NOISE POLLUTION:

NOISE POLLUTION – A silent killer

- Sound that is unwanted or disrupts one's quality of life is called as noise. When there is lot of noise in the environment, it is termed as noise pollution.

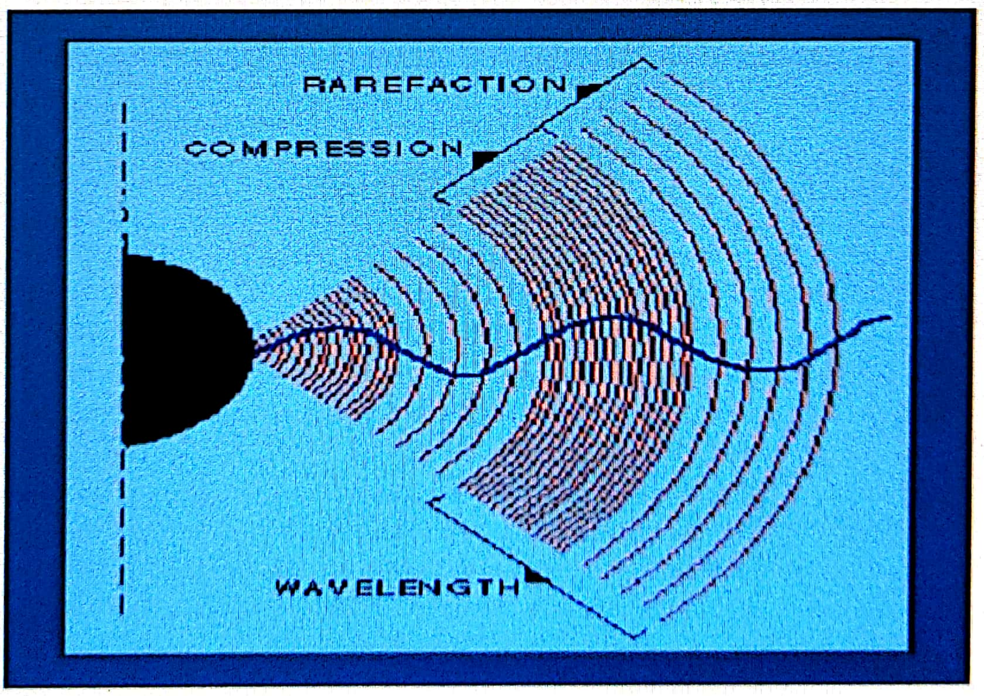
- Sound becomes undesirable when it disturbs the normal activities such as working, sleeping, and during conversations.

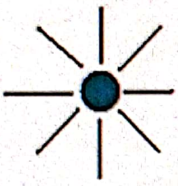
- It is an underrated environmental problem because of the fact that we can't see, smell, or taste it, and still it is ubiquitous and omnipresent.

- World Health Organization stated that "Noise must be recognized as a major threat to human well-being"

- The disturbance (noise) gradually diminishes as it travels outwards since the initial amount of energy is gradually spreading over a wider area.

- If the disturbance is confined to one dimension (tube / thin rod), it does not diminish as it travels (except loses at the walls of the tube)

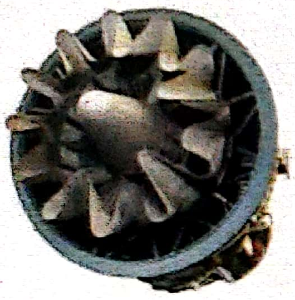




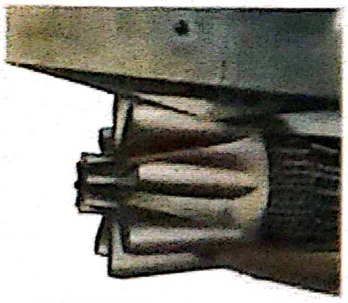
Source

Path

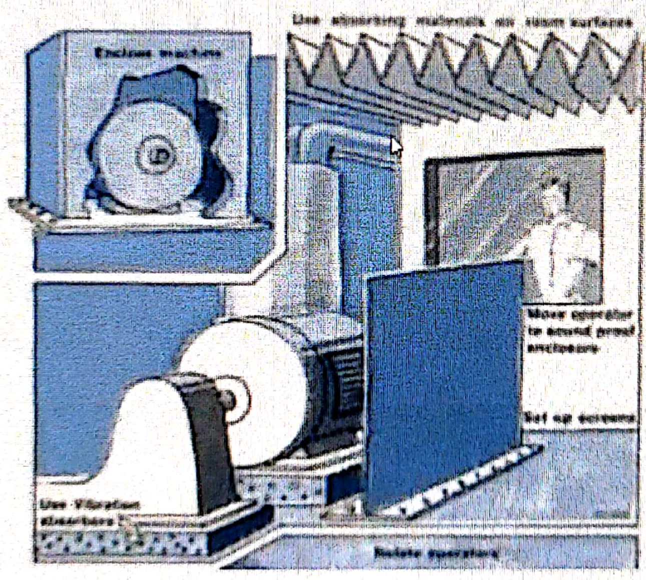
Reciever



CORRUGATED INTERNAL MIXER



LOBE-TYPE NOZZLE



CPCB-Standards with respect to noise in ambient air

Area Code	Category of area	Limits in dB	
		Day time	Night time
(A)	Industrial	75	70
(B)	Commercial	65	55
(C)	Residential	55	45
(D)	Silence	50	40

NOTE:

(1) Day time is reckoned in between 6 a.m. to 10 p.m.

(2) Night time is reckoned in between 10 p.m. to 6 a.m.

(3) *Silence zone* is defined as areas up to 100 mts around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the competent authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.

WHAT IS NOISE POLLUTION?

Noise can be defined as an unpleasant and unwanted sound that interferes significantly with the comfort, health or welfare of persons, or with the full use of enjoyment of property.

Noise in itself is a source of pollution.

It has been recognized as a significant health problem related to hearing damage.

Environmental noise may be defined as unwanted sound that is caused by emissions from traffic (roads, air or railways), industrial sites and recreational infrastructures.

Whether or not a sound is undesired by a person will depend on a number of factors, e.g.

(a) Loudness
(b) Frequency
(c) Continuity
(d) Variation with time
(e) Time of occurrence
(f) Origin of the sound (Distance of the receiver)
(g) Recipient's state of mind and temperament

FREQUENCY

Frequency can be defined as number of pressure cycles / time

It is also known as pitch of sound

Its unit is Hz.

In sound, frequency is as important as its level

<20Hz	20Hz to 20,000Hz	> 20,000Hz
Infrasonic	Audible Range	Ultrasonic

In acoustics, the sound pressure (in *dB*) of a spherical wavefront radiating from a point source decreases by 50% as the distance (r) is doubled.

Note that the decrease is 6 *dB*, since *dB* represents an intensity ratio.

The equation for calculating sound intensity levels with distance from the source is:

$$L_{P2} = L_{P1} - \left[20 \cdot log_{10}\left(\frac{r_2}{r_1}\right)\right]$$

where: L_{P1} = sound pressure level at location of first measurement (in dB)

r_1 = distance from source of first measurement (in *meters*)

r_2 = distance from source of second measurement (in *meters*)

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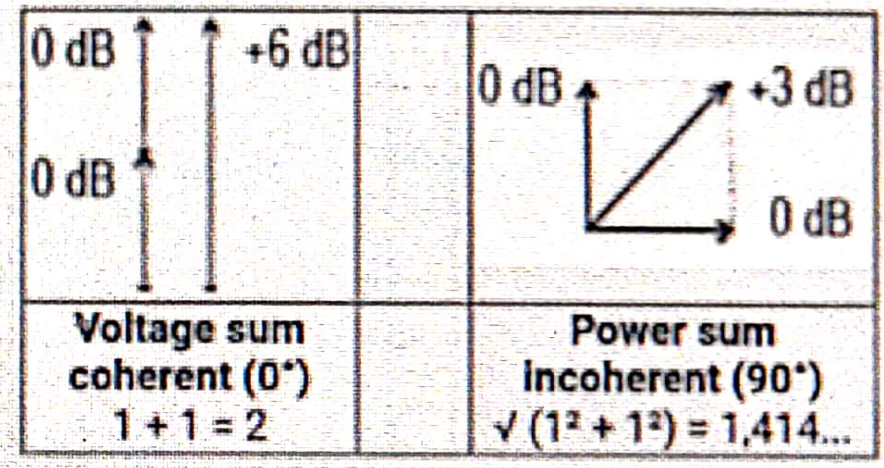
Adding amplitudes (and levels



Adding of two **coherent** pressure or voltage level:

$$L_A \; and \; L_B = 20 \log_{10}\left(10^{\frac{L_A}{20}} + 10^{\frac{L_B}{20}}\right) \text{ dB}$$

Adding of two values of the same level results in an increase in the overall level here of **(+) 6 dB.**
This is obtained with the equal input of two closely standing speakers.

Adding of two **incoherent** (noncoherent) pressure or voltage level:

$$L_A \; and \; L_B = 10 \log_{10}\left(10^{\frac{L_A}{10}} + 10^{\frac{L_B}{10}}\right) \text{ dB}$$

Adding of two values of the same level results in an increase of the total level of **(+) 3 dB.**
This equation is used for both the electric incoherent addition of signals, and for the calculation of the energy level of two loudspeakers.

Sound pressure level:

It is given by the formula below, where the reference sound pressure is the minimum sound pressure that can be perceived by the human ear. Its value is equivalent to 20 μPa (20×10^{-6} Pa)

$$SPL = 10\log\left(\frac{pres^2}{refpres^2}\right)$$

Where,

pres = sound pressure;

refpres = reference sound pressure.

The unit used is the decibel (dB), submultiple of the bel (B).

- The disturbance (noise) gradually diminishes as it travels outwards since the initial amount of energy is gradually spreading over a wider area.
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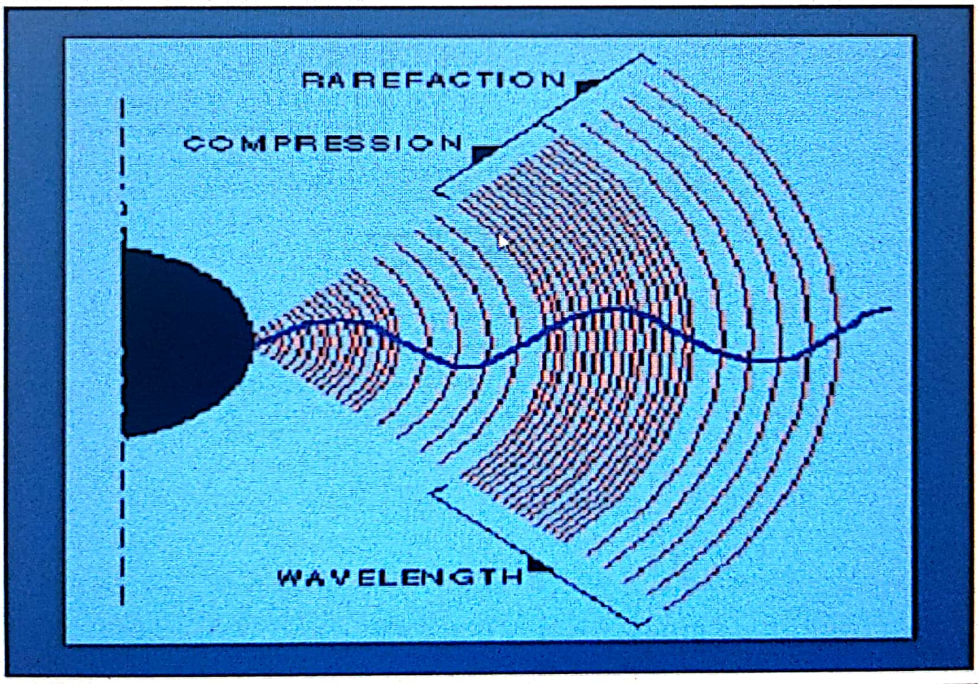


Example Problem: Sound Pressure Level

The acoustic wave radiated by a source is measured some distance away from the source and is found to generate a sound pressure level of 156 μPa.

What is the decibel level of the sound wave at the point where it was measured?

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_0}\right)$$

where: p = measured Root-Mean-Square (RMS) sound pressure (in μPa)

p_0 = reference RMS sound pressure (20 μPa)

$$L_p = 20 \cdot \log_{10}\left(\frac{156\ \mu Pa}{20\ \mu Pa}\right)$$

$$L_p = 20 \cdot \log_{10}(7.8)$$

$$L_p = 20 \cdot 0.89$$

$$L_p = 17.8\ dB$$

Example Problem: Sound Pressure Level

The acoustic wave radiated by a source is measured some distance away from the source and is found to generate a sound pressure level of 0.144 Pa.

What is the decibel level of the sound wave at the point where it was measured?

ANS: 77.146 dB

Example Problem: Sound Pressure Level

Noise level at a busy traffic intersection of Surat city was recorded as 86.1 dB. Convert the same into Pa.

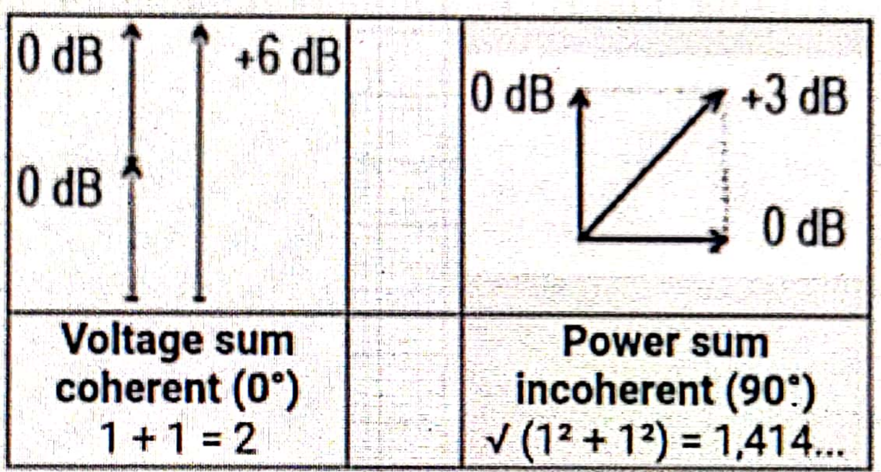
ANS – 0.403 Pa

Example Problem:

Coherent noise levels were measured at three different locations of an industry. Recorded values were 72.1 dB, 74.5 dB and 71.9 dB What is the combined noise level of these three sources?

ANS : 82.45

Adding amplitudes (and levels



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Adding of two values of the same level results in an increase in the overall level here of **(+) 6 dB.**
This is obtained with the equal input of two closely standing speakers.

Adding of two **incoherent** (noncoherent) pressure or voltage level:

$$L_A \; and \; L_B = 10 \log_{10}\left(10^{\frac{L_A}{10}} + 10^{\frac{L_B}{10}}\right) \text{ dB}$$

Adding of two values of the same level results in an increase of the total level of **(+) 3 dB.**
This equation is used for both the electric incoherent addition of signals, and for the calculation of the energy level of two loudspeakers.

Example Problem: Sound Pressure Level

Noise level at a busy traffic intersection of Surat city was recorded as 86.1 dB. Convert the same into Pa.

ANS – 0.403 Pa

Example Problem:

Coherent noise levels were measured at three different locations of an industry. Recorded values were 72.1 dB, 74.5 dB and 71.9 dB What is the combined noise level of these three sources?

ANS : 82.45 dB

In-coherent noise levels were measured at three different locations of an industry. Recorded values were 72.1 dB, 74.5 dB and 71.9 dB What is the combined noise level of these three sources?

ANS : 77.77 dB

In acoustics, the sound pressure (in *dB*) of a spherical wavefront radiating from a point source decreases by 50% as the distance (*r*) is doubled.

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r_1 = distance from source of first measurement (in *meters*)

r_2 = distance from source of second measurement (in *meters*)

Example Problem:

In a power plant, a compressor radiates a sound of 88 dB at a distance of 1 m from the source. What would be the sound pressure level at a distance of 4 m & 8 m & 12 m?

ANS – 75.96 dB, 69.94, 66.42

Q:4	Attempt:	
(i)	What sound pressure level in dB would result from combined effects of three coherent noise sources of 60dB, 70dB and 75dB?	(02)
(ii)	In a power plant, a compressor radiates a sound of 88 dB at a distance of 1 m from the source. What would be the sound pressure level at a distance of 4 m?	(02)
(iii)	Calculate the hearing handicap (%) of a road side open shutter shopkeeper from his following audiogram data. Also, comment on the degree of hearing loss of the shopkeeper.	(04)

Pure Tone Thresholds	500 Hz	1 KHz	2 KHz	4 KHz
Right Ear	35	25	35	55
Left Ear	25	35	40	75

==** Shrimad Bhagvad GITA is a sacred text for motivation, inspiration and devotion **==

ıble 2: Sound Pressure Table

›und pressure (*μPa*)	*dB*	equivalent level
20	0	threshold of hearing (reference power level)
63	10	human breath, rustling leaf
200	20	whisper, very calm room
630	30	quiet conversation
2000	40	normal conversation
6300	50	quiet office
20,000	60	busy restaurant, washing machine
60,000	70	noisy office
200,000	80	urban street traffic, heavy traffic
630,000	90	industries / work place
20,00,000	100	lawn mower, jack hammer
63,00,000	110	chain saw
2,00,00,000	120	sonic boom (*risk of instantaneous hearing loss)

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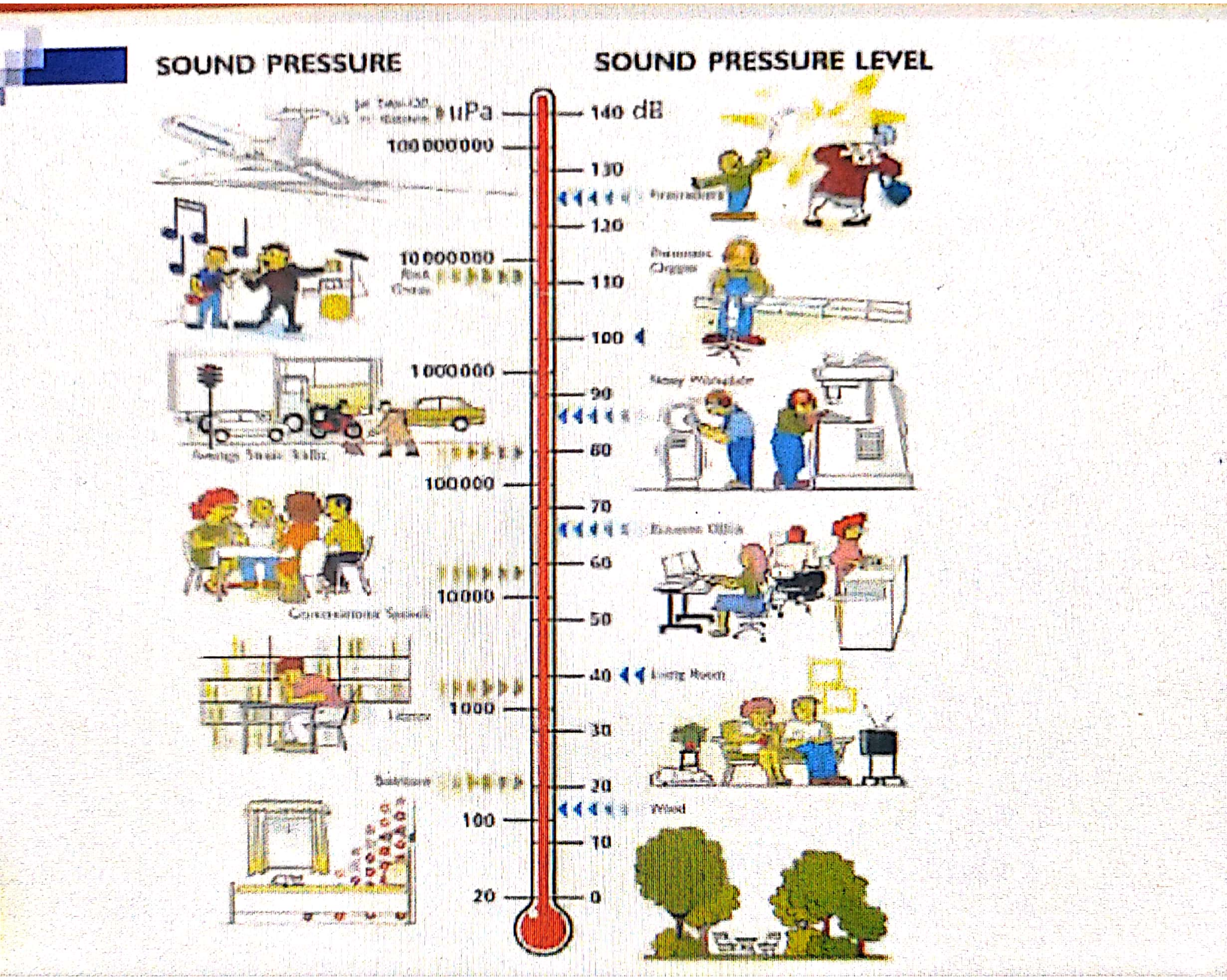
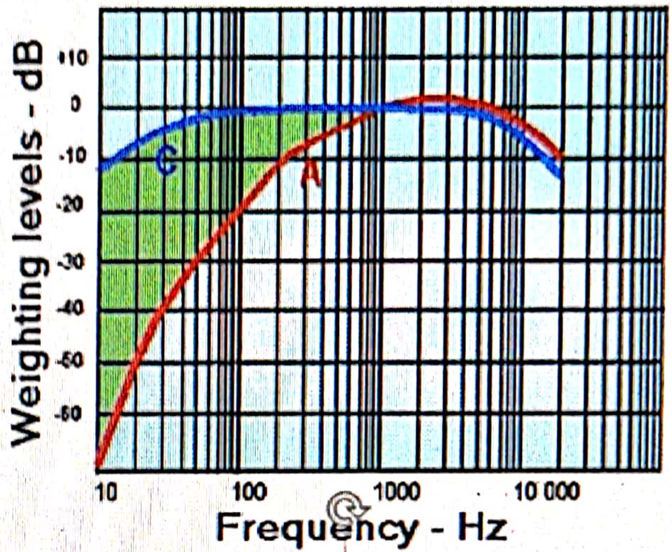


SOUND PRESSURE
SOUND PRESSURE LEVEL
µPa
140 dB
100 000 000
130
120
10 000 000
110
100
1 000 000
90
80
100 000
70
60
10 000
50
40
1000
30
20
100
10
20
0

A & C weighted frequencies



- Several different weighting networks have been developed over the years. The one which has been found to best describe the damaging effect of noise is the **A-weighting network.** dB(A)

- The sound level meter replicates the human response of the ear by using an electronic filter which is called "A" filter.

- The sound pressure level in dB (A) gives a close indication of the subjective loudness of the noise.

dB SCALE

Human ear responds logarithmically to power difference

Alexander Graham Bell invented a unit Bel to measure the ability of people to hear

Power Ratio of 2 = dB of 3

Power Ratio of 10 = dB of 10

Power Ratio of 100 = dB of 20

$$SPL = 10\log\left(\frac{pres^2}{refpres^2}\right)$$

Where,

pres = sound pressure;

refpres = reference sound pressure.

The unit used is the decibel (dB), submultiple of the bel (B).

FREQUENCY

Frequency can be defined as number of pressure cycles / time

It is also known as pitch of sound

Its unit is Hz.

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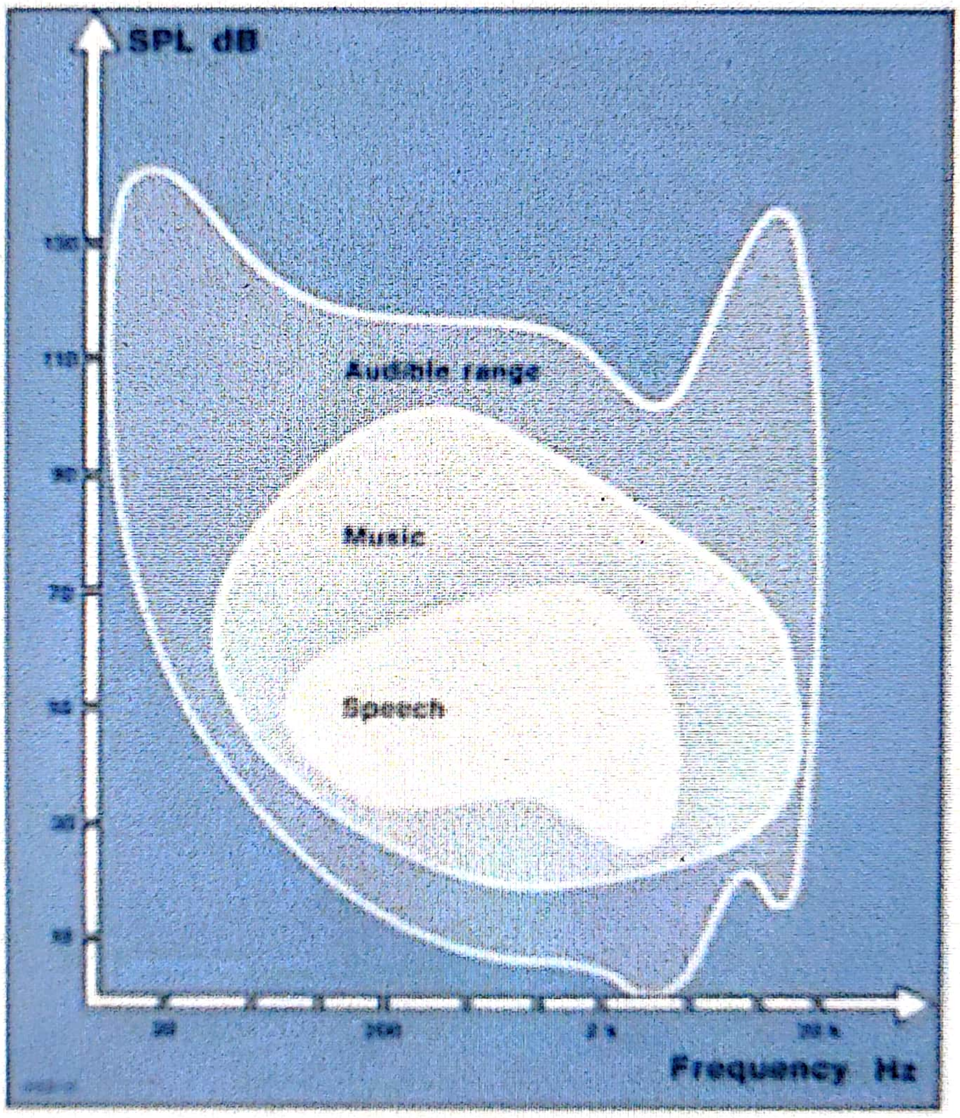
<20Hz	20Hz to 20,000Hz	> 20,000Hz
Infrasonic	Audible Range	Ultrasonic

HUMAN PERCEPTION



Effects of Noise Pollution

- Adverse health effects of noise have been observed in the work environment.
- Industrial activities that generate noise have received the greatest attention, with several reports on noise-induced hearing loss among factory workers.
- Outside the work environment, less attention is paid to noise.
- Noise in the environment or community seriously affects people, interfering with daily activities at school, work and home. World Health Organization (WHO) has identified a number of health risks of noise;
  - Annoyance / Irritability / Tenseness
  - Hearing Impairment
  - Interference with social behaviour
  - Interference with speech communication
  - Sleep disturbance
  - Cardiovascular effects
  - Hormonal responses
  - Decrease in work performance

SOURCES: (1) Industrial (2) Non-industrial

(1) Industrial:

Various industries contributing to noise pollution:

- Textile
- Iron and steel
- Pulp & paper
- Chemicals
- Thermal power stations

In industrial cities like Surat, Kolkata, Ludhiana, Kanpur etc. often the industrial zones are not separated from the residential zones of the city, especially in the case of small scale industries.

(2) <u>Non-Industrial:</u>

- Domestic Noise (Household)
- Entertainment devices, musical instruments, air conditioners, kitchen appliances.
- <u>**Loudspeakers**</u> during political processions, festivals and religious rituals. (Public Address System)
- Construction & demolition work.
- Transportation noise viz. <u>**road**</u>, rail and air.
- Crowded markets and commercial areas.
- Places near airports-noise due to take off and landing of aircrafts.

- Transportation systems are the main source of noise pollution in urban areas.

- Construction of buildings, highways, and streets cause a lot of noise, due to the usage of air compressors, bulldozers, loaders, dump trucks, and pavement breakers.

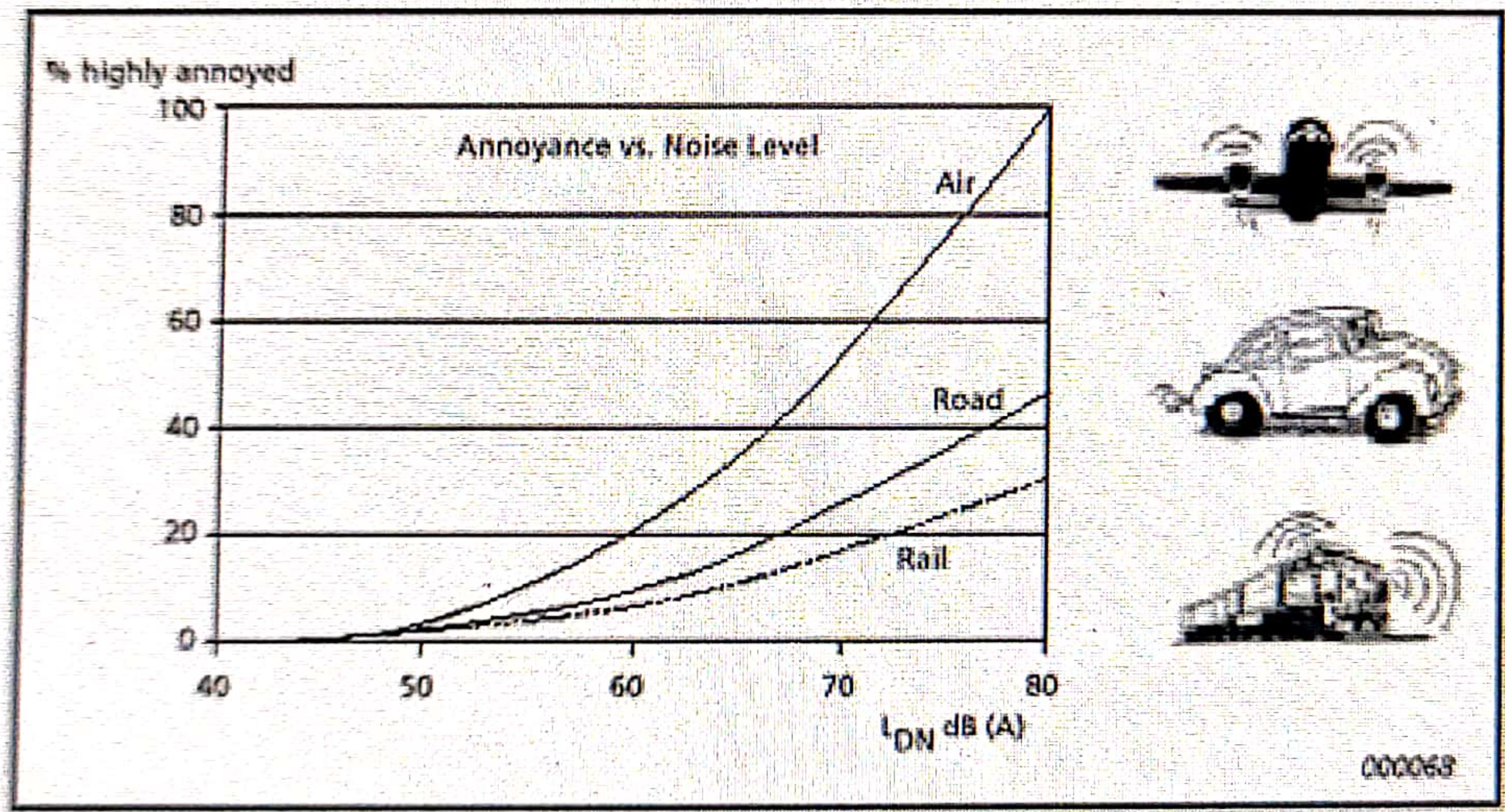
- Loud speakers, plumbing, boilers, generators, air conditioners, fans, and vacuum cleaners add to the existing noise pollution.

SIGNIFICANCE OF ROAD TRAFFIC NOISE:

- Traffic related noise pollution accounts for nearly ⅔ (67%) of the total noise pollution in an urban area.

- Traffic noise on existing urban road-ways lowers the quality of life and property values for person residing in vicinity of these urban corridors.

Major transportation sources of noise pollution: rail, road, and air



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Noise Level and Effects

<55dBA	Desirable level outdoor sub-urban neighbourhood
55-65dBA	Urban "Grey Areas" Annoyance
>65dBA	Black spots Stress effects, sleep disturbance, communication, performance deficits
>75dBA	Unfit for Human habitation, hearing loss, cardiovascular effects

Auditory Effects

- Acoustic Trauma: Sudden hearing damage
- Tinnitus: Ringing in the Ears
- TTS: Temporary threshold shift
- PTS: Permanent threshold shift

The Human Ear

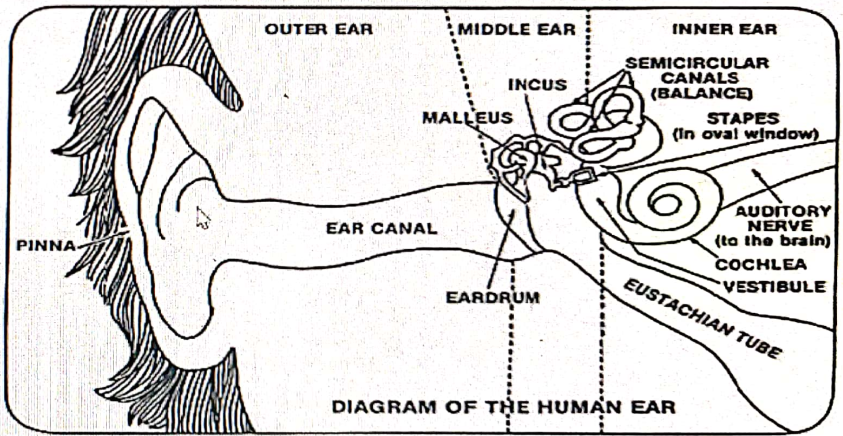
Outer Ear: Pinna and auditory canal concentrate pressure on to drum

Middle Ear: Eardrum, Small Bones connecting eardrum to inner ear

Inner Ear: Filled with liquid, ***cochlea*** with basilar membrane respond to stimulus of eardrum with the help of thousands of tiny, highly sensitive hair cells, different portions responding different frequencies of sound.

The movement of hair cells is conveyed as sensation of sound to the brain through nerve impulses

Masking takes place at the membrane; Higher frequencies are masked by lower ones, degree depends on freq.difference and relative magnitudes of the two sounds



NOISE POLLUTION: Effects on human beings:

(1) Auditory effects:

Hearing loss

There are two types of hearing loss caused by noise.

(a) Acoustic trauma

It consists of instantaneous damage to the ear from a sharply rising wave front, such as occurs in an explosion and may produce rupture of the ear drum.

(b) Noise Induced Hearing Loss (NIHL)

- It results from long term exposure to intense sound.
- The effect usually occurs slowly.
- Its severity depends on the intensity, frequency and duration of noise exposure.
- The absence of comfort makes noise induced hearing loss especially treacherous since the loss of hearing appears only after significant permanent loss has occurred.

Acoustic Trauma

It is damage to ear resulting from a single exposure or relatively few exposure to a very intense level of sound (peak level greater than 140-150 dB), usually impulsive in nature, e.g. explosions.

(2) Non-Auditory effects:

(i) Physiological effects:

(a) Headache
(b) Increase in the rate of heart beat
(c) Narrowing of arteries
(d) Pain in the heart beat
(e) Decrease in the rate of colour perception
(f) Lowering of concentration
(g) Muscular strain and nervous breakdown
(h) Digestive spasm
(i) Eye strain
(j) Nausea
(k) Dizziness

The physiological effect of noise upon particular individuals is very variable, and not yet fully understood.

(ii) Psychological effects:

(1) Annoyance.

(2) Psychological or non-pathological noise effects are also variable and very difficult to measure.

(3) The mildest effect is often physical and mental fatigue and lack of concentration.

(4) It results in lowered efficiency, a reduced work rate, increased absenteeism, and a higher potential for accidents and injuries.

(5) Psychological noise effects impinge upon sleep thereby resulting into insomnia.

(6) Noise can also affect verbal communication upon which we all depend, whether in the work, domestic or social environments.

(7) Depression, which reduces the efficiency of a person.

Temporary Threshold Shift (TTS)

Temporary threshold shift (TTS) can be defined as a change in hearing threshold, primarily due to exposure to high intensity noise that usually can recover in 14 to 72 hours away from noise exposure.

TTS is a warning sign that the hearing mechanism is being overloaded.

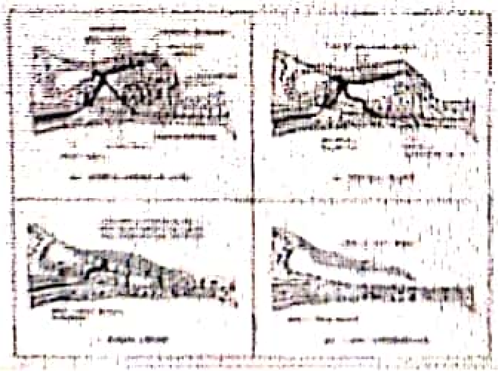
NIHL Type 1

Permanent Threshold Shift (PTS)
It is the permanent damage to the ear as a result of continued or repeated exposure to excessive noise over a period of time.

Normally it is the hair cells in the human ear, which detect the 4-6 KHz frequencies, which deteriorate first.

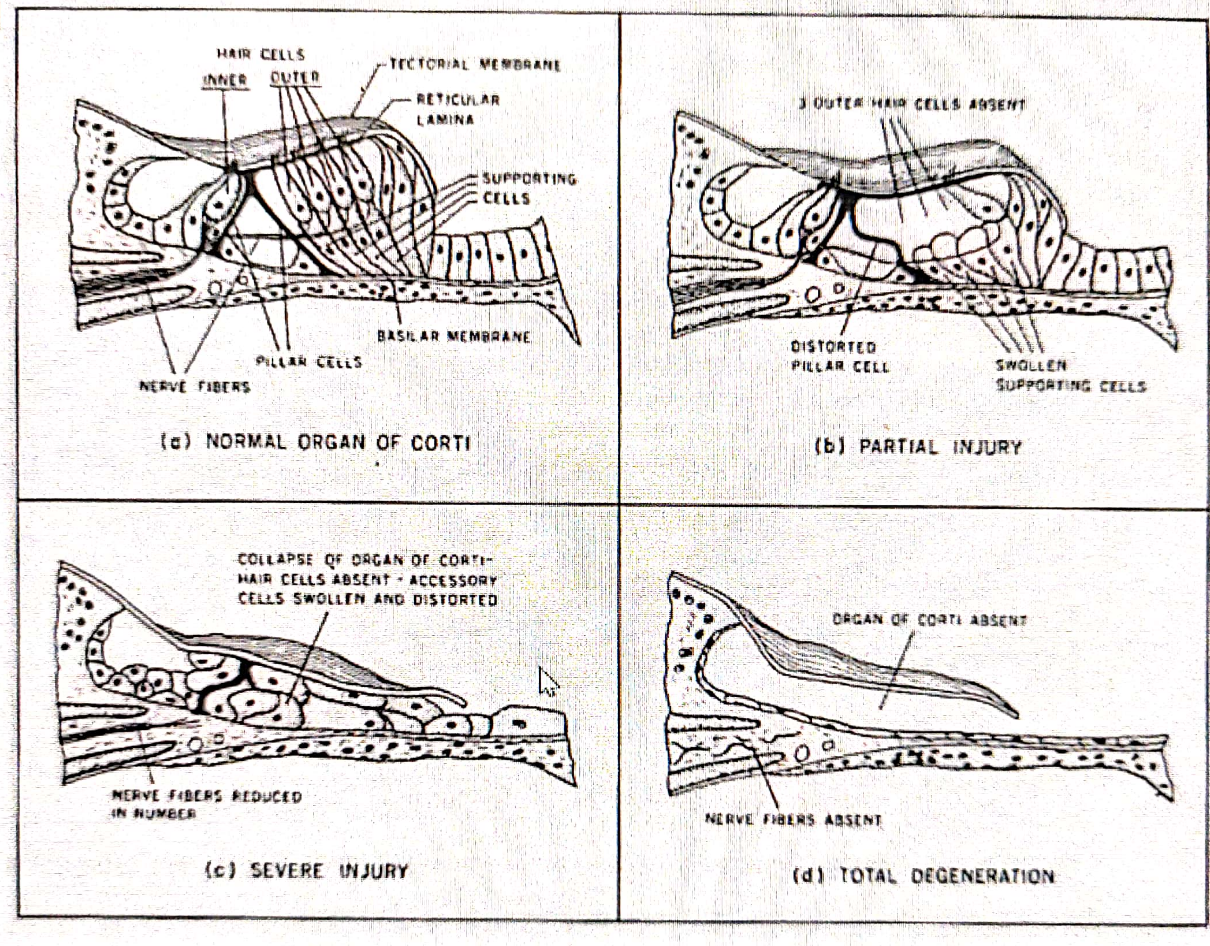
With further excessive noise exposure, the hearing loss increases and extends down to lower frequencies as well and the person begins to have trouble understanding speech.

Permanent threshold shift (Permanent hearing loss) is again classified in three categories:
(1) Sensorineural hearing loss (2) Conductive hearing loss (3) Mixed hearing loss.



NIHL Type 2

Human organ of Corti - increasing degrees of noise-induced permanent damage

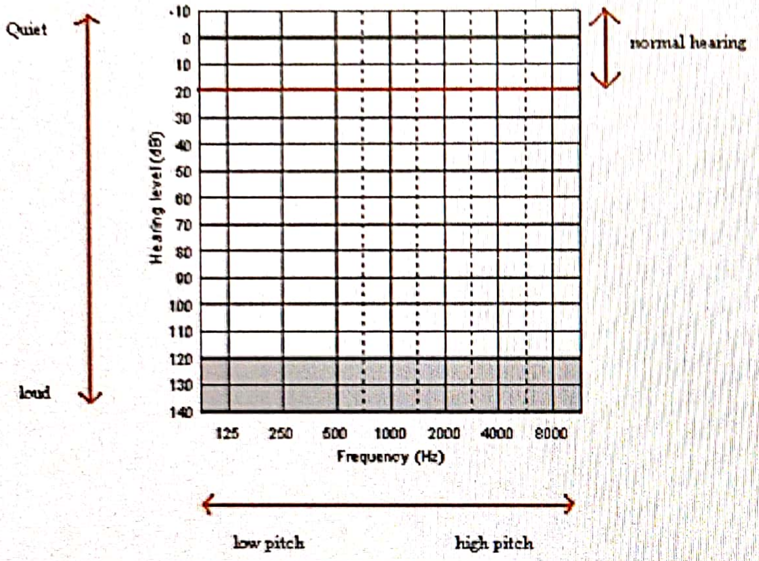


Human organ of CORTI –
increasing degrees of noise induced permanent damage
(Permanent Threshold Shift – PTS)

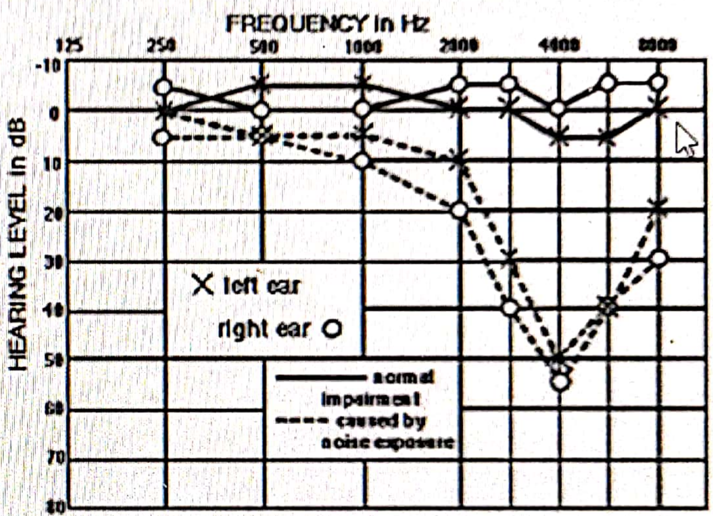
Measurement of Hearing Loss

- **AUDIOMETRY:**
  - It is the process of examining ears of the patients and taking audiograms.
  - When earphones are used to evaluate hearing of the outer, middle and inner ear, response at any frequency is called air conduction response (AC).
  - When a bone conduction oscillator placed on the mastoid bone, is used to evaluate hearing of the inner ear only, response at any frequency is called bone conduction response (BC).
- **AUDIOGRAMS:**
  - An audiogram is a graph that charts the way a person responds to specific sounds called pure tones.
  - The audiogram reads in frequency (pitch) across the top or horizontal axis and it reads in decibels (loudness) down the side or vertical axis.
  - The pitches are low on the left side (125 or 250 Hz), and then gradually climb to higher pitches on the right side (8000 Hz). The loudness scale goes from very soft sounds at the top (-10 or 0 dB) to very loud sounds at the bottom (110 dB).

EXPLANATION OF AUDIOGRAM:



Legend	Right	Left
Air Conduction	O	X
•with masking	△	□
Bone Conduction	<	>
•with masking	[	]
No Response	↙	↘



Degree of hearing loss as given by WHO:

Range in dB	Degree of Hearing Loss
0-25	Normal
26-40	Mild
41-55	Moderate
56-70	Moderately Severe
71-90	Severe
Above 90	Profound

Degree of hearing loss is found out by the notch at a particular frequency (mostly 4,000 Hz) and comparing this value with the table shown above. Typical Audiogram is given in the next slide.

Although several methods exist to calculate hearing handicap (HH), the most commonly accepted formula is the AAO-1979 rule.

Source : American Speech-language Hearing Association

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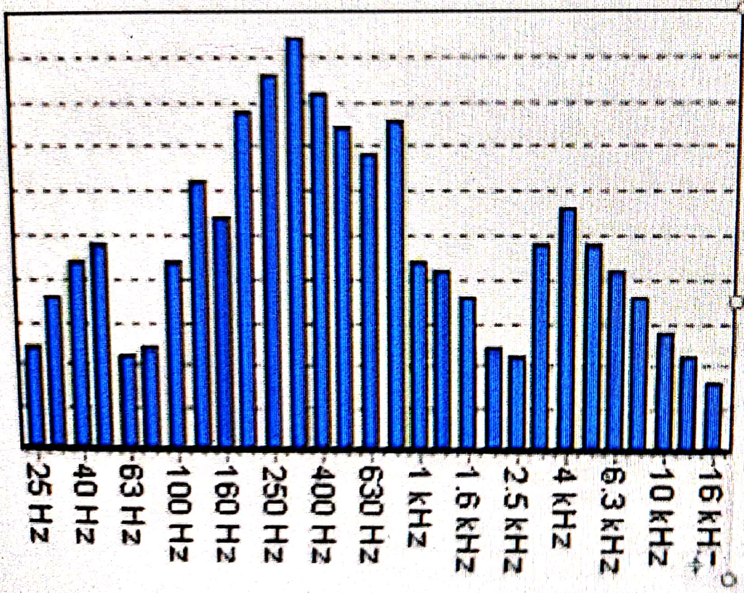
Octave Band

Calculated from	$10^{1.5}$	$10^{1.8}$	$10^{2.1}$	$10^{2.4}$	$10^{2.7}$	$10^{3.0}$	$10^{3.3}$	$10^{3.6}$	$10^{3.9}$	$10^{4.2}$
Exact frequency (Hz)	31.62	63.10	125.9	251.2	501.2	1000	1995	3981	7943	1585
Nominal frequency (Hz)	31.5	63	126	250	500	1000	2000	4000	8000	16000

Frequencies of Octave Band

One-Third Octave Band



Octave Band Frequency Distribution

- When more detailed information about frequency is required, it can be provided by selecting narrower bands, such as one-third octave bands.
- One third octave band centre frequencies in the audible range are:

25, 31.5, 40, 50, 63, 80, 100, 126, 160, 200, 250, 315, 400, 500, 630, 800, 1K, 1.25K, 1.6K, 2K, 2.5K, 3.15K, 4K, 5K, 6.3K, 8K, 10K, 12.5K, 16K, 20K Hz

Sam[redacted] of HEARING HANDICAP (HH) for POLICEMAN-1

Calculation of Hearing Handicap:

PTA Thresholds	500Hz	1kHz	2kHz	4kHz
Right Ear	30	25	20	55
Left Ear	25	25	20	50

(1) Calculate monaural PTA (Pure Tone Analysis)

Right Ear:	$\frac{30+25+20+55}{4} =$	$\frac{130}{4} =$	32.5 dB
Left Ear:	$\frac{25+25+20+50}{4} =$	$\frac{120}{4} =$	30.0 dB

(2) Calculate monaural impairment **{MI = 1.5 (PTA – 25)}**

Right Ear:	1.5 (32.5 dB – 25) dB = 7.5 X 1.5 % =	11.25 %
Left Ear:	1.5 (30 dB – 25) dB = 5 X 1.5 % =	7.5 %

(3) Calculate hearing handicap HH = **{(5 * MI_b)+ MI_w} / 6**

HH = {(5 * 7.5) + (11.25)} / 6 = **8 %**