# Sound Transmission

Auditory Perception – Lecture Notes #3
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## 1.0 Introduction

1.1 sound propagation
static air pressure (related to density of air molecules in a volume)
condensation and rarefaction
wavelength

$$\lambda = \frac{c}{f}$$

in air, $c = 350$ meters per second

1.2 RMS Amplitude

1.3 Pressure and intensity
– sound pressure:

$$p(t) = mv/tA$$

units: dynes$/$cm$^2$

1.4 RMS Pressure
– work, energy, power

1.5 Sound intensity (a measure of power):

$$I = p^2/(p_0 c)$$

units: watts$/$cm$^2$

*intensity*: used when measurement is in terms of sound intensity (power)
*amplitude*: used for measures of pressure or displacement

## 2.0 Decibels

2.1 measured in intensity or pressure, the range of hearing is very large
about $10^{14}$
– therefore logarithmic measure is used

2.2 one Bel: ratio of intensities of 10:1
decibel (dB): one-tenth of a Bel

$$\text{\# of decibels} = 10\log(I_1/I_0) = 20(10)\log(p_1/p_2)$$

– in decibels, the rnage of hearing is about 140

2.3 dB is a ratio of two quantities, therefore dB is meaningless until we state the reference

20 µPa is the standard reference pressure, written *dB SPL* (sound pressure level) or *dB re: 20 µPa*

(approximately the softest audible pressure for a pure tone in the range 1000-4000Hz)

*dB SL* (sensation level) is another useful reference — the threshold of a particular subject in a particular situation

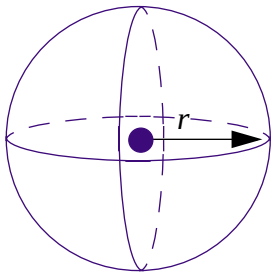
When we speak of (*sound*) *pressure level* or *intensity level*, the term level means that we are working in dB

# 3.0 Interference

3.1 The farther from a sound, the softer the sound is

remember, the pressure (and intensity) depends on area

so for a sound source of constant (RMS) power, intensity decreases as area increases




$I \propto 4\pi r^2$, where r is the distance from the source ($4\pi r^2$ is the surface area of the sphere)

therefore, when distance doubles, intensity decrease by a factor of 4 (distance squared) — pressure decreases by a factor of two (distance)

3.2 Usually obstacles impede sound transmission

Impedence, *Z*, has two components:

Reactance, *X*

Resistance, *R*

The mass and spring system is a good example:

3.2.1 The mass and spring stiffness provide reactance

two components ($X_m$ and $X_s$)

3.2.2 Friction provides resistance

Total impedence is

$$Z = \sqrt{[R^2 + (X_m - X_s)^2]}$$

The impedence of any medium is called the characteristic impedence of the medium

$$Z_c = \rho_0 c$$

3.3 When sound encounters an obstacle (a new medium) a portion of the wave will be reflected, and the rest is transmitted or absorbed by the new medium

3.3.1 Reflection causes both

consructive interference (reinforcement), and

destructive interference (cancellation)

3.3.2 Objects can also cause sound shadows

3.4 Sound field

– any environment containing sound

free field — sound field without reflections

— anechoic room

diffuse field — sound field of uniform intensity

— reverberation room

3.5 Standing waves