Basics of Noise and Its Measurement

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Some Key Terms

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Sound Terminology

- Decibels
- Octaves
- Decades
- Bandwidth
- Wave-number
- Tones
- Pink noise
- White noise
- Weighting
Tones & Octave

- Ear sensitivity – on a geometric scale
  - Frequency: 20 – 20,000 Hz
  - Pressure: $2 \times 10^{-5}$ to 20 N/m²

- Octave - Interval between two sound pitches (frequencies), separated by a factor of two

- Decade – Interval between two sound frequencies separated by a factor of 10
An Octave in Western Classical Music

<table>
<thead>
<tr>
<th>Hz</th>
<th>Ratio</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>240.0</td>
<td></td>
<td>C</td>
</tr>
<tr>
<td>254.3</td>
<td>1.0595</td>
<td>C sharp or D flat</td>
</tr>
<tr>
<td>269.4</td>
<td>1.0595</td>
<td>D</td>
</tr>
<tr>
<td>285.4</td>
<td>1.0595</td>
<td>D sharp or E flat</td>
</tr>
<tr>
<td>302.4</td>
<td>1.0595</td>
<td>E</td>
</tr>
<tr>
<td>320.4</td>
<td>1.0595</td>
<td>F</td>
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<tr>
<td>339.4</td>
<td>1.0595</td>
<td>F sharp or G flat</td>
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<td>359.6</td>
<td>1.0595</td>
<td>G</td>
</tr>
<tr>
<td>381.0</td>
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<tr>
<td>403.6</td>
<td>1.0595</td>
<td>A</td>
</tr>
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<td>427.6</td>
<td>1.0595</td>
<td>A sharp or B flat</td>
</tr>
<tr>
<td>453.1</td>
<td>1.0595</td>
<td>B</td>
</tr>
</tbody>
</table>
An Octave in Indian Classical Music

Srutis in an Indian Octave

Sargam
Shadaj
Rishabh
Gandhaar
Madhyam
Pancham
Dhaivata
Nishaad

Just Tempered Scale
Octaves & Decades

- Logarithmic frequency scale
  - Why?

- Octaves & decades refer to frequency ratios
  - Octave: \( f_2 / f_1 = 2 \)
  - Decades: \( f_2 / f_1 = 10 \)
  - One-third octave: \( f_2 / f_1 = 2^{1/3} \approx 1.26 \)

<table>
<thead>
<tr>
<th>Preferred Frequencies</th>
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<tbody>
<tr>
<td>1/1</td>
</tr>
<tr>
<td>1</td>
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<tr>
<td>2</td>
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<tr>
<td>4</td>
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<tr>
<td>8</td>
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<td>16</td>
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<td>63</td>
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<tr>
<td>125</td>
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<tr>
<td>250</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>1000</td>
</tr>
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</table>
Bandwidth & Wave Number

- **Bandwidth** - difference between upper and lower frequencies in a contiguous set of frequencies
  - Center frequency
  - Audio bandwidth: 20 to 20,000
    - Bass
    - Middle
    - High

- **Wave number** \((k) = \frac{2\pi}{\lambda} = \frac{2\pi f}{c} = \frac{\omega}{c}\)
  - Used to dimensionalize distance and size
    - \(kd \gg 1\) is acoustically far or large
    - \(Kd \ll 1\) is acoustically near or small
Tones and Noise

- Tone - purely sinusoidal sound wave

- Noise - mixture of all frequencies
  - White noise - equal power within a fixed bandwidth for any center frequency
    - i.e. constant power spectral density
  - Pink noise - power spectral density is inversely proportional to frequency
    - Equal power in each octave
    - Also called 1/f-noise
### White & Pink Noise (example)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Power Spectral Density</th>
<th>Power Pink</th>
<th>Power White</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>4</td>
<td>0.25</td>
<td>0.75</td>
<td>1.5</td>
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<tr>
<td>8</td>
<td>0.125</td>
<td>0.75</td>
<td>3</td>
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<tr>
<td>16</td>
<td>0.0625</td>
<td>0.75</td>
<td>6</td>
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<tr>
<td>32</td>
<td>0.03125</td>
<td>0.75</td>
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<tr>
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<td>0.75</td>
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References


