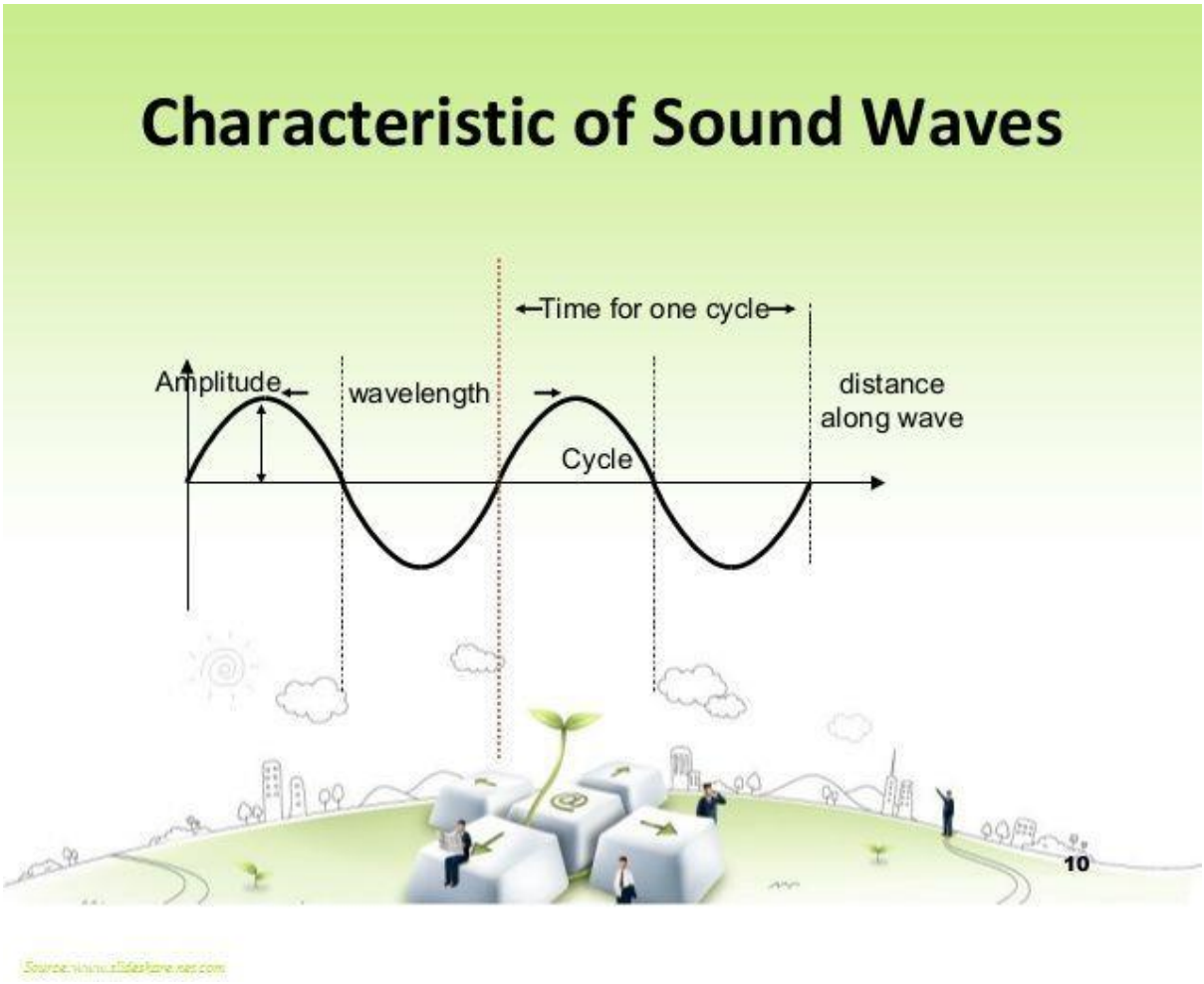
When you clap your hands, you force air particles together and then apart. This effect ripples out and away from your hands as a small group of sound waves. The particles close to your hands are pushed outwards and bump into neighbouring particles, and these then move and bump into more particles. The effect is very much like dropping a stone into a pool of water and causing a ripple pattern (sound waves) extending outwards from the original source (your clapping hands)

What are the characteristics of Sound Waves?

Sound is a form of energy which makes us hear. It travels in the form of wave. Sound wave can be described by five characteristics. Let us study through this article about it.



he sensation felt by our ears is called **sound.** It is a form of energy which makes us hear. We hear several sounds around us in our everyday life.

We know that *sound travels in the form of wave*.

A wave is a vibratory disturbance in a medium which carries energy from one point to another without there being a direct contact between the two points.

We can say that a wave is produced by the vibrations of the particles of the medium through which it passes.

There are two types of waves: Longitudinal waves and Transverse waves.

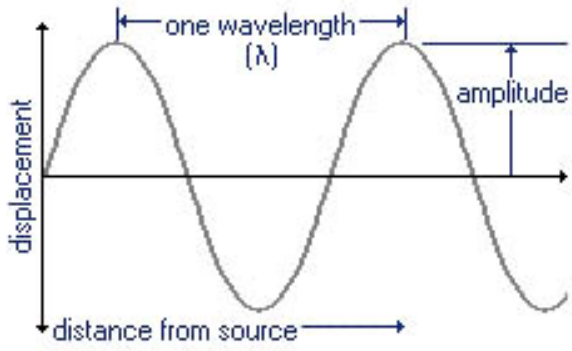
Longitudinal Waves: A wave in which the particles of the medium vibrate back and forth in the 'same direction' in which the wave is moving. Medium can be solid, liquid or gases. Therefore, sound waves are longitudinal waves.

Transverse Waves: A wave in which the particles of the medium vibrate up and down 'at right angles' to the direction in which the wave is moving. These waves are produced only in a solids and liquids but not in gases.

Sound is a longitudinal wave which consists of compressions and rarefactions travelling through a medium.

Sound wave can be described by five characteristics: Wavelength, Amplitude, Time-Period, Frequency and Velocity or Speed.

1. Wavelength

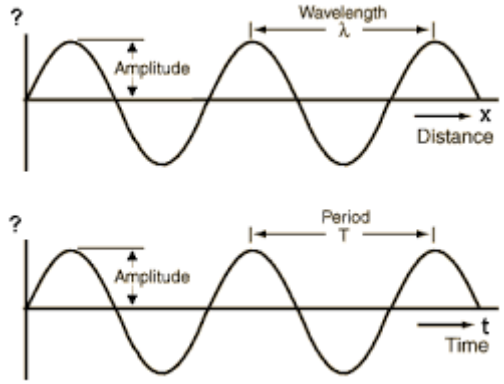


The minimum distance in which a sound wave repeats itself is called its wavelength. That is it is the length of one complete wave. It is denoted by a Greek letter λ (lambda). We know that in a sound wave, the combined length of a compression and an adjacent rarefaction is called its wavelength. Also, the distance between the centres of two consecutive compressions or two consecutive rarefactions is equal to its wavelength.

Note: The distance between the centres of a compression and an adjacent rarefaction is equal to half of its wavelength i.e. λ/2. The S.I unit for measuring wavelength is metre (m).

2. Amplitude

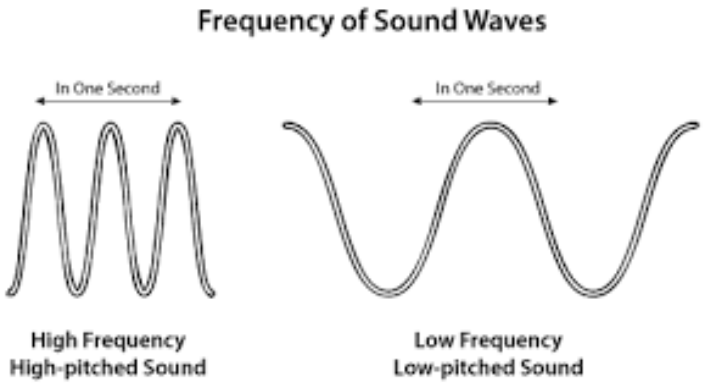
When a wave passes through a medium, the particles of the medium get displaced temporarily from their original undisturbed positions. The maximum displacement of the particles of the medium from their original undisturbed positions, when a wave passes through the medium is called amplitude of the wave. In fact the amplitude is used to describe the size of the wave. The S.I unit of measurement of amplitude is metre (m) though sometimes it is also measured in centimetres. Do you know that the amplitude of a wave is the same as the amplitude of the vibrating body producing the wave?



3. Time-Period

The time required to produce one complete wave or cycle or cycle is called time-period of the wave. Now, one complete wave is produced by one full vibration of the vibrating body. So, we can say that the time taken to complete one vibration is known as time-period. It is denoted by letter T. The unit of measurement of time-period is second (s).

4. Frequency



The number of complete waves or cycles produced in one second is called frequency of the wave. Since one complete wave is produced by one full vibration of the vibrating body, so we can say that the number of vibrations per second is called frequency. For example: if 10 complete waves or vibrations are produced in one second then the frequency of the waves will be 10 hertz or 10 cycles per second. Do you know that the frequency of a wave is fixed and does not change even when it passes through different substances?

The S.I unit of frequency is hertz or Hz. A vibrating body emitting 1 wave per second is said to have a frequency of 1 hertz. That is 1 Hz is equal to 1 vibration per second. Sometimes a bigger unit of frequency is known as kilohertz (kHz) that is 1 kHz = 1000 Hz. The frequency of a wave is denoted by the letter f.

The frequency of a wave is the same as the frequency of the vibrating body which produces the wave.

What is the relation between time-period and frequency of a wave?

The time required to produce one complete wave is called time-period of the wave. Suppose the time-period of a wave is T seconds.
In T seconds number of waves produced = 1
So, in 1 second, number of waves produced will be = 1/T
But the number of waves produced in 1 second is called its frequency.
Therefore, **F = 1/Time-period**
f = 1/T
where f = frequency of the wave
T = time-period of the wave

5. Velocity of Wave (Speed of Wave)

The distance travelled by a wave in one second is called velocity of the wave or speed of the wave. It is represented by the letter v. The S.I unit for measuring the velocity is metres per second (m/s or ms-1).

What is the relationship between Velocity, Frequency and Wavelength of a Wave?

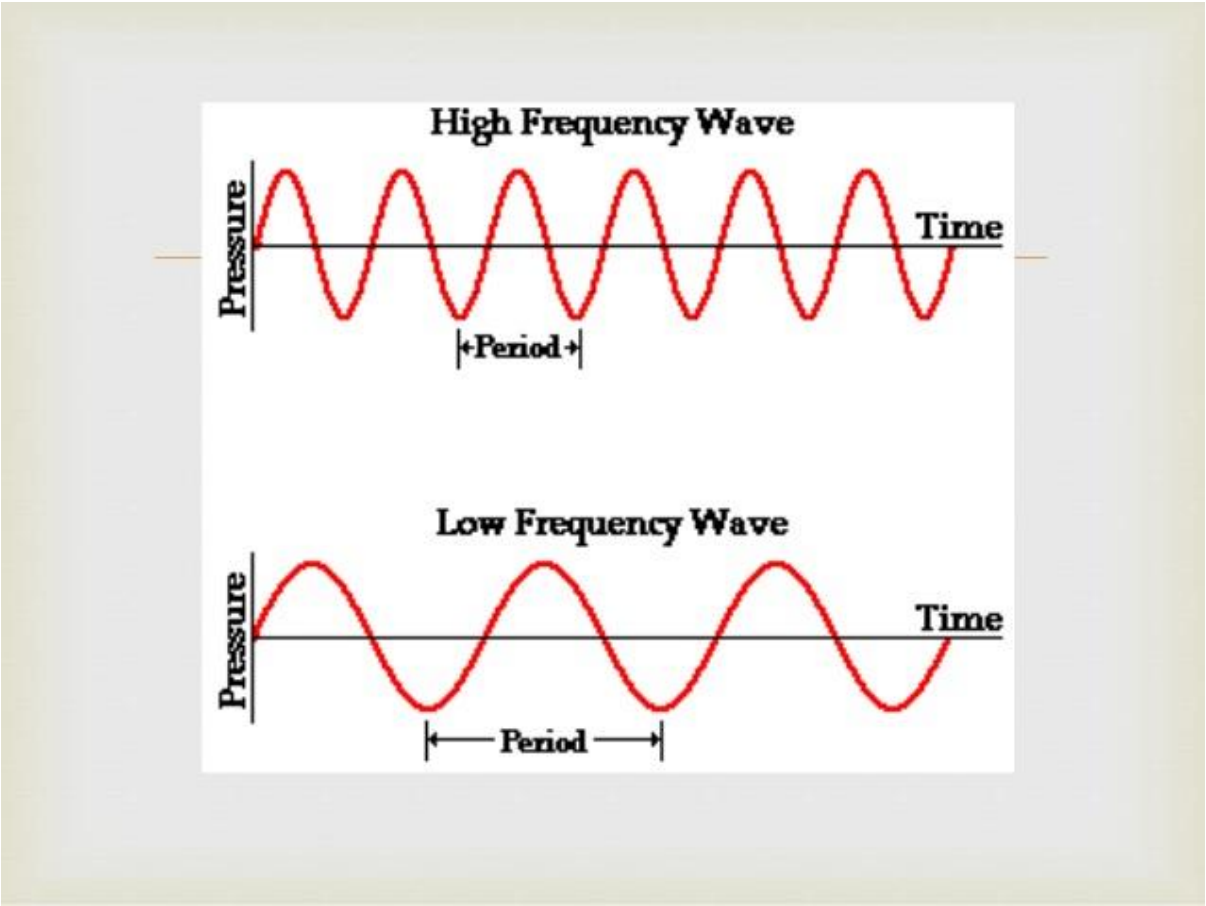
Velocity = Distance travelled/ Time taken
Let $v = \lambda / T$
Where T = time taken by one wave.
$\mathbf{v = f X \lambda}$ as f=1/T
This formula is known as wave equation.
Where v = velocity of the wave
f = frequency
λ = wavelength
Velocity of a wave = Frequency X Wavelength

This applies to all the waves like transverse waves like water waves, longitudinal waves like sound waves and the electromagnetic waves like light waves and radio waves Therefore we have learnt various characteristics of sound waves.

Pitch

The frequency of a sound wave is what your ear understands as pitch. A higher frequency sound has a higher pitch, and a lower frequency sound has a lower pitch. For instance, the chirp of a bird would have a high pitch, but the roar of a lion would have a low pitch.

The human ear can detect a wide range of frequencies. Frequencies from 20 to 20 000 Hz are audible to the human ear. Any sound with a frequency below 20 Hz is known as an **infrasound** and any sound with a frequency above 20 000 Hz is known as an **ultrasound**. The pitch of a human voice in normal conversation occurs at frequencies between 250 Hz and 2,000 Hz.



The following table lists the ranges of some common animals compared to humans.

	lower frequency (Hz**)**	**upper frequency (**Hz**)**
Humans	20	20 000
Dogs	50	45 000
Cats	45	85 000
Bats	20	120 000
Dolphins	0,25	200 000
Elephants	5	10 000

Intensity :-The rate, at which sound energy is transmitted, called sound intensity.

Or

Sound intensity is the amount of energy flowing per unit time through a unit area that is perpendicular to the direction in which the sound waves are travelling.

Sound intensity may be measured in units of energy or work—e.g., microjoules (10^{-6} joule) per second per square centimetre—or in units of power, as microwatts (10^{-6} watt) per square centimetre. The SI unit of sound intensity, is the **watt per square meter (W/m^2)**

Loudness

Loudness is the subjective perception of sound pressure. More formally, it is defined as, "That attribute of auditory sensation in terms of which sounds can be ordered on a scale extending from quiet to loud." The relation of physical attributes of sound to perceived loudness consists of physical, physiological and psychological components.

The loudness of a sound is also determined by the sensitivity of the ear. The human ear is more sensitive to some frequencies than to others. loudness of a sound is subjective. Sound loudness varies from person to person. Furthermore, sounds with equal intensities but different frequencies are perceived by the same person to have unequal loudness. For instance, a 60 dB sound with a frequency of 1000 Hz sounds louder than a 60 dB sound with a frequency of 500 Hz. The unit **phon** is used to indicate an individual's perception of loudness. By definition, 1 phon is equivalent to 1 deciBel at 1000 Hz (1 kHz). The **sone** scale is a third scale associated with the loudness of a sound. The sone scale is based on the observation that a 10 phon increase in a sound level is most often perceived as a doubling of loudness. According to the sone scale, a 1 sone sound is defined as a sound whose loudness is equal to 40 phons.

Sound pressure

Sound pressure is the pressure measured within the wave relative to the surrounding air pressure. Loud sounds produce sound waves with relatively large sound pressures, while quiet sounds produce sound waves with relatively small sound pressures.

Sound pressure, like other kinds of pressure, is commonly measured in units of **Pascals (Pa).** The quietest sound that most people can hear has a sound pressure of 2×10^{-5} Pa, so this pressure is called the threshold of human hearing.

If your ear happens to be in the path of the sound wave, the vibrating air molecules hit your eardrum and cause it to start vibrating too. When your eardrum starts vibrating, it bumps into the tiny bones in your middle ear and makes them vibrate. The vibration passes all the way into your inner ear where the vibration of tiny hair cells sends signals to your brain, thus letting you hear the sound. The pressure of the sound wave corresponds to how loudly you hear the sound. As the sound pressure increases, the pressure on your eardrum increases as well, making the sound seem louder to you.

Measurement of sound

Sound is measured by **sound pressure level** or by **sound intensity level**. Because your ears are sensitive to a very wide range of sound pressure, it makes sense to use a logarithmic scale to measure the loudness of a sound. **Sound pressure level** uses a logarithmic scale to represent the sound pressure of a sound relative to a reference pressure. The reference sound pressure is typically the threshold of human hearing. Sound pressure level is measured in units of **decibels (dB)** and is calculated using the following equation, where p is the sound pressure of the sound wave and p_o is the reference sound pressure:

$$L_P = 20\ log_{10}\left(\frac{p}{p_0}\right)\ dB$$

Sound intensity level can be calculated as

$L_I=10\log(I/I_0)$

where L_I is the **sound intensity level** in **decibels (dB)** relative to a reference value,

I is the intensity of the sound expressed in watts per meter and Io is the reference intensity defined to be 10^{-12} w/m^2. This value of Io is the threshold (minimum sound intensity) of hearing at 1 kHz for a young person under the best circumstances.

Thus we see that the sound level or loudness can be measured by sound pressure as well as sound intensity.

This essentially tells you that we perceive something as being loud in a *relative* manner.

- If there is a lot of background noise, a song on the car radio will seem quiet, even if the volume is normal.
- In a completely quiet room, someone dropping a pin is noticeably loud, even though it may not be loud on an absolute level.

Sound pressure level L_p (SPL air)	↔	**Sound intensity level L_I (air)**
85 dB (decibel)		85 dB (decibel)
$L_p = 20\ \log_{10}\left(\frac{\tilde{p}}{p_0}\right)\ \text{dB}$		$L_I = 10\ \log_{10}\left(\frac{I}{I_0}\right)\ \text{dB}$
Reference sound pressure p_0 **= 20 µPa =** 2×10^{-5} Pa **pW/m² =** 10^{-12} W/m²		Reference intensity I_0 **= 1**
The same "sound level" in dB at Specific acoustic impedance of air Z_0 = **400 N·s/m³**		

Noise pollution:- unwanted or excessive sound that can have deleterious effects on human health and environmental quality. Noise pollution is commonly generated inside many industrial facilities and some other workplaces, but it also comes from highway, railway, and airplane traffic and from outdoor construction activities.

Various Sources of Noise Pollution

1. Industrialization

Most of the industries use big machines which are capable of producing a large amount of noise. Apart from that, various equipment like compressors, generators, exhaust fans, grinding mills also participates in producing big noise. Therefore, you must have seen workers in these factories and industries wearing earplugs to minimize the effect of noise.

2. Poor Urban Planning

In most of the developing countries, poor urban planning also plays a vital role. Congested houses, large families sharing small space, fight over parking, frequent fights over basic amenities leads to noise pollution which may disrupt the environment of society.

3. Social Events

Noise is at its peak in most of the social events. Whether it is marriage, parties, pub, disc or place of worship, people normally flout rules set by the local administration and create nuisance in the area. People play songs on full volume and dance till midnight which makes the condition of people living nearby pretty worse. In markets, you can see people selling clothes via making a loud noise to attract the attention of people.

4. Transportation

A large number of vehicles on roads, airplanes flying over houses, underground trains produce heavy noise and people get it difficult to get accustomed to that. The high noise leads to a situation wherein a normal person loses the ability to hear properly.

5. Construction Activities

Under construction activities like mining, construction of bridges, dams, buildings, stations, roads, flyovers takes place in almost every part of the world. These construction activities take place every day as we need more buildings, bridges to accommodate more people and to reduce traffic congestion. The down point is that these construction equipment are too noisy.

6. Household Chores

We people are surrounded by gadgets and use them extensively in our daily life. Gadgets like TV, mobile, mixer grinder, pressure cooker, vacuum cleaners, washing machine and dryer, cooler, air conditioners are minor contributors to the amount of noise that is produced but it affects the quality of life of your neighbourhood in a bad way.

While this form of pollution may seem harmless, it, in fact, has far-reaching consequences. The adverse effects on the health of the environment are quite severe. Not only is the local wildlife affected by pollution but humans also face a number of problems due to it.

Effects of Noise Pollution

1. Hearing Problems

Any unwanted sound that our ears have not been built to filter can cause problems within the body. Our ears can take in a certain range of sounds without getting damaged. Man-made noises such as jackhammers, horns, machinery, airplanes and even vehicles can be too loud for our hearing range. Constant exposure to loud levels of noise can easily result in the damage of our eardrums and loss of hearing. It also reduces our sensitivity to sounds that our ears pick up unconsciously to regulate our body's rhythm.

2. Health Issues

Excessive noise pollution in working areas such as offices, construction sites, bars and even in our homes can influence psychological health. Studies show that the occurrence of aggressive behavior, disturbance of sleep, constant stress, fatigue, and hypertension can be linked to excessive noise levels. These, in turn, can cause more severe and chronic health issues later in life.

3. Sleeping Disorders

Loud noise can certainly hamper your sleeping pattern and may lead to irritation and uncomfortable situations. Without a good night sleep, it may lead to problems related to

fatigue and your performance may go down in the office as well as at home. It is therefore recommended to take a sound sleep to give your body proper rest.

4. Cardiovascular Issues

Blood pressure levels, cardiovascular disease, and stress-related heart problems are on the rise. Studies suggest that high-intensity noise causes high blood pressure and increases heartbeat rate as it disrupts the normal blood flow. Bringing them to a manageable level depends on our understanding of noise pollution and how we tackle it.

5. Trouble Communicating

High decibel noise can put trouble and may not allow two people to communicate freely. This may lead to misunderstanding and you may get difficult understanding the other person. Constant sharp noise can give you a severe headache and disturb your emotional balance.

6. Effect on Wildlife

Wildlife faces far more problems than humans because of noise pollution since they are more dependent on sound. Animals develop a better sense of hearing than us since their survival depends on it. The ill effects of excessive noise begin at home. Pets react more aggressively in households where there is a constant noise.

They become disoriented more easily and face many behavioural problems. In nature, animals may suffer from hearing loss, which makes them easy prey and leads to dwindling populations. Others become inefficient at hunting, disturbing the balance of the eco-system.

Species that depend on mating calls to reproduce are often unable to hear these calls due to excessive man-made noise. As a result, they are unable to reproduce and cause declining populations. Others require sound waves to echolocate and find their way when migrating. Disturbing their sound signals means they get lost easily and do not migrate when they should. To cope up with the increasing sound around them, animals are becoming louder, which may further add to the pollution levels. This is why understanding noise pollution can help us lower the impact it has on the environment.

EFFECTS OF NOISE ON HUMAN BEINGS

	Noise (dB)	Effects observed
1.	0	Threshold of audibility
2.	110	Stimulation of reception in skin
3.	120	Pain threshold
4.	130-135	Nausea, Vomiting, Dizziness, Nervous disorder
5.	140	Pain in ear, Prolonged exposure causing insanity
6.	140	Extreme limit of human noise tolerance.
7.	150	Significant change in pulse rate, Prolonged exposure causing burning of the skin.
8.	160	Minor permanent damage if prolonged
9.	190	Major permanent damage in a short time.

Social and Economic Costs of Noise Pollution

The World Health Organization estimates that one out of three people in Europe is harmed by traffic noise. More than the purely medical effects of noise pollution on the individual, there is a significant social and economic impact. Since noise pollution leads to sleep disturbance, it affects the individual's work performance during the day, it leads to hypertension and cardiovascular disease and costs the health system additional time and money, and it negatively affects school performance in children.

Tips for Avoiding Noise Pollution

- Wear earplugs whenever exposed to elevated noise levels
- Maintain a level of around 35 dB in your bedroom at night, and around 40 dB in your house during the day
- If possible, choose your residential area as far removed from heavy traffic as you can
- Avoid prolonged use of earphones, especially at elevated sound levels
- If possible, avoid jobs with regular exposure to elevated sound levels