II. Tuning & Setup

A. The Grand Staff

I’ve lately felt that guitar music really should be written on a Grand Staff, like piano music. In standard tuning, our lowest open string is tuned to the E which is normally notated on the first ledger line below the Bass Clef staff. Our highest open string is tuned to the E that is normally notated on the 1st line of a Treble Clef staff. Our high E at the 12th fret is tuned to the pitch that is normally notated on the 4th space of a Treble Clef staff.

But virtually all guitar music is notated an octave higher than it actually sounds so that music that is written for the guitar will fit nicely on a single Treble Clef staff. This is fine for reading guitar music, but creates some conceptual problems when *thinking* about music on the guitar.

But no-one’s really going to listen to me, so we might as well get used to things the way they are. Just try to be aware which note you are really playing when you are improvising or reading a guitar part, and get comfortable reading non-guitar music “up” an octave from where you would if it were an actual guitar part (like the music you would find in a fake book).

Figure 1: This is where the guitar’s open string’s pitches really SOUND.

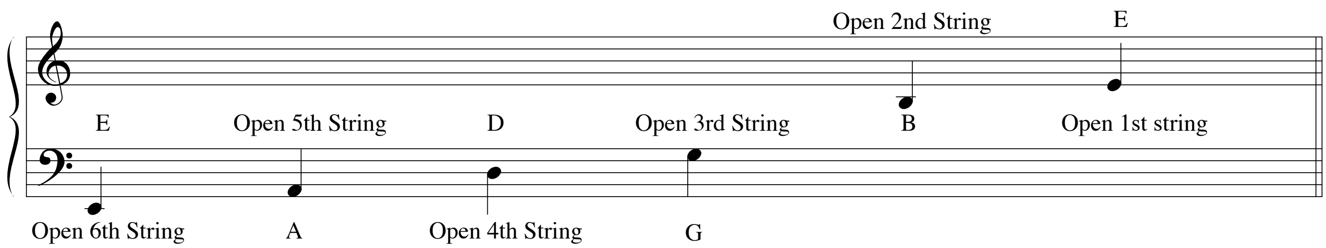
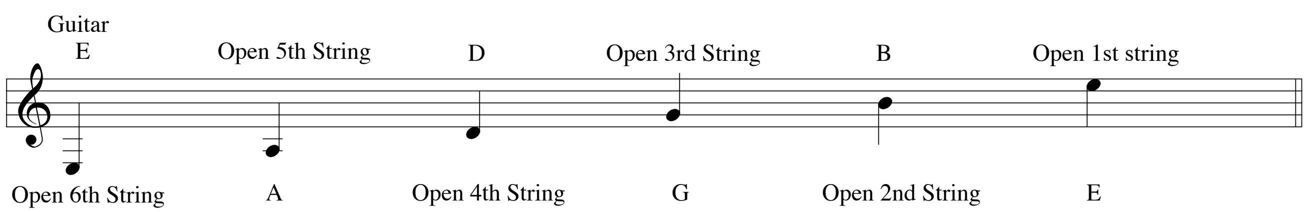


Figure 2: This is where the guitar’s open strings’ pitches are WRITTEN in guitar music.



B. Using A Tuner

Tuning a guitar by ear is actually quite difficult. When I was starting out, there were no electronic tuners to help us. We learned a simple method of comparing fretted notes to open strings. This happens to be a very good method, once your ears have developed enough to hear when two pitches are perfectly in-tune with each other. But developing those types of ears takes time.

Here’s the method. It assumes that your guitar is already properly set-up and intonated:

1. Use a pitch pipe, a piano, or a tuning fork, etc., tuned to A = 440 vibrations per second to tune your A string by ear. Your A string actually is tuned to A = 110 which is 2 octaves lower than A = 440, so this is a bit tricky right from the start.
We say that two unison (or octave) pitches are "in-tune" when there are no audible beats heard when the two pitches are sounded simultaneously. So listen closely for these beats between your A440 source and your open A string.

2. Fretting your A string at the 5th fret produces the note D. Play this D, and tune your open 4th string so that it sounds "in-tune" with the fretted note. Be extremely careful not to apply too much pressure to the fretted note, or to pull on the string from side to side, or you will affect its pitch. This, again, assumes that your gui-

tar is set-up properly, and that fretting a note properly at the 5th fret will produce a D that is perfectly in-tune. (Please see II. C. - Intonation, below) Once your D string is perfectly in-tune proceed to step 3.

3. Fretting your D string at the 5th fret produces the note G. Play this G and tune your open 3rd string so that it sounds in-tune with the fretted note.

4. Fretting your G string at the *4th fret* produces the note B. Play this B and tune your open 2rd string so that it sounds in-tune with the fretted note.

5. Fretting your 2nd string at the 5th fret produces the note E. Play this E and tune your open 1st string so that it sounds in-tune with the fretted note.

6. Your low 6th string is also tuned to the note E, but it is 2 octaves below the E on the open 1st string. You could just play both open E strings and tune the low one until it sounds in-tune with the high one, but most people find it easier to use the 6th string's "harmonic" (Please see II. F. - Other Tuning Methods below) at the 12th fret. This "harmonic" will produce a note that is 1 octave higher than the open 6th string, but still one octave lower than the open 1st string.

Two notes of the same pitch - or an octave apart - that are out of tune, will have an audible beating when they are sounded simultaneously. Two notes of the same pitch - or an octave apart - that are in-tune with each other, will have no beating effect. You must learn to listen very closely for this.

Not real easy for a beginner, eh?

These days, a beginner can use one of the extremely accurate and inexpensive electronic tuners that are on the market. This is an important investment for a novice guitarist. If you are constantly practicing on a guitar that is not in-tune, or is not set-up properly to play in-tune all over the neck, then your hands will try to compensate, and you will be subconsciously tugging on the strings to make them sound more in-tune. This will pave the way for many bad habits that are quite difficult to break once they take hold.

Owning a tuner, and knowing how to use it, can save you a lot of money too. A typical guitar shop around here charges $50.00 for a set-up. This "set-up" is usually something extremely simple (setting the intonation and the string height) that you could do yourself for free, if you owned a decent tuner and understood some basic guitar mechanics. (See II. C. - Intonation below) Actually, the more you know about how your guitar works, the better off you will be anyway. It's worth learning how to wire in your own pickups, how to change your tuning pegs, adjust your truss rod, etc. Sometimes a musical problem you are having may not have a musical origin. It might be your instrument!

There are a few different tuner types on the market. I prefer the "chromatic" models because they are easier and faster to use. These tuners "know" what note you are playing and simply tell you whether it is sharp or flat. ... Simple. One thing to be careful of when you are using an electronic tuner, is to make sure that only 1 string is vibrating at a time. By physically muting the other strings, you will send a much clearer audio signal to the tuner.

As far as a guitar's tuning is concerned, it is either in-tune or it isn't. There is no middle ground. Learn to become a fanatic about tuning now, and your musicality will develop much more quickly. I have yet to see a guitar that stays perfectly in-tune for longer than 5 minutes. They are extremely sensitive to temperature, humidity and other factors. I always try to have a tuner in line when I'm playing a gig so that I can make adjustments on the fly.

In the meantime, you should probably develop a rapport with a good guitar tech, but plan on learning how to do a set-up by yourself. It's not hard. Most guitar techs are happy to show you how to do this stuff too.

C. Intonation

In order for your guitar to play in-tune across the entire fretboard, the lengths of the strings sometimes need adjusting. The 12th fret marks the halfway point along each string. The vibrational frequency of the note produced at the 12th fret should be an exact octave doubling of the vibrational frequency of the note produced by the open string.

Example: Your open A is tuned to A = 110 vps (Vibrations Per Second). The pitch produced at the 12th fret of your 5th string should be exactly A = 220 vps. If it is not, then something needs to be adjusted. Most electric guitars now have movable bridge saddles. By moving the 5th string's saddle backwards or forwards, we can change the length of the string so that the open string and the fretted note at the 12th fret can be made to match perfectly. If the 12th fret pitch is sharper than the open string's pitch, then the length of string, between the 12th fret and the bridge saddle, needs to be increased. If the 12th fret pitch is flatter than the open string's pitch, then the length of string, between the 12th fret and the bridge saddle, needs to be decreased. Etc.

D. Jazz Guitar Tone

There is a range of guitar tones that are readily recognized as the "jazz guitar sound". It is darker and fuller and less distorted than the sounds usually associated with rock music. In my mind, the two most important features of an electric guitar - to get the "jazz guitar sound" - are, relatively heavy strings and a humbucking pickup in the neck position. It is rare for a jazz player to use any other pickup besides the neck pickup. Single coil pickups generally have a thinner sound than what is usually desirable for a jazz tone.

I use a Gibson 57 Classic pickup in the neck position of all my jazz guitars. The lightest high E string that I use for playing jazz is 0.011" gauge. I often use a set of strings with an unwound 3rd string, but most traditional sounding jazz guitar players prefer a wound 3rd string, and heavier strings than me. This is, of course, highly subjective advice.

A good jazz sound can be gotten from a solid body electric. Ed Bickert uses a Fender Telecaster with a humbucker in the neck position. His high E string is 0.012" gauge. He uses an unwound G string. However, most jazz players prefer the sound of a good archtop acoustic-electric guitar, strung with relatively heavy strings.

Most jazz guitarists reduce the treble output from their pickups by turning their tone controls down quite a bit. I believe that started, mostly, to reduce the sound the fingers make when sliding along the wound strings. Guys just do it now because they like the sound. It yields a fuller warmer tone that blends better with other acoustic instruments.

Some players use flat wound strings which are also designed to reduce the sound of finger slides.

E. About Whammy Bars

A good whammy bar system, like a properly installed and properly setup Floyd Rose system, can actually enable your guitar to stay in-tune even better than a fixed bridge system, believe it or not! However, it is rare to see a whammy bar system set-up properly. My advice is, if you don't know exactly what you're doing, stay away from these things. They can make you sound lousy, even if you're playing really well. They are not ideal with heavier strings either.

F. Other Tuning Methods

There is a tuning method that many players use that is not really 100% accurate. This method involves using harmonics at 2 different "nodes" along a string's length. A "harmonic" is the pitch that results when you lightly touch a string at spots where the string's length is divided equally, and start the string vibrating.

By lightly touching a string near the 12th fret, you actually divide the string into 2 equal lengths, and they both vibrate separately. The pitch that is produced is 1 octave higher than the open string. The vibrational frequency of the harmonic is exactly 2 times that of the open string.

By lightly touching a string near the 7th fret you actually divide the string into 3 equal lengths and they all vibrate separately. The pitch that is produced is an octave plus a perfect 5th (a Perfect 12th) above the open string. The vibrational frequency of this harmonic is exactly 3 times that of the open string.

The vibrational frequency ratio of the open string to the 12th fret harmonic is 1:2. The two tones that make up the interval of a perfect octave have a frequency ratio of 1:2. Perfect unisons are 1:1, by the way. The frequency ratio of the open string to the 7th fret harmonic is 1:3. I.e. Perfect 12ths have a frequency ratio of 1:3. Perfect 5ths are 2:3, by the way.

An harmonic can theoretically be created at any of the mathematical divisions of a string's length. (1/2, 1/3, 1/4, 1/5 etc.) Each one of these mathematical divisions along the string is called a "node". Harmonics are easier to hear on the lower strings. The higher strings produce some harmonics that are too high and/or too quiet to be perceived well by the human ear.

Examples:

The 5th string is tuned to A110. When you lightly touch this string near the 12th fret (without actually fretting it), you cause it to be divided into 2 equal vibrating bodies so that the pitch, A220, is produced when the string is plucked. When you lightly touch this string near the 7th fret, you divide the string into 3 equal vibrating bodies and the pitch, E330, is produced. When you lightly touch this string near the 5th fret, you divide the string into 4 equal vibrating bodies and the pitch, A440, is produced. Etc.

The same concept can be applied to any vibrating body and the resulting pattern of pitches produced is known as the Harmonic Overtone Series. The theory goes like this: No matter what the length of a vibrating body, it will vibrate in its full length and also in all of its mathematical divisions. Each one of these divisions, above the “fundamental” (the starting pitch), is known as an “harmonic”. The fundamental is also called the 1st “partial”. The 1st harmonic above the fundamental is called the 2nd “partial” etc.

The guitar tuning method I was referring to at the beginning of this sub-chapter also involves the concept of overtone-series-based "perfect" intervals. Most pairs of pitches, when sounded simultaneously, will produce an audible, regularly repeating, beating sound. Not so with Perfect intervals. When two pitches are sounded that have their vibrational frequencies in the simplest ratios: 1:1 (Perfect Unison), 2:1 (Perfect Octave), 3:2 (Perfect 5th) and 4:3 (Perfect 4th) this beating effect is neutralized. The Perfect intervals are Unisons, Octaves, 5ths, 4ths, and their corresponding compound intervals; double octaves, 11ths, 12ths, etc.

The tuning method being questioned is as follows:

1. Use a pitch pipe, a piano, or a tuning fork tuned to A440 to tune your A string by ear. (I.e. No audible beating between the tuning fork and the string.) Remember that your open A string sounds at A110. You could also use the 12th fret harmonic, A220, if you like.

2. Lightly touch your 5th string near the 5th fret node to divide the string into 4 equal divisions. This produces the harmonic that yields the pitch, A, 2 octaves above the open string (A110 X 4 = A440). Lightly touch your 4th string near the 7th fret node to divide the string into 3 equal lengths. This produces the harmonic which also yields the pitch A (a Perfect 12th above the open D string). Adjust the tension on the 4th string until its A is in-tune with the A on the 5th string.

3. Repeat as above for the 4th and 3rd strings.

4. Repeat as above for the 6th and 5th strings, adjusting the tension on the 6th string to match the pitch on the already tuned 5th string.

5. Lightly touch and pluck your 6th string near the 5th fret node to divide the string into 4 equal divisions. This will produce the harmonic that yields the pitch, E, 2 octaves above the open E string's pitch. Compare this to the open 1st string, and adjust the 1st string’s tension until it is in-tune with the 6th string’s harmonic.

6. Lightly touch and pluck your 2nd string near the 5th fret node to divide the string into 4 equal divisions. This produces the harmonic that yields the pitch B (2 octaves above the open B string). Compare this B with the B that is produced by the 1st string’s 7th fret harmonic. Adjust the 2nd string’s tuning accordingly.

The problem with this method of tuning is that on fretted instruments and keyboards, for the last few hundred years, we have been using a tuning system where 5ths are not “Perfectly” in-tune (see below)! So tuning the guitar with any harmonics other than those that yield an octave above the open string, will actually result in slightly *detuning* the guitar away from what is called 12-tone equal temperament, which is the tuning system that the spacing of guitar frets happens to be based on!

The pitches we use in contemporary Western music are actually slightly altered (aka “tempered”) from the vibrational frequencies that occur naturally via the overtone series. What is known as the “12 Tone Equally Tempered” scale (12-TET) has been in use on guitars and keyboards since approximately Bach’s time. In 12-TET the only pure, perfectly in-tune intervals, are octaves! Every other possible interval in 12-TET is slightly out-of-tune, relative to the types of intervals found in the overtone series. In 12-TET, all 12 tones within any octave are tuned an exact equal distance from each other.

Consider this:
The overtone series of A110 results in the following pitches:

1st	Partial	A	=	110 (aka the fundamental)
2nd	Partial	A	=	220 (aka the 1st harmonic)
3rd	Partial	E	=	330
4th	Partial	A	=	440
5th	Partial	C♯	=	550
6th	Partial	E	=	660
7th	Partial	G	=	770

Note: In 12-TET the pitch a “Perfect” 12th above A110 is not tuned to E330, as you might expect. It is tuned to E329.628.

So, any method for tuning the guitar that uses pure overtone 5ths (via 7th fret harmonics) as some sort of tuning reference, will actually never be able to tune the guitar accurately to 12-TET, the way it’s designed to be tuned! When you use a 7th fret harmonic, a pure overtone perfect 12th above the open string is produced. If you use this tone as a reference to tune some other string to, you will not be tuning properly to 12 TET.
For Example: The note produced from the 7th fret harmonic of a properly tuned A string @ A110vps is exactly E330vps.
In 12 TET, your E string’s 5th fret harmonic (remember that perfect octaves, not 5ths, are produced at the 12th fret harmonic and the 5th fret harmonic), as well as your open high E string, should be exactly E329.628vps (see the chart below), not E330. So, if your guitar was tuned accurately to 12-TET, there should be a slight beating heard between the A string’s 7th fret harmonic and the 6th string’s 5th fret harmonic (or between the A string’s 7th fret harmonic and the open high E string). This proves that 7th fret harmonics should be left out of any strategy for tuning the guitar by ear. Tuning by ear can only work properly by comparing the sounds of octaves and unisons and tuning until there are no audible beats.

FYI: The formula that can be used to determine the vibrational frequency of a minor 2nd above any given pitch in the 12 Tone Equal Temperament tuning system is this:

(x) times 1.0594631 = (y) where (x) is the original pitch and (y) is a semitone above.

The following table shows the exact frequencies of the pitches in 12-TET and shows one spot on the fretboard where these pitches are found on a well-tuned and properly setup guitar:

String/Fret	Note	Frequency
Sixth Open	E	82.407
1	F	87.307
2	F♯/G♭	92.499
3	G	97.999
4	G♯/A♭	103.826
Fifth Open	A	110.000
1	A♯/B♭	116.541
2	B	123.471
3	C	130.813
4	C♯/D♭	138.591
Fourth Open	D	146.832
1	D♯/E♭	155.563
2	E	164.814
3	F	174.614
4	F♯/G♭	184.997

Third Open	G	195.998	
1	G♯/A♭	207.652	
2	A	220.000	
3	A♯/B♭	233.082	
Second Open	B	246.942	
1	C	261.626	(Middle C)
2	C♯/D♭	277.183	
3	D	293.665	
4	D♯/E♭	311.127	
First Open	E	329.628	
1	F	349.228	
2	F♯/G♭	369.994	
3	G	391.995	
4	G♯/A♭	415.305	
5	A	440.000	

This system is consistent, in that the vibrational frequencies of *all octaves are exact multiples of each other*. Example: E82.407 times 2, yields E164.814, a Perfect octave higher. Etc.

My own tuning method is as follows. It also assumes that your guitar is properly intonated, and properly setup, so that fretted notes all across the fretboard are as close as possible to being perfectly in-tune:

Tune your A string using a pitch pipe, tuning fork, piano, electronic tuner, or whatever.

Fret your 4th string at the 7th fret (A) and adjust the tuning of the 4th string until there are no beats with the open 5th string.

Fret your 3rd string at the 2nd fret (A) and adjust the tuning of the 3rd string until there are no beats with the open 5th string.

Fret your 2nd string at the 10th fret (A) and adjust the tuning of the 2nd string until there are no beats with the open 5th string.

Fret your 1st string at the 5th fret (A) and adjust the tuning of the 1st string until there are no beats with the open 5th string.

Tune your low E string to the high E string so that there are no beats.

Now, some acoustic guitars (including archtops) and most classical guitars do not have bridges that allow for exact intonation adjustments via individual bridge saddles. These guitars will always play somewhat out-of-tune across the entire fretboard. If you play one of these types of guitars I suggest that you tune with an electronic tuner, or by the very first method I gave in this chapter using the fretted notes at the 5th fret, etc. But, you will have learn to adjust your touch for certain chords and notes at various fretboard positions to bend and/or pull on the strings a bit in order to make certain chords and certain single note passages sound more in-tune.

On a guitar that is intonated as well as can be (nothing's perfect), we usually try to develop the lightest touch possible, so that we do not influence the tuning very much at all by bending or pulling on the strings. If the guitar is in-tune, is setup properly, is intonated properly, and is being played with a light touch, then any out-of-tune-ness we notice is just an artifact of the way that 12-TET actually sounds. Except for octaves, we are just slightly “out-of-tune” at all times! Still, we all adjust our touch dynamically to one degree or another, trying to make things as pleasant sounding as we can.