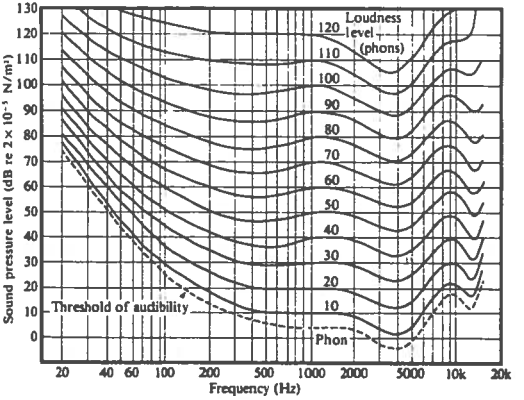
Demonstration 6. Frequency Response of the Ear (2:07)

Although sounds with a greater sound pressure level usually sound louder, this is not always the case. The sensitivity of the ear varies with the frequency and the quality of the sound. Many years ago Fletcher and Munson (1933) determined curves of equal loudness for pure tones (that is, tones of a single frequency). The curves shown below, recommended by the International Standards Organization, are similar to those of Fletcher and Munson. These curves demonstrate the relative insensitivity of the ear to sounds of low frequency at moderate to low intensity levels. Hearing sensitivity reaches a maximum around 4000 Hz, which is near the first resonance frequency of the outer ear canal, and again peaks around 13 kHz, the frequency of the second resonance.



Equal-loudness curves for pure tones (frontal incidence). The loudness levels are expressed in phons.
(from Rossing, 1982)

The contours of equal loudness are labeled in units called *phons*, the level in phons being numerically equal to the sound pressure level in decibels at f = 1000 Hz. The phon is a rather arbitrary unit, however, and it is not widely used in measuring sound.

In this demonstration, we compare the thresholds of audibility (in a room) of tones having frequencies of 125, 250, 500, 1000, 2000, 4000, and 8000 Hz. The tones are 100 ms in length and decrease in 10 steps of −5 dB each.

Naturally, the threshold of audibility in a room depends very much on the character of the background noise. Nevertheless, in most rooms the threshold should increase measurably at low frequency. The listener should be reminded that pure tones cause standing waves in a room, especially at the higher frequencies, in which the maximum and minimum levels may differ by 10 dB or more.

Commentary

> "First adjust the level of the following calibration tone so that it is just audible."
> "You will now hear tones at several frequencies, presented in 10 decreasing steps of 5 decibels. Count the number of steps you hear at each frequency. Frequency staircases are presented twice."

References

- H.Fletcher and W.A.Munson (1933), "Loudness, its definition, measurement and calculation," J. Acoust. Soc. Am. *5*, 82-108.
- ISO R226 (1961), "Normal equal-loudness contours for pure tones and normal threshold of hearing under free-field listening conditions," (International Standards Organization, Geneva, Switzerland).