SLAPI
Sting Length and Pitch Interval

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I created *String Length and Pitch Interval* (SLAPI) so my music theory students could easily explore the intervals found in the *harmonic series*. These intervals are called *just intervals*. Enter a frequency ratio and SLAPI will report the just ratio's simplest form, decimal expansion, and size in cents. SLAPI will also visualize the ratio as a string length division on a virtual monochord. Students can then play the just interval and its equal tempered counterpart. All intervals are sounded with respect to the standard pitch A4 = 440 Hz. The program not only allows students to explore the sonic signatures of just intervals, but it also allows the student to hear discover exactly how far "out of tune" equal tempered counterpart is from the harmonic series. The current version of SLAPI was created with, and runs under, Cycling '74's Max 9. SLAPI is available for download at:[1]

https://www.reginaldbain.com/software.html

QuickStart
SLAPI's interface is shown in Figure 1 with the ratio 3/2 loaded into the program.[2]

Figure 1. SLAPI interface
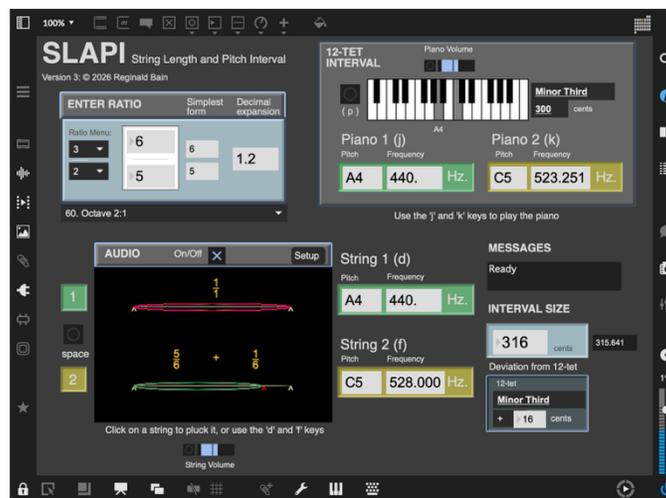
Enter Ratio Interface
In the ENTER RATIO interface, there are three ways to enter a ratio: 1) *Ratio Menu*, 2) *Number Boxes*, and 3. *Interval Menu*. To use the Ratio Menu, select a numerator (1-32) and a denominator (1-32) from the menus. The selected values will be loaded into the Number Boxes. Alternatively, you can type a numerator (1-999) and denominator (1-999) into the two large Number Boxes, or choose one of the 60 pre-programmed intervals from the Interval Menu.

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[1] Max may be downloaded at: https://cycling74.com/downloads.
[2] To learn more about interval representation in tuning theory, visit <https://reginaldbain.com/vc/musc726t/pub/intervals>.

Virtual Monochord Interface
The VIRTUAL MONOCHORD interface is located under the AUDIO interface. Set against a black background we find two string diagrams labeled *String 1 & String 2*. String 1 always sounds the pitch A4 whose frequency is 440 Hz. It represents the prime unity 1/1. String 2 is divided into two parts. When the current ratio (*n/d*) falls between 1/1 unison and 2/1 octave, inclusive, the left string part will be *d/n*, and the right part will be (1 – *d/n*). For other ratios outside these bounds the string length divisions will not be drawn.

Tuning Calculator
Once you enter a ratio, SLAPI will compute the just ratio's *simplest form*, *decimal expansion*, and *size in cents*. For example, if the current ratio is 6/4, SLAPI will report its simplest form as 3/2, its decimal expansion as 1.5, and its size in cents as 702¢ (and 701.995¢). What is more, it will list the component pitches and frequencies of the just interval and equal tempered counterpoint. For example, as shown in Figure 1 for the ratio 3/2:

Figure 2. Instruments

Instrument	Key	Frequency	Cents
String 1	A4	440.0 Hz	0
String 2	E4	660.0 Hz	702
Piano 1	A4	440.0 Hz	0
Piano 2	E4	659.225 Hz	700

SLAPI uses the following formula to convert a frequency ratio to cents:

$$c \; = \; 1200 \, log_2 \left(\frac{f_2}{f_1} \right)$$

SLAPI uses Max's **ftom** object[3] to calculate the nearest *equal-tempered counterpart* for the current ratio. For example, the nearest equal tempered counterpart of the interval 3/2, or 660/440, is the 12-tet perfect fifth (702¢). Finally, SLAPI calculates difference between the size of the just and 12-tet intervals, or *12-tet deviation*, as: 702 – 700 = +2 cents. That is, the just 3/2 perfect fifth is 2 cents larger than an equal tempered perfect fifth.

Audio Interface
The AUDIO interface allows the user to to the program's audio on/off via the toggle box. Audio settings may be accessed via the Setup message.

Playback
To play the current just interval on A4 = 440 Hz, press the space bar. To play the 12-tet counterpart on A4 = 440 Hz, press the 'p' key. To play the just interval's component pitches, press 'd' and 'f' keys, respectively. To play the 12-tet counterpart's component pitches, press 'j' and 'k' keys, respectively. A summary of all the playback keys is provided in Figure 2.

Figure 3. Playback keys

Key	Play Sound	Key	Play Sound
d	String 1	j	Piano 1
f	String 2	k	Piano 2
space	String 1 & String 2	p	Piano 1 & Piano 2

References
Cycling '74. 2026. *Max 9 Documentation*. Available online at: <https://docs.cycling74.com>.
Gann, Kyle. 2019. *The Arithmetic of Listening: Tuning Theory and History for the Impractical Musician*.
    Urbana, IL: University of Illinois Press.

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[3] **ftom** converts frequency to MIDI note numbers.