SLAPI

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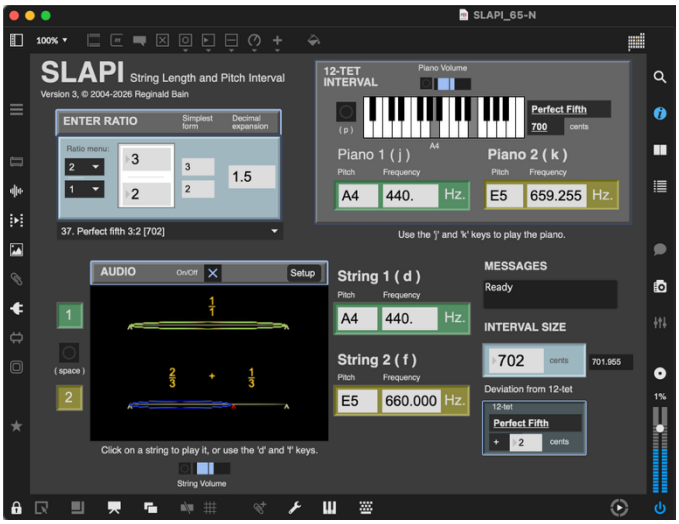
SLAPI (String Length and Pitch Interval) is a playground for hands-on experimentation with harmonic series intervals. It is a tool that allows the curiosity-driven learner to discover exactly how far out of tune 12-tone equal-tempered intervals are with respect to nature. Created with Cycling '74's Max, SLAPI is currently distributed as a Max patcher that runs under Max 9. The program allows students to easily explore the sonic signatures of just intervals on a plucked-string timbre and quickly compare them with their equal-tempered counterparts on the 12-tet piano. Enter a whole-number interval frequency ratio (e.g., 3/2) and SLAPI will report the ratio's simplest form (3/2), decimal expansion (1.5), size in cents (702¢ and 701.955¢), and deviation from 12-tet in cents (+2¢). SLAPI will also visualize the ratio on a virtual monochord (2/3 + 1/3 = 3/3), reporting the associated pitch interval's component pitches (A4 and E5) and frequencies (440 Hz and 659.255 Hz) with respect to the standard pitch A4 = 440 Hz. SLAPI may be download at:

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

QuickStart

SLAPI's interface is shown in Figure 1 with the current ratio $\frac{3}{2}$ loaded into the Max 9 patcher.[1]

Figure 1. SLAPI interface



1. THE ENTER RATIO AREA

SLAPI provides the user with three ways to enter a whole-number interval frequency ratio:

1. Ratio menu
2. Current ratio ($\frac{n}{d}$) number boxes
3. Interval menu

[1] To learn more about *intervals* in the context of tuning theory, visit <https://reginaldbain.com/vc/musc726t/pub/intervals>.

To enter a ratio via the *Ratio menu*, select a numerator (*n*) and denominator (*d*) from the two small menus (values range from 1-32, inclusive). The selected values will be loaded into the two large *Current ratio* number boxes.[2] Alternatively, the user may type whole numbers directly into the two large number boxes (values for *n* and *d* may range from 1-999, inclusive). Or the user may select one of 60 pre-programmed ascending intervals from the *Interval menu* (see §9 for more info.). Please note that SLAPI will accept ascending and descending pitch interval ratios within the octave as input, but it will only draw string-length diagrams for ascending pitch intervals.

2. INTERVAL CALCULATIONS

When the current ratio is entered, SLAPI will compute the ratio's simplest form, decimal expansion, and equivalent size in cents. For example, if the current ratio is 3/2, SLAPI will report its simplest form as 3/2, its decimal expansion as 1.5, and its size in cents as 702¢, rounded to the nearest cent, and 701.955¢, rounded to 3 decimal places (see §8). SLAPI will then list the component pitches and frequencies for the current ratio (see §6). and its 12-tet counterpart (see §7).

3. INSTRUMENTS, PITCHES AND FREQUENCIES

SLAPI has two sampled instruments, named *String*[3] & *Piano*[4], on which the four component pitches are played. *String 1* & *String 2* are located in the Virtual Monochord area (see §6). *Piano 1* & *Piano 2* are located in the 12-TET area (see §7). Component pitch, frequency, and cent values for the 3/2 perfect fifth are shown in Figure 2.

Figure 2. Values for the 3/2 perfect fifth

	Instrument	Pitch	Frequency (Hz)	Cents (¢)	
1.	String 1	A4	440.0	0	
2.	String 2	E4	660.0	702	701.995
3.	Piano 1	A4	440.0	0	
4.	Piano 2	E4	659.225	700	

4. PLAYBACK KEYS

To play the current ratio on A4 = 440 Hz, press the `space bar`. To play its 12-tet counterpart, press the '`p`' key. To play the associated pitch interval's component pitches, press the '`d`' or '`f`' keys, respectively. To play the 12-tet counterpart's component pitches, press '`j`' or '`k`' keys, respectively. Figure 3 provides a summary of all six QWERTY playback keys.

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

5. THE AUDIO AREA

The AUDIO area allows the user to the turn the program's audio on/off via the square toggle box. Max's audio settings may be accessed via the Setup message.

6. THE VIRTUAL MONOCHORD AREA

The virtual monochord is located under the AUDIO area. Here we find two string-length diagrams on a black background labeled String 1 & String 2. String 1 always sounds A4 = 440 Hz, the prime unity 1/1. String 2 is divided into two parts. When the current ratio (*n*/*d*) is between 1/1 unison and 2/1 octave, inclusive, the length of the left string segment will be *d*/*n*, and the length of the right segment will be (1 – *d*/*n*). Again, string-length division diagrams will NOT be drawn for current ratios that fall outside range: $1/1 \leq n/d \leq 2/1$.

[2] For more information about Max number boxes, visit: <https://docs.cycling74.com/reference/number/>.
[3] A 2-second sampled string tone that was generated using the Karplus-Strong physical model algorithm.
[4] A 2 second sampled piano tone that was autotuned to precisely match the A4 440 Hz. string tone.

7. THE 12-TET AREA

The 12-TET area displays the 12-tet counterpart's component pitches, component frequencies, traditional interval name, and size in cents. It also visualizes the 12-tet interval as keys depressed on the 2-octave piano keyboard.

8. MESSAGES AND THE INTERVAL SIZE AREAS

The MESSAGES area reports all system status messages. The INTERVAL SIZE area shows the current ratio's equivalent size in cents.[5] For extra precision, the interval's size is also rounded to 3 decimal places: 701.995¢. SLAPI uses Max's **ftom** and **mtof** objects[6] to calculate the current ratio's nearest *12-tet counterpart* and *Deviation from 12-tet*. Regarding the latter, here are two concrete examples: an ascending 3/2 perfect fifth (702¢) is 2 cents larger a 12-tet perfect fifth (700¢), +2¢; and an ascending 4/3 perfect fourth (498¢) is 2 cents smaller than a 12-tet perfect fourth (500¢), or -2¢.

9. INTERVAL MENU

Located at the bottom of the ENTER RATIO area, the *Interval menu* contains 60 pre-programmed pitch intervals. Select an interval (Figure 4) to load that interval into the two large *Current ratio* number boxes. Interval names are compatible with Kyle Gann's *The Arithmetic of Listening* (Gann 2019). After each interval name, you will find the ratio and interval size in cents within square brackets. All cent values are rounded to the nearest cent.

Figure 4. The 60 pre-programmed ascending pitch intervals

1. Unison 1:1 [0]	31. Small septimal tritone 7:5 [583]
2. Syntonic comma 81:80 [22]	32. Large just (5-limit) tritone 45:32 [590]
3. Diesis 128:125 [41]	33. Small just (5-limit) tritone 64:45 [610]
4. ET quarter-tone approx. 35:34 [50]	34. Large septimal tritone 10:7 [617]
5. Small half step (5-limit) 25:24 [71]	35. Diminished fifth (5-limit) 36:25 [631]
6. Pythagorean half step 256:243 [90]	36. Wolf fifth 40:27 [680]
7. ET half step approx. 18:17 [99]	37. Perfect fifth 3:2 [702]
8. Overtone half-step 17:16 [105]	38. Diminished sixth (5-limit) 192:125 [743]
9. Large half step (5-limit) 16:15 [112]	39. Septimal minor sixth 14:9 [765]
10. Cowell just half step 15:14 [119]	40. Augmented fifth (5-limit) 25:16 [773]
11. Undecimal half step 12:11 [151]	41. Undecimal minor sixth 11:7 [783]
12. Small whole tone 10:9 [182]	42. Pythagorean minor sixth 128:81 [792]
13. Large whole tone 9:8 [204]	43. Minor sixth (5-limit) 8:5 [814]
14. Septimal whole tone 8:7 [231]	44. Overtone sixth 13:8 [841]
15. Diminished third (5-limit) 144:125 [245]	45. Undecimal median sixth 18:11 [853]
16. Septimal minor third 7:6 [267]	46. Major sixth (5-limit) 5:3 [884]
17. Augmented second (5-limit) 75:64 [275]	47. Pythagorean major sixth 27:16 [906]
18. Pythagorean minor third 32:27 [294]	48. Diminished seventh (5-limit) 128:75 [925]
19. Overtone minor third 19:16 [298]	49. Septimal major sixth 12:7 [933]
20. Minor third (5-limit) 6:5 [316]	50. Augmented sixth (5-limit) 125:72 [955]
21. Undecimal median third 11:9 [347]	51. Septimal minor seventh 7:4 [969]
22. Major third (5-limit) 5:4 [386]	52. Pythagorean minor seventh 16:9 [996]
23. Pythagorean major third 81:64 [408]	53. Minor seventh (5-limit) 9:5 [1018]
24. Diminished fourth 32:25 (5-limit) [427]	54. Undecimal median seventh 11:6 [1049]
25. Septimal major third 9:7 [435]	55. Major seventh (5-limit) 15:8 [1088]
26. Augmented third 125:96 (5-limit) [457]	56. Pythagorean major seventh 243:128 [1110]
27. Septimal fourth 21:16 [471]	57. Septimal major seventh 27:14 [1137]
28. Perfect fourth 4:3 [498]	58. 31st harmonic 31/16 [1145]
29. Undecimal tritone 11:8 [551]	59. Augmented seventh 125:64 (5-limit) [1159]
30. Augmented fourth (5-limit) 25:18 [569]	60. Octave 2:1 [1200]

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.

[5] SLAPI uses the following formula to convert the current ratio to cents: $c = 1200 \log_2 (f_2/f_1)$, were c is cents and f_2 and f_1 are n and d, respectively

[6] The **ftom** object converts a frequency to a MIDI note number. The **mtof** object converts a MIDI note number to frequency.