* 1. ***CHARACTERISTICS OF MUSICAL NOTES***

A **musical note** is produced by vibrations that are regular and repeating, i.e. by periodic motion. Non-periodic motion results in **noise** which is not pleasant to the ear. Many behaviors of musical note can be explained using a few characteristics: intensity and loudness, frequency and pitch, and quality or timber.

**1.3.1. Pitch and frequency**

The sound of a whistle is different from the sound of a drum. The whistle makes a high sound. The drum makes a low sound. The highness or lowness of a sound is called its **pitch**. The higher the frequency, the higher is the pitch. The frequency of an audible sound wave determines how high or low we perceive the sound to be, which is known as pitch.

Whether a sound is high-pitched or low-pitched depends on how fast something vibrates. Fast vibrations make high-pitched sounds. Slow vibrations make low-pitched sounds.

Do not confuse the term **pitch** with **frequency**. Frequency is the physical measurement of the number of oscillations per second. Pitch is a psychological reaction to sound that enables a person to place the sound on a scale from high to low, or from treble to bass.

**1.3.2 Intensity and amplitude**

A police siren makes a loud sound. Whispering makes a soft sound. Whether a sound is loud or soft depends on the force or power of the sound wave. Powerful sound waves travel farther than weak sound waves. To talk to a friend across the street you have to shout and send out powerful sound waves. Your friend would never hear you if you whispered.

 The energy carried by a sound wave is proportional to the square of its amplitude. The energy passing a unit area per unit time is called the **intensity** of the wave.

The intensity of spherical sound wave at a place *p* is defined as the energy per second per m2, or power per m2 flowing normally through an area at *X*. i.e

 

So the unit of intensity is *W* / *m*2

where r is the distance from the source for a spherical wave.

**Example**

1. If the intensity of an earth-quake P wave 100 km from the source is *I* = 1.0 ×10 6 *W* / *m*2 , what is the intensity 400 km from the source ?

**Answer**

Power 

**Sound intensity level**

We measure sound level intensity in terms of "decibels". The unit *bel* is named after the inventor of the telephone, Alexander Graham Bell (1847–1922). The decibel is a "relative unit" which is actually dimensionless, comparing a given sound to a standard intensity which represents the smallest audible sound:

|  |  |  |  |
| --- | --- | --- | --- |
| *β* =10 log | *I* |  |  |
| *Io* |
|  |  |
| Where *I*0 = 10−12 *W* / *m*2 | at 1000 Hz is the reference intensity. 0 dB thus represents the softest |

audible sound (threshold of human hearing), while 80 dB (i.e., moderately loud music) represents an intensity which is one hundred million times greater.

**Example**

1. Two identical machines are positioned the same distance from a worker. The intensity of sound delivered by each machine at the location of the worker is 2.0 ×10−7 *W* / *m*2 . Find the sound level heard by the worker (a) when one machine is operating and (b) when both machines are operating.

**Answer**

(a) The sound level at the location of the worker with one machine operating is

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *β*1 | = 10 log |  | 2.0 | ×10 | −7 | = 53 *dB* |
| 1.00 | ×10 | −12 |
|  |  |  |

(b) When both machines are operating, the intensity is doubled to 4.0 ×10−7 *W* / *m*2 ; therefore, the

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| sound level now is | *β*2 | = 10 log |  | 4.0 | ×10 | −7 | = 56 *dB* |
| 1.00 | ×10 | −12 |
|  |  |  |  |

From these results, we see that when the intensity is doubled, the sound level increases by only 3 dB.

**Quick check 1.4:**

A point source emits sound waves with an average power output of 80.0 W.

Find the intensity 3.00 m from the source. Find the distance at which the sound level is 40 dB.

The **loudness** or softness of sound depends on the intensity of the sound wave reaching the person concerned. Loudness is a subjective quantity, unlike intensity. Sound which is not wanted or unpleasant to the ear is called **noise**. High intensity can damage hearing. The higher the intensity, the louder is the sound. Our ears, however, do not respond linearly to the intensity. A wave that carries twice the energy does not sound twice as loud.

**1.3.3 Quality or timbre**

If the same note is sounded on the violin and then on the piano, an untrained listener can tell which instrument is being used, without seeing it. We would never mistake a piano for flute. We say that the quality or timbre of note is different in each case. The manner in which an instrument is played strongly influences the sound quality.

Two tones produced by different instruments might have the same fundamental frequency (and thus the same pitch) but sound different because of different harmonic content. The difference in sound is called *tone color, quality,* or **timbre.** A violin has a different timbre than a piano.