

L29- Sensitivity of Ear, Hearing underwater and Hearing test**Dynamic Range of Hearing**

- In addition to its remarkable sensitivity, the human ear is capable of responding to the widest range of stimuli of any of the senses. The practical dynamic range could be said to be from the threshold of hearing to the threshold of pain:

	Threshold of Hearing	Threshold of Pain
Hearing Intensity threshold	$I_0 = 10^{-12} \text{ w/m}^2$	$10^{13} I_0 = 10,000,000,000,000 I_0$
Hearing Intensity level threshold $10\log (I/ I_0)$	0 decibels	130 decibels

Medical importance of hearing threshold

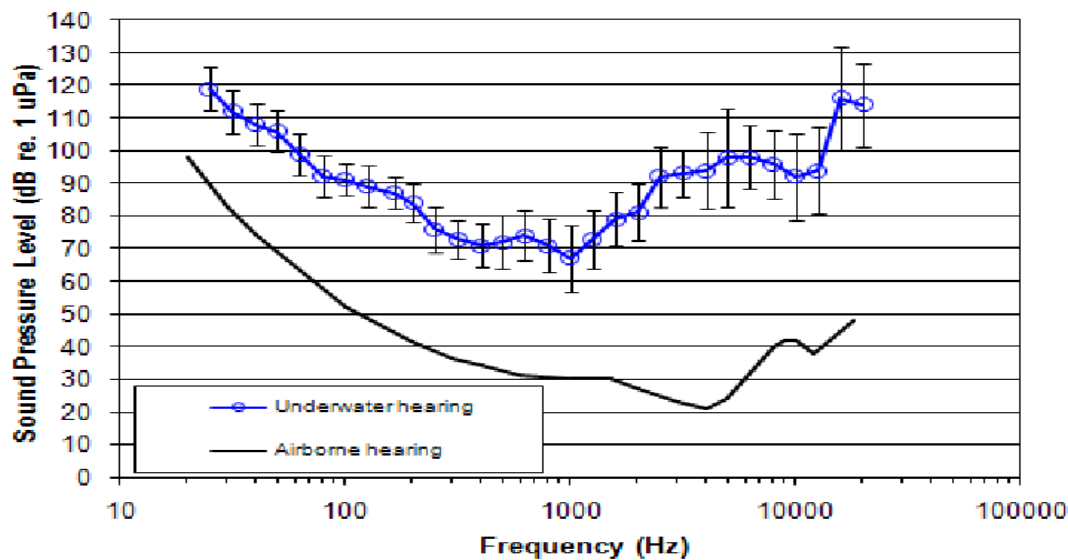
- The threshold of hearing can not only differ amongst people , but also due to pathological reasons differ among your left and your right ear.
- Pathologically the absolute threshold of hearing can be influenced by being exposed to loud noise over a long time (as an industrial construction worker e.g.) or by listening to very loud music overhead speakers etc.
- **Determination of the hearing threshold**

Methods which are used to determine the individuals hearing threshold are called *psychophysical* methods.

This name derived by the measurement, consisting of a *physical* signal (the sound) which is perceived by the individual through his sense-organs and changed in his nervous system into a *psychological* response , which he reflects to the outside by giving e.g. a hand signal to the examiner.

Hearing underwater

- Sound may be heard through solid, liquid , or gaseous matter.
- Sound traveling through air soon becomes less loud as you get farther from the source. This is because the waves' energy quickly gets lost along the way. Sound keeps its energy longer when traveling through water because the particles can carry the sound waves better.
- **Underwater** sound waves reaching us at a faster pace *and* keeping their intensity longer seem like they should make us perceive those sounds as louder when we are also underwater.
- The human ear, however, evolved to hear sound in the air and is not as useful when submerged in water. Our head itself is full of tissues that contain water and can transmit sound waves when we are underwater. When this happens, the vibrations bypass the eardrum, the part of the ear that evolved to pick up sound waves in the air.
- The way in which humans hear above or below water differs; that difference means they only hear between 20 and 20,000 hertz through the air, while they can catch sounds all the way up to 200,000 hertz when submerged.
- Hearing threshold and the ability to localize sound sources are reduced underwater, in which the speed of sound is faster than in air.
- Underwater hearing is by bone conduction, and localization of sound appears to depend on differences in amplitude detected by bone conduction. (sound comes through the mastoid, or the bone you can feel if you put your fingers behind the ear).



What does hearing loss or hearing impairment mean?

When someone is hard of hearing, his or her hearing still works, but not as well as usual. Hearing loss may be permanent or temporary, already present at birth, or develop following an illness. It often occurs in older people.

A hearing loss of up to 20 decibels below the hearing threshold is still considered to be normal hearing. More severe hearing loss can be described according to severity, as follows:

1. Normal hearing:

If your hearing is normal, you should see an X or a circle that falls into the 0-20 decibel range for each frequency. That means you can understand speech in a noisy environment and no amplification or hearing aids are needed.

2. Mild hearing loss

If you have mild hearing loss you will see the X or circle in the 20-40 decibel range. Mild hearing loss means you may be having difficulty understanding speech in noisy environments. It may also mean that you require a higher volume level when watching the television or listening to the stereo. Because of this, family members are often the first to notice. Adults will benefit from In-the-Ear or Mini-Behind the Ear hearing aids.

3. Moderate hearing loss

Moderate hearing loss will be marked in the 40-70 decibel range. With moderate hearing loss you will frequently have difficulty understanding speech in noisy environments including the telephone, television and listening to speakers at public gatherings. You may find that you are regularly asking people to repeat themselves and you get frustrated because you are missing what they are saying. People may also tell you that you speak too loudly in conversations. Adults will see the greatest benefit from Mini-Behind the Ear hearing aids.

4. Severe hearing loss

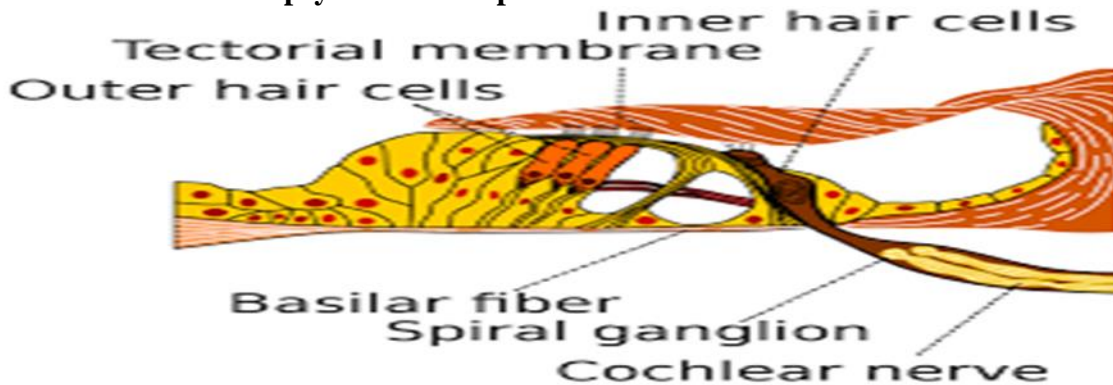
If you have severe hearing loss, the X or circle will fall in the 70-90 decibel range. This means you are having significant difficulty hearing during most types of communication and you may start avoiding noisy places where you know you will miss much of the conversation. You still may have communications difficulties with Behind the Ear hearing aids

5. Profound hearing loss

And if your hearing loss is profound, you will see the mark in the 90-120 decibel range. At this level you are having major communication problems in all situations. Profound hearing loss typically requires visual assistance while communicating, such as lip-reading or sign language. You will still have communication difficulties with hearing aids but fullsize, super-powerful, behind the ear hearing aids will be very useful for obtaining cues and environmental sounds.

Hearing loss

- The small, outer hair cells in the human ear are able to transfer received acoustic signals and to enhance quiet sounds or to lessen loud sounds.
- If those cells are damaged due to the mentioned factors, the absolute threshold is raised; the capability of enhancement of lower intensity acoustic signals is blocked.
- On the other hand, very loud signals cannot be reduced so they appear very uncomfortable and loud. This psychoacoustic phenomenon is called the Recruitment effect.



There are two types of hearing test

1. Conductive hearing test (Air conduction)(Conductive hearing loss)

- The bone conduction levels differ from the air conduction levels, sound waves probably being obstructed on their passage through the eardrum and middle ear.
- It is measured hearing loss caused by any obstruction that prevents sound waves from reaching the inner ear.

Some of the causes of conductive hearing loss can include:

- An accumulation of earwax
- A collection of fluid in the middle ear (for example, “glue ear” in children)
- Abnormal bone growth in the middle ear (otosclerosis)
- Middle ear infections (otitis media)
- Perforation of the eardrum

2. Nerve hearing test (Bone conduction) (sensorineural hearing loss).

- Air and bone conduction are the same; it indicates that the problem is likely to be located in the inner ear. Refers to problems in the cochlea or the auditory nerve.
- Most are due to deterioration of the tiny inner or outer hair cells. This accounts for 90% of permanent hearing losses and although it may be a natural part of aging.

Other causes can include:

- Traumatic exposure to noise
- Head injury
- Viral infections of the inner ear and/or auditory nerve such as Mumps
- Certain medical treatments such as chemo- and radiation therapy
- Genetic predisposition

Sensor neural hearing losses cannot currently be corrected medically

Note:

It is quite possible for a conductive hearing loss to occur together with a sensorineural hearing loss. When this occurs, the hearing loss is referred to as a mixed hearing loss.

3. Age related hearing loss (presbycusis)

The audiograms below show bilateral (both ears) age related hearing loss. With age related hearing loss a person can usually hear low-pitched sounds better than high-pitched sounds. Clarity of sound is affected – ‘I can tell that someone is talking but cannot understand what they have said’.

Why does hearing get worse with age?

- It's very common for people's hearing to get worse as they get older. About 25 to 40 out of 100 people over the age of 65 are affected.
- Half of all people above the age of 75, and 80% of 80-year-olds, are hard of hearing.
- This usually affects their ability to understand what people are saying more than the range of tones they can hear, and they can hear low frequencies better than high frequencies.
- That's why people with age-related hearing loss find it particularly difficult to follow conversations in noisy environments.
- The exact causes of age-related hearing loss aren't known. Changes in the inner ear and brain are thought to play a role.
- Nowadays, there are various sound-amplifying hearing aids that improve people's hearing and help them understand conversations.
- All of these hearing aids filter out background noise. They are adapted to the individual needs of their wearer and can be worn behind or in the ear, where they are hardly visible.

When can noise damage our hearing ?

- Our ears are constantly exposed to sounds, some of which can be damaging.
- **Noise above 140 decibels**, like a loud explosion, can lead to **acute hearing loss**. If the sound waves damage the eardrum, the middle ear and/or the inner ear, it is known as an acoustic trauma.
- This kind of damage is usually temporary, but some hearing loss may be permanent.
- **Chronic hearing loss** can also be caused by less loud sounds (**about 90 dB and above**) if someone is regularly exposed to them.
- Examples include hearing impairments caused by listening to loud music a lot (for example, through headphones), or working with pneumatic drills without enough ear protection.

Protection of hearing

- You can protect your hearing in various ways. Foam ear plugs offer protection against occasional noise.
- Acoustic ear muffs are an alternative. They completely cover both ears and are easy to put on and take off. People who work with loud machinery, for instance in industry or road building, have to use hearing protection.

Deafness

The inner ear is home to some of the most delicate bones in the body, and damage to the eardrum or middle ear can cause hearing loss and deafness in a range of ways.

Deafness and Hearing Aids

- Hearing loss is the reduced ability to hear sound. (Hearing loss: This is a reduced ability to hear sounds in the same way as other people.)
- Deafness is the complete inability to hear sound. (This occurs when a person cannot understand speech through hearing, even when sound is amplified.)
- Deafness and hearing loss have many causes and can occur at any age.
- People can go deaf suddenly as a complication of a virus, or lose their hearing over time because of disease, nerve damage, or injury caused by noise. About 3 in 1,000 babies is born deaf, often because of genetic factors.

Hearing test

- Hearing can be measured by behavioral tests using an **audiometer**. Electrophysiological tests of hearing can provide accurate measurements of hearing thresholds even in unconscious subjects.
- Hearing graphed on an audiogram, a graph of the softest sounds you can hear.
- To determine your subjective audible sensitivity, it is possible to make an audiogram.

- This measurement is frequency dependent and gives the test person tones in different loudness levels on air-contacted earphone, and on a bone-conducted earphone afterwards (bone conductor for comparison with the vibration sensitivity in the ear canal).
- It is necessary for the examination that the test person is pressing a button in the moment he can perceive the signal to show the examiner/physician that he is able to hear the tone at a certain frequency/sound level.

What is an audiogram?

An audiogram is a graph that shows information about a person's hearing abilities. An Audiogram is a hearing test that measures the softest sound you can hear. The softest level at which you can hear a sound is called the threshold.

The audiogram measures sound intensity, or loudness, in decibels which are listed from 0 decibels at the top to 120 decibels at the bottom. Running from left to right is frequency, or pitch, which is measured in hertz. The frequency starts on the left side with 125 hertz and goes up to 8000 hertz on the right side. This is just like a piano keyboard that has the lowest frequencies on the left and the highest frequencies on the right.

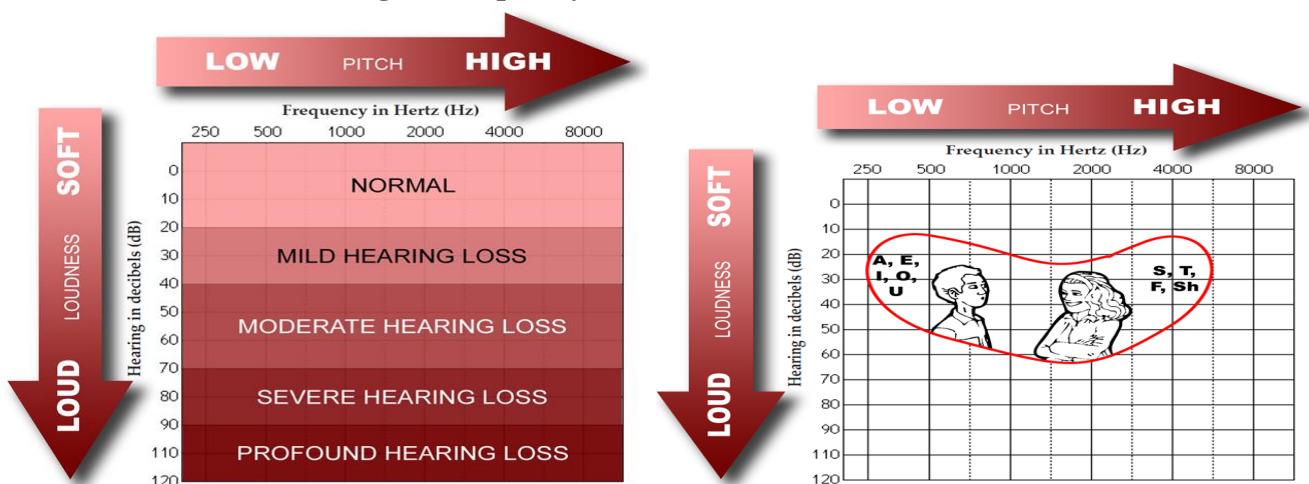
On a typical audiogram you will also see two lines: One red and one blue. The red line represents the hearing in your right ear and the blue line represents your left ear.

If your audiogram does not have colors, then the line with the X's represent your left ear and the line with the "O's" or circles represent your right ear.

So once your graph is filled in (x represents the left ear, o the right), it shows your hearing sensitivity for different frequencies at different intensities (at different pitches and different volumes).

At the frequency which runs from left to right. Vowels such as A, E, I, O and U are the lowest pitch and fall towards the left side of the hearing range. Consonants, such as S, T, F and Sh are higher pitched and fall towards the right side of the hearing range. Often times these higher frequencies are also associated with women's voices.

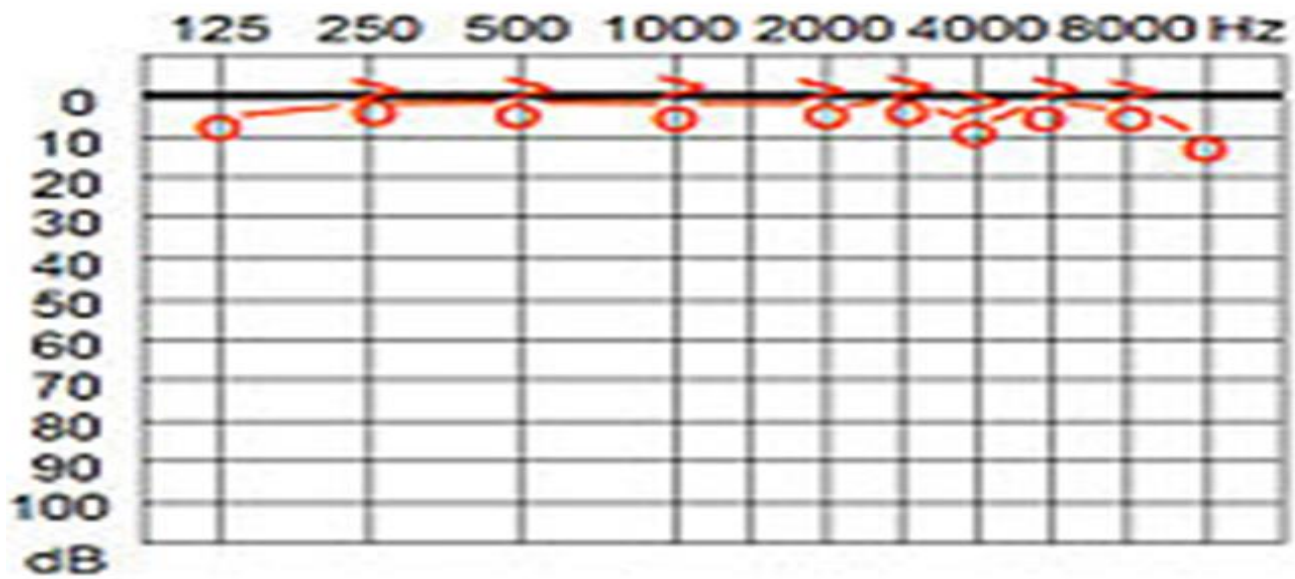
This section of the audiogram is commonly referred to as the speech zone because most human voices reside within this range of frequency and volume.



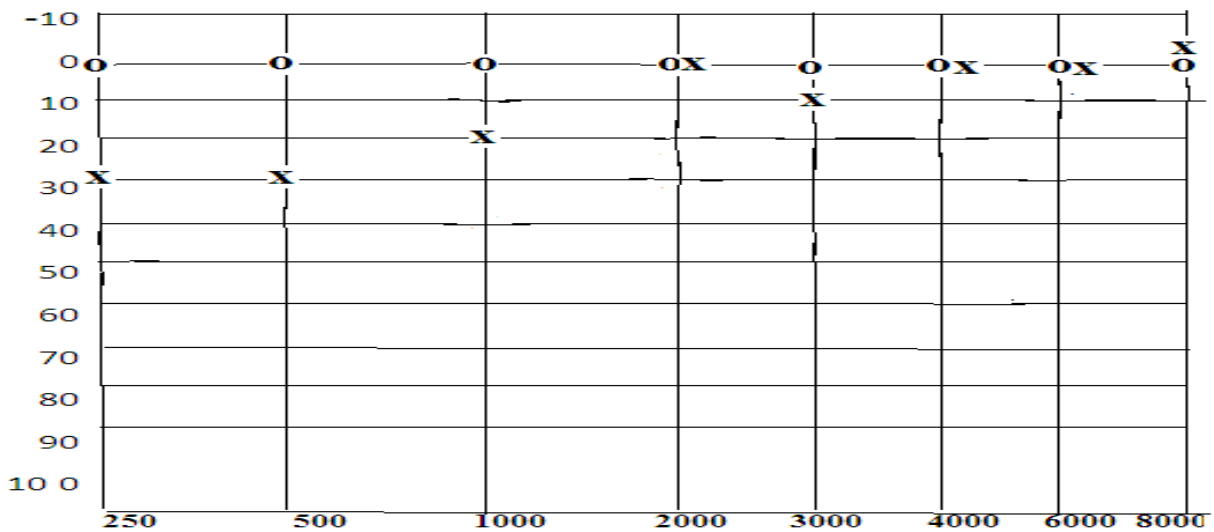
Your hearing loss is classified according to how far down the graph the marks go, and in what frequencies the loss occurs

Classification of Hearing Loss	Hearing Threshold
Normal hearing	0 to 20 dB
Mild	21 to 40 dB
Moderate	41 to 55 dB
Moderately-severe	56 to 70 dB
Severe	71 to 90 dB
Profound	91+ dB

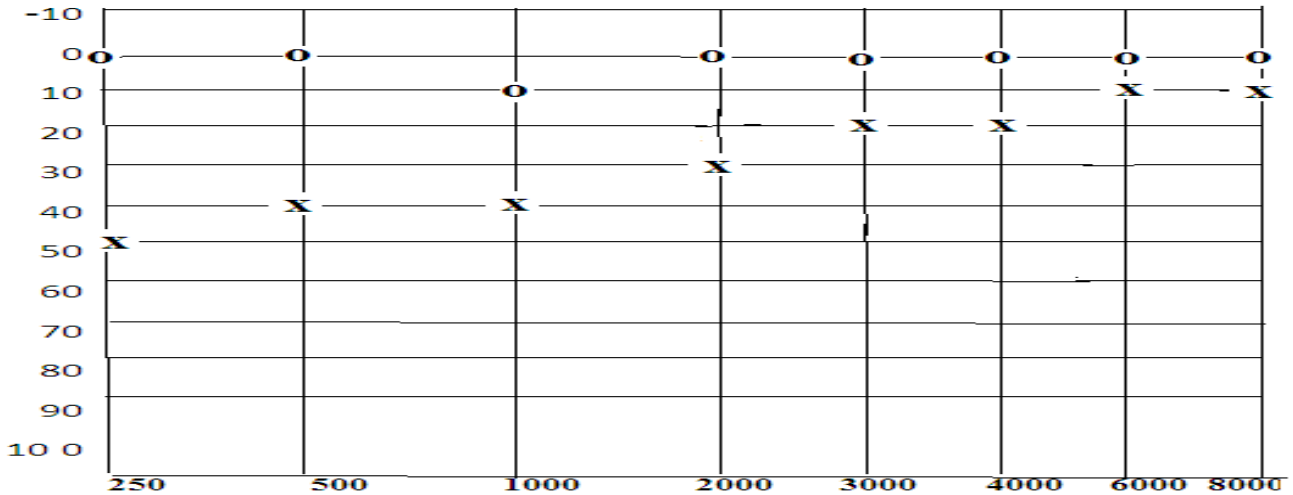
1. Normal hearing ranges from 0 to 20 dB in all frequencies.



2. Audiogram of deafness resulting from wax . × for air conduction and o for bon conduction

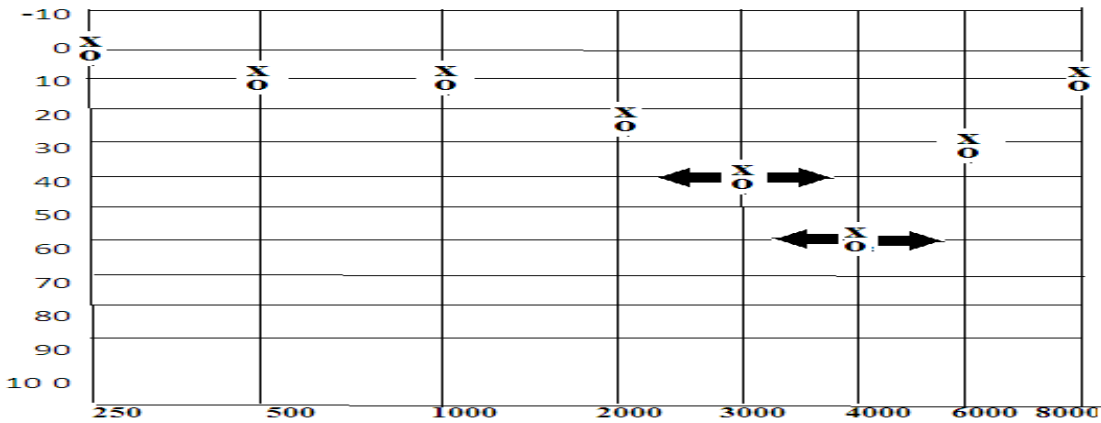


3. Problem with the small bones (ossicles) in the ear (otosclerosis) Stiffening of the chain of small bones in the middle ear prevents sound from passing easily through to the inner ear.



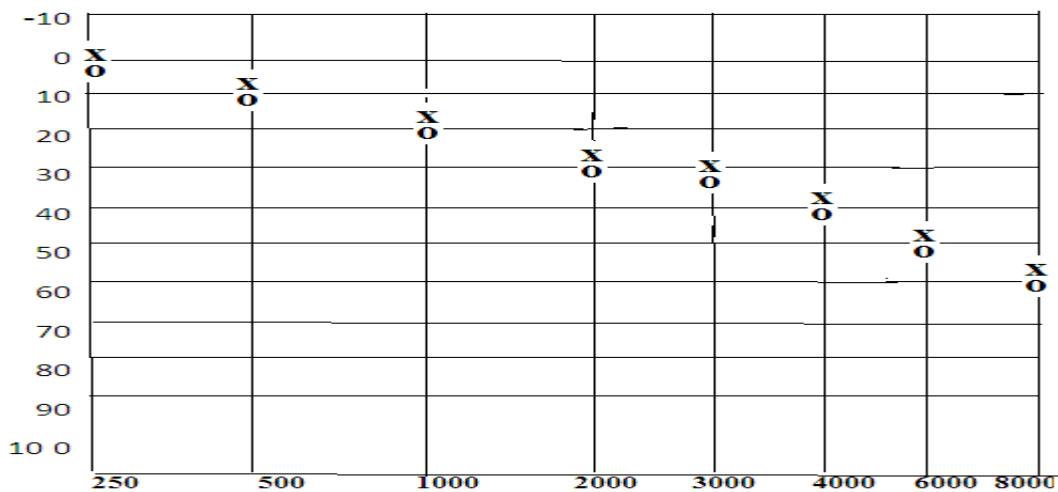
4. Atypical noise-induced hearing loss in the region of 4000 Hz .

× for air conduction .and o for bon conduction. The black triangles indicate thresholds for bone conduction .

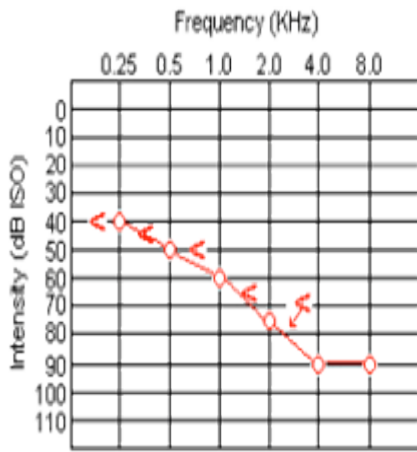


5. Audiogram of the old age type of nerve deafness in the left ear

× :for air conduction and o : for bon conduction

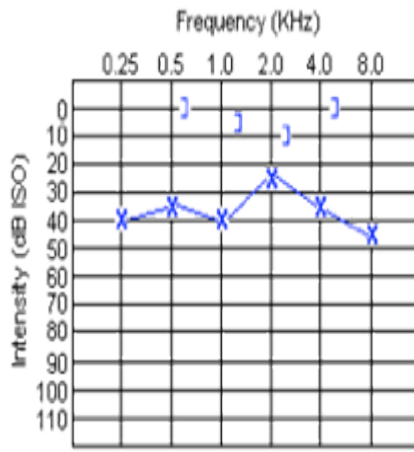


SENSORINEURAL HEARING LOSS



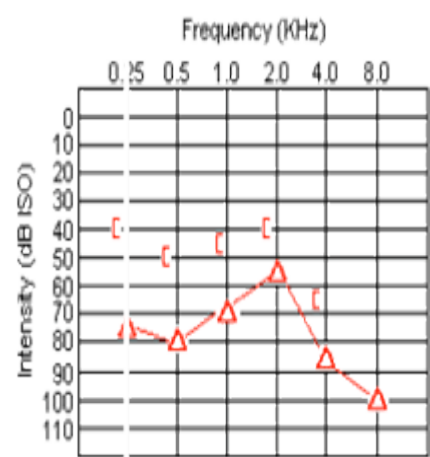
Moderate to severe sensorineural hearing loss

CONDUCTIVE HEARING LOSS



Mild to moderate conductive loss

MIXED HEARING LOSS



Moderately severe to profound mixed loss

This person has hearing that falls into the normal range up to about 1500 hertz. At 2000 hertz their hearing starts to make its way into the mild hearing loss category, more so for the left ear. At 4000 hertz there is a significant difference and the hearing is now in the moderate hearing loss category. At 8000 hertz this person's hearing falls into the severe hearing loss category.

