The Kazoo

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Abstract: The goal of this lab was to analyze how one kazoo (which I believed to be unwanted party favors) differs from another kazoo made from the same material, as well as if it would be entertaining to study. Based on my data, I concluded that while kazoos may sound effectively the same to the average listener, the harmonics and phases of the two materials noticeably vary. Also, it *was* pretty entertaining doing this lab.

Instrument: The kazoo is a musical instrument that uses a very thin membrane to achieve the desired buzzing noise. The noise is activated when the player hums into the kazoo, which vibrates the membrane. The instrument, or rather, the concept of using the membrane for musical purposes originated in Africa, hundreds of years ago. However, the kazoo as we know it was first manufactured in the US in 1883 (link here), but the design was altered to familiar submarine style in the early 1900's (other link). The kazoos used in this lab are primarily made from either plastic or metal, as shown here:

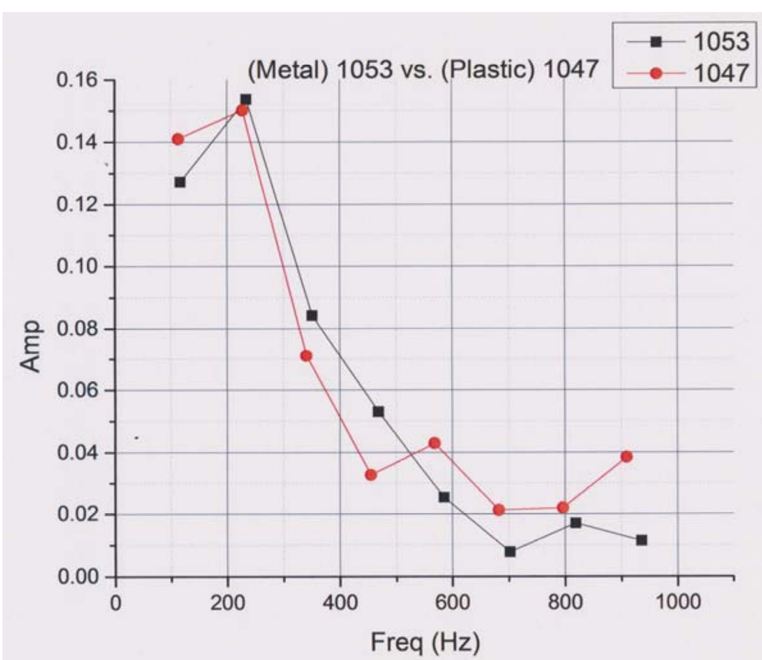
Setup: Not much was required to begin work on this lab. First, I had to order some kazoos. If nothing else, I wanted to study the makeup of two different kazoos, so I ordered a plastic kazoo and a metal kazoo. Next, I realized I needed to learn how to play the kazoo. Fortunately for me, kazoos are not difficult instruments to learn, and it took about 10 minutes to get used to the things. Finally, I acquired some recording hardware from Prof. Errede, and I made my way into an isolated room to record my sound data.

Procedure: Initially, a TA and I moved to an isolated room so as to remove as much background noise as possible (this attempt fails, as will be pointed out later). The TA sets up the recording device, and I play a single note multiple times, each time the same note for about 5 seconds. I took 6 recordings total, 3 recordings of my plastic kazoo, and 3 recordings of my metal kazoo. However, during these recording sessions, there was a fan blowing through the air ducts that neither the TA or myself could notice, and we were only notified of them via Prof. Errede a week later. The white noise, we were told, actually influenced a not-insignificant amount of background noise in my recordings, and I was forced to scrap them.

Next week fared better, with the ambient noise at a minimum (for the building), so I made 15 new recordings: 6 from my plastic kazoo, 6 from my metal kazoo, and 3 that I purposefully did not keep track of, to see if I could eventually use analysis data to distinguish them. After making the recordings, I uploaded the digital copies of the recordings onto the lab computers, where I ran them through the MATLAB wave-analysis program. This created a list of raw, numerical data that I was able to enter into the Origins graphing program.

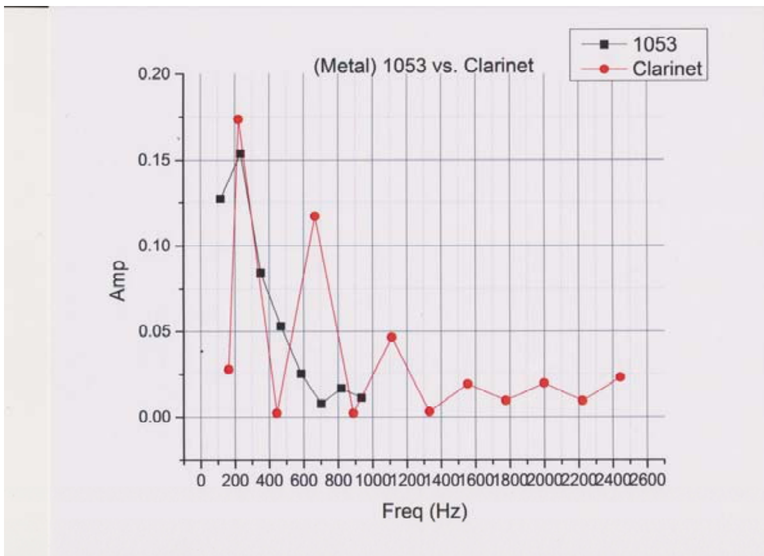
	Amp 1053	Freq Hz 1053	Phase Deg 1053	Amp 1047	Freq Hz 1047	Phase Deg 1047	Freq Hz	Amp 1053	Amp 1047	Phase Deg 1053	Phase Deg 1047	Amp Clarinet	Freq Hz Clarinet	Freq Hz	Amp 1053	Amp Clarinet
1	0.12731	117.029	170.8036	0.14097	113.768	139.0919	117.029	0.12731		170.8036		0.02785	163.9895	117.029	0.12731	
2	0.15369	234.0635	259.1741	0.15019	227.5509	7.21141	234.0635	0.15369		259.1741		0.17361	222.2171	234.0635	0.15369	
3	0.08423	351.0938	431.73	0.07112	341.3164	138.9251	351.0938	0.08423		431.73		0.00232	444.3323	351.0938	0.08423	
4	0.05305	468.1352	578.7377	0.0327	455.1596	20.0558	468.1352	0.05305		578.7377		0.11723	666.6074	468.1352	0.05305	
5	0.02532	585.1472	411.6339	0.04296	568.8445	240.6015	585.1472	0.02532		411.6339		0.00224	888.7247	585.1472	0.02532	
6	0.00779	702.2313	698.493	0.02124	682.5829	39.42259	702.2313	0.00779		698.493		0.04651	1111.054	702.2313	0.00779	
7	0.01699	819.2207	550.287	0.02193	796.6159	147.7492	819.2207	0.01699		550.287		0.00312	1331.842	819.2207	0.01699	
8	0.01134	936.2463	699.2621	0.03842	910.1359	295.7389	936.2463	0.01134		699.2621		0.01931	1555.456	936.2463	0.01134	
							113.768		0.14097		139.0919	0.0096	1778.304	163.9895		0.02785
							227.5509		0.15019		7.21141	0.01978	2000.224	222.2171		0.17361
							341.3164		0.07112		138.9251	0.00939	2223.268	444.3323		0.00232
							455.1596		0.0327		20.0558	0.02317	2444.269	666.6074		0.11723
							568.8445		0.04296		240.6015	--	--	888.7247		0.00224
							682.5829		0.02124		39.42259	--	--	1111.054		0.04651
							796.6159		0.02193		147.7492			1331.842		0.00312
							910.1359		0.03842		295.7389			1555.456		0.01931
														1778.304		0.0096
														2000.224		0.01978
														2223.268		0.00939
														2444.269		0.02317

After creating a number of graphs comparing my metal and plastic kazoos, I used some acoustic data in the MATLAB data base (more specifically, a clarinet playing a B-flat) and compared that acoustic data to my own. I determined the B-flat note after looking over my graphs, which can be view as such:

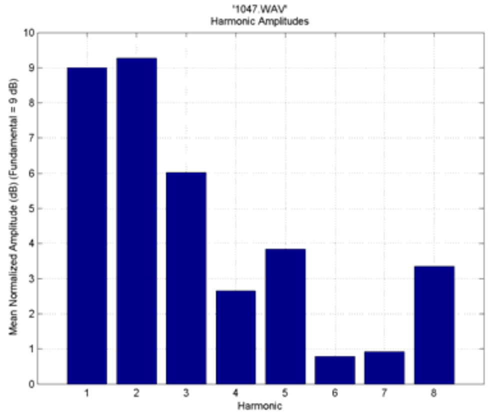


As seen by the graph above, the amplitude peaks at the second harmonic, which is at frequency 234 Hz for the metal kazoo, and 227 Hz for the plastic kazoo. These frequencies are very close to what the clarinet considers a B-flat (222 Hz), so it made sense that the notes were most likely B-flats. I then copied the data from the clarinet files and compare them to my kazoos in the Origins program, and graphed/printed them.

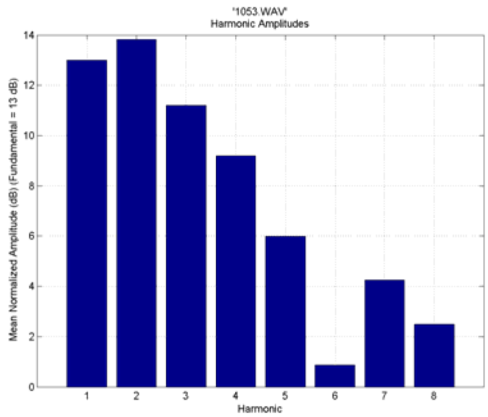
<u>Conclusion:</u> As seen by this graph:



the greatest amplitudes come from the B-flat (Bb) frequencies. But more importantly, the differences between a metal and plastic kazoo are actually quite noticeable. Not audibly, anyway; both kazoos sound enough alike that it's fairly difficult to differentiate between the two. Actually, the harmonics between the two vary by a not-insignificant margin. Take the harmonics of the plastic kazoo:

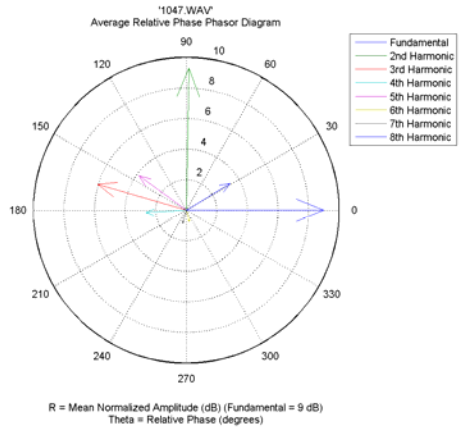


…and the metal kazoo:

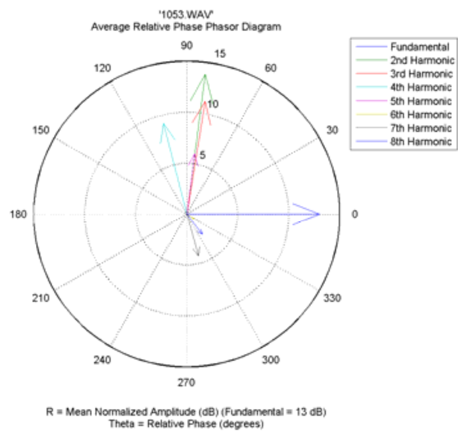


The behavior of the harmonics are incredibly different as you reach higher harmonics. The metal kazoo has an almost linear drop in harmonic amplitude, while the plastic kazoo seems a bit more... wild.

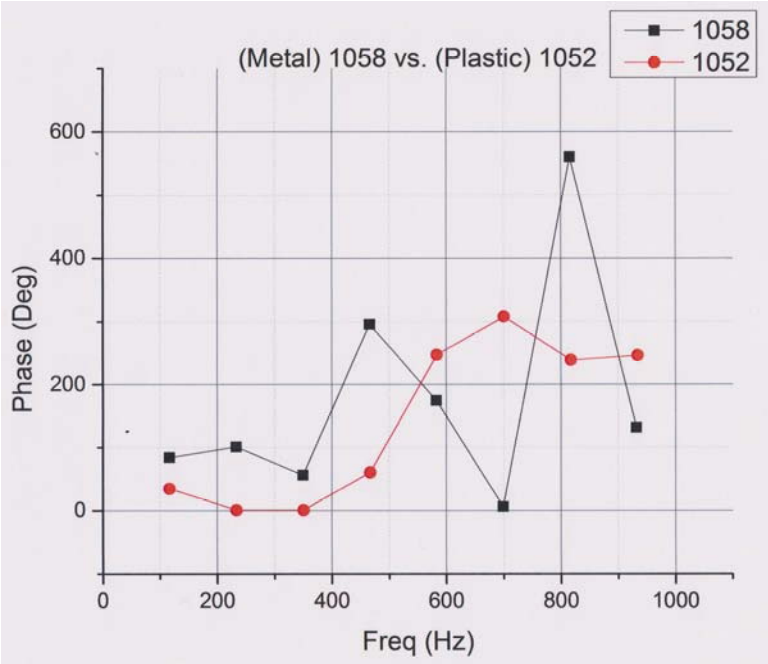
Not only are the harmonics different, but the phases between each kazoo is different, and quite so. Here is a radial-polar graph of the plastic kazoo's phases for each harmonic:

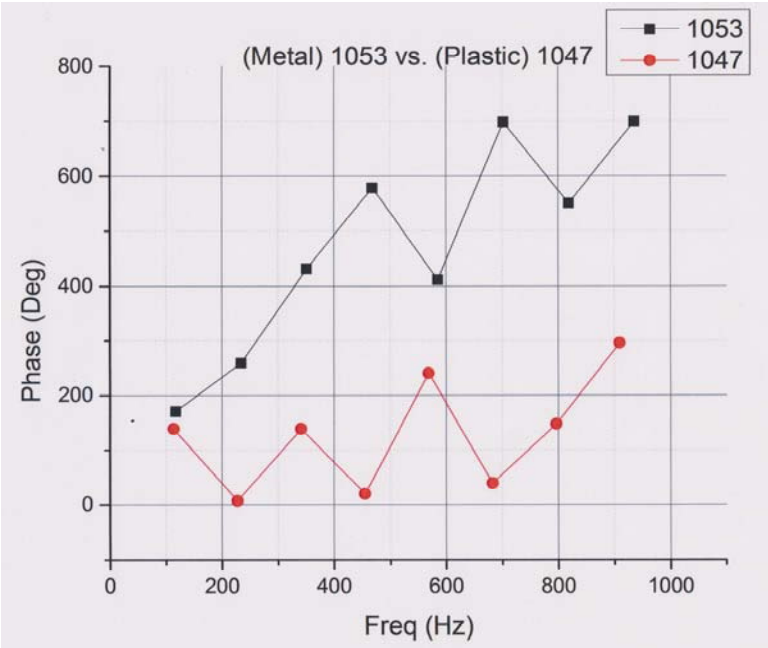


and then here is another graph of the metal kazoo's phases for each harmonic:



Put simply, the way the overall shapes of the phasors are between the graphs indicate that each kazoo vibrates completely differently, which probably shouldn't come as much of a surprise, considering the materials that make up both are completely different. And consider the amount of phase itself, for each kazoo. Comparing these two graphs:

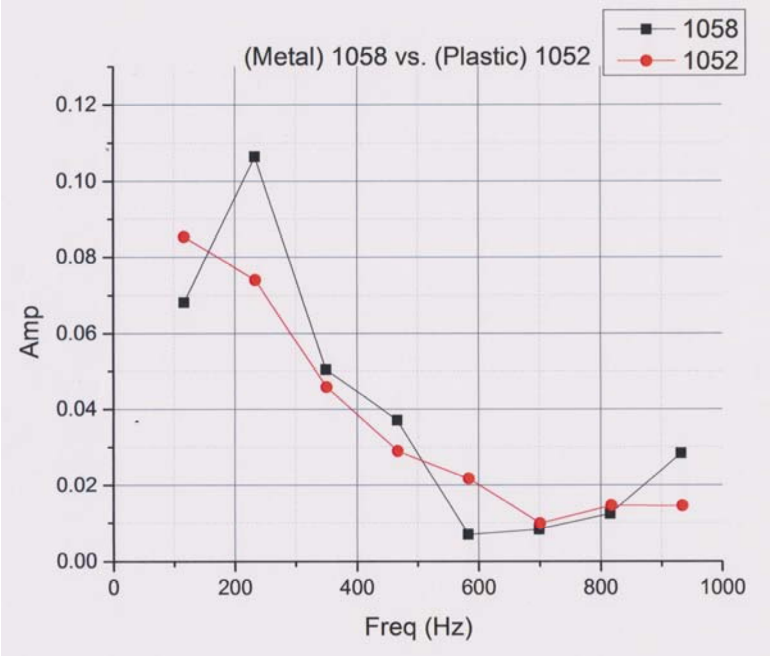




It becomes quite clear that the metal kazoo has an amazingly-higher phase than the plastic kazoo.

Therefore, it is apparently that the metal kazoo vibrates much more than the plastic kazoo.

Taking another look at the Amplitude-Frequency graph between the metal and plastic kazoos...



Here, an overall pattern emerges where the amplitudes of the metal kazoo are greater at lower frequencies, while the amplitudes of the plastic kazoo dominate at higher frequencies. It's not a phenomenon that is easily noticed by the naked ears (unless you have really good ears), and serves to highlight that while both kazoos are different, one kazoo is not inherently better than the other, taking into consideration the necessities of higher harmonics. Which aren't all that many for a kazoo, but there you go.

Ultimately, while I wasn't able to research farther into how a kazoo can be used by different people, or how it compares with other instruments, this lab has provided quite an insight into the inner workings of a kazoo. It's a small, annoying little instrument that produces an annoying noise that acoustically very complex and interesting to look at. And the lab itself was actually kind of funny.