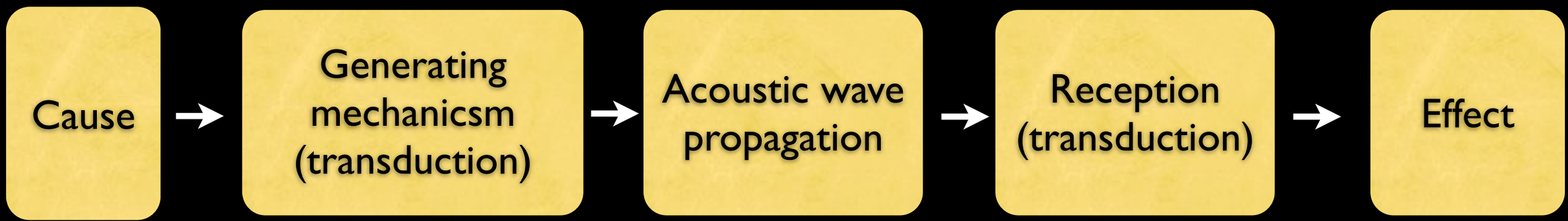
Room Acoustics

Alexander Refsum Jensenius
MUS2800 Sound Theory 1 H2010
University of Oslo

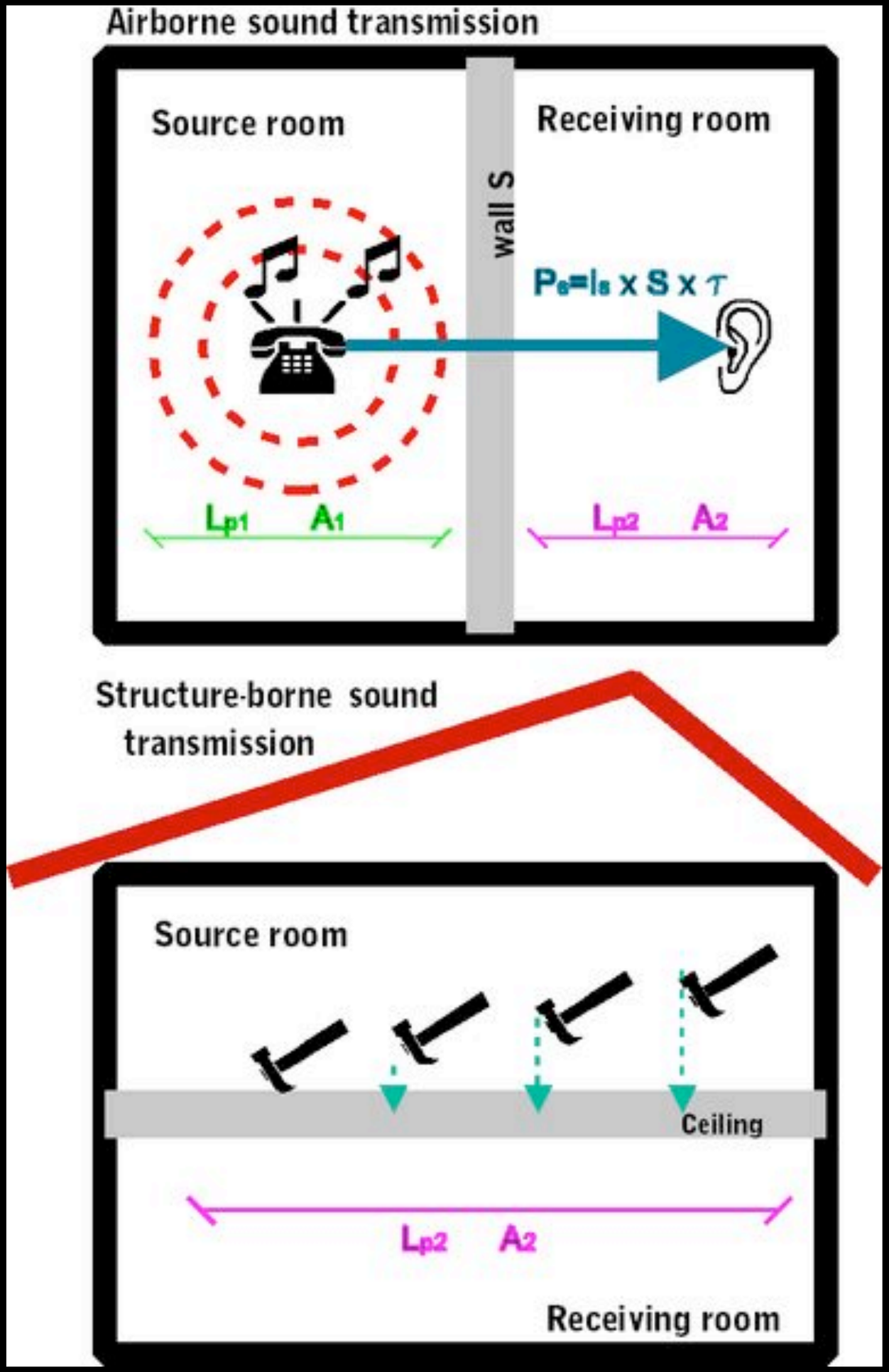
Acoustics ?

“Acoustics is the interdisciplinary science that deals with the study of all mechanical waves in gases, liquids, and solids including vibration, sound, ultrasound and infrasound.”

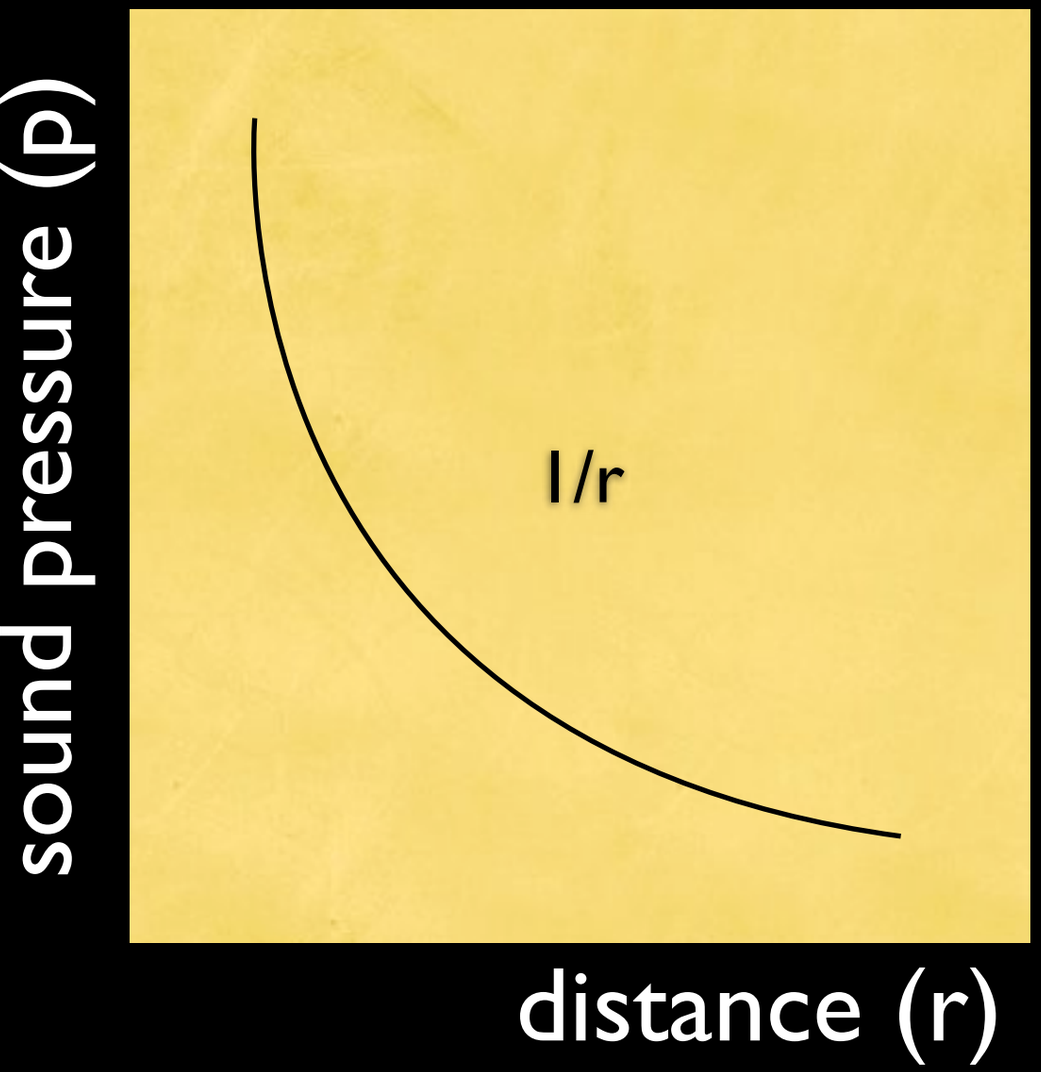
Wikipedia

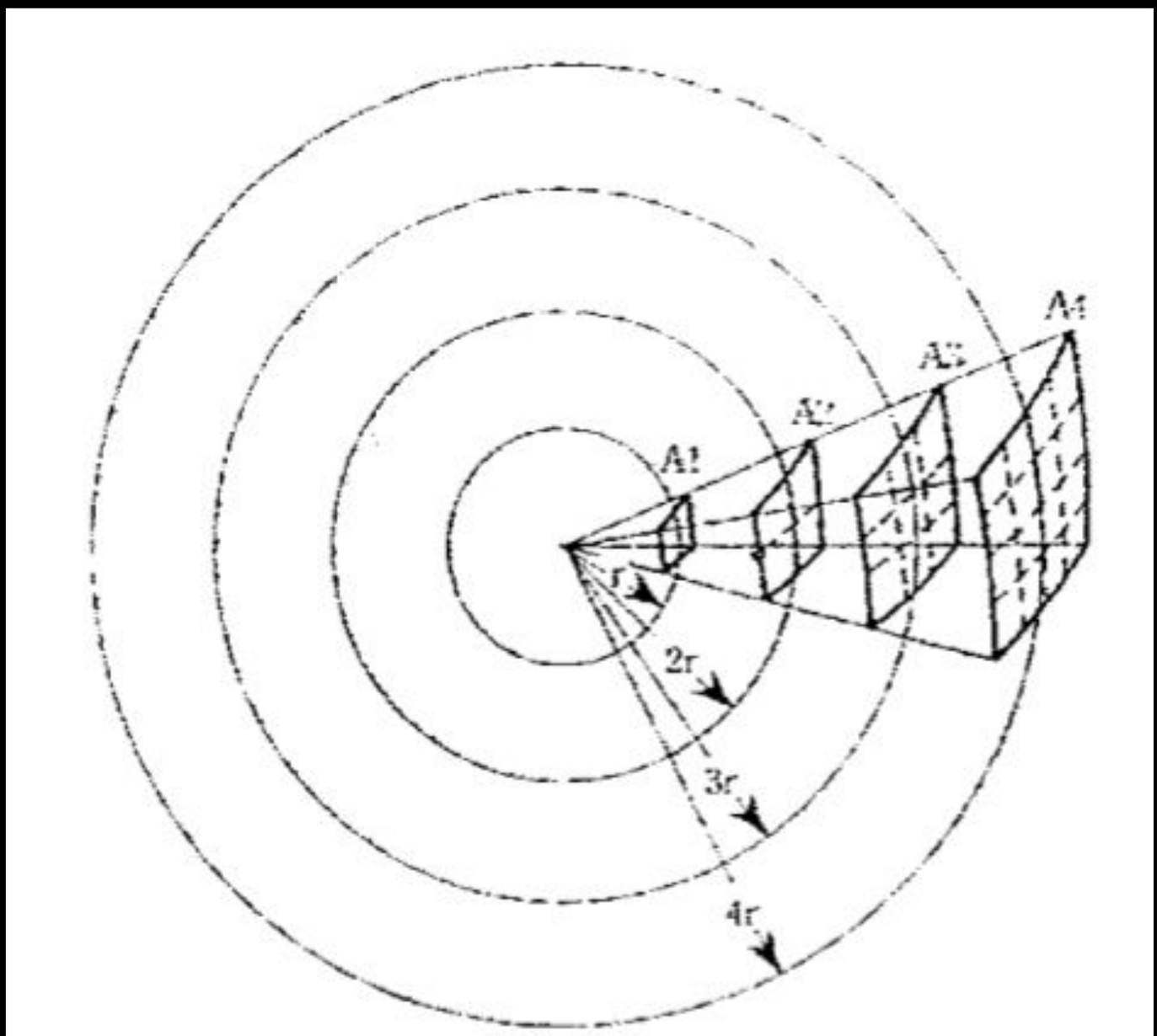

Cause
Generating mechanicsm (transduction)
Acoustic wave propagation
Reception (transduction)
Effect

Acoustic propagation



Free field

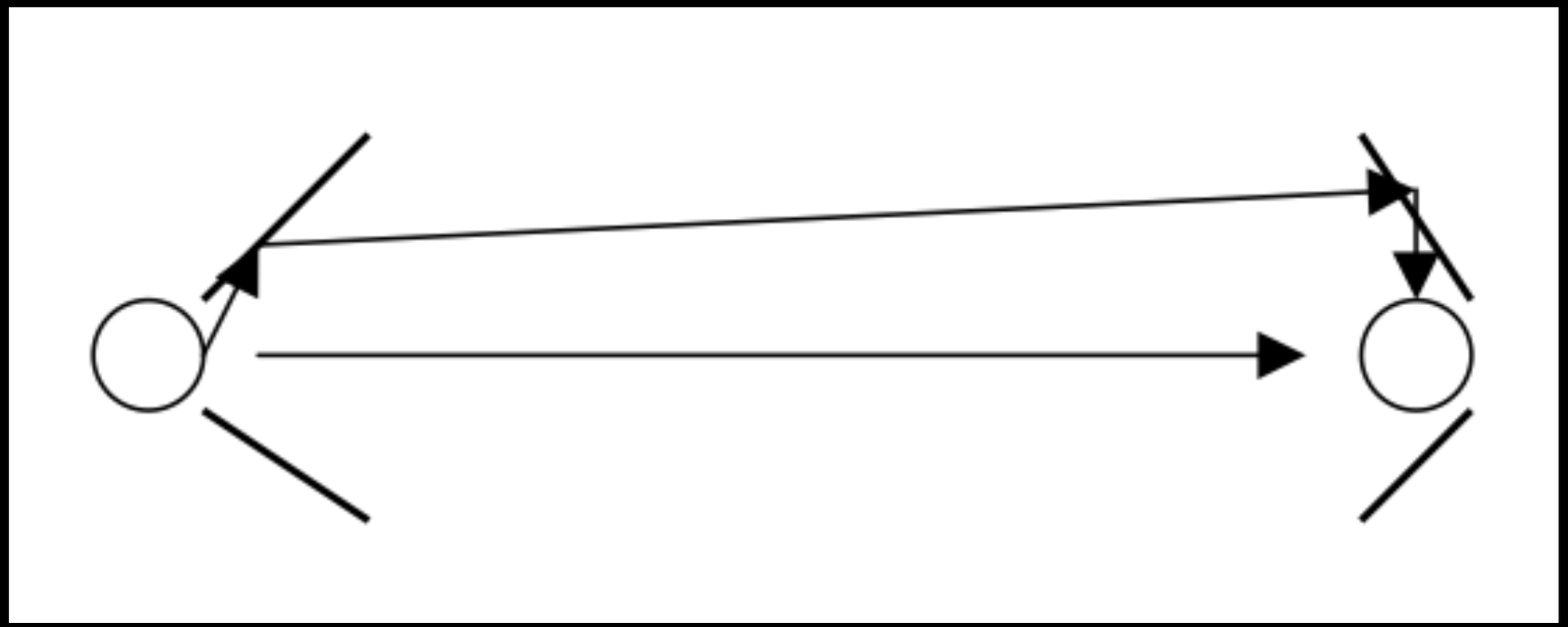

sound pressure (p)
1/r
distance (r)

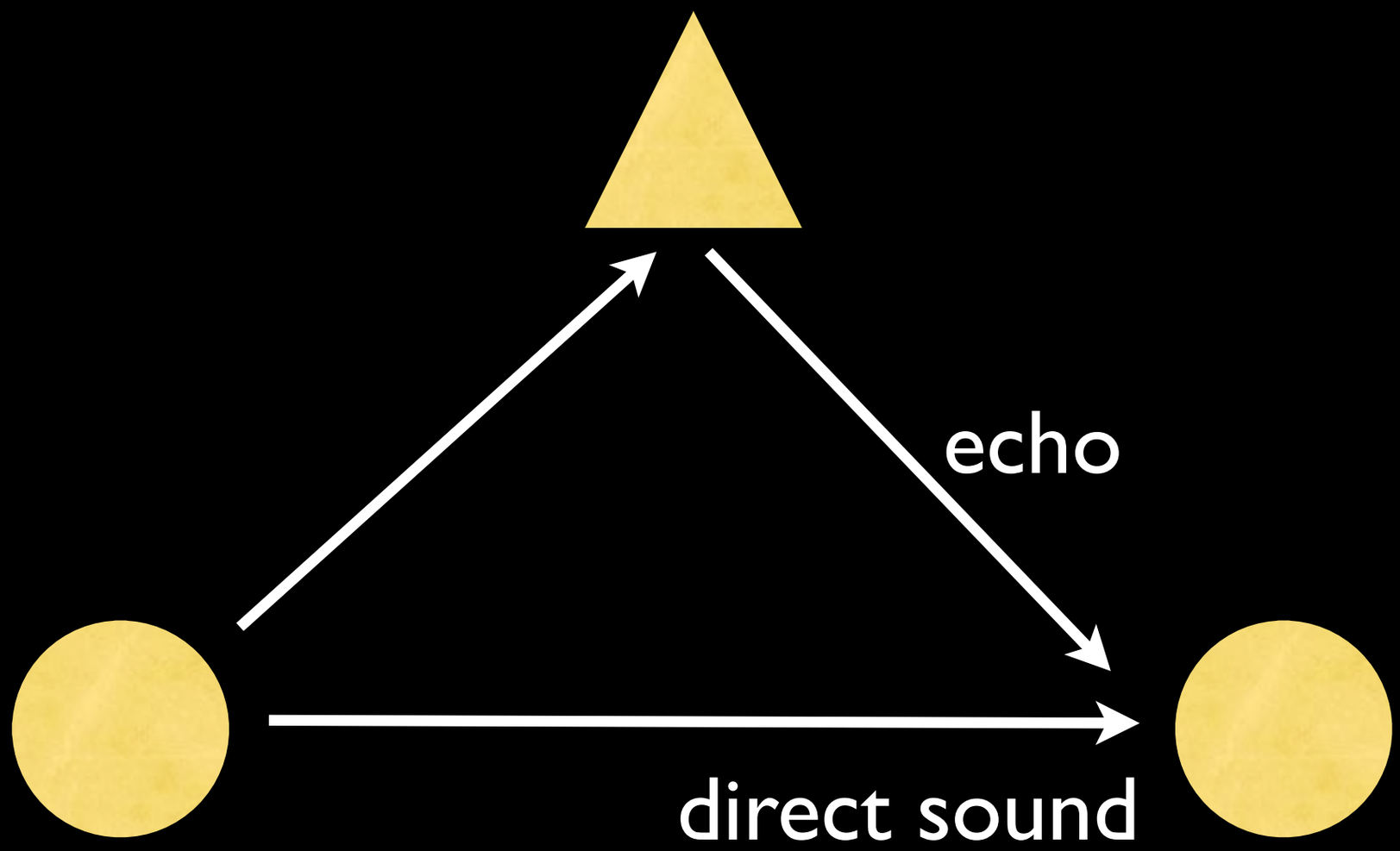

A1
A2
A3
A4
r
2r
3r
4r

6dB difference per doubling of distance

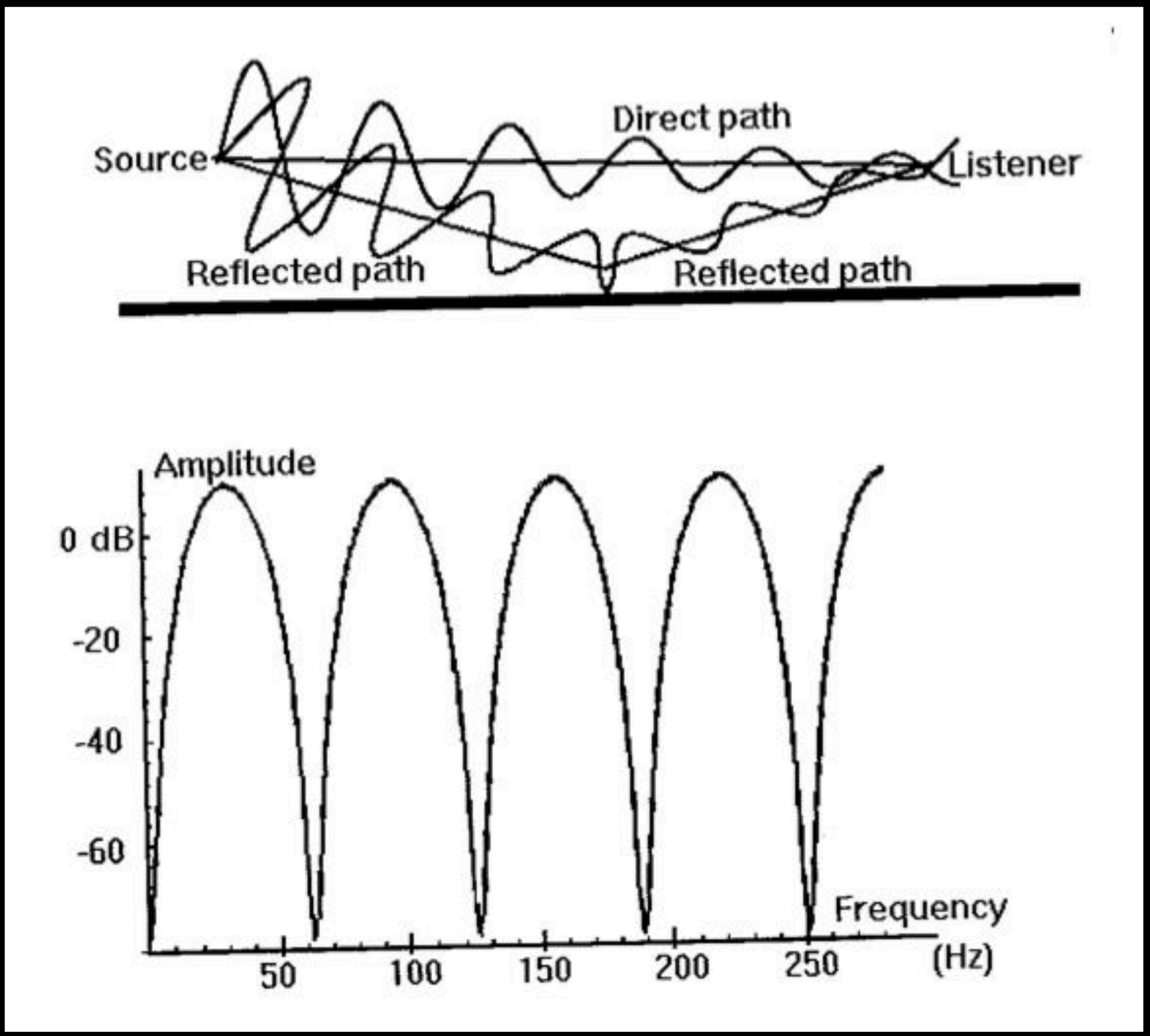
YdB at 10m distance => Y-6dB at 20m distance
ZdB at 1m distance => Z-6dB at 2m distance
=>Z+6dB at 0.5m distance

Reflections



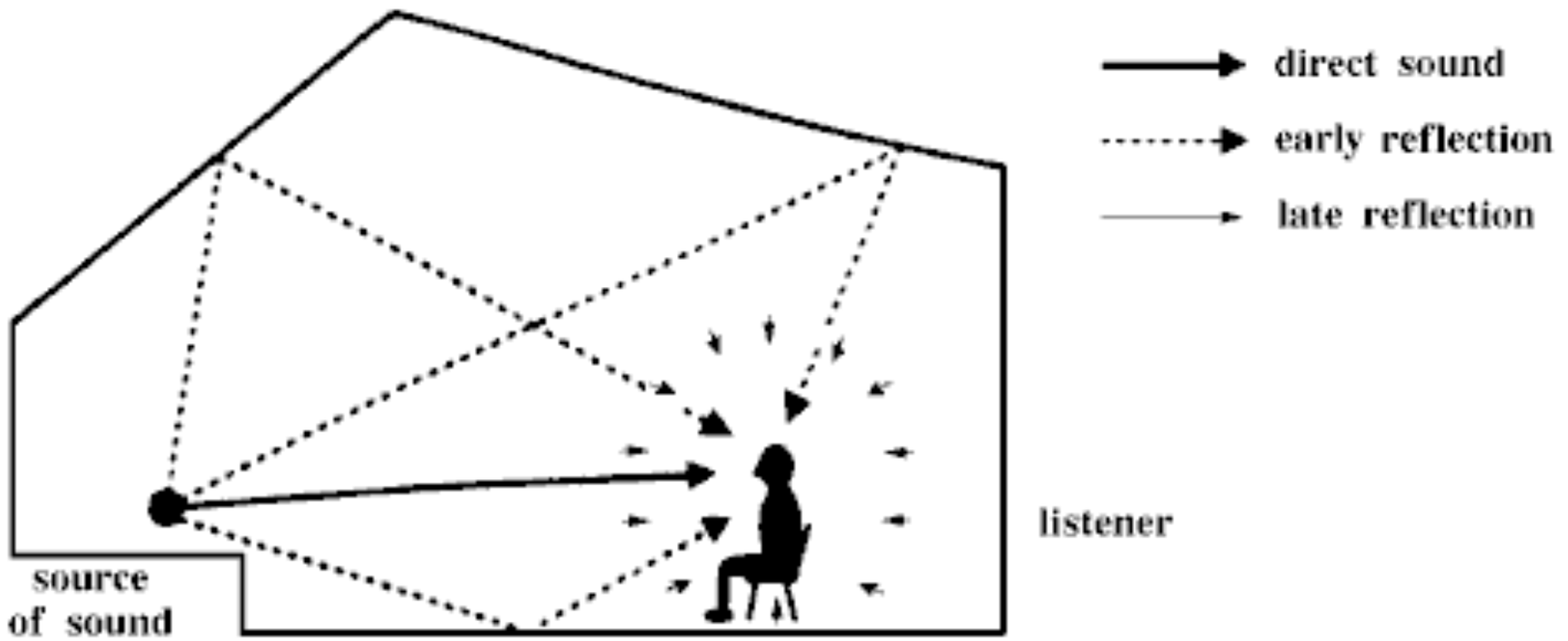


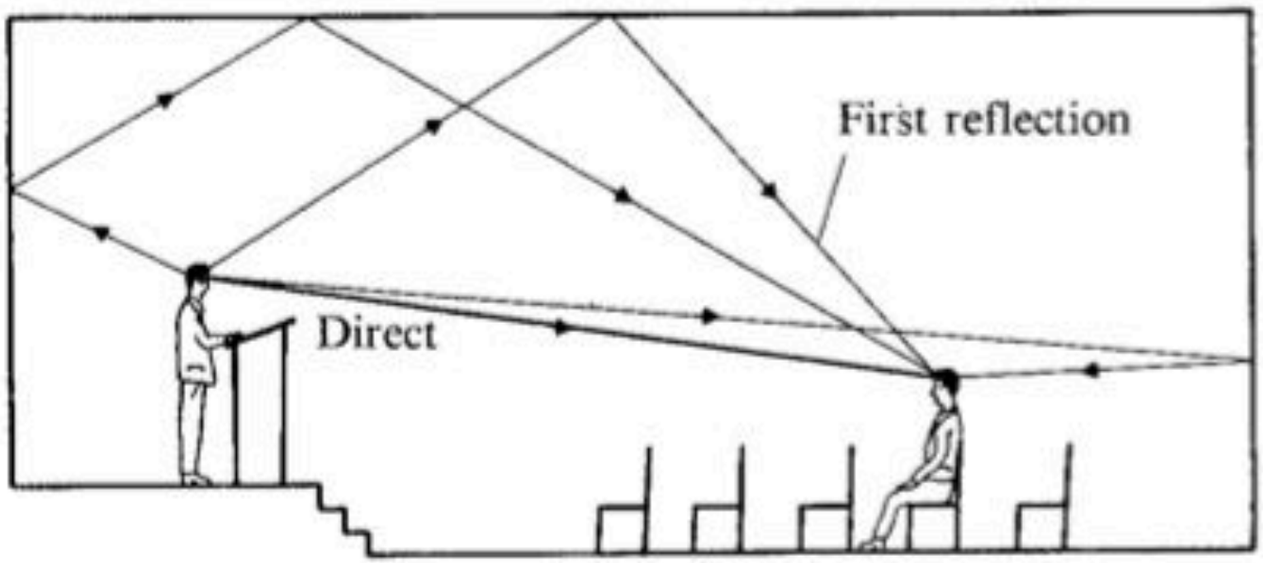
How long echo?
mountain wall at 1000m

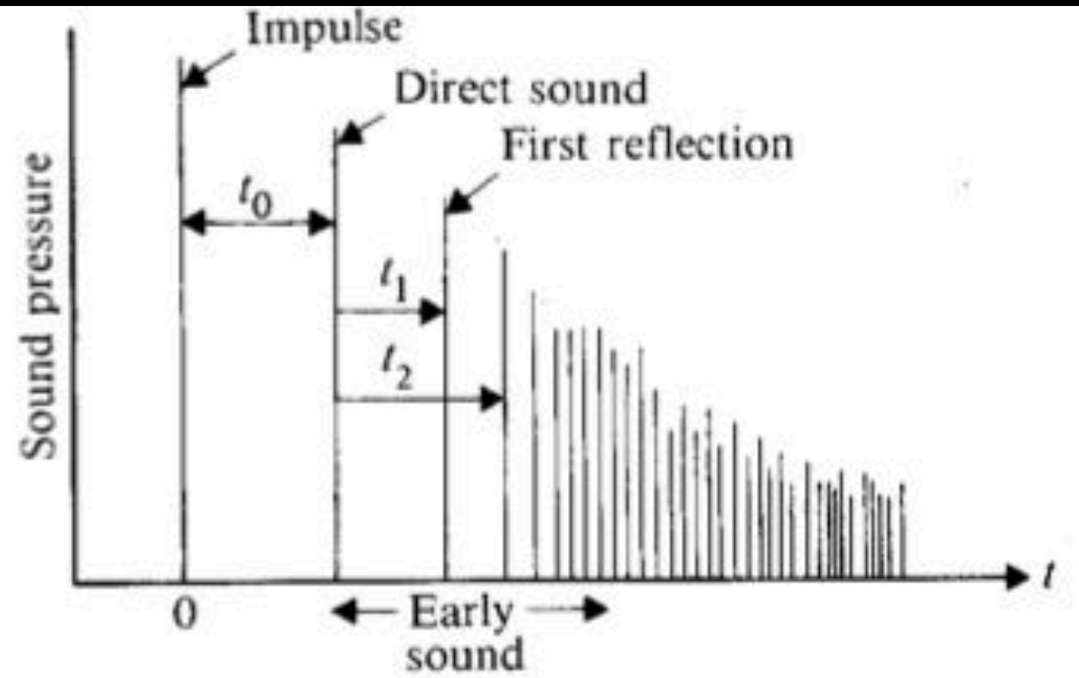

Source
Direct path
Listener
Reflected path
Reflected path
Amplitude
0 dB
-20
-40
-60
Frequency
(Hz)
50
100
150
200
250

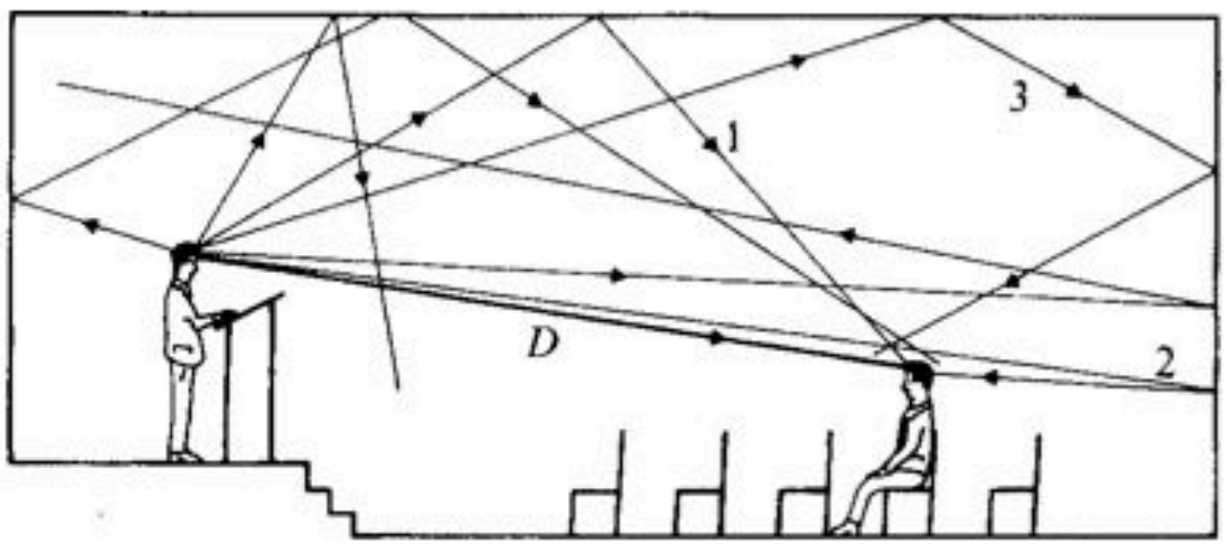
Comb filter

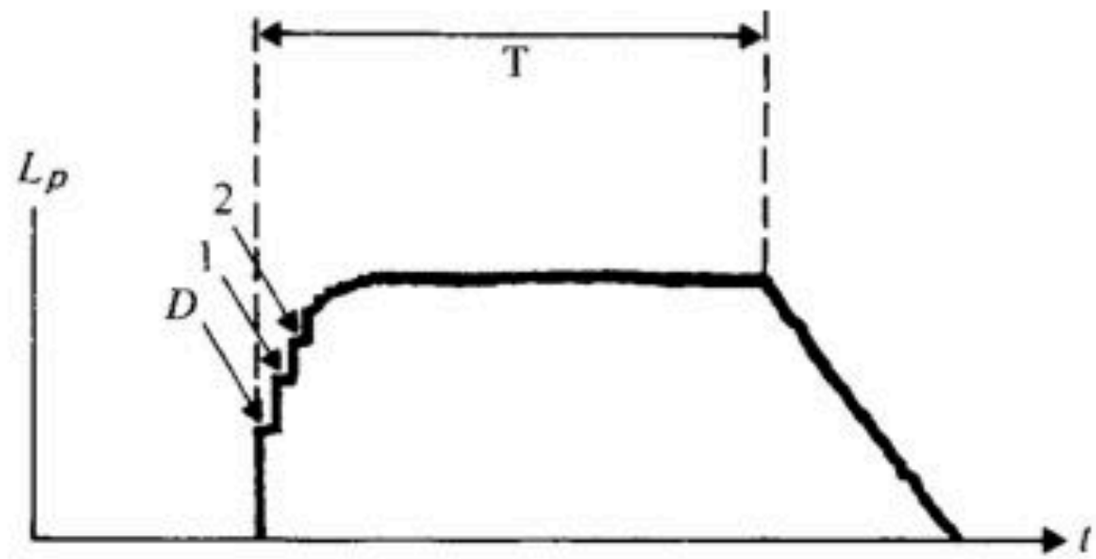
Auditorium acoustics

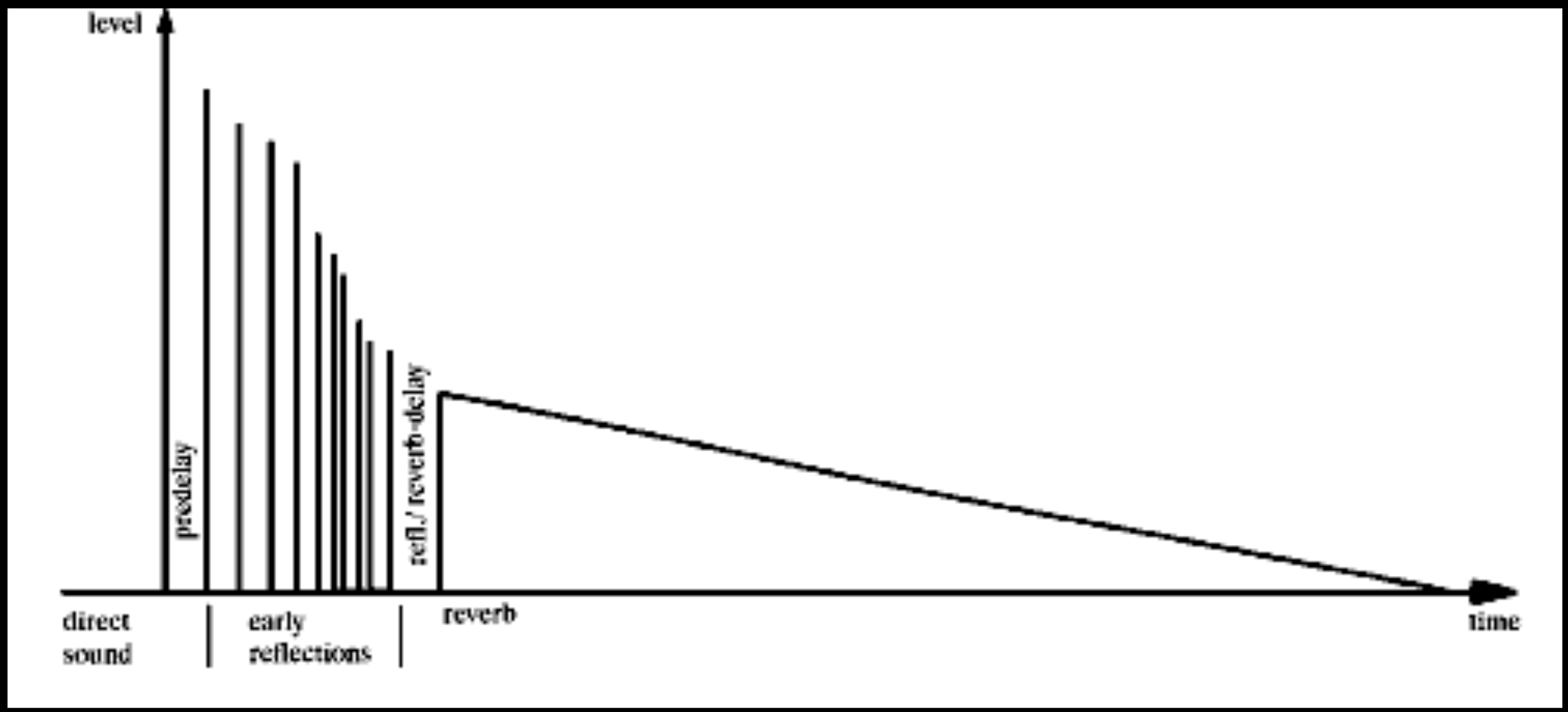

direct sound
early reflection
late reflection
listener
source
of sound


First reflection
Direct

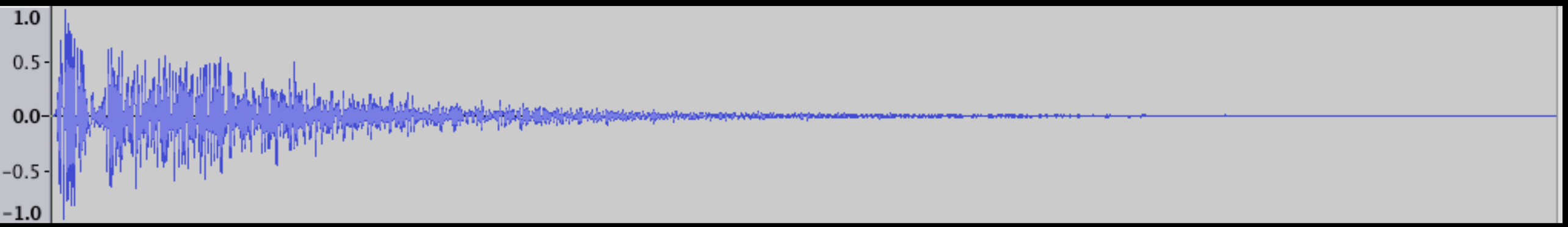

Impulse
Direct sound
First reflection
t_0
t_1
t_2
Sound pressure
0
Early sound
t


3
1
D
2

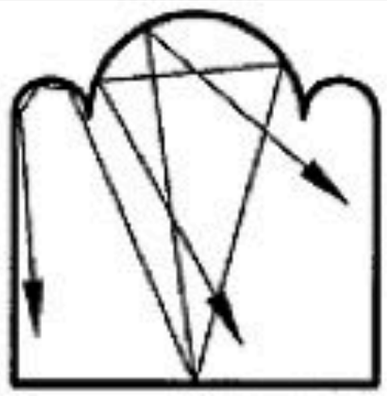

T
L_p
2
1
D
t


level
predelay
refl./ reverb-delay
direct sound
early reflections
reverb
time

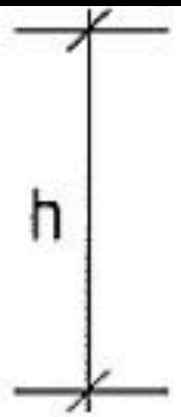
Test yourself in Audacity:

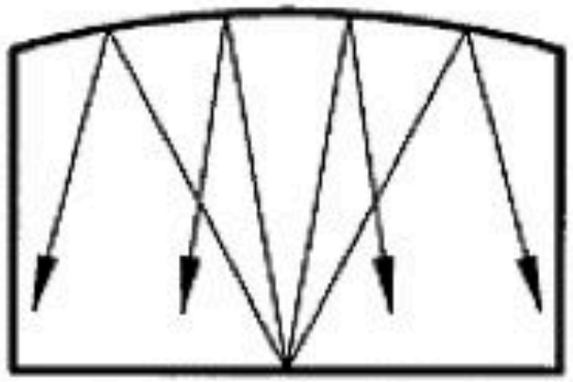


a



r < 1/2h

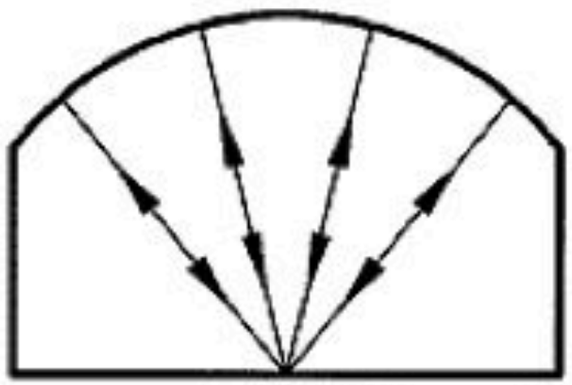


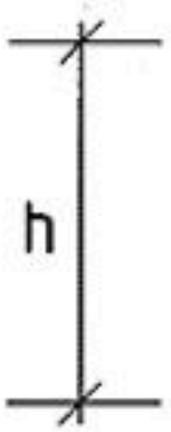


r > 2h

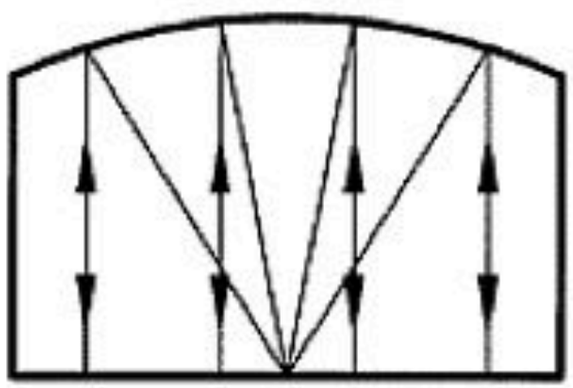
b

r = 1/2h

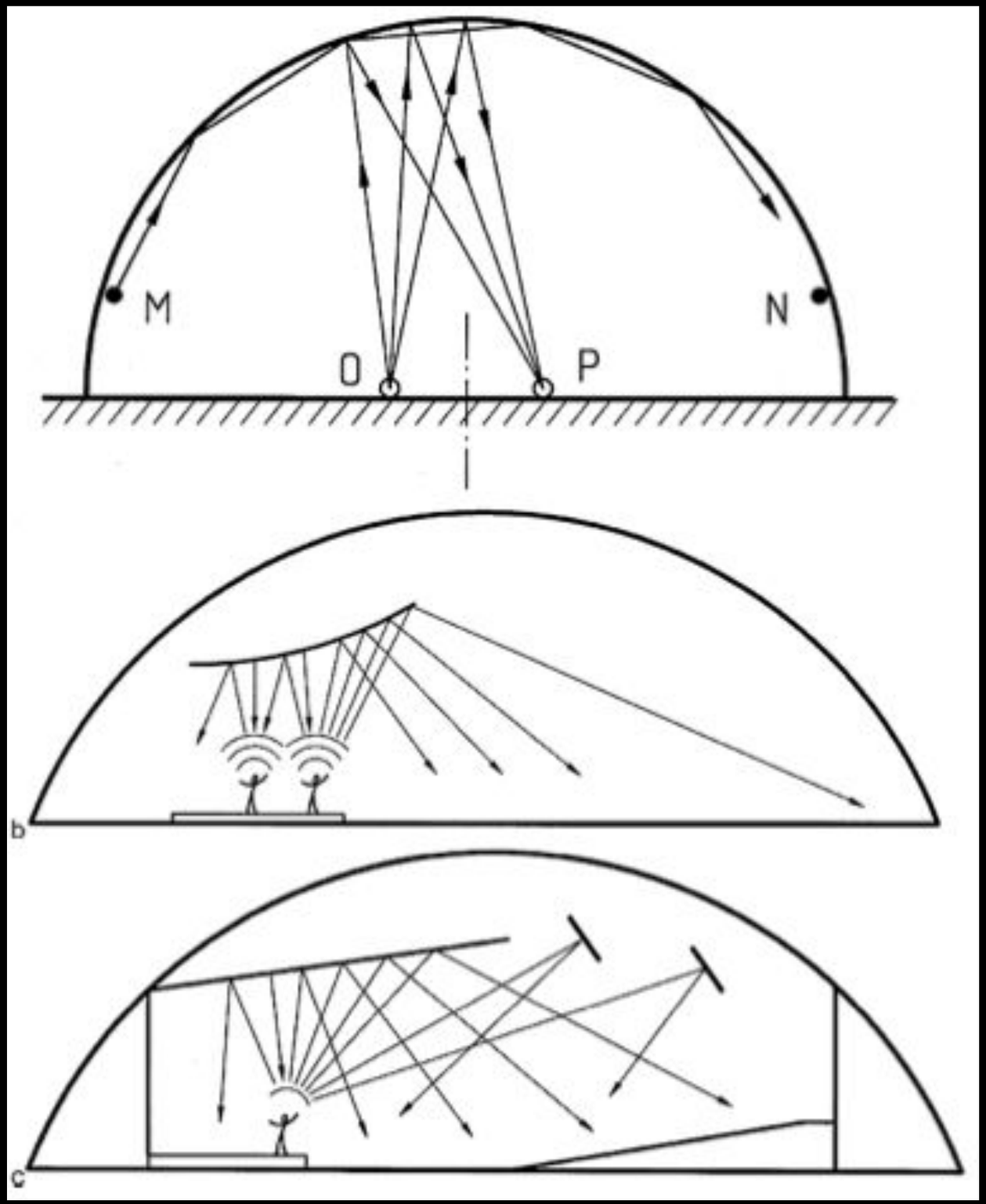




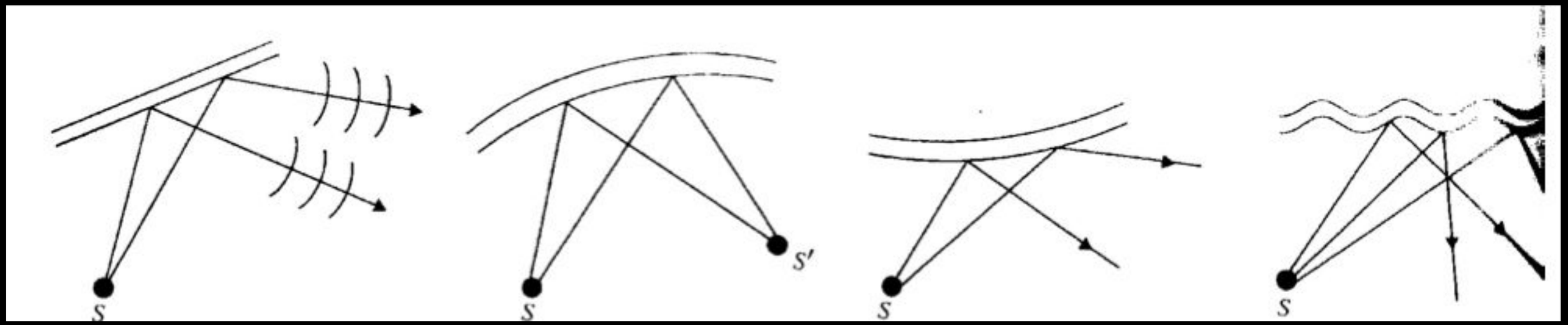
r = h



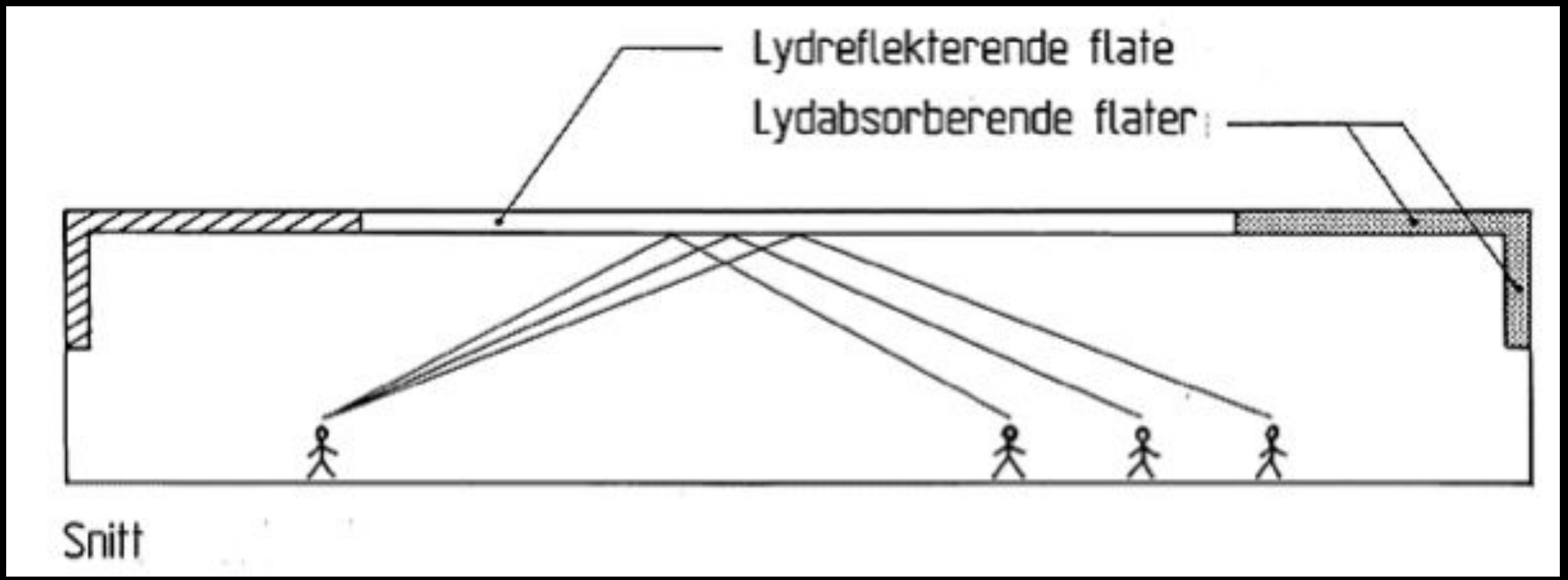
r = 2h


M
N
O
P
b
c

Surface reflection



Speech audibility



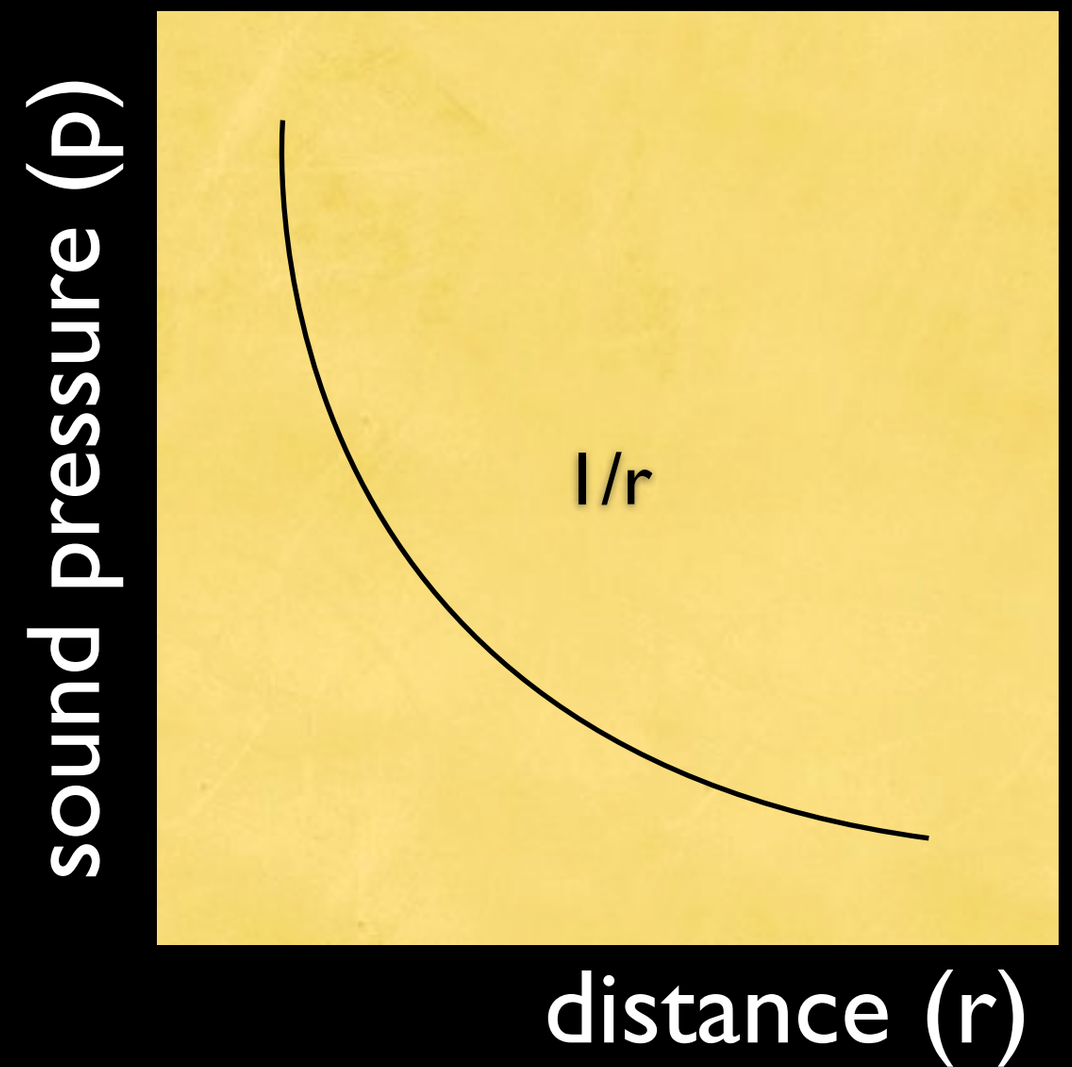
Reverberation time T: $T = 0.16 * V/A$

V = room volume
A = total absorption

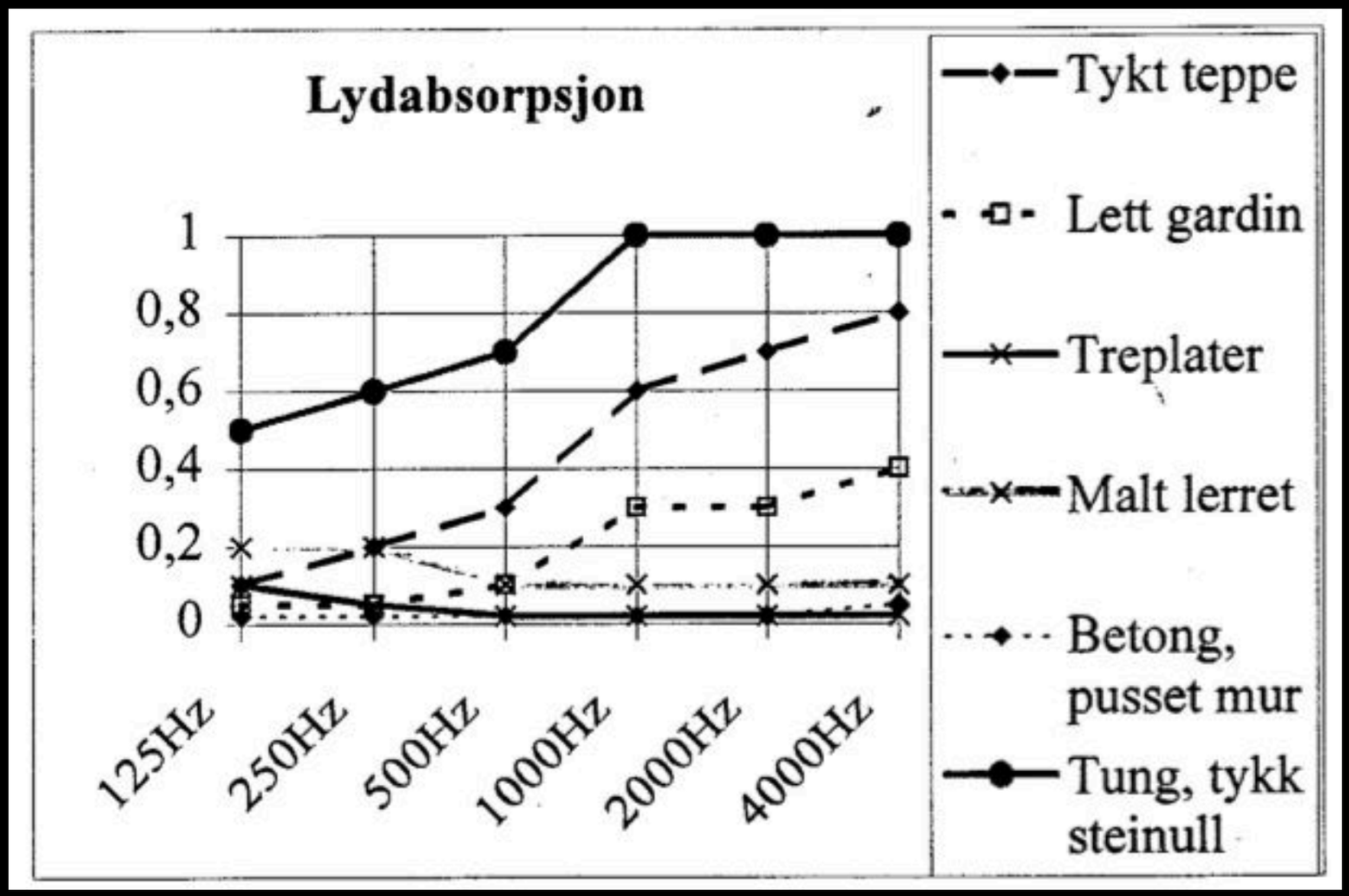
Soundproofing

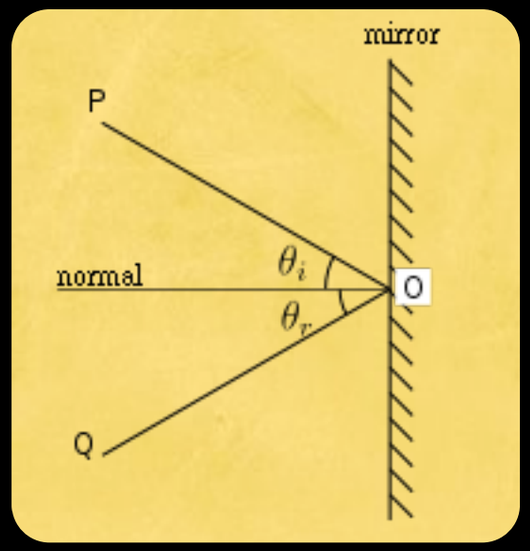
1. Improve sound within room
2. Reduce sound leakage to/from room

Distance



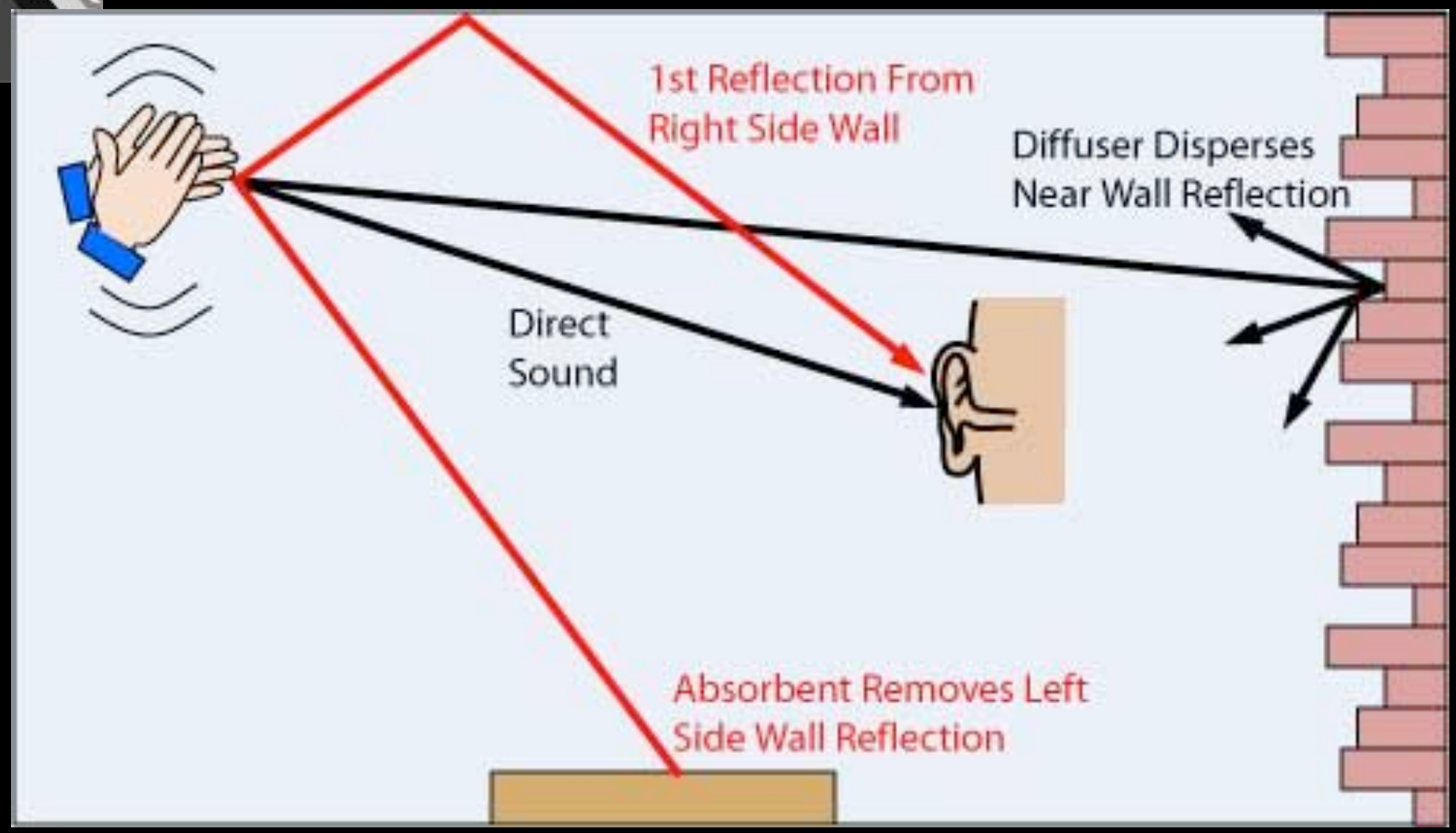
Damping


Lydabsorpsjon
1
0,8
0,6
0,4
0,2
0
125Hz
250Hz
500Hz
1000Hz
2000Hz
4000Hz
Tykt teppe
Lett gardin
Treplater
Malt lerret
Betong, pusset mur
Tung, tykk steinull



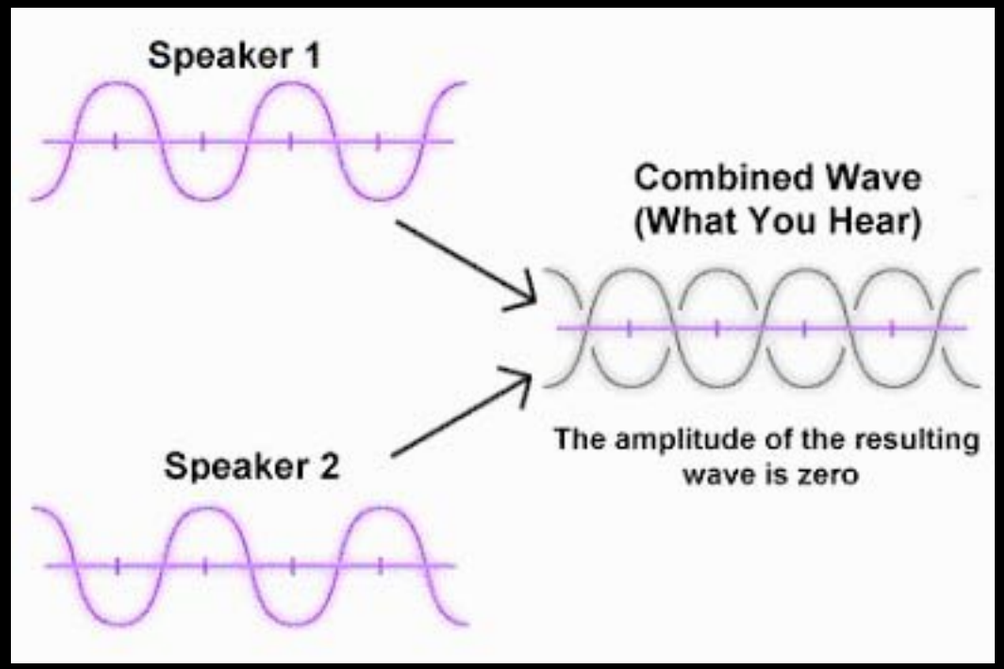
Reflection

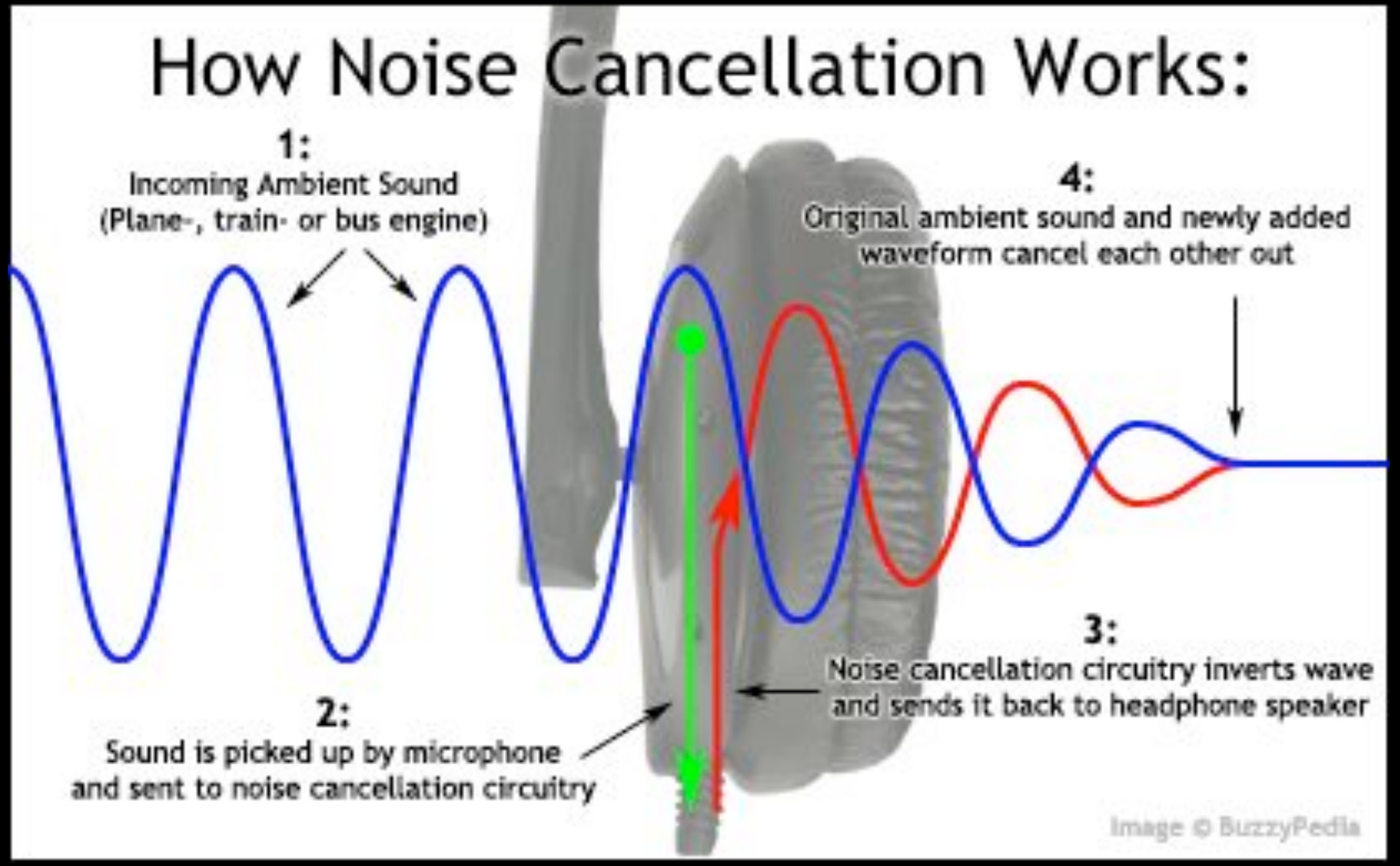
Diffusion


1st Reflection From
Right Side Wall
Diffuser Disperses
Near Wall Reflection
Direct
Sound
Absorbent Removes Left
Side Wall Reflection

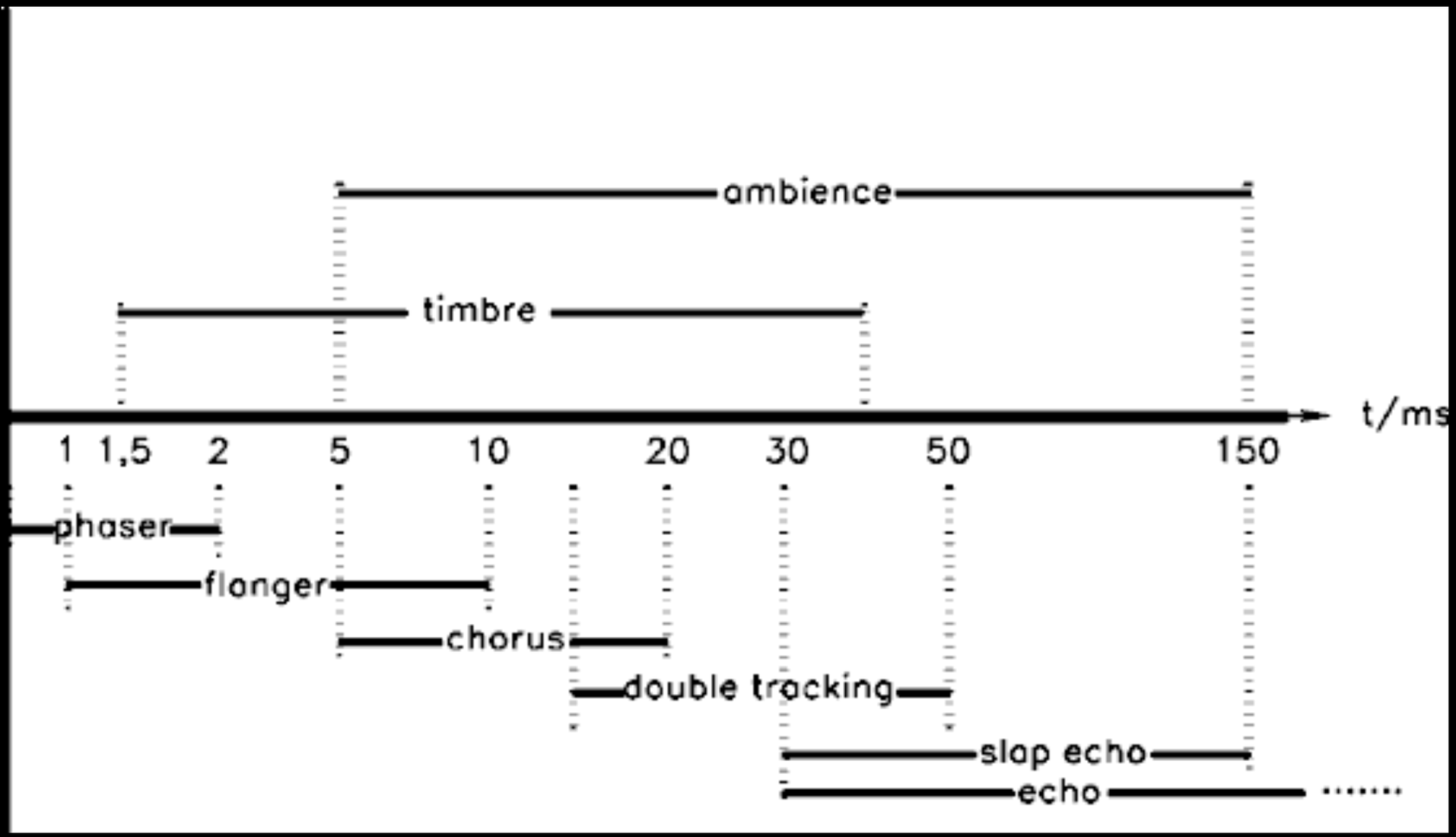
Room within a room

Noise cancellation



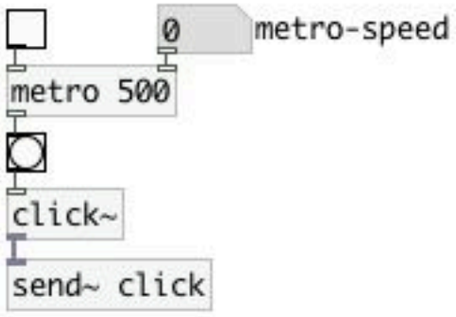


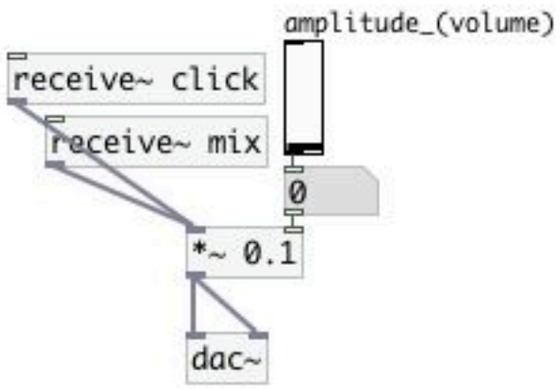
Electronic


ambience
timbre
t/ms
1
1,5
2
5
10
20
30
50
150
phaser
flanger
chorus
double tracking
slap echo
echo

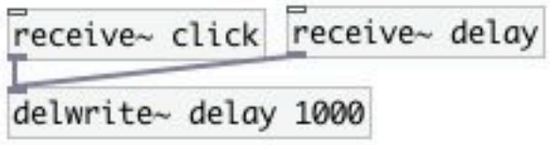
Demo

This is where we create the initial impulse response:

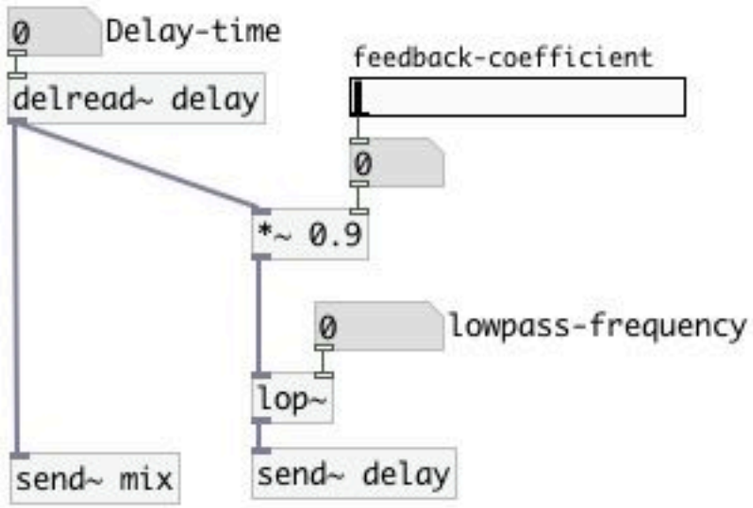


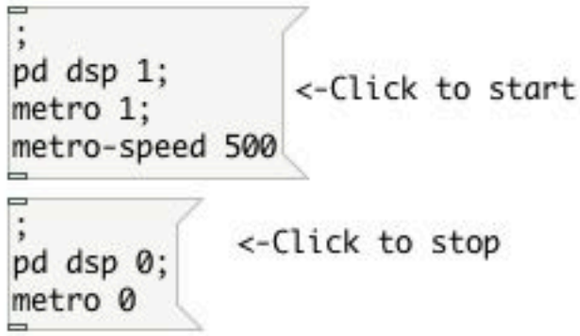


Here we write the signal to a delay buffer:

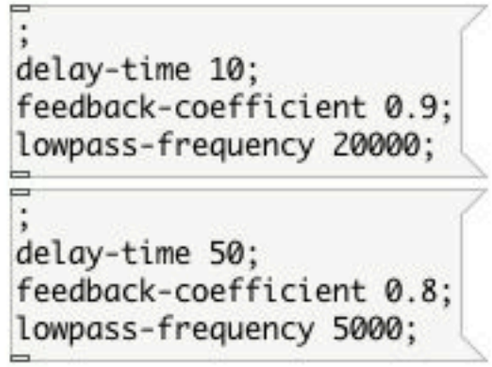


And here we read from the delay line, and add feedback and some filtering:





Try some presets:



Alexander Refsum Jensenius
Department of Musicology
University of Oslo
v0.1 28.10.2010