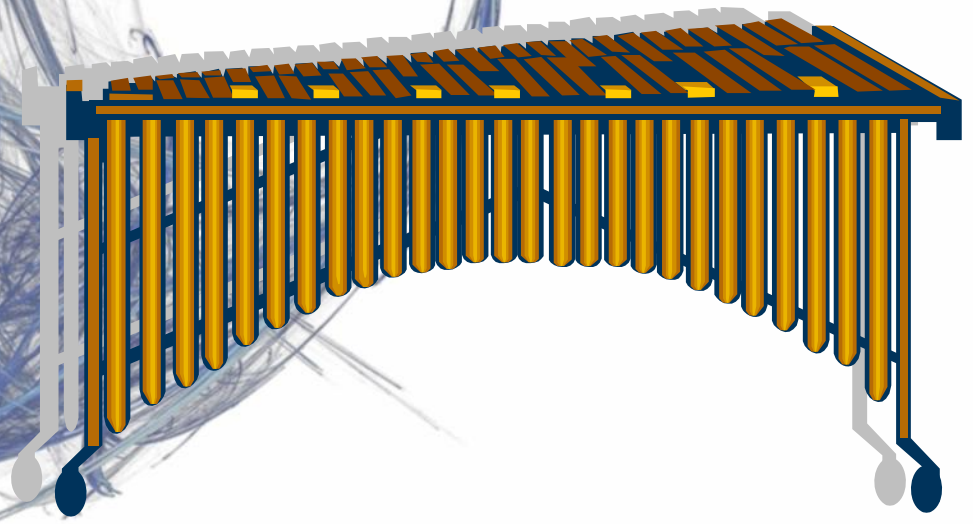


Harmonic Analysis of Mallet Percussion

By Max Candocia





Goals

- Basic understanding of sound waves and mallet percussion
- Understand harmonic analysis
- Understand difference in sounds of different mallets and striking location

Marimba 📣

Recording: Vermont Counterpoint, Nathaniel Bartlett



Photo courtesy of vichitex.com

Vibraphone 📣

Recording: La Fille Aux Cheveux de Lin, Ozone Percussion Ensemble



Photo courtesy of woodbrass.com

Xylophone 🥁

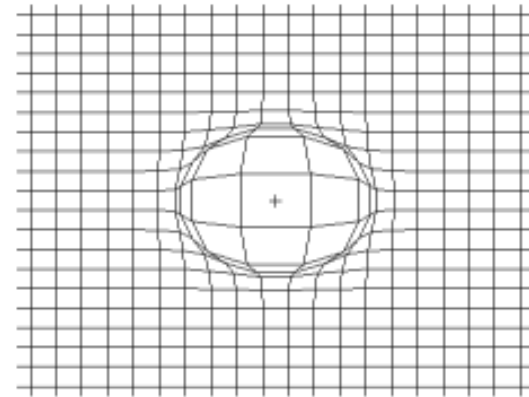
Recording: Fantasy on Japanese Wood Prints





Photo courtesy of onlinerock.com

Sound Waves

- Vibrating medium (ie. Air, water, ground)
- Longitudinal
- Harmonics
 - Sinusoidal Components



Sine: 
Sawtooth: 

Images courtesy of Wikipedia

Qualities of Harmonics

- Frequency

- Cycles per second (Hertz); determines pitch

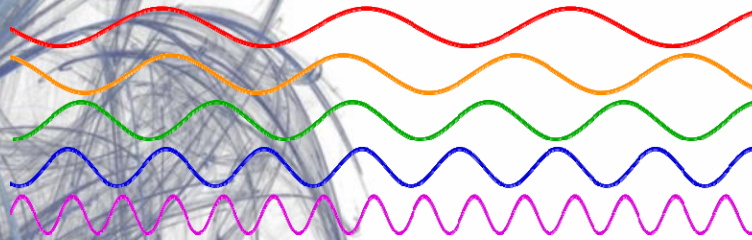


Photo courtesy of Wikipedia

- Amplitude

- Power of wave; determines loudness

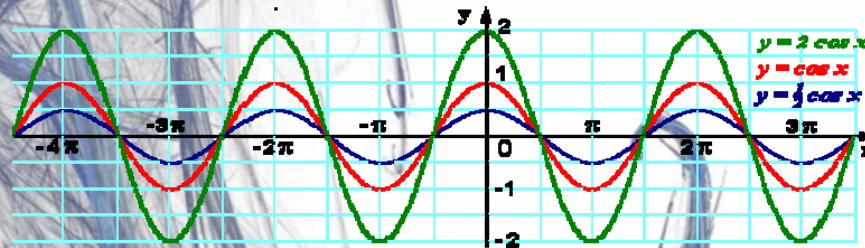


Photo courtesy of physics.cornell.edu

- Phase

- Location of harmonic relative to other harmonics

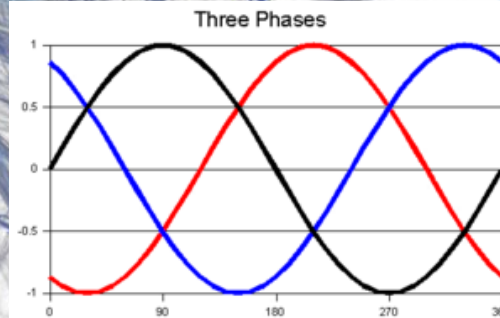
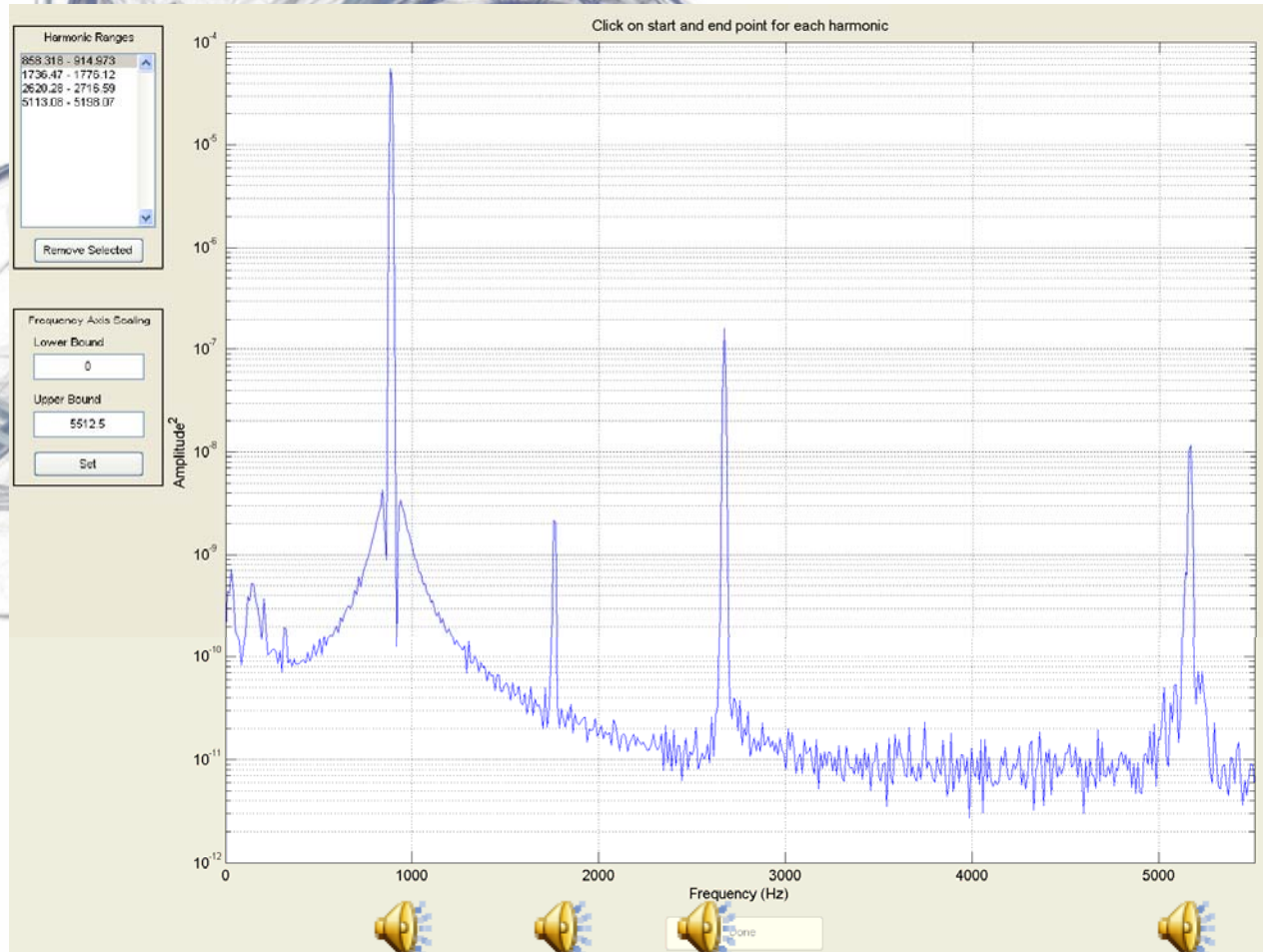


Photo courtesy of 3phasepower.org

Harmonic Analysis

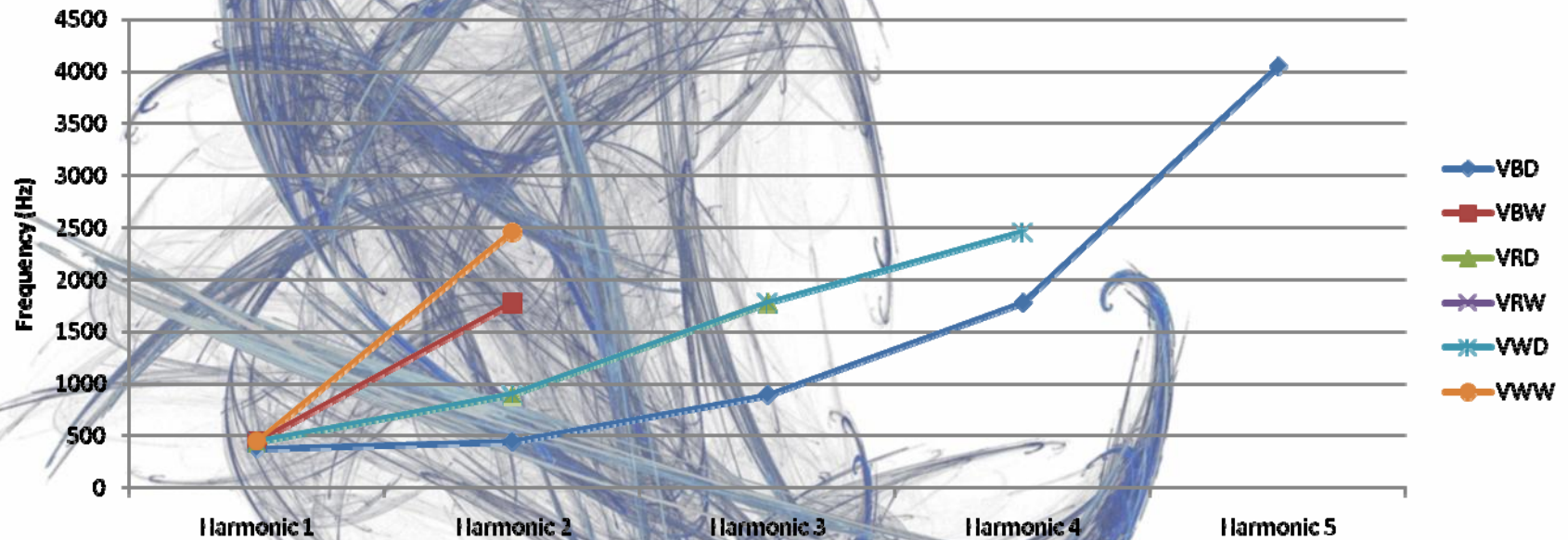


Harmonics of Kelon xylophone struck in center with hard rubber mallet

Vibraphone Harmonics

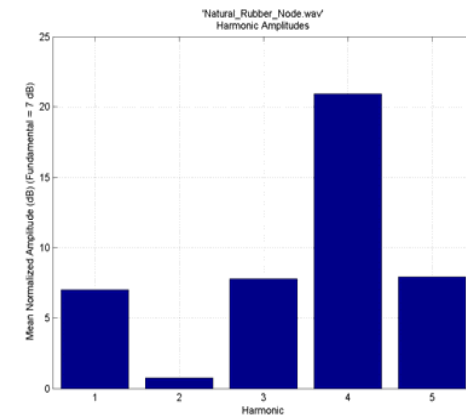
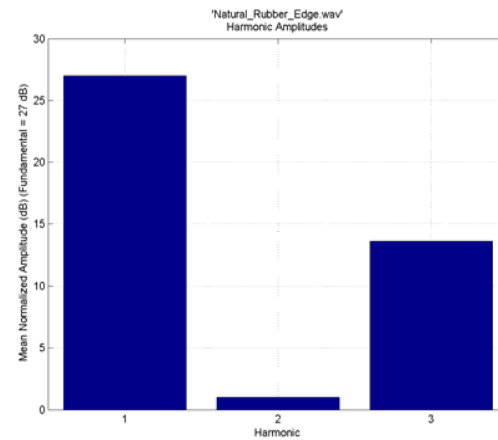
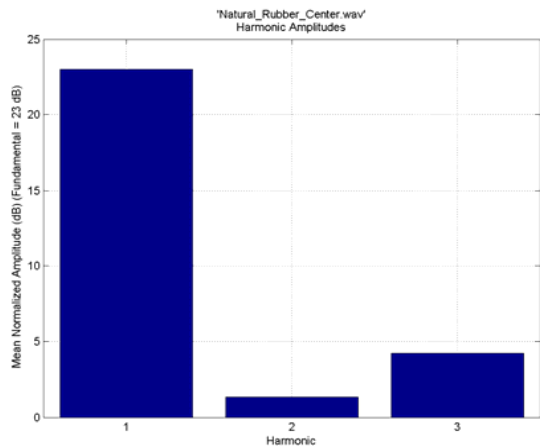
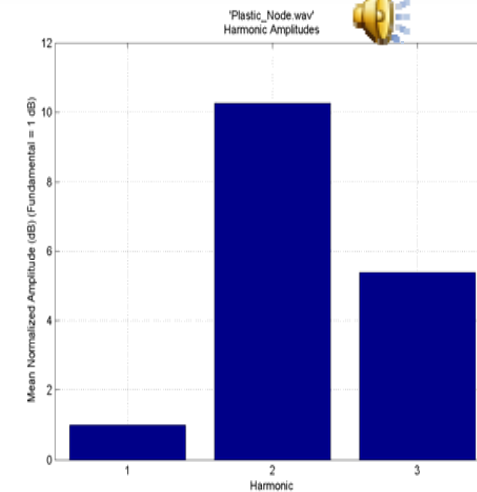
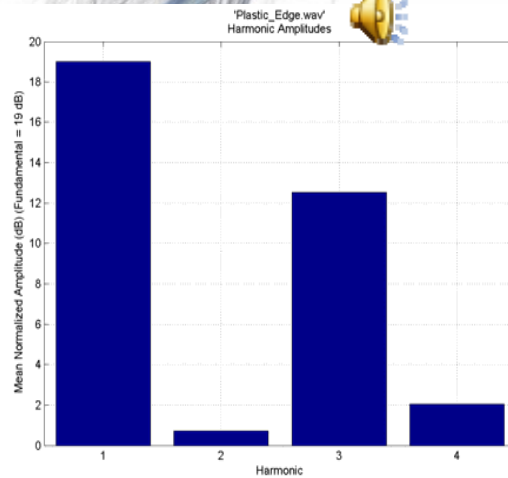
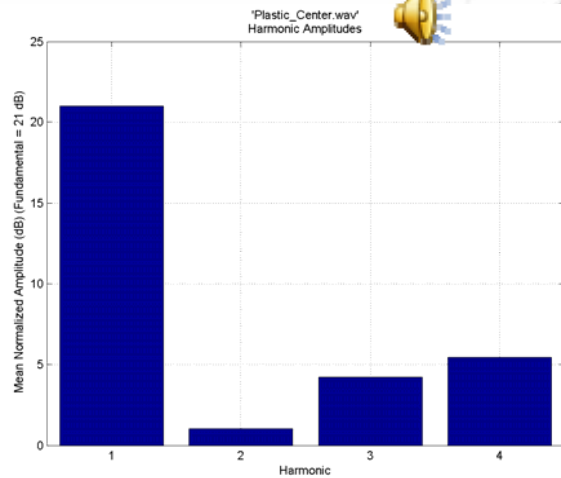
Wet: 

Harmonics and Frequencies of Vibraphone Struck with Mallets



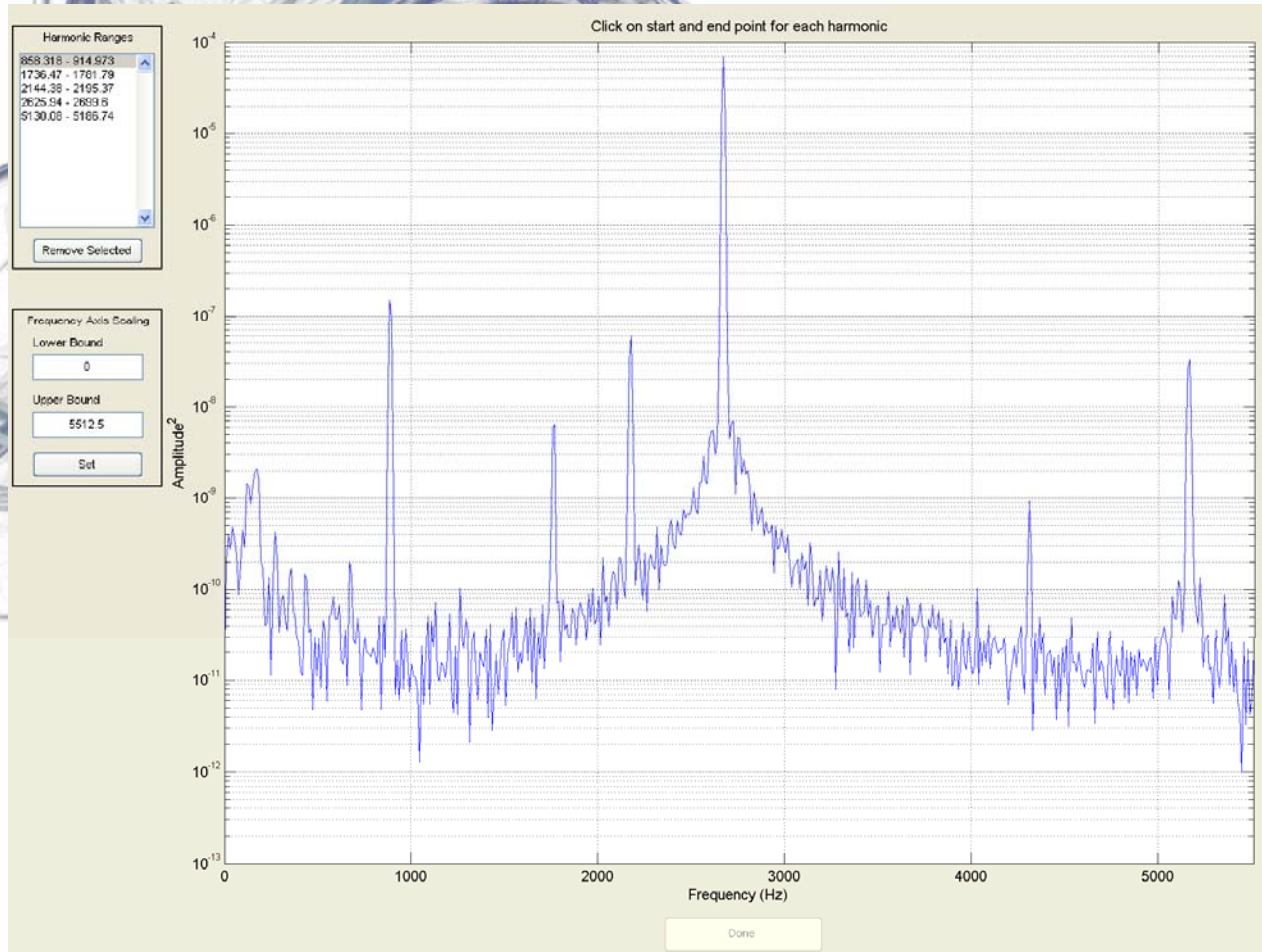
Instrument	Mallet	Location	# Harmonics	H1 dB	H2 dB	H3 dB	H4 dB	H5 dB
Vibraphone	Black	Dry	5	6	19	0.8	13	3
Vibraphone	Black	Wet	2	16	1.1			
Vibraphone	Red	Dry	3	22	3.5	1.5		
Vibraphone	Red	Wet	1	1				
Vibraphone	White	Dry	4	16	0.5	9	0.6	
Vibraphone	White	Wet	2	25	1.5			

Xylophone Harmonics

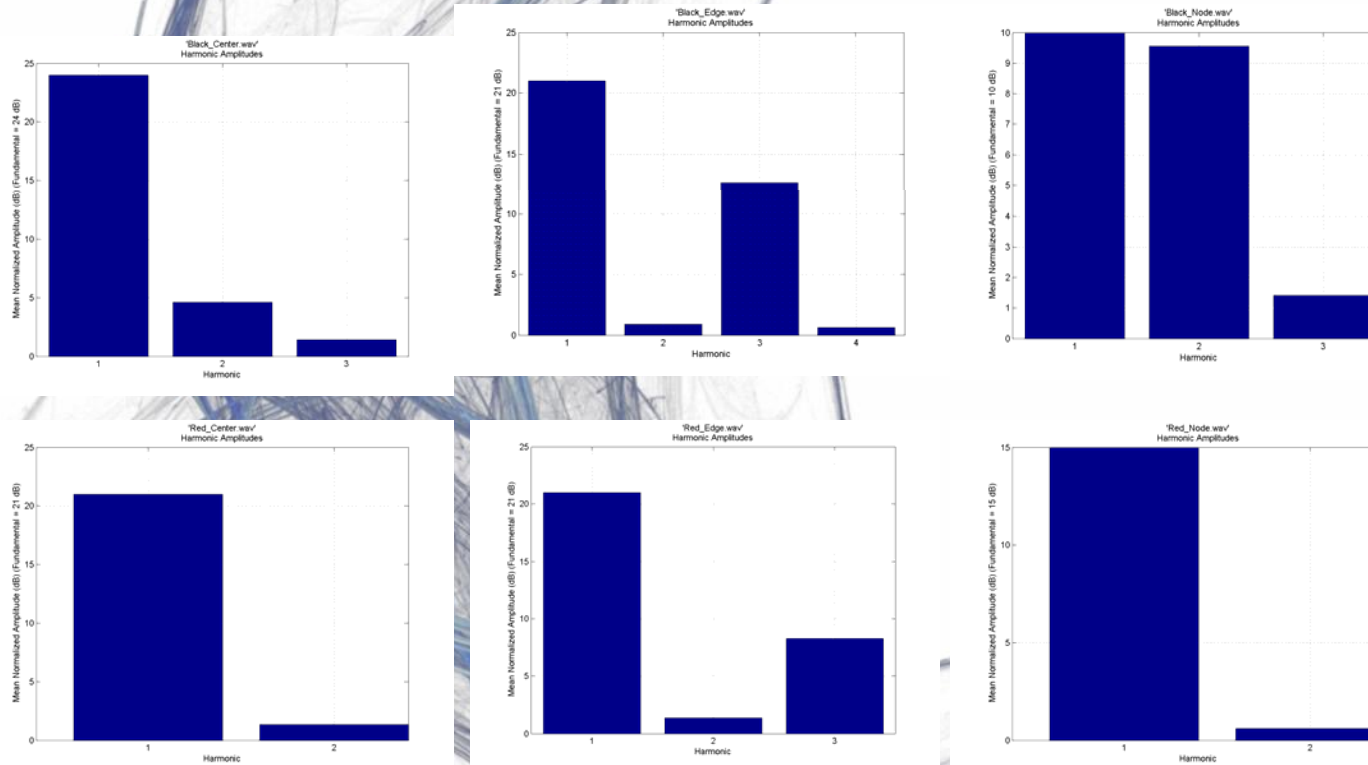


Instrument	Mallet	Location	# Harmonics	H1 Freq	H2 Freq	H3 Freq	H4 Freq	H5 Freq
Xylophone	Hard Rubber	Center	4	886.9	1750	2670	5100	
Xylophone	Hard Rubber	Edge	4	886.9	1760	2670	5150	
Xylophone	Hard Rubber	Node	3	886.85	2670.5	5155		
Xylophone	Natural Rubber	Center	3	886.9	1750	2670		
Xylophone	Natural Rubber	Edge	3	886.95	1760	2670		
Xylophone	Natural Rubber	Node	5	887	1759	2167	2670.5	5150
Xylophone	Plastic	Center	4	886.9	1750	2670	5100	
Xylophone	Plastic	Edge	4	886.95	1760	2670	5170	
Xylophone	Plastic	Node	3	886.85	2670.5	5200		

On the Node

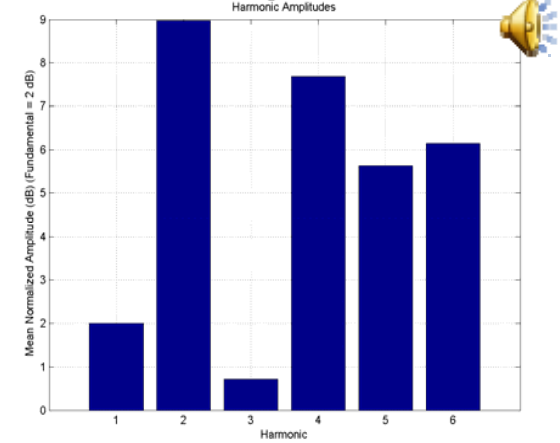
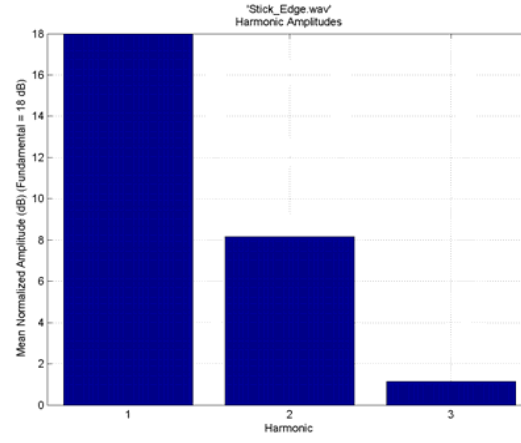
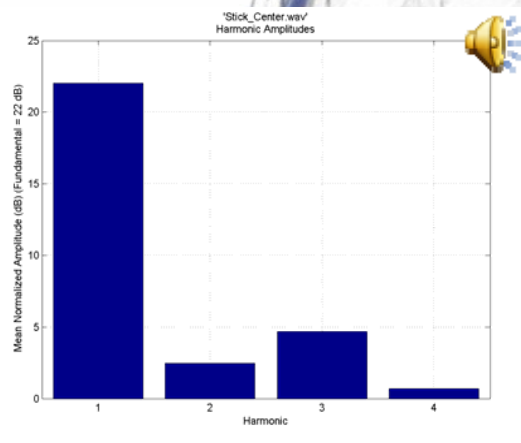


Marimba Harmonics



Instrument	Mallet	Location	# Harmonics	H1 Freq	H2 Freq	H3 Freq	H4 Freq
Marimba	Black	Center	3	221.5	665	990	
Marimba	Black	Edge	4	221.4	665	885	2240
Marimba	Black	Node	3	221.5	885.5	2210	
Marimba	Red	Center	2	221.6	664		
Marimba	Red	Edge	3	221.4	664	885.5	
Marimba	Red	Node	2	221.5	885		

Using a Stick on Marimba



Instrument	Mallet	Location	# Harmonics	H1 Freq	H2 Freq	H3 Freq	H4 Freq	H5 Freq	H6 Freq
Marimba	Stick	Center	4	222	2100	2210	2400		
Marimba	Stick	Edge	3	221.5	885	2205			
Marimba	Stick	Node	6	221	855.3	2064	2210	3900	4460



Conclusion

- Sounds made of harmonics
- Relative phase has no apparent pattern in mallet percussion
- Vibraphone very simple sound when wet, more complicated when dry
- Soft mallets on marimba and vibes induce sounds with less harmonics
- Xylophone has different sounds depending on striking location
- Harder mallets on marimba produce trends in harmonics similar to xylophone

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- Thanks to:
 - Professor Steve Errede
 - Adam Watts
 - Dan Carson
 - 3M



Richard Feynman playing conga; photo
courtesy of physics.miami.edu