The Sine of Music

From the crass bangs by the prehistoric man to ‘Bang Bang’ by the glamorous Lolita, Nancy Sinatra, prayers as the polyphonic perfection of the Dark Ages to ‘Like a Prayer’, a dance pop anthem. In each case music was meant to set the feeling into motion, as a type of universal translator or even a message board, a snapshot of the time or a dictionary using sound as the connective tissue between words. So what about it is so universal in a way that we can comprehend the music of ancient Babylon the same way as any modern 4-to-the-floor or house beat? The answer lies in the composition of music and the meaning of sound.

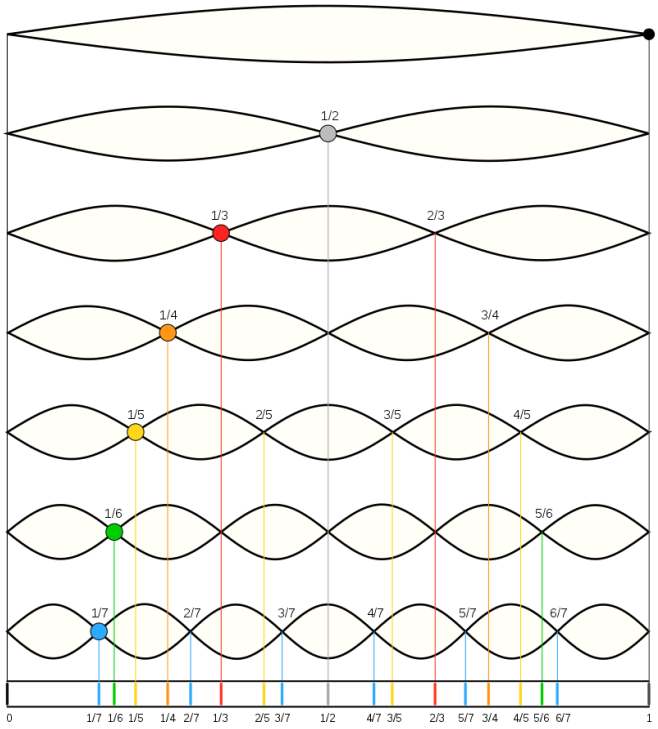
Sound is essentially any kind of vibration which can occur in any medium. So the uneven movement of particles in the air can cause the formation of sound. However, this randomness isn’t the reason we like music, nor the reason we imitate it. For us to actually comprehend a sound, that is for us to be able to repeat it, we as humans need to find an easily observable pattern which we can then replicate. When these vibrations follow a pattern, a series, that’s when we tend to acknowledge them as something more than categorical noise. This only happens when these vibrations form waves which follow mathematical functions.

Every once in a while in nature, vibrations occur evenly and periodically, moving in the form of a sine function. Sine functions describe the oscillations between the ratios of the opposite side and the hypothenuse at a certain angle, and is described with the following formula:

$$y(t) = A\sin(2\pi ft + \varphi) = A\sin(\omega t + \varphi)$$

where:

- A, amplitude, the peak deviation of the function from zero.
- f, ordinary frequency, the number of oscillations (cycles) that occur each second of time.
- ω = 2πf, angular frequency, the rate of change of the function argument in units of radians per second
- φ phase, specifies (in radians) where in its cycle the oscillation is at t = 0.



And every time the vibration follows a sine wave, we say it has a certain wavelength determined by the multiple translations and transcriptions which can be done on the sine function.

Depending on the exact shape of the function, i.e. the wavelength, the sound can vary in pitch, which gives us specific notes used in music.

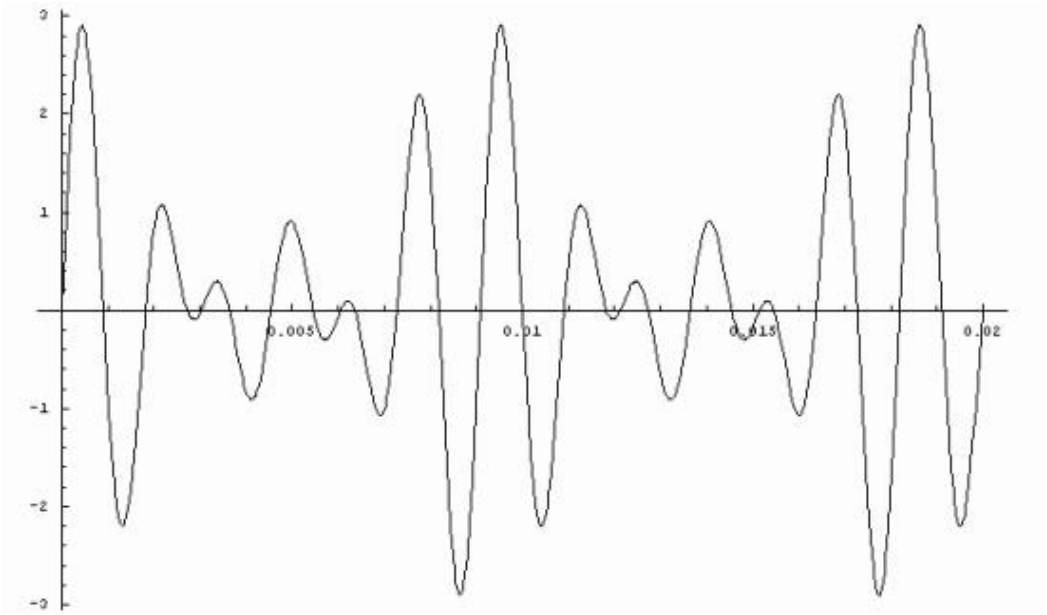
Each color on the picture represents a different wavelength which corresponds to a specific note. The periodic property of the sine wave allows us to have octaves, which means that every eighth note repeats.

When we show that even the most artistic and unique aspects of life can be proven using mathematical formulae, it seems absurd to associate something personal to the generality of a formula. But, music isn't just a few notes, it's the way they correlate to one another, the relationship, the harsh consonants they can produce, the melodramatic sequence which resembles a sentence. Specific wavelengths describe specific notes, but once we put them together or even on top of one another we get a whole new set of words. So even with a limited number of notes, the stories they can tell are endless.

These stories can describe something tense, melancholic, grotesque, often using specific notes which clash with each other, giving this feeling of unease, but they can also provide moments of tenderness, love and beauty. For the latter, mathematical patterns and preciseness is used, forming something called harmonies.

Harmonies consist of harmonics, which are essentially integer multiples of the original sine function, called a fundamental function. For example, if the fundamental frequency is 50 Hz, the frequencies of the first three higher harmonics are 100 Hz (2nd harmonic), 150 Hz (3rd harmonic), 200 Hz (4th harmonic) and any addition of waves with these frequencies is periodic at 50 Hz. Specific fundamental sine functions along with specific integers form something known as a scale, a sample of notes which is used whenever a specific feeling is meant to be evoked. Some of the most notable ones are Minor 3rd scale (mellow, sorrowful sounds), Tritone (disturbing, violent), Major 6th (happy, concord) etc.

When three notes of the same scale, i.e three harmonics are played at the same time, a harmony is achieved. This is an example of a A-C#-E chord (part of A-major scale)



$$y=(\sin(220(2Pix)))+(\sin(277.187(2Pix)))+(\sin(329.63(2Pix)))$$

Note: When a harmony is achieved through chords it is no longer a sine function, but it is periodical

Chords can also be stacked next to each other to form a full composition. They are the simplest way to form a harmony, incorporating melodies and duration to form beats while making a cohesive structure.

When a simple chemical/physical occurrence, a random happenstance, follows the universal laws of mathematics, it gains all of the integrated univerality and becomes something just as timeless and precise. Music is essentially just a combination of different sine functions, but when you combine the different ways you can transform those functions to achieve sound with a pitch, with the number of combinations and durations each of those notes can form you gain a myriad of possibilities. However, when you add the subjective factor, the human interpretation, music truly becomes a language of its own, one which is dictated by the laws of mathematics.

We as humans might never achieve perfection in the most true meaning of the word, but music as a derivative of barely comprehensible aspects of life, which are the definition of perfection, is as close as we're ever going to get.

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