Finding the Harmonic Series on piano and guitar

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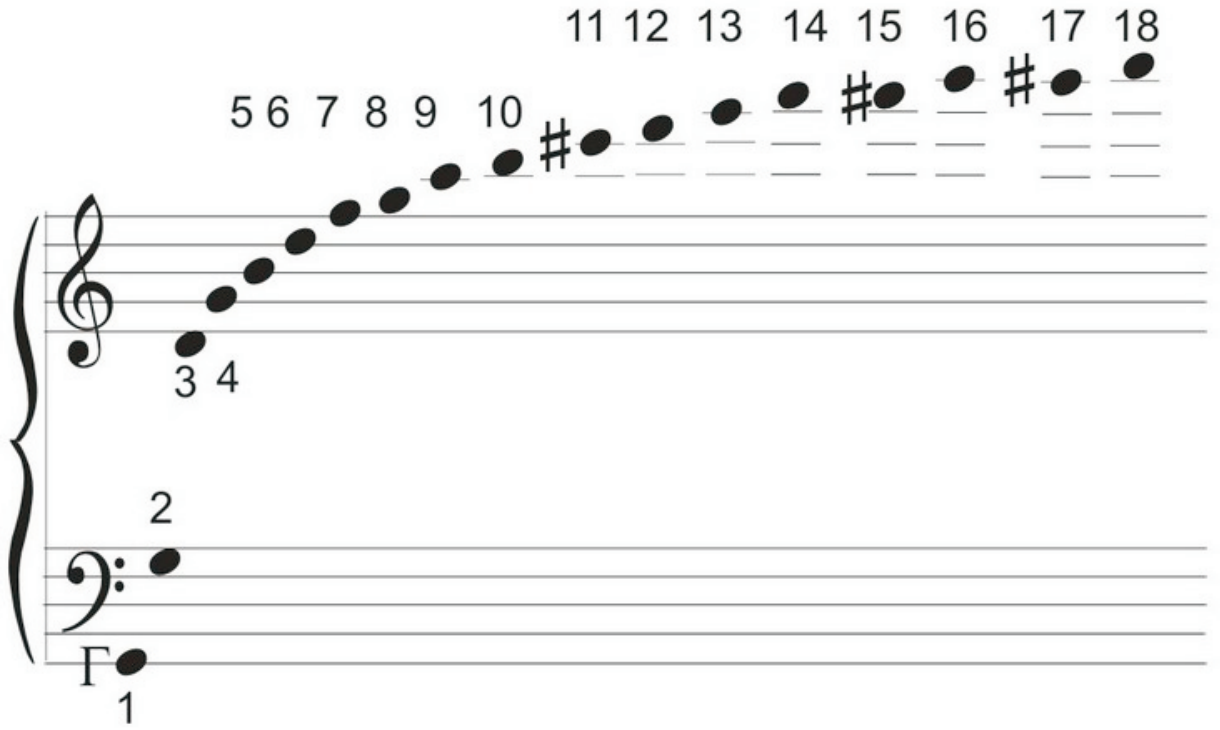

Every note sung by the human voice and played by most instruments contains the harmonic series.

To demonstrate this the most convenient note is G at the bottom of the bass clef. Around 1025 Guido of Arezzo called this note Gamma (the third letter of the Greek alphabet, the ancestor our Roman G and written G or g , upper and lower case respectively) This was the lowest note used in his voice training method and is the origin of the expression “running the whole gamut” a contraction of Gamma-Ut i.e. running up the whole range of available notes.

If you have guitar handy tune the A string down two semitones to become Gamma. If you pluck the string while lightly touching the string above the 12th fret , ½ way along, you will hear a note an octave above. That is the 2nd harmonic. If you touch the string above the 7th fret, 1/3 of the way along, you will hear the 3rd harmonic. The harmonics continue upwards to infinity getting closer and closer together - the harmonic series. Gamma is the fundamental or first harmonic and the others are all multiples of the rate of vibration of Gamma. A list of the first 18 harmonics sits nicely on the stave as can be seen on this diagram.

The tuning of the harmonics do not all agree perfectly with piano notes and frets but there is a rough correspondence. The first 10 harmonics suggest a G9 chord (favoured

by Debussy and jazz musicians). By amazing coincidence harmonics 7 to 13 run approximately in parallel with the notes one might find in a chord symbol. However the harmonics are getting closer and closer together. The intervals between 7, 8, 9 and 10 approximate a whole tone. From then the intervals get smaller and smaller, somewhere between a tone and a semitone until the semitone is approximated between the 17th and 18th harmonics.

Pitch was not standardised in Renaissance times and could vary from district to district. For convenience let's say Gamma equals 100 Hz (slightly sharper than todays piano note but a nice round number). Then the second harmonic will be 200 Hz, the third harmonic will be 300 Hz and so on. Notice how the tuning standard A=440 sits between the 4th and 5th harmonics of Gamma. 1000 Hz corresponds to the B above the treble staff. The highest G on the piano corresponds to the 32nd harmonic and is thus 3200 Hz. The G below Gamma is 50 Hz and is the mains frequency adopted throughout Europe and gives the familiar mains hum.

The piano and guitar frets only give an approximation of harmonics rounded to the nearest semitone. To hear the true harmonics return to the guitar and pluck the string while touching the string above the appropriate fret as shown in this table. For all except the octave (2nd harmonic) the best place to obtain the harmonic is in between frets so each fret is divided into a hundred parts.

The harmonics between the 12th and 18th are hard to isolate. It helps to pluck with a plectrum or coin and to pluck very close to the bridge.

Harmonic	Fret
1	0
2	12
3	7.02
4	4.98
5	3.86
6	3.16
7	2.67
8	2.31
9	2.04
10	1.82
11	1.65
12	1.51
13	1.39
14	1.28
15	1.19
16	1.12
17	1.05
18	0.99

The 3rd and 4th harmonics are very close to the 7th and 5th fret, only .02 of a fret away. However the 5th harmonic is flatter than the 4th fret by .14 of a fret (or 14 cents).This difference between a pure 3rd and the fourth fret is the cause of much angst. The interval between the 4th and 5th hamonic is 3.86 semitones not 4. A whole book has been devoted to this difference “How equal temperament ruined harmony” by Ross. W. Duffin

http://www.amazon.co.uk/Equal-Temperament-Ruined-Harmony-Should/dp/B001ULOPUY/ref=sr_1_3?s=books&ie=UTF8&qid=1293150835&sr=1-3