Laboratory Investigation — Name ______________________

Physics@Frisch: Form L8.2A — Date ______________ Period ____

Sound, Perception, and Music

PROBLEM

How is musical sound different from other sound?

INTRODUCTION

We rarely hear only one sound wave at a time. Our brains and ears are constantly processing sound from many sources, at many frequencies and intensity levels. In fact, the meaning in sound comes from patterns in frequency and loudness. Speech is actually a pattern of frequencies and amplitudes of sound that you have learned to interpret as words with meaning. Musical sounds have special relationships between the frequencies they contain. Musical notes are different frequencies of sound. Over thousands of years people have found combinations of frequencies that sound good together. When two frequencies sound bad together, we call it dissonance. Beats are the biggest cause of dissonance. The opposite of dissonance is consonance. When different frequencies sound good together we call it consonance. Sounds that don't make beats combine more smoothly and are usually consonant. In this investigation, you will: use several sound generators to study musical chords, and explore the science and math of music theory.

MATERIALS *(per group)*

Data Collector; Sound generator; Speakers

PROCEDURE

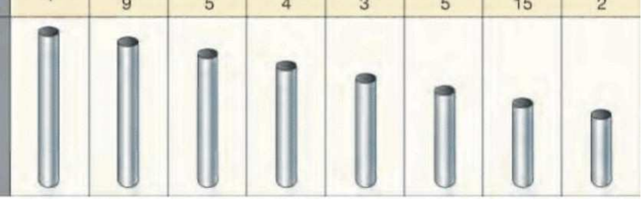
1. Set up your sound generator, speakers, and Data Collector. Turn down the volume so that you cannot hear the sound but you can still read the frequency.

2. Each group in the class will be given a different frequency to play (264 Hz, 311 Hz, 330 Hz, 396 Hz, or 528 Hz.) Tune your frequency until you are within +/– 1 Hz. Your instructor will tell each group to turn up and down different frequencies so they can be heard together. Don't change the frequency, just adjust the volume up and down when you are asked.

3. Note what the frequencies 264 Hz, 330 Hz, 396 Hz, and 528 Hz sound like when you hear them together. Then, note what the frequencies 264 Hz, 311 Hz, 396 Hz, and 528 Hz sound like when you hear them together. Contrast the two sound combinations. Does one sound more happy or sad compared with the other? Does one sound spookier than the other? Which combination reminds you more of spring, which of fall?

4. Musical instruments are devices designed to play specific frequencies of sound, usually from the musical scale. Instruments work on the principle of resonance. The natural frequency of a chime is proportional to its length, just like a vibrating string. Longer chimes have lower natural frequencies because they are resonant at longer wavelengths. Because frequency and wavelength are inversely related, a chime that must vibrate at a frequency 5/4ths higher than another chime must be 4/5ths as long. This proportionality rule is the basis for constructing almost all musical instruments. Using your setup, work with another group to explore how far apart two frequencies have to be to sound consonant together. Find two notes from the C major scale that sound dissonant when played together, and two notes that sound consonant when played together. Find 3 dissonant pairs and three consonant pairs, and record your observations.

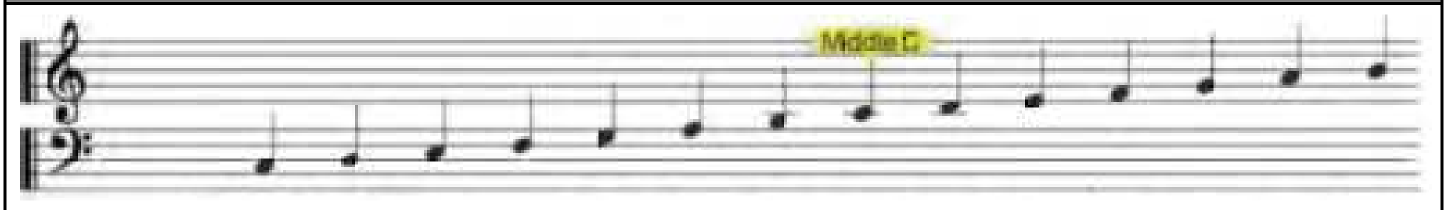
	C	D	E	F	G	A	B	C
C major scale								
Frequency (Hz)	264	297	330	352	396	440	495	528
Ratio to C-264	1/1 $\frac{264}{264}$	9/8 $\frac{297}{264}$	5/4 $\frac{330}{264}$	4/3 $\frac{352}{264}$	3/2 $\frac{396}{264}$	5/3 $\frac{440}{264}$	15/8 $\frac{495}{264}$	2/1 $\frac{528}{264}$
Length ratio	1	$\frac{8}{9}$	$\frac{4}{5}$	$\frac{3}{4}$	$\frac{2}{3}$	$\frac{3}{5}$	$\frac{8}{15}$	$\frac{1}{2}$



CALCULATIONS

1. When the frequency of a sound doubles, the new note has the same name. Notes that are an octave apart are double in frequency. Two notes where one is half the frequency of the other are also an octave apart. Calculate and record the missing frequencies for each of the notes below using the rules for the octave.

The Octave Below Middle C



Note	**C**	**D**	**E**	**F**	**G**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**A**	**B**
Frequency								264	297	330	352	396	440	495

2. Suppose you wish to design a musical chime to play the notes C, E, and G. If the chime that plays the note C is 1 meter long, how long should you make the chimes that play the notes E and G? Refer to the graphic on the previous page.

C: ____________________________ E: ___________________________ G: ______________________________

3. Suppose a 1.2-meter string vibrates at a frequency of 440 Hz. What length of string would vibrate one octave higher? What length would vibrate one octave lower? Assume the tension in the string is the constant. ____

OBSERVATIONS

How different do the frequencies of two different notes need to be to sound consonant? ______________________________

Frequencies	Consonant Pairs		Dissonant Pairs	

CONCLUSIONS

1. Which combination of frequencies (264 Hz, 330 Hz, 396 Hz, and 528 Hz *or* 264 Hz, 311 Hz, 396 Hz, and 528 Hz) sounds more happy or sad compared with the other? ____

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2. Chords are combinations of notes. Based on your understanding are chords composed of dissonant or consonant frequencies? ____

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3. When a guitar and a piano play the same note, how do the fundamental frequencies compare? ___________________________

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