

TUNING PROBLEMS GOT YOU BEAT?

HOW BEAT-NOTES HELP YOU TUNE.

If you play a musical instrument then chances are that you have spent your share of time tuning. Have you ever thought about what you are actually listening for when you tune an instrument? And what about those days when you just can't seem to tune if your life depended upon it? Let's take a look at what might be the ultimate tuning nightmare, the piano, and see what we can learn from that.



BY
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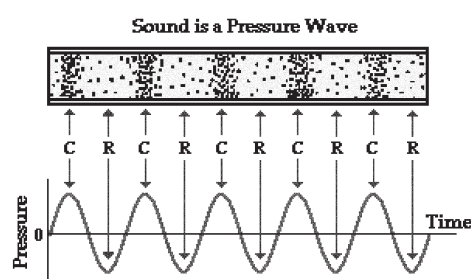
There was a time when I considered becoming a piano tuner. I found the idea attractive because it seemed like a nice portable and self-directed way to make a living. I began to learn what I could about piano tuning. I took a little trip to San Francisco to visit a friend who was working as a piano tuner. I got the tools he recommended so I could start learning by doing. I got a copy of White's "Piano Tuning and Allied Arts" which, besides being considered the piano tuner's bible, was also just about the only reference still in print then.

Tuning a piano begins with a process called "laying the bearings" which is the method for tuning the octave surrounding middle C. As my friend tried to demonstrate this to me he kept referring to something he called counting the "beat notes." Truth is, I had trouble just hearing these beats, much less counting them. The process involves tuning one note to a tuning fork (Figure 1) and then tuning the remainder of the notes by moving through a sequence of fifths, fourths and octaves. So where does the need to count beats come into the picture? It turns out that the only true intervals that you will find on a correctly tuned piano are the octaves. For the system to work correctly all of the other intervals, by design, must be slightly off. So when you tune say a fifth interval to be harmonically correct it will not produce any beats. You must then adjust the interval to be slightly off and you judge the correct distance by counting the beat notes that ensue.

Let's talk about the beat notes. What are they and how do they work? The beats are produced when two sound waves of different frequencies interact with one another. Sound is caused by small areas of high and low pressure propagating outward from a source. When a musical instrument's string is struck or plucked and it vibrates back and forth it becomes a source of alternating high and low pressure.



Figure 1. A Tuning Fork.



NOTE: "C" stands for compression and "R" stands for rarefaction
Figure 2. Sound Visualized as Pressure or Waves.

The number of changes in pressure per second that reach the ear is referred to as the frequency of the sound and we perceive that as a musical pitch. Figure 2 shows how this can be represented as either pressure pulses

or as sine waves on an oscilloscope display in the lab.

The measurable parts of a sine wave are:

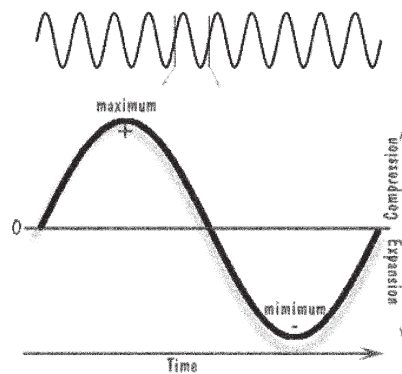


Figure 3. A sine wave

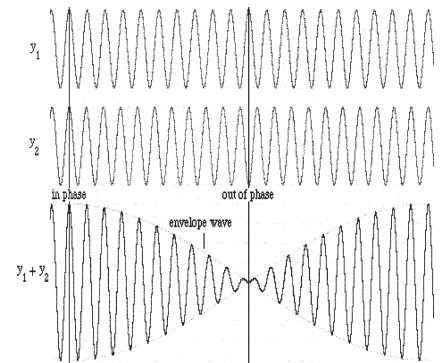


Figure 4. Interference beats

Amplitude: The size of the pressure differences or loudness. It is usually measured in **decibels (dB)** and is the vertical (up and down) displacement in Figure 3.

Cycle: One complete up and down movement in Figure 3 is called a cycle.

Frequency: Frequency is a count of the cycles per second, usually measured in **Hertz (Hz)** and is the same thing as **pitch**. Piano tuners use a tuning fork that produces the standard pitch of A at 440 Hz or cps.

Wavelength: Wavelength is the inverse of frequency. If the frequency doubles then there must be twice as many cycles in the same amount of time so the wavelength must be halved. Wavelength is measured as the horizontal displacement of one cycle in Figure 3.

Frequency and amplitude are independent of each other. Two sine waves may have the same frequency and different amplitudes or the same amplitudes and different frequencies. When two notes are sounded together you can visualize the result of their interaction by adding their representative sine waves together following these rules:

- A high pressure from one will cancel out a low pressure from the other.
- Two high pressures will reinforce each other.
- Two low pressures will reinforce each other.

We can see how this works in Figure 4 where the first two sine waves are of equal amplitude but are of slightly different frequencies. At the beginning (at the first vertical line) they are in-phase (in-step) so adding them together results in the amplitude being doubled. They will gradually drift apart and at the second vertical line they are completely out of phase. Now when we add the amplitudes they cancel each other out. After that they will drift back to being in-phase, then out and so on. The effect presents itself to the ear as pulsating amplitude or beat notes – QED! (look it up).

The resulting pulse has a frequency of its own which turns out to be the difference between the two original frequencies. So if the two frequencies were 440 Hz and 442 Hz then you would hear two beats per second. If they were 440 Hz and 445 Hz you would hear five beats per second. So this is why a piano tuner is able to use beat notes. When two strings are supposed to be the same but one of them is slightly off you will hear one beat per second for every frequency difference between the two. Tuning then becomes a matter of adjusting the offending string until all the beats disappear. That's for unisons only – for all other intervals they must be "de-tuned" until you hear the proper number of beats per second. I suppose this is why it is called the "art" of piano tuning and is also one of the many reasons why I did not continue my pursuit of the profession. Some people become totally enraptured with the whole experience and wind up as piano tuners. It could happen to you.

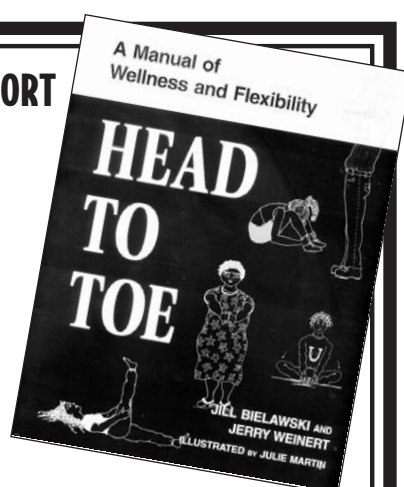
So, what about those days when you just can't seem to get that guitar in tune? Maybe you are actually listening for those harmonically satisfying, beat-less intervals. Unless that interval is an octave, you have just shot yourself in the foot – musically speaking. Perhaps a better method on such days would be to listen to an entire chord and fix the notes that sound out of tune in relation to that chord. Then change chords and do it again. This will force you to average out the intervals over the chord and keep you from the temptation of getting rid of the beats on any one interval.

If you want to experience some beat notes without having to destroy your parent's piano I have listed some web sites below. So, as usual, keep playing, keep learning and please stay tuned.

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