# Audacity for Sound

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# Objectives

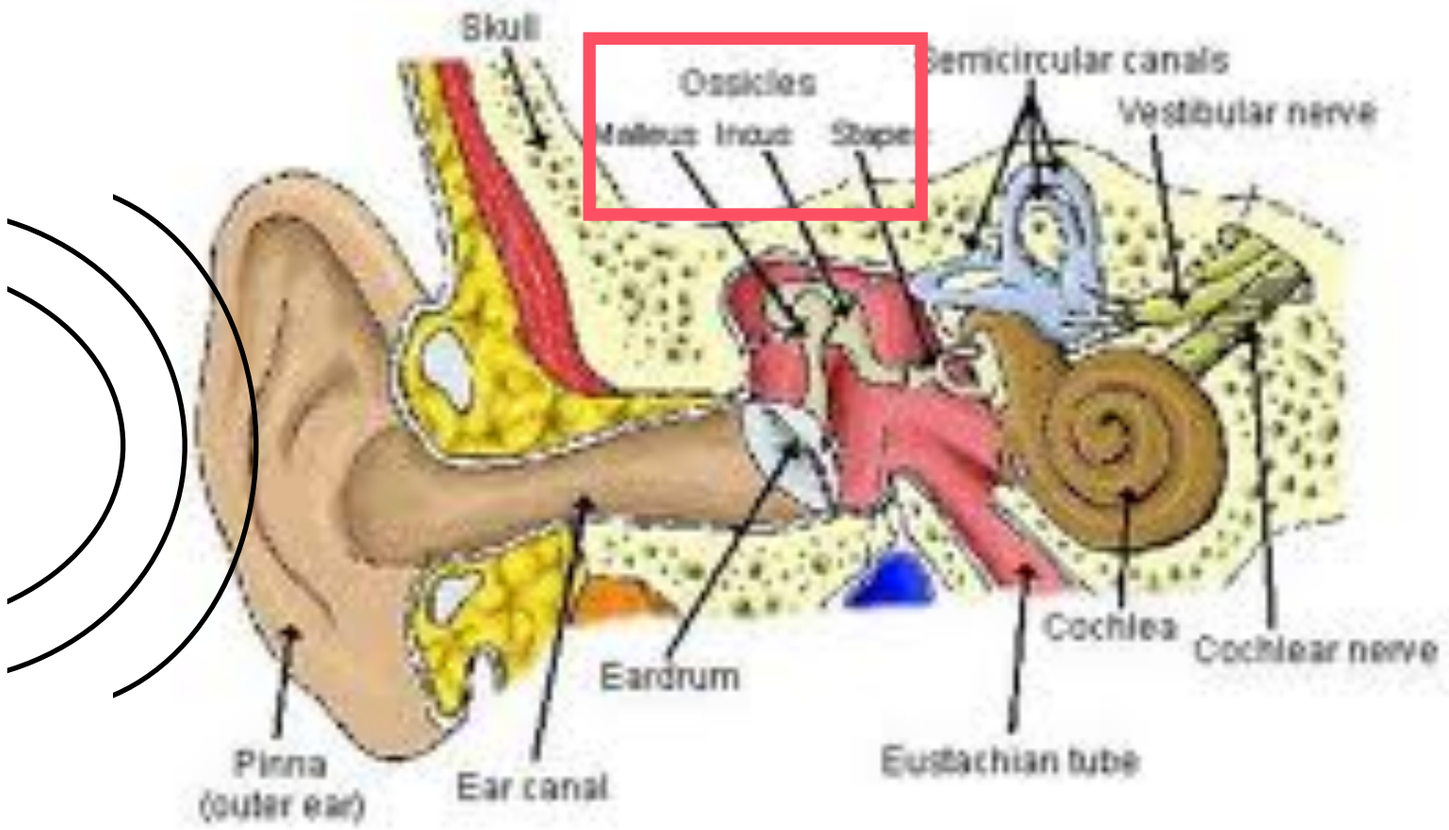
- Explain sound in heuristic terms
  - What characterizes sound?
  - What is the shape of a sound wave?
- Introduction to Audacity
- Sound manipulation in Audacity
- Reading a sound file into R
  - what libraries are required to work with sound in R?

# What is sound?

http://psychology.wikia.com/wiki/Sound

- Sound is produced when pressure waves hit your air-drum
- The characteristics of these pressure waves produce the specific sound heard
  - the shape of the inner ear further changes the way one hears the sound

# The Ear



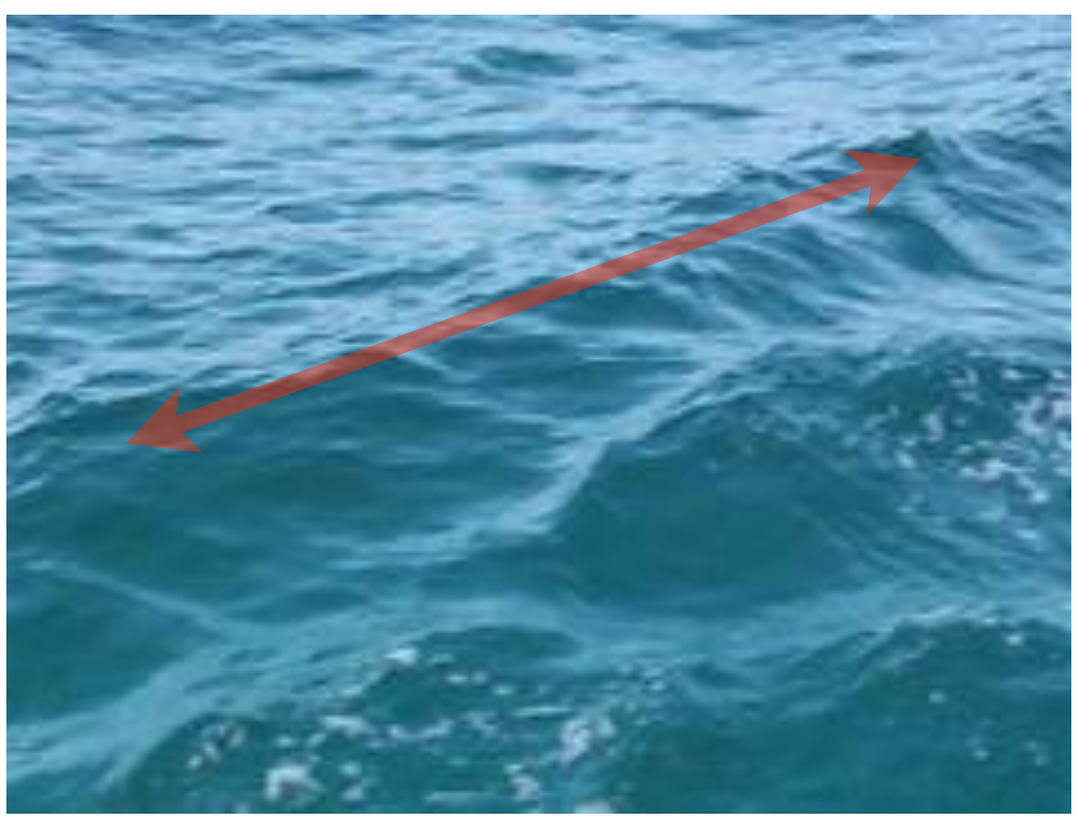

Sound waves make eardrum vibrate

Eardrum communicates vibration to three **bones**

Bone vibration is transferred to auditory nerve, which sends the information to the brain to be interpreted

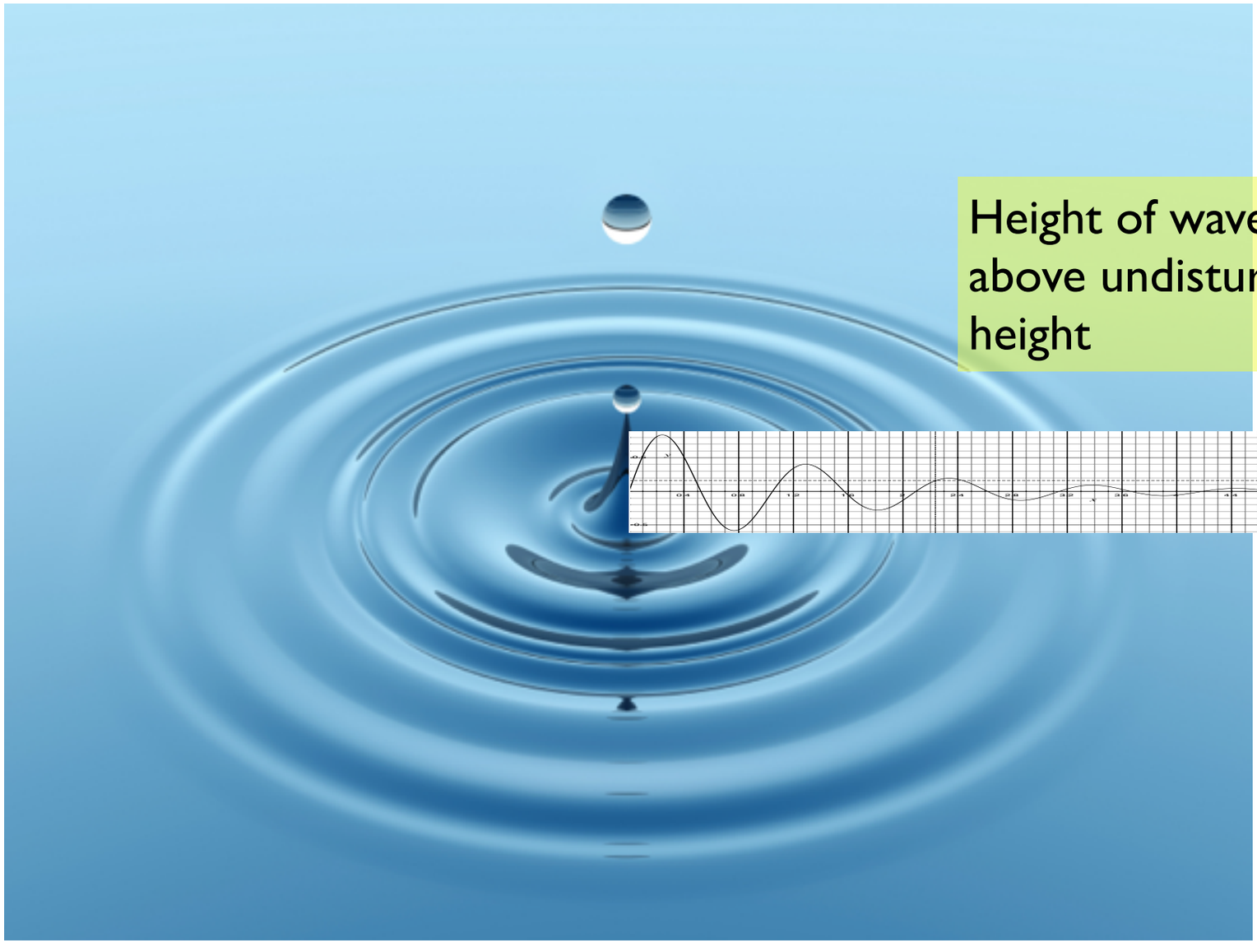
# Water waves

Linear waves

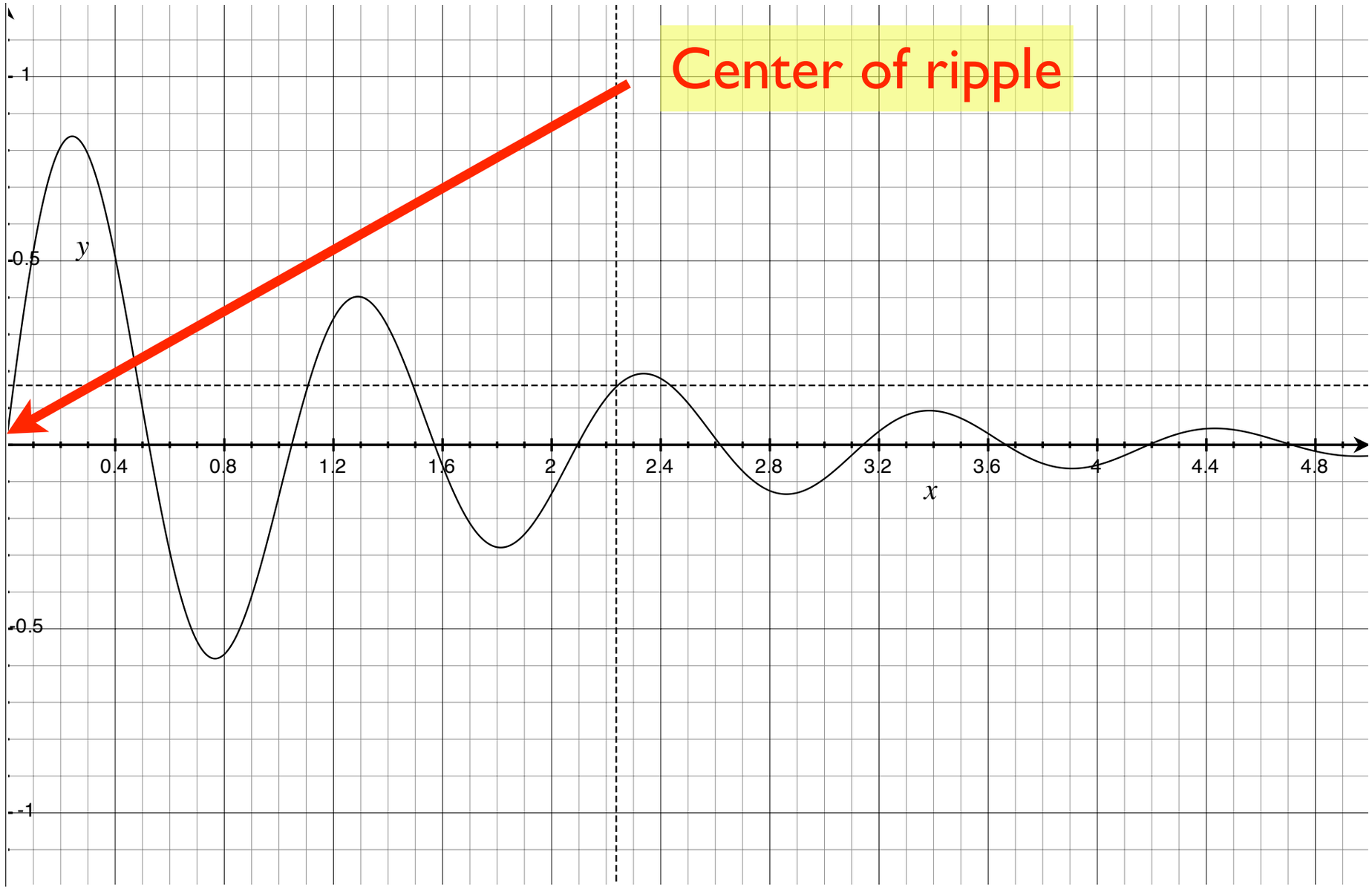


Circular waves

# Ripple generator
## point source



# Cross-section of ripple

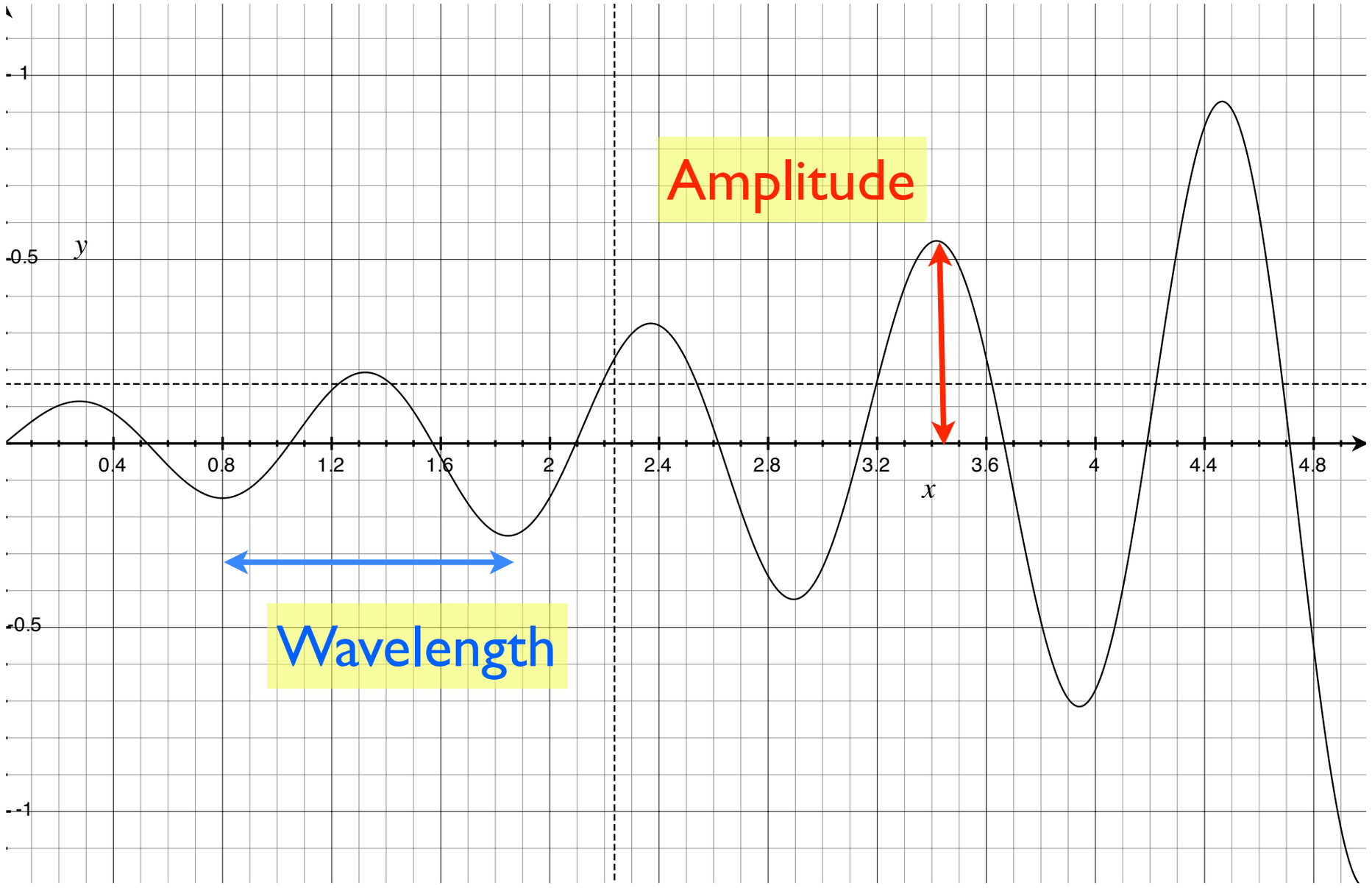


# Sound versus water waves

- Wave properties are characterized by the variation of pressure in the atmosphere (sound) or in water (ripples).

- What are the main characteristics of a sound wave?
  - frequency / wavelength / pitch
  - amplitude

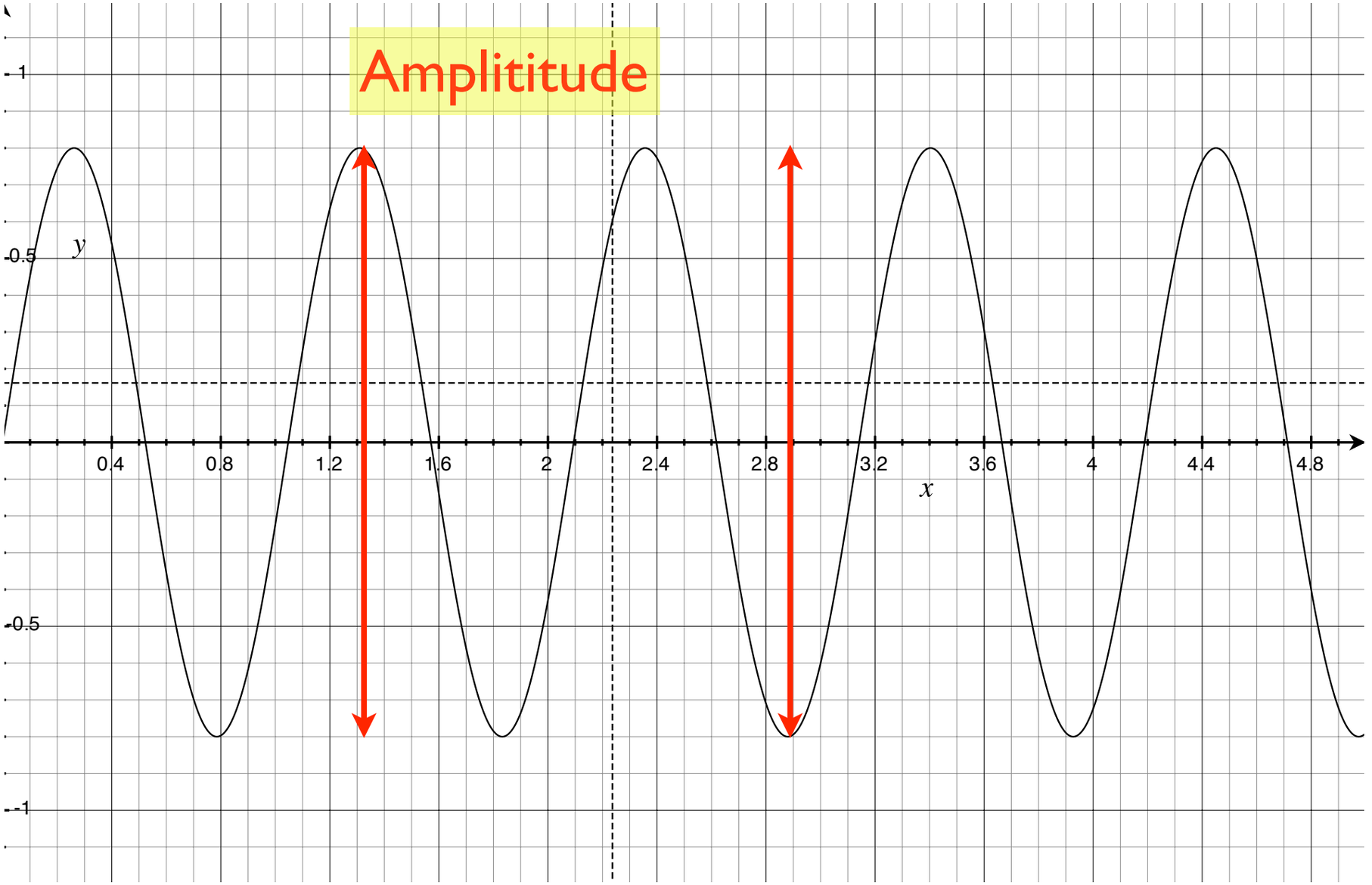
# Increasing amplitude



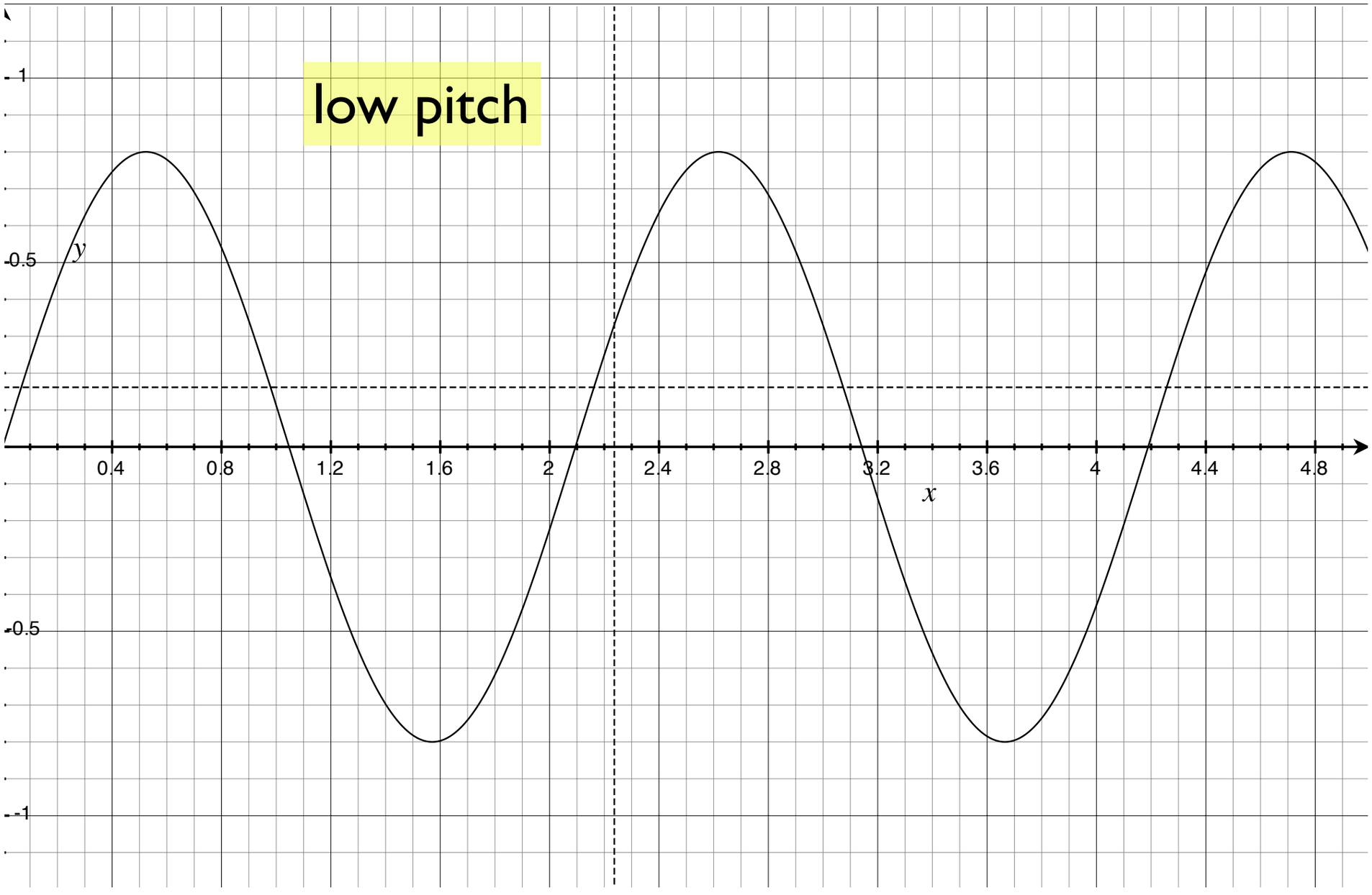
# Increasing volume

- Higher volume
  - increasing wave amplitude
- Lower volume
  - decreasing wave amplitude
- Higher pitch
  - ambulance coming towards me
  - higher wave frequency, shorter wavelength
- Lower pitch
  - ambulance moving away from me
  - lower wave frequency, higher wavelength

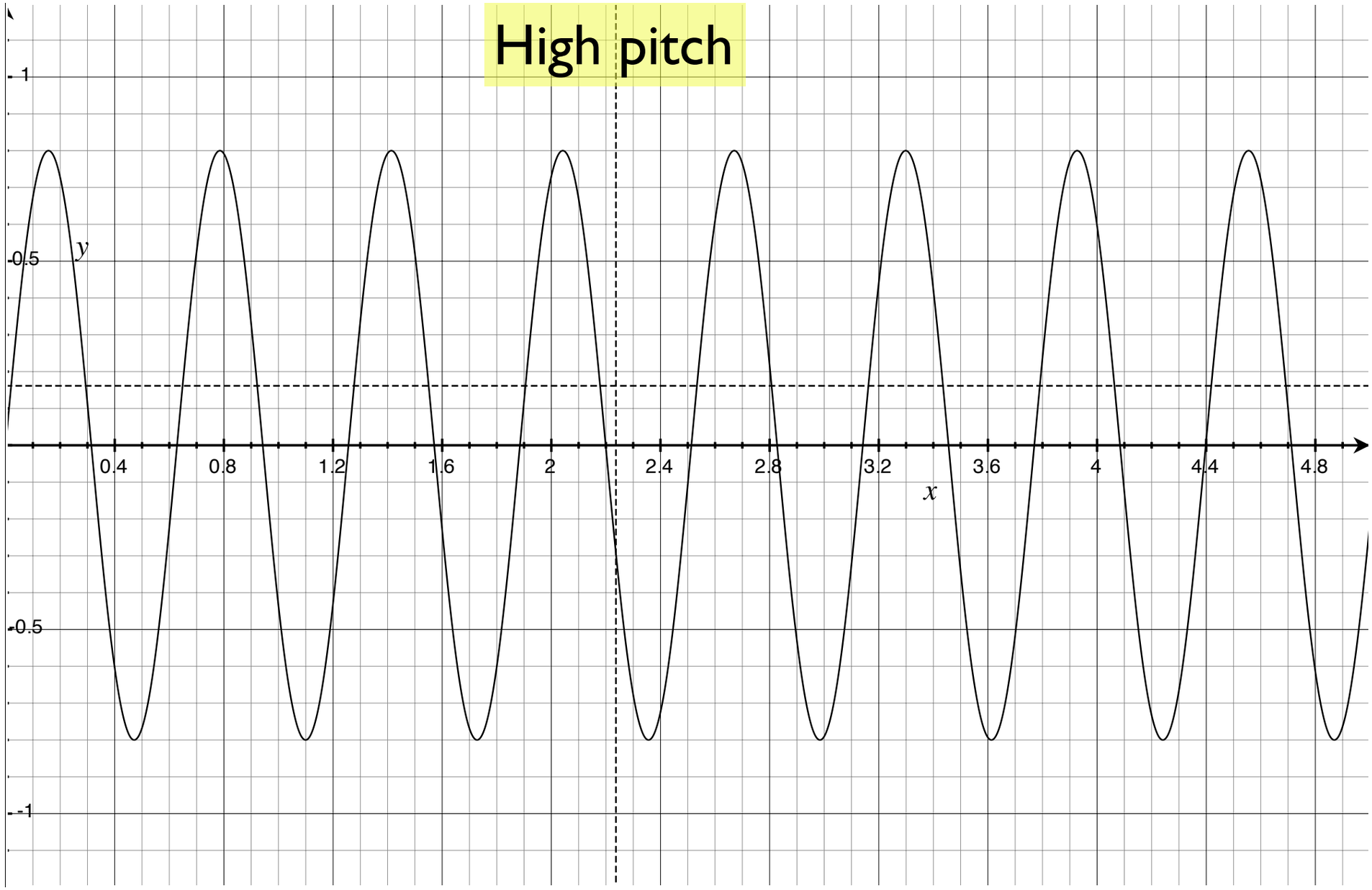
# Fixed Amplitude



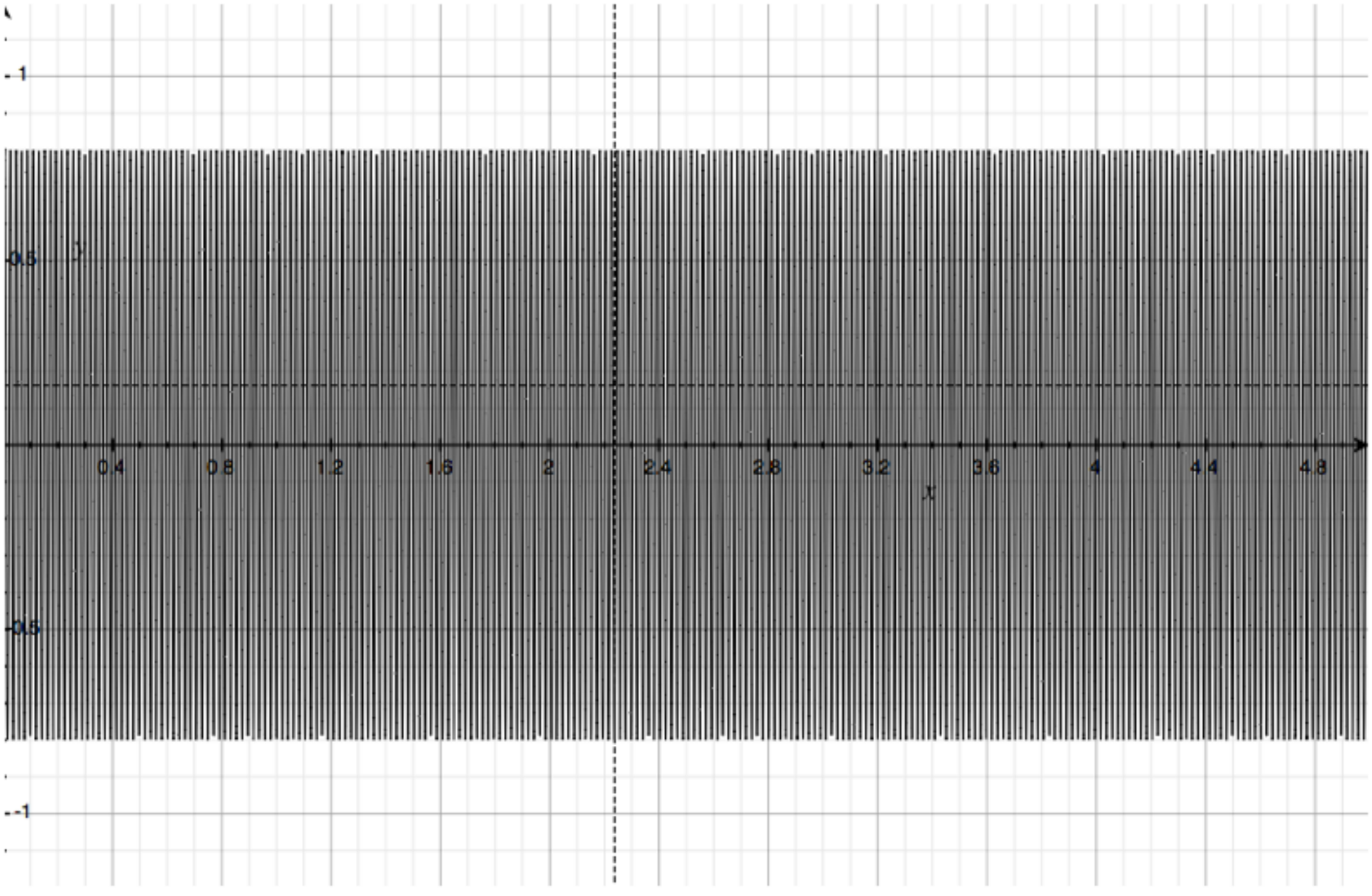
# Low frequency wave



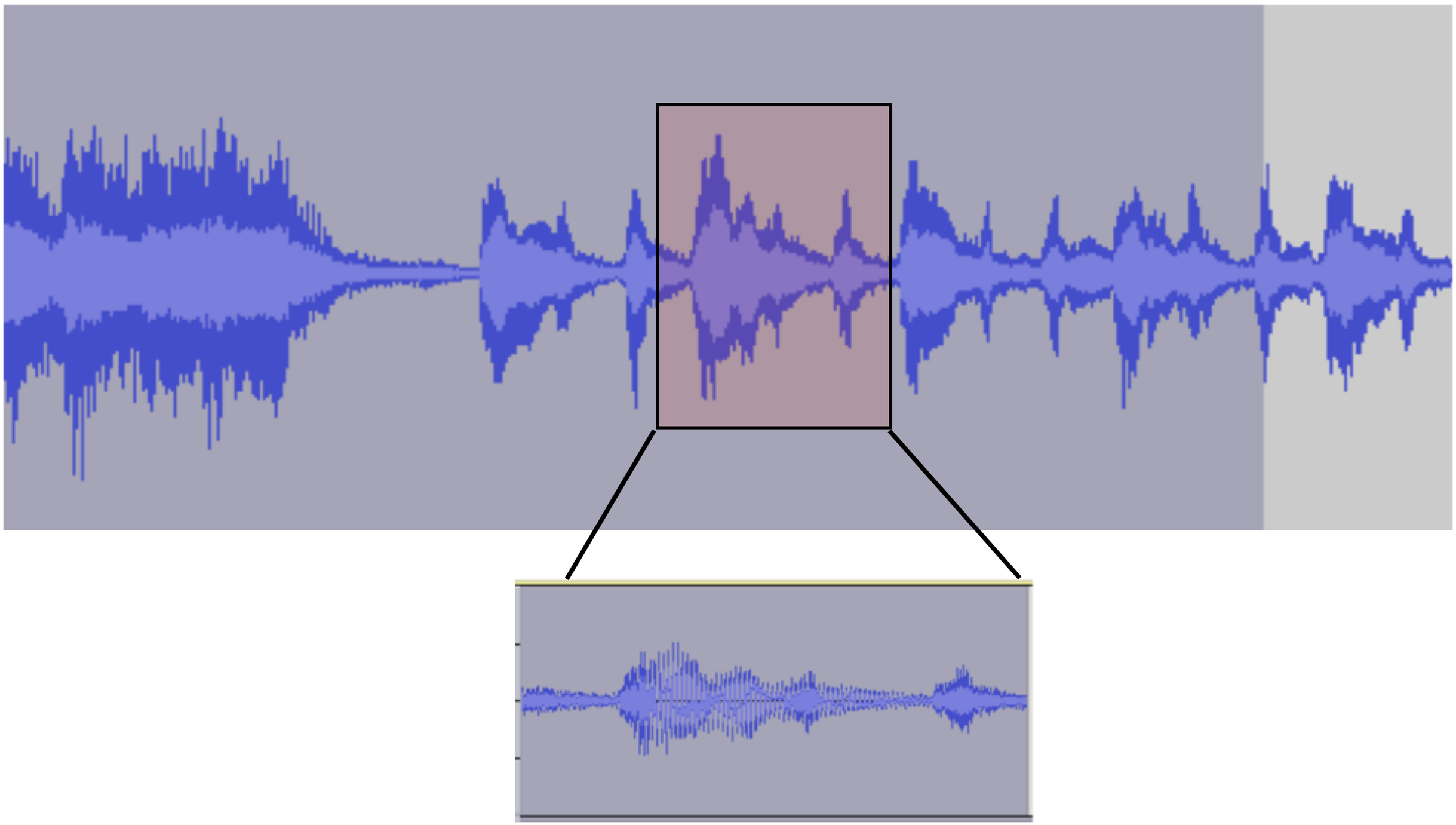
# High-frequency wave

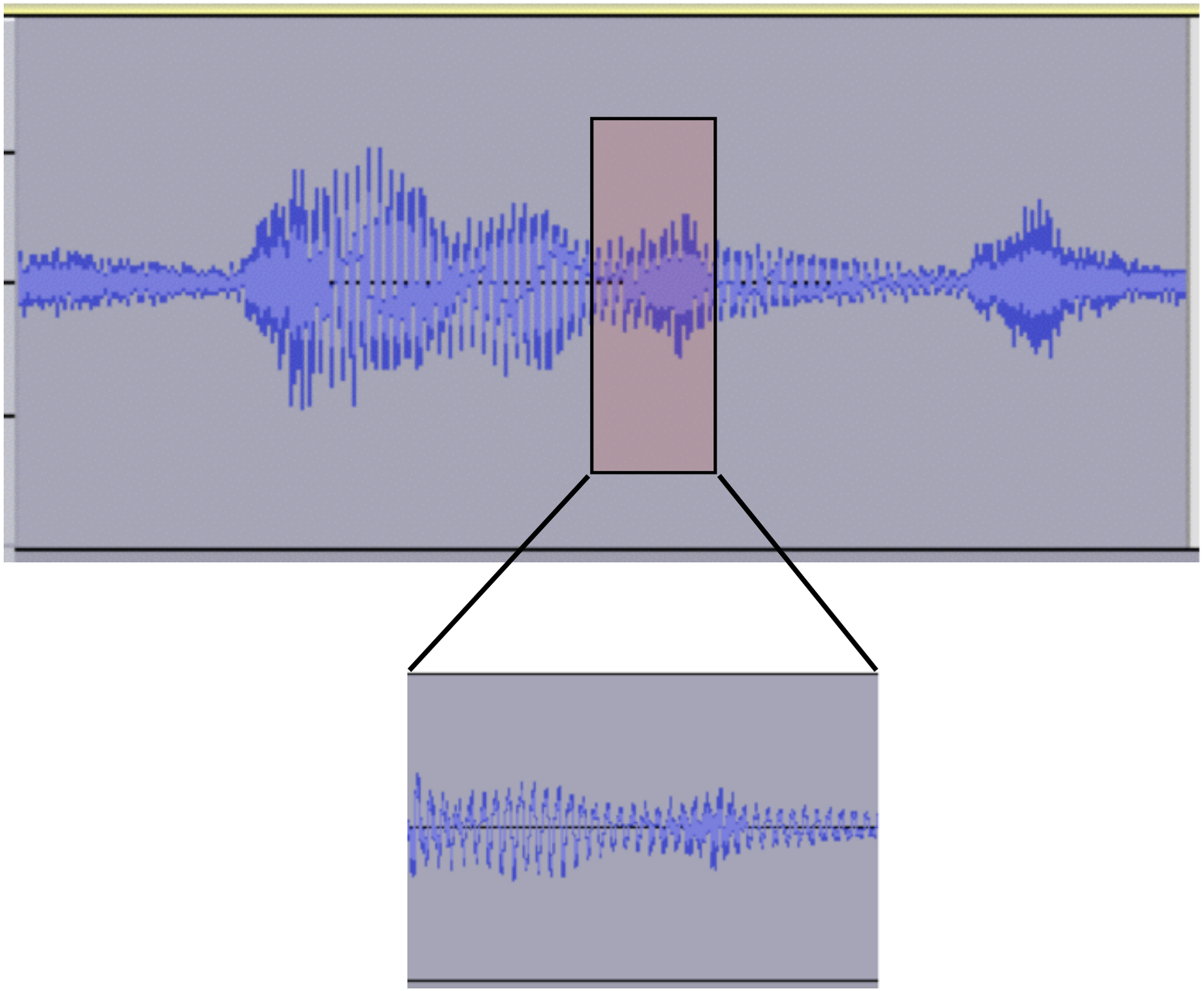


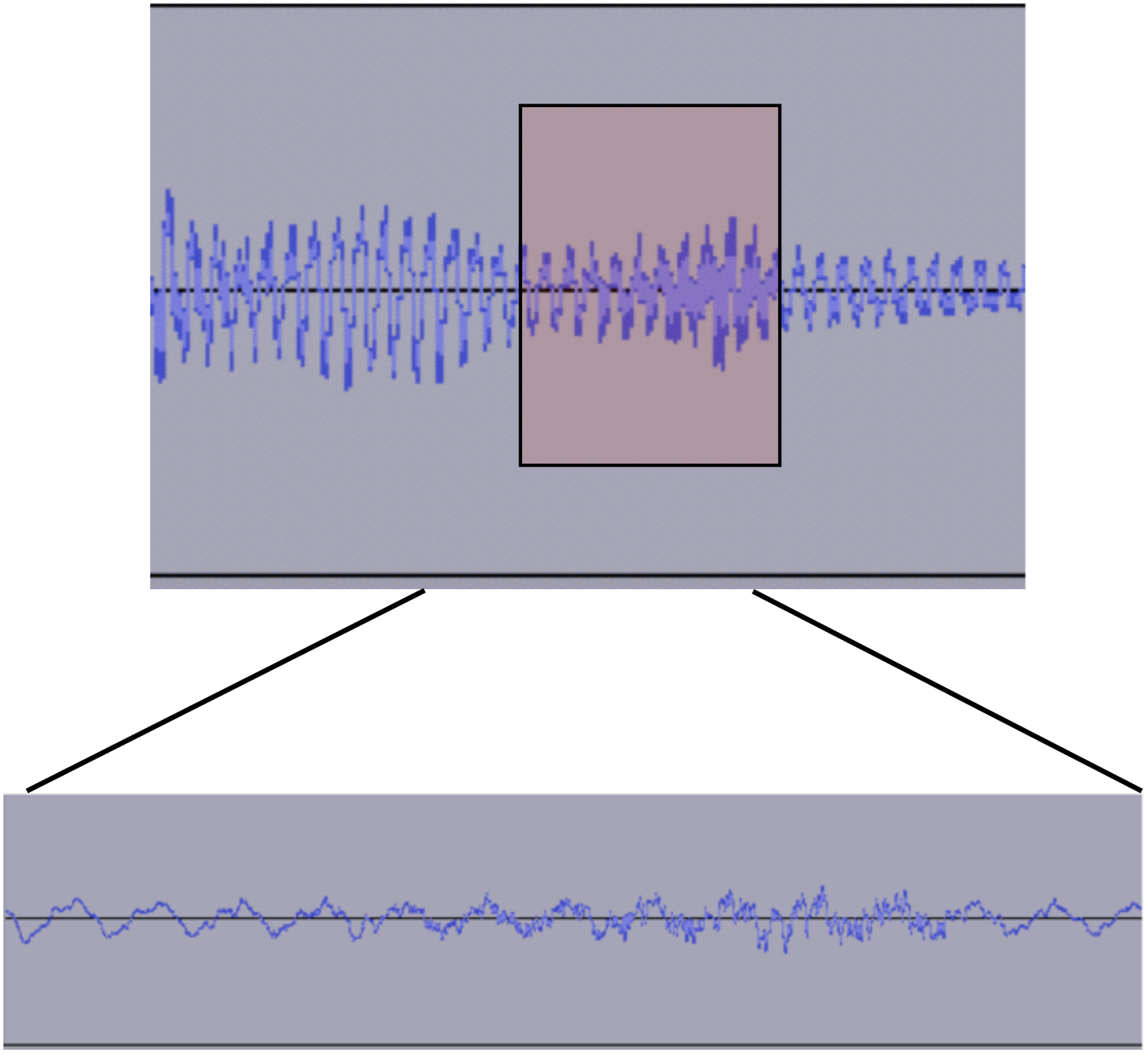
# Very high-frequency wave

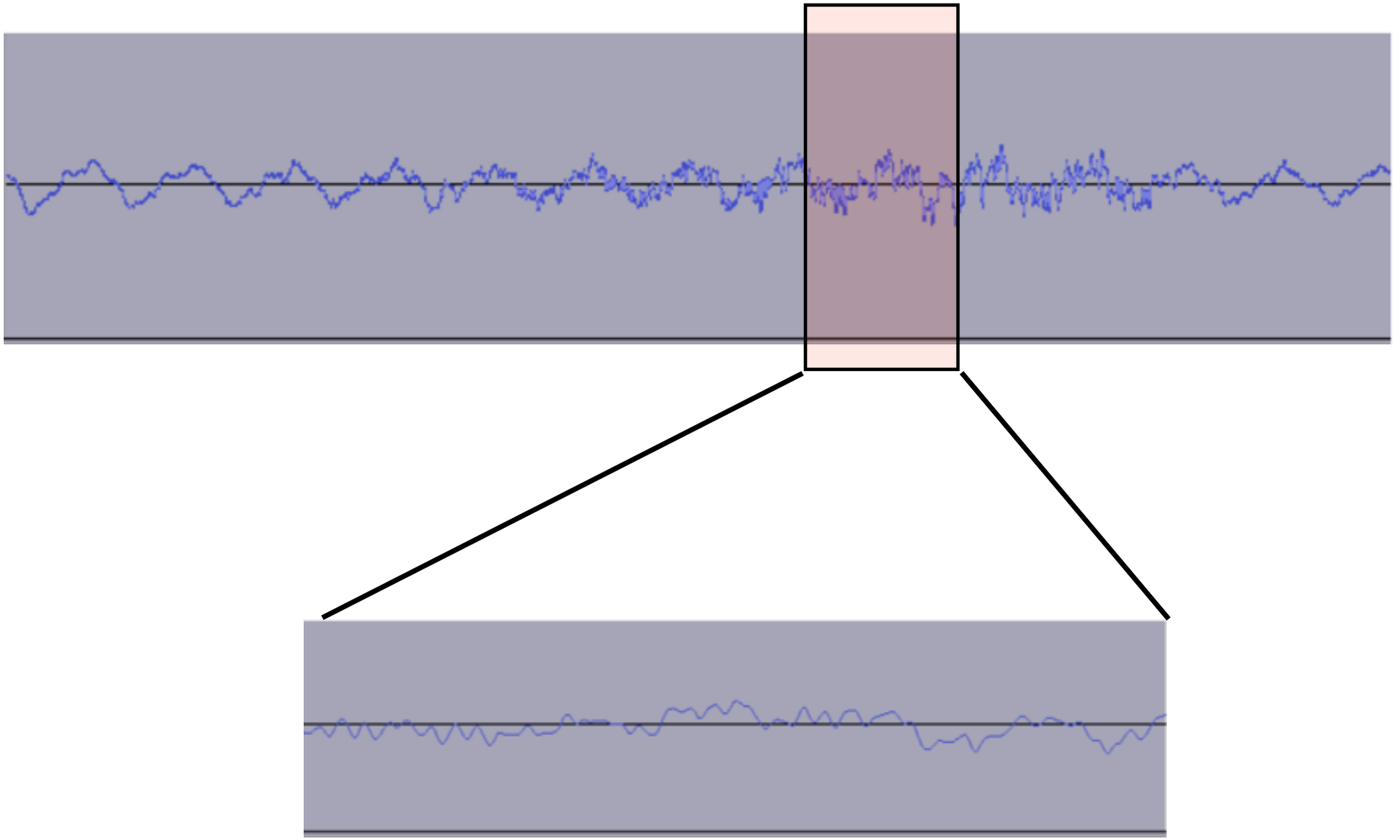


# General sound wave

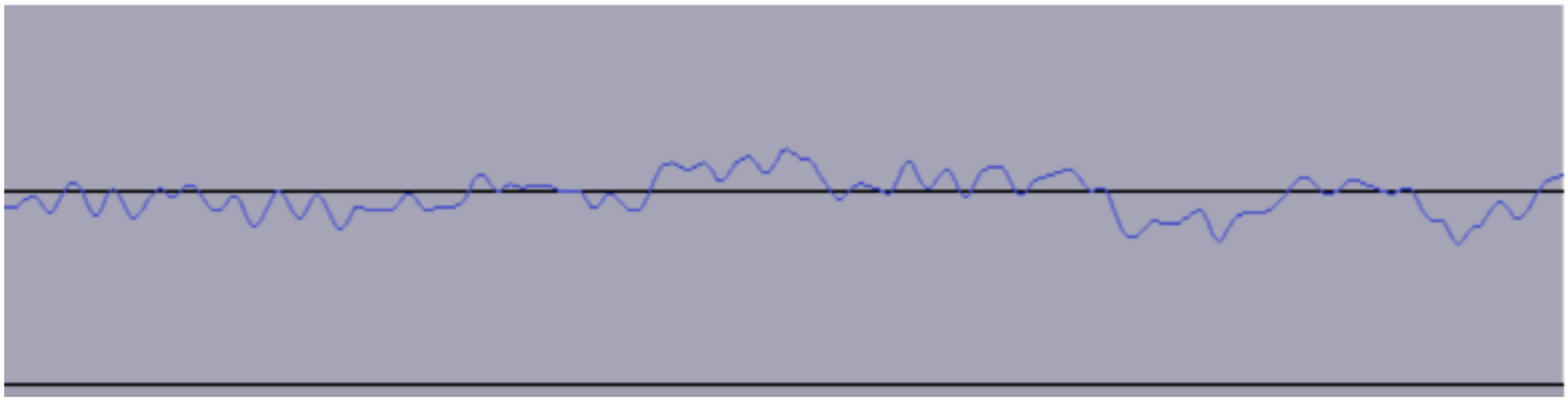








# Final Magnification

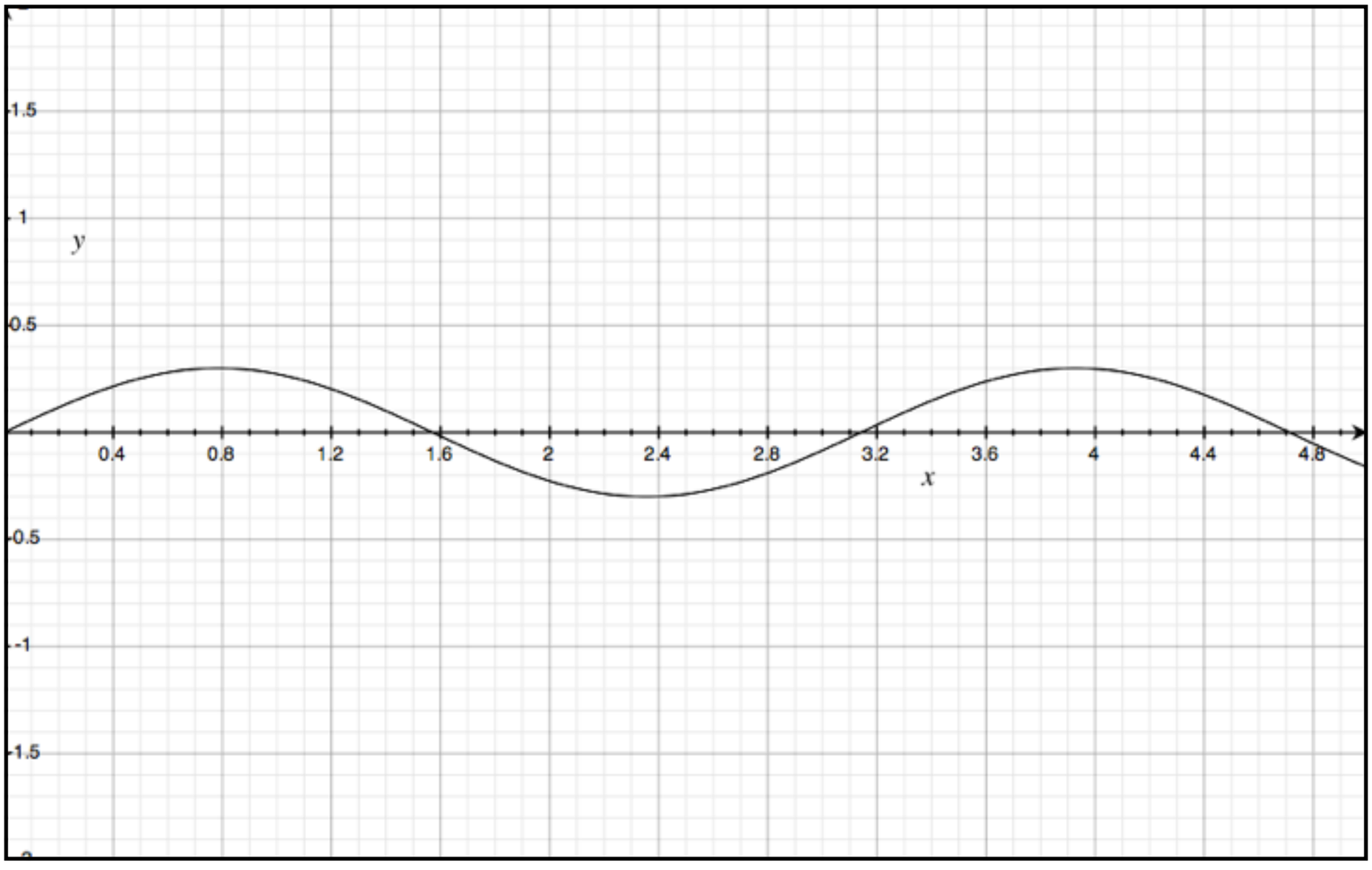


Simple waveform

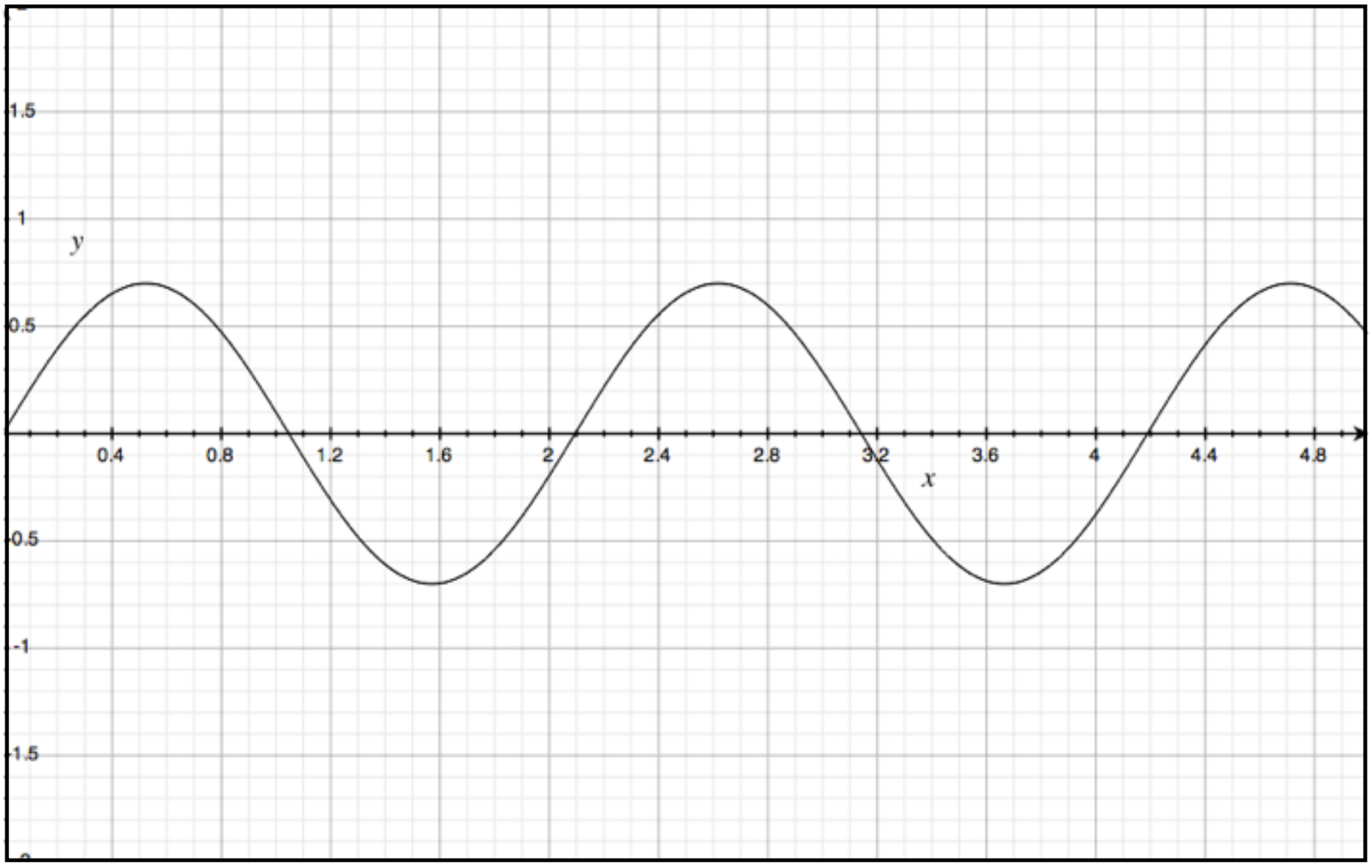
is a collection of sine waves of

different frequencies and amplitudes

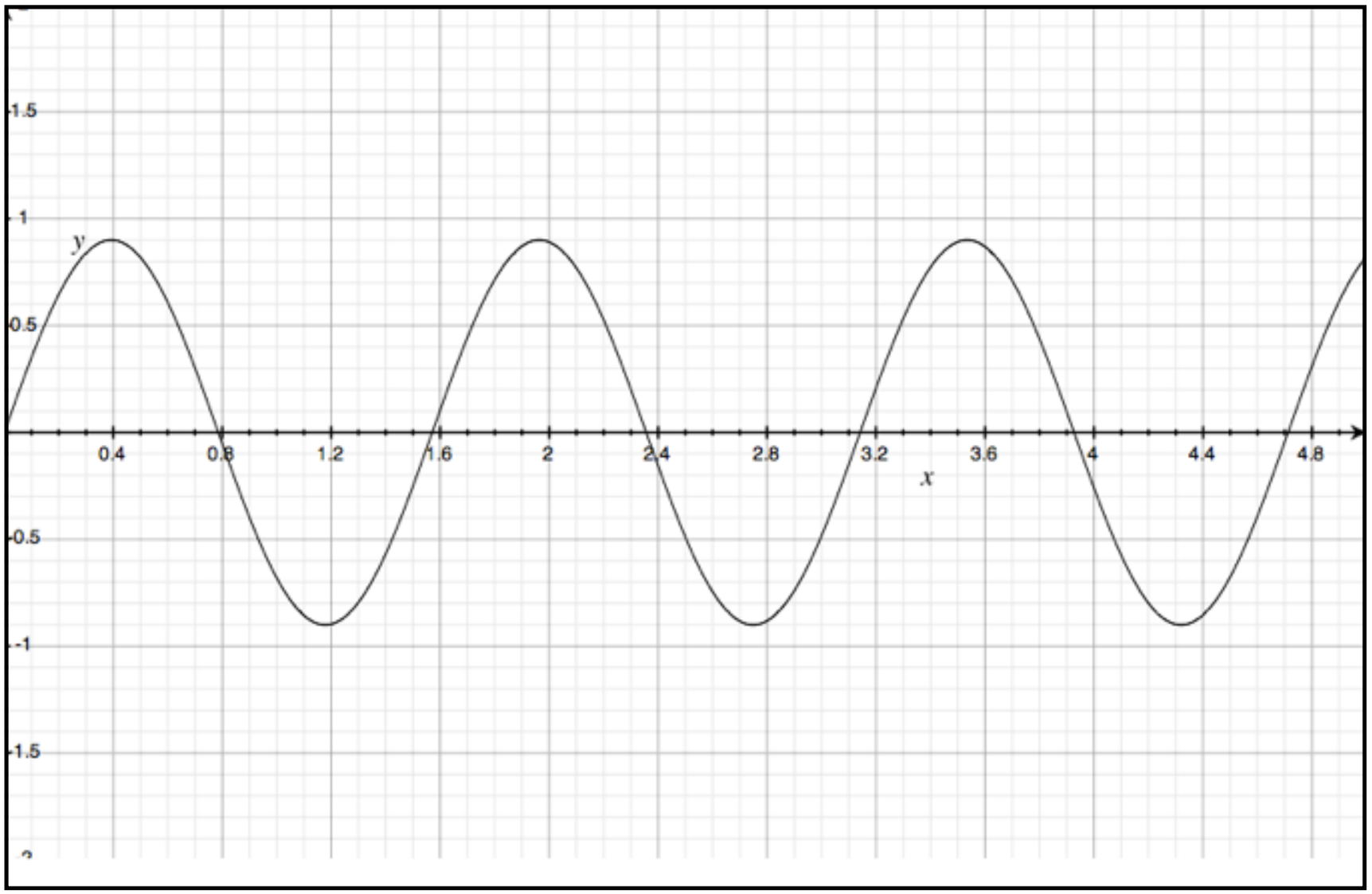
# y=.3sin(2x)



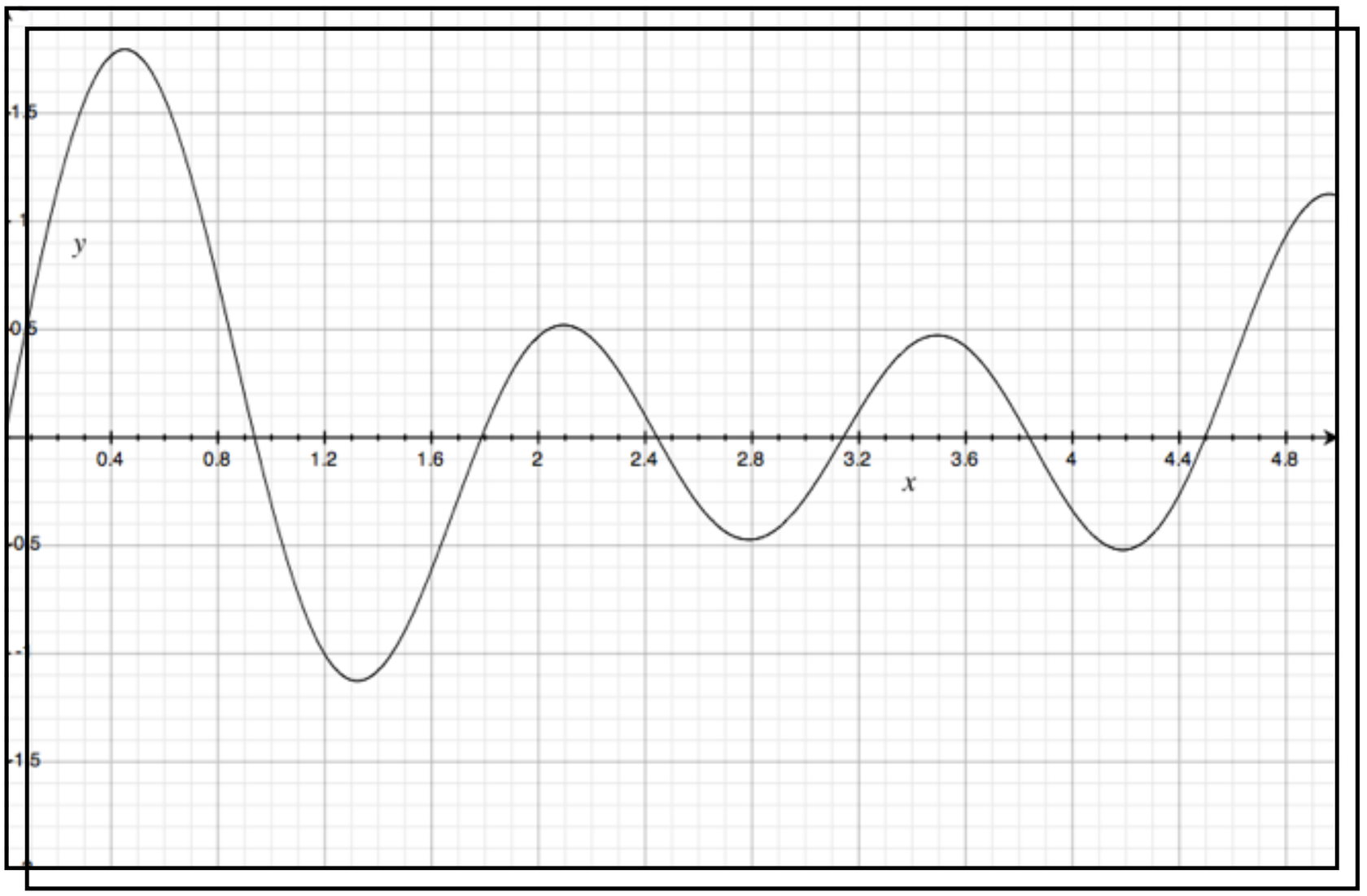
# y=.7sin(3x)



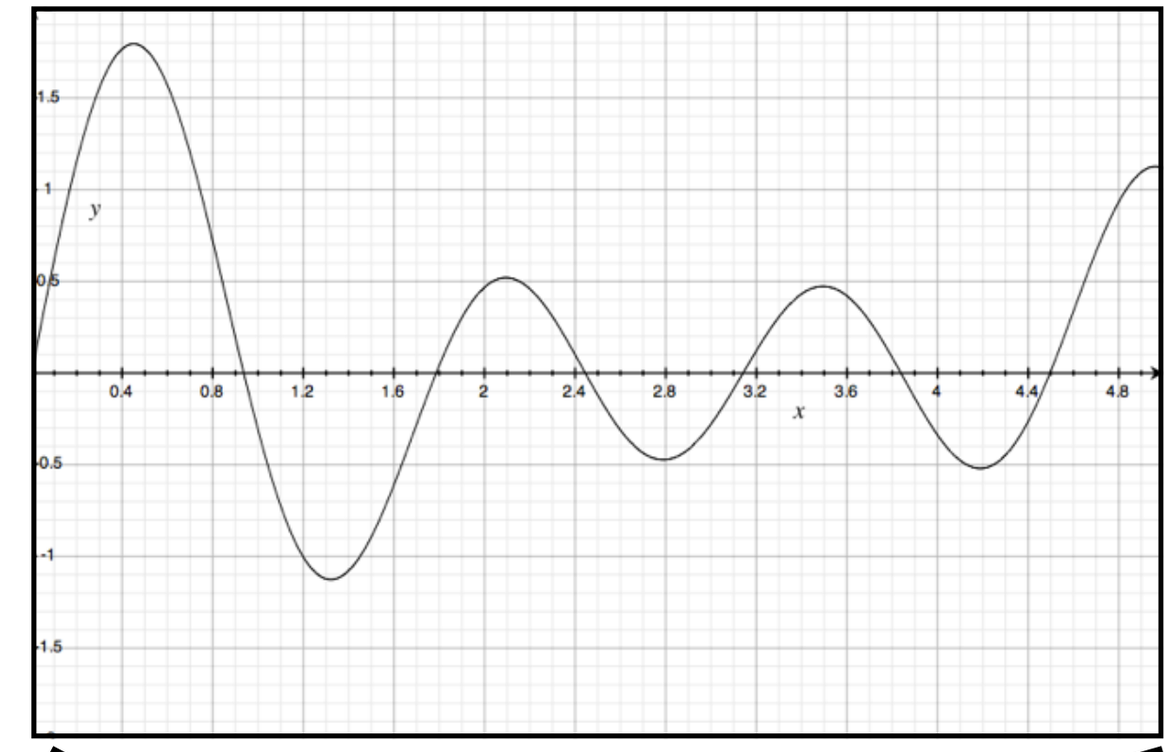
# y=.9sin(4x)



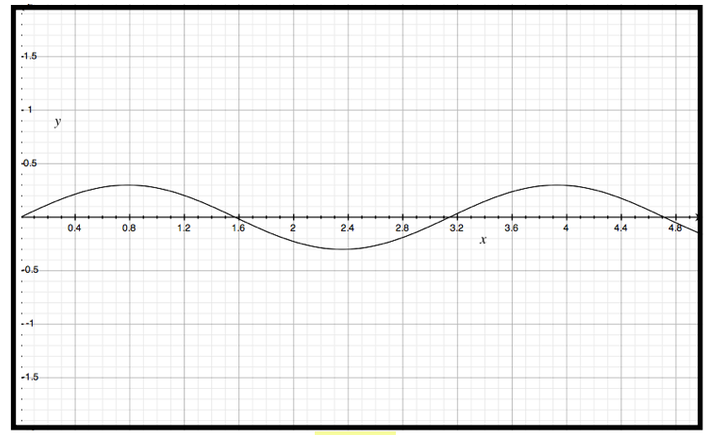
# y=.3sin(2x)+.7sin(3x)+.9sin(4x)



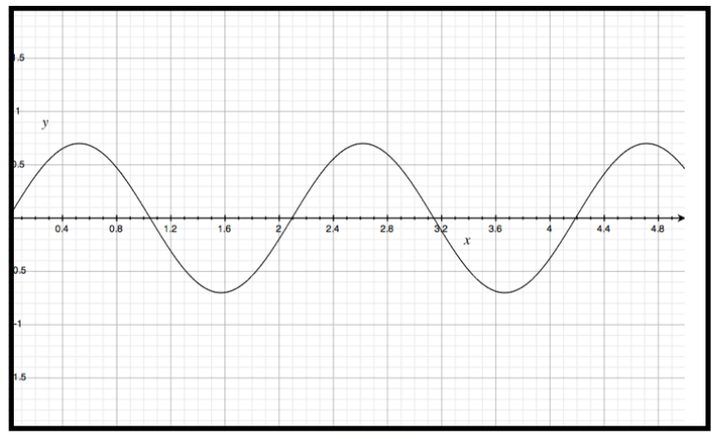
# Fourier decomposition of a sound wave into the sum of sines and cosines



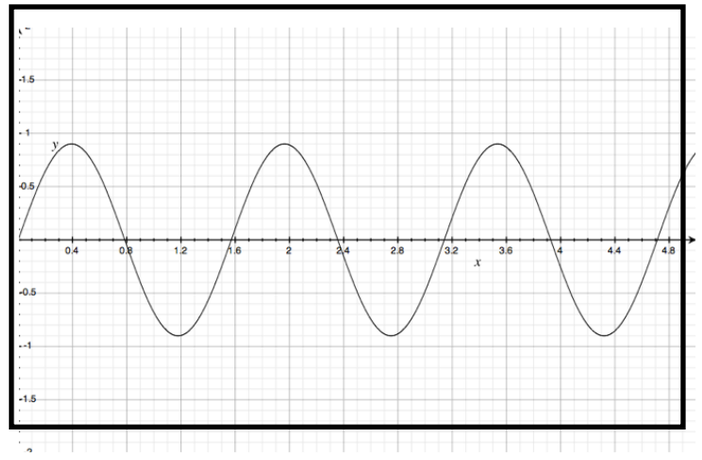

=

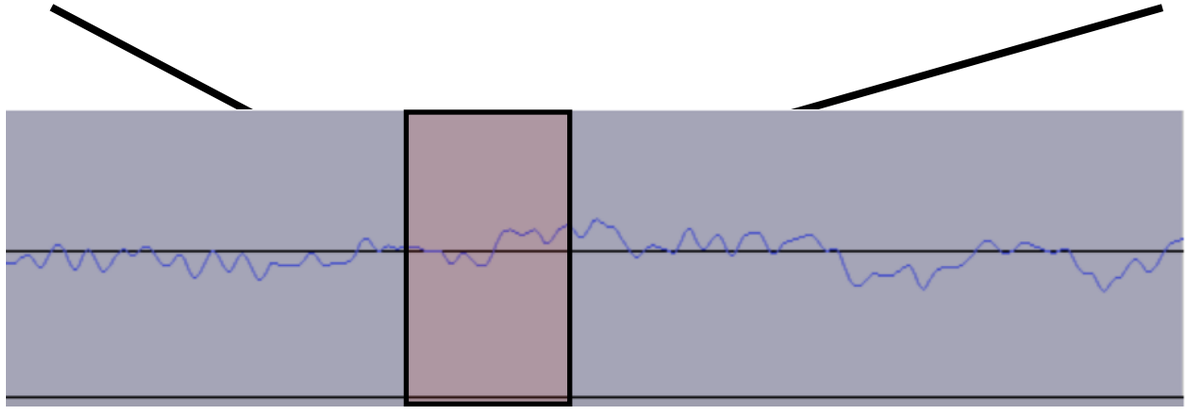



+

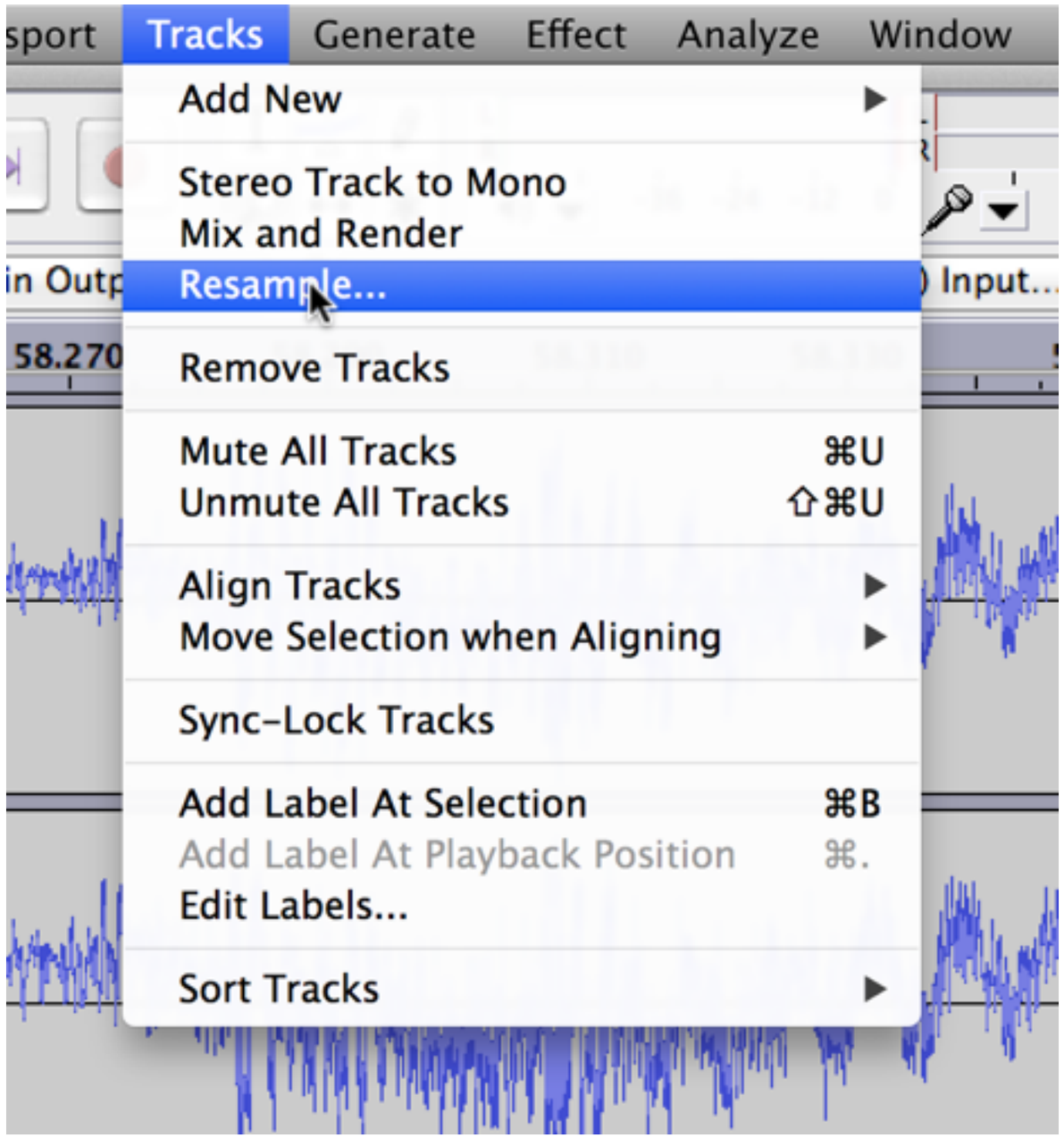



+



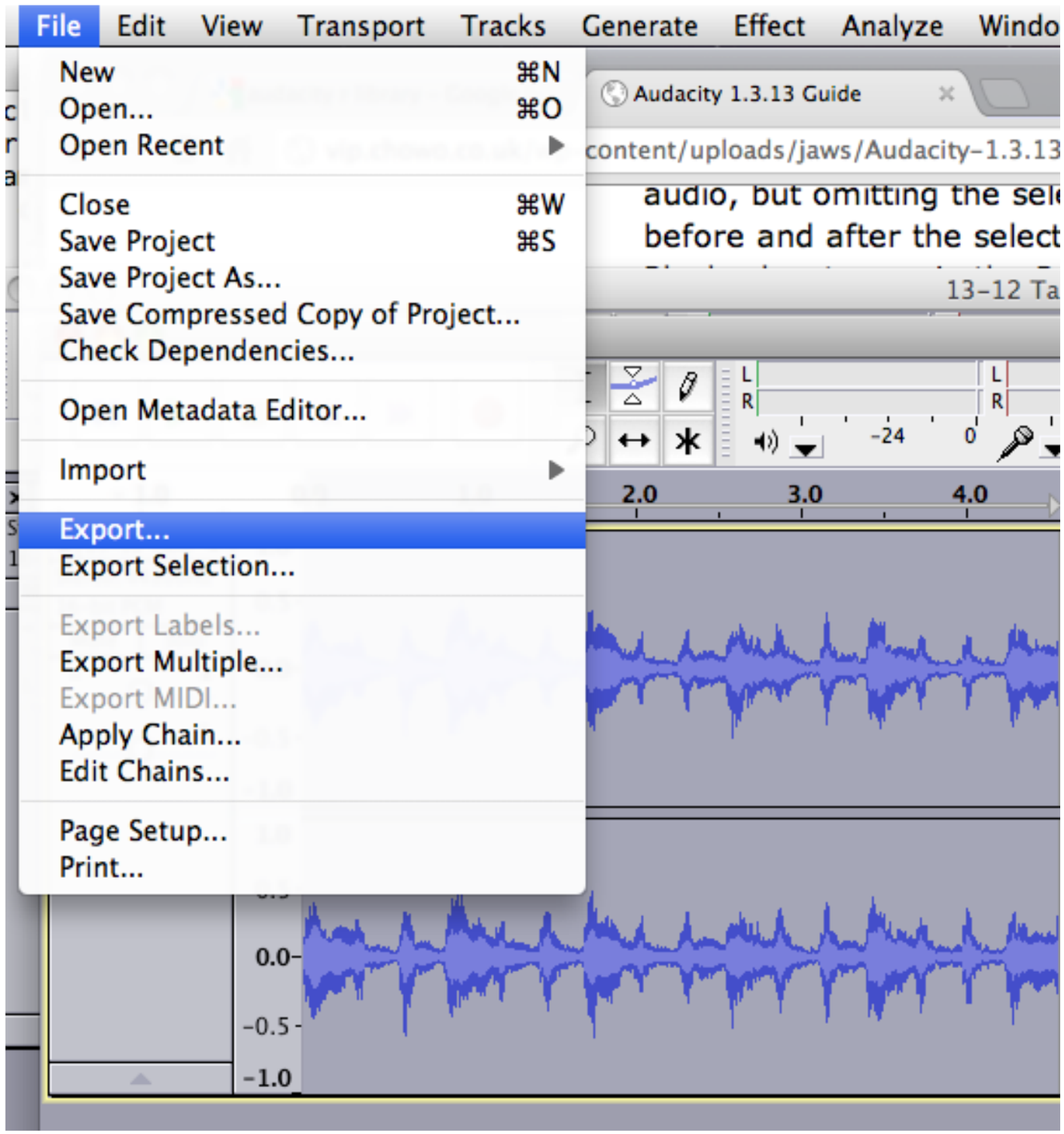



# Resampling in Audacity

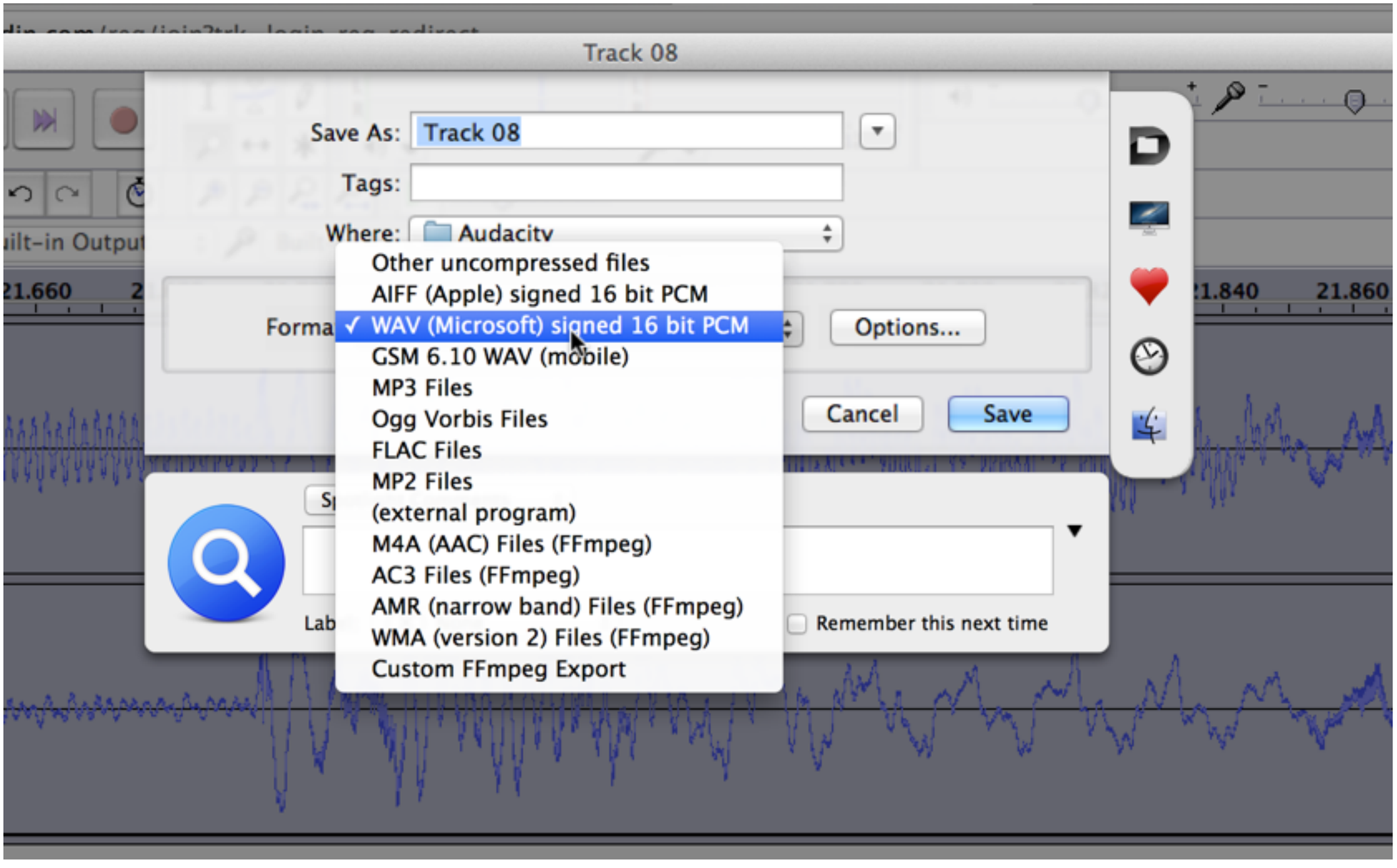


Track 08
tereo, 44100Hz
2-bit float
Mute
Solo
1.0
0.5
0.0
-0.5
-1.0
44000 Hz (samples per sec)
Track 08
tereo, 2000Hz
2-bit float
Mute
Solo
1.0
0.5
0.0
-0.5
-1.0
Sampling
2000 Hz (samples per sec)

# Export Waveform



# File Formats



# Popular sound formats

- wav (microsoft)
- mp3
- aiff (non-compressed)
- mp4 (AAC) (Apple)
- ...

# What do we need?

- How to find out what packages are available?
- Use ?  (help on individual commands that are loaded into R)
- Use ?? (helps to find commands in packages not yet loaded into R)

# ?

> **?sound**

No documentation for 'sound' in specified packages and libraries:

you could try '??sound'

>

> ?sound<tab>

> # nothing, so there are no commands that start with sound

> ?wav<tab>

??

- Search not only R, but also search all the libraries that can be loaded into R

# ??sound

See next slides

No longer works as in previous version of R.

Use to print all packages/functions related to sound, even those not on my laptop.

# Now what?

- Identify routines that appear to be related to sound.
- We emphasize them in **blue**.

# Format

Each element of the list is of the form:

**tuneR::setWavPlayer  Getting and setting the default player for Wave files**

**Library name : tuneR**

**Function name: setWavPlayer**

**Description: Getting and setting the default player for Wave files**

spam::Math2 Rounding of Numbers

spam::Summary Rounding of Numbers

spatstat::bdist.pixels

Distance to Boundary of Window

spatstat::bdist.points

Distance to Boundary of Window

spatstat::bdist.tiles Distance to Boundary of Window

spatstat::bounding.box

Bounding Box of a Window or Point Pattern

spatstat::bounding.box.xy

Convex Hull of Points

spatstat::[.hyperframe

Internal spatstat functions

spatstat::zapsmall.im Rounding of Pixel Values

splancs::bboxx Generate a non-closed bounding polygon

splancs::sbox Generate a box surrounding a point object

stats::rect.hclust Draw Rectangles Around Hierarchical Clusters

strucchange::boundary.Fstats

Boundary for F Statistics

**tuneR::Waveforms Create Wave Objects of Special Waveforms**

**tuneR::play-methods Playing Waves**

**tuneR::readMP3 Read an MPEG-2 layer 3 file into a Wave object**

urca::bh5lrtest Likelihood ratio test for restrictions under

partly known beta

urca::bh6lrtest Likelihood ratio test for restrictions under

partly known beta in a subspace

VGAM::bisa Birnbaum-Saunders Distribution Family Function

VGAM::Bisa The Birnbaum-Saunders Distribution

VIM::bgmap Backgound map

VIM::kola.background Background map for the Kola project data

Type '?PKG::FOO' to inspect entries 'PKG::FOO', or 'TYPE?PKG::FOO' for

entries like 'PKG::FOO-TYPE'.

Help files with alias or concept or title matching 'sound' using fuzzy

matching:

AER::MarkPound DEM/GBP Exchange Rate Returns

anchors::anchors.chopit.check

Compound Hierarchical Ordered Probit (CHOPIT)

anchors::anchors.chopit.fit

Compound Hierarchical Ordered Probit (CHOPIT)

anchors::anchors.chopit.parm

Compound Hierarchical Ordered Probit (CHOPIT)

anchors::chopit Compound Hierarchical Ordered Probit (CHOPIT)

base::ceiling Rounding of Numbers

base::round.POSIXt Round / Truncate Data-Time Objects

base::zapsmall Rounding of Numbers

BayesX::bnd2gra Convert Boundary Format to Graph Format

BayesX::read.bnd Read Geographical Information in Boundary

Format

BayesX::smooth.bnd Round Boundary Information

fields::US Plot of the US with state boundaries

geoR::tce TCE concentrations in groundwater in a vertical

cross section

ggplot2::diamonds Prices of 50,000 round cut diamonds

ggplot2::surround_viewports

Generate viewports for plot surroundings

graphics::box Draw a Box around a Plot

grid::roundrect Draw a rectangle with rounded corners

grid::grobX Create a Unit Describing a Grob Boundary

Location

grid::xDetails Boundary of a grid grob

gWidgets::gWidgets-undocumented.Rd

Undocumented, but exported, functions

Hmisc::dataDensityString

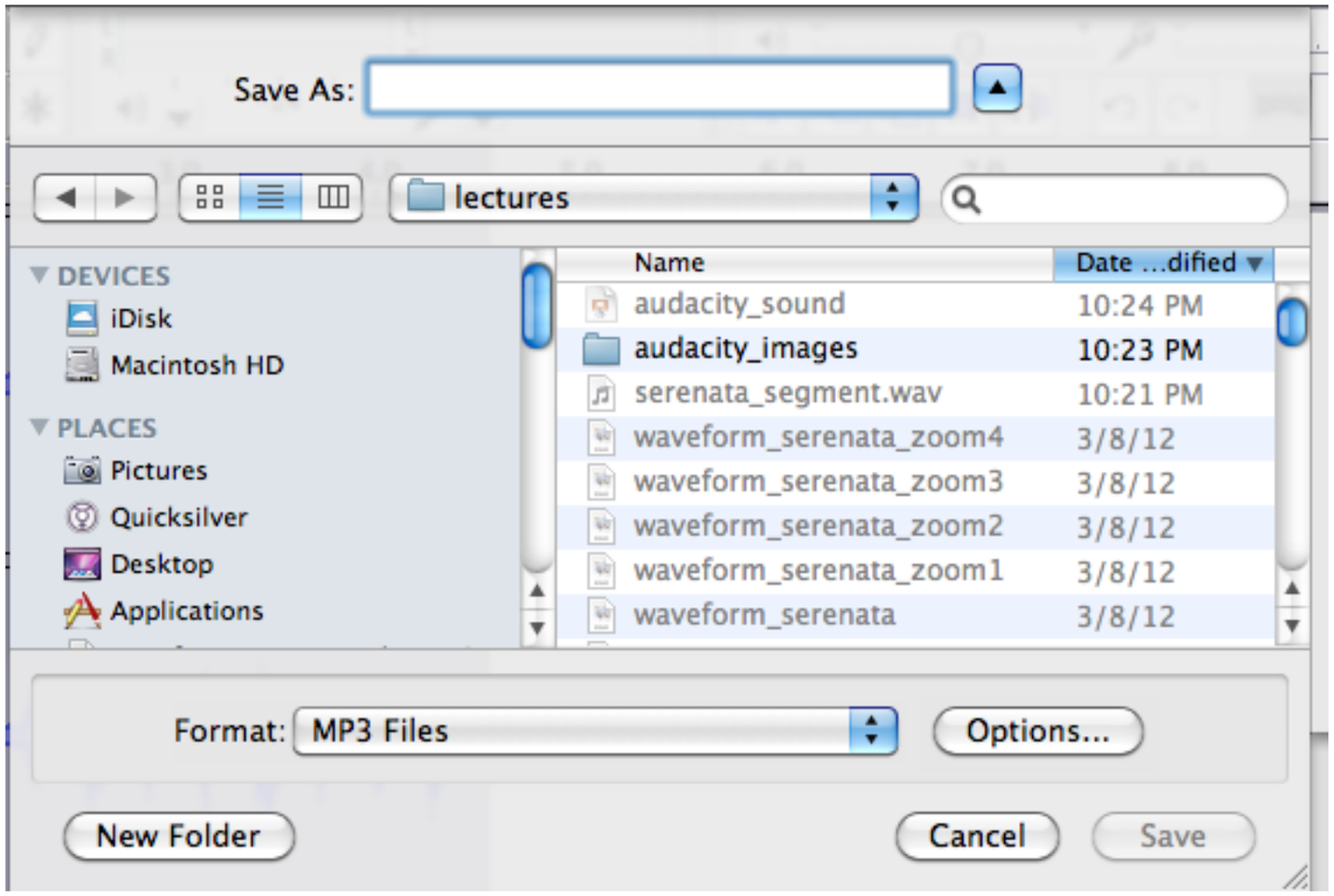
Internal Hmisc functions

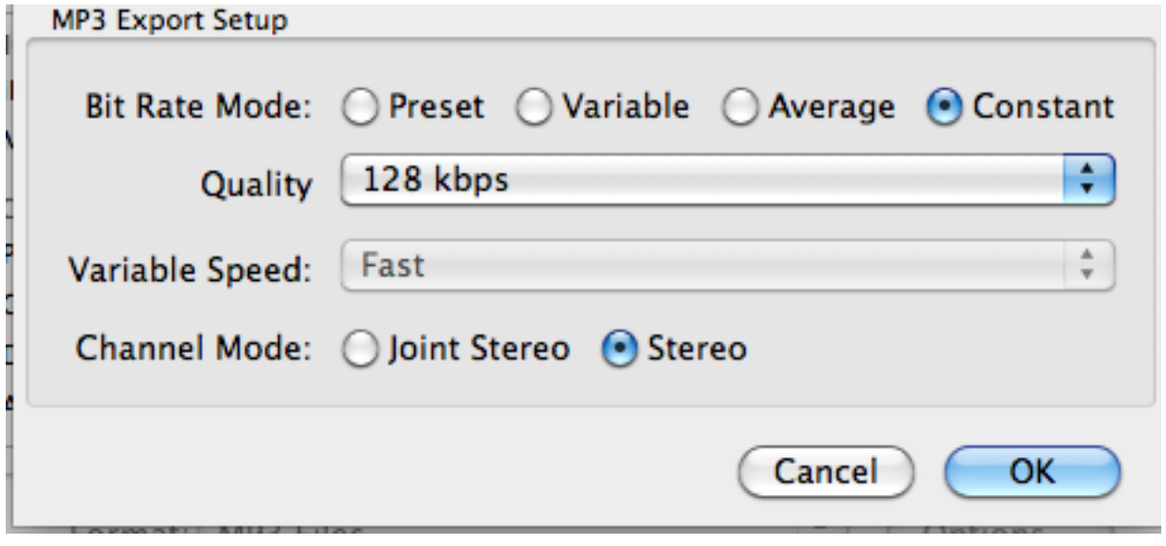
Hmisc::dataRep Representativeness of Observations in a Data

Set

Hmisc::ldBands Group Sequential Boundaries using the

Lan-DeMets Approach


Save As:
lectures
DEVICES
iDisk
Macintosh HD
PLACES
Pictures
Quicksilver
Desktop
Applications
Name
Date ...dified
audacity_sound
10:24 PM
audacity_images
10:23 PM
serenata_segment.wav
10:21 PM
waveform_serenata_zoom4
3/8/12
waveform_serenata_zoom3
3/8/12
waveform_serenata_zoom2
3/8/12
waveform_serenata_zoom1
3/8/12
waveform_serenata
3/8/12
Format:
MP3 Files
Options...
New Folder
Cancel
Save


MP3 Export Setup
Bit Rate Mode:
Preset
Variable
Average
Constant
Quality
128 kbps
Variable Speed:
Fast
Channel Mode:
Joint Stereo
Stereo
Cancel
OK

# Summary of csound routines

csound::.csoundCleanup

Low-level Csound API functions

csound::cleanupCrash Perform score statements with specified Csound

orchestra

csound::getCsoundError

Get Csound error message text

csound::getHeaderInfo Get the header specifications of a Csound

instance

csound::.csoundGetVersion

Get and set the Csound shared library for

accessing Csound's functionality.

csound::writeCsoundScore

Write a Csound score file, given lists of i and

f statements

# We are not finished

- Let us repeat this process with the words
  - wave
  - audio

# ??wave

akima::akima Waveform Distortion Data for Bivariate Interpolation

audio::load.wave WAVE file manipulations

HSAUR::waves Electricity from Wave Power at Sea

sgeostat::fit.variogram Variogram Model Fit

sound::Sine Create Sample Objects for the Basic waveforms

sound::sound The Waveform Matrix of a Sample Object

tuneR::FF Estimation of Fundamental Frequencies from a Wspec object

tuneR::mono Converting (extracting, joining) stereo to mono and vice versa

tuneR::setWavPlayer Getting and setting the default player for Wave files

tuneR::Wave-class Class Wave

tuneR::Wave Constructors and coercion for class Wave objects

tuneR::Arith-methods Arithmetics on Waves

tuneR::readWave Reading and writing Wave files

tuneR::preWaveform Internal support functions for Waveforms

tuneR::Waveforms Create Wave Objects of Special Waveforms

tuneR::Wspec-class Class Wspec

tuneR::WspecMat-class Class WspecMat

tuneR::bind Concatenating Wave objects

tuneR::channel Channel conversion for Wave objects

sound::Sine Create Sample Objects for the Basic waveforms

sound::sound The Waveform Matrix of a Sample Object

tuneR::FF Estimation of Fundamental Frequencies from a Wspec object

tuneR::mono Converting (extracting, joining) stereo to mono and vice versa

tuneR::setWavPlayer Getting and setting the default player for Wave files

tuneR::Wave-class Class Wave

tuneR::Wave Constructors and coercion for class Wave objects

# ??audio

AER::DutchAdvert TV and Radio Advertising Expenditures Data

alr3::caution Caution data

audio::audio.drivers Audio Drivers

audio::$.audioInstance

Audio instance class methods

audio::$.audioSample Audio sample class methods

audio::audioSample Audio sample class and constructor

audio::pause Control audio instance

audio::play Play audio

audio::record Record audio

audio::wait Wait for an event

DAAG::audists Road distances between 10 Australian cities

geoRglm::rongelap Radionuclide Concentrations on Rongelap Island

gWidgets::gWidgets-classes

Classes for gWidgets instances

gWidgets::gradio Radio button group widget

gWidgetsRGtk2::as.gWidgetsRGtk2

RGtk2::gtkActionGroupAddRadioActionsFull

gtkActionGroupAddRadioActionsFull

RGtk2::gtkCellRendererToggleGetRadio

gtkCellRendererToggleGetRadio

RGtk2::gtkCellRendererToggleSetRadio

gtkCellRendererToggleSetRadio

RGtk2::gtkCheckMenuItemGetDrawAsRadio

gtkCheckMenuItemGetDrawAsRadio

RGtk2::gtkCheckMenuItemSetDrawAsRadio

gtkCheckMenuItemSetDrawAsRadio

RGtk2::gtkRadioActionGetCurrentValue

gtkRadioActionGetCurrentValue

RGtk2::gtkRadioActionGetGroup

gtkRadioActionGetGroup

RGtk2::gtkRadioActionNew

gtkRadioActionNew

RGtk2::gtkRadioActionSetCurrentValue

gtkRadioActionSetCurrentValue

RGtk2::gtkRadioActionSetGroup

# Sound-related libraries

- audio
- csound
- sound
- TSA
- tuneR

# Even more information

**Search Google:** "searching for packages" r

Best way to search for **R** packages? - Stack Overflow

stackoverflow.com/.../best-way-to-search-for-**r**-packages
7 answers - Sep 8, 2009
As such, what are some best practices for **searching for packages**? That is, when I realize I have a need that my current set of **R** packages will **...**

http://stackoverflow.com/questions/1395180/best-way-to-search-for-r-packages

http://stackoverflow.com/questions/1395180/best-way-to-search-for-r-packages

I believe crantastic.org is hoping to help people discover and collaboratively rate/discuss packages. It might be of use once it gets more traffic.

`help.search()` or the shorthand `??`.

use the `findFn` function in the `sos` package.

`RSiteSearch()`

# Experimentation

- Try out the sites on the previous page
  - sound, psychology, wave, audio
  - graphics, scattergram
  - what else?

help(package=stats)
   information about different functions

library(help=stats)
   same information as help(...) when outside RStudio

Using RStudio, the help(package=...) is much more informative

# Recap

- The sound libraries of interest are:
  - **csound**
  - **sound**
  - **audio**
  - **tuneR**

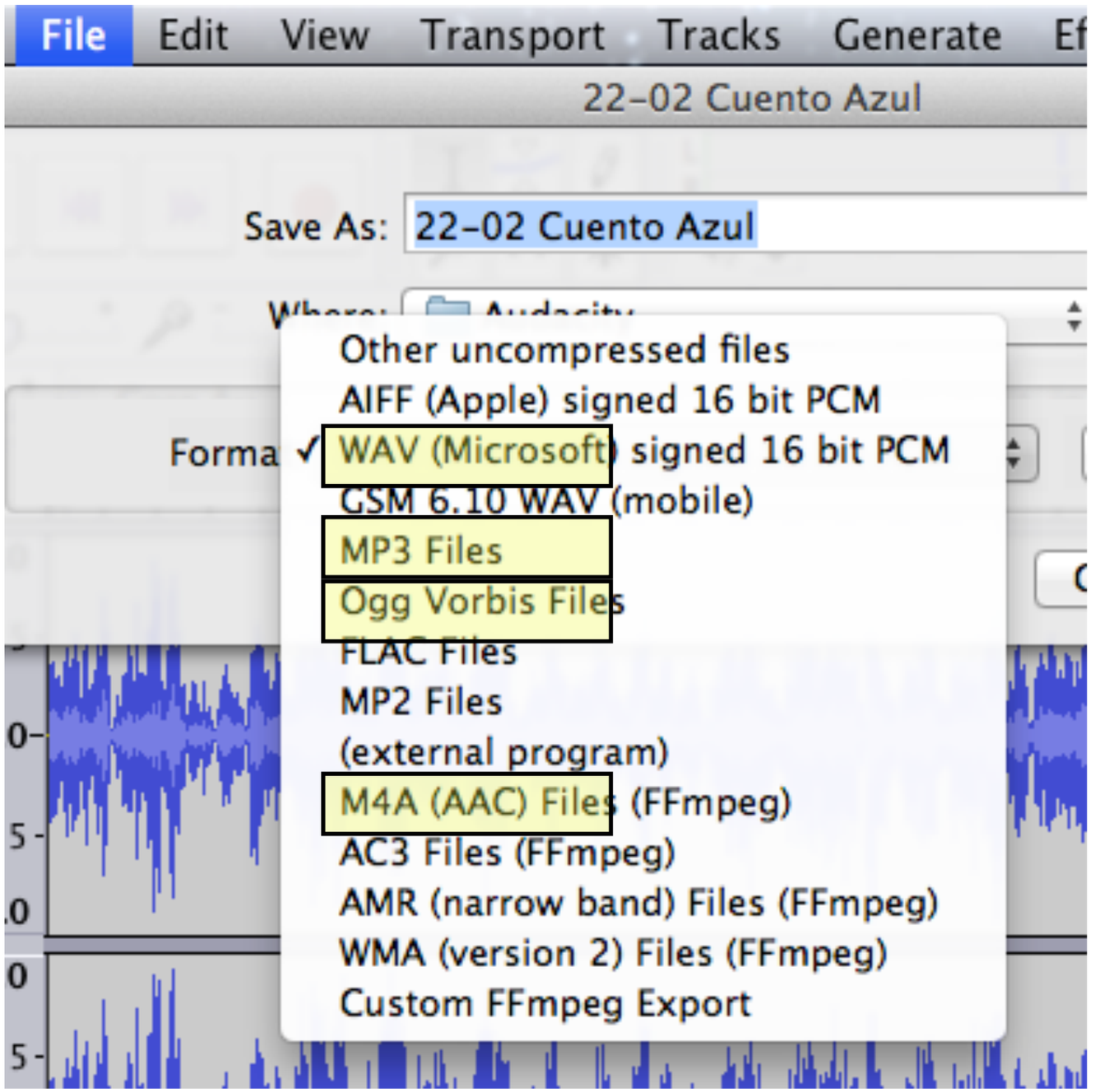
# Next task

- How do we read a sound file into R for manipulation?
  - Step 1: understand various sound libraries
  - Step 2: search for examples on the web
  - Step 3: try it out with R!

# Importing into R

- What file types can be exported from Audacity?
- Find a package with routines to load sound files into R
- Choose the appropriate format

# Exporting from R



# Simple Program

```
library(sound)


#The Mac has no default player. Window does I believe.
setWavPlayer('open -a \"QuickTime Player.app\"')


#
```

Let us look at manual page for these two commands

**setWavPlayer** and **play**

Also look on the web for information on how to use

# Pitch control

- sound::pitch

Examples:

```
## Not run:

s <- Sine(440,1)

# Now play it 12 semitones = 1 octave deeper,

# that is half the frequencies and twice the length,

# or played at half speed.

play(pitch(s,-12)) # is the same as...

play(Sine(220,2))

## End(Not run)
```

# Useful commands in sound library

- pitch — Pitch a Sample Object
- play — Play a Sample Object or a WAV File
- plot.Sample — Plot a Sample Object
- print.Sample — Print a Sample Object
- rate — The Sampling Rate
- sampleLength — Length of a Sample Object
- saveSample — Save a Sample Object as a WAV File
- cutSample — Cut Sample Objects
- bits — Bits per Sample
- loadSample — Load a WAV File from Disk

# Do some exercises

- Class work with examples done live