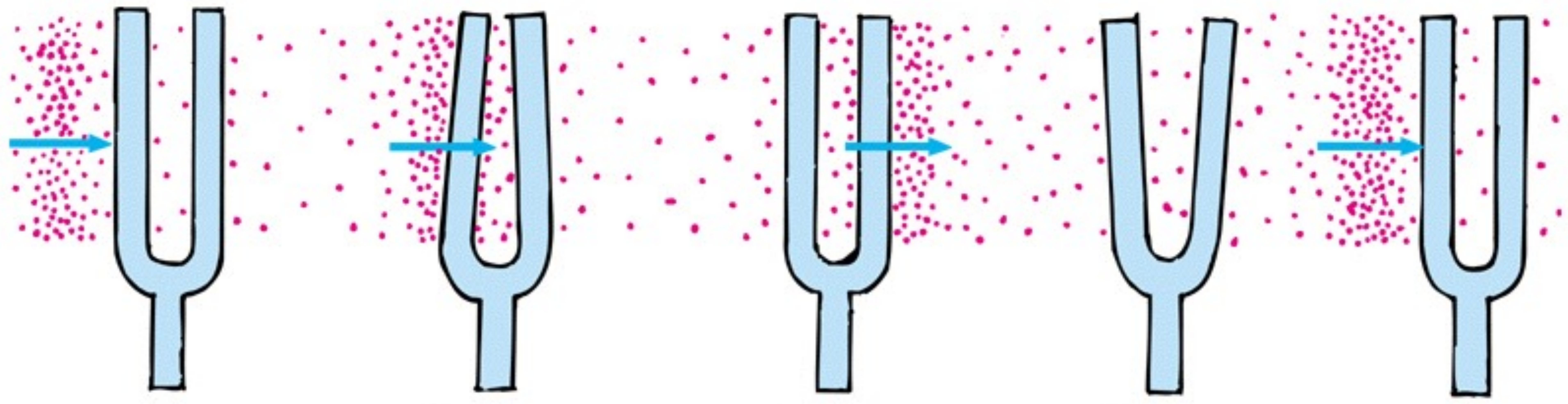
Playing **sound**.

How **sound** works.



a
b
c
d
e

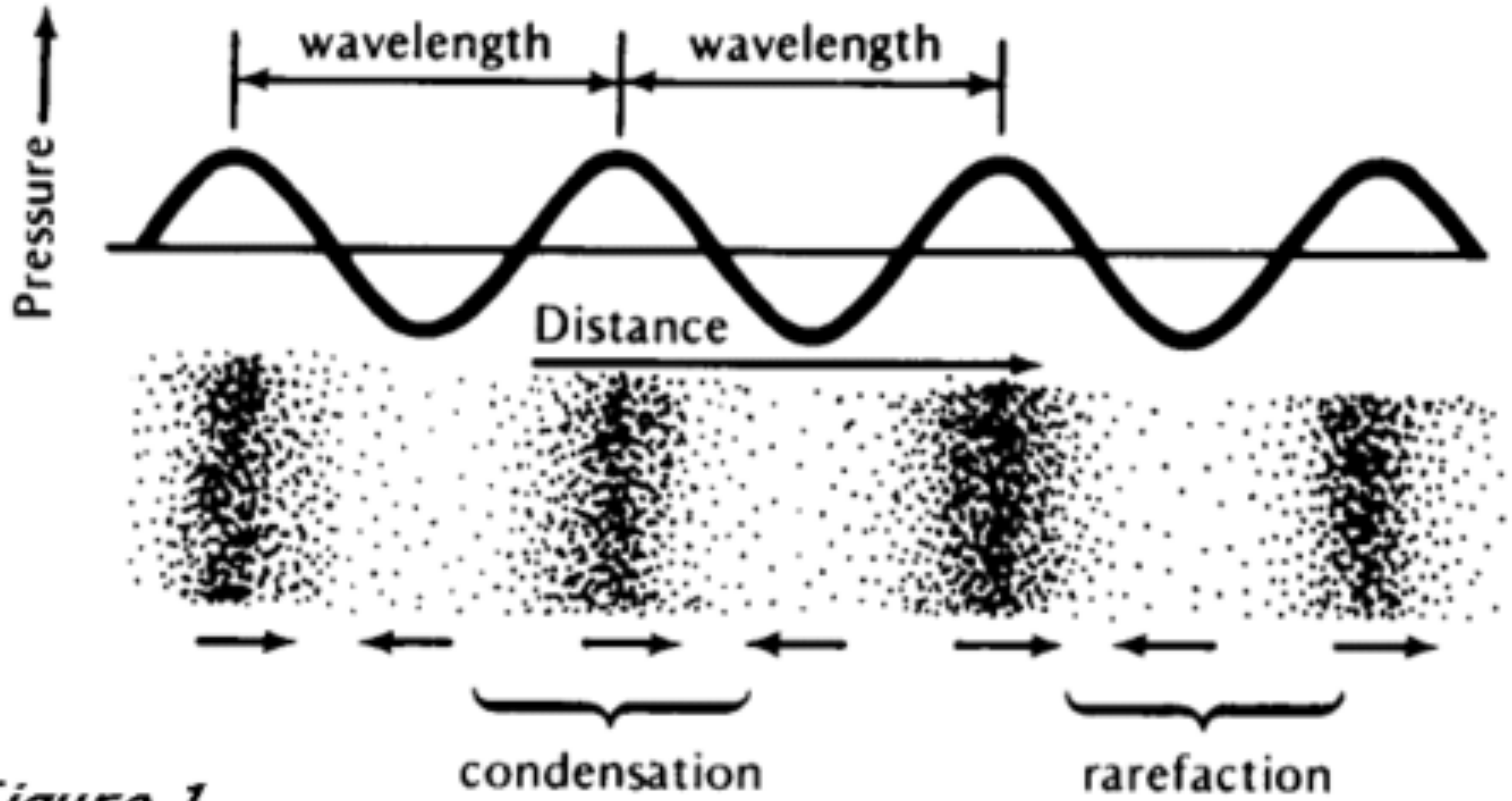
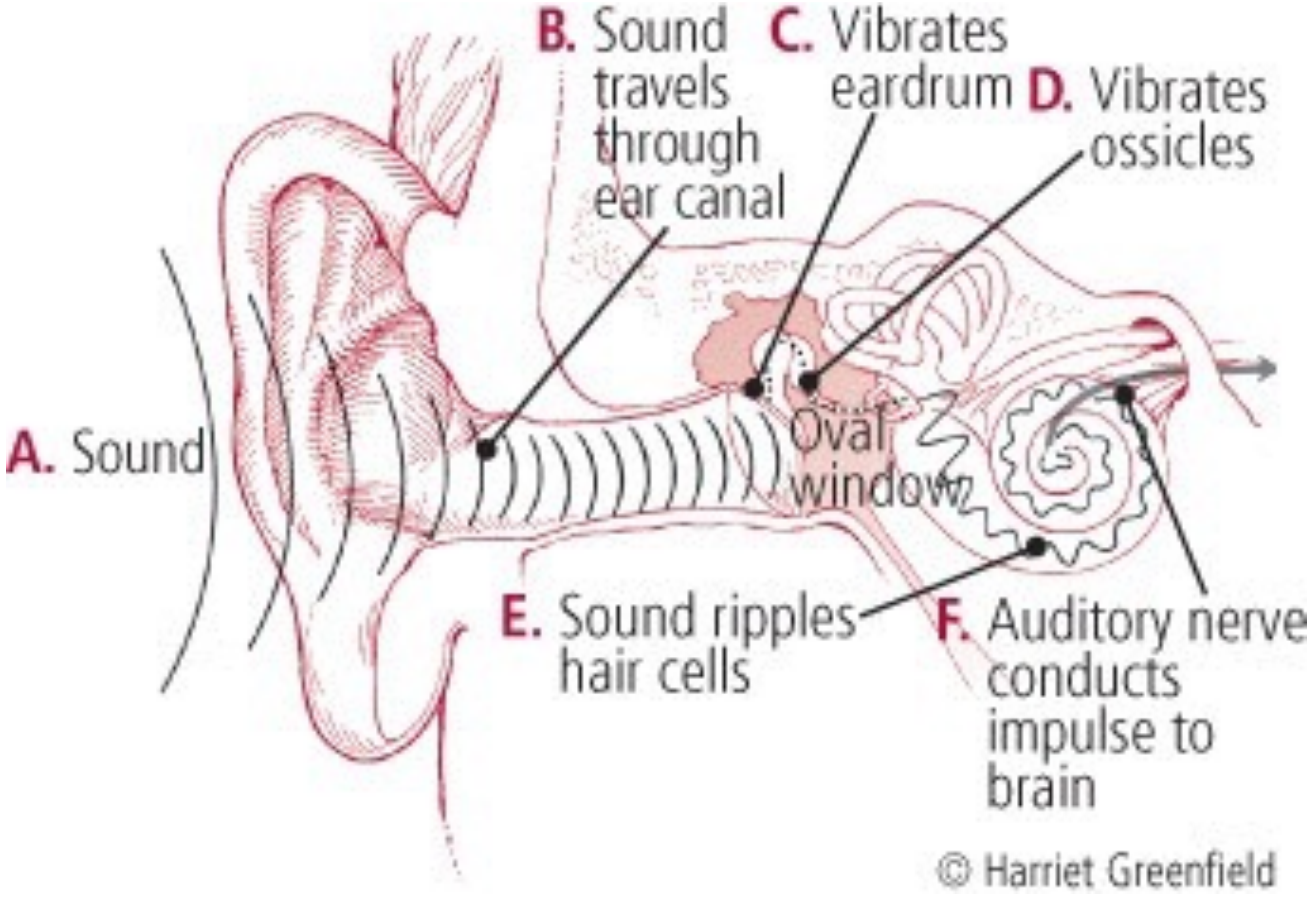
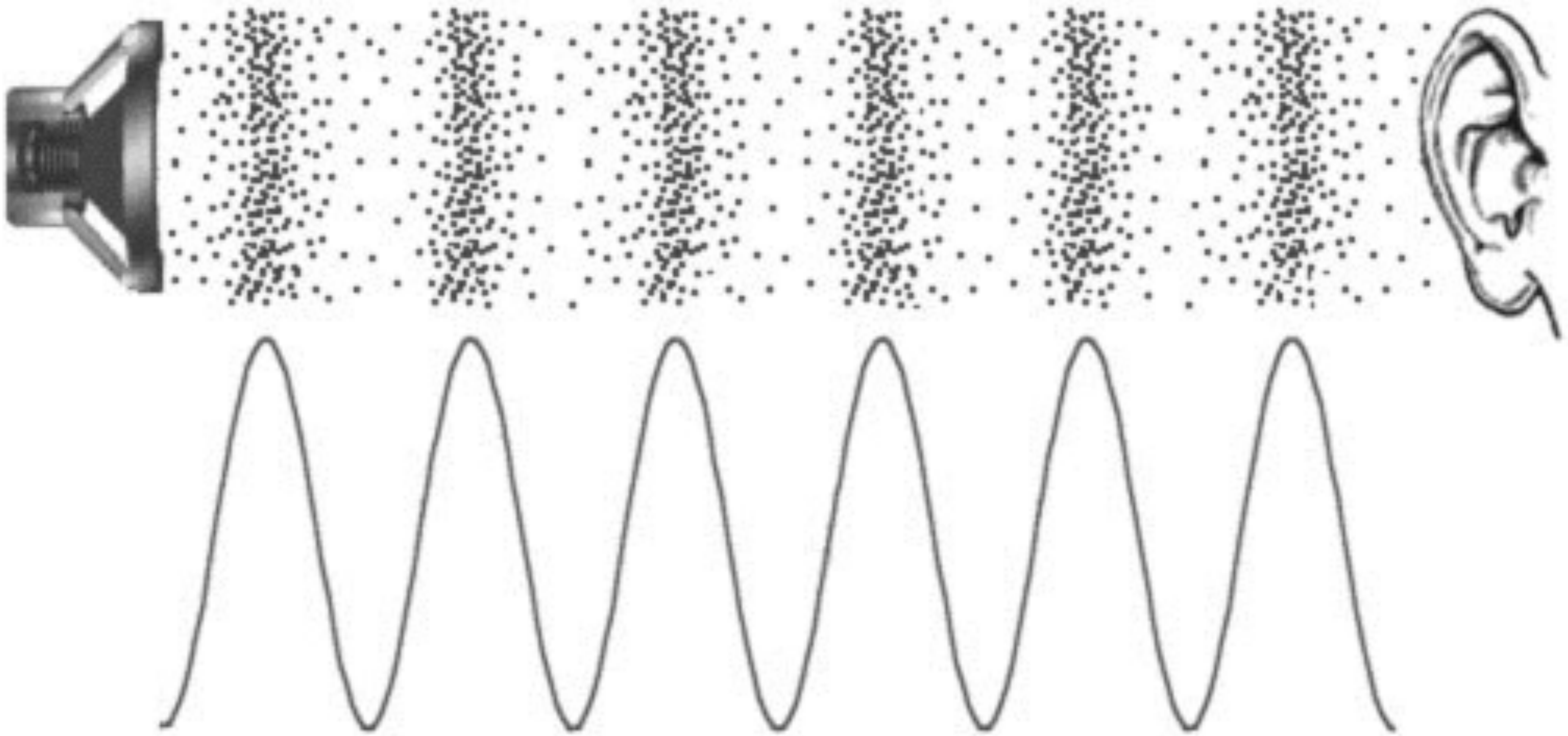
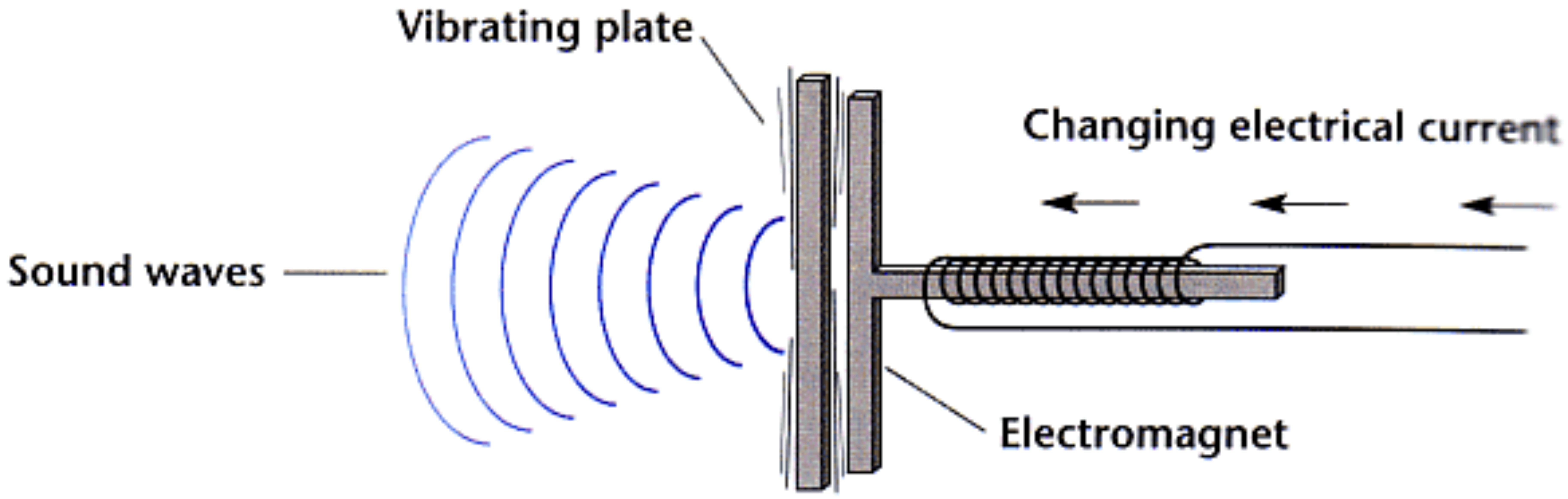

wavelength
wavelength
Pressure
Distance
condensation
rarefaction

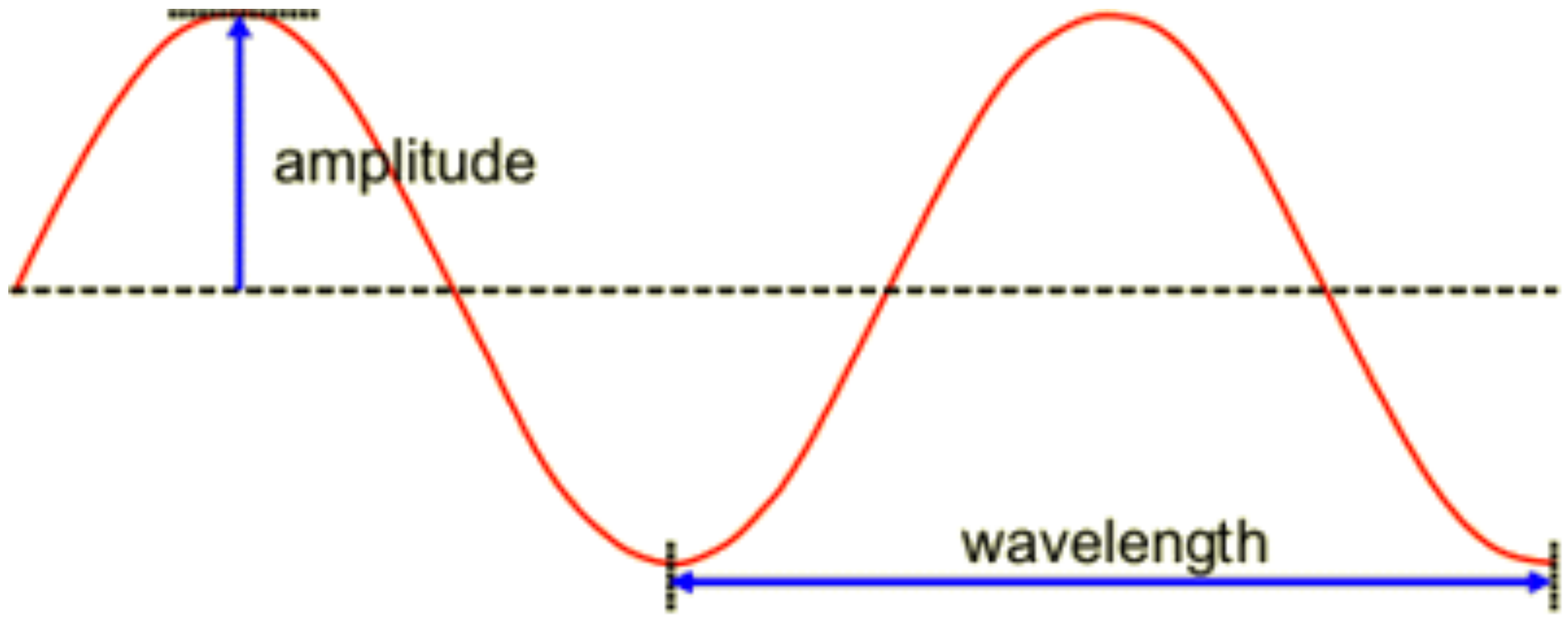
Figure 1

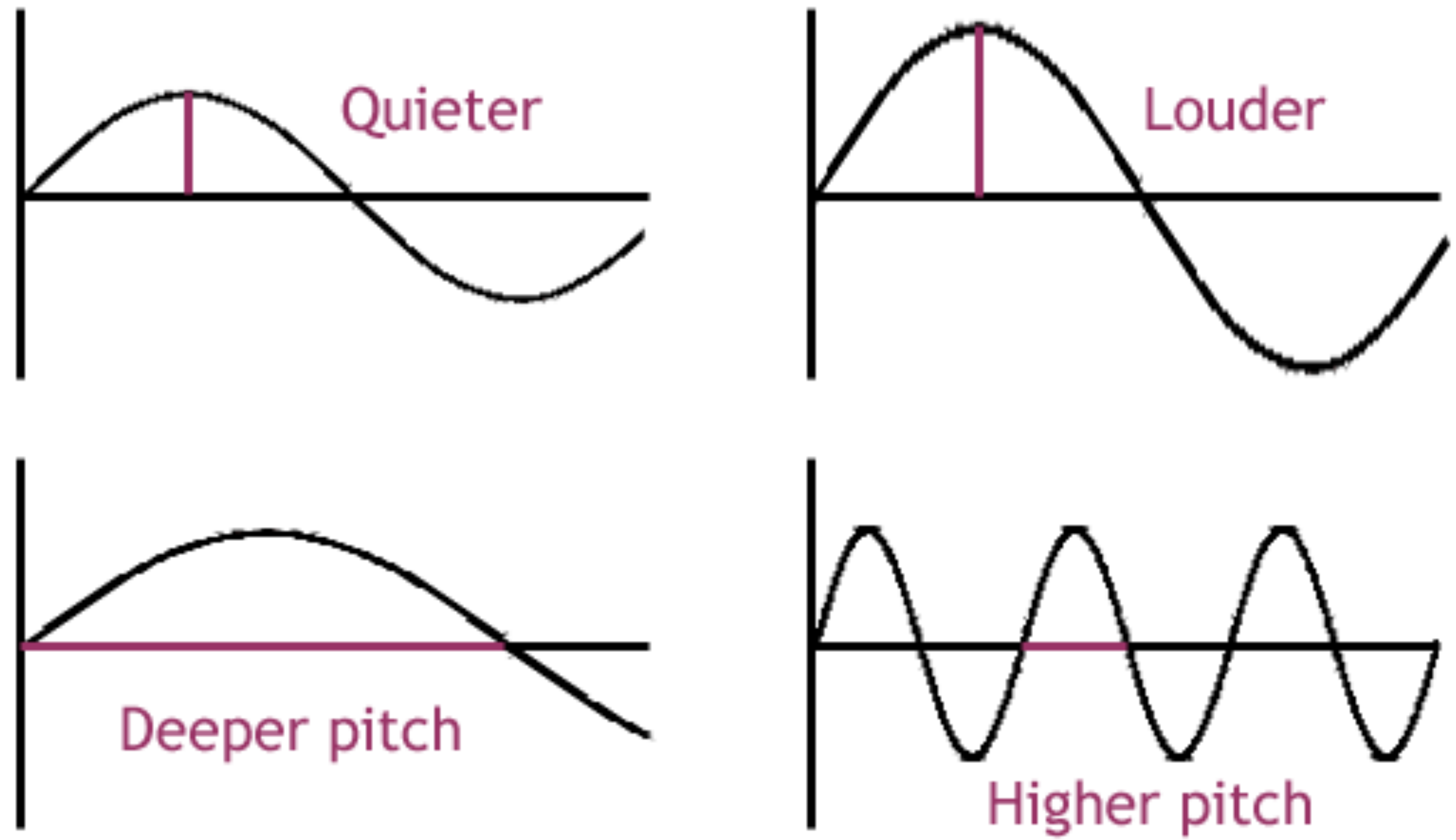

A. Sound
B. Sound travels through ear canal
C. Vibrates eardrum
D. Vibrates ossicles
Oval window
E. Sound ripples hair cells
F. Auditory nerve conducts impulse to brain
© Harriet Greenfield




Vibrating plate
Changing electrical current
Sound waves
Electromagnet

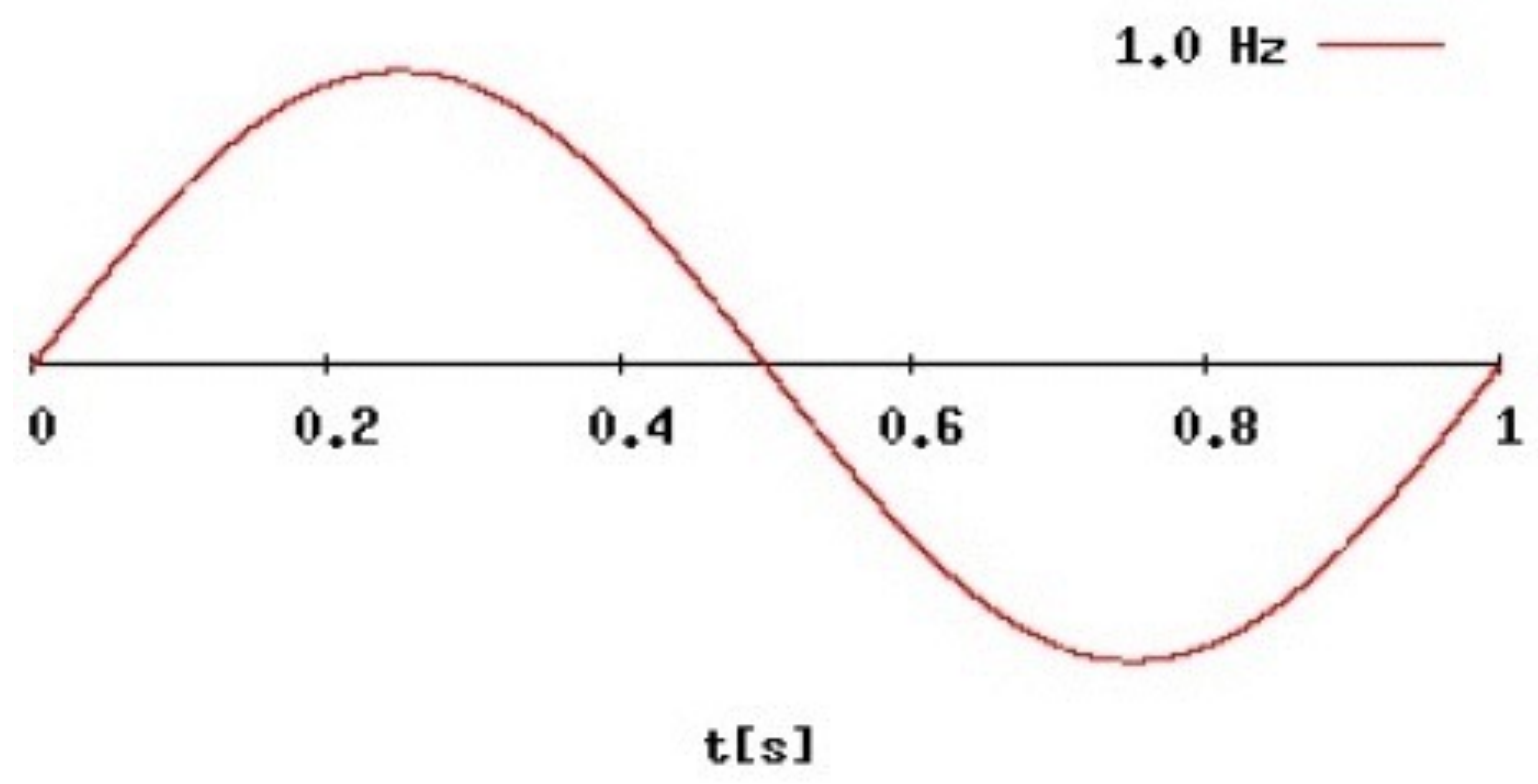
Sound wave properties.

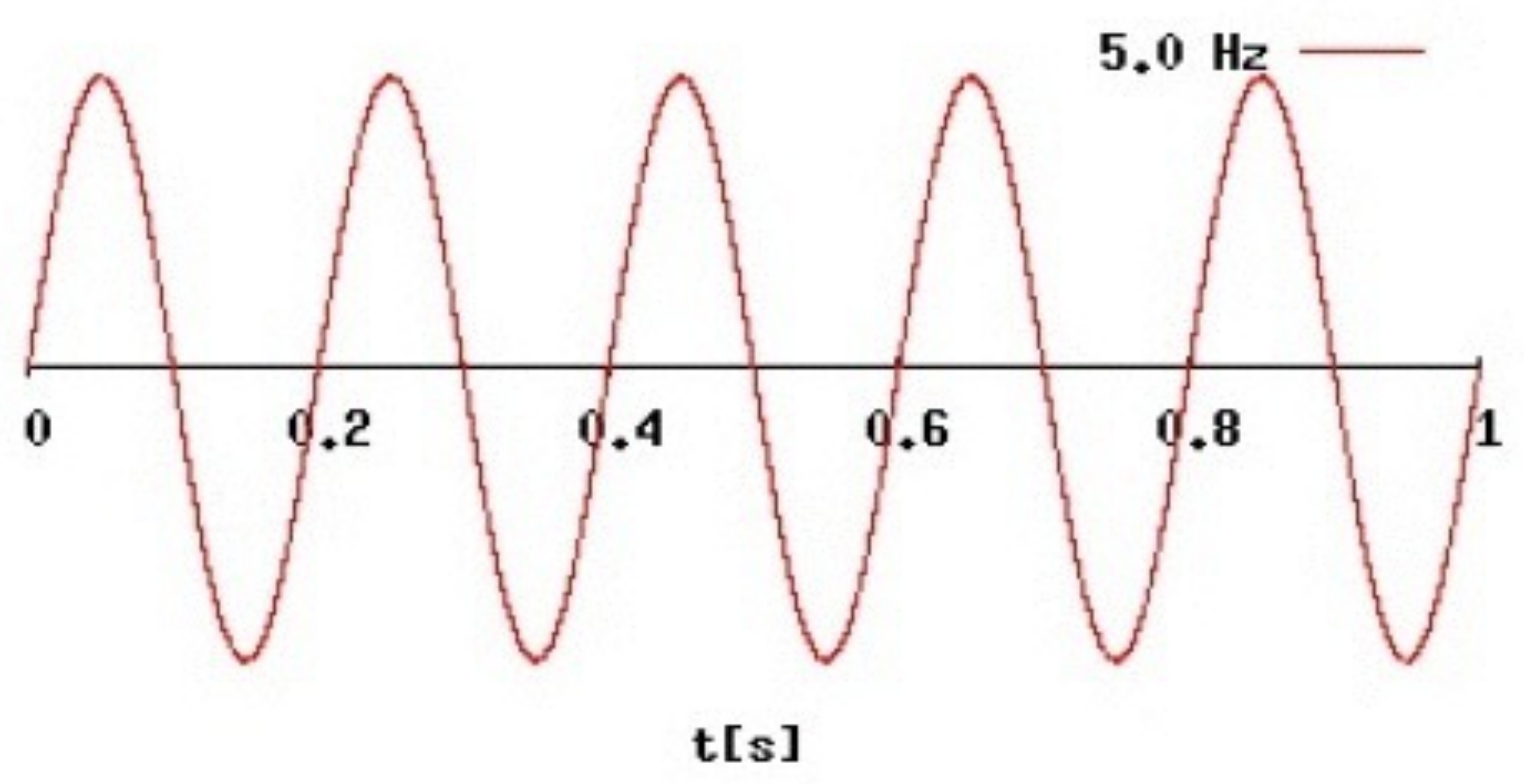

amplitude
wavelength


Quieter
Louder
Deeper pitch
Higher pitch

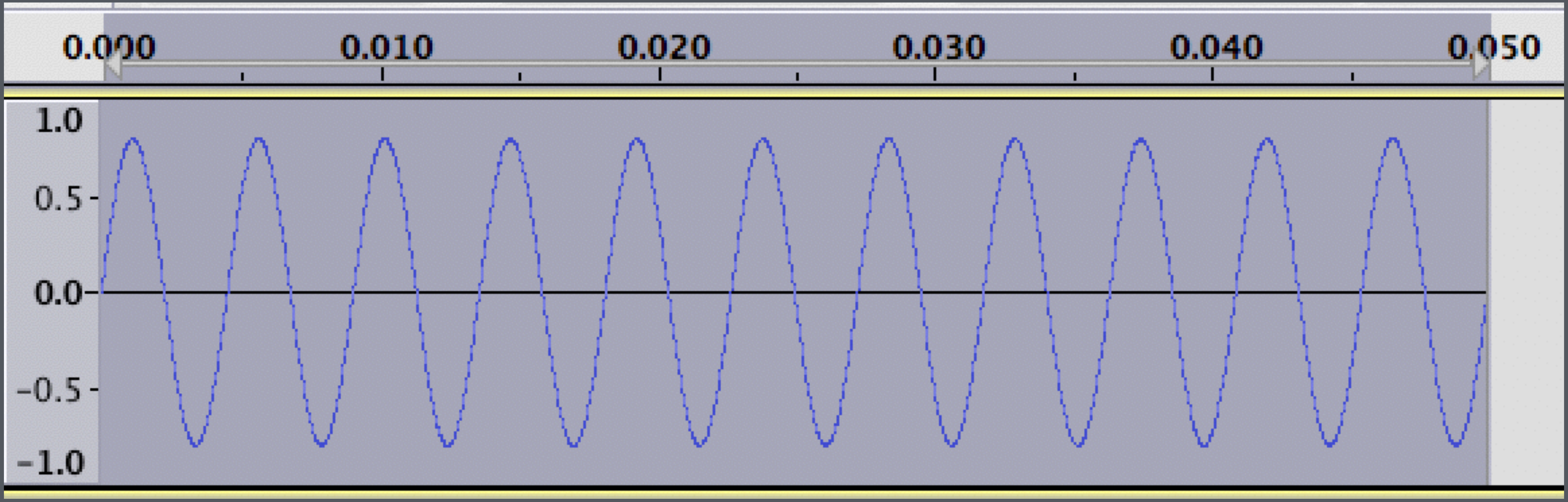
Sound **frequency**.

hertz (Hz) = 1 **cycle per second**.

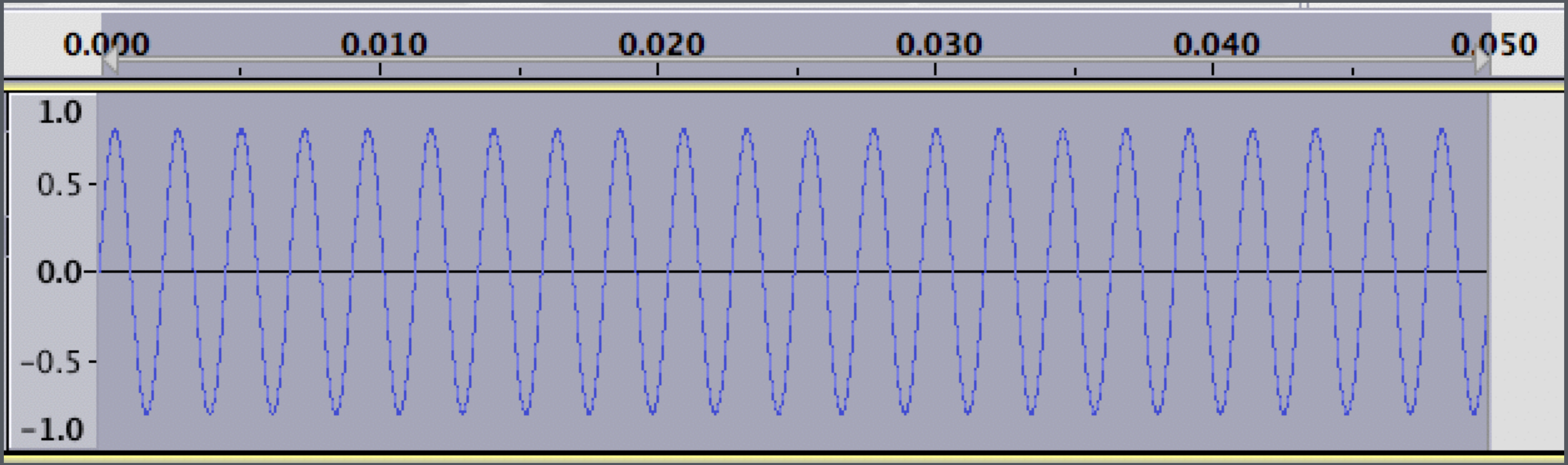




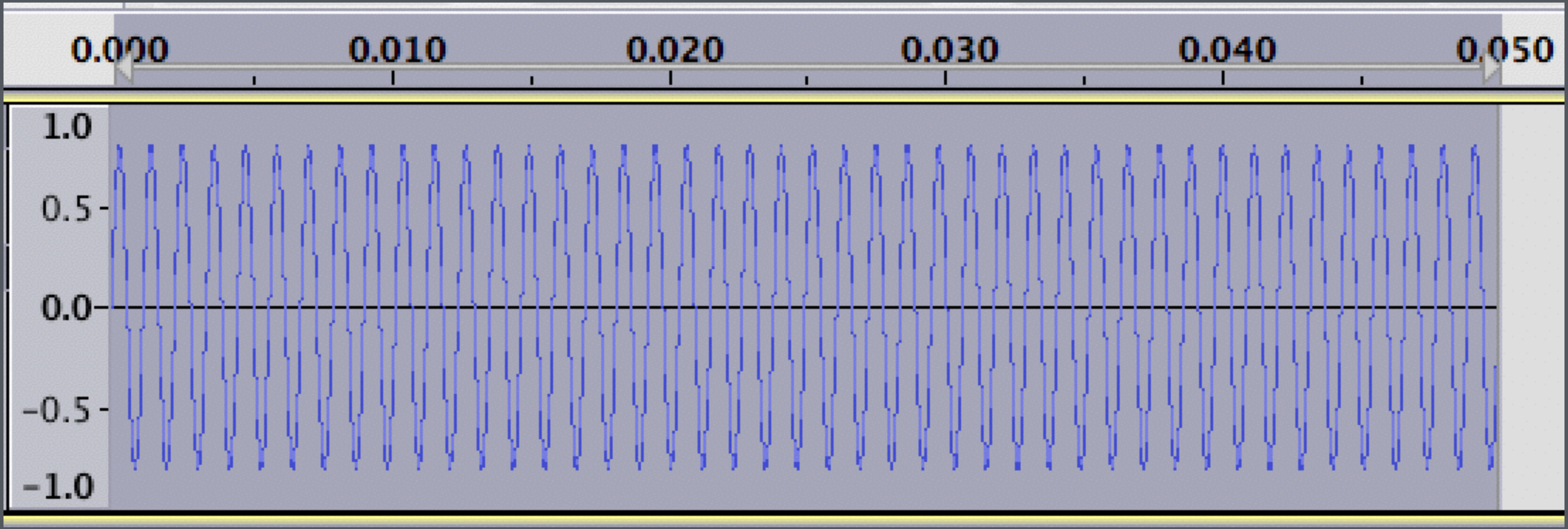
220 Hz



440 Hz

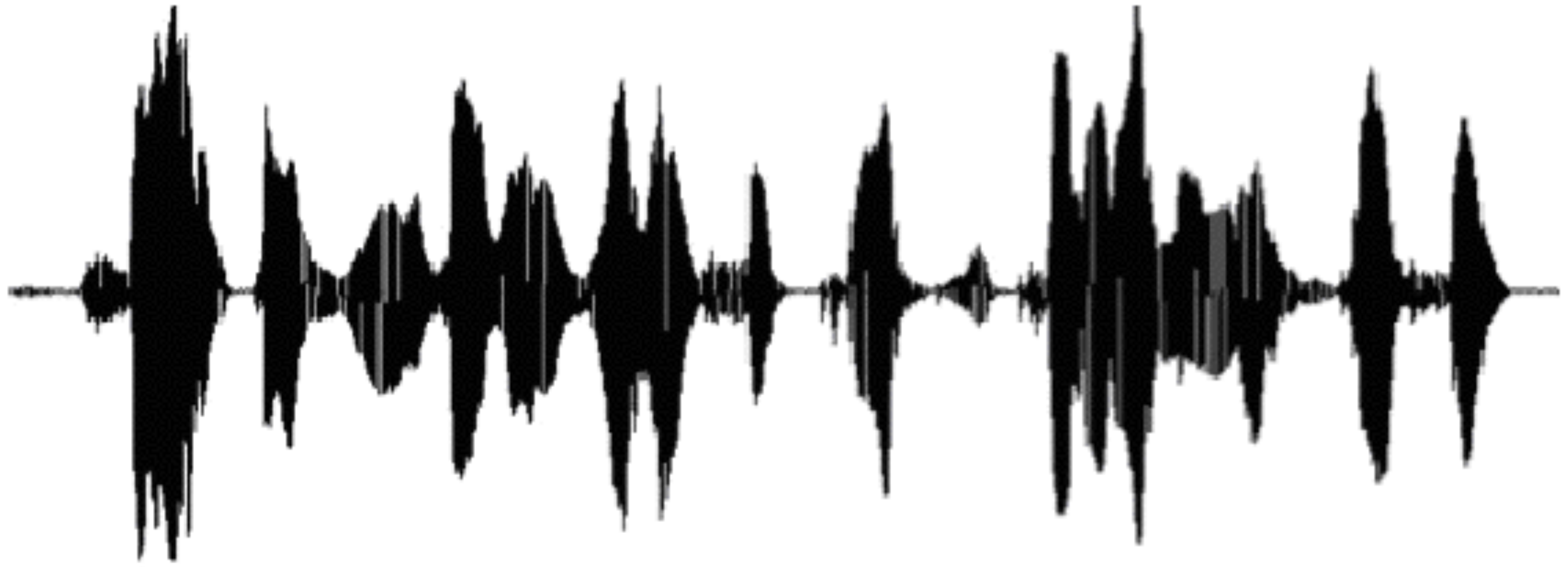


880 Hz

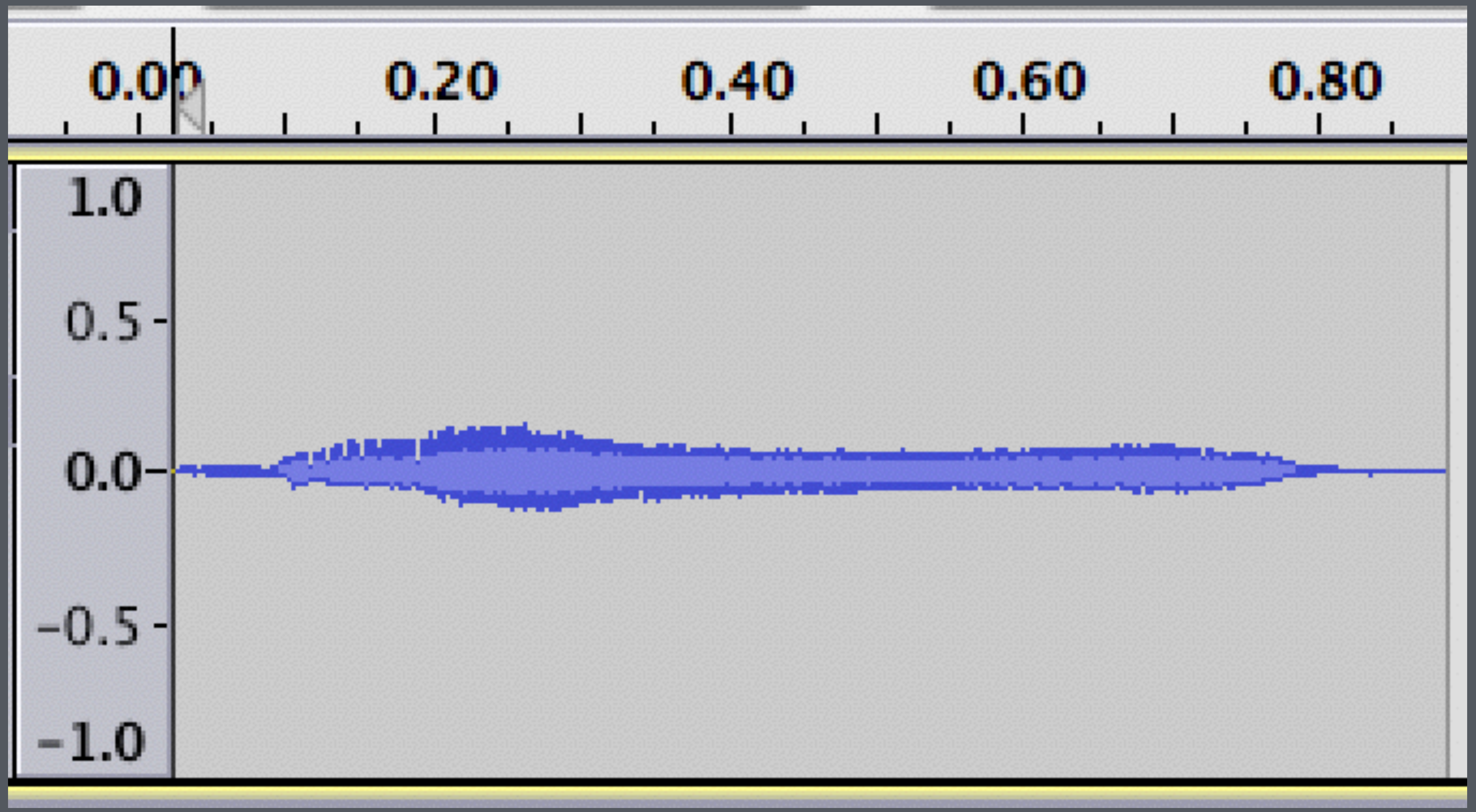


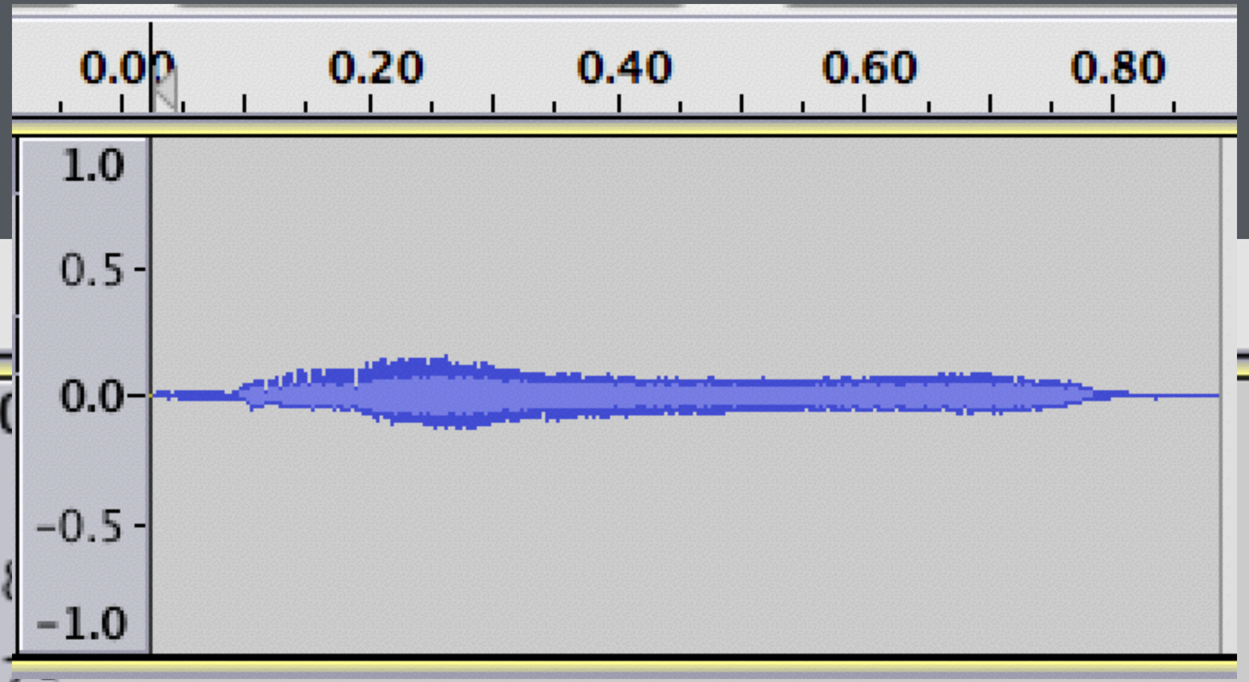
Complex **waveforms**.

Modulating frequency.

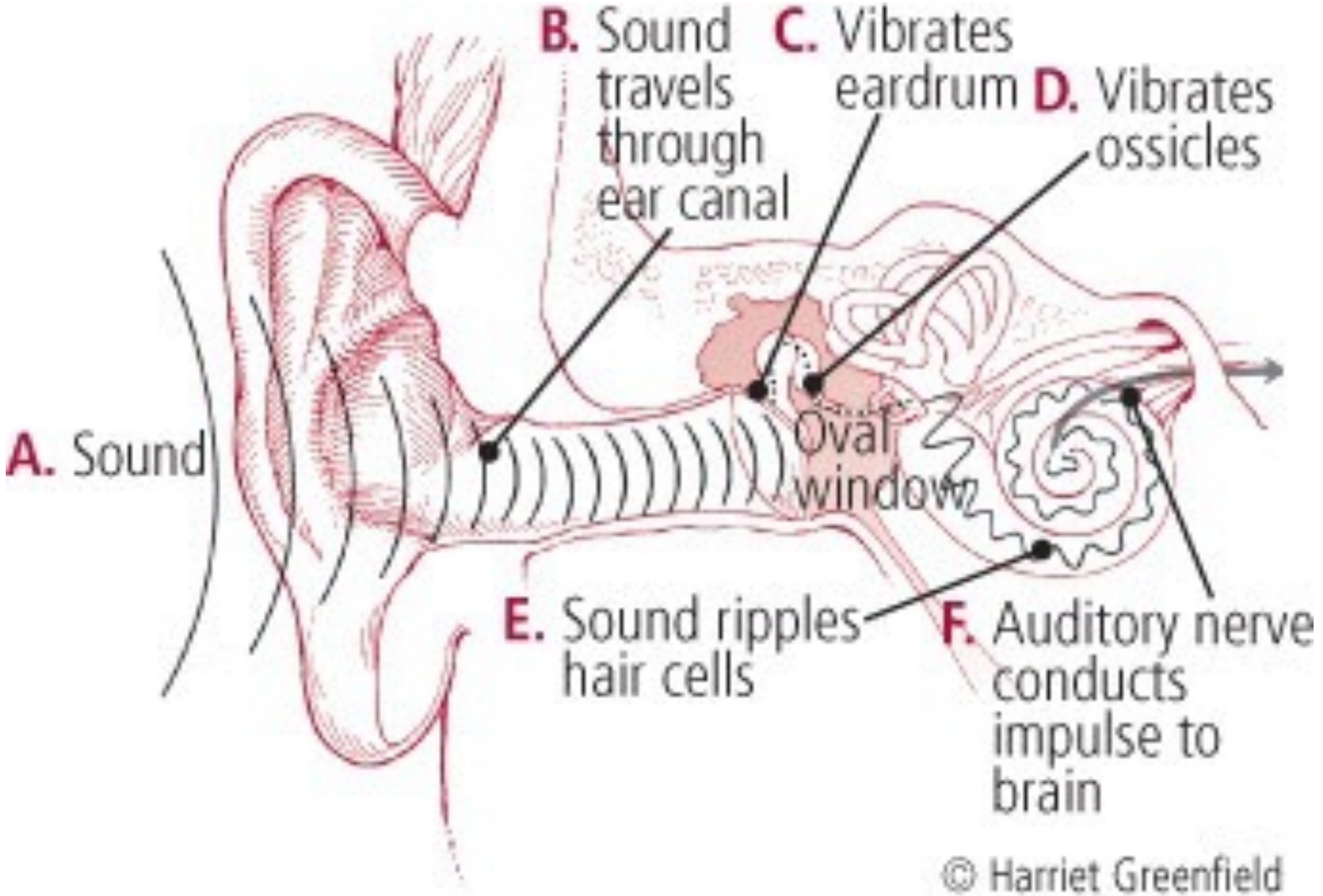


Hello



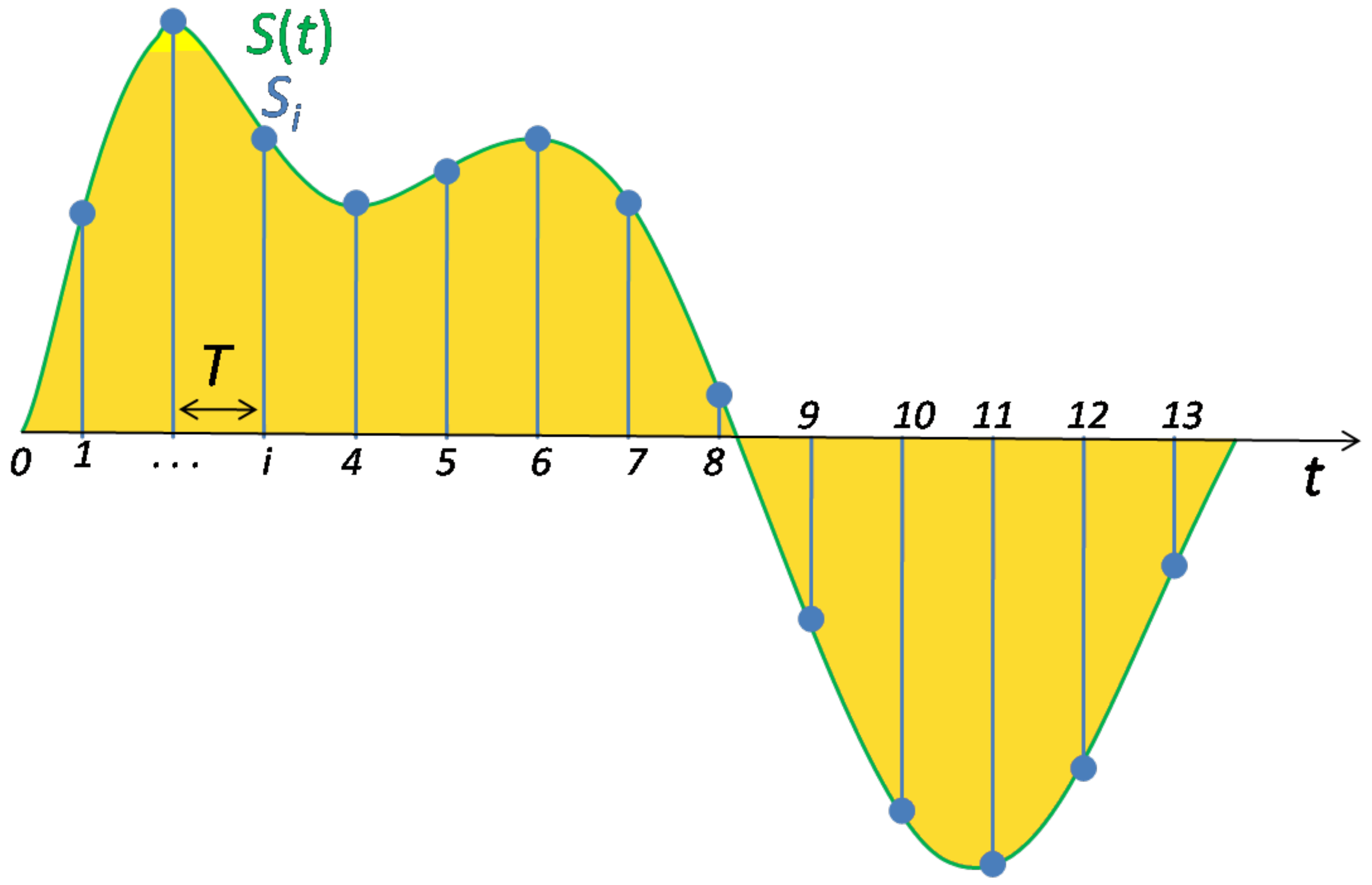
0.30
0.40
0.50
0.60
0.70
0.80
1.0
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-1.0

0.00
0.20
0.40
0.60
0.80
1.0
0.5
0.0
-0.5
-1.0

0.080
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


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

How **digital sound** works.

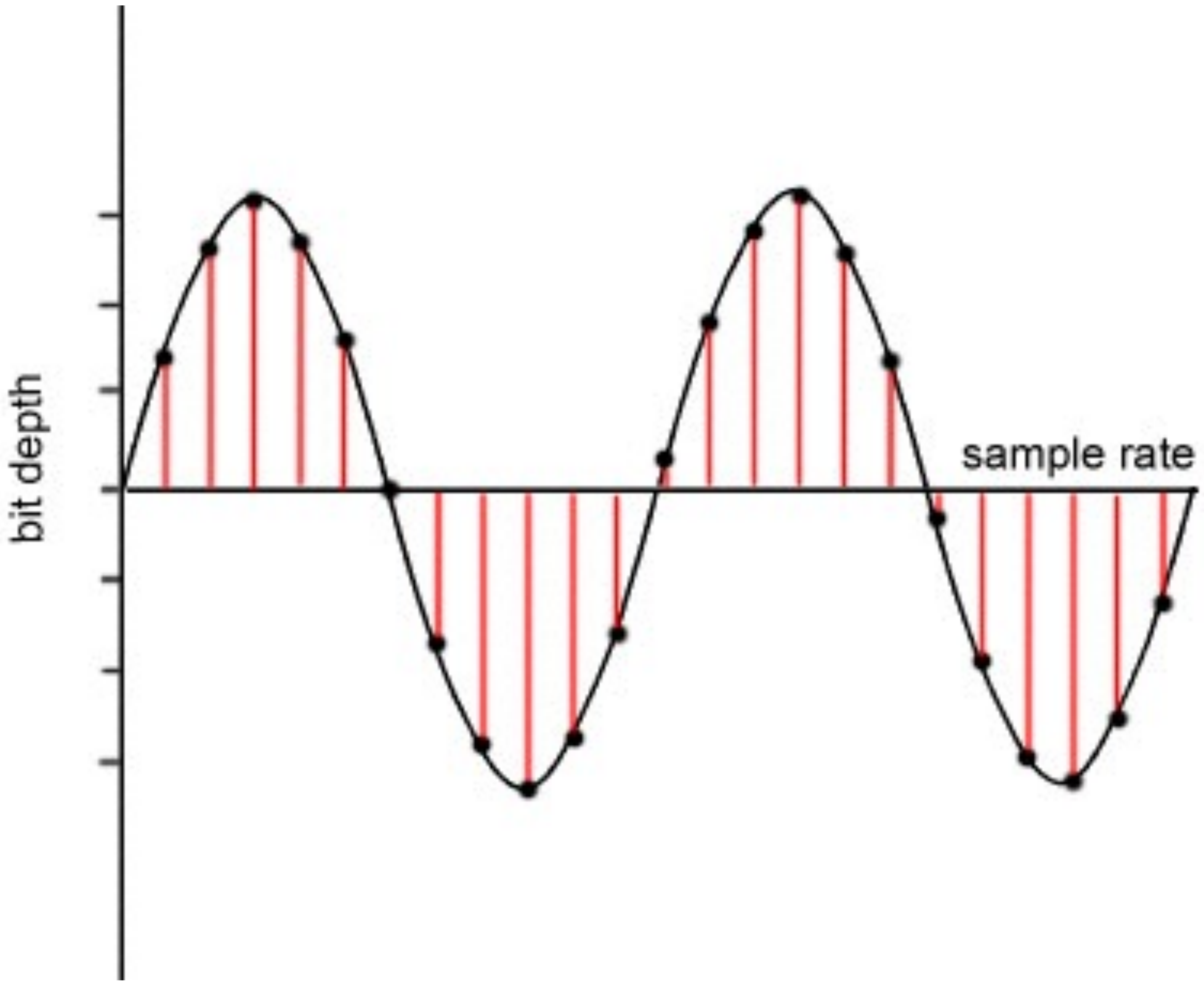
Digital **sampling**.



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

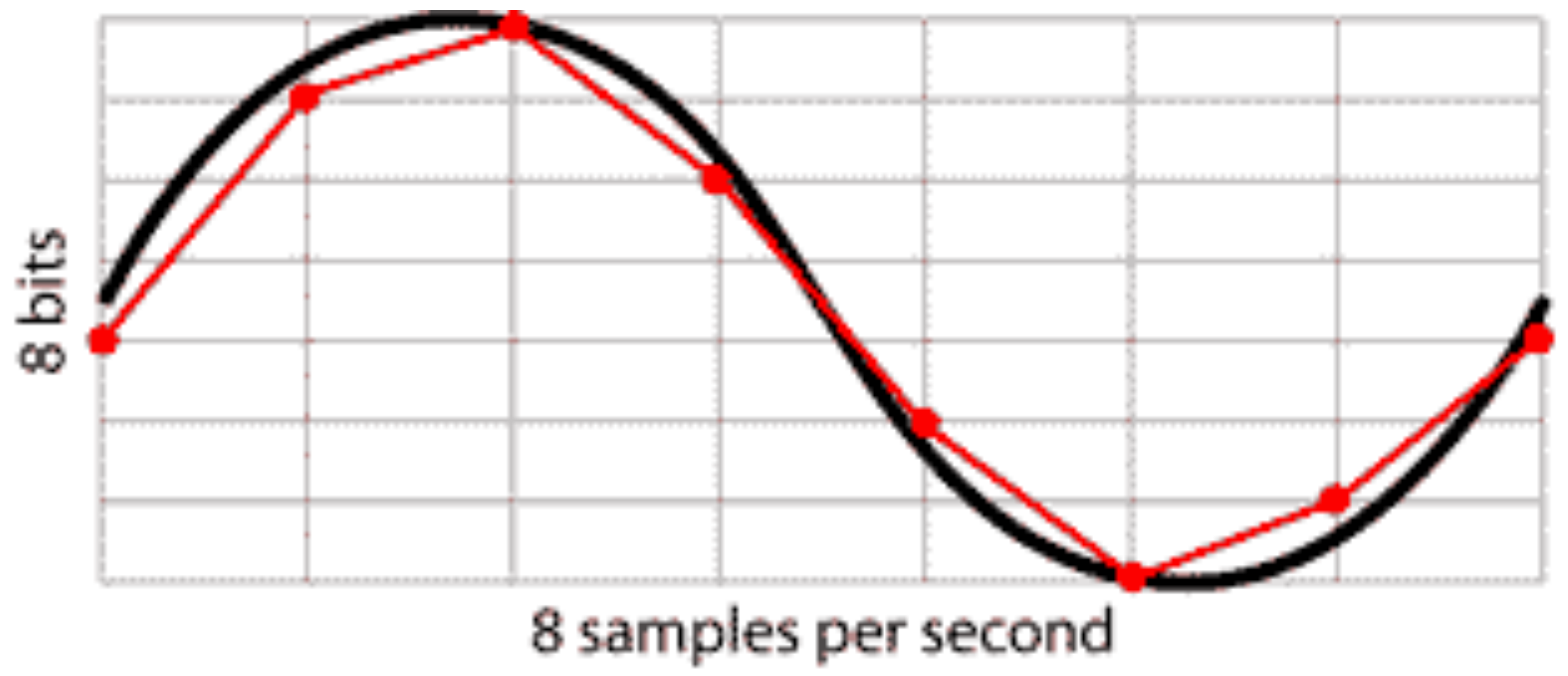
Sampling **quality**.

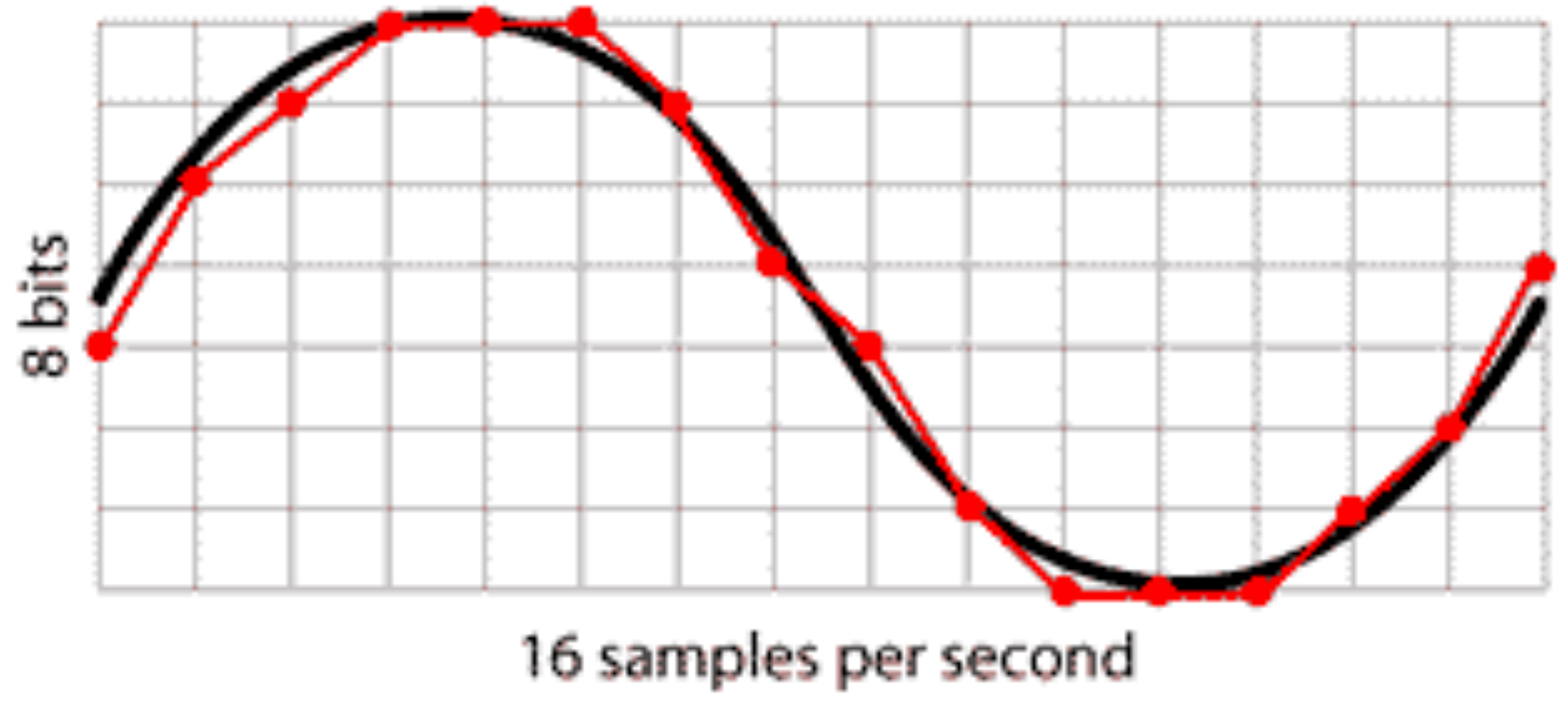
Sample rate and **bits per sample**.


bit depth
sample rate

Sample **rate**.

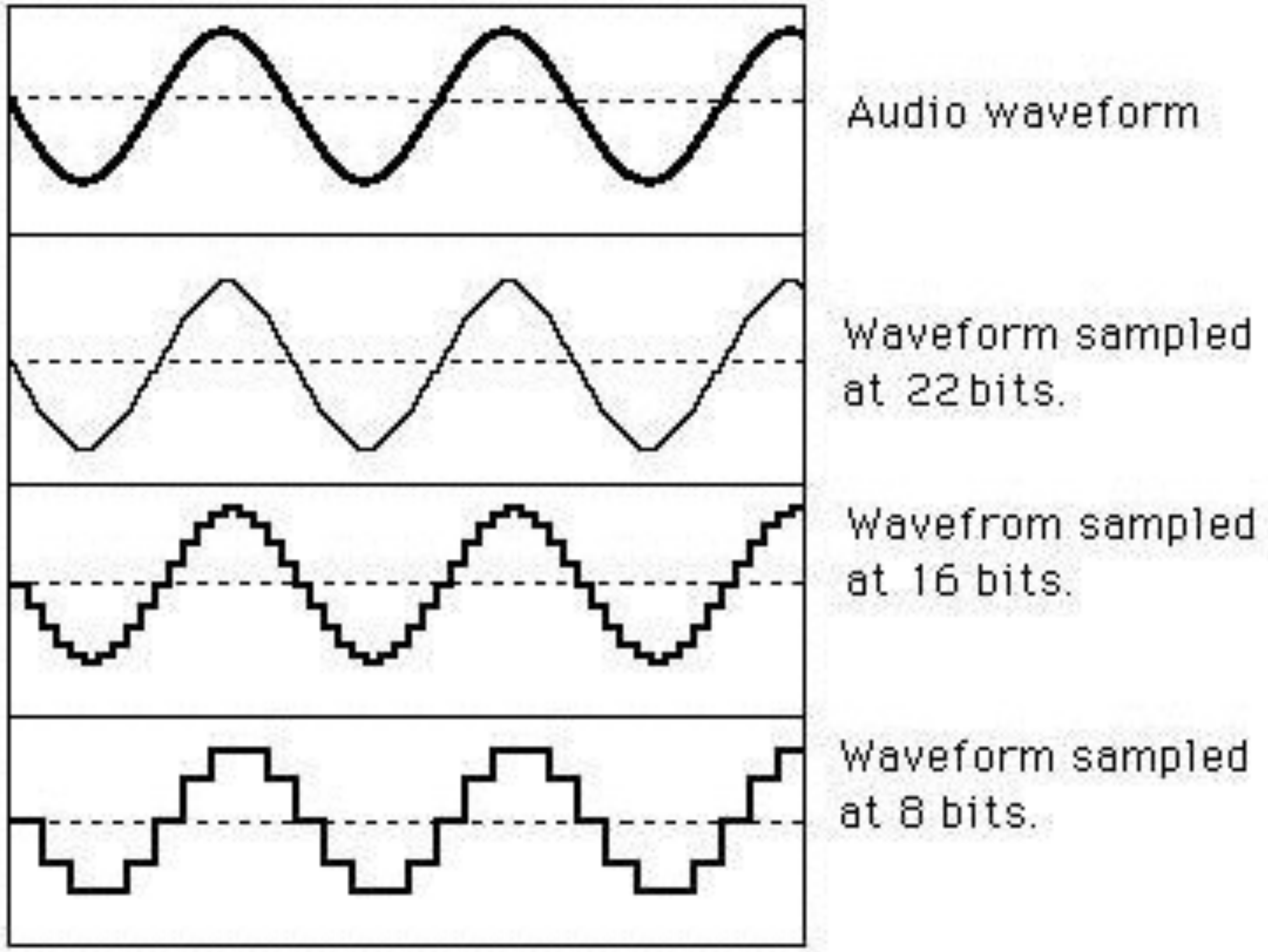
How many **discrete samples per second** (measured in Hz).





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.

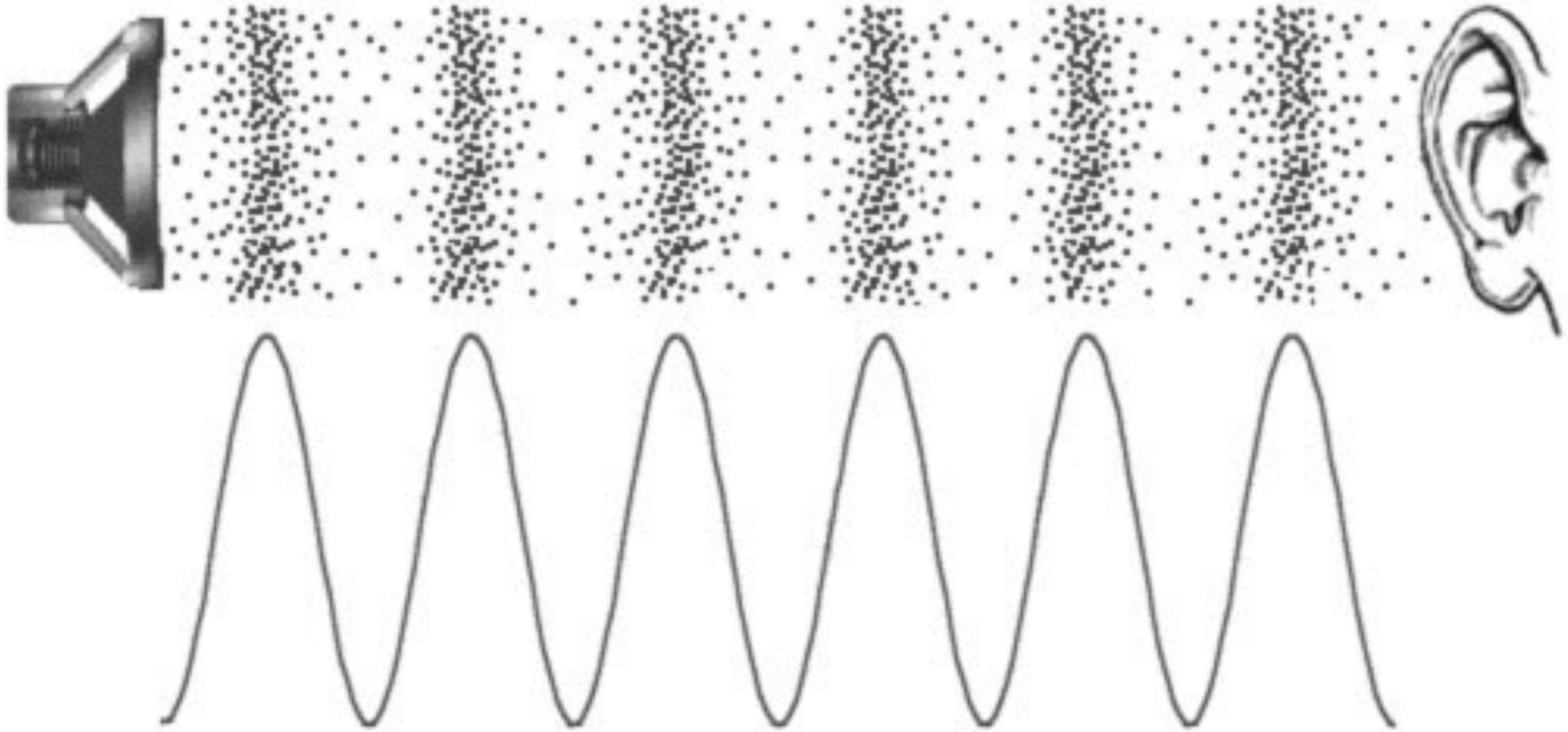
Bitrate.

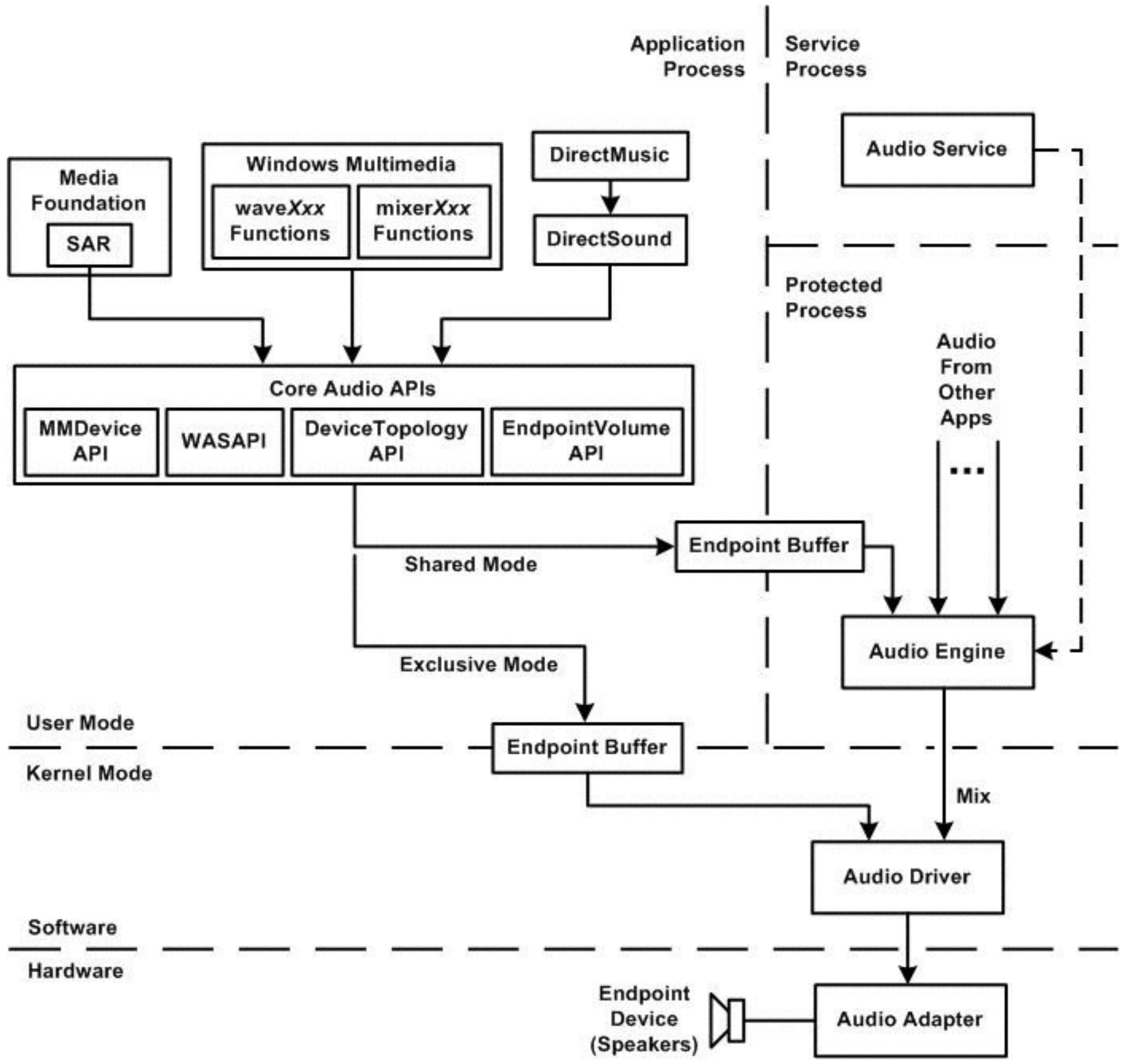
Sampling rate combined with **bit depth**.

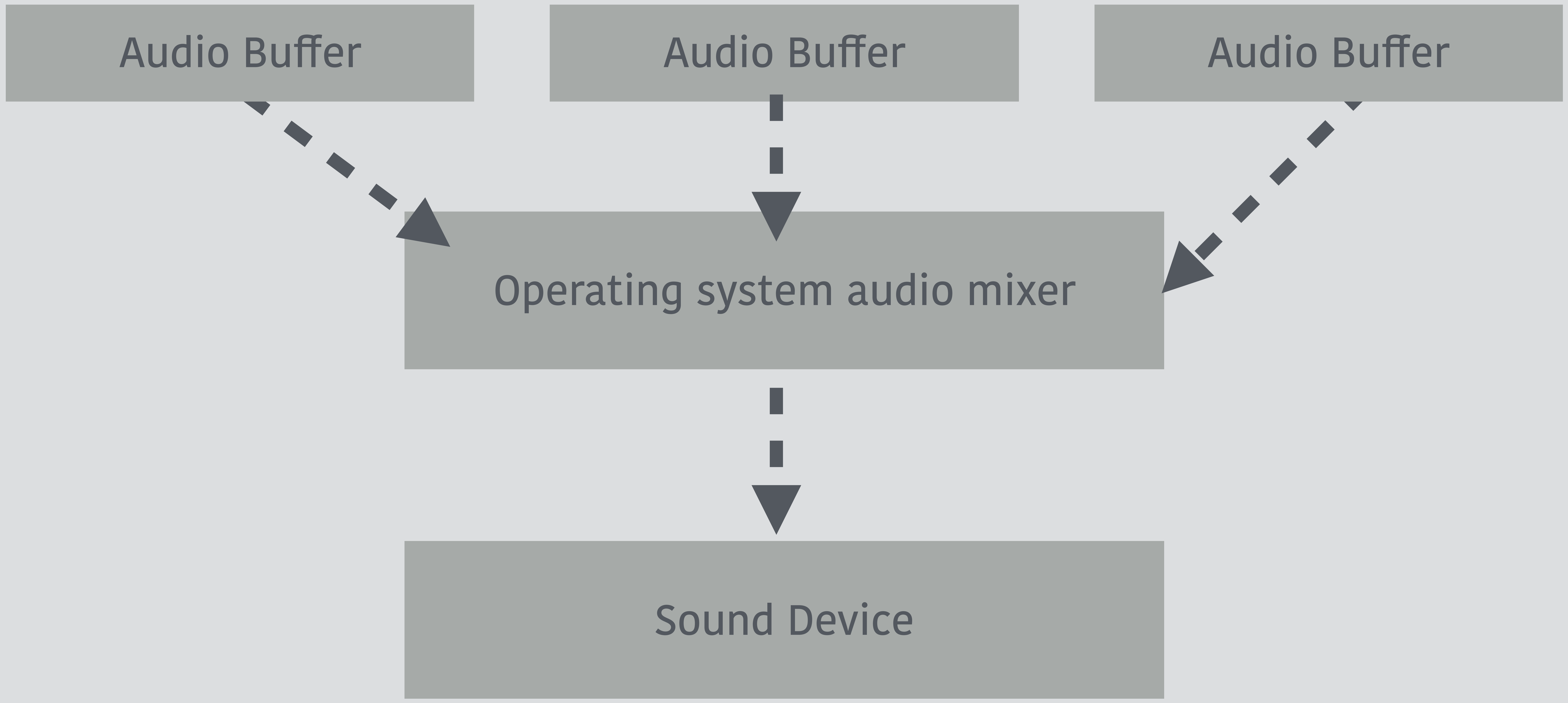
Reflects the **total bit count processed per second**.

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

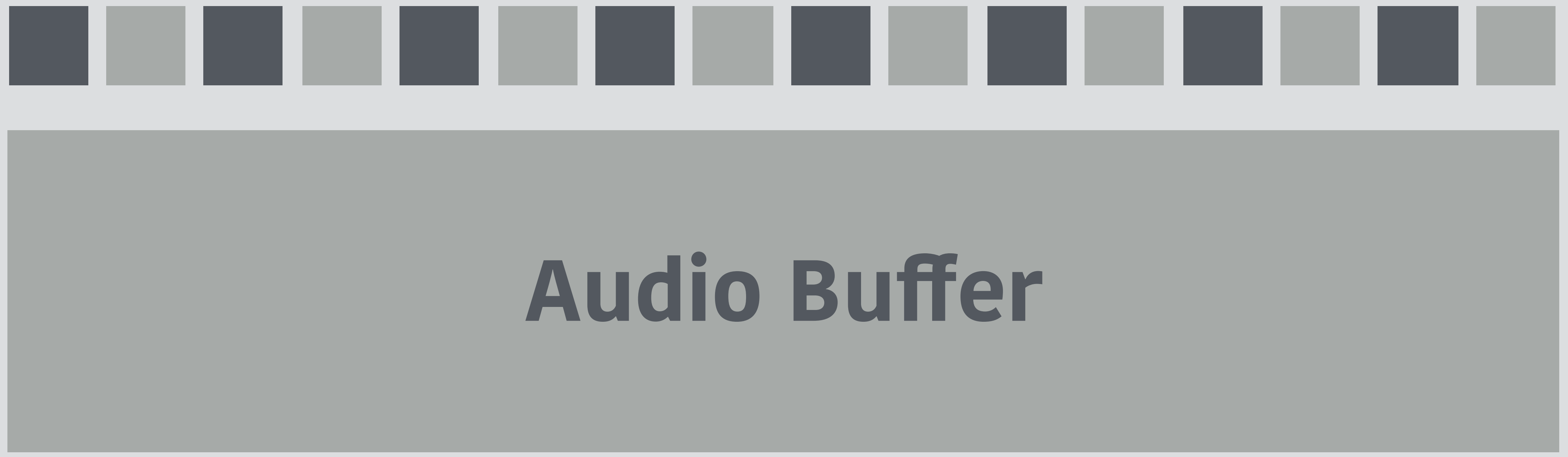
Playing **digital audio**.




Application Process
Service Process
Audio Service
Media Foundation
SAR
Windows Multimedia
waveXxx Functions
mixerXxx Functions
DirectMusic
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.

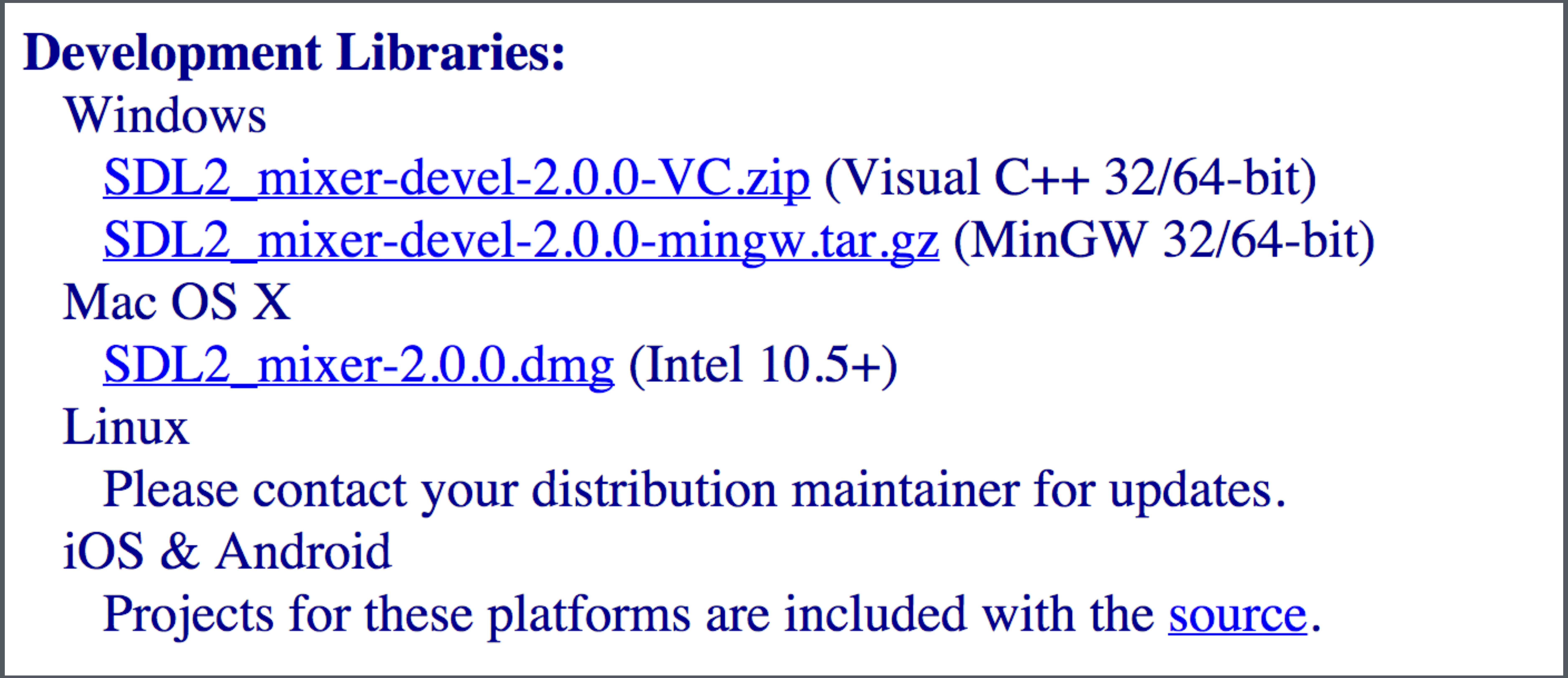


Playing audio with **SDL2**

SDL_mixer (the easy way).

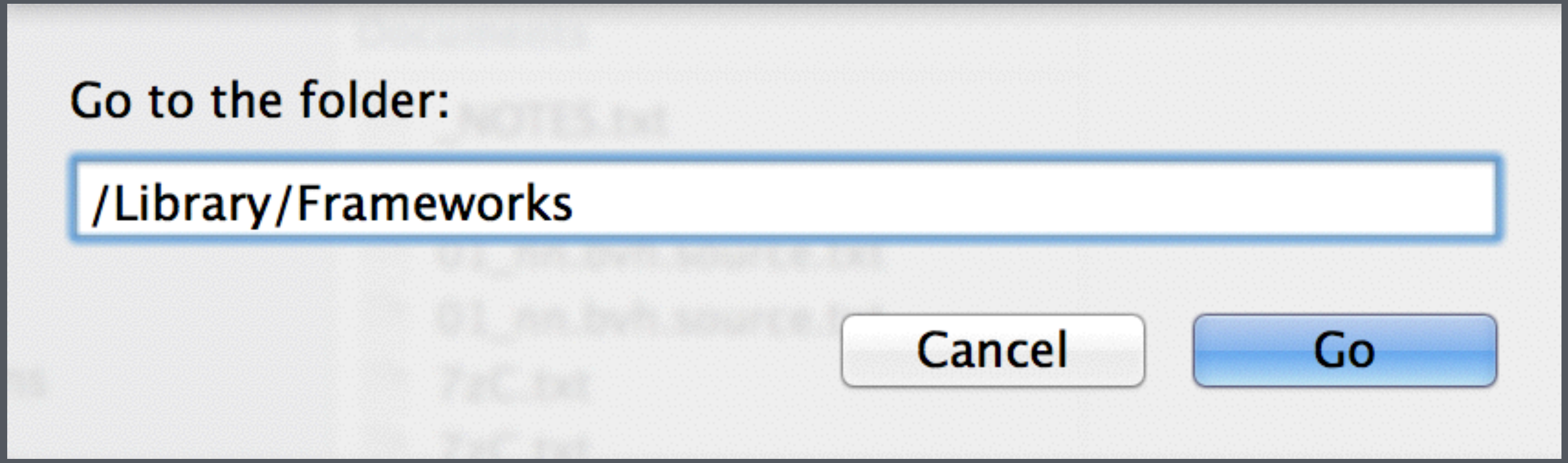
Download SDL_mixer.

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



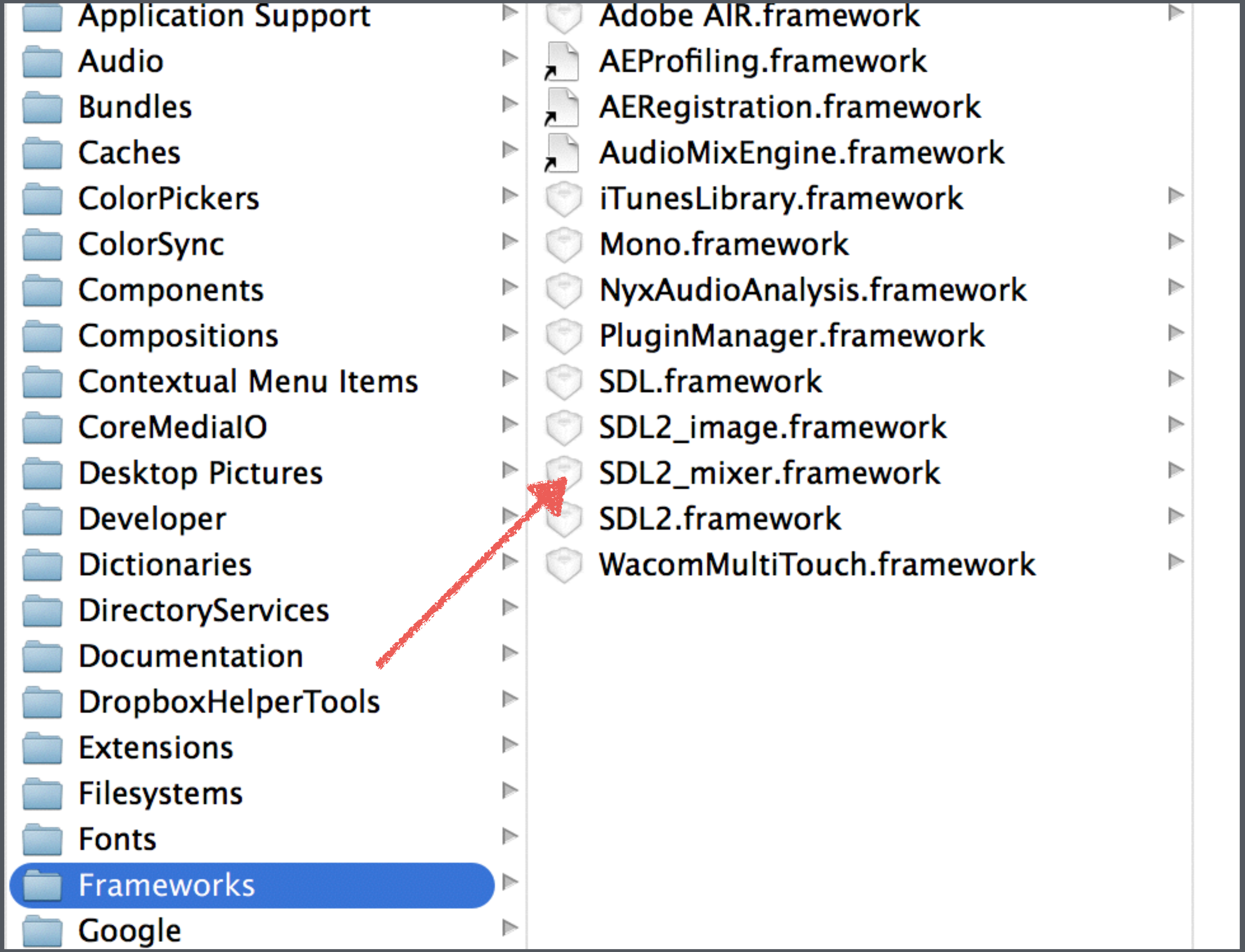
Development Libraries:
Windows
SDL2_mixer-devel-2.0.0-VC.zip (Visual C++ 32/64-bit)
SDL2_mixer-devel-2.0.0-mingw.tar.gz (MinGW 32/64-bit)
Mac OS X
SDL2_mixer-2.0.0.dmg (Intel 10.5+)
Linux
Please contact your distribution maintainer for updates.
iOS & Android
Projects for these platforms are included with the source.

On **Mac**



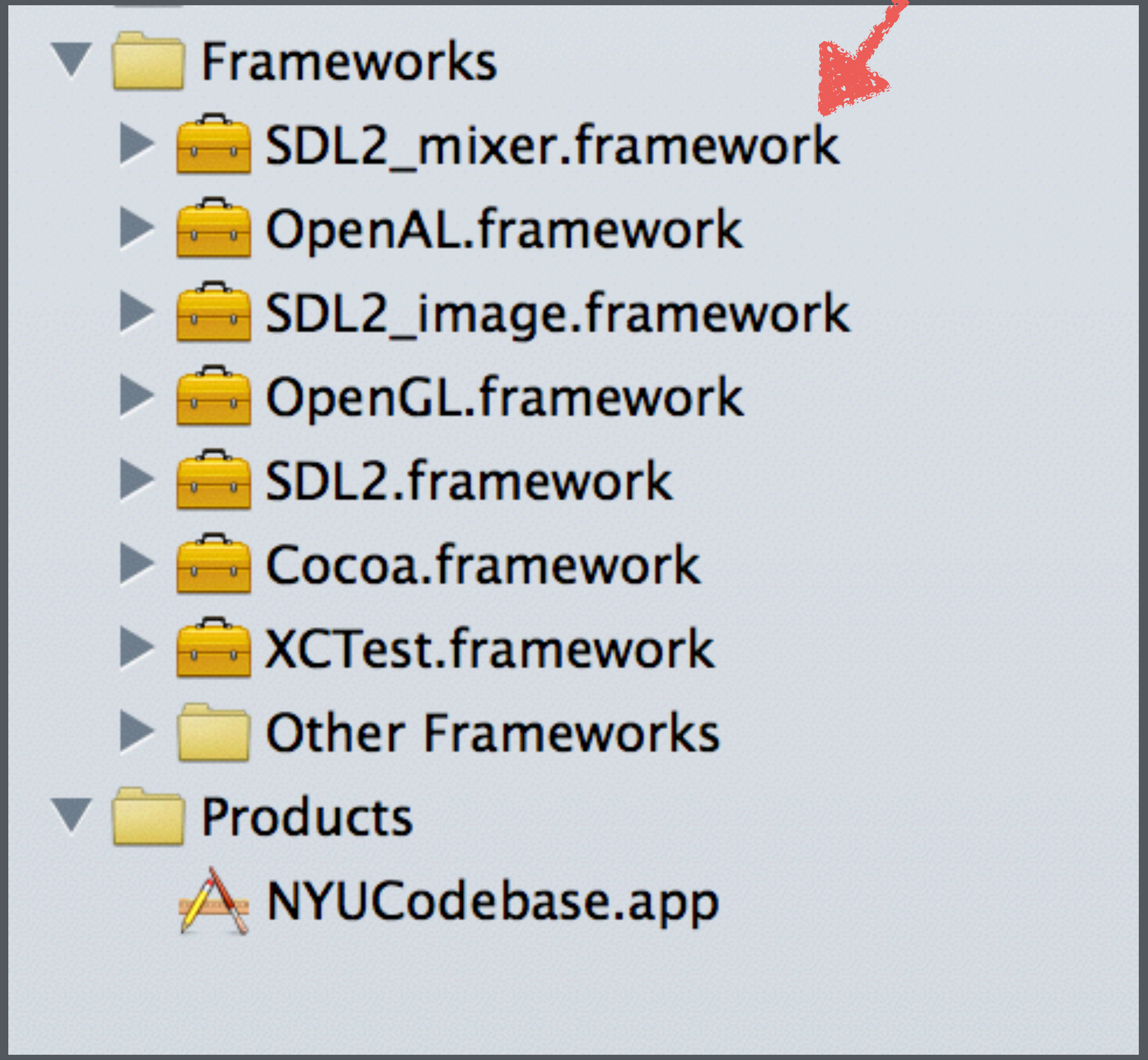
Go to the folder:

/Library/Frameworks

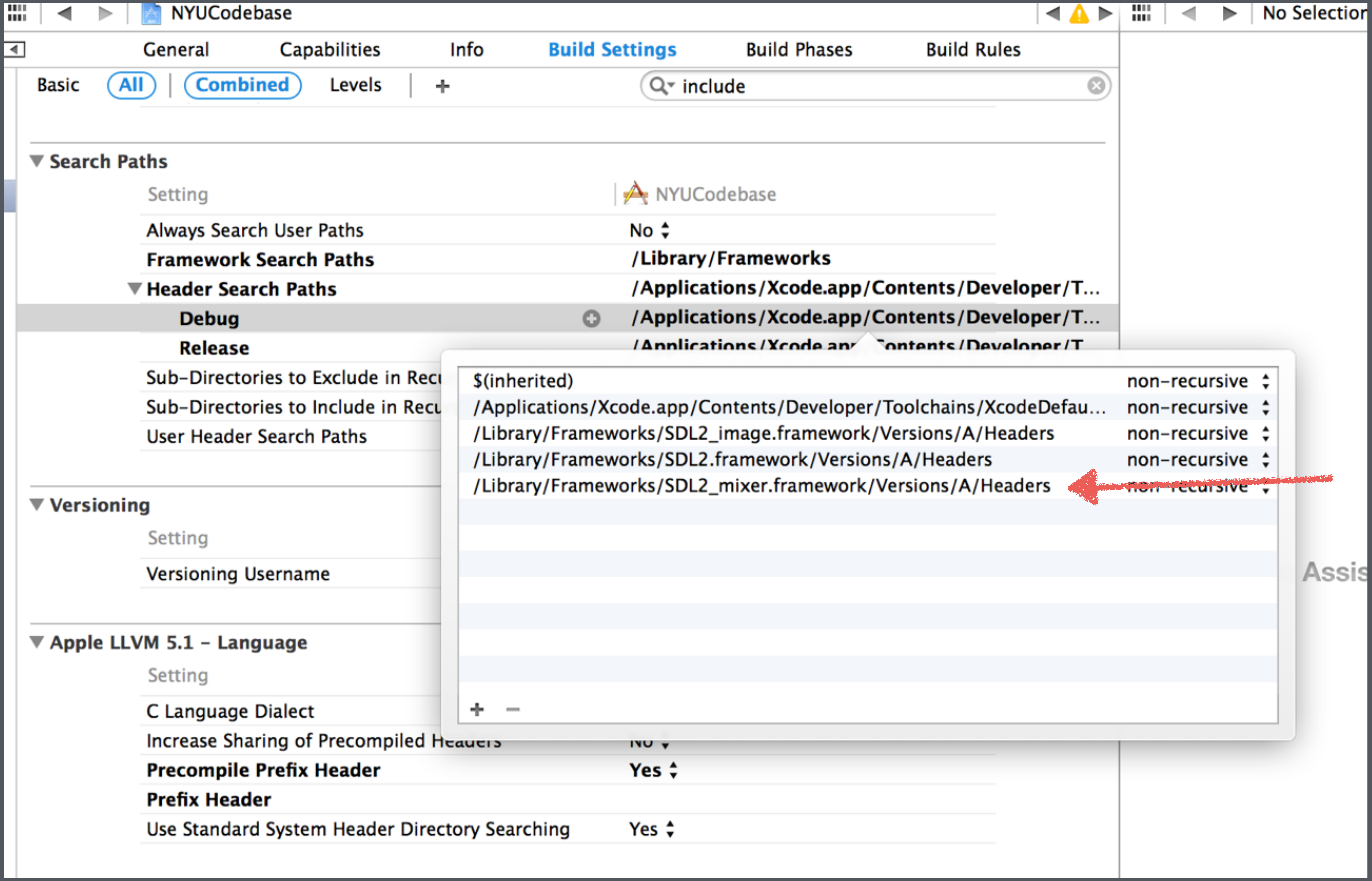


```
Application Support      Adobe AIR.framework
Audio                    AEProfiling.framework
Bundles                  AERegistration.framework
Caches                   AudioMixEngine.framework
ColorPickers             iTunesLibrary.framework
ColorSync                Mono.framework
Components     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

DRAG FROM FINDER



- Frameworks
  - SDL2_mixer.framework
  - OpenAL.framework
  - SDL2_image.framework
  - OpenGL.framework
  - SDL2.framework
  - Cocoa.framework
  - XCTest.framework
  - Other Frameworks
- Products
  - NYUCodebase.app



Search Paths

Setting	NYUCodebase
Always Search User Paths	No
Framework Search Paths	**/Library/Frameworks**
Header Search Paths	**/Applications/Xcode.app/Contents/Developer/T...**
Debug	**/Applications/Xcode.app/Contents/Developer/T...**
Release	**/Applications/Xcode.app/Contents/Developer/T...**
Sub-Directories to Exclude in Recu	
Sub-Directories to Include in Recu	
User Header Search Paths	

$(inherited)	non-recursive
/Applications/Xcode.app/Contents/Developer/Toolchains/XcodeDefau...	non-recursive
/Library/Frameworks/SDL2_image.framework/Versions/A/Headers	non-recursive
/Library/Frameworks/SDL2.framework/Versions/A/Headers	non-recursive
/Library/Frameworks/SDL2_mixer.framework/Versions/A/Headers	non-recursive

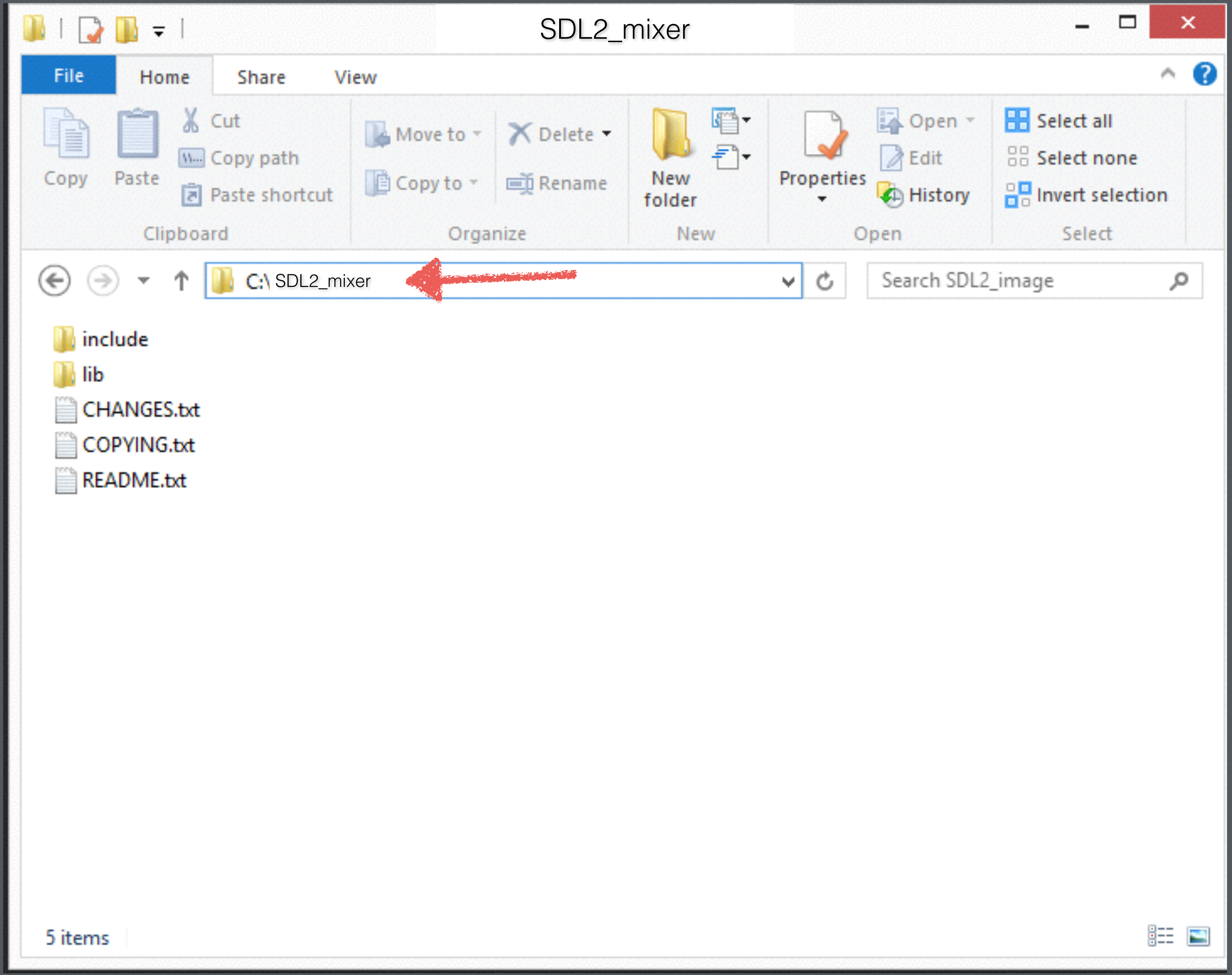
Versioning

Setting	
Versioning Username	

Apple LLVM 5.1 – Language

Setting	
C Language Dialect	
Increase Sharing of Precompiled Headers	No
Precompile Prefix Header	**Yes**
Prefix Header	
Use Standard System Header Directory Searching	Yes

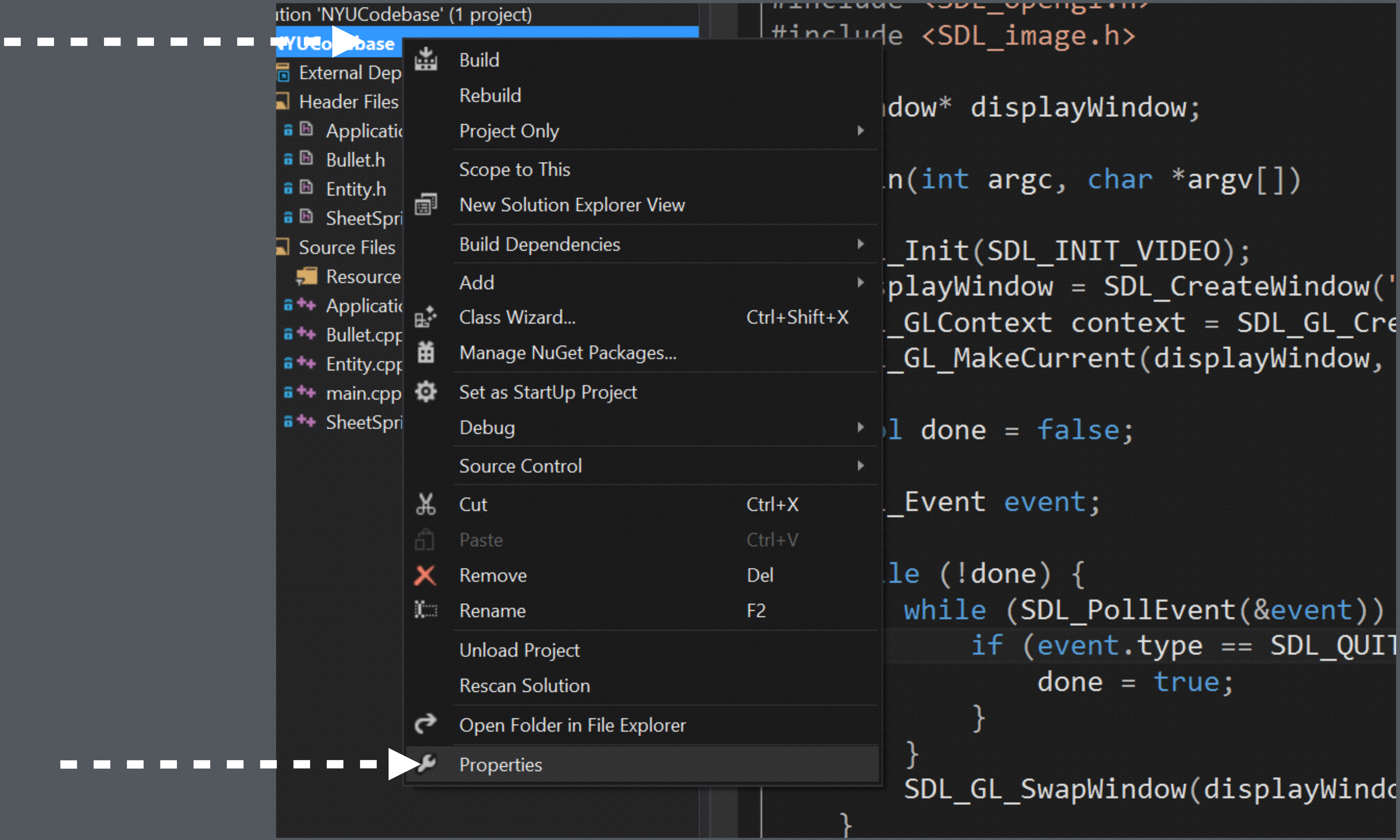
On **Windows**



C:\ SDL2_mixer

include
lib
CHANGES.txt
COPYING.txt
README.txt

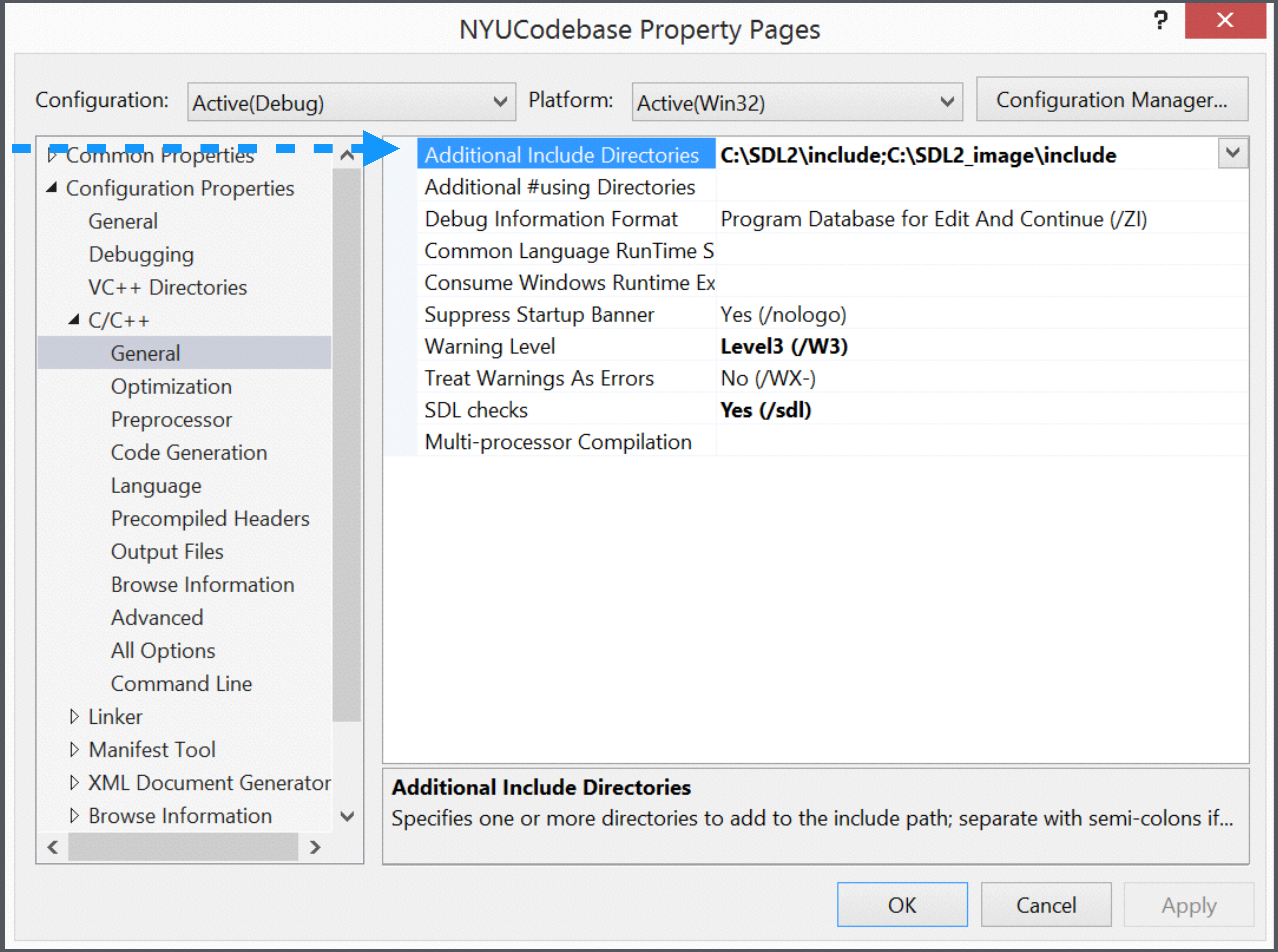
RIGHT CLICK PROJECT



```
#include <SDL_opengl.h>
#include <SDL_image.h>

dow* displayWindow;

n(int argc, char *argv[])

_Init(SDL_INIT_VIDEO);
playWindow = SDL_CreateWindow('
_GLContext context = SDL_GL_Cre
_GL_MakeCurrent(displayWindow,

l done = false;

_Event event;

le (!done) {
    while (SDL_PollEvent(&event))
        if (event.type == SDL_QUIT
            done = true;
        }
    }
    SDL_GL_SwapWindow(displayWindo
}
```

GO TO PROPERTIES

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

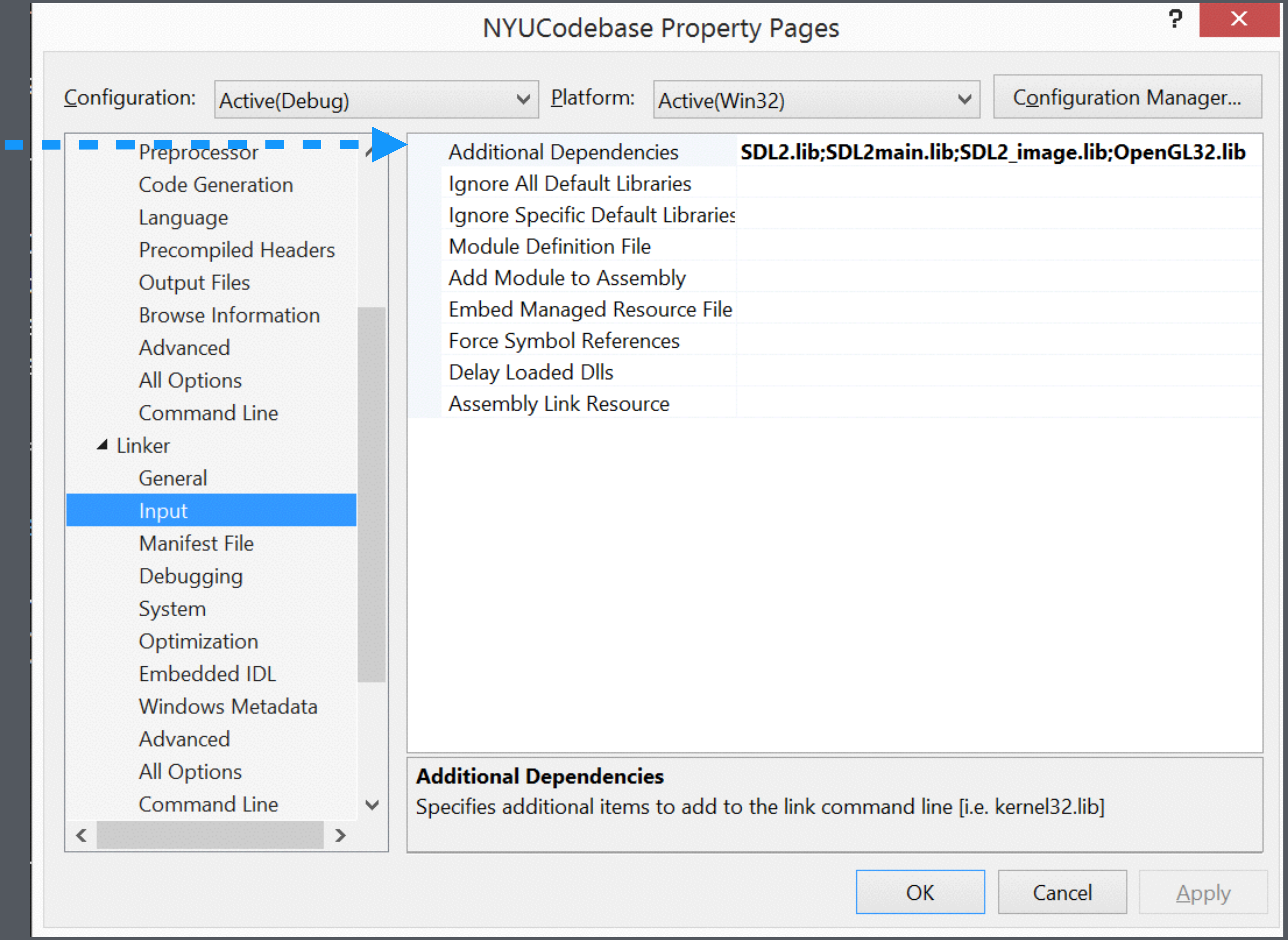

NYUCodebase Property Pages

Configuration: Active(Debug) Platform: Active(Win32) Configuration Manager...

Additional Include Directories	C:\SDL2\include;C:\SDL2_image\include
Additional #using Directories	
Debug Information Format	Program Database for Edit And Continue (/ZI)
Common Language RunTime S	
Consume Windows Runtime Ex	
Suppress Startup Banner	Yes (/nologo)
Warning Level	Level3 (/W3)
Treat Warnings As Errors	No (/WX-)
SDL checks	Yes (/sdl)
Multi-processor Compilation	

Additional Include Directories
Specifies one or more directories to add to the include path; separate with semi-colons if...

ADD **SDL2_mixer.lib** to additional dependencies



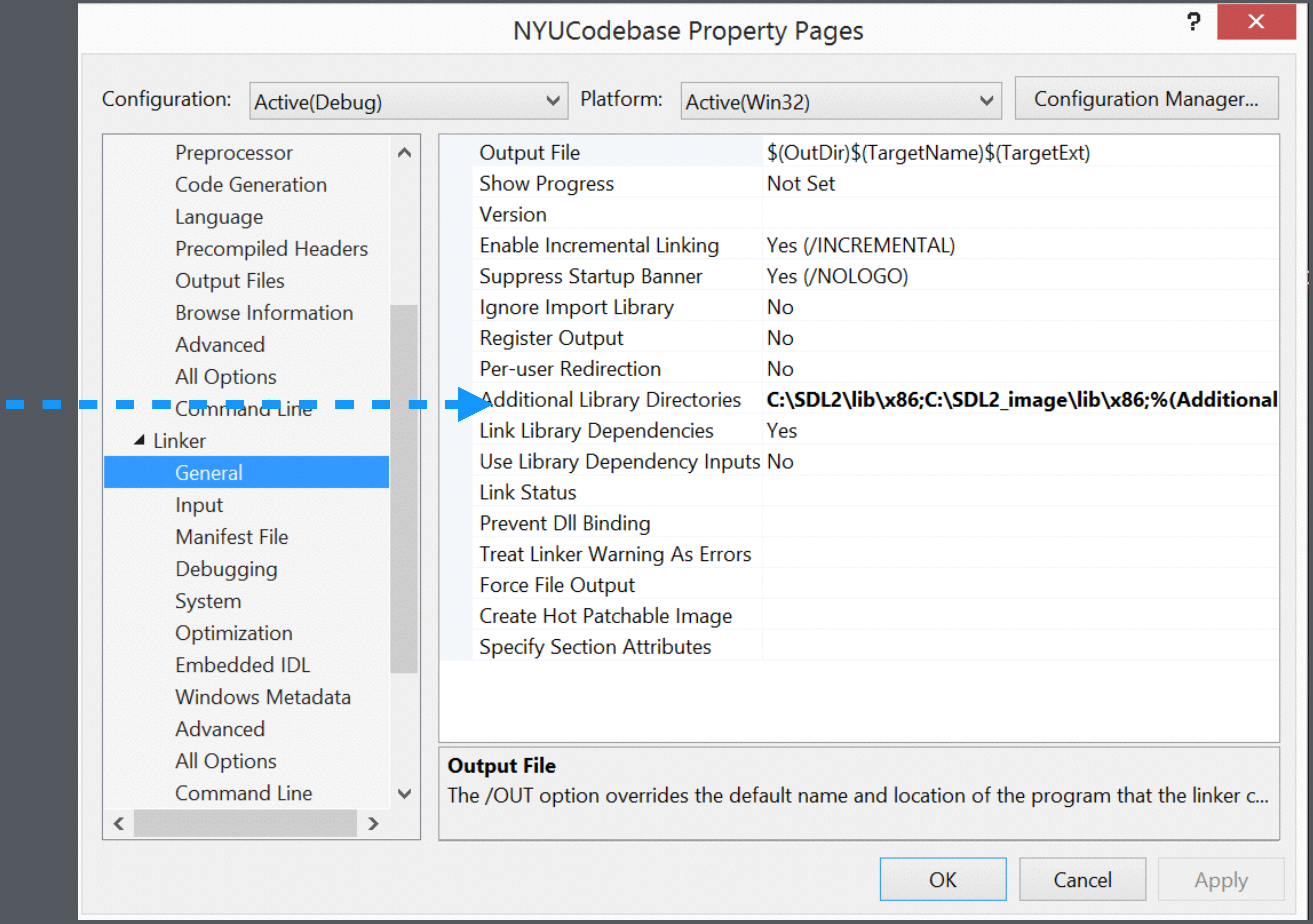
NYUCodebase Property Pages

Configuration: Active(Debug) Platform: Active(Win32) Configuration Manager...

Additional Dependencies	**SDL2.lib;SDL2main.lib;SDL2_image.lib;OpenGL32.lib**
Ignore All Default Libraries	
Ignore Specific Default Libraries	
Module Definition File	
Add Module to Assembly	
Embed Managed Resource File	
Force Symbol References	
Delay Loaded Dlls	
Assembly Link Resource	

Additional Dependencies
Specifies additional items to add to the link command line [i.e. kernel32.lib]

Add **C:\SDL_mixer\lib\x86** to additional library directories



NYUCodebase Property Pages

Configuration: Active(Debug) Platform: Active(Win32) Configuration Manager...

Output File	$(OutDir)$(TargetName)$(TargetExt)
Show Progress	Not Set
Version	
Enable Incremental Linking	Yes (/INCREMENTAL)
Suppress Startup Banner	Yes (/NOLOGO)
Ignore Import Library	No
Register Output	No
Per-user Redirection	No
Additional Library Directories	**C:\SDL2\lib\x86;C:\SDL2_image\lib\x86;%(Additional**
Link Library Dependencies	Yes
Use Library Dependency Inputs	No
Link Status	
Prevent Dll Binding	
Treat Linker Warning As Errors	
Force File Output	
Create Hot Patchable Image	
Specify Section Attributes	

Output File
The /OUT option overrides the default name and location of the program that the linker c...

Do the same thing for both **Release** and **Debug** configurations.

Copy all DLL files from C**:\SDL_mixer\lib\x86** 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.

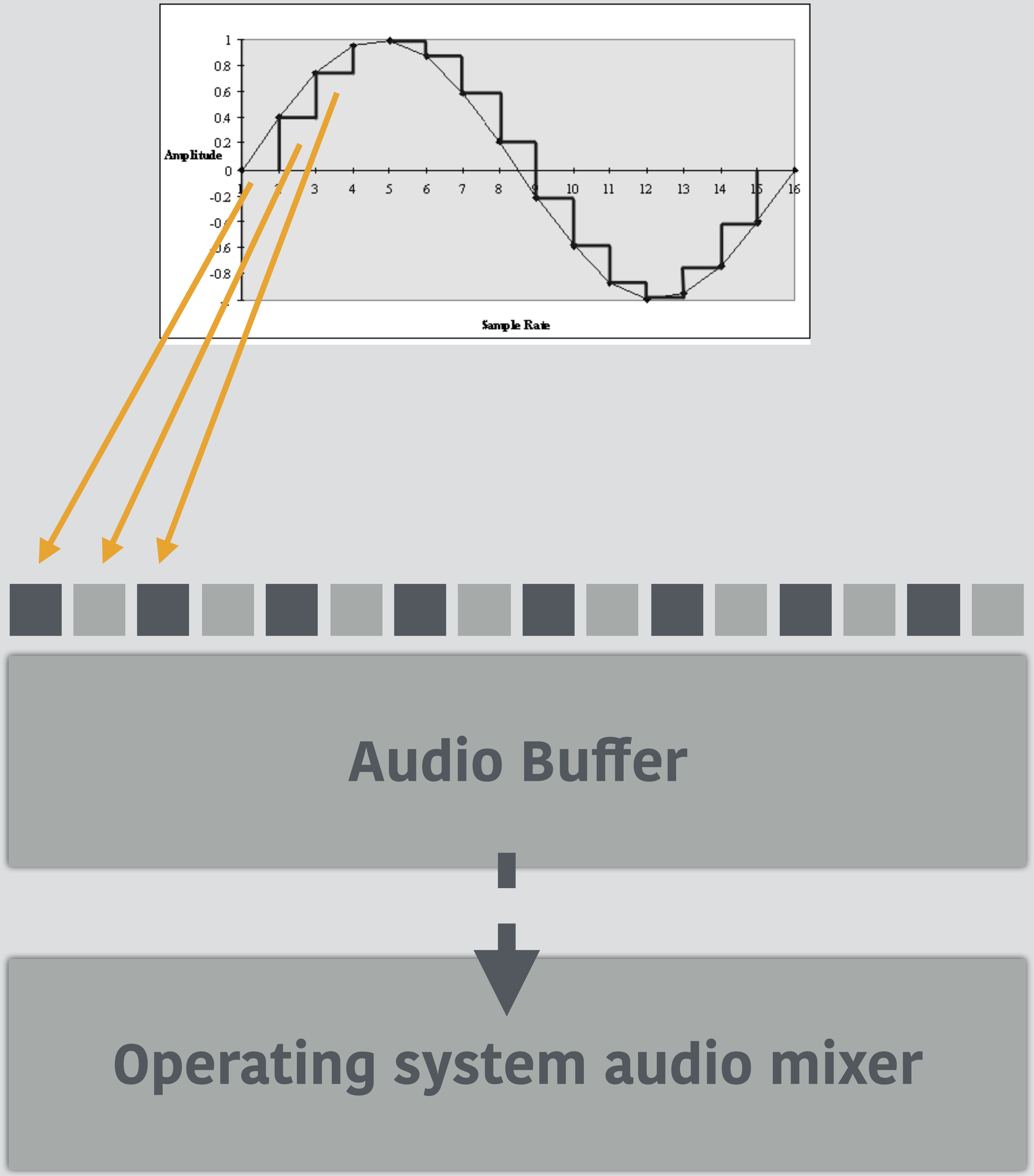
```
Mix_PlayMusic(music, -1);
```

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).


Amplitude
Sample Rate
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.

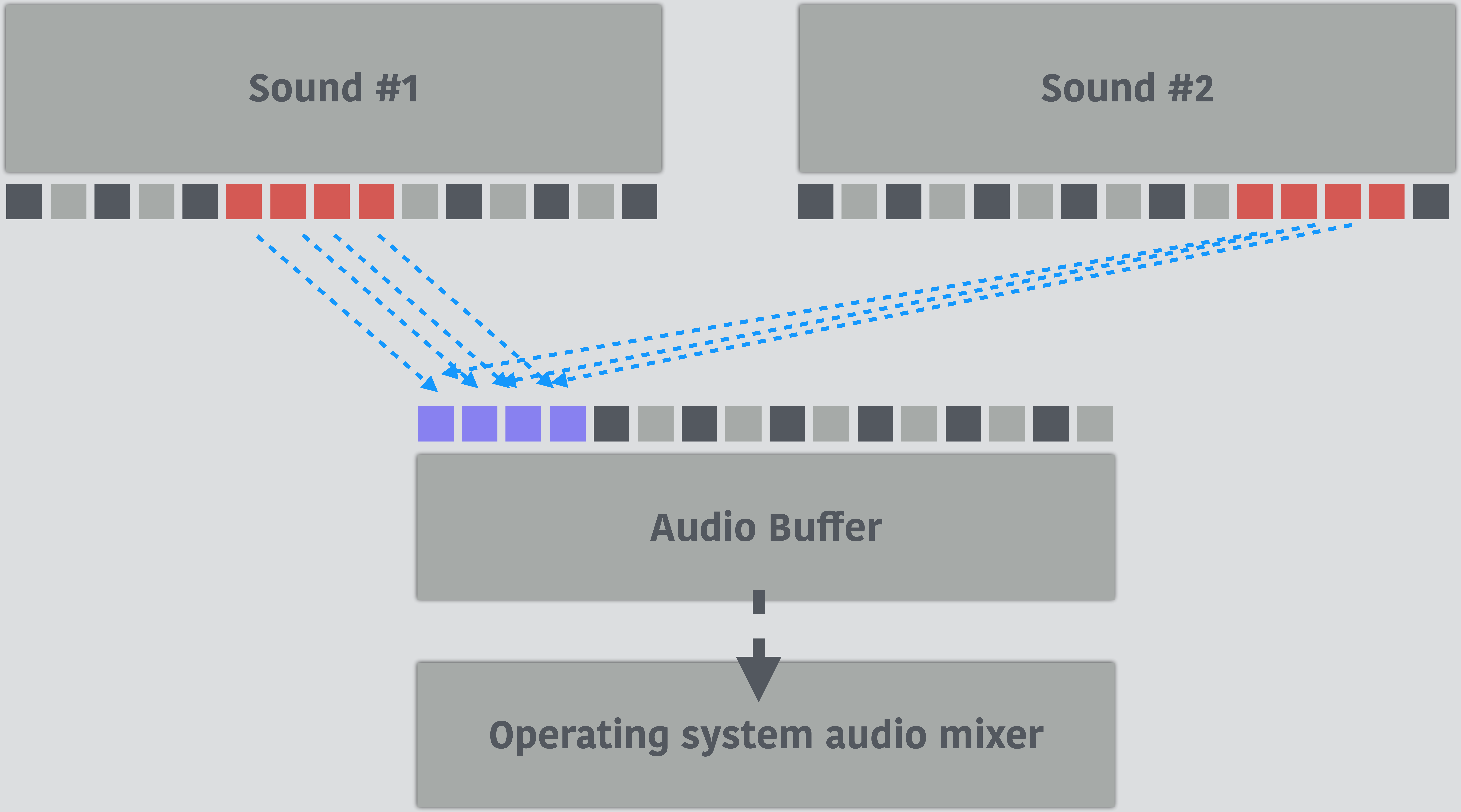
```
    SDL_AudioSpec deviceSpec;
    deviceSpec.freq = 44100; // sampling rate (samples a second)
    deviceSpec.format = AUDIO_F32; // audio format
    deviceSpec.channels = 1; // how many channels (1 = mono, 2 = stereo)
    deviceSpec.samples = 512; // audio buffer size in samples (power of 2)
  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

```
float mixSamples(float A, float B) {
    if (A < 0 && B < 0 ) {
        return  (A + B) - (A * B)/-1.0;
    } else if (A > 0 && B > 0 ) {
        return (A + B) - (A * B)/1.0;
    } else {
        return A + B;
    }
}

void DemoApp::appAudioCallback(void *userdata, Uint8 *stream, int len) {
    ClassDemoApp *app = (DemoApp*) userdata;
    memset(stream, 0, len);

    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);
                ((float*)stream)[s] = mixSamples(((float*)stream)[s],(sourceBuffer[s] * sound->volume));
            }
            sound->offset += len;
            if(sound->offset >= sound->length-len) {
                if(sound->loop) {
                    sound->offset = 0;
                } else {
                    sound->playing = false;
                }
            }
        }
    }
}
```

```
deviceSpec.callback = DemoApp::appAudioCallback;
deviceSpec.userdata = (void*)this;
```

Playing a sound.

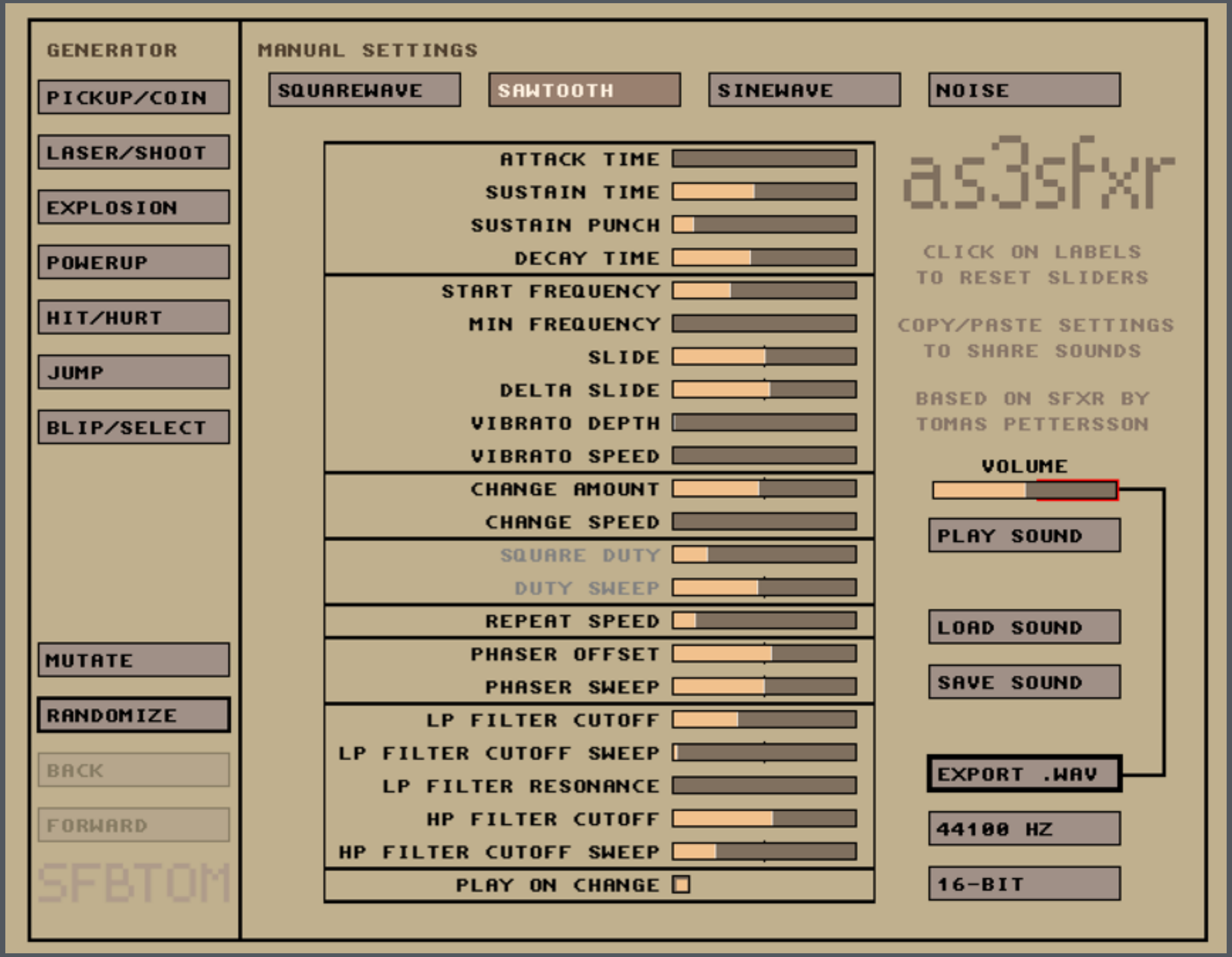
```
void DemoApp::playSound(int soundIndex, bool loop) {
    if(soundIndex >= 0 && soundIndex < mixerSounds.size()) {
        mixerSounds[soundIndex].playing = true;
        mixerSounds[soundIndex].offset = 0;
        mixerSounds[soundIndex].loop = loop;
    }
}
```

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

Sound **resources**.

SFXR

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



CLICK ON LABELS TO RESET SLIDERS

COPY/PASTE SETTINGS TO SHARE SOUNDS

BASED ON SFXR BY TOMAS PETTERSSON

Free Music Archive

http://freemusicarchive.org/

Assignment.

- Add **sound** and **music** to a previous game.
- Start thinking about your **final project**.