Decibel and intensity scales

Loundness

You might think that sound intensity in watts per square metre would be the natural choice for reporting *loudness* but the ear (like most biological sensors) has a logarithmic response, in this case complicated by a selective frequency response.

To deal first with the logarithmic response a decibel scale is used. Intensity is converted to dB by taking the log to base 10 of the ratio of the measured intensity over a reference intensity. The reference is often taken as 10^{-12} watts per square metre: the lowest intensity that an average unaided young ear will respond to. In the dB plot below the reference is the maximum recorded intensity. To demonstrate the difference between a dB scale and an intensity scale it is convenient to examine a sound spectrum that is rich in harmonics plotted in both scales.

An air horn

A large range of harmonics with a low frequency fundamental is achieved with a vibrating membrane above a long tube. The small air-tight pot is pressured via the aquarium hose, which raises the membrane. Air escapes through the tube and the membrane descends. The cycle repeats ensuring that membrane resonance is achieved. The arrangement is known as an air horn (or vibraphone).

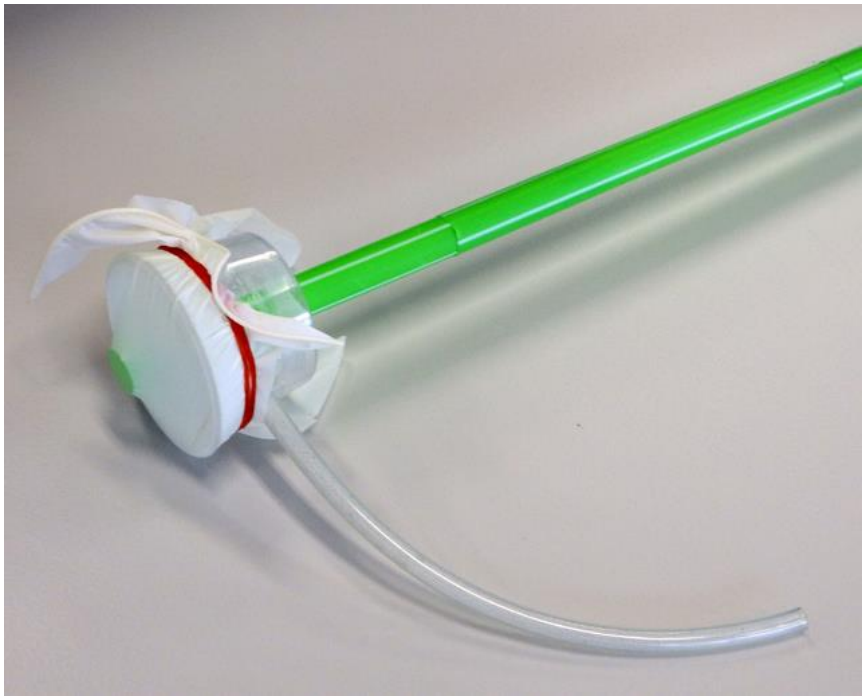

Fig 1– an improvised air horn made with a surgical glove and 92 cm (not shown) of telescoped drinking straws.

A low resolution spectrum of an air horn blast is first plotted in dB in Audacity.

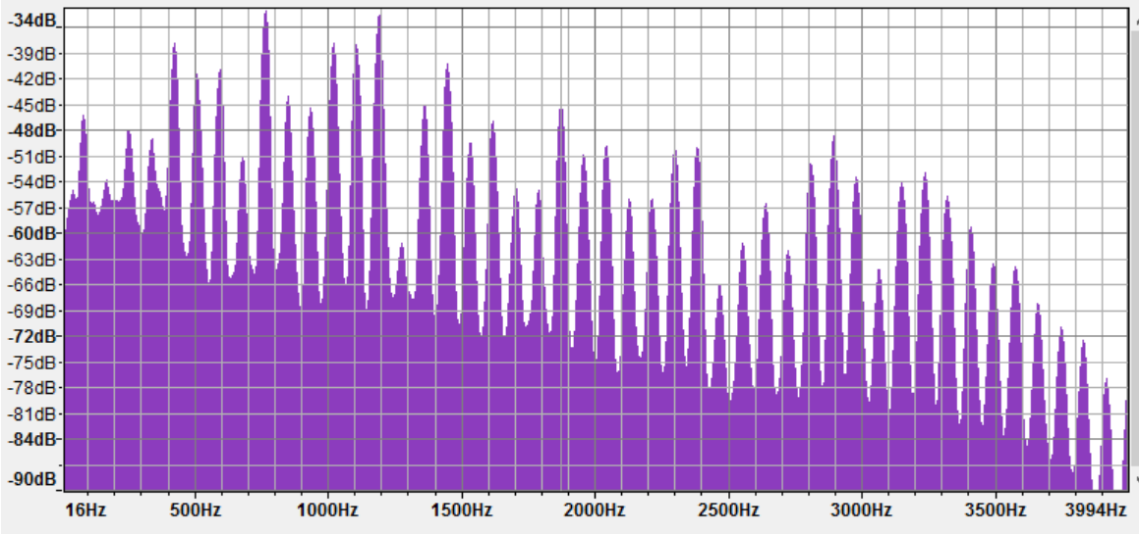

Fig 2 – the fundamental is at 85 Hz with a series of equally spaced overtones (harmonics).

Exporting the FFT data file from Audacity and pasting to Logger Pro allows intensity to be plotted (with an arbitrary scale) in a new calculated column. [Expression … 10^("dB"/10)]

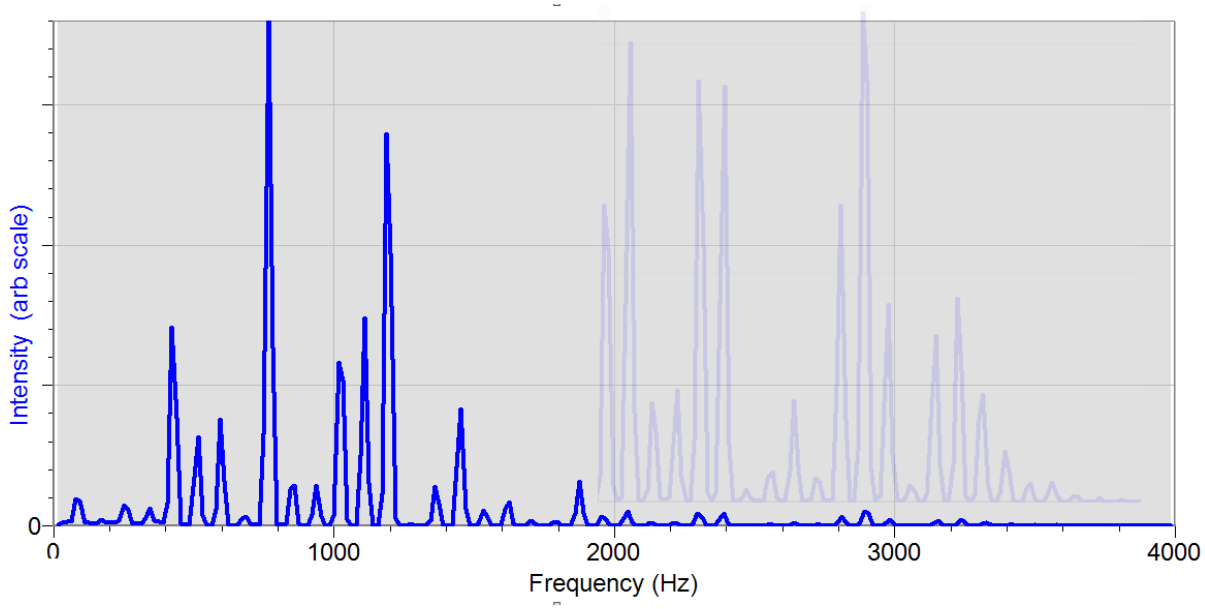

Fig 3 – the corresponding intensity plot.

Greatly increasing the vertical scale shows many upper harmonics (pale inset). We see one advantage of a decibel plot. The full range of harmonics are displayed in a single figure.

Note: the average frequency response of the human ear has been determined in large studies. The subjective loudness scale in **phons** requires the multiplication of the dB scale through the frequency range by an empirical factor. *The student may like to extract values from published data and design their own filter to convert dB to phons.*