

Noise at Work

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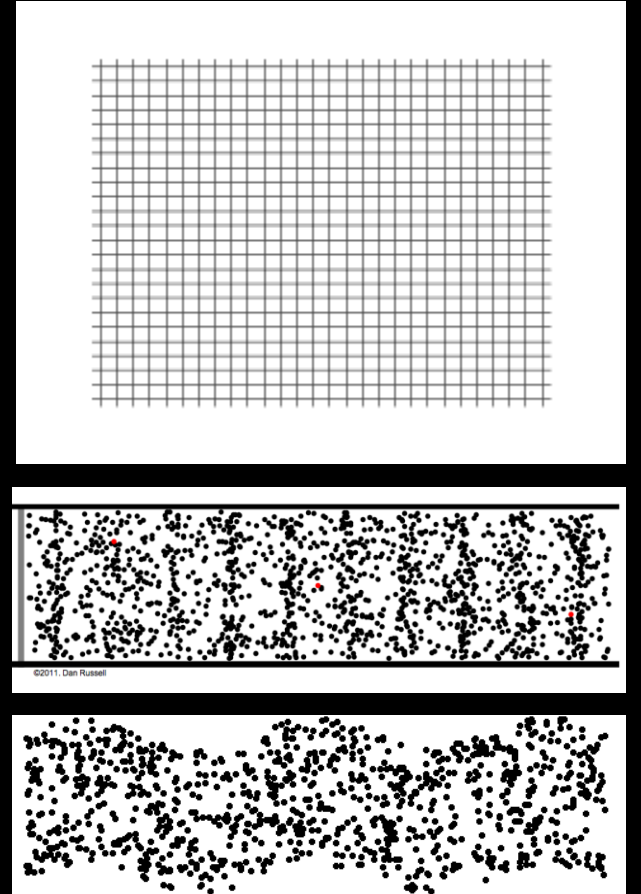
Sound

“sound is a vibration that propagates as an audible wave of pressure, through a transmission medium such as a gas, liquid or solid”

“Sound is the reception of such waves and their perception by the brain”

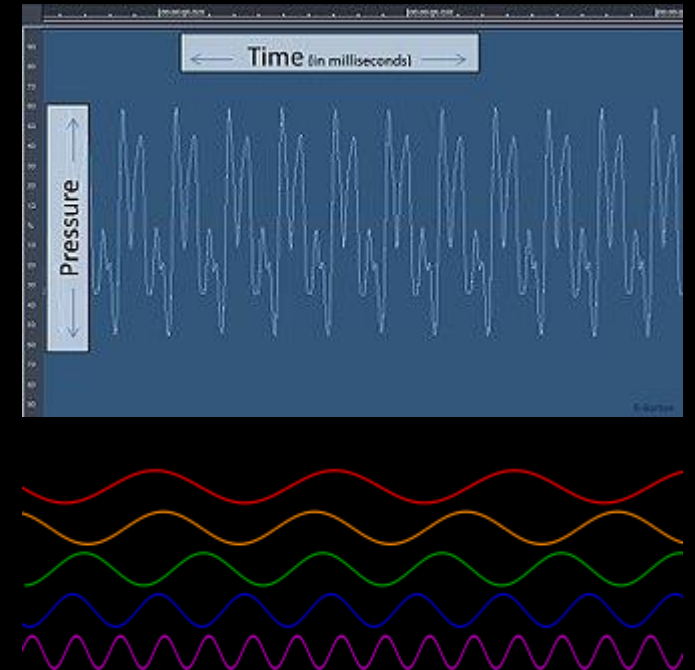
Sound Facts - Waves

- Sound is a wave, with the audible range (for humans) between 20Hz to 20,000Hz
- Waves can be;
 - longitudinal waves** travel in the direction of the oscillating (vibrating) particles
 - Transverse waves** travel perpendicular to the direction of particle oscillations
- Sound usually travels as longitudinal waves through media such as gases and liquids, but in solids these can both be longitudinal as well as transverse
- Sound waves are also called **compression** waves



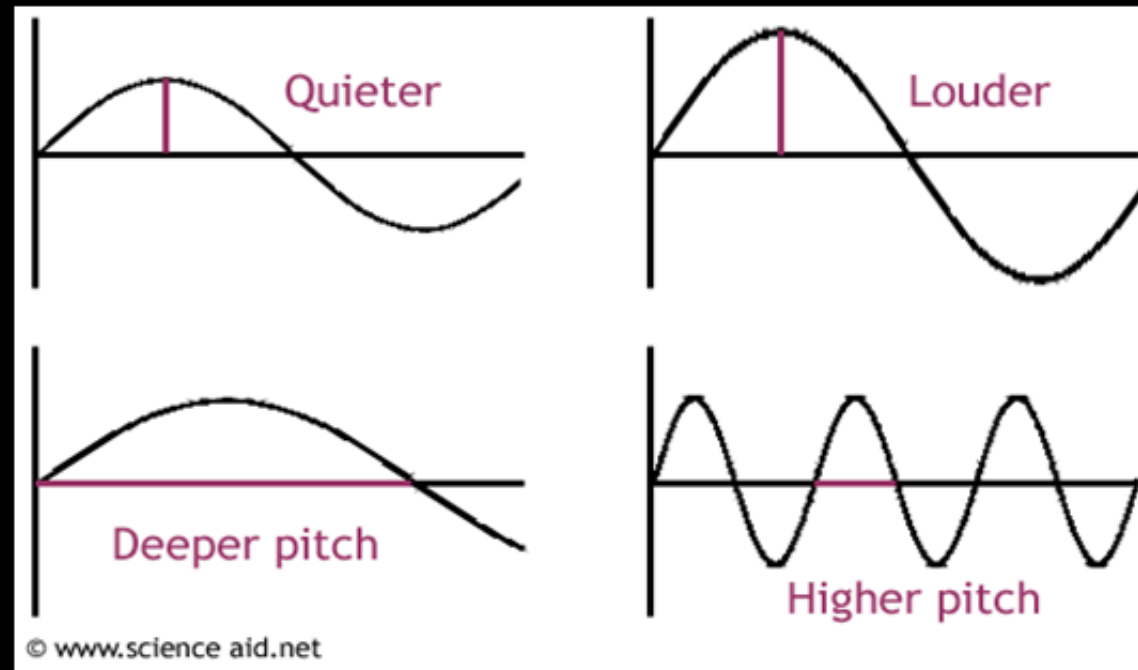
Sound Facts – Waves (Characteristics)

- At the point of reception (i.e., the ears) sound is characterized by two simple elements: **Pressure** and **Time**
- Differences in pressure and time allows us to discern between two different sounds
- Sound waves are complex, as shown in blue, but can be separated in to components as shown
- When simplified, sound waves are shown as simple sinusoidal waves, which are characterised by the generic properties;
 - **Frequency** (or inversely the **wavelength**, say $20\text{Hz}=17\text{m}$, $20,000\text{Hz}=17\text{mm}$)
 - **Amplitude**, **Sound Pressure** or **Sound Intensity**
 - **Speed**
 - **Direction**



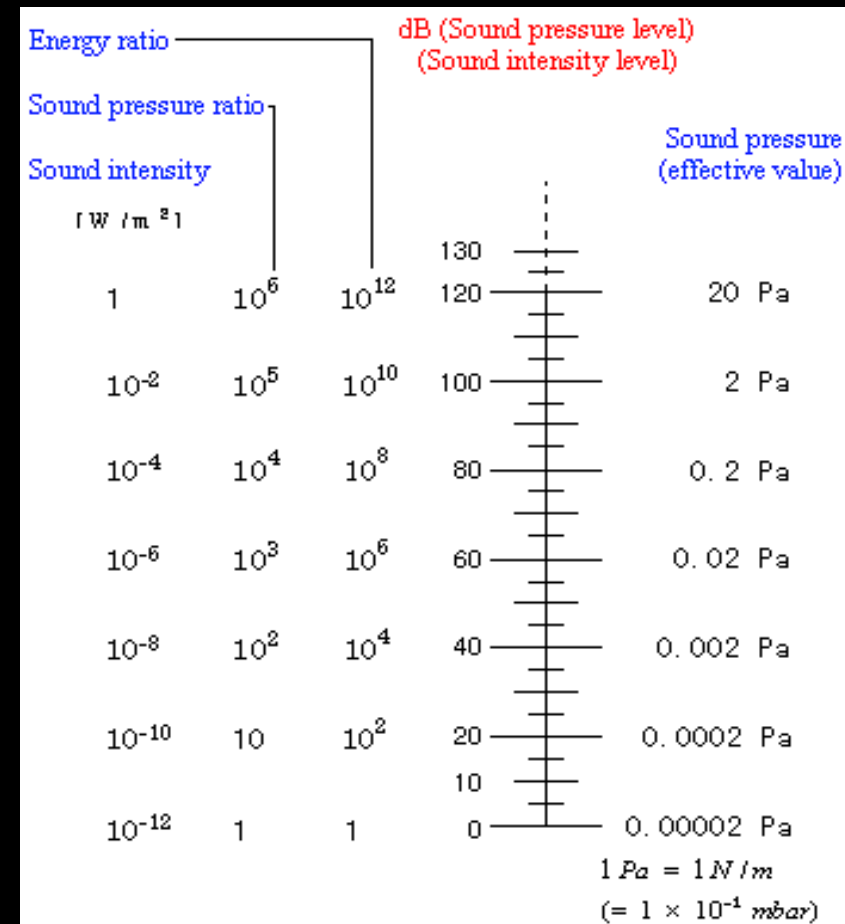
Sound Facts – Amplitude & Frequency

- **Amplitude** – Loudness measured in **decibels, dB**
- **Frequency** – Measured in **hertz, Hz ($= s^{-1}$)**



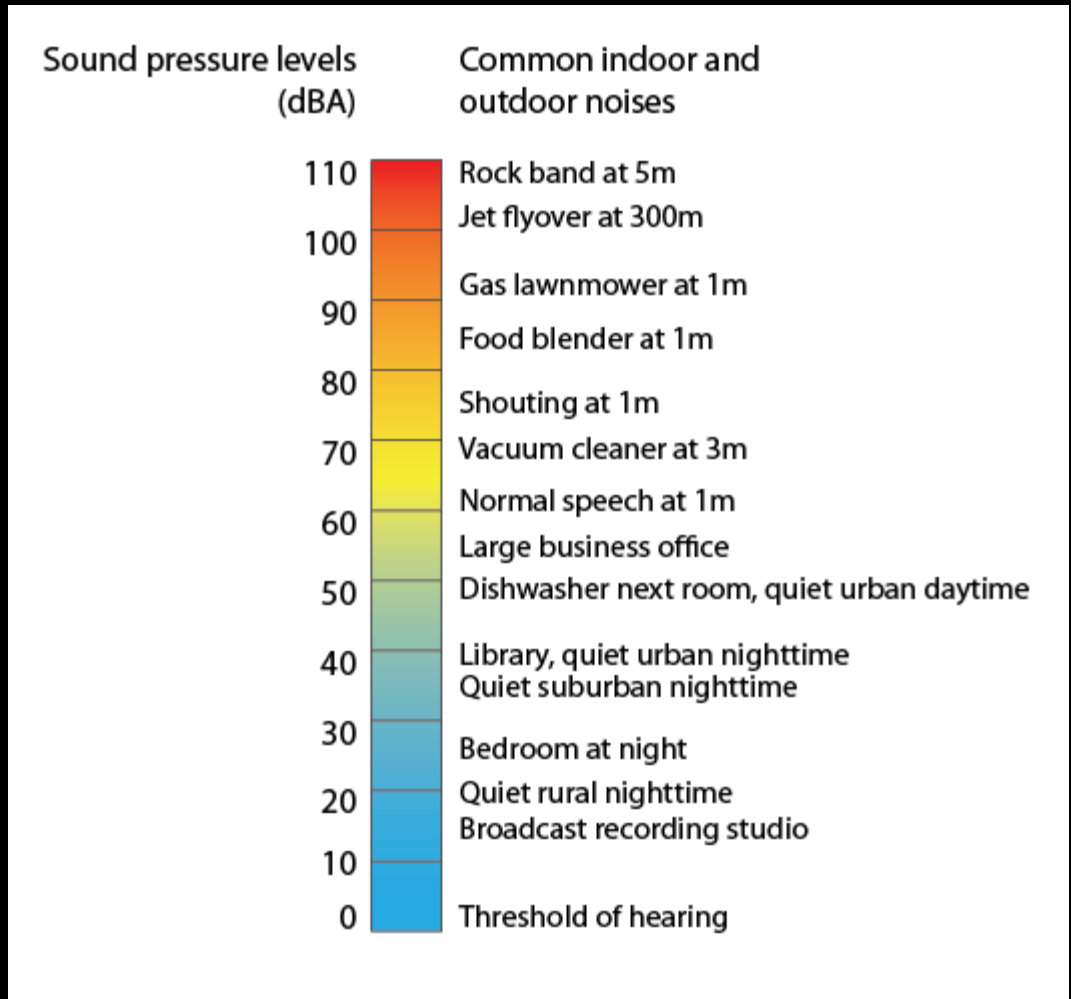
Sound Facts – Pressure (Pa)

- Sound pressure is the amount of air pressure fluctuation that a sound source creates
- We “**hear**” or perceive sound pressure as “**loudness**”
- 0 decibels (0 dB) is the quietest sound audible to a healthy human ear = 0.00002 Pa
(1 Pa = 10^{-6} N/mm²)
- Sound pressure converted to the decibel scale is called the “**Sound Pressure Level**”

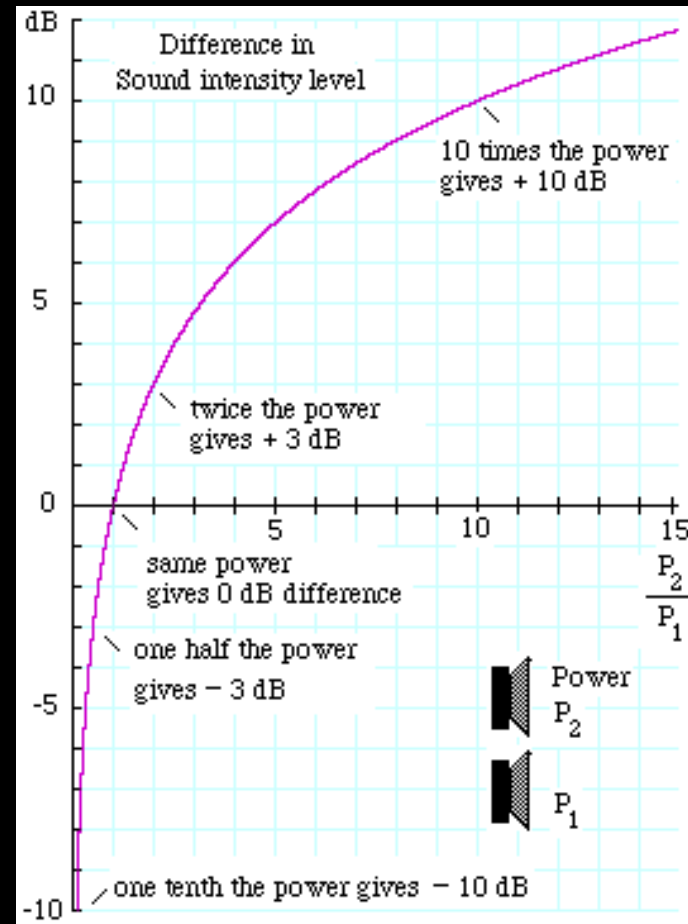


Sound Facts – Pressure Levels (dB)

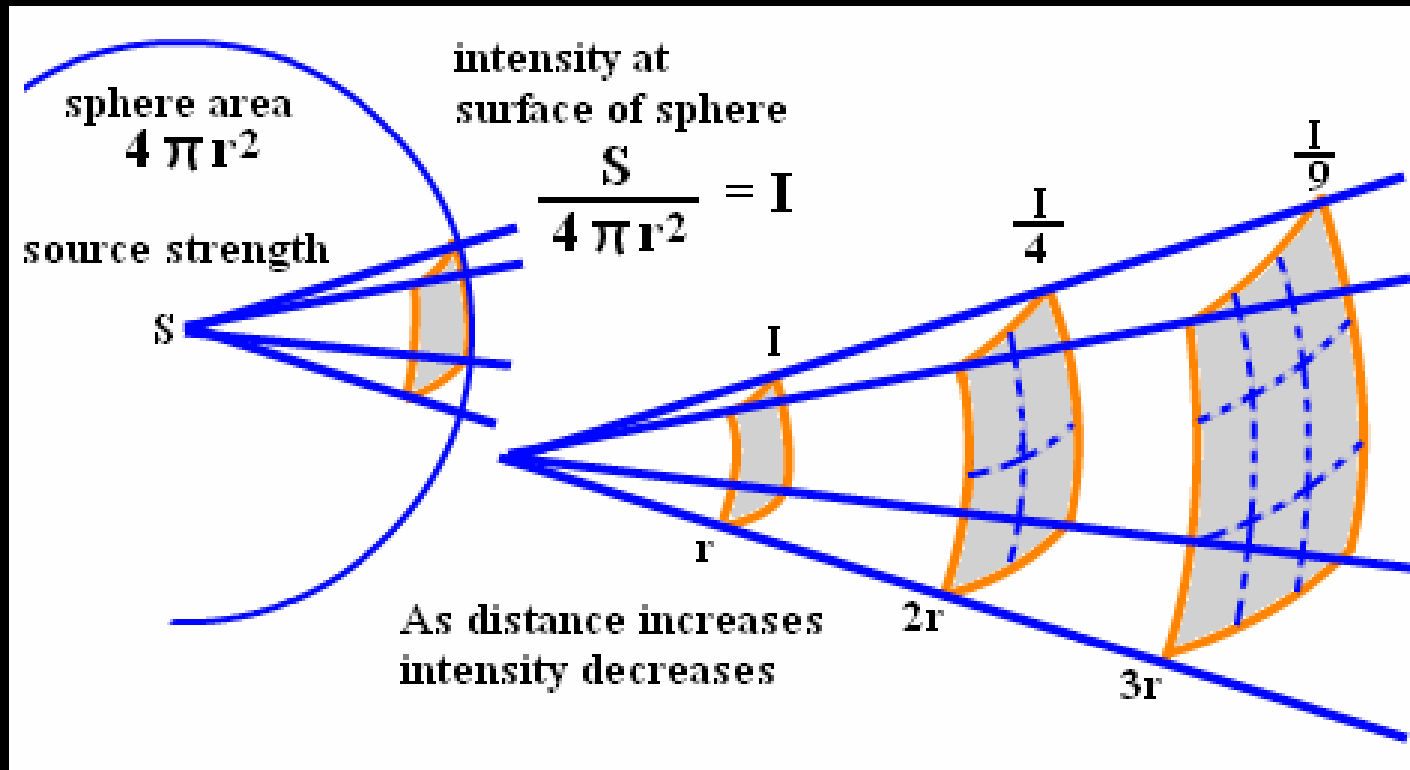
- Pressure levels cannot be added arithmetically
- Imagine two sound sources in the same room;
 - A discussion, say = 62 dB
 - A TV, say = 73 dB
- The total combined sound level therefore is the logarithmic sum;
$$= 10 \times \log (10^{62/10} + 10^{73/10})$$
$$= 73.3 \text{ dB}$$



Sound Facts – The decibel (dB) scale



Sound Facts – intensity vs distance (the Inverse Square Law)



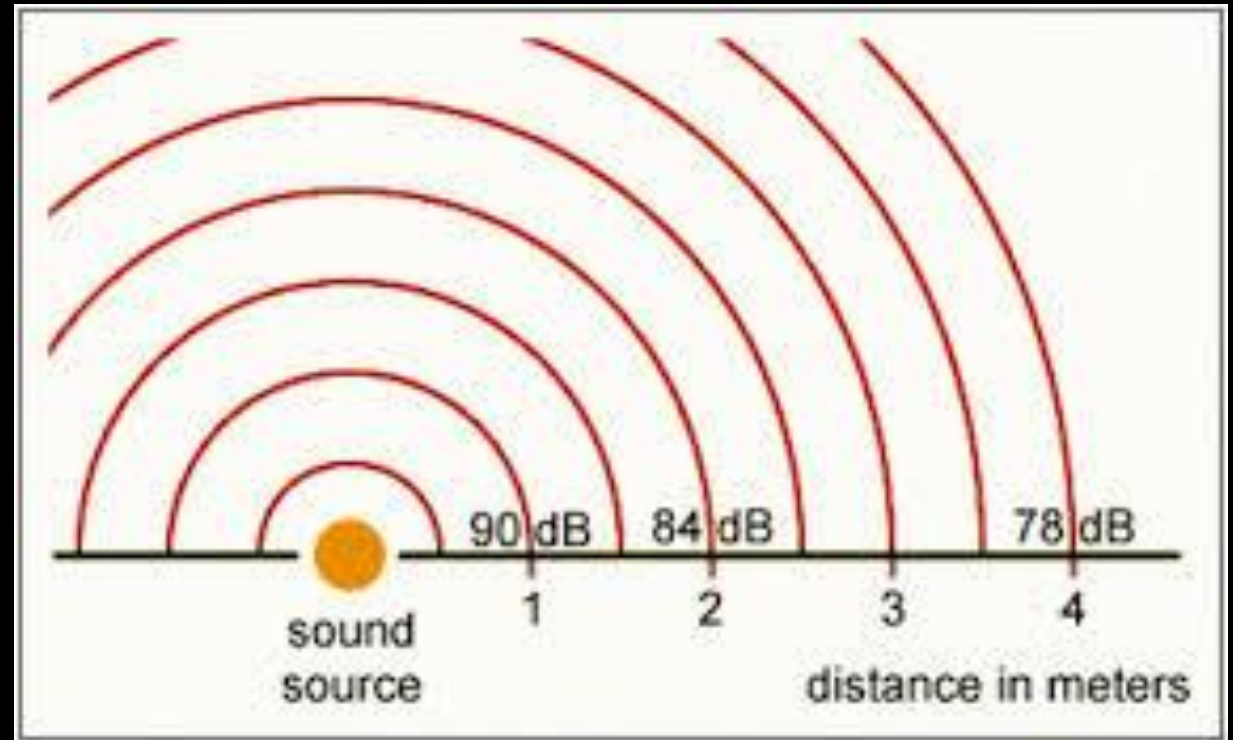
The Inverse Square Law

$$\frac{I_1}{(I_2)} = \frac{(d_2)^2}{(d_1)^2}$$

I_1 is the initial intensity of radiation, d_1 is the initial distance, and d_2 is the final distance, and I_2 is the final intensity.

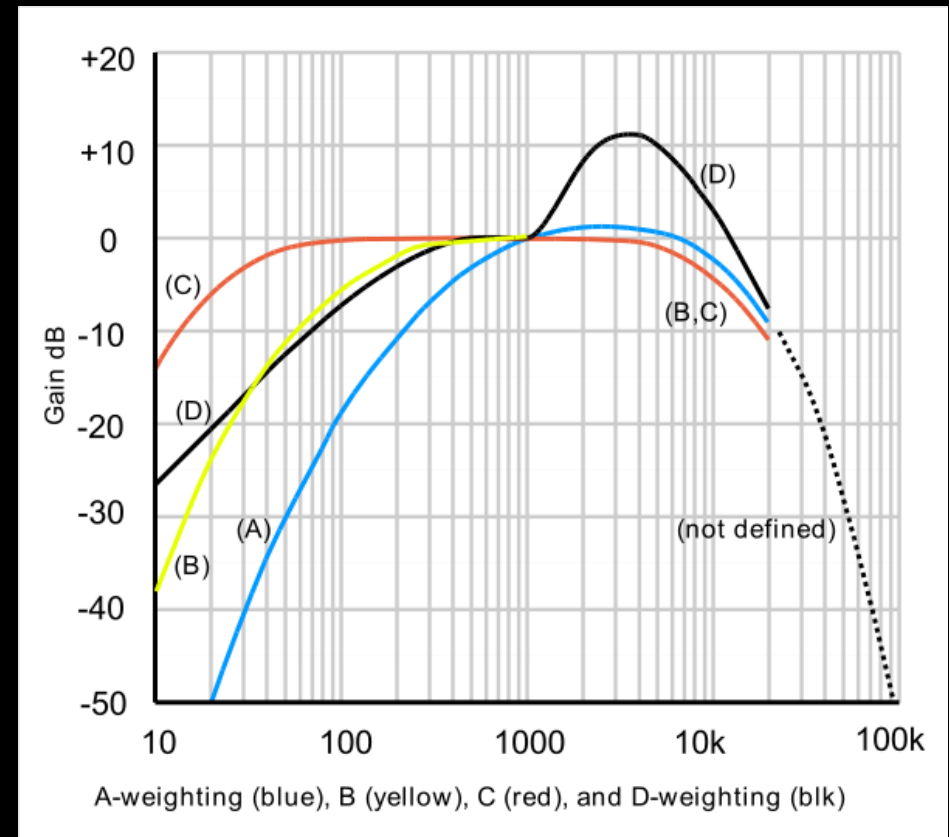
Sound Facts – Rule of Thumb (dB vs m)

- A gain (or loss) of 3dB corresponds to an increase of twice (or decrease to one-half)
- Distance increasing from 1m to 2m, according to inverse square law, should decrease the intensity by $1/4^{\text{th}}$
- -3dB = $\frac{1}{2}$ loss of intensity
- Meaning, -6dB = $\frac{1}{2} \times \frac{1}{2}$ loss of intensity
- Therefore, from 1m to 2m, there is a loss of 6 dB



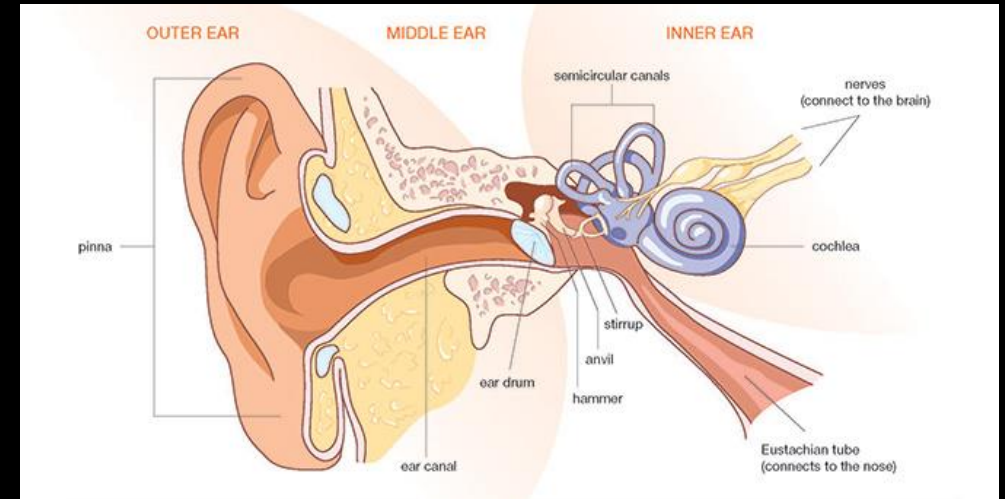
Sound Facts – the Weighting (dBA etc.)

- “**Loudness**” is only a human perception. It does not necessarily correlate with the “**Sound Level**”
- dB are a measurement of sound intensity over the **standard threshold of hearing**
- Human ear responds to different frequencies of sound differently
- To reflect this, **filters** are frequently added for different frequencies
- “**A**” **filter**, resulting in **dBA** scale, is usually used in regulatory frameworks on the belief that it correlates well with relative risk of noise induced hearing loss (but underestimates the annoyance and stress of low frequency noises)



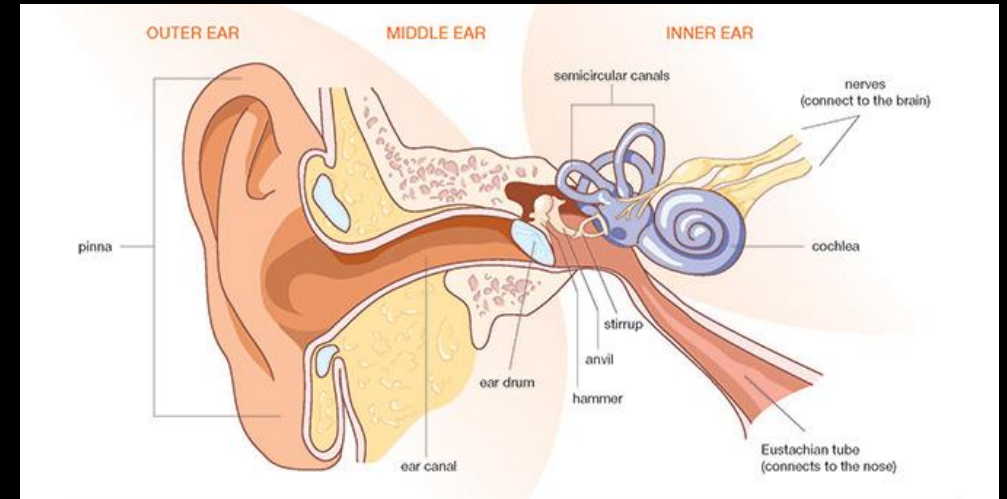
Hearing

- Sound wave → Outer ear → Ear Canal → Eardrum
- The eardrum vibrates and sends the vibrations to the three bones, “malleus” (hammer), “incus” (anvil) and “stapes” (stirrup)
- These three bones amplify the vibrations and send them to cochlea (filled with fluid)
- An elastic partition (“basilar membrane”) runs from the beginning to the end of the cochlea, splitting it into upper and lower parts
- Vibrations inside the cochlea causes the fluid inside to ripple, causing a wave to form on the basilar membrane
- Hair cells (sensory cells) sitting on the basilar membrane ride the wave



Hearing contd...

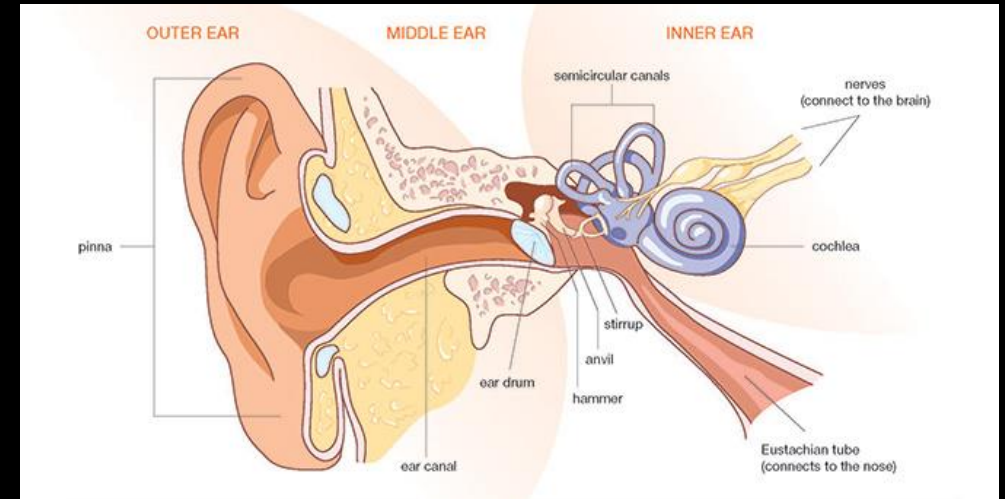
- Hair cells near the end of the cochlea detect high pitched sounds, while those at the centre detect lower pitched sounds
- When the hair cells move up and down, microscopic hair like projections (“stereocilia”) on the top of the hair cells bump against an overlying structure and bend
- Bending causes pore-like channels at the tips of the stereocilia to open up
- When these pores open a chemical rush into the cells creating an electrical signal
- The auditory nerve carries this electrical signal to the brain, which interprets the sound to how we understand it



Video: <https://youtu.be/eQEaiZ2j9oc>

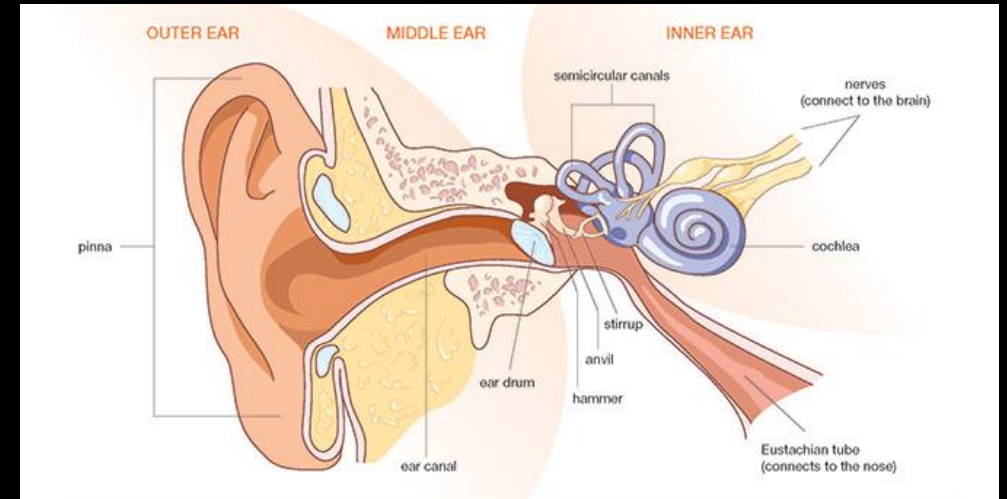
Hearing Loss (treatable)

- Ear Infection
 - Inflammation of the middle ear. In the acute stages, a cold or allergies lead to mucus build-up and blockage of the Eustachian tube
 - This tube allows the drainage from the middle ear and maintains pressure equilibrium
 - When its blocked, bacteria can grow and multiply, leading to hearing loss ranges from 25-45dB
 - Treated with antibiotics and will clear up within a week or so
- Excessive Earwax
 - Earwax is produced by the ear canal, for protection from foreign agents such as dust and microorganisms from entering the ear
 - Usually these are naturally flushed out, but when the glands overproduce, the wax can harden
 - Cotton swabs are not good, better to soften with oil or hydrogen peroxide and allow natural drainage
 - Sometimes medical intervention may be necessary



Hearing Loss (not so easily treated)

- Ruptured Eardrum
 - If an infection is not treated quickly enough, the pressure build-up can rupture the eardrum
 - Foreign objects, sudden pressure imbalances, loud noises etc., can also rupture the eardrum
 - The eardrum, being the barrier between the middle and external ears, rupture can cause drainage, causing hearing loss
 - Mostly heals naturally, but severe ruptures may need surgery
- Inner Ear Damage
 - Worst, occurs slowly over time
 - The hair cells inside cochlea, when exposed to loud sounds, break down and are no longer stimulated
 - Hereditary abnormalities can cause some more prone to these breakdowns than others
 - Once gone, unfortunately, the hair cells do not regrow



Video: <https://youtu.be/mMiwXUUj7Xg>

Hearing Loss (how does it sound)

Audio: <http://www.hse.gov.uk/noise/audio/noise-induced-hearing-loss.mp3>

Hearing Loss – Facts & Checks

- Hearing loss due to work related noise – **preventable**, but once the hearing is gone, it is **not recoverable**
- **17,000** people in the UK suffer deafness, ringing in the ear (**tinnitus**) or other forms of hearing loss
- Factors that contribute are **noise levels** and the **exposure periods**
- **Simple checks** are available

SIMPLE CHECKS: where you work;

- Is the noise **intrusive**?
- Do you have to **raise the voice** to talk to someone 2m away?
- Do you use **noisy tools** for over **½ hour a day**?
- Is this a **noisy industry**?
- Do you have noise from **detonators** or **guns**?
- Even if you feel better next day, do you have **muffled hearing** at the end of the day?

If the answer is **YES** to any of the above, you are at **RISK**!

Hearing Loss – Early Symptoms & Your Responsibilities

- Conversation becomes **difficult** or **Impossible**
- **Family complaints** about loud TV
- Trouble having **telephone** conversations
- Find it difficult to catch sounds like **“t”, “d” and “s”**, resulting in confusing similar words
- Permanent **tinnitus** (**ringing**, **whistling**, **buzzing** or **humming** in the ears)

What do you have to do?

- **Co-operate**: Use facilities and equipment provided, follow suitable work methods
- **Wear hearing protection** given
- **Look after** your hearing protection
- **Attend** hearing checks
- **Report** any problems

All the above are **LEGAL DUTIES** on the worker!

Noise – the Law

- “The Control of Noise at Work Regulations 2005” (the “Noise Regulations”)
- Eliminate or reduce risks to H & S from noise
 - Take action to reduce exposure to noise
 - Provide employees with personal hearing protection
- Duties
 - Make sure the legal limits are not exceeded
 - Maintain and use of equipment to control noise risks
 - Provide employees with information, instruction and training
 - Carry out health surveillance (monitor workers’ hearing ability)

Protection of Hearing – Employer Responsibilities

- Provide **quieter** equipment, processes
- Engineering/Technical **changes** to reduce noise levels
- Using **barriers, screens, enclosures** or **absorbent** materials
- Laying out of the workplace to create **quiet workstations**
- Provide **improved** work methods
- **Limiting** exposure times

Noise – the “Exposure Levels”

- Employees are responsible for making a reliable estimate of the workers' **daily personal exposure levels** to noise – $L_{EP,d}$
- This represents a daily **noise dose** – **how loud, how long**
- Also need to determine the likely **peak sound pressure levels** – $L_{C,peak}$
- Could be done either by referring to **published information**, or through **measurements at workplace** (or **similar workplaces**)
- If the noise exposure levels are expected to vary within the week, a weekly personal exposure level may be calculated – $L_{EP,w}$

Hearing Loss – HSE Calculators & Guidance

- Daily Noise exposure calculator: [Link: http://www.hse.gov.uk/noise/dailycalc.xls](http://www.hse.gov.uk/noise/dailycalc.xls)
- Daily exposure: ready-reckoner: [Link: http://www.hse.gov.uk/noise/dailyexposure.pdf](http://www.hse.gov.uk/noise/dailyexposure.pdf)
- Weekly Noise exposure calculator: [Link: http://www.hse.gov.uk/noise/weeklycalc.xls](http://www.hse.gov.uk/noise/weeklycalc.xls)
- Weekly exposure: ready-reckoner: [Link: http://www.hse.gov.uk/noise/weeklyexposure.pdf](http://www.hse.gov.uk/noise/weeklyexposure.pdf)
- Hearing Protection calculator: [Link: http://www.hse.gov.uk/noise/hearingcalc.xls](http://www.hse.gov.uk/noise/hearingcalc.xls)

Exercise – Daily Exposure Levels



You can enter data in the white cells only

Exposure Calculator

	Noise Level (L_{Aeq} dB)	Exposure duration (hours)	Exposure points (job/task)	Exposure points per hour
Job / task 1				
Job / task 2				
Job / task 3				
Job / task 4				
Job / task 5				
Job / task 6				
Job / task 7				
Job / task 8				
Total duration				
Daily noise exposure ($L_{EP,d}$)				

Note: Exposure points can be used to prioritise noise control. The highest exposure points are given by the jobs, tasks, etc. which make the greatest contributions to daily noise exposure. Therefore, tackling these noise exposures will have the greatest effect on daily noise exposure.

Instructions for exposure calculator

Enter the L_{Aeq} (in dB) and select the daily exposure duration (in hours) in the white areas for up to eight jobs or tasks carried out by a person during their working day. Rounding noise levels to the nearest decibel and durations to the nearest 15 minutes (0.25 hours) is sufficiently precise. Exposure points will appear for each entry and the overall daily personal noise exposure ($L_{EP,d}$) will be displayed.

The Lower Exposure Action Value (an $L_{EP,d}$ of 80 dB) is represented by 32 exposure points, the Upper Exposure Action Value ($L_{EP,d}$ of 85 dB) by 100 points.

Reference: Control of Noise at Work Regulations 2005, Schedule 1 Part 1

Exercise – Weekly Exposure Levels



You can enter data in the white cells only

Weekly Noise Exposure Calculator

Daily exposure
($L_{EP,d}$ dB)

Day 1	
Day 2	
Day 3	
Day 4	
Day 5	
Day 6	
Day 7	

$L_{EP,w}$ **dB**

Instructions for weekly exposure calculator

Enter the daily personal noise exposure $L_{EP,d}$ (in dB) in the white areas for the days worked in the week. Leave a blank for the days not worked.
The weekly personal noise exposure ($L_{EP,w}$) will be displayed.

Reference: Control of Noise at Work Regulations 2005, Schedule 1 Part 2

Exposure Action Values

Exposure action values

The Noise Regulations define 'exposure action values' – levels of noise exposure which, if exceeded, require you to take specific action. There are 'lower' and 'upper' action values.

You need to compare your estimated noise exposure with the action values to know what specific actions are required of you in addition to your general duty to reduce risks from noise.

	Lower exposure action value (decibels)	Upper exposure action value (decibels)
Daily or weekly personal noise exposure ($L_{EP,d}$ or $L_{EP,w}$)	80	85
Peak sound pressure (L_{Cpeak})	135	137

Exposure Limits

Exposure limits

There are legal limits on the levels of noise to which workers may be exposed.

To comply with the exposure limits you must ensure that your workers' noise exposure, reduced by an appropriate factor if they are using personal hearing protection, is not above:

- 87 decibels for daily or weekly personal noise exposure ($L_{EP,d}$ or $L_{EP,w}$); and
- 140 decibels for peak sound pressure (L_{Cpeak}).

Complying with exposure limits is only one aspect of your legal duties under the Noise Regulations. It is separate from your duty to reduce risks from noise to as low as is reasonably practicable.

Exercise – Hearing Protection Calculator



SNR Method

You can use this method if you know the C-weighted noise levels

Data on the hearing protector

Noise levels

SNR

C-weighted noise level, L_c dB

Calculated level at the ear according to BS EN ISO 4869-2:1995 ($\alpha=1$) dB

HSE recommends allowing 4dB for 'real-world' factors. Assume that this device will give: dB at the ear

Colour codes:

Protector gives adequate protection, and does not 'over-protect'

Protector does not give adequate protection, or it 'over-protects'

Each calculator is on a separate 'tab' within the spreadsheet. Click on the tab to go to the appropriate calculator. You can also move between the tabbed sheets by pressing Ctrl+Page Up or Ctrl+Page Down.

Enter values in both white cells.

Select a protector so that daily exposure is reduced to at least below 85 dB. Ideally, aim for between 80 and 75 at the ear. Avoid protectors resulting in less than 70 dB at the ear - this is 'over-protection' (see BS EN 458:2004).

Example 1: 3M Peltor SportTac

Example 1: [ScrewFix Search](#)