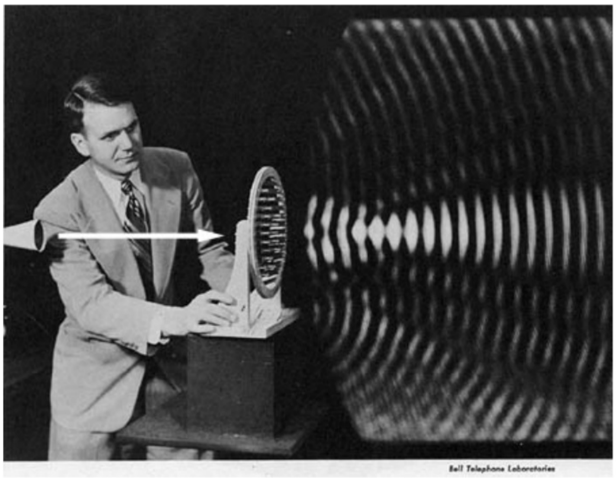
Sound waves



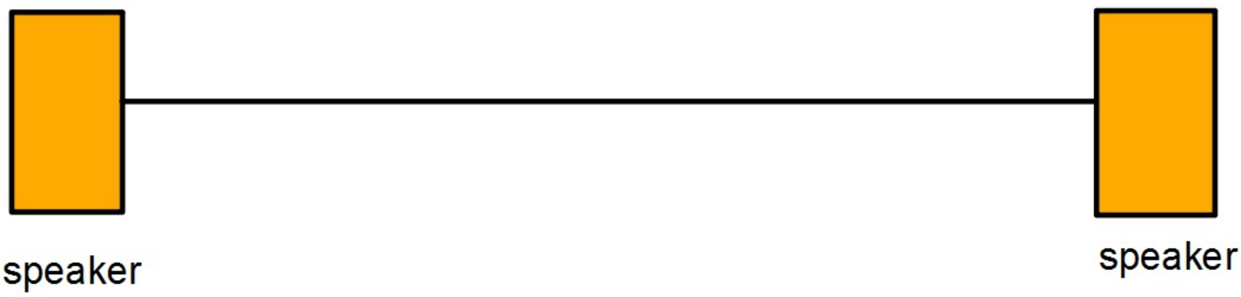
Sound is a wave:

1. There is a disturbance. Disturbance in the air is _____

2. Sound travels and propagates (spreads) outward

3. Sound experiences constructive and destructive interference

Example:



Speed of sound:

$v \cong (331 + 0.60\ T)$ m/s

T is temperature in Celcius

Usually, we take T = 20°C. What is the speed of sound at 20°C?

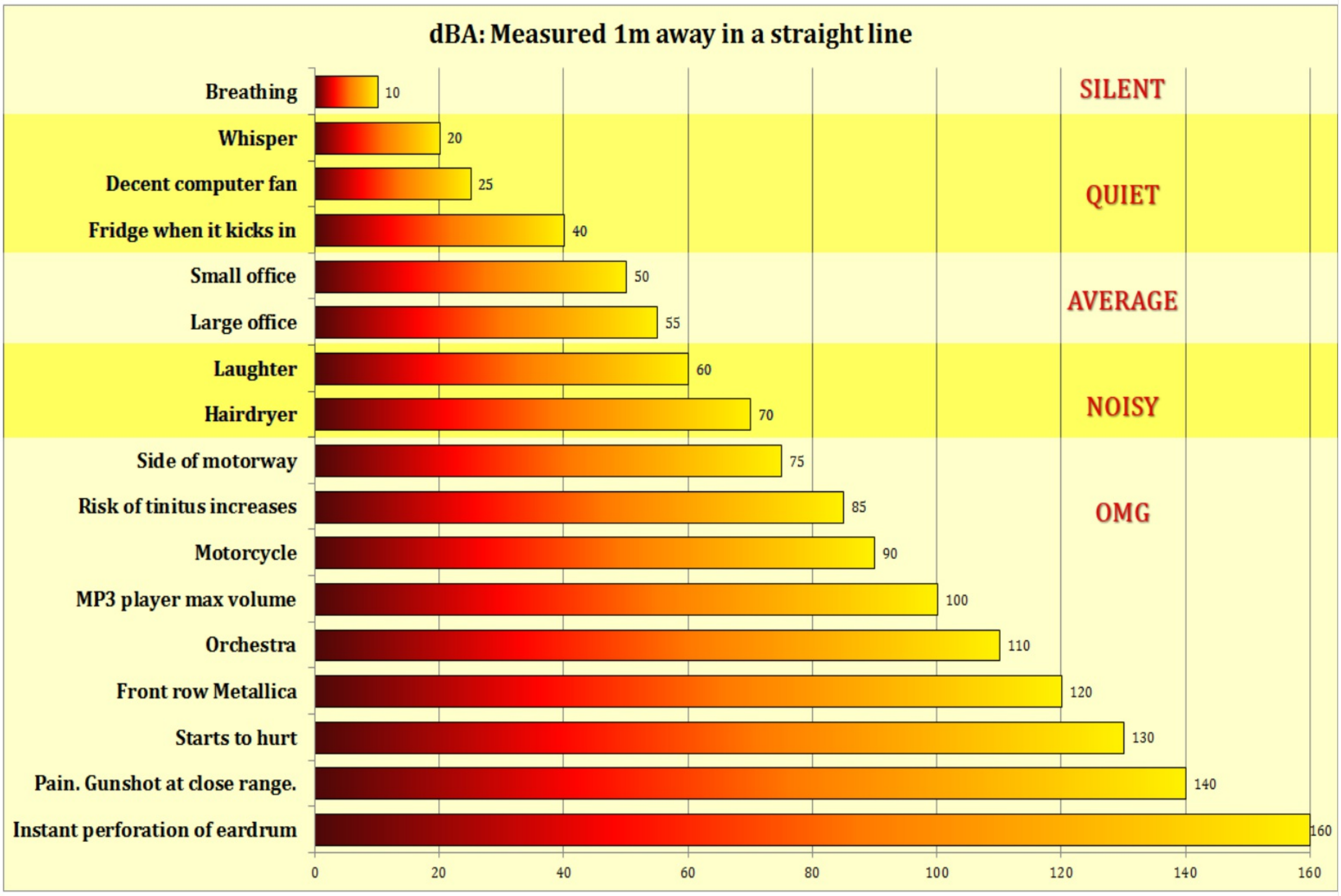
Amplitude, Energy, Power,

Sound intensity: decibels

$$dB = 10\log\frac{I}{I_0}$$

$I_0 = 1.0 \times 10^{-12} W/m^2$

I_0 is the quietest sound that can be heard, the threshold of human hearing


dBA: Measured 1m away in a straight line
Breathing
10
Whisper
20
Decent computer fan
25
Fridge when it kicks in
40
Small office
50
Large office
55
Laughter
60
Hairdryer
70
Side of motorway
75
Risk of tinitus increases
85
Motorcycle
90
MP3 player max volume
100
Orchestra
110
Front row Metallica
120
Starts to hurt
130
Pain. Gunshot at close range.
140
Instant perforation of eardrum
160
SILENT
QUIET
AVERAGE
NOISY
OMG
0
20
40
60
80
100
120
140
160

In.terlace example: a high-quality loudspeaker advertises that it can produce frequencies from 30 Hz - 18000 Hz with a uniform (constant) sound level ±5dB. How much of a change in intensity is a difference of 5dB?

"loudspeaker response"

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Differences in logarithms

Example: volume increase

A single trumpet player can play at a volume of 130dB.
How loud can two trumpet players play?

int.erlace example: Volume increase

If 20 monkeys typing on 20 typewriters have a volume of 94dB, how loud is one monkey typing on one typewriter?

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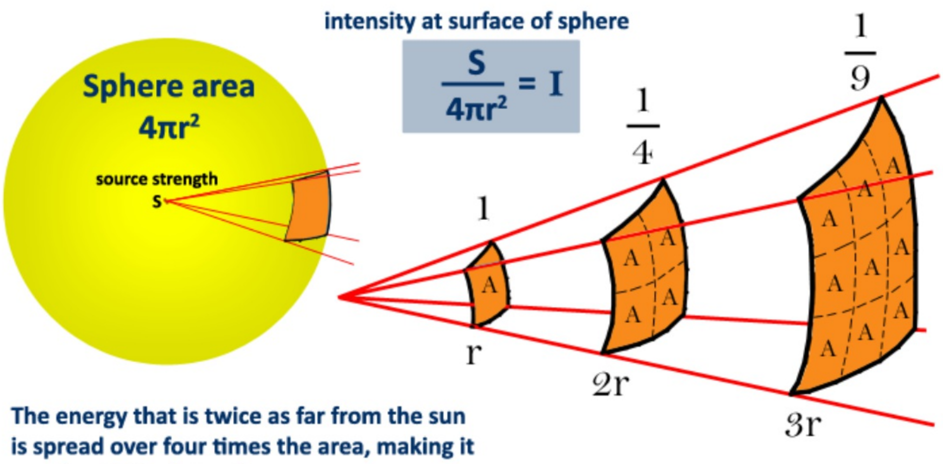
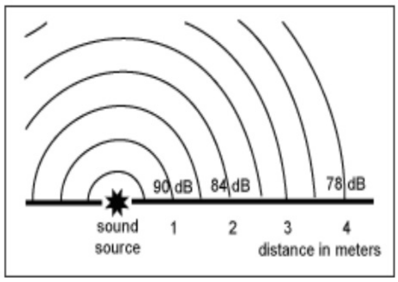
Example: airplane roar

The sound level measured 30m from a jet plane is 140dB. Estimate the sound level at 300 m.

Why does this happen?



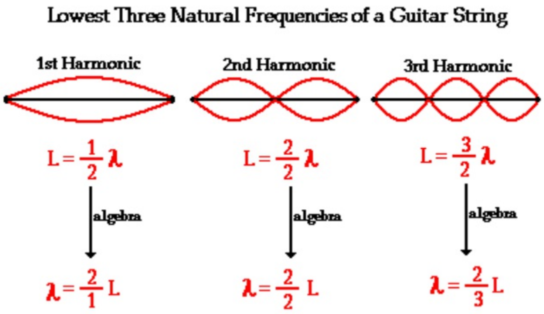
The energy that is twice as far from the sun is spread over four times the area, making it one-fourth the intensity.

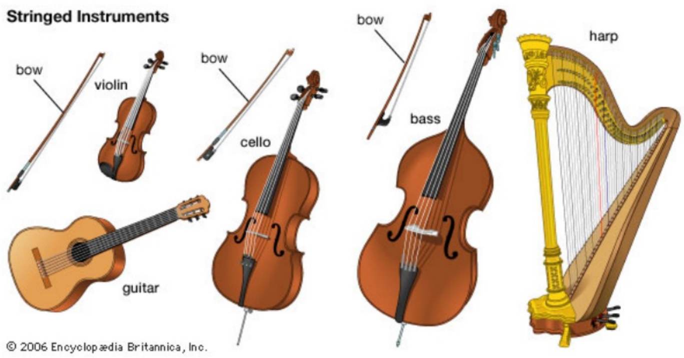


Example: I hear a noise at 50db. If I travel to twice the distance:
(a) By what factor does the intensity change?

(b) How many decibels difference is it?

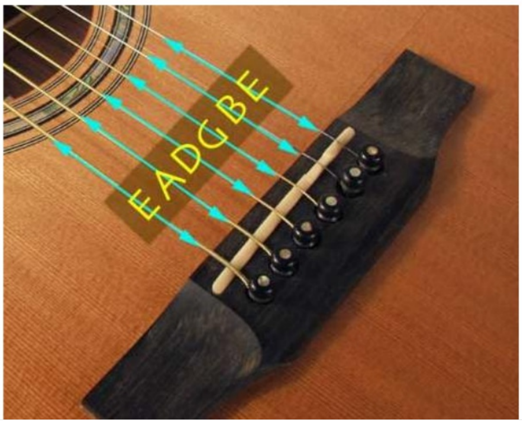
String instruments (or closed tubes):





Int.erlace question: How do the different strings of a guitar or a violin make different notes if they are the same length?

"different notes"



$$f\lambda = v \Rightarrow f = \_\_\_\_$$

$$v = \sqrt{\frac{T}{\mu}} \Rightarrow v = \_\_\_\_\_$$

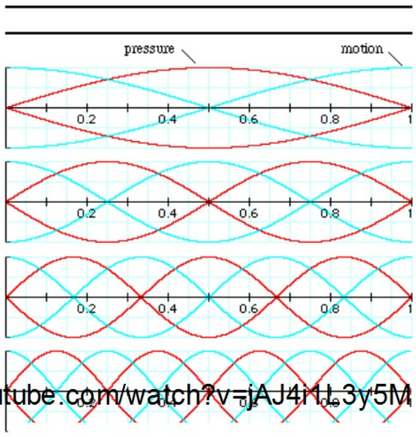
Two ways to adjust pitch (frequency):

1.Change _____

2. Change ____

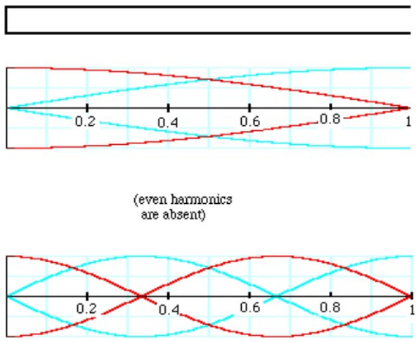
Open tube instruments, why does a flute sound different from a clarinet:

Flute



https://www.youtube.com/watch?v=jAJ4i1LL3y5M

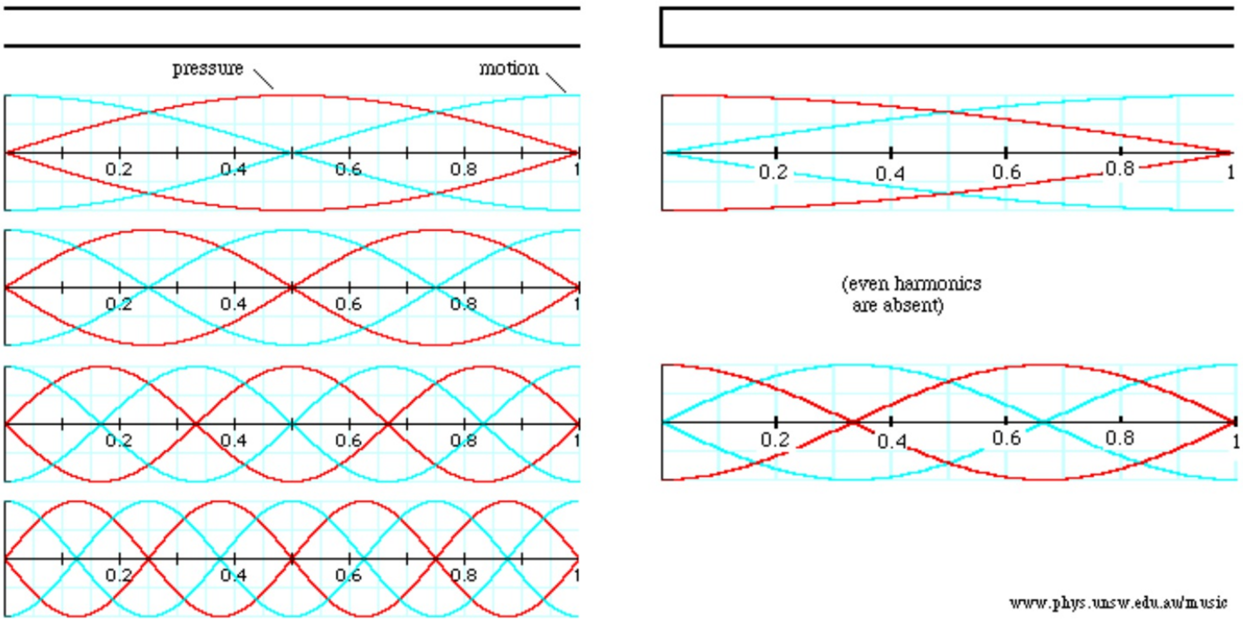
Clarinet



https://www.youtube.com/watch?v=8AzV_Sz-oYw#t=40s

www.phys.unsw.edu.au/music

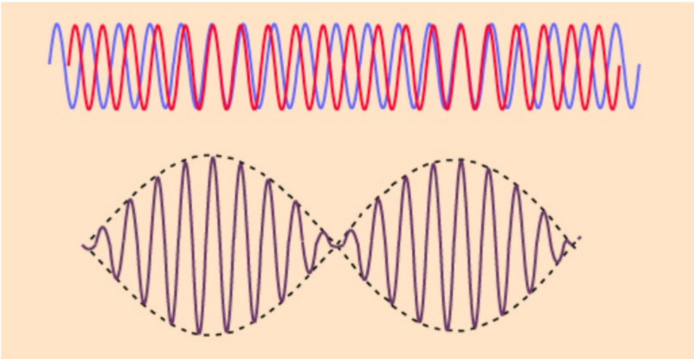
Open tube instruments:



Rules:

1. A closed end of a tube (tied end of a string) must have a ______[**node/antinode]** because motion is ____[**allowed/not allowed**]
2. A open end of a tube (free end of a string) must have a ______[**node/antinode]** because motion is ____[**allowed/not allowed**]

Beats: what happens when you add together two waves that have very close frequencies



https://www.youtube.com/watch?v=V8W4Djz6jnY

$$f_{beat} = f_2 - f_1$$

Doppler effect:

https://www.youtube.com/watch?v=0mEF9v21Dh
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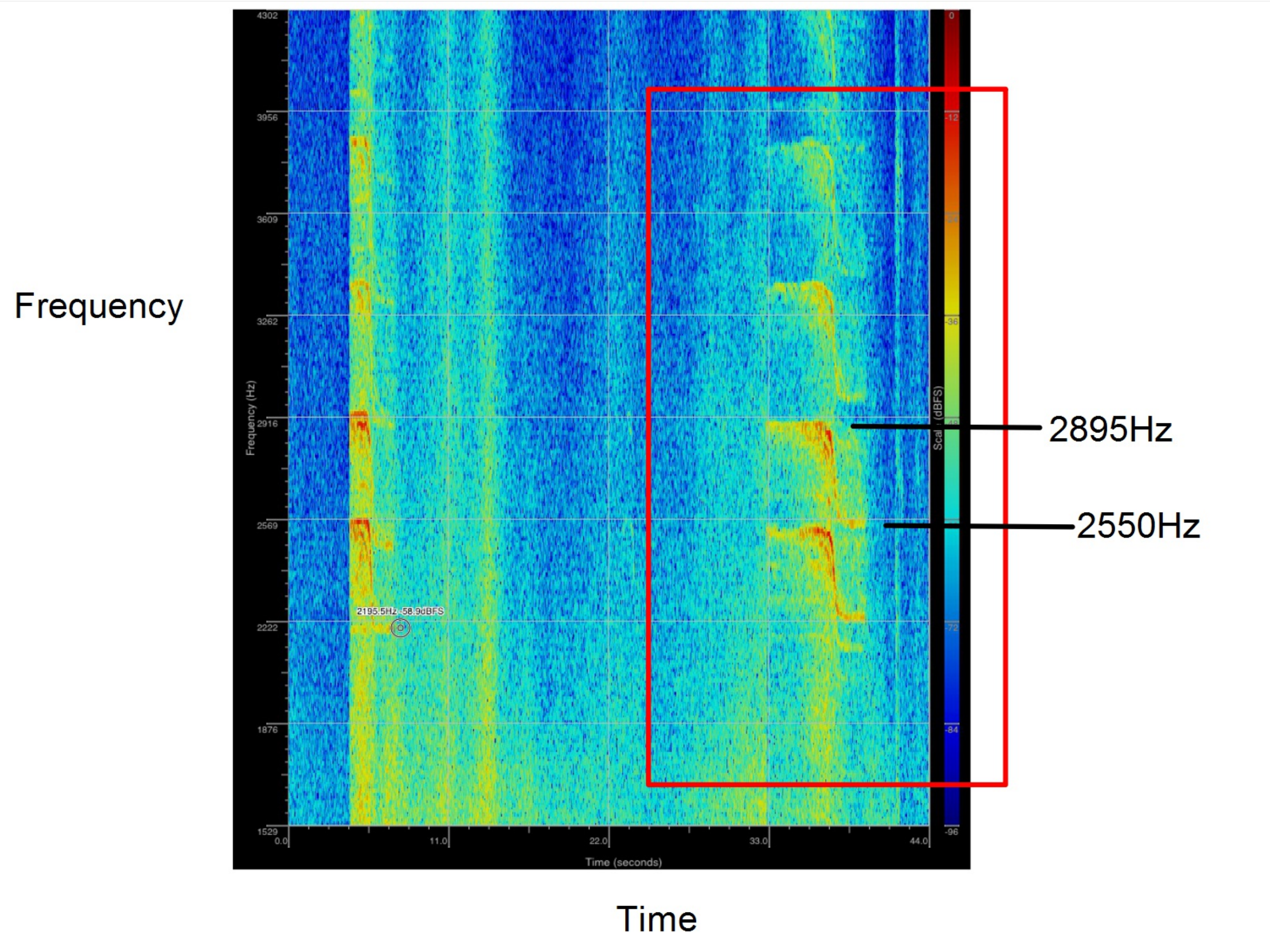
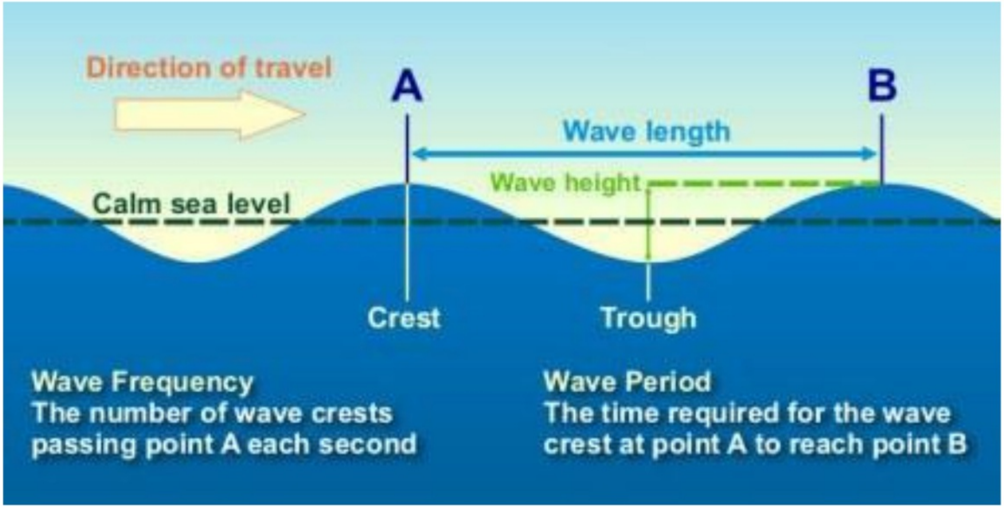


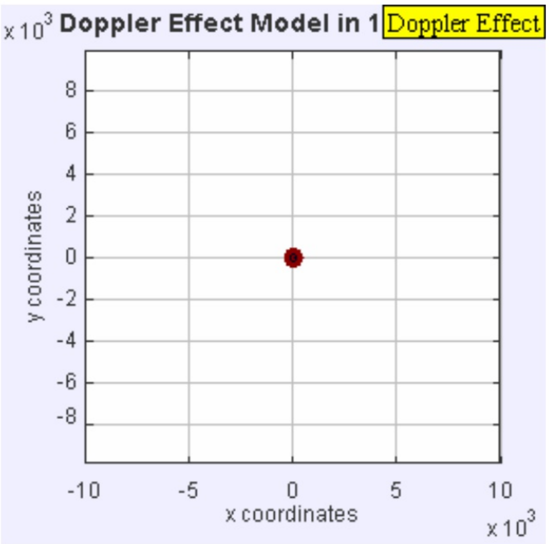
Frequency
2895Hz
2550Hz
Time
Time (seconds)
Frequency (Hz)
2195.5Hz -58.9dBFS

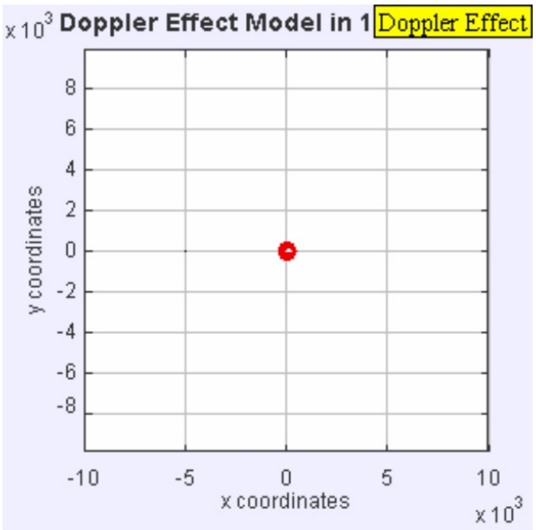
Explaining it - observer moves:



When you travel against the waves the frequency of the waves seems [higher/lower?]

What about when source moves?





When source moves away from you, space between waves (wavelength) appears __________[larger/smaller]

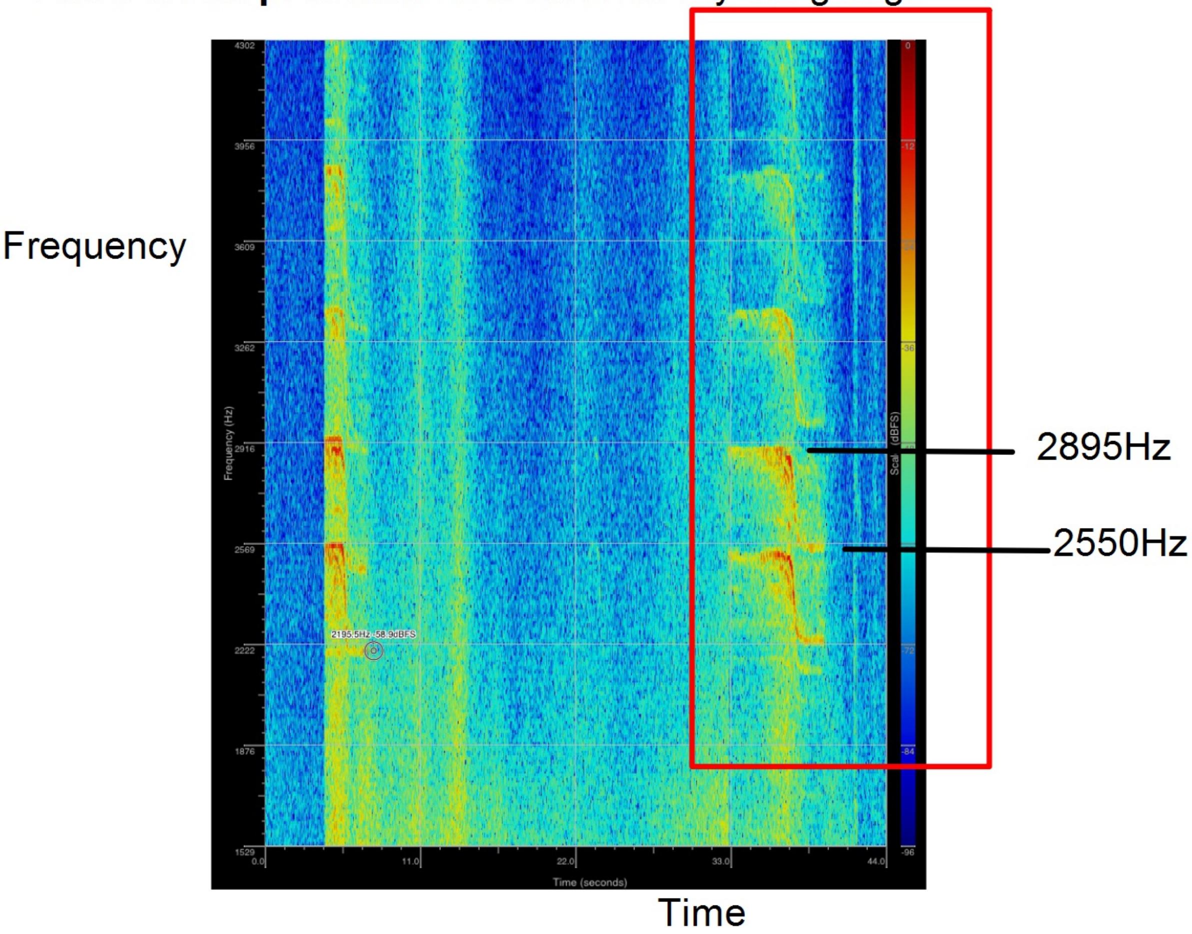
When source moves toward you, space between waves (wavelength) appears __________[larger/smaller]

Full formula

$$f' = \left(\frac{v \pm v_o}{v \pm v_s} \right) f$$

where
f' = the apparent frequency
f = the original frequency
v = speed of sound (or other wave)
v_o=speed of observer (use **+** if observer is moving [toward/away from] sound source, use - if observer is moving [toward/away from] sound source
v_s=speed of source (use **+** if source is moving [toward/away from] observer, use - if observer is moving [toward/away from] observer

Extra credit problem: How fast was my car going?



If an ambulance siren has a frequency of 2000hz
(a) What is the apparent frequency when the ambulance is moving towards the observer at 60kph

$$f' = \left(\frac{v \pm v_o}{v \pm v_s} \right) f$$

(b) What is the apparent frequency when the ambulance is moving away from the observer at 60kph?