudioCallback;
```

# Playing a sound.

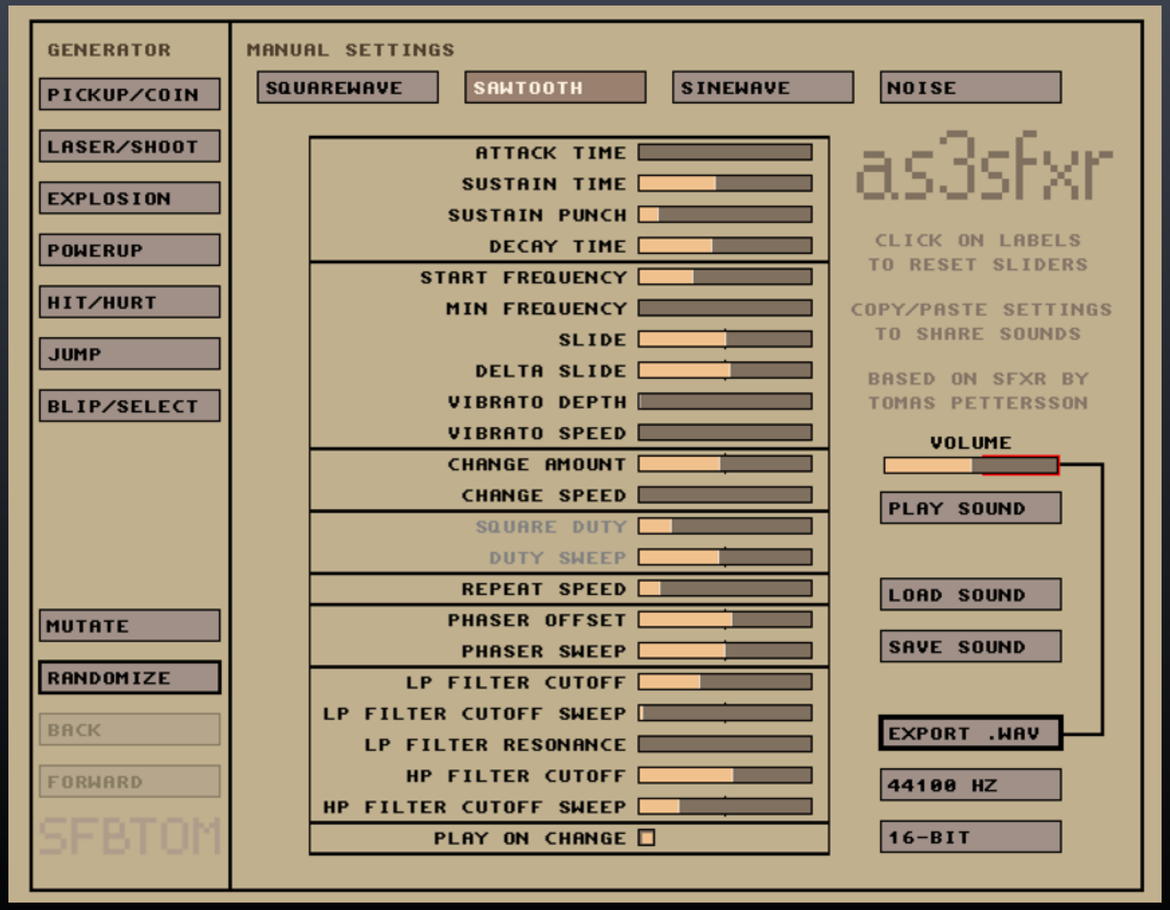
```
void DemoApp::playSound(int soundIndex, bool loop) {
    if(soundIndex >= 0 && soundIndex < mixerSounds.size()) {
        mixerSounds[soundIndex].playing = true;
        mixerSounds[soundIndex].offset = 0;
        mixerSounds[soundIndex].loop = loop;
    }
}
```

```
playSound(someSound, false);
```

# Sound resources.

# SFXR

http://www.superflashbros.net/as3sfxr/



# FREE MUSIC ARCHIVE

http://freemusicarchive.org/

# Assignment.

# Add sound to an existing game.

- Can use SDL_mixer or implement your own.
- Must have music and at least two sound effects.