2018

Science in Music

Joy Lee
Parkland College

SCIENCE IN MUSIC

By: Joy Lee

Chemistry 101

24 October 2018

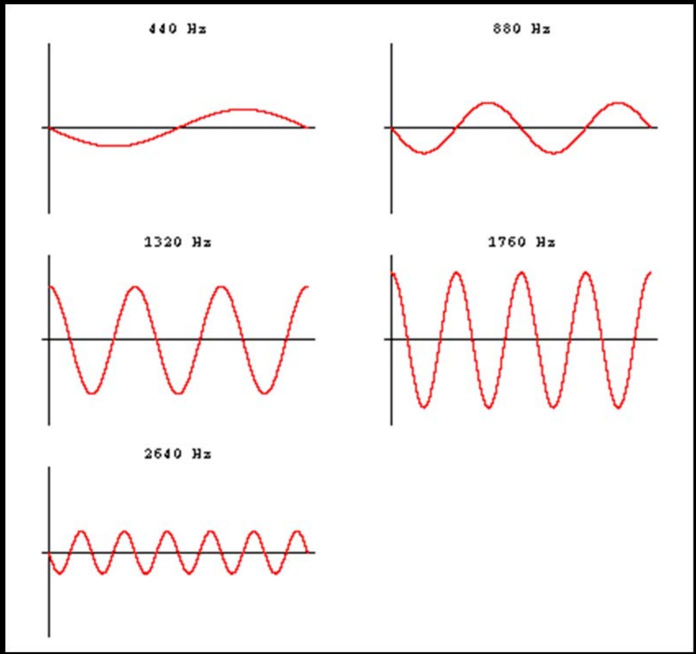
WHY MUSIC IN CHEMISTRY?

- Why is this student talking about music when it is a chemistry project?
- Did you know that sound is energy? And it has a measurement?
- Did you see any video of a person breaking a glass by screaming?

FREQUENCIES OF VIBRATION

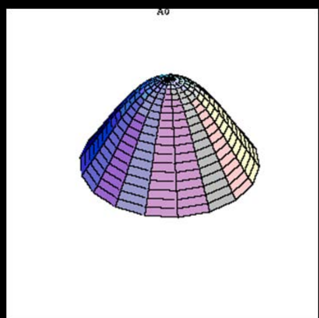
- Vibration is energy. Sounds have vibration, which means that they produce energy(Hungerford).
- The frequency of sound is measured in Hertz(Hz), also known as 1/seconds (Burdge, Julia, and Jason 62).
- Thus, the sound can be modelled depending on their Hz. The sound is travelling so it going up and down(Harrison).

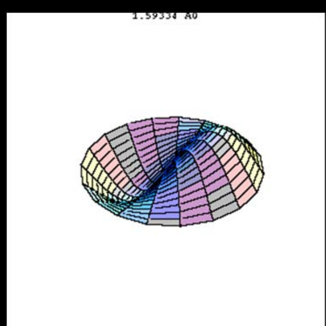
2D representation



(Harrison)

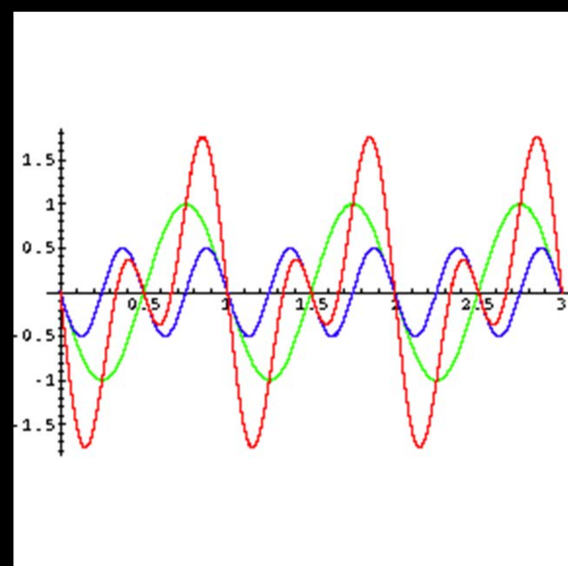
MODELS OF SOUNDS





3D Models

- When different sounds meet and make harmony, they create a totally different frequency.



Green- fundamental
Blue- harmonic
Red-sum of both

(Harrison)

SOUND'S WAVELENGTH

- The speed of sound in 20 degrees Celsius is 343 m/s(Elert).
- The range of human's hearing is from 20Hz to 20,000Hz(Elert).

$c=\lambda v$
c: speed
λ: Wavelength
v: Frequency

343m/s = 20Hz(λ)

343m/s = 20,000Hz(λ)

Range of the wavelength is 17.15m>λ>1.715cm

(Burdge, Overby 62)

FREQUENCY FOR NOTES

- Many instruments are tuned with A4 or middle C.
- A4 has 440Hz and C4 has 261.63Hz, which are between the Hertz that humans can hear.
- If you noticed with the table, C4's frequency is twice as C3's frequency, and A4's frequency times 16/27 is equal to the the frequency of C4.

Note	Frequency	Note	Frequency
C3	130.81	C4	261.63
D3	146.83	D4	293.66
E3	164.81	E4	329.63
F3	174.61	F4	349.23
G3	196	G4	392
A3	220	A4	440
B3	246.93	B4	493.88

(Musical Note Sounds, Pitches & Their Frequency)

HISTORY OF MUSICOLOGY

Pythagoras

- Pythagoras is mostly known as a Greek mathematician who discovered Pythagorean theorem(O'Connor, Robertson).
- One day Pythagoras was walking past a brazier's shop where he heard the harmony of the workers pounding with large hammers and got interested as a person who believed in beauty. Then he realized that the sounds of the pounding were different regarding to the composition, size, and weight of the metals.After observing with curiosity, he discovered the Pythagorean scale(The Pythagorean Theory of Music and Color).

(Pythagorean Hammers)

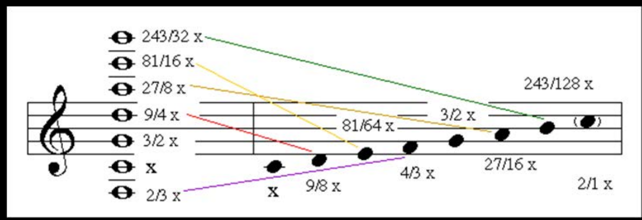
PYTHAGORAS SCALE

- He found the consonance of two notes has the difference of frequency ratio of 3:2.
- Listen to the recordings and guess which one is the consonance. Even try to guess what notes are being played.

(The Pythagorean Theory of Music and Color)

1.

2.



(Bain)

ANSWER

- The answer for the previous slide is the second one. The second one was C and G which have the ratio of 3:2 making it a perfect fifth*.
- The first recording was C and D, which is not a constancy.

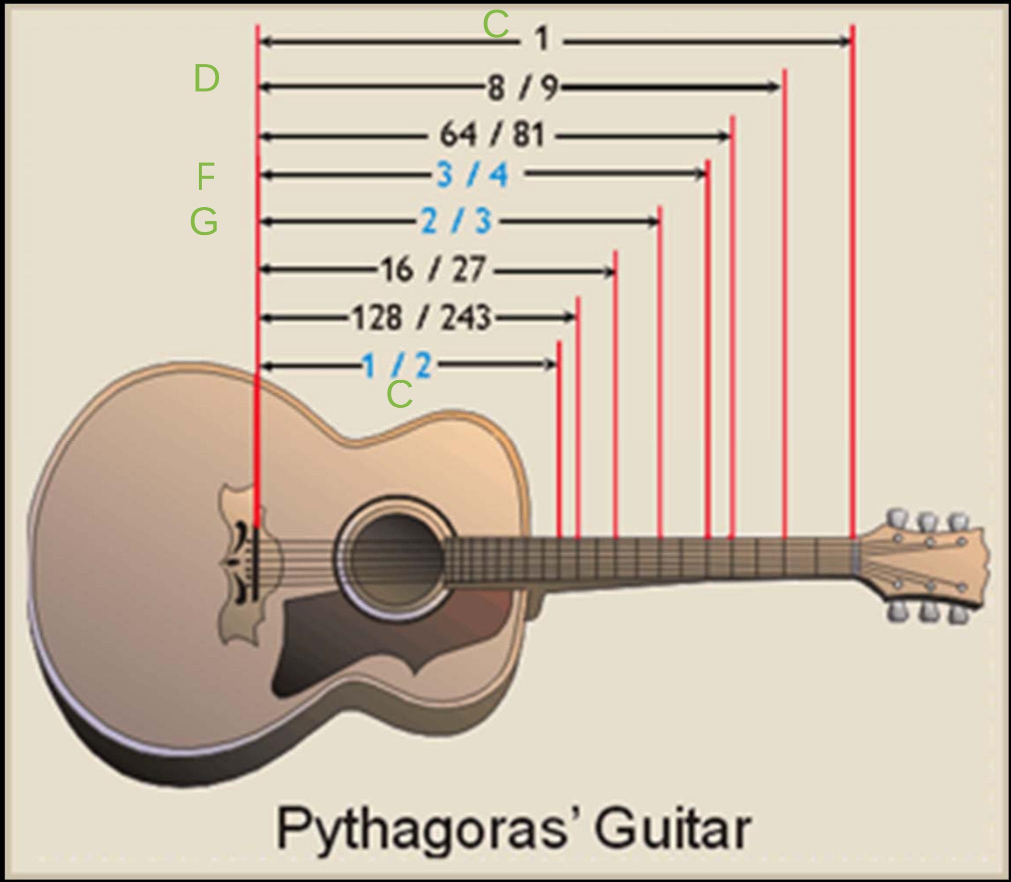
(The Pythagorean Theory of Music and Color)

*This is where fifth harmony came from

WITH THE PYTHAGORAS SCALE, WE CAN THE RATIO BETWEEN NOTES.

One octave has the difference ratio of ½.

If you start with do and want raise five notes to sol, you have to hold the place where it is 2/3 of the strong. And if you raise four notes from do to fa, you should hold the 3/4 of the string. Thus, if you start with sol and want to go down four notes. You have to multiply 2/3 with 4/3, making it 8/9, which is re.



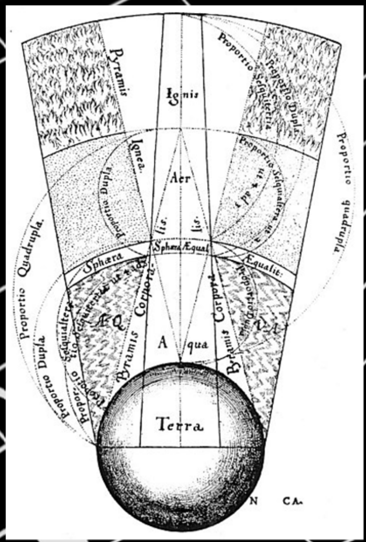
(The Pythagorean Theory of Music and Color)

(Harrison)

MUSIC NOTES

Father of Greek Music

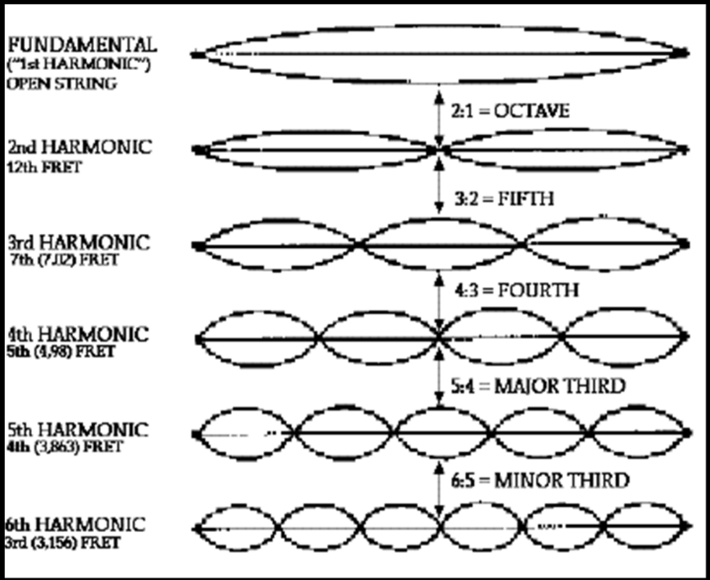
- Pythagoras's discovery of the scale made a huge impact in music history because he identified the clear distinction among notes.
- This might be the reason that some of the traditional non-Western music can sound uncomfortable since the notes they used might not even be on the scale.



(The Pythagorean Theory of Music and Color)

SIMPLE NOTES CREATING HARMONY

- After Pythagoras's discovery in musicology that was more than two thousand years ago, it continued to develop until today. Since he noticed that perfect fifth, other harmonies were noticed depending on their ratio (The Pythagorean Theory of Music and Color.
- Harmony and cords are important in music and even in electronic dance music. And patterns of music is continuously being studied(Conklin 1).



(Guy)

CHORD SEQUENCE

The problem repetition in music like electronic dance music loops wouldn't able to be solved with the pervasive types, n-gram and context-free grammar. Thus, Conklin did a study to partially solve this problem by using patterns and diatomicity of plug in. In his methods, he showed patterns between cords including major and minor ones.

$$\mathbb{P}(\boldsymbol{d},\boldsymbol{c}) = \mathbb{P}(d_1 \ldots d_\ell) \times \mathbb{P}(c_1 \ldots c_\ell \mid d_1 \ldots d_\ell) \approx \prod_{i=1}^{\ell} \mathbb{P}(d_i) \times \mathbb{P}(c_i \mid d_i, h_i)$$

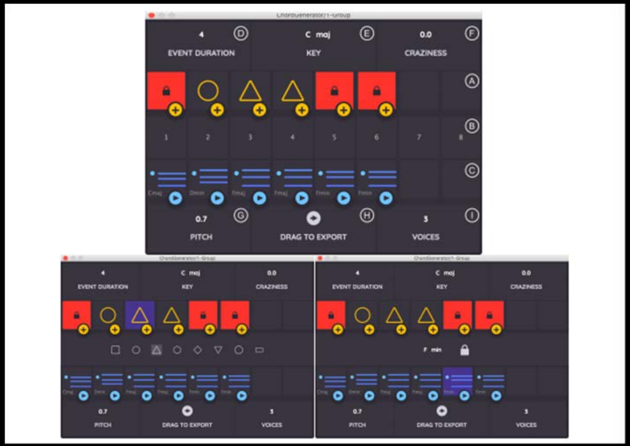
chord	A♭M	G♭M	F♭M	E♭m	D♭m	F♭M	G♭M	A♭M
root	A♭	G♭	F♭	E♭	D♭	F♭	G♭	A♭
qual	M	M	M	m	m	M	M	M
crm	⊥	m7	m7	m7	m7	m3	M2	M2
cqm	⊥	MM	MM	Mm	mm	mM	MM	MM
crm ⊗ cqm	⊥	m7,MM	m7,MM	m7,Mm	m7,mm	m3,mM	M2,MM	M2,MM
pattern	◇	○	□	△	▽	□	○	◇

This table shows different patters of the cords.

(Conklin 1-3)

PLUG-IN: FEEDBACK

- Each of the variable has different probability generation, which can change, lock and unlock chord in the sequence. After describing the plug-in, feedbacks were received by users. Some of the users had problems in using it when others didn't, but many complimented the intuitive design for being simple to use.



Variables when used for electronic dance music

(Conklin 7-10)

WORK CITATION

- *The Human Hearing Range - What Can You Hear?*, Widex, www.widex.com/en-us/blog/the-story-of-sound/human-hearing-range-what-can-you-hear.
- Bain, Reginald. *BAIN: A Pythagorean Tuning of the Diatonic Scale*, 24 Sept. 2002, in.music.sc.edu/fs/bain/atmi02/pst/index.html.
- Burdge, Julia, and Jason Overby. Chemistry: Atoms First. McGraw-Hill Education, 2018.
- Conklin, Darrell, et al. "Creative Chord Sequence Generation for Electronic Dance Music." *Applied Sciences*, vol. 8, no. 9, 2018, p. 1704., doi:10.3390/app8091704.
- Hungerford, Del. "Energy Is Frequency." *Healing Frequencies Music*, 22 Nov. 2015, www.healingfrequenciesmusic.com/energy-is-frequency/.
- Elert, Glenn. "Frequency Range of Human Hearing." *Frequency Range of Human Hearing - The Physics Factbook*, hypertextbook.com/facts/2003/ChrisDAmbrose.shtml.
- Elert, Glenn. "Speed of Sound in Air." *Speed of Sound in Air - The Physics Factbook*, hypertextbook.com/facts/2000/CheukWong.shtml.
- Guy, Paul. *Tuning and Temperament*, www.guyguitars.com/eng/handbook/Tuning/temperament.html.
- Harrison, David M. *Standing Waves*, 24 Mar. 2003, faraday.physics.utoronto.ca/PVB/Harrison/Vibrations/Vibrations.html.
- "Musical Note Sounds, Pitches & Their Frequency." *Piano Music Theory*, 2 July 2018, piano-music-theory.com/2016/05/29/musical-note-sounds-pitches-and-their-frequency/.
- "'Music.'" *Royalty Free Stock Video, Footage, Backgrounds and More*, www.videoblocks.com/videos/motion-backgrounds/music.
- O'Connor, J J, and E F Robertson. "Pythagoras of Samos." *Pythagoras Biography*, School of Mathematics and Statistics University of St Andrews, Scotland, www-groups.dcs.st-and.ac.uk/history/Biographies/Pythagoras.html.
- "Pythagorean Hammers." *Wikipedia*, Wikimedia Foundation, 20 May 2018, en.wikipedia.org/wiki/Pythagorean_hammers.
- "The Pythagorean Theory of Music and Color." *Secret Teachings of All Ages: The Pythagorean Theory of Music and Color*, www.sacred-texts.com/eso/sta/sta19.htm.