Themed: 03-02

Measures of sound amplitude, dB scale examples, impact on human hearing

Measures of sound amplitude

- Three measures
  1. Intensity – pure, direct physics (W/m^2)
  2. dB scale (log scale of Intensity – easier numbers)
  3. Volume – human perception (we treat like exact)
     - We underestimate sound changes (human tolerance)
     - A 10x reach change = about 2x perceived change

Measures of sound amplitude

- Distance from sound source is “r”
- r relates to distance with inverse square law:
  - I changes inversely with r^2
  - I relates to dB and volume (aka “loudness”)
    - 10x change in I same as 2x change in volume or loudness
    - 10x change in I same as +10 dB change
    - Symbol Δ stands for delta and means “change”, know this
- Example

1. Moving from 10 m to 1,000 m
   - Changes intensity by what factor? (more or less?)
   - Seems how much less loud?
   - Does what to the dB reading?

Sound – Loudness, solving problems

- **changes** in sound amplitude scales follow:

+10 dB = 2x volume (human) = 10x I

dB, *volume*, *intensity*

These are steps to do, but not necessarily in this order

1. Relate distance CHANGE (r) to intensity CHANGE → I changes up as r^2 changes down
2. Relate scale type CHANGES using:
   - +10 dB = 2x Vol. = 10x I
3. Add or subtract any dB change to original dB value
4. Multiply or divide any distance change to original distance (r is distance from sound source)

Did I underline CHANGE enough for you to notice?

Measure of amplitude - examples

$I \propto 1/r^2$

+10 dB = 2x volume (human) = 10x I

(dB, volume, intensity)

- (1) If wave energy increases by 10 times (10 times the number of watts), how many more dB would be measured? How much louder would it "seem" to you?
- (2) If wave energy increases by 100 times (100 times the number of watts), how many more dB would be measured? How much louder would it "seem" to you?
- (3) If wave energy increases by 1000 times (1000 times the number of watts), how many more dB would be measured? How much louder would it "seem" to you?
- (4) At 2 m from loud speakers, you measure 97 dB. What (dB) would you measure at 20 m? At 6.2 m?
- (5) 400 m from loudspeakers you measure the loudness a quiet 55 dB, what would you measure 4 m from the speakers?
- (6) Sound protection is required for long term exposure to 85 dB and above. If a piece of manufacturing equipment puts out 115 dB at 0.15 m, how far away must workers be to avoid needing hearing protection?

Measure of amplitude - examples

$I \propto 1/r^2$

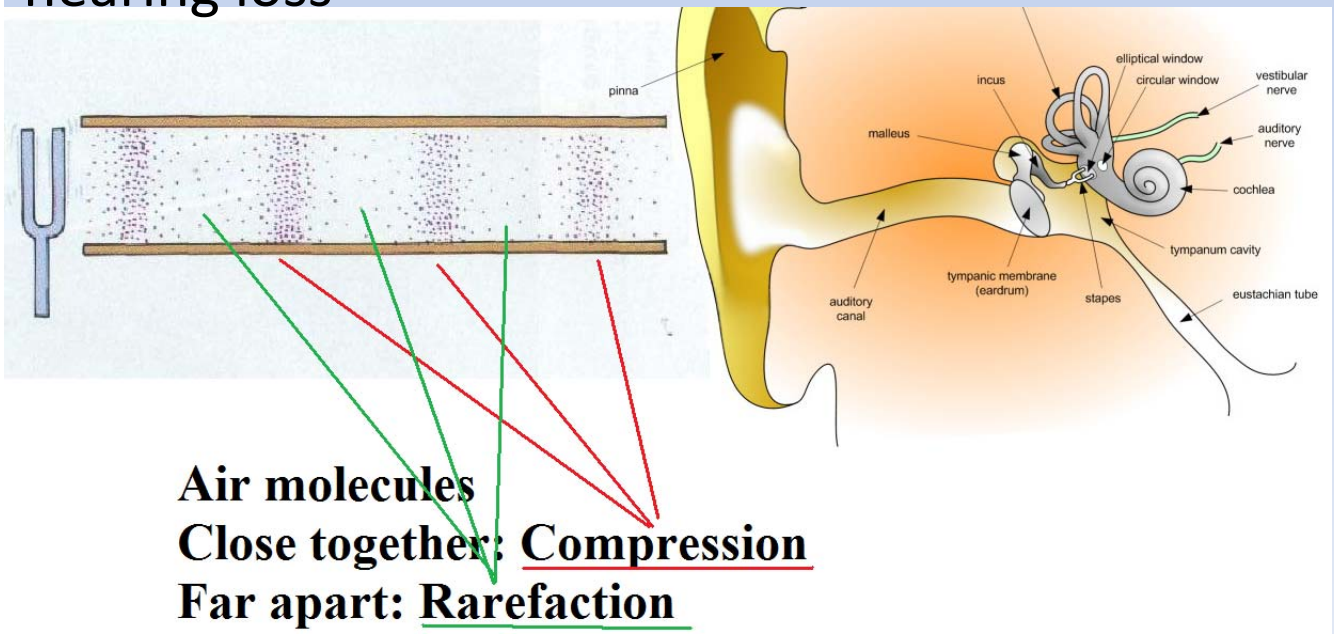
+10 dB = 2x volume (human) = 10x I

(dB, volume, intensity)

- (1) If wave energy increases by 10 times (10 times the number of watts), how many more dB would be measured? How much louder would it "seem" to you? (10 MORE dB, 2x louder)
- (2) If wave energy increases by 100 times (100 times the number of watts), how many more dB would be measured? How much louder would it "seem" to you? (20 MORE dB, 4x louder)
- (3) If wave energy increases by 1000 times (1000 times the number of watts), how many more dB would be measured? How much louder would it "seem" to you? (30 MORE dB, 8x louder)
- (4) At 2 m from loud speakers, you measure 97 dB. What (dB) would you measure at 20 m? At 6.2 m? (77 dB (since r^2 changes by 100), 87 dB (since r^2 changes by 10))
- (5) 400 m from loudspeakers you measure sound as a quiet 55 dB, what would you measure 4 m from the speakers? (95 dB (since r^2 changes by 10,000))
- (6) Sound protection is required for long term exposure to 85 dB and above. If a piece of manufacturing equipment puts out 115 dB at 0.15 m, how far away must workers be to avoid needing hearing protection? (4.7 m (since dB changes by 30, I changes by 1,000, r^2 changes by 1,000, r changes by $\sqrt{1000} = 31.6$, workers must be 31.6x farther than 0.15 m))

Impact on sound amplitude on hearing (loss)

- Loud sound:
  - VERY high pressure compressions coupled with very low pressure rarefactions
  - Pushes in and pulls out on the ear drum with BIG force
- Loud sound = “Big wave amplitude” (same as above!)
- Push too hard – permanent damage to hearing
- Push “pretty hard” too long – permanent damage to hearing
- “studies show that 1 in 5 American teenagers already suffers from hearing loss”*



*http://www.beltone.com/hearing-health/ear-buds.aspx

Hearing loss prevention

- BIG PROBLEM:
  - **Improper** use of ear buds
  - Ear bud volume is typically too high because of poor seal in ear
    - you're trying to play it too loud because you want to overwhelm outside noises
    - But…not safe to cut out ambient noise while walking outside, biking etc.
    - Hearing damage results from the product (yes, this is MATH) of loudness x duration
    - Consider: limiting ear bud time, using a good seal, leaving them at home while outside (unsafe to walk around with them on!)
    - Also consider: Noise cancelling ear buds (same as good seal, gets rid of outside, competing noises)

Decibel examples

- 85 dB will eventually cause hearing loss
- 0 dB is not silence; it's the threshold of normal human hearing; you might be able to hear some sounds at -5 dB
- It's loud, but if it's your favorite song, you get used to it
- Loud sounds damage sensitive hair cells in your ears
- Humans don't make new cells (gone forever)
- Hearing loss won't heal
- Like wearing hearing aids?
- People love it when you say: What? What did she say? – Not!

Sound Levels and Human Response

This decibel (dB) table compares some common sounds and shows how they rank in potential harm to hearing.

Common sounds	Noise level (in decibels dB)	Effect
Jet engines (near)	140	Beyond threshold of pain (125 dB)
Jet takeoff (100-200 ft.)	130	
Rock concerts (varies)	110-140	
Boom box	120	Threshold of sensation (120 dB)
Thunderclap (near)	120	
Stereos (over 100 watts)	110-125	
Power saw (chain saw)	110	Regular exposure of more than 1 minute risks permanent hearing loss (over 100 dB).
Pneumatic drill/ jackhammer	110	
Snowmobile	105	
Jet flyover (1,000 feet)	103	
Garbage truck/cement mixer	100	No more than 15 minutes unprotected exposure recommended (90-100 dB).
Farm tractor	98	
Newspaper press	97	
Subway, motorcycle (25 ft.)	90	Very annoying; 85 is level at which hearing damage (8 hours) begins.
Lawn mower, food blender	85-90	
Recreational vehicles, TV	70-90	
Diesel truck (40 mph, 50 ft.)	84	
Average city traffic noise	80	Annoying, interferes with conversation. Constant exposure may cause damage.
Washing machine	78	
Dishwasher	75	
Vacuum cleaner, hair dryer	70	Intrusive, interferes with telephone use
Inside a car (loud engine)	70	
Garbage disposal	50-65	
Normal conversation	50-65	Comfortable (under 60 dB)
Refrigerator humming	40	
Whisper	30	Very quiet
Broadcasting studio	30	
Rustling leaves	20	
Normal breathing	10	Just audible

Decibel table developed by the National Institute on Deafness and Other Communication Disorders, National Institutes of Health.