
About The Author
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Alex first picked up a bass when studying engineering at university, and his quest for sonic perfection led him to found Barefaced Audio, while also leading The Reluctant, an alt-ska/funk outfit.

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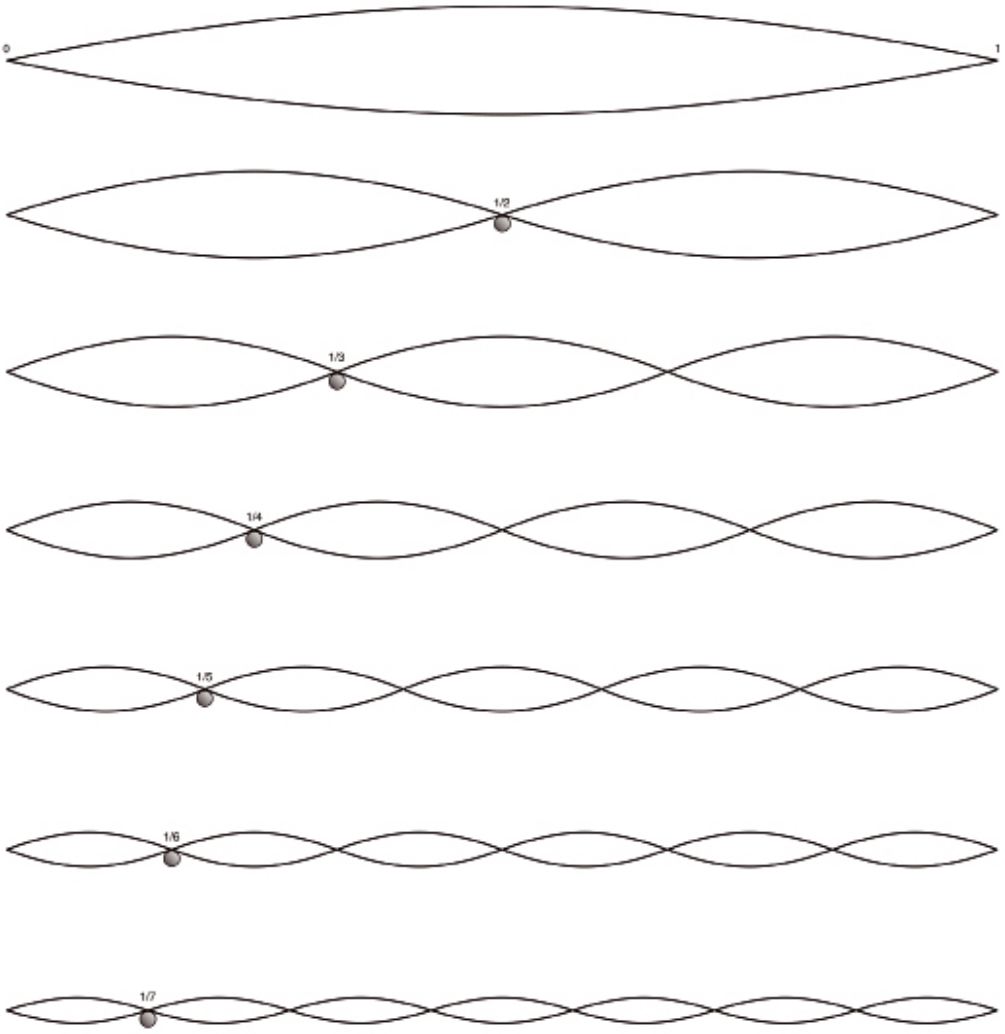
# But This Goes to 11…

## Welcome to the world of bass rigs.

Phew, that got a bit deep last time ... Hopefully you all spotted the incorrect sums where some superscripts went missing but I'm pleased to say there aren't any calculations this month! Instead we're going to step away from amplification and look at where it all starts – the strings.

The sound of a stringed instrument starts with what hits the strings, how hard it hits them, how fast it hits them, and where on the string said finger/thumb/nail/pick/hammer/drumstick* hits. This sets the string moving, generating the percussive attack of the note, and within a tiny fraction of a second the movement is pulled into a pattern determined by the tuning frequency of the string. This pattern is called the 'harmonic series' and it is the relative loudness and the envelope of each harmonic within the series, in addition to the percussive attack sound, that determines the tone (aka timbre) of the instrument (and this is true for every pitched instrument, stringed or otherwise).

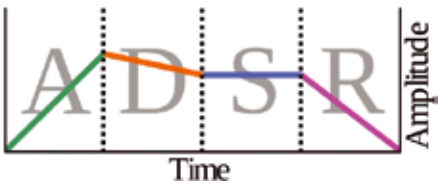



This illustration shows the first seven harmonics of a string. If we look at our A string, it's tuned to a fundamental frequency of 55 Hz – that's the frequency of the top vibration pattern shown – and this is the first harmonic of the note. The next pattern has a frequency of 110 Hz – this is the first overtone but it is the second harmonic (unsurprisingly these terms are often mixed up!). If we consider the fundamental as the root note of a chord, the second harmonic is the octave. Not much of a chord yet but here's how it continues:

| Harmonic | Overtone | Frequency | Interval |
|---|---|---|---|
| 1st | Fundamental | 55 Hz | Root |
| 2nd | 1st | 110 Hz | Octave |
| 2nd | 1st | 110 Hz | Octave |
| 3rd | 2nd | 165 Hz | Octave + Fifth |
| 4th | 3rd | 220 Hz | Two Octaves |
| 5th | 4th | 275 Hz | Two Octaves + Major Third |
| 6th | 5th | 330 Hz | Two Octaves + Fifth |
| 7th | 6th | 385 Hz | Two Octaves + Minor Seventh |
| 8th | 7th | 440 Hz | Three Octaves |
| 9th | 8th | 495 Hz | Three Octaves + Major Second |
| 10th | 9th | 550 Hz | Three Octaves + Major Third |
| 11th | 10th | 605 Hz | Three Octaves + Tritone |
| 12th | 11th | 660 Hz | Three Octaves + Fifth |
| 13th | 12th | 715 Hz | Three Octaves + Minor Sixth |
| 14th | 13th | 770 Hz | Three Octaves + Minor Seventh |
| 15th | 14th | 825 Hz | Three Octaves + Major Seventh |
| 16th | 15th | 880 Hz | Four Octaves |
| 17th | 16th | 935 Hz | Four Octaves + Minor Second |
| 18th | 17th | 990 Hz | Four Octaves + Major Second |
| 19th | 18th | 1045 Hz | Four Octaves + Minor Third |
| 20th | 19th | 1100 Hz | Four Octaves + Major Third |

If you've had the pleasure of learning music theory or know a bit about how chords are made, you'll see a correlation between the intervals that occur most frequently in the series and the consonance (that's the opposite of dissonance) and thus popularity in composition of the chords. Play the first five harmonics and you get a major chord, play the first seven and you get a dominant seventh chord, play the first nine and you get a dominant ninth chord. Nice. You might also have noticed that the overtones get much closer together in a musical sense as you go higher in the series. Indeed, if we continued our table along you'd find the 'Four Octaves +' harmonics take in every note in the chromatic scale.

We mentioned a curious word, 'envelope', earlier. This word describes the way the note starts, sustains and dies and can be basically broken into four parts – attack, decay, sustain and release.




If we slap rather than gently pluck the string we get a steeper attack, then a steep decay, then the note sustains until we mute the string and the release tends to be pretty quick (though if you're playing loud in a small room the natural feedback slows down the release phase). However, the tone of a bass isn't merely the percussive attack (which lives in the attack part of the envelope) followed by the envelope shape and the balance of harmonics within it – every single harmonic has its own unique envelope. This is where we get into the deep and mystical world of luthiery, how balancing different woods and construction techniques gets the most musical balance of harmonics and their envelopes for your needs. I have no doubt that you could do a PhD on this and barely scratch the surface – tone is the essence of music. Without tone, notes would sound unmusical, chords would not make sense and melody would be utterly bare, because within every note of a melody there is harmony happening inside that note.

How we pluck and work a note (vibrato and muting) affects the envelope and balance of all the harmonics as well as the percussive attack segment of the note. That's the origin of that 'tone is in the hands' statement – it really is true! The instrument then acts as a filter for this sound. Unfortunately, that'll have to wait until next month. But in the meantime, consider that a note is not really about the fundamental frequency but the whole harmonic series that makes up the note and makes it sound musical, which is why twisting a mid-range knob that only affects frequencies many octaves above the fundamental frequency of low B still affects the tone of that low B.