

Common (and uncommon) causes of intonation problems

Setup - Every aspect of an instrument's setup will affect its intonation. When changing the setup of an instrument or when changing the brand or gauge of strings, the intonation should be checked and adjusted as necessary.

Tuning Method - The use of harmonics or open chords to tune is a very common tuning error. Try tuning to fretted notes, octaves, or a quality digital tuner.

Worn or Faulty Strings - Strings can become worn, bent, clogged with dirt and oils, or have loose or unbalanced windings. Any of these factors can throw a string out of balance and lead to intonation problems.

Fret Wear - When frets become worn, they will no longer accurately determine the correct string length. A proper fret dress can greatly improve intonation.

Playing Style - The pressure and placement of your fretting hand, as well as the position and aggressiveness of your picking hand have significant effects on intonation. Instruments can usually be set up to accommodate a variety of styles, but this relies on consistency on the player's part.

Fret Placement - Although uncommon, it is not impossible for a manufacturer's tools to be improperly adjusted, and frets can be slightly out of place. If you notice intonation problems in only a few positions, this may be worth checking.

Suggested Reading

Stuart Isacoff, TEMPERAMENT: THE IDEA THAT SOLVED MUSIC'S GREATEST RIDDLE. Alfred A. Knopf, a division of Random House, Inc., New York, 2001.

John Meffen, A GUIDE TO TUNING MUSICAL INSTRUMENTS. David & Charles Inc., 1982.

Sir James Jeans, SCIENCE AND MUSIC. Cambridge University Press, 1937.

J. Murray Barbour, TUNING AND TEMPERAMENT: A HISTORICAL SURVEY. Michigan State College press, 1951.

Anita T. Sullivan, THE SEVENTH DRAGON: THE RIDDLE OF EQUAL TEMPERAMENT. Metamorphous Press, 1985.

Hideo Kamimoto, COMPLETE GUITAR REPAIR. Oak Publications, 1978.

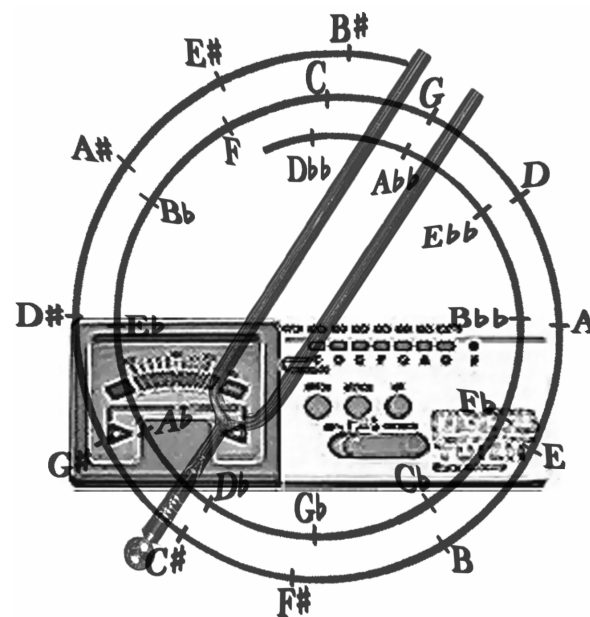
Arthur A. Reblitz, PIANO SERVICING, TUNING, AND REBUILDING FOR THE PROFESSIONAL, THE STUDENT, THE HOBBYIST. The Vestal Press, Ltd., 1976.

John Backus, THE ACOUSTICAL FOUNDATIONS OF MUSIC. W. W. Norton & Company, Inc., 1969.

**Although several of these books are currently out of print, they may be available through your local library or inter-library exchange.*

Written by David P. Collins, 2003

Tuning, Intonation & Temperament



A Brief Guide to Equal Temperament & Intonation For Fretted Instruments

The twelve-tone scale is imperfect. Though it is common to assume that the scale from which virtually all western music is created is something natural and perfect, it is actually far from that. Over the last 2,500 years great minds such as Galileo, Newton, da Vinci, and countless others including kings, popes, architects and composers have struggled to reach a solution. What they have created is a compromise we call *temperament*.

Temperament is well understood by music theorists and piano tuners, but few people beyond that have much knowledge of how our twelve-tone system actually works. Many musicians experience frustration when they cannot get their instruments to play “in tune”. Understanding temperament and intonation can help musicians to understand what to expect from their instruments, and in the process possibly redefine what “in tune” means - it’s not as simple as most would assume.

Crash Course in Temperament

The *temperament* of an instrument is the set of specific frequencies at which each note is designed to ring.

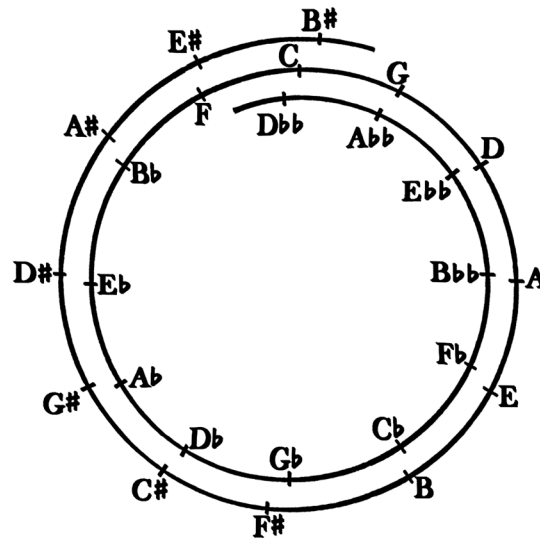
Tuning a stringed instrument is the act of adjusting the string tension to achieve the intended notes.

Intonation includes both the temperament and the tuning of an instrument, as well as adjustments in the length of the strings to compensate for any changes in string tension as the instrument is being played.

While there is still some debate as to the origins of our twelve-tone scale, we can accurately track its development from the time of Pythagoras. Pythagoras attempted to define “agreeable” harmonies by using simple ratios (for example, 2:1 is an octave, 3:2 is a 5th, 4:3 creates a 4th), and it is his ideas which eventually led to what we now call *perfect* or *natural temperament*.

Harmonies played in natural temperament are what would be considered most pleasant to the human ear. These are the pitches to which we would naturally tune our voices when we form a chord with other singers. This works beautifully when using basic intervals in a particular key, but once music leaves the protection of a single chord or key, problems quickly become apparent.

The Pythagorean spiral of fifths demonstrates one of the basic flaws of natural tuning. In a series of consecutive fifths ranging from a low D^{bb}, through a middle C, to a high B[#], one may assume that these three notes would be perfect octaves. In natural tuning however, the difference between them would be 48 cents (48/100 of a semi-tone, or almost half of a note in the chromatic scale).



Another example would be that a C[#] in the key of A would be a very different pitch than a D^b used in the key of F. This can be dealt with by a cellist or a soprano who can constantly adjust a note to fit its context, but for instruments which are limited to 12 predetermined tones in an octave (such as pianos or guitars) it presents more of a problem.

Rather than use keyboards with several different keys for a single note (split key organs were common in the 16th & 17th centuries), each note must be tempered so that it is not *too* disagreeable in any key or chord. Hundreds of temperaments have been tried, but the only one that shows no bias towards any one key or interval is *equal temperament*.

Pitch	Natural Temperament	Equal Temperament	Difference
C	0	0	0
C#	112	100	+12
D	204	200	+4
E ^b	316	300	+16
E	386	400	-14
F	498	500	-2
F#	603	600	+3
G	702	700	+2
A ^b	814	800	+14
A	884	900	-16
B ^b	1018	1000	+18
B	1088	1100	-12
C	1200	1200	0

Intervals represented in cents (1/100 of a semitone)

Temperament for Fretted Instruments

Virtually all fretted instruments made today are designed using equal temperament. The setup and intonation of your instrument may need to be adjusted by a technician to fit your string choice and playing style. The proper tuning is then left in the hands of the player.

If all these things are done correctly, your instrument should consistently play in tune with equal temperament, which ironically means that it is perfectly *out of tune*. It is a compromise, but it is a limitation of our scale that we are forced to live with. The goal of a properly tuned, tempered, and intonated instrument is to allow any chord to be played in any key without hearing any terrible disharmony in the context of playing. This does not mean that all notes will be in perfect harmony with one another, but rather that no intervals will be grossly dissonant.