CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)
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Project Number
J1523

Project Title
Frequency Relationship of Notes in Musical Harmony

Abstract

Objectives/Goals
This experiment is designed to determine whether musical notes in harmony bear a specific mathematical relationship in the ratio between their respective frequencies. The hypothesis is that such a specific mathematical relationship does exist for notes in an interval to be in musical harmony. Intervals (formed by two notes only) on different keys will be examined.

Methods/Materials
The procedure to the experiment is:
1. Setup an Electronic Keyboard configured to simulate a Flute instrument.
2. Connect the Headphone Jack output signal of the keyboard to an input channel of an oscilloscope.
3. Adjust the vertical signal gain and horizontal time base settings appropriately on the oscilloscope, as required.
4. Measure the signal wave period for each of 18 consecutive notes in chromatic sequence. The key direct measurement results are the time interval for two times the actual period of the waveforms for each of the 18 chromatically consecutive notes (i.e. C, C#, D, D#, E, F, F#, G, G#, A, A#, B, C, C#, D, D#, E). In this particular case, the first C note is an octave above the middle C key on the keyboard. From the raw data, the actual respective signal period and frequency can be calculated for each of these 30 notes. The ratio between frequencies for all 12 possible intervals (from minor 2nd, major 2nd , and so on until finally the perfect octave interval) within an octave are tabulated for the 15 keys C, C#, D, D#, E, F, F#, G, G#, A, A#, B, C, D and E respectively.

Results
From musical theory, for the notes within an octave, there are 6 out of the 12 intervals that are surely in harmony (i.e. minor 3rd, major 3rd, perfect 4th, perfect 5th Major 6th and Perfect Octave), 4 definitely not in harmony (i.e. minor 2nd, Augmented 5th, minor 7th and Major 7th) and 2 marginally/barely in harmony (i.e. Major 2nd and minor 6th). Analysis of the experimental results seems to suggest that there is always a certain specific ratio between the two notes in a particular interval independent of the actual key or the actual pitch tone (frequency) of the tonic key note.

Conclusions/Discussion
For any interval, the first note and second note must bear a certain ratio in their frequencies, though this actual ratio is dependant on the particular interval type. Given that only some of the intervals are in musical harmony, musical notes that are in musical harmony must also bear a certain fixed ratio in their frequencies.

Summary Statement
This experiment is designed to determine whether musical notes in harmony bear a specific mathematical relationship in the ratio between their respective frequencies.

Help Received
Dad taught me how to use the oscilloscope.