Semester 2 BSc Hns Physics MJC-2

Characteristics of Musical Sound and Their Analysis

Introduction

Sound is produced due to vibrations of bodies and is transmitted through a material medium in the form of waves. Based on its nature, sound can be classified into noise and musical sound. A musical sound is pleasant to the ear and has a regular and periodic waveform. Musical sounds possess certain definite characteristics by which we can distinguish one sound from another. These characteristics are loudness, pitch, and quality (timbre).

---

1. Loudness

Loudness is the characteristic of a musical sound that enables us to distinguish between a loud and a soft sound.

Key Points:

- **Loudness is a subjective sensation of the ear.**
- **It depends on the intensity of sound reaching the ear.**
- **Intensity is defined as the sound energy per second per unit area.**
- **Unit of intensity level is decibel (dB).**

Relation between Loudness and Intensity:

Loudness∝log⁡I\text{Loudness} \propto \log ILoudness∝logI

Where III is the intensity of sound.

Factors Affecting Loudness:

1. **Amplitude of vibration**
2. **Distance of listener from the source**
3. **Size and shape of the vibrating body**
4. **Sensitivity of the ear**

Greater the amplitude or intensity, greater is the loudness of sound.

---

2. Pitch

Pitch is the characteristic of sound by which we distinguish between shrill (high) and deep (low) sounds.

Key Points:

- **Pitch depends on the frequency of the sound wave.**
- **Frequency is the number of vibrations per second.**
- **Unit of frequency is hertz (Hz).**
- **Higher frequency → higher pitch**
- **Lower frequency → lower pitch**

Examples:

- **Female voice → high pitch**
- **Male voice → low pitch**
- **Mosquito sound → very high pitch**
- **Drum sound → low pitch**

Pitch does not depend on amplitude or loudness.

---

3. Quality or Timbre

Quality (or timbre) is the characteristic of musical sound that enables us to distinguish between two sounds having the same loudness and pitch, produced by different instruments.

Key Points:

- **Quality depends on the waveform of sound.**
- **It is determined by the presence of harmonics and overtones.**
- **Different instruments produce different sets of harmonics.**

Example:

A note played on:

- **Flute**
- **Violin**
- **Guitar**

may have the same frequency and loudness but sounds different due to different harmonic content.

Quality is responsible for the "color" or "texture" of sound.

Analysis of Musical Sound

Meaning of Analysis

The process of resolving a complex musical sound into its constituent frequencies is called analysis of musical sound.

Musical sound is not a single frequency. It is a combination of:

1. **Fundamental frequency**
2. **Harmonics (Overtones)**

Fundamental Frequency

- **The lowest frequency present in a musical sound.**
- **It determines the pitch of the sound.**
- **Denoted by fff.**

Harmonics and Overtones

Harmonics:

Frequencies which are integral multiples of the fundamental frequency.

f, 2f, 3f, 4f, …f,\; 2f,\; 3f,\; 4f,\; \dotsf,2f,3f,4f,…

- **1st harmonic = fff**
- **2nd harmonic = 2f2f2f**
- **3rd harmonic = 3f3f3f**

Overtones:

- **Frequencies above the fundamental.**
- **1st overtone = 2nd harmonic**
- **2nd overtone = 3rd harmonic**

Fourier Analysis

According to Fourier's theorem, any periodic sound wave can be expressed as a sum of simple harmonic waves.

Musical sound=f+2f+3f+…\text{Musical sound} = f + 2f + 3f + \dotsMusical sound=f+2f+3f+…

Role of Harmonics:

- **Pitch → depends on fundamental frequency**

- **Loudness → depends on amplitudes of components**
- **Quality → depends on relative amplitudes of harmonics**

Types of Sound (Comparison)

Sound Type	Nature
Pure Tone	Single frequency
Musical Sound	Periodic, multiple harmonics
Noise	Irregular, non-periodic

Conclusion

Musical sound is characterized by loudness, pitch, and quality. These properties help us identify and distinguish different sounds. The analysis of musical sound using Fourier's theorem shows that every musical note is a combination of a fundamental frequency and several harmonics. The relative presence of these harmonics gives each instrument its unique quality.