

Unlike a pure sinusoidal signal, a musical pitch is characterized by what is known as a “harmonic overtone series”: The various overtones sound at the same time as the fundamental frequency. The frequency of each harmonic is a multiple of the fundamental frequency. Together, the fundamental and its harmonics produce an overall musical pitch.

Example: The 2nd overtone of the pitch a1 (= 440 Hz) has a frequency as follows (remember the 2nd overtone is the same as the 3rd harmonic):

$$3 \times 440\text{Hz} = 1320\text{Hz}.$$

This basic principle is truly the fundamental law of music. It can be generalized as follows:

$$F_0 = \Delta f$$

Here,  $F_0$  is the frequency of the fundamental and  $\Delta f$  is the frequency spacing between each of the pairs of overtones  $F_i$  and  $F_{i+1}$ . The human ear is capable of hearing the pitch of a musical sound even in cases where the fundamental  $F_0$  is outside the range of sounds we can hear. This is possible since we can hear the “virtual pitch” based on  $F_0 = \Delta f$  from the perceived series of harmonic overtones (with the relevant overtones spaced at frequencies of  $\Delta f$  apart).

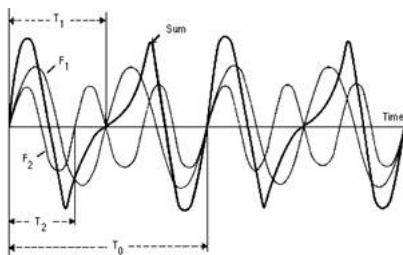


Abb.: Zeitbereich einer Schwingung. Die dicke Linie zeigt die Summe des zweiten und dritten Harmonischen. ( $F_1$  bzw.  $F_2$ ) mit der jeweiligen Periodendauer  $T_1$  bzw.  $T_2$ . Die Periodendauer der Summe ist gleich lang wie die Periodendauer der Grundschiwingung ( $T_0$ )!

This process is known as “fundamental tracking” and is very important with an instrument such as the cello. Otherwise, the notes produced in the first position on the C string would not be audible at all since the fundamental is almost entirely missing (due to a lack of resonance in this low-frequency range for reasons related to the design of the instrument).