
ic25
infocomm
Education
June 7 - 13
Exhibits
June 11 - 13
Orange County
Convention Center

Acoustics: The Mayhem Continues

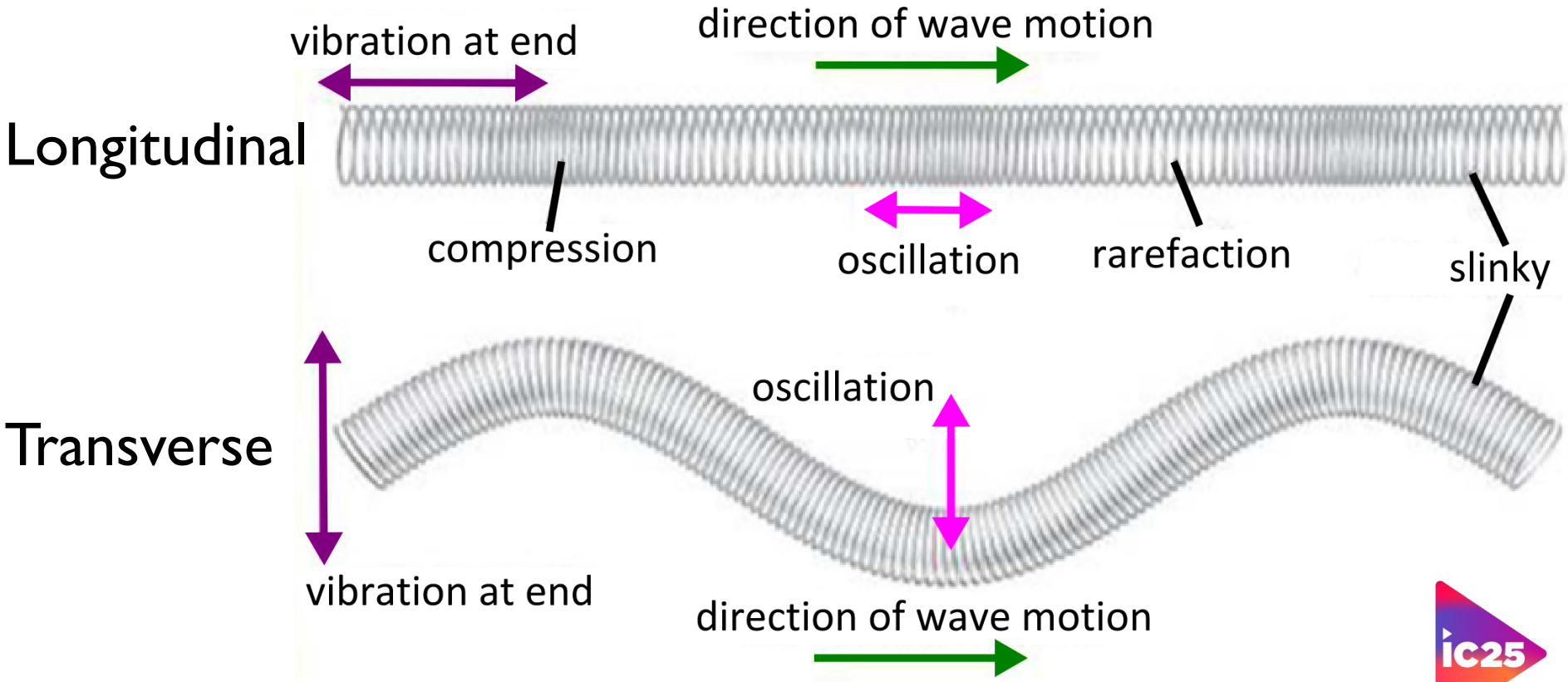
Linda A. Gedemer, PhD

AV Engineering Manager

Faith Group LLC.

Quick Recap

Wave Types


Longitudinal
vibration at end
direction of wave motion
compression
oscillation
rarefaction
slinky
Transverse
oscillation
vibration at end
direction of wave motion

The Decibel

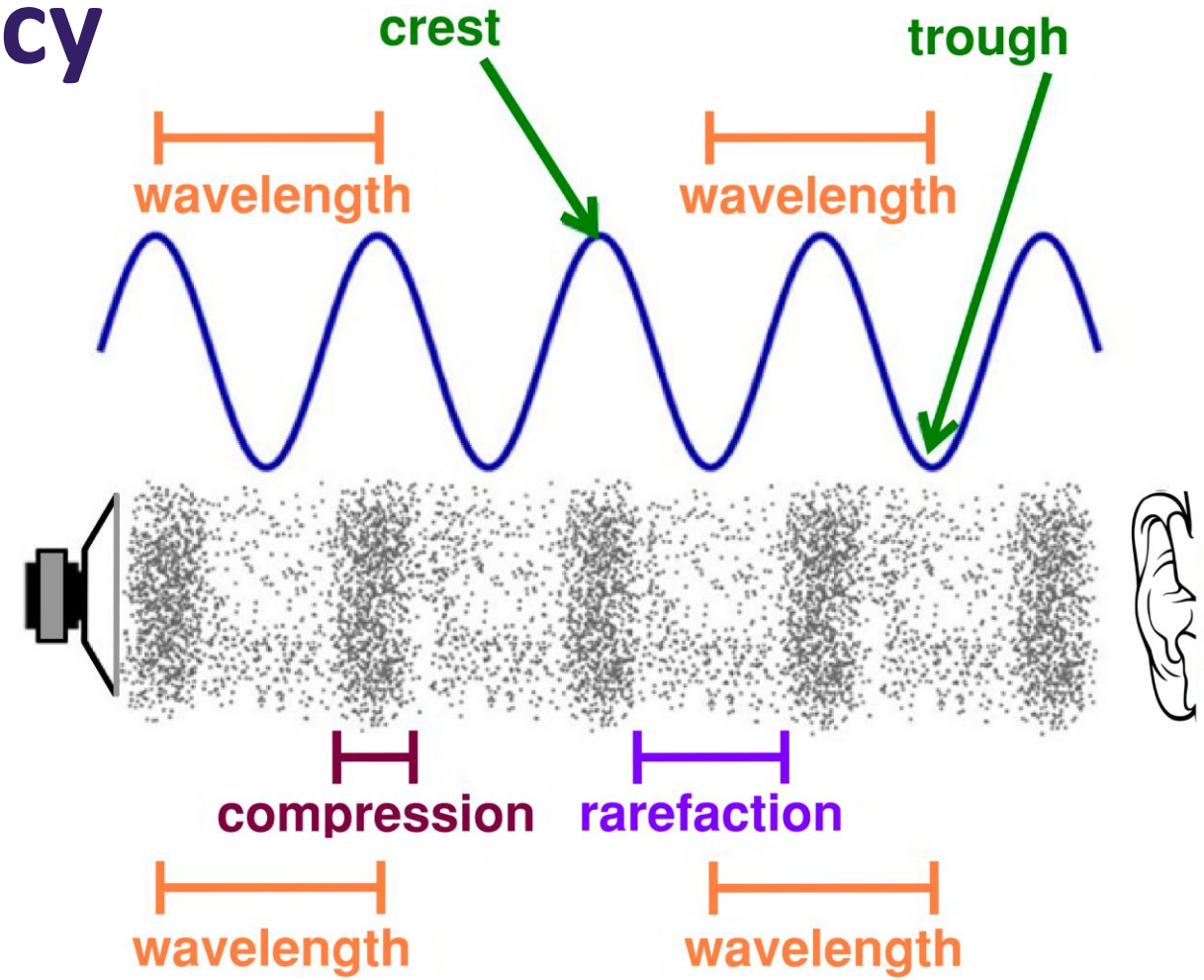
Decibel – logarithmic unit used to describe the ratio of a signal level - like pressure or power - to a reference level.

Threshold of Pain

$$20\log\frac{20}{20\mu} = 120dB_{SPL}$$

Threshold of Hearing

Frequency


crest
trough
wavelength
wavelength
compression
rarefaction
wavelength
wavelength

Frequency / Wavelength / Time / Speed

$\boldsymbol{\lambda}$ = Symbol for wavelength

$\boldsymbol{c}$ = Speed of sound: 1,125ft/s or 343 m/s

$\boldsymbol{f}$ = Frequency (Hz)

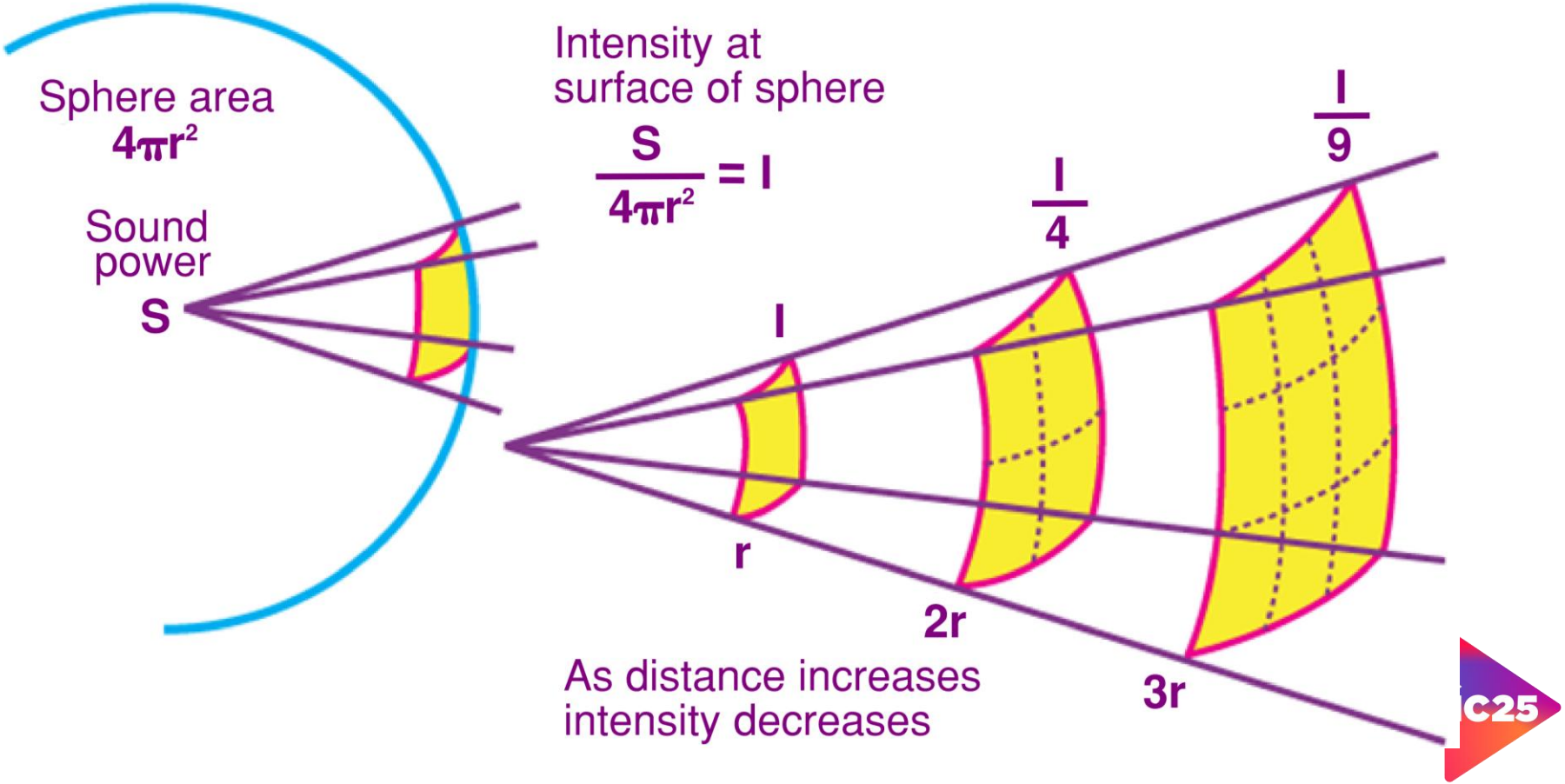
$\boldsymbol{t}$ = Time for wavelength to complete 1 cycle (sec)

$$\boldsymbol{\lambda = \frac{c}{f}} \qquad \boldsymbol{t = \frac{1}{f}} \qquad \lambda = \frac{1{,}125\ ft/s}{1000Hz} = 1.125ft$$

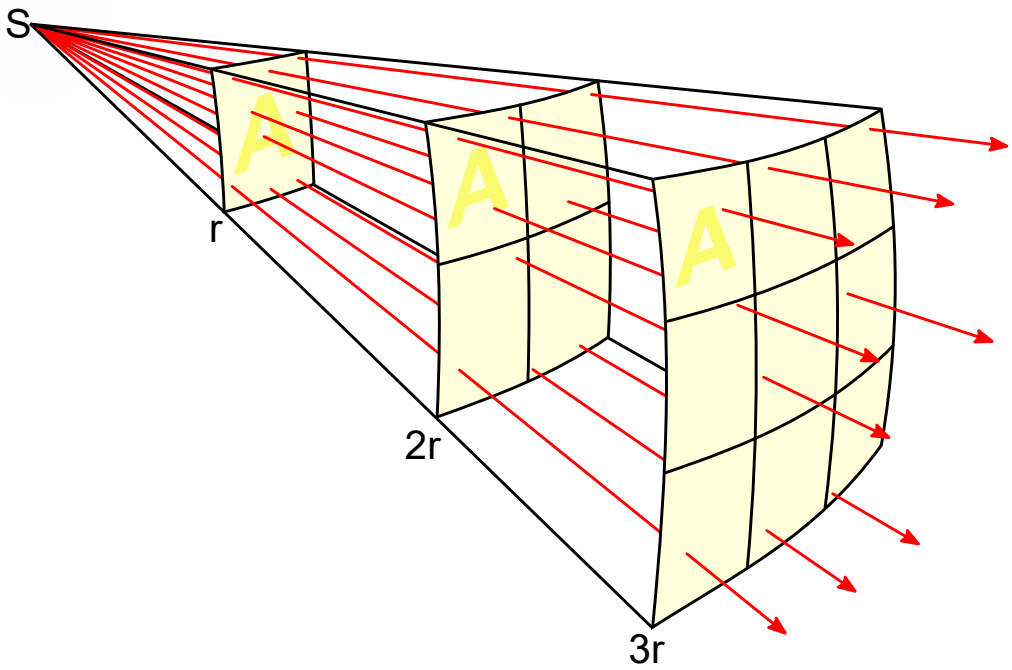
$$\boldsymbol{f = \frac{c}{\lambda}} \qquad \boldsymbol{f = \frac{1}{t}} \qquad t = \frac{1}{1000Hz} = 0.001sec$$

Fun with Math
(no seriously)

Inverse Square Law



Inverse Square Law



$$20\log\frac{1}{2} = 6dB_{SPL}$$

$$10\log\frac{1}{4} = 6dB_{SIL}$$

Pressure/Power/Voltage vs Decibels

$$20\log\frac{2}{1} = 6dB_{SPL}$$ Pressure

$$10\log\frac{2}{1} = 3dB_{w}$$ Power

$$20\log\frac{2}{1} = 6dB_{v}$$ Voltage

Pressure/Power/Voltage vs Decibels

$$20\log\frac{90_{dB}+90_{dB}}{90_{dB}}=96dB_{SPL}$$

Adding 2 Sources

$$10\log\frac{200_{w}}{100_{w}}=3dB_{w}$$

Change w/ Amplifier Power Increase

$$20\log\frac{1_{mV}}{8_{mV}}=-18dB_{mv}$$

Comparing Mic Sensitivity

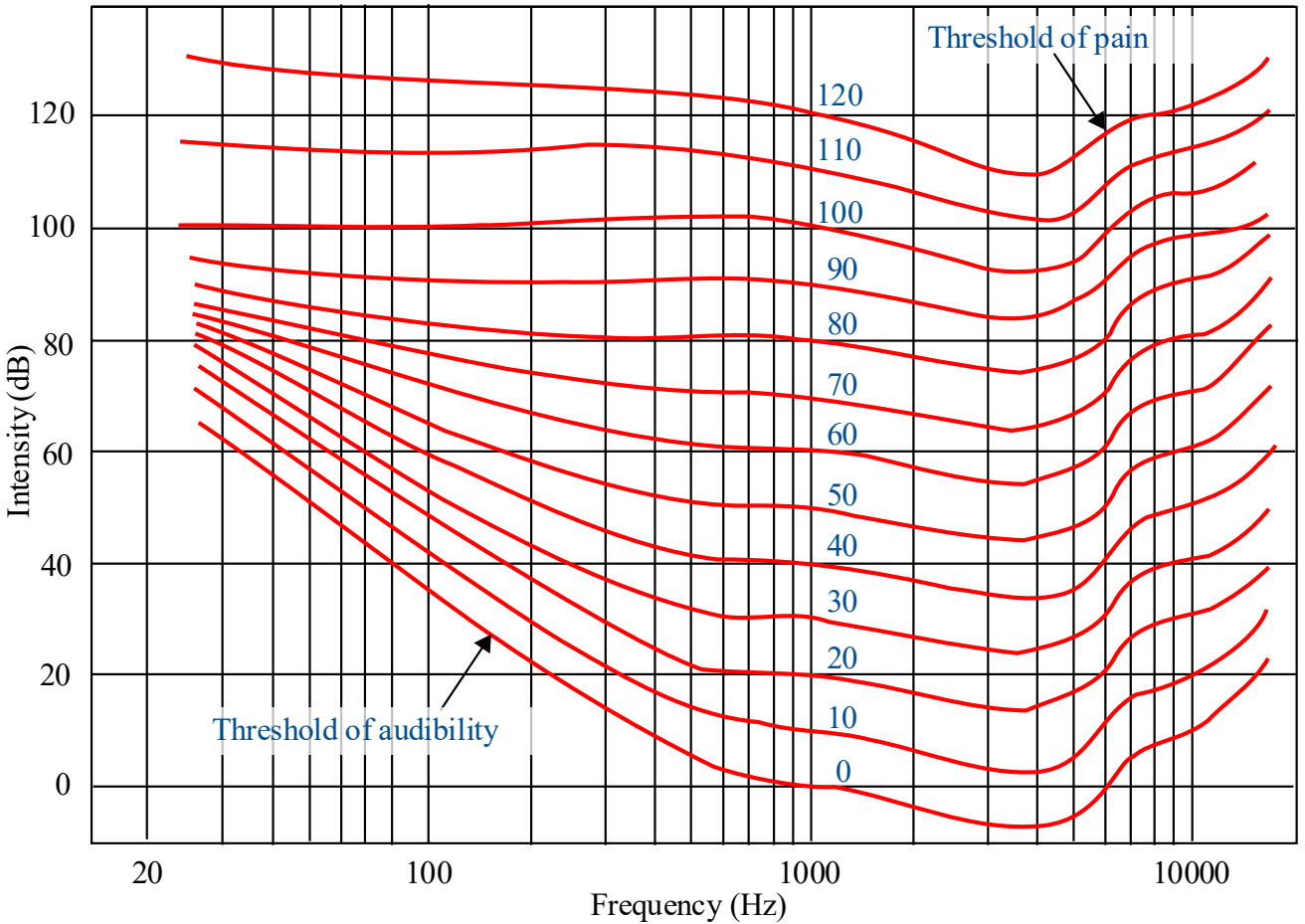
Calculating Reverberation Time

$$T_{RT60} = \frac{0.161V_m}{S\bar{\alpha}} = \frac{0.049V_f}{S\bar{\alpha}}$$ **Sabine Equation**

T_{RT60} = RT_{60} Reverberation Time (sec)
V_f = Volume of Room (cu ft)
V_m=Volume of Room (cu mt)
S = Total Surface Area of Room
$\bar{\alpha}$ = Average Absorption Coefficient of Room Surfaces
$S\bar{\alpha}$ = Total Absorption (Sabines)

Audio Perception

Audio Perception – Freq. vs Loudness



Audio Perception - Localization

Interaural Time Difference (ITD)

- Time and phase differences
- <1000Hz

Interaural Level Difference (ILD)

- Level differences
- >1500Hz

Audio Perception - Reflections

Precedence Effect

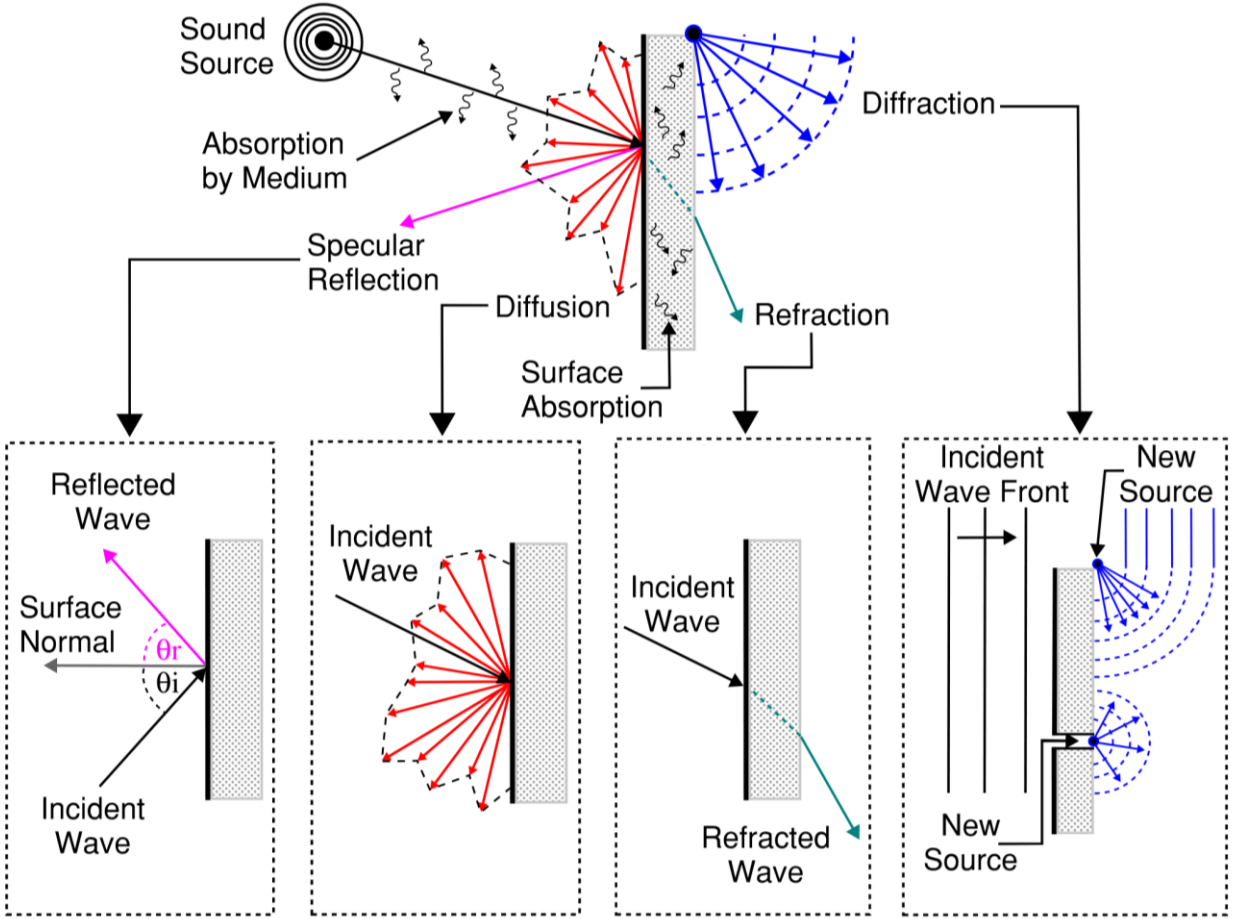
- Identical sounds are “fused” together
- Within 5ms for simple & 40ms for complex sounds

Haas Effect

- Reflections 5-30ms can be 10dB louder without being perceived as an echo
- >50ms for speech & >100ms for music = echo

Acoustic Treatments

Sound in Enclosed Spaces



Acoustic Treatments

Common Types

- Absorption
- Diffusion
- Combined Absorption / Diffusion

Acoustic Absorption

Common Materials

- **Mineral fibers and fabrics:** The most common type of panel. Mineral-fiber base is covered in stretched fabric.
- **Fiberglass:** High-density fiberglass bonded to a sound-absorbing glass fiber blanket
- **Wood and Wood Fiber:** Often perforated to enhance acoustic absorption.
- **Natural fibers:** E.g., sugarcane, cotton

Acoustic Treatments - Walls

Acoustic Plaster

3-D Polyester Fiber Board

Wood Slats

RPG Skyline

Slat Absorber

Acoustic Moss

Acoustic Treatments - Ceilings

Ceiling Clouds

Ceiling Clouds

Acoustic Pendant Lights

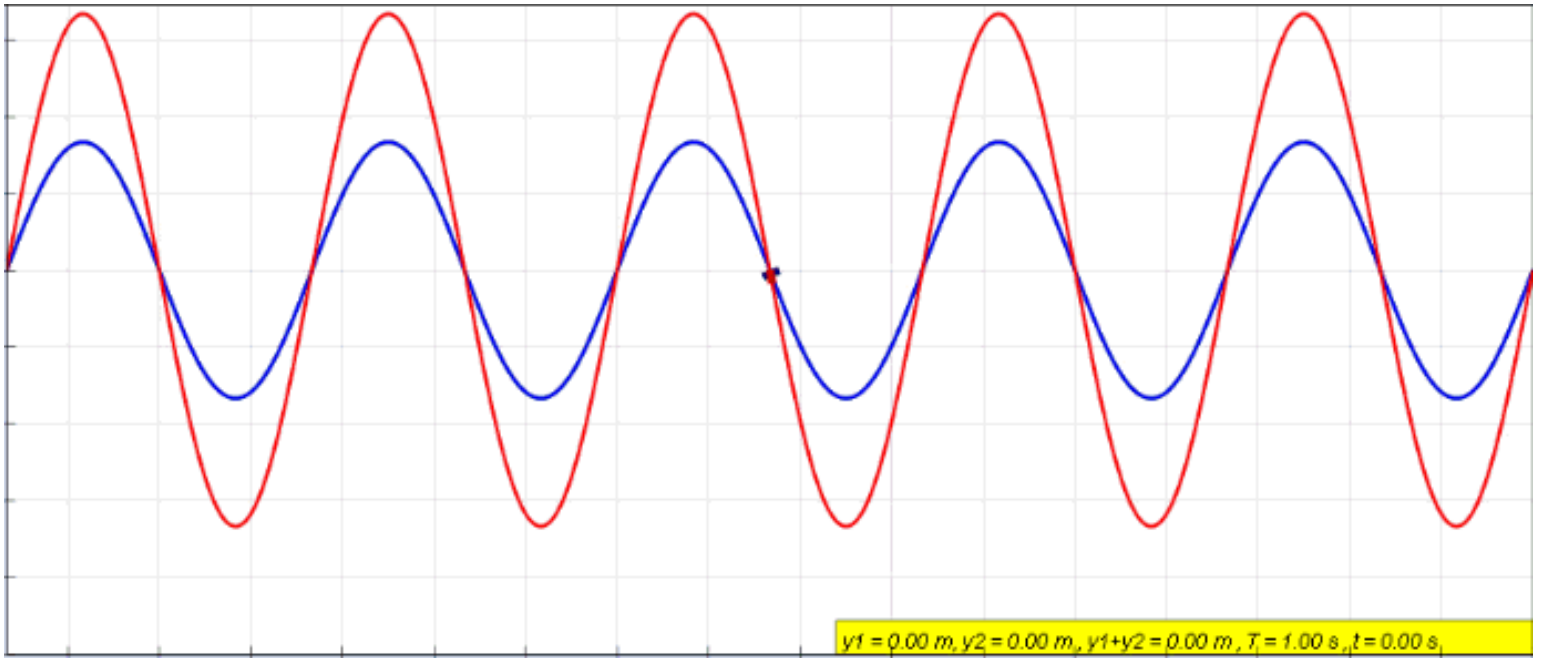
Wood Slat

Acoustic Ceiling Tiles

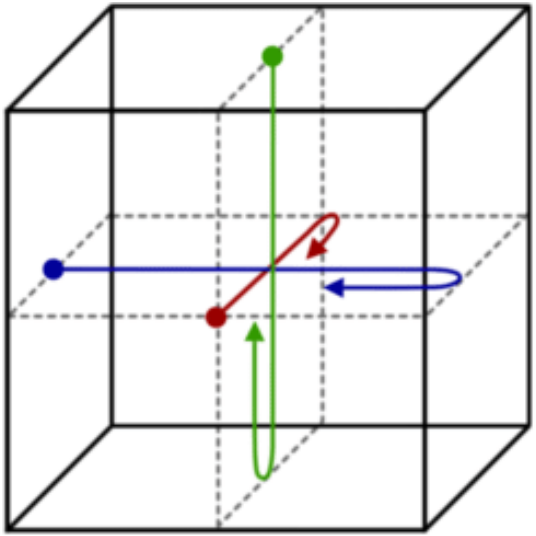
Room Modes & Bass Traps

Standing Wave (flutter echo)

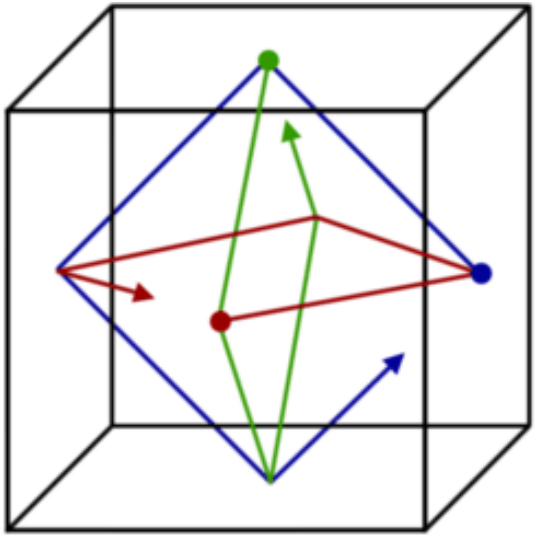
$$f_n = \mathrm{c} \cdot \frac{n}{d} \qquad f_1 = 1125 \cdot \frac{1}{20} = 56.25\mathrm{Hz}$$



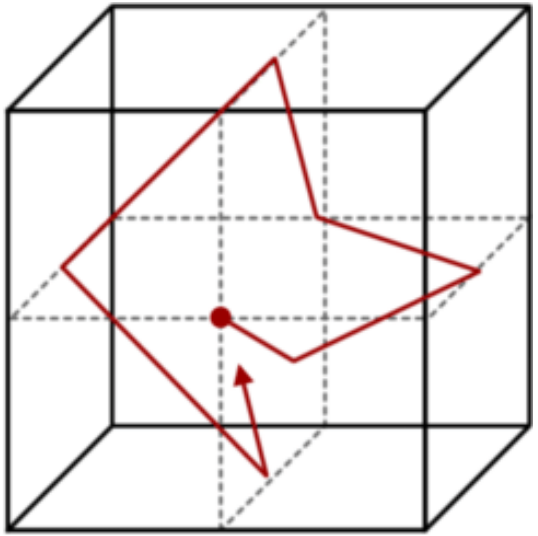
Room Modes



Axial modes: 2 boundaries

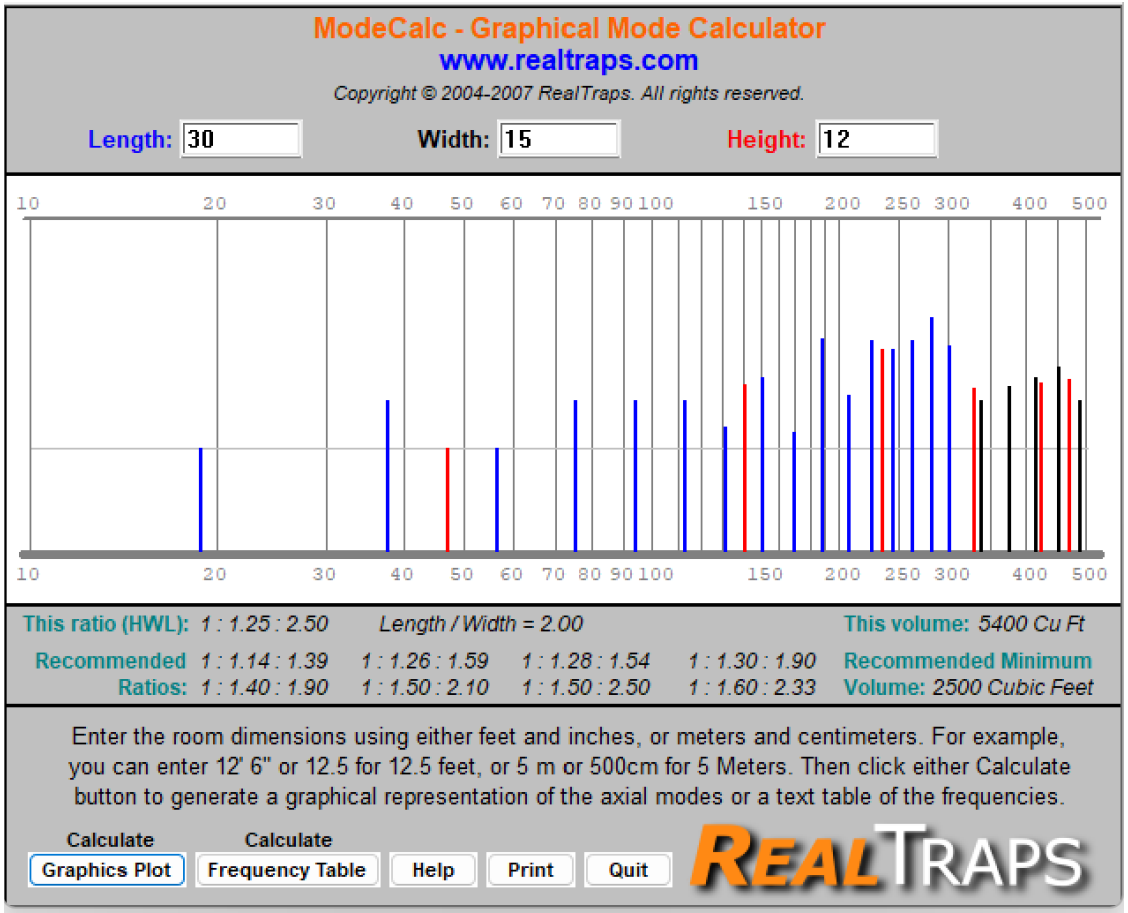


Tangential modes: 4 boundaries



Oblique modes: 6 boundaries

Room Modes


ModeCalc - Graphical Mode Calculator
www.realtraps.com
Copyright © 2004-2007 RealTraps. All rights reserved.
Length: 30
Width: 15
Height: 12
10 20 30 40 50 60 70 80 90 100 150 200 250 300 400 500
This ratio (HWL): 1 : 1.25 : 2.50
Length / Width = 2.00
This volume: 5400 Cu Ft
Recommended Ratios: 1 : 1.14 : 1.39 1 : 1.40 : 1.90 1 : 1.26 : 1.59 1 : 1.50 : 2.10 1 : 1.28 : 1.54 1 : 1.50 : 2.50 1 : 1.30 : 1.90 1 : 1.60 : 2.33
Recommended Minimum Volume: 2500 Cubic Feet
Enter the room dimensions using either feet and inches, or meters and centimeters. For example, you can enter 12' 6" or 12.5 for 12.5 feet, or 5 m or 500cm for 5 Meters. Then click either Calculate button to generate a graphical representation of the axial modes or a text table of the frequencies.
Calculate Graphics Plot
Calculate Frequency Table
Help
Print
Quit
REALTRAPS

Room Modes

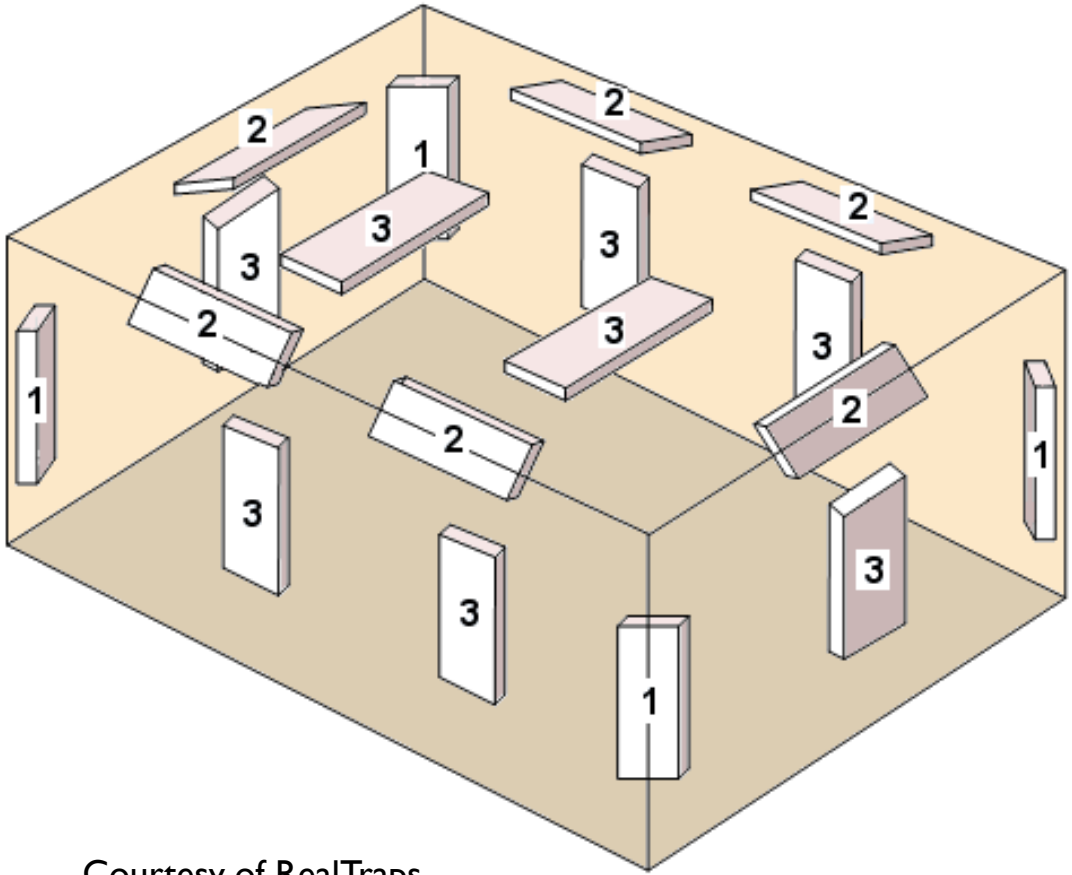
ModeCalc - Graphical Mode Calculator

www.realtraps.com

Length: 30 **Width:** 15 **Height:** 12

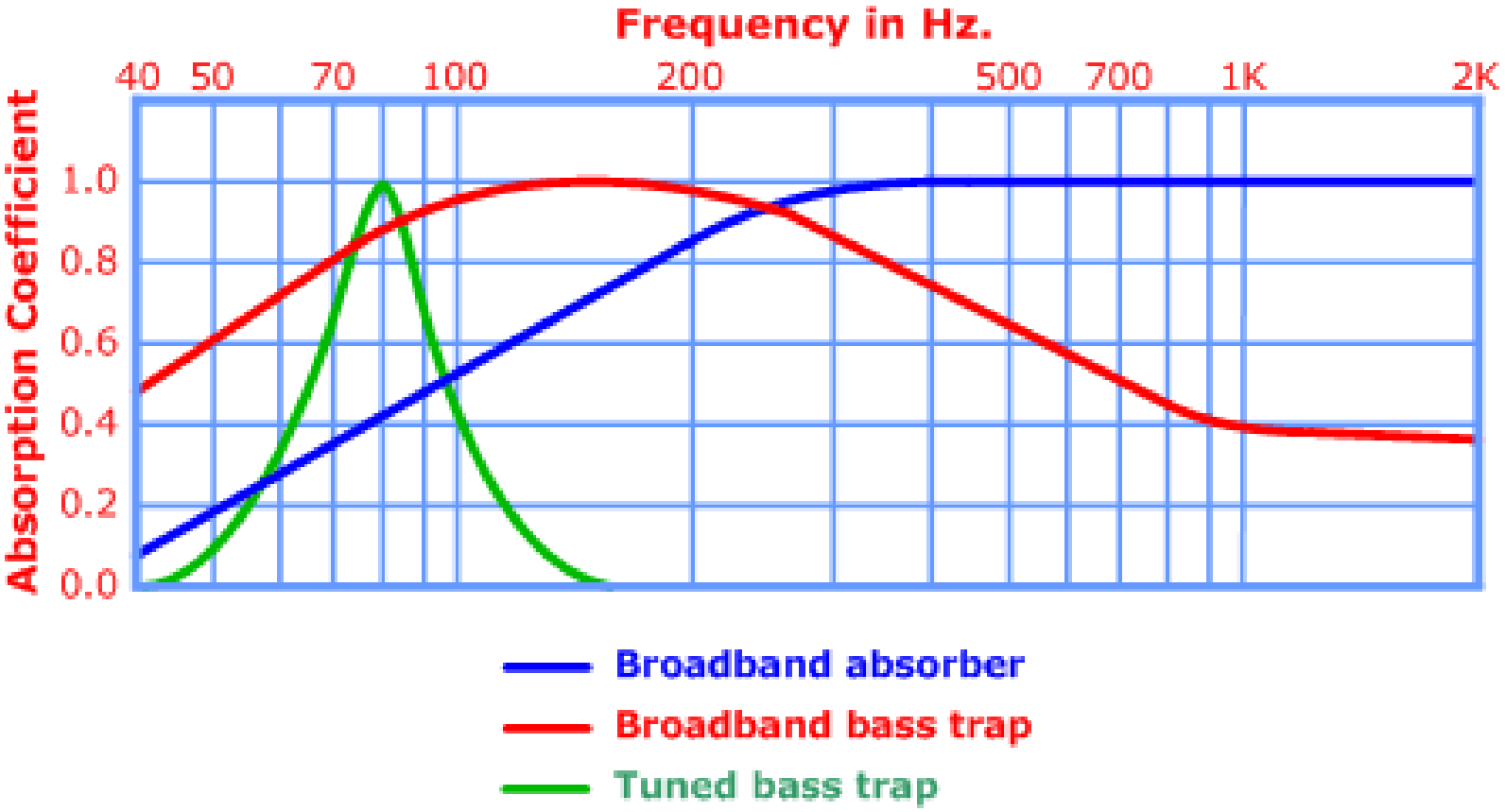
18.83	37.67	47.08
37.67	75.33	94.17
56.50	113.00	141.25
75.33	150.67	188.33
94.17	188.33	235.42
113.00	226.00	282.50
131.83	263.67	329.58
150.67	301.33	376.67
169.50	339.00	423.75
188.33	376.67	470.83
207.17	414.33	
226.00	452.00	
244.83	489.67	
263.67		
282.50		
301.33		

Bass Traps



Courtesy of RealTraps

Bass Traps


Frequency in Hz.
40
50
70
100
200
500
700
1K
2K
Absorption Coefficient
1.0
0.8
0.6
0.4
0.2
0.0
Broadband absorber
Broadband bass trap
Tuned bass trap

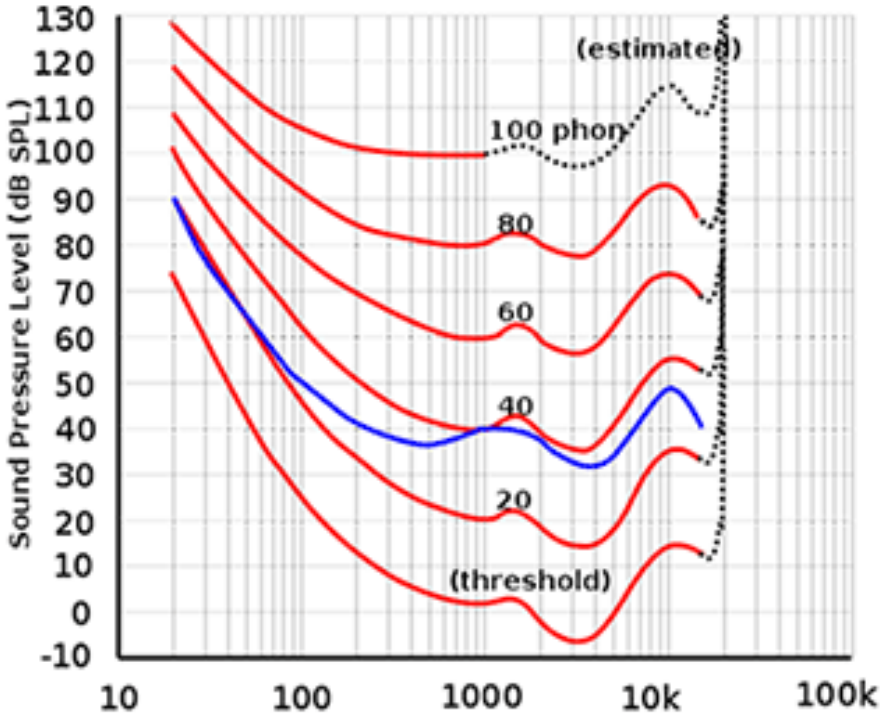
Audio Measurement & Tools

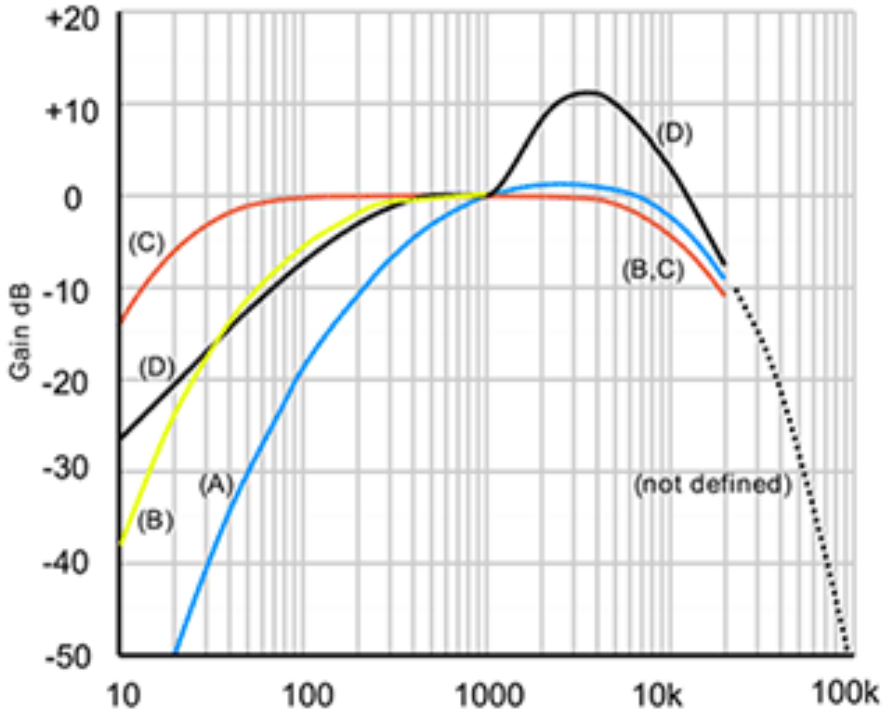
Standard Audio Measurements

- Sound Pressure Level (SPL)
- Frequency Response
- Reverberation Time (RT)
- Speech Transmission Index (STI)

Sound Pressure Level

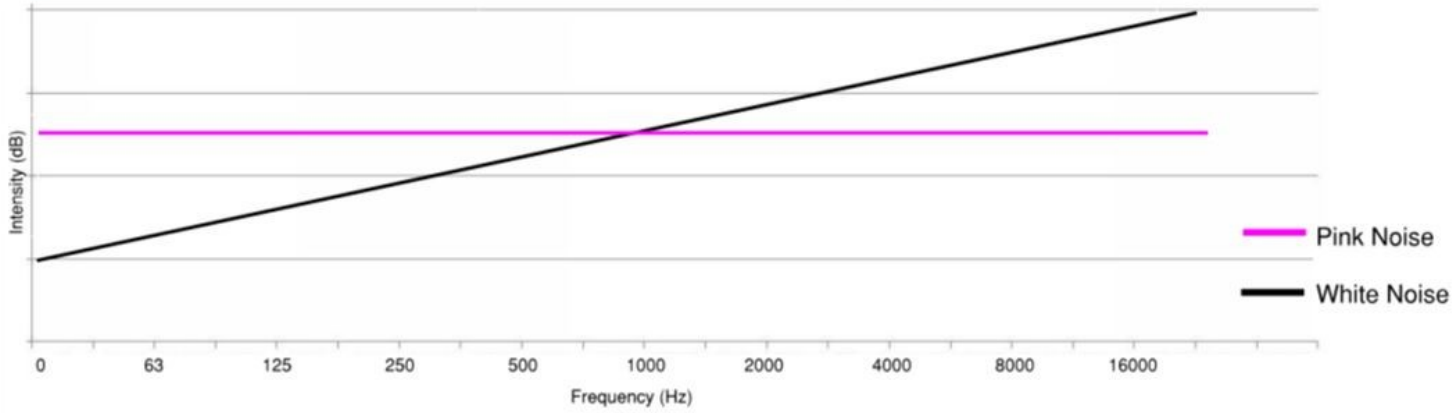
Sound Pressure Level - Weighting

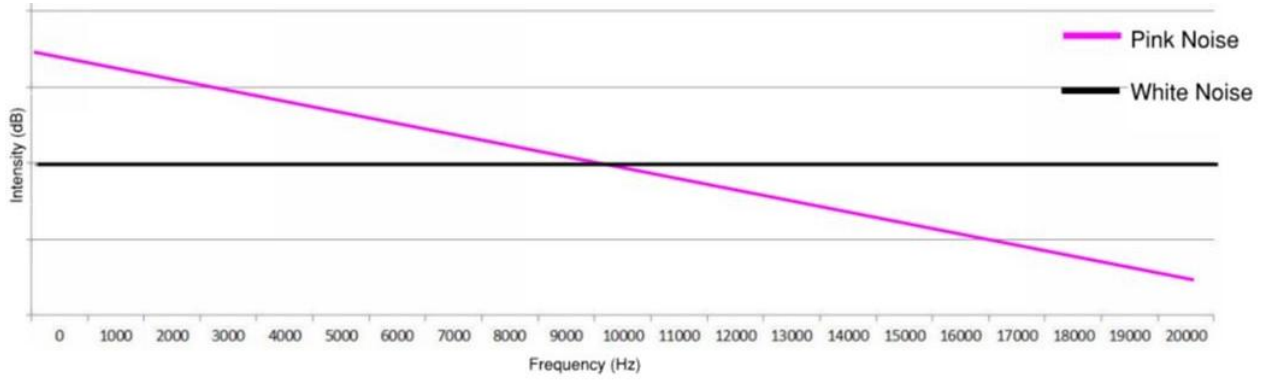




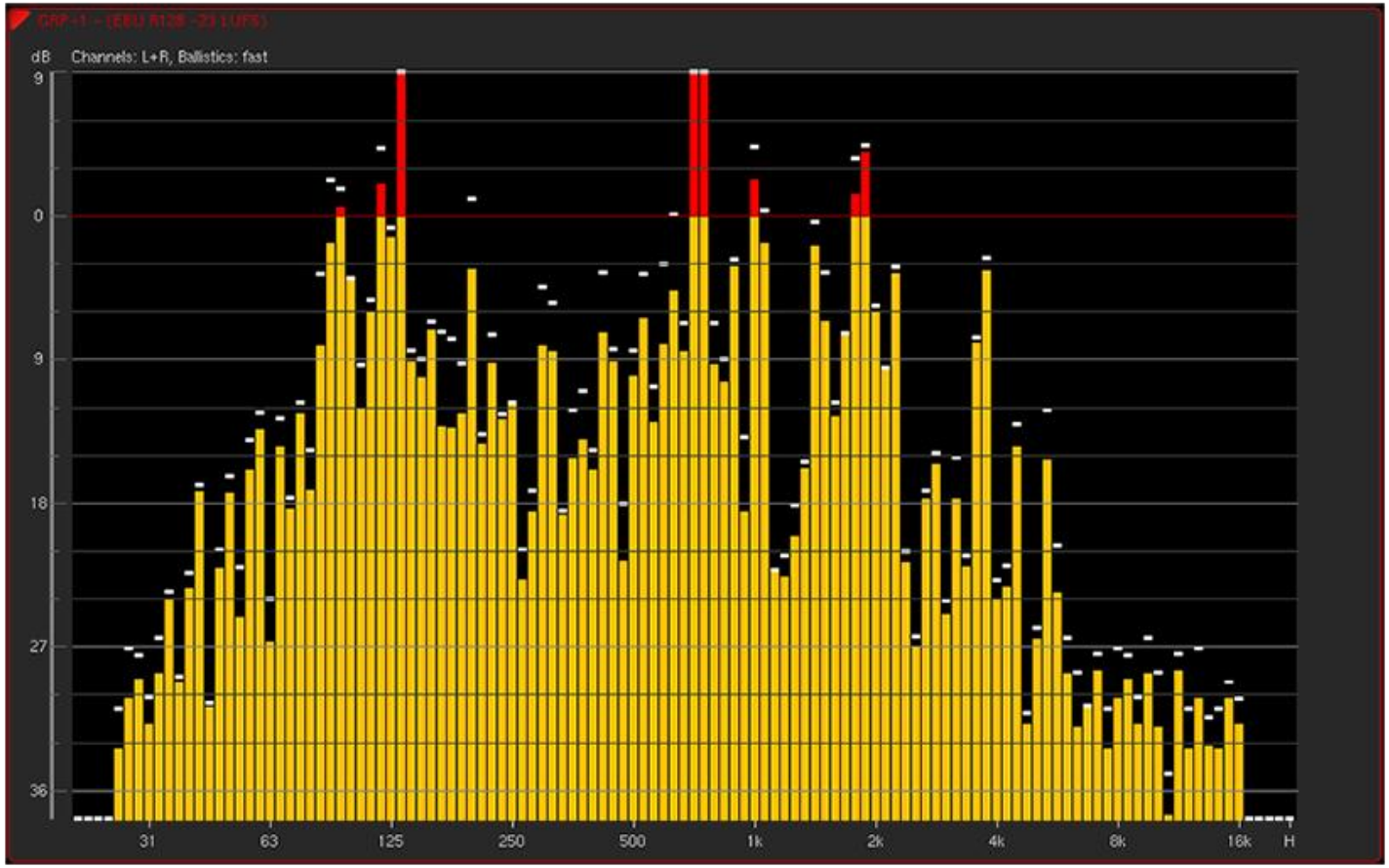
Frequency Response

Frequency Response – Noise Source

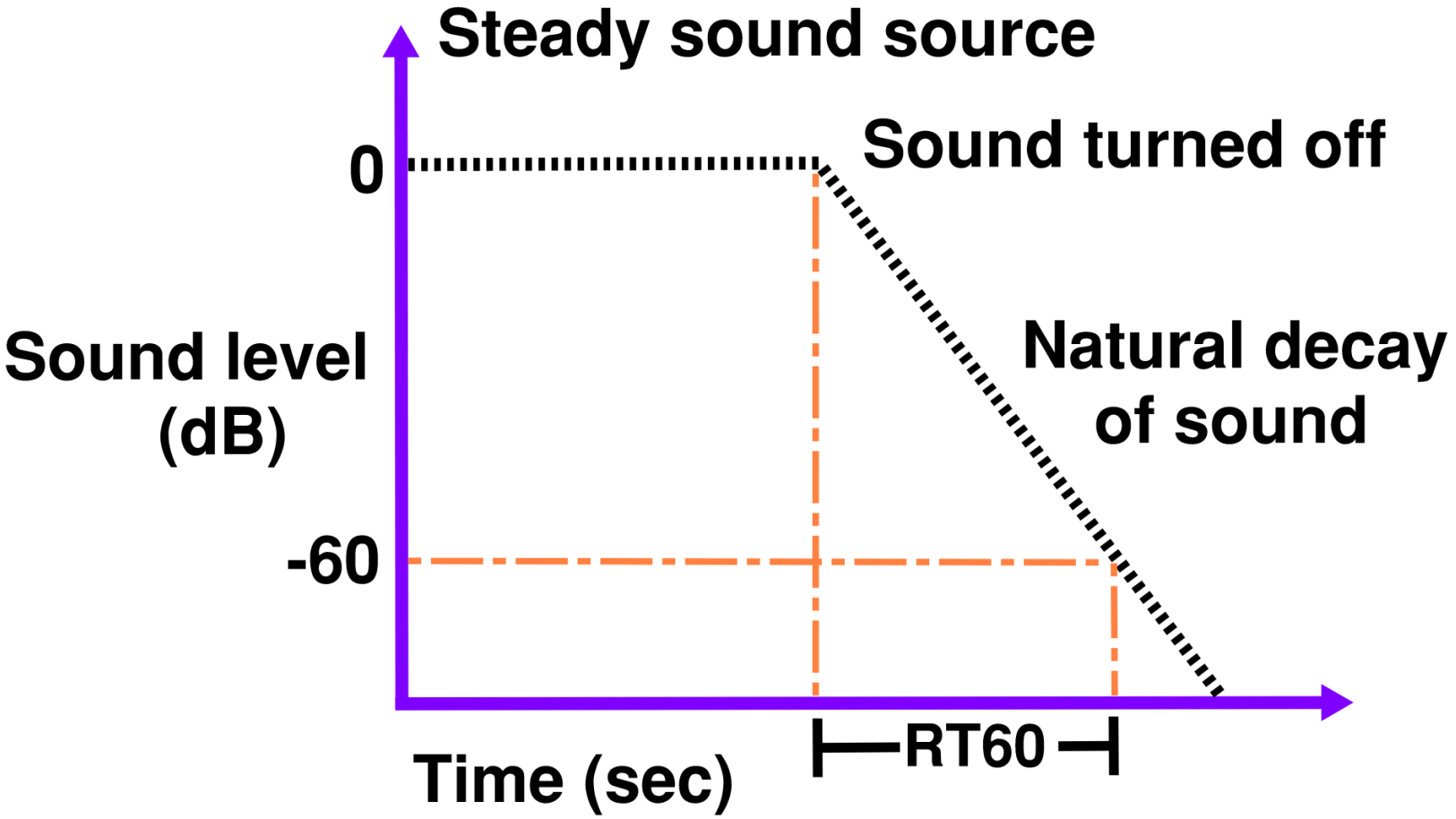




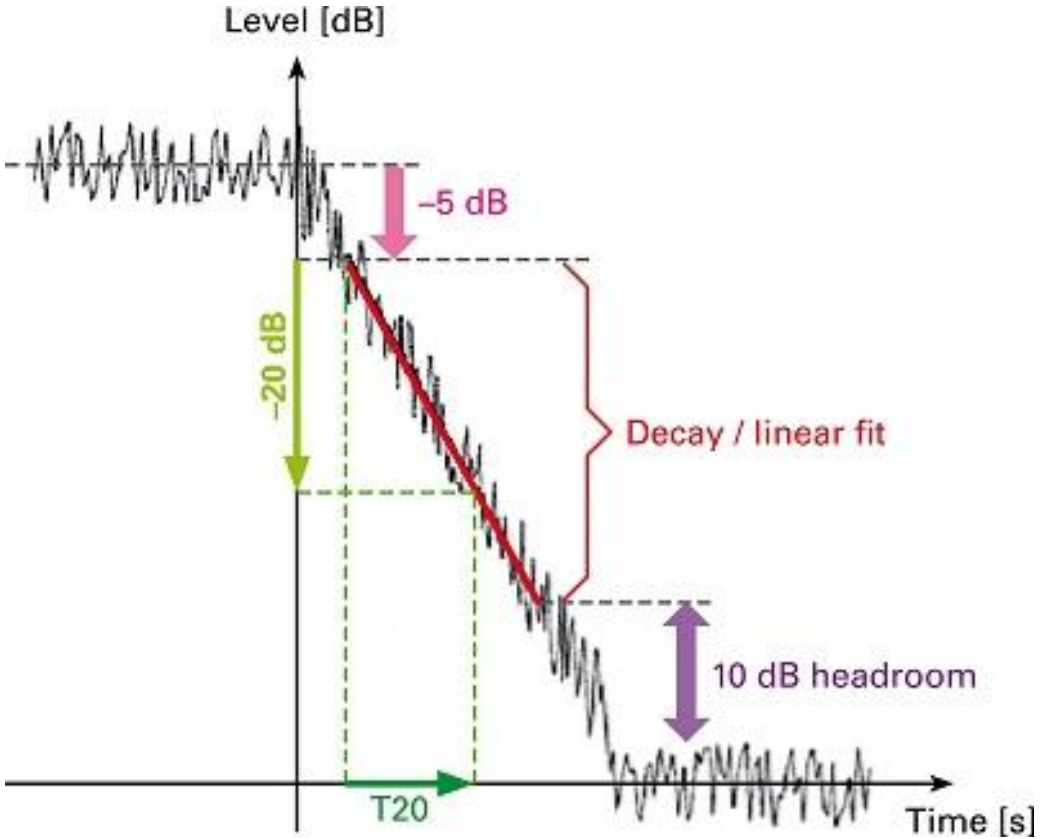
Frequency Response



Reverberation Time (RT)



Reverberation Time



Speech Transmission Index (STI)

STI Measurements:

- Based on pink noise
- 7 octave bands of the human voice, 125Hz to 8kHz
- 14 different modulation frequencies for 98 combinations

Speech Transmission Index for Public Address (STIPA):

- Simplified less time-consuming method
- Uses only 14 of the STI combinations

Speech Intelligibility

Factors that influence the intelligibility of speech

- Sound pressure level (speech must be loud enough, but not too loud)
- Ambient noise level (e.g. crowds or passing traffic)
- Reverberation time

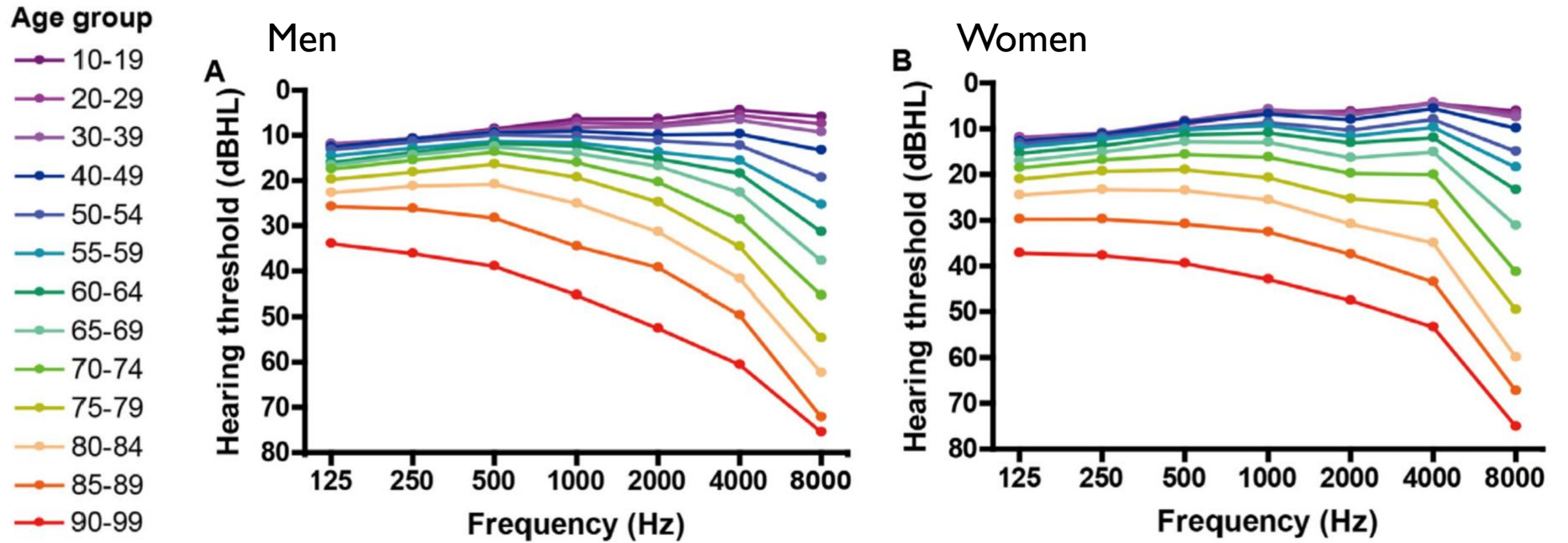
Also, if a Public Address (PA) system is being used

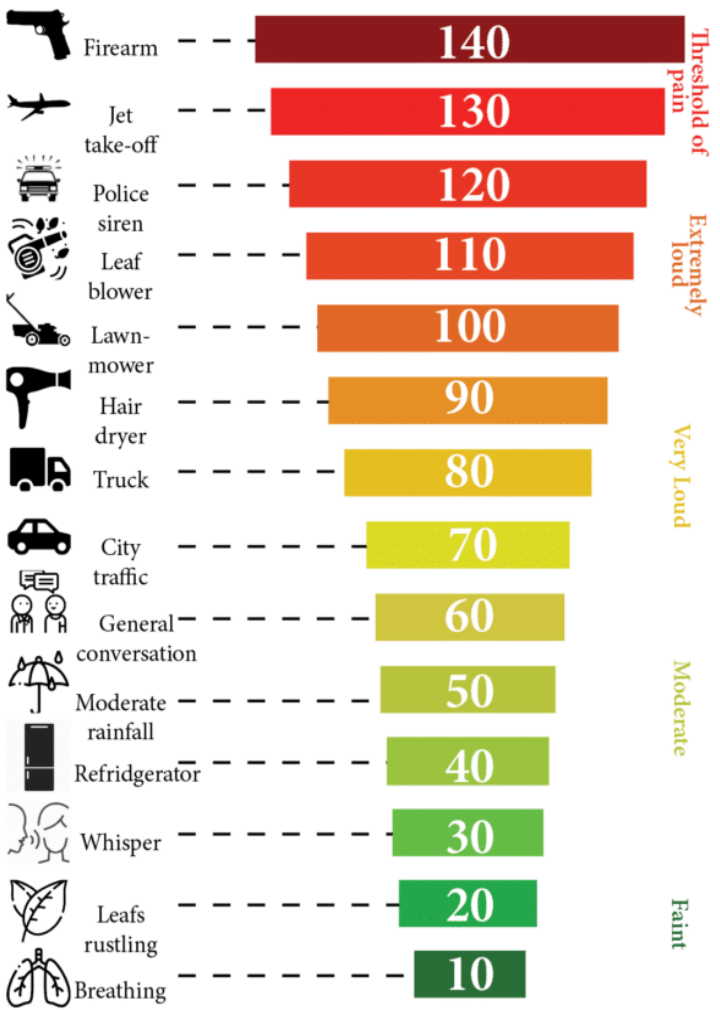
- Frequency response of the PA system (e.g. too much low frequencies)
- Signal-to-noise ratio (i.e. quality of the system)

Hearing Loss & Protection

Who has near perfect hearing?

Hearing Loss and Age





Time Exposure

30 sec

15 min

2 hours

8 hours

OSHA Standard sets maximum working level at 85dBA

Use Protection!

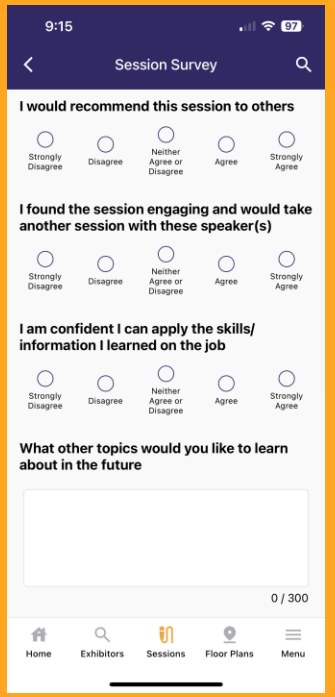
You got questions, I got answers!

THANK YOU!!

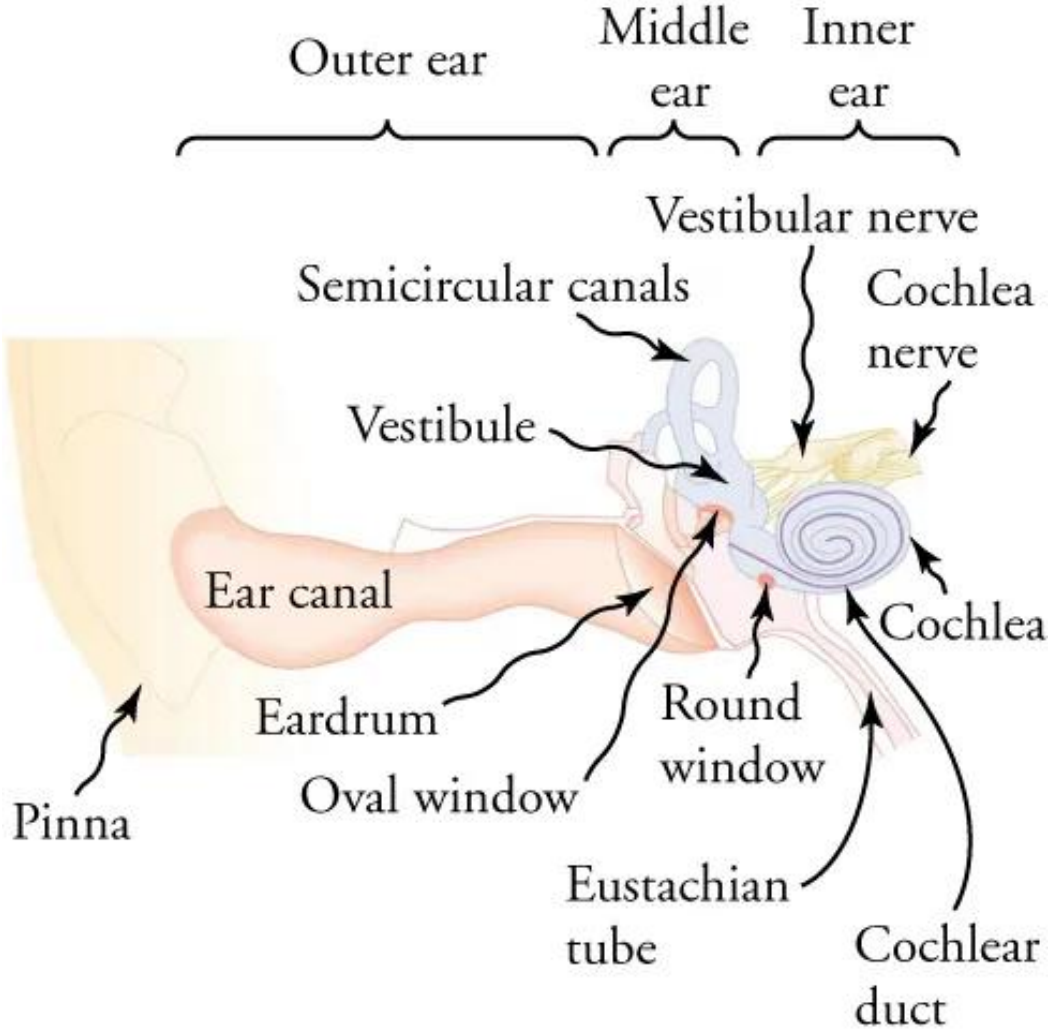
Please fill out the digital evaluations on the InfoComm app!

We Value Your Feedback!

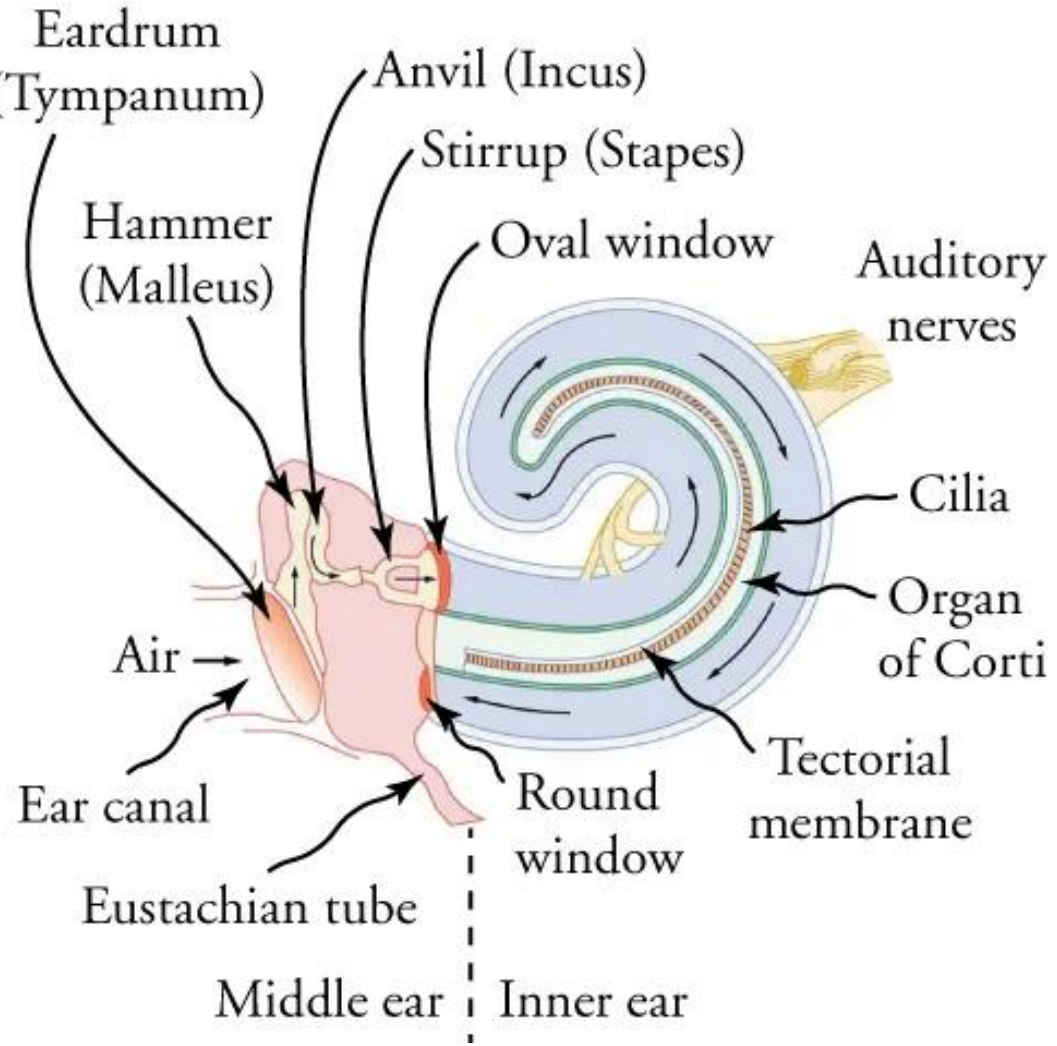
Please take 2-3 minutes to complete the session feedback in our app by downloading the mobile app using the QR code!



The Ear


Outer ear
Middle ear
Inner ear
Vestibular nerve
Semicircular canals
Cochlea nerve
Vestibule
Ear canal
Cochlea
Eardrum
Round window
Oval window
Pinna
Eustachian tube
Cochlear duct

The Ear


Eardrum
(Tympanum)
Anvil (Incus)
Stirrup (Stapes)
Hammer
(Malleus)
Oval window
Auditory
nerves
Cilia
Organ
of Corti
Air
Tectorial
membrane
Ear canal
Round
window
Eustachian tube
Middle ear
Inner ear