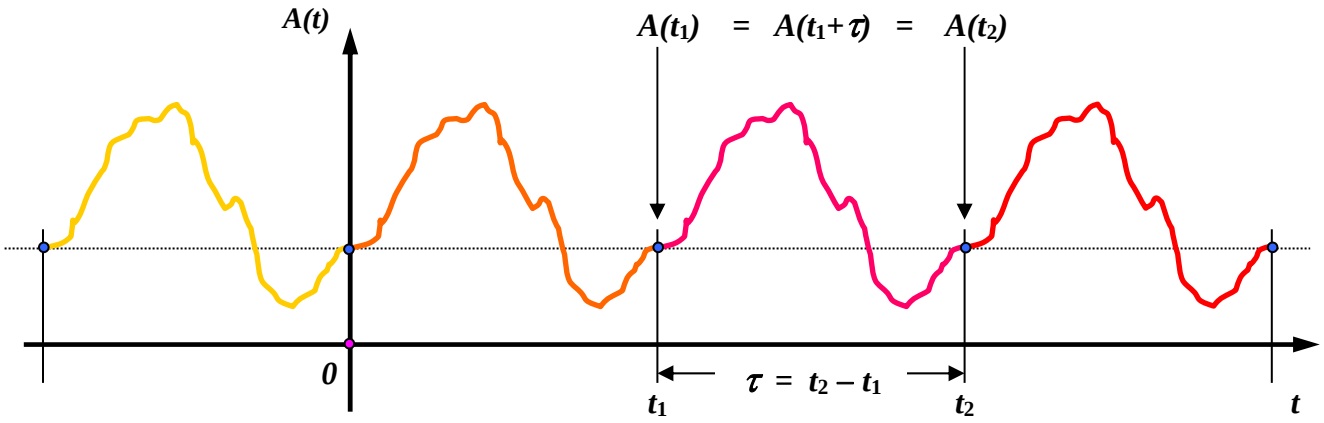
Tone Quality — Timbre

A ***pure*** tone (*aka* ***simple*** tone) consists of a ***single*** frequency, *e.g.* $f = 100\ Hz$.

Pure tones are rare in nature – natural sounds are often ***complex*** tones, consisting of/having more than one frequency – often many!

A ***complex*** tone = a ***superposition*** (*aka* linear combination) of several/many frequencies, each with its own amplitude and phase.

Musical instruments with a ***steady*** tone (*i.e.* a tone that doesn't change with time) create a periodic complex acoustical waveform (periodic means that it repeats every so often in time, *e.g.* with repeat period, τ):



Fourier analysis (*aka* harmonic) analysis — mathematically can represent ***any*** periodic waveform by an infinite, linear superposition of sine & cosine waves – integer harmonics of fundamental/lowest frequency:

$$A_{tot}(t) = a_o + \sum_{n=1}^{\infty} a_n \cos(n\omega_1 t) + \sum_{n=1}^{\infty} b_n \sin(n\omega_1 t)$$

$\omega_1 = 2\pi f_1$ $\quad f_1$ = fundamental frequency, repeat period $\tau = 1/f_1$

Please see UIUC Physics 406 Lecture Notes – Fourier Analysis I, II, III & IV for more details… http://courses.physics.illinois.edu/phys406/406pom_lectures.html

A complex tone - *e.g.* plucking a single string on a guitar - is perceived as a single note, but consists of the fundamental frequency f_1, plus integer *harmonics* of the fundamental frequency: $f_2 = 2f_1$, $f_3 = 3f_1$, $f_4 = 4f_1$, $f_5 = 5f_1$, *etc.*