Music Blocks Programming Guide

A complete guide to learning and programming with Music Blocks

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Music Blocks is a programming environment for children interested in music and graphics. It expands upon Turtle Blocks by adding a collection of features relating to pitch and rhythm.

The Turtle Blocks guide (https://github.com/sugarlabs/turtleblocksjs/blob/master/guide/README.md) is a good place to start learning about the basics. In this guide, we illustrate the musical features by walking the reader through numerous examples.

The Music Blocks basic documentation (../documentation/README.md) is also a good resource.

And there is a short Guide to Debugging (../Debugging.md) to help you with your programming.

This guide details the many musical features of the language.

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Many of the examples given in the guide have links to code you can run. Look for `RUN LIVE` links.

1. Getting Started

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Music Blocks is designed to run in a browser. Most of the development has been done in Chrome, but it should also work in Firefox, Opera, and some versions of Safari. You can run it from musicblocks.sugarlabs.org (https://musicblocks.sugarlabs.org), from github io (https://musicblocks.sugarlabs.org), or by downloading a copy of the code and running a local copy directly from the file system of your computer. (Note that when running locally, you may have to use a local server to expose all of the features.)

This guide details the music-specific features of Music Blocks. You may also be interested in the Turtle Blocks Guide (http://github.com/sugarlabs/turtleblocksjs/tree/master/guide), which reviews many programming features common to both projects.

For more details on how to use Music Blocks, see Using Music Blocks (http://github.com/sugarlabs/musicblocks/tree/master/documentation). For more details on how to use Turtle Blocks, see Using Turtle Blocks JS (http://github.com/sugarlabs/turtleblocksjs/tree/master/documentation).

2. Making Sounds

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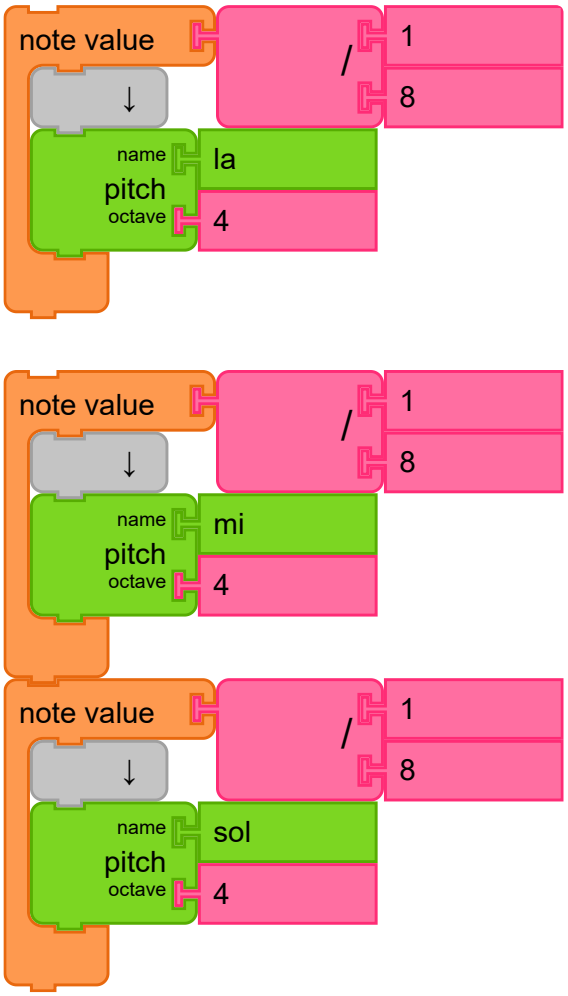
Music Blocks incorporates many common elements of music, such as pitch, rhythm, volume, and, to some degree, timbre and texture.

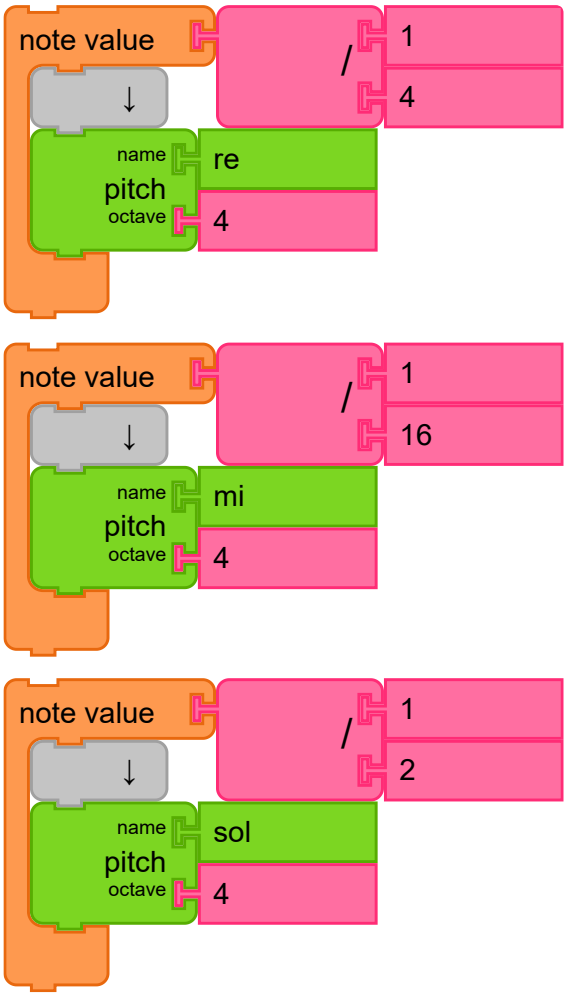
2.1 Note Value Blocks

At the heart of Music Blocks is the *Note value* block. The *Note value* block is a container for a *Pitch* block that specifies the duration (note value) of the pitch.



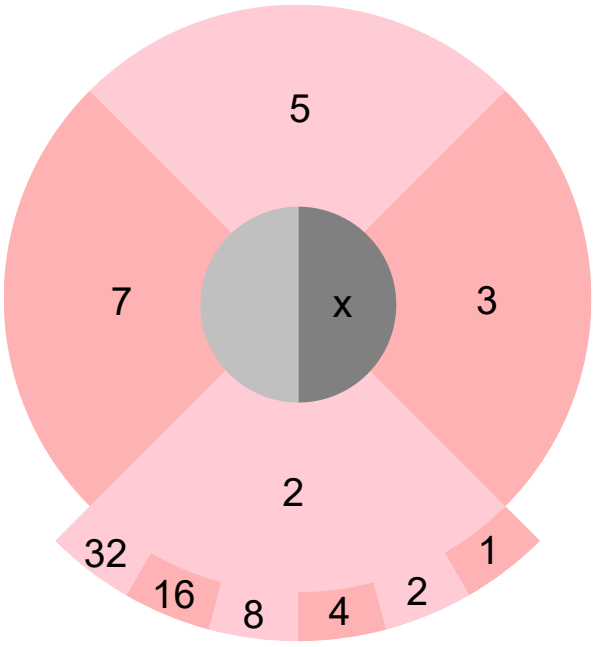
At the top of the example above, a single (detached) *Note value* block is shown. The `1/8` is value of the note, which is, in this case, an eighth note.

At the bottom, two notes that are played consecutively are shown. They are both `1/8` notes, making the duration of the entire sequence `1/4` .

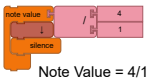
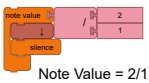
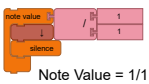
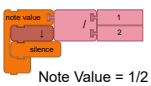
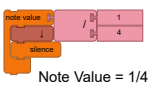
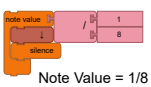
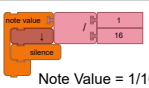
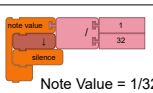
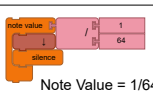
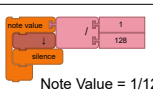


In this example, different note values are shown. From top to bottom, they are: `1/4` for an quarter note, `1/16` for a sixteenth note, and `1/2` for a half note.

Note that any mathematical operations can be used as input to the *Note value*.



As a convenience, a pie menu is used for selecting common note values.

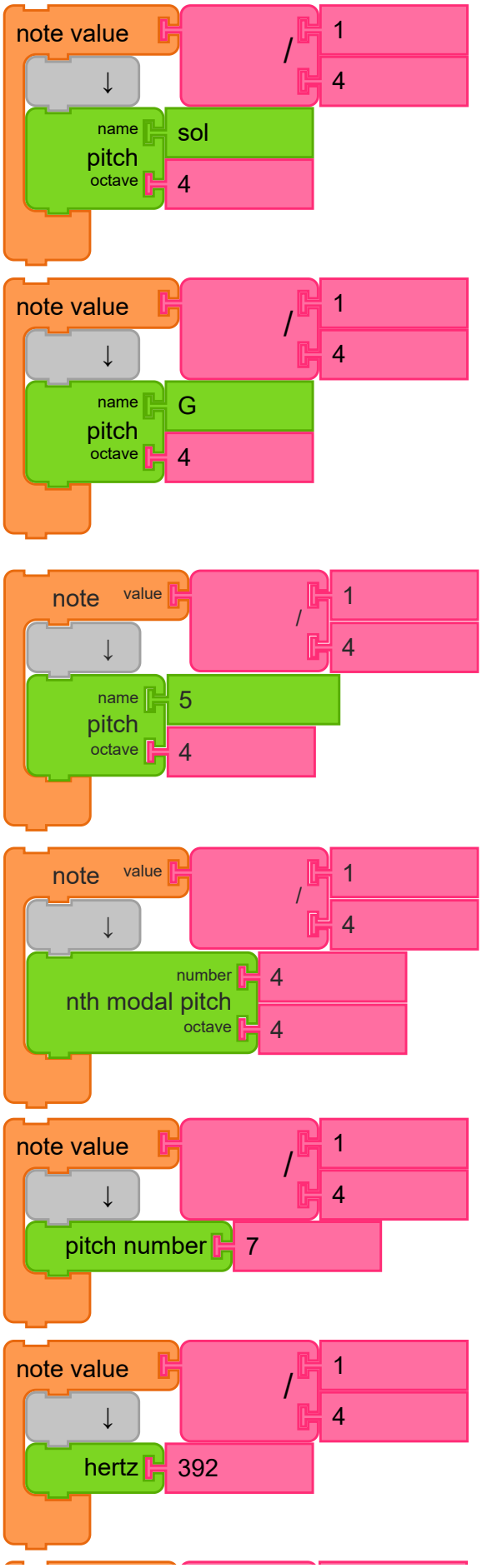
Note Value Blocks	Western Notation (Notes)	Silence Blocks	Western Notation (Rests)
 Note Value = 4/1	 Longa Note	 Note Value = 4/1	 Longa Rest
 Note Value = 2/1	 Breve Note	 Note Value = 2/1	 Breve Rest
 Note Value = 1/1	 Whole Note	 Note Value = 1/1	 Whole Rest
 Note Value = 1/2	 Half Note	 Note Value = 1/2	 Half Rest
 Note Value = 1/4	 Quarter Note	 Note Value = 1/4	 Quarter Rest
 Note Value = 1/8	 Eighth Note	 Note Value = 1/8	 Eighth Rest
 Note Value = 1/16	 Sixteenth Note	 Note Value = 1/16	 Sixteenth Rest
 Note Value = 1/32	 Thirty-second Note	 Note Value = 1/32	 Thirty-second Rest
 Note Value = 1/64	 Sixty-fourth Note	 Note Value = 1/64	 Sixty-fourth Rest
 Note Value = 1/128	 Hundred twenty-eighth Note	 Note Value = 1/128	 Hundred twenty-eighth Rest

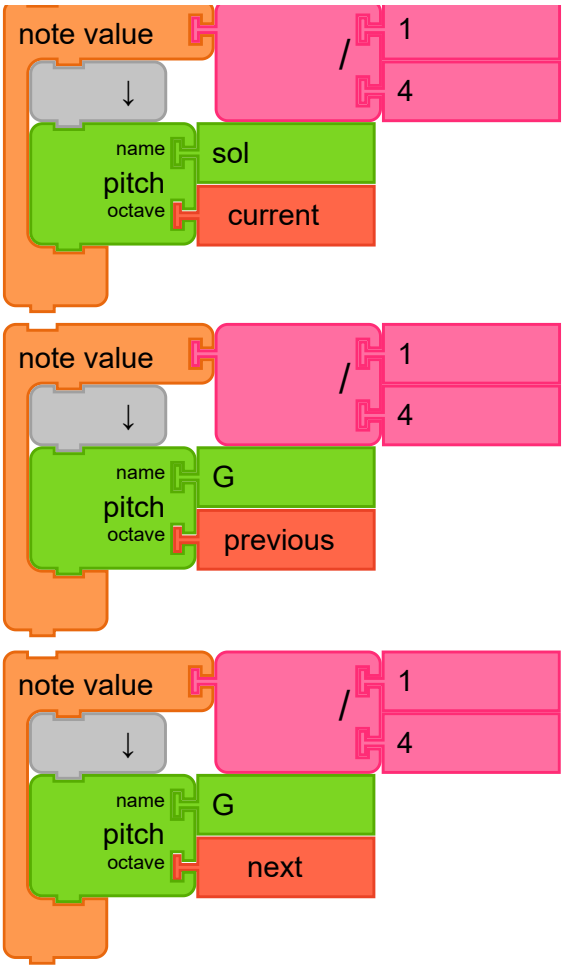
The image dimensions exceed the optimal size. Kindly select the image to access an expanded view.

Please refer to the above picture for a visual representation of note values.

2.2 Pitch Blocks

As we have seen, *Pitch* blocks are used inside the *Note value* blocks. The *Pitch* block specifies the pitch name and pitch octave of a note that in combination determines the frequency (and therefore pitch) at which the note is played.


note value
/
1
4
name
sol
pitch
octave
4
note value
/
1
4
name
G
pitch
octave
4
note
value
/
1
4
name
5
pitch
octave
4
note
value
/
1
4
number
4
nth modal pitch
octave
4
note value
/
1
4
pitch number
7
note value
/
1
4
hertz
392



There are many systems you can use to specify a *pitch* block's name and octave. Some examples are shown above.

The top *Pitch* block is specified using a *Solfege* block (`Sol` in `Octave 4`), which contains the notes `Do Re Me Fa Sol La Ti` .

The pitch of the next block is specified using a *Pitch-name* block (`G` in `Octave 4`), which contains the notes `C D E F G A B` .

The next block is specified using a *Scale-degree* block (the `5th note` in the scale, 'G', also in 'Octave 4'), `C == 1, D == 2, ...` . The *Scale-Degree* block has numbers like the *Number* block, but also has an accidental so that the user may play pitches outside a given key.

The next blocks is specified using a *Nth Modal Pitch* block. This block takes a number argument and turns it into the "nth pitch of a given scale" with an index of 0 (i.e. C for C major is 0). Therefore in order to get `G` , we input the number 4. The octave argument will force the octave up or down; otherwise the user may just keep going up or down in either direction to go through scalar pitches of any mode.

The next block is specified using a *Pitch-number* block (the `7th semi-tone` above `C` in `Octave 4` is `G`). The offset for the pitch number can be modified using the *Set-pitch-number-offset* block.

The pitch of the next block is specified using the *Hertz* block in conjunction with a *Number* block (`392` Hertz is `G` in `Octave 4`), which corresponds to the frequency of the sound made.

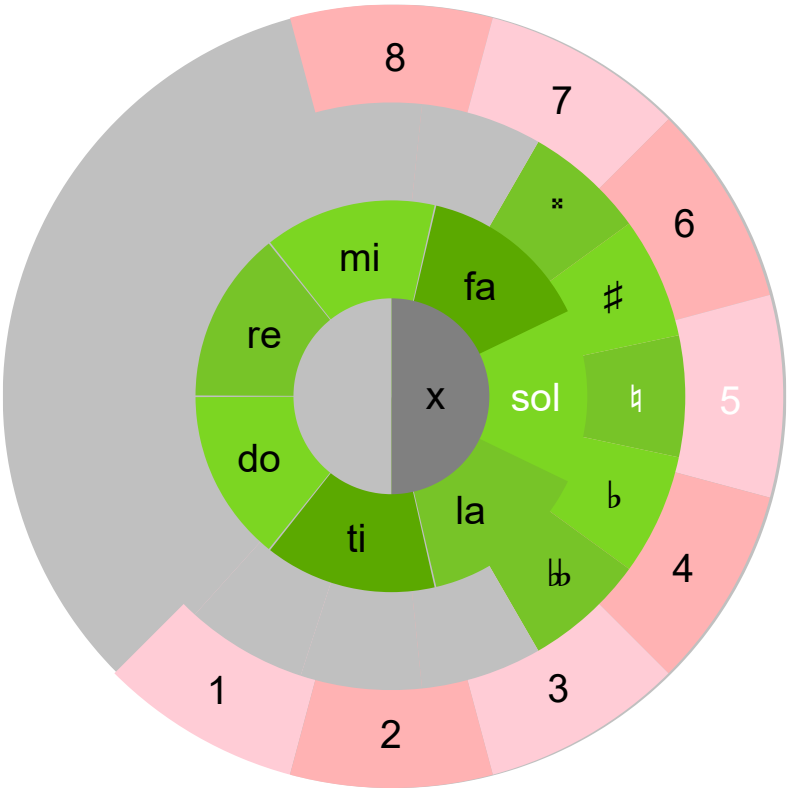
The octave is specified using a number block and is restricted to whole numbers. In the case where the pitch name is specified by frequency, the octave is ignored.The octave argument can also be specified using a *Text* block with values *current*, *previous*, *next* which does as 0, -1, 1 respectively.

The octave of the next block is specified using a *current* text block (`Sol` in `Octave 4`).

The octave of the next block is specified using a *previous* text block (`G` in `Octave 3`).

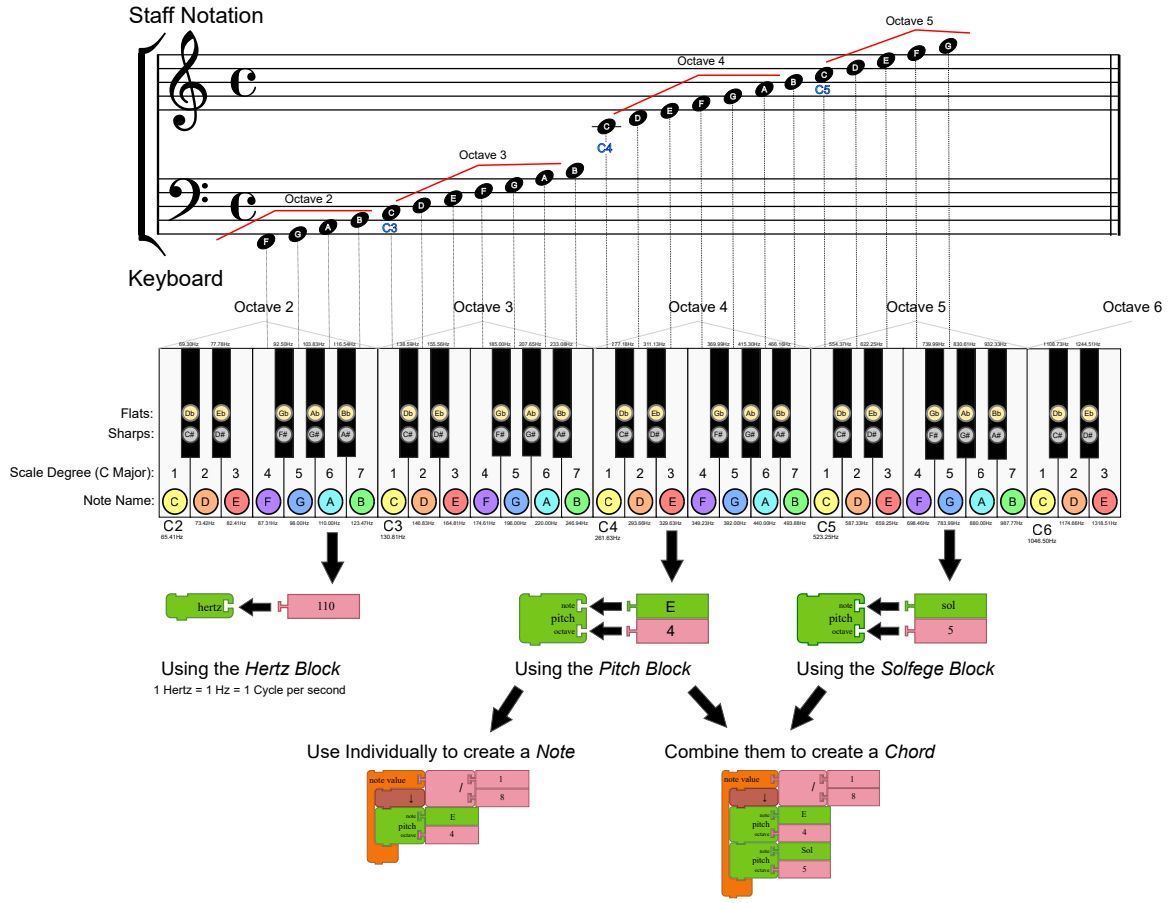
The octave of the last block is specified using a *next* text block (`G` in `Octave 5`).

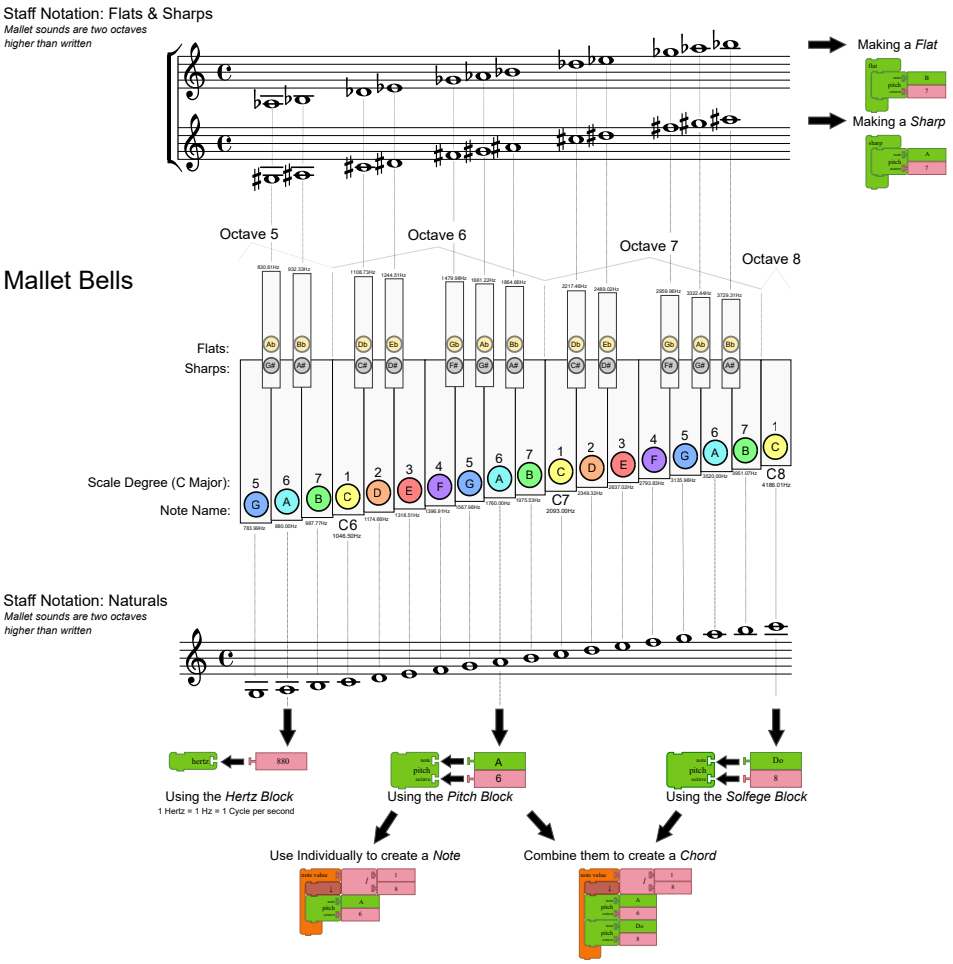
Note that the pitch name can also be specified using a *Text* block.



As a convenience, a pie menu is used for selecting pitch, accidental, and octave.

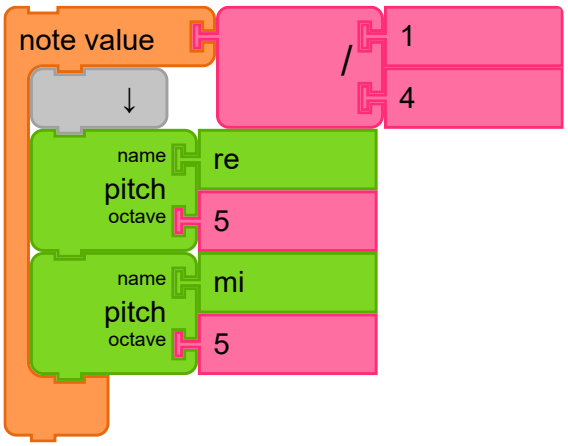
The image dimensions exceed the optimal size. Kindly select the image to access an expanded view.


Staff Notation
Octave 2
Octave 3
Octave 4
Octave 5
C3
C4
C5
Keyboard
Octave 2
Octave 3
Octave 4
Octave 5
Octave 6
Flats:
Sharps:
Scale Degree (C Major):
Note Name:
C2
C3
C4
C5
C6
hertz
110
note
pitch
octave
E
4
sol
5
Using the Hertz Block
1 Hertz = 1 Hz = 1 Cycle per second
Using the Pitch Block
Using the Solfege Block
Use Individually to create a Note
Combine them to create a Chord
note value
Sol



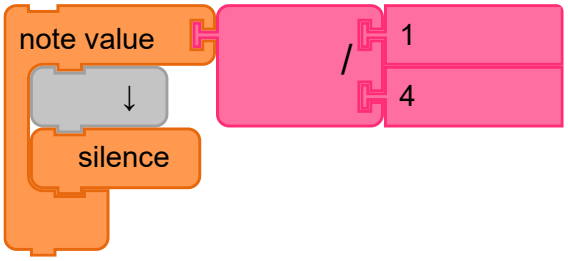
Please refer to the above charts for a visual representation of where notes are located on a keyboard or staff.

2.3 Multiple Pitches



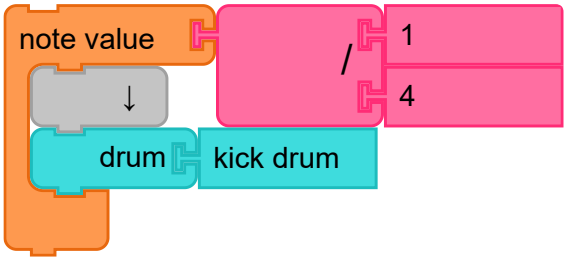
Multiple, simultaneous pitches can be specified by adding multiple *Pitch* blocks into a single *Note value* block, like the above example.

2.4 Rests

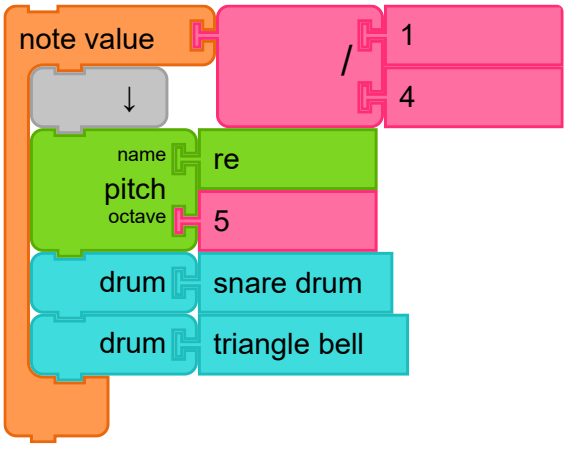


A rest of the specified note value duration can be constructed using a *Silence* block in place of a *Pitch* block.

2.5 Drums



Anywhere a *Pitch* block can be used—e.g., inside of the matrix or a *Note value* block—a *Drum Sample* block can also be used instead. Currently there about two dozen different samples from which to choose. The default drum is a kick drum.



Just as in the multi-pitch example above, you can use multiple *Drum* blocks within a single *Note value* blocks, and combine them with *Pitch* blocks as well.

3. Programming with Music

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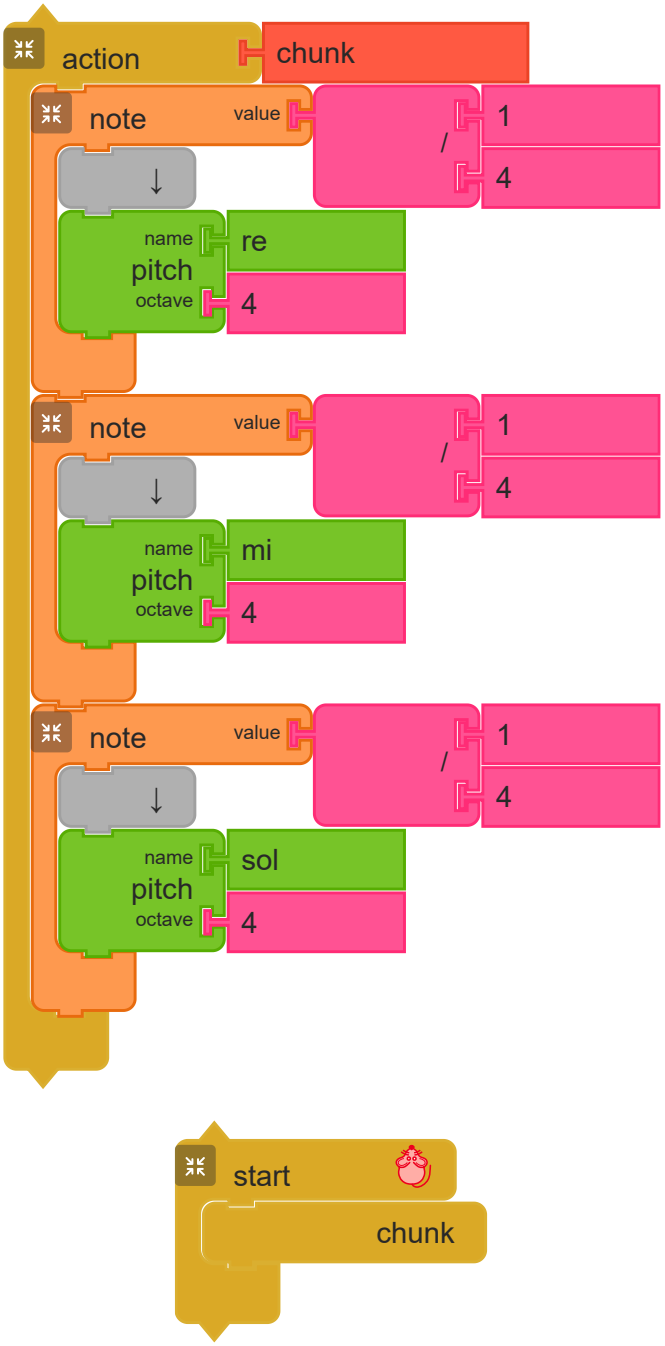
This section of the guide discusses how to use chunks of notes to program music. Note that you can program with chunks you create by hand or use *The Phrase Maker* widget to help you get started.

3.1 Actions



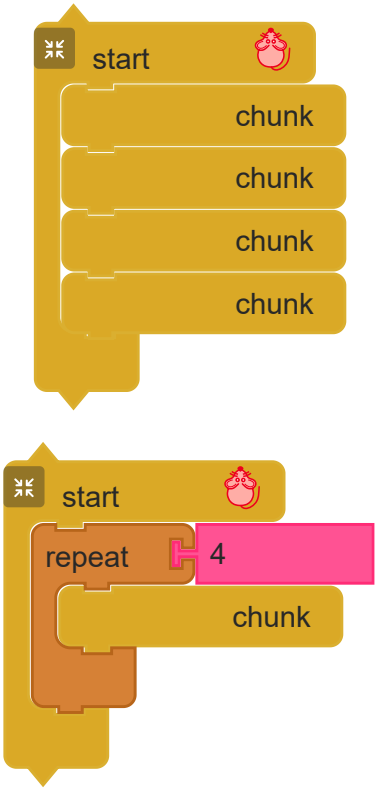
Every time you create a new *Action* stack, Music Blocks creates a new block specific to, and linked with, that stack. (The new block is found at the top of the *Block* palette, found on the left edge of the screen.) Clicking on and running this block is the same as clicking on your

stack. By default, the new blocks are named `chunk`, `chunk1`, `chunk2` ... but you can rename them by editing the labels on the *Action* blocks.

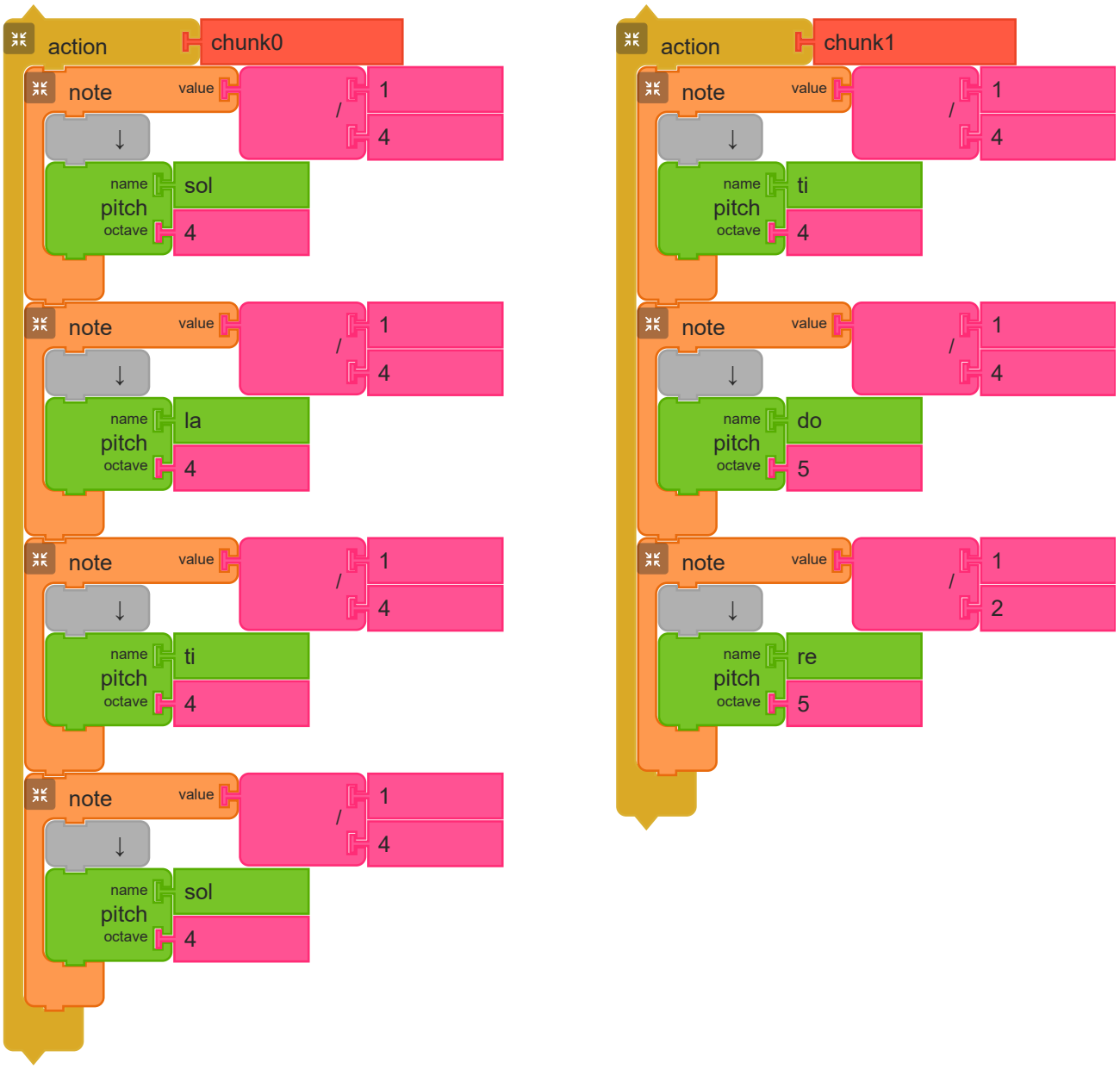
An *Action* block contains a sequence of actions that will only be executed when the block is referred to by something else, such as a start block. This is useful in orchestrating more complex programs of music.

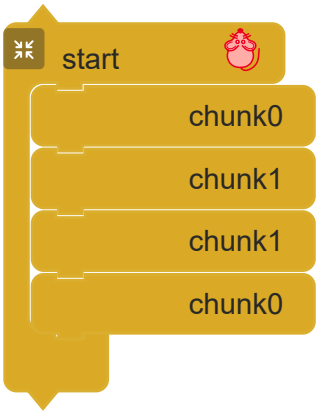
A *Start* Block is an *Action* that will automatically be executed once the start button is pressed. This is where most of your programs will begin at. There are many ways to *Run* a program: you can click on the *Run* button at the upper-left corner of the screen to run the music at a fast speed; a long press on the *Run* button will run it slower (useful for debugging); and the *Step* button can be used to step through the program one block per button press. (An extra-long press of the *Run* button will play back the music slowly. A long press of the *Step* button will step through the program note by note.)

In the example above, the *Action* block named "chunk" is inside of a *Start* block, which means that when any of the start buttons is pressed, the code inside the *Start* block (the *Action* block) will be executed. You can add more chunks after this one inside the *Start* block to execute them sequentially.

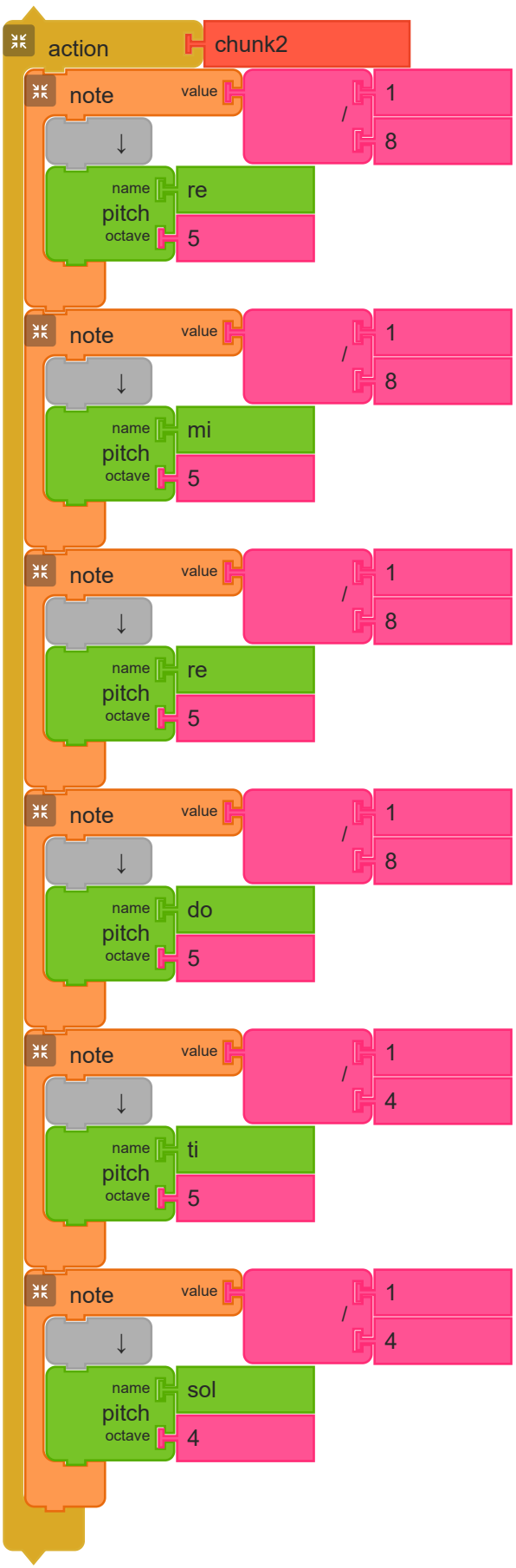


You can repeat actions either by using multiple *Action* blocks or using a *Repeat* block.





You can also mix and match actions. Here we play the *Action* block with name `chunk0`, followed by `chunk1` twice, and then `chunk0` again.


action
chunk2
note
value
/
1
8
name
pitch
octave
re
5
note
value
/
1
8
name
pitch
octave
mi
5
note
value
/
1
8
name
pitch
octave
re
5
note
value
/
1
8
name
pitch
octave
do
5
note
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1
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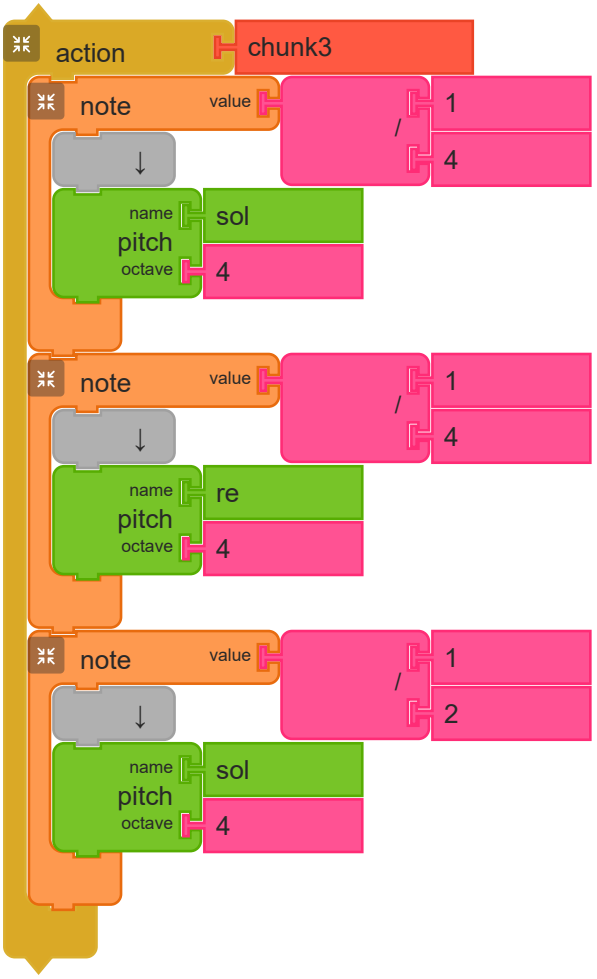
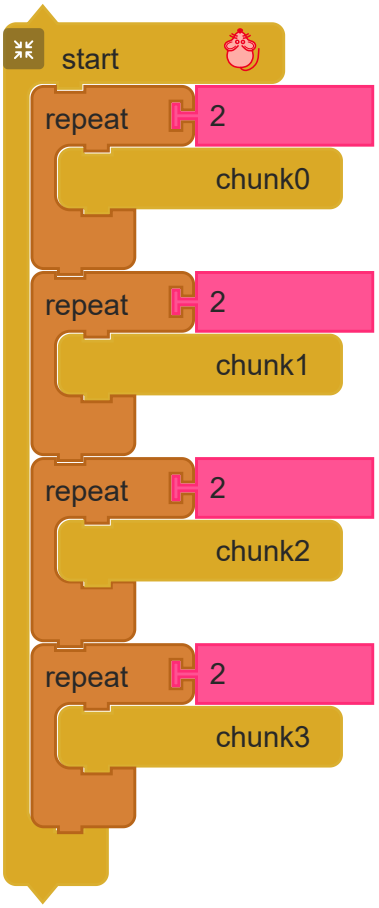
name
pitch
octave
ti
5
note
value
/
1
4
name
pitch
octave
sol
4


action
chunk3
note
value
/
1
4
name
pitch
octave
sol
4
note
value
/
1
4
name
pitch
octave
re
4
note
value
/
1
2
name
pitch
octave
sol
4

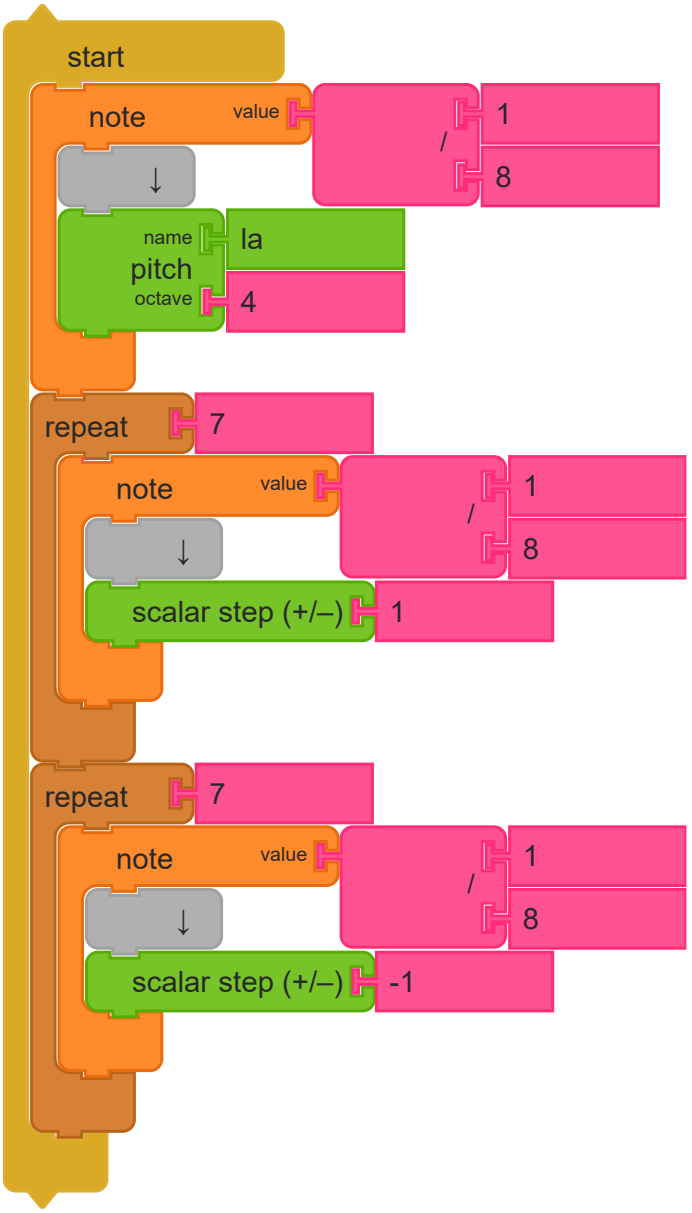


A few more chunks and we can make a song. (Can you read the block notation well enough to guess the outcome? Are you familiar with the song we created?)

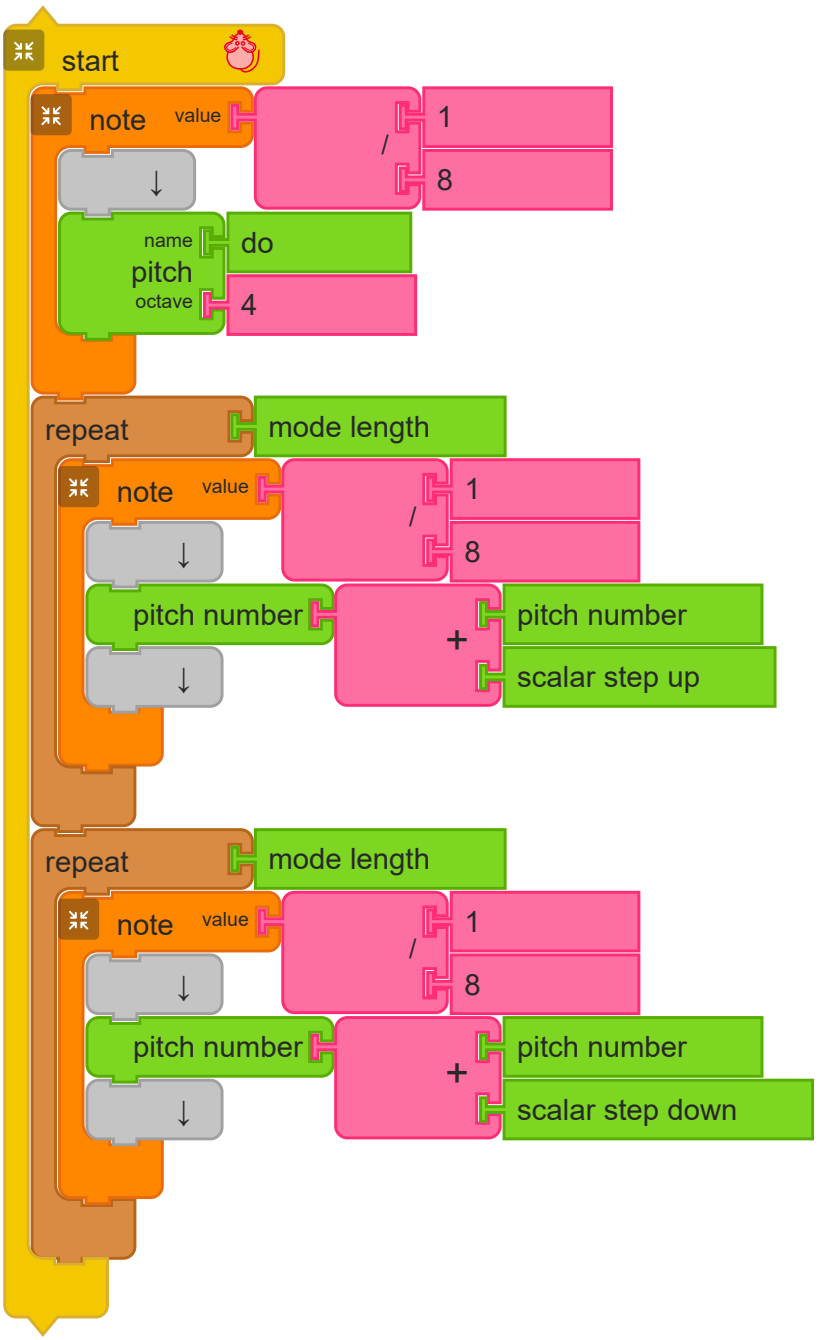
3.2 Pitch Transformations

There are many ways to transform pitch, rhythm, and other sonic qualities.

3.2.1 Step Pitch Block



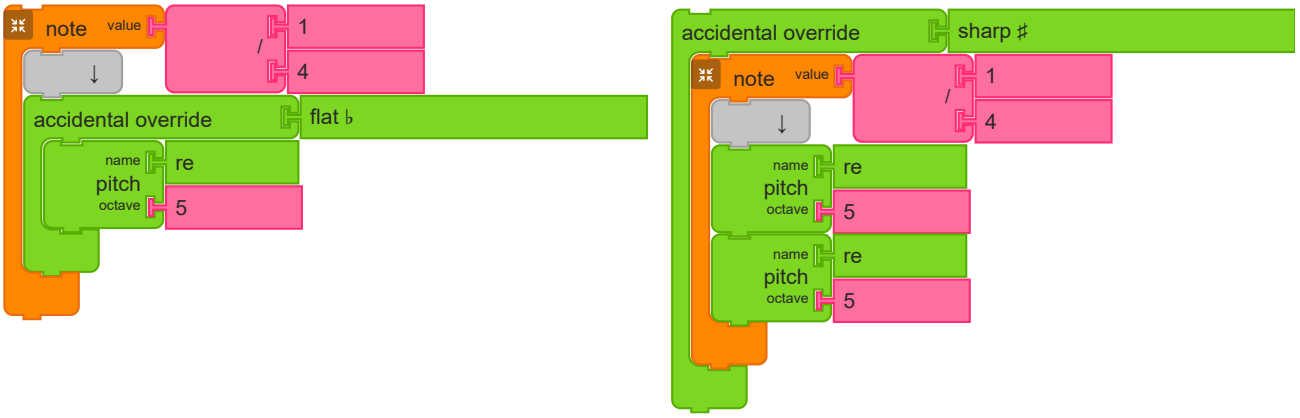
The *Step Pitch* block will move up or down notes in a scale from the last played note. In the example above, *Step Pitch* blocks are used inside of *Repeat* blocks to repeat the code 7 times, playing up and down a scale.



Another way to move up and down notes in a scale is to use the *Scalar Step Up* and *Scalar Step Down* blocks. These blocks calculate the number of half-steps to the next note in the current mode. (You can read more about Musical Modes below.) Note that the *Mouse Pitch Number* block returns the pitch number of the most recent note played.

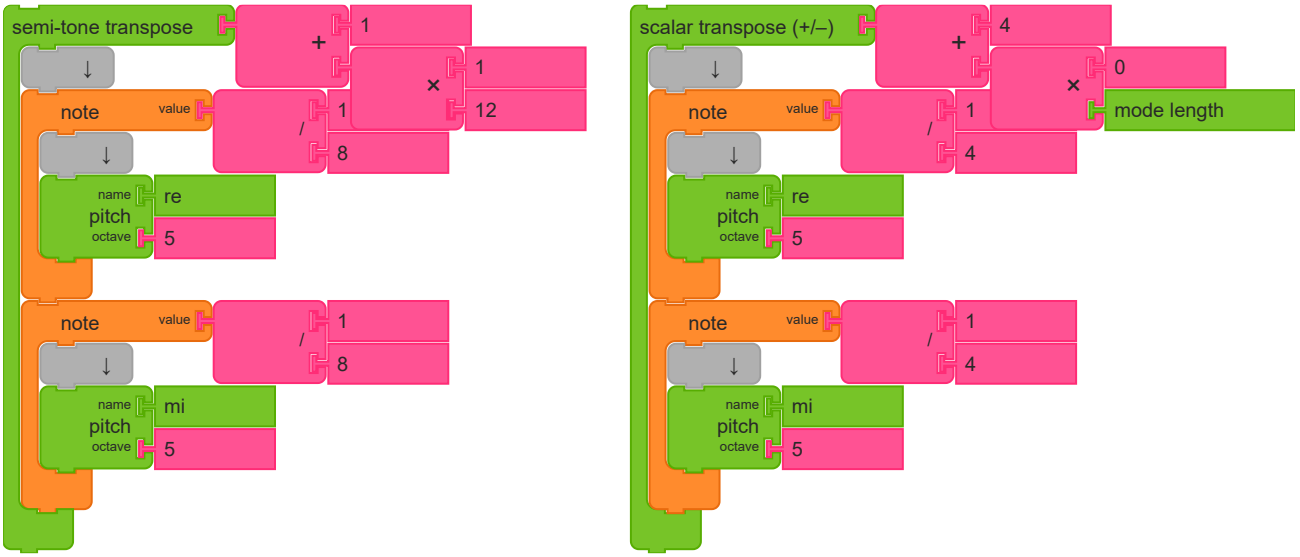
In this example, we are using the *Mode length* block, which returns the number of scalar steps in the current mode (7 for Major and Minor modes).

3.2.2 Sharps And Flats



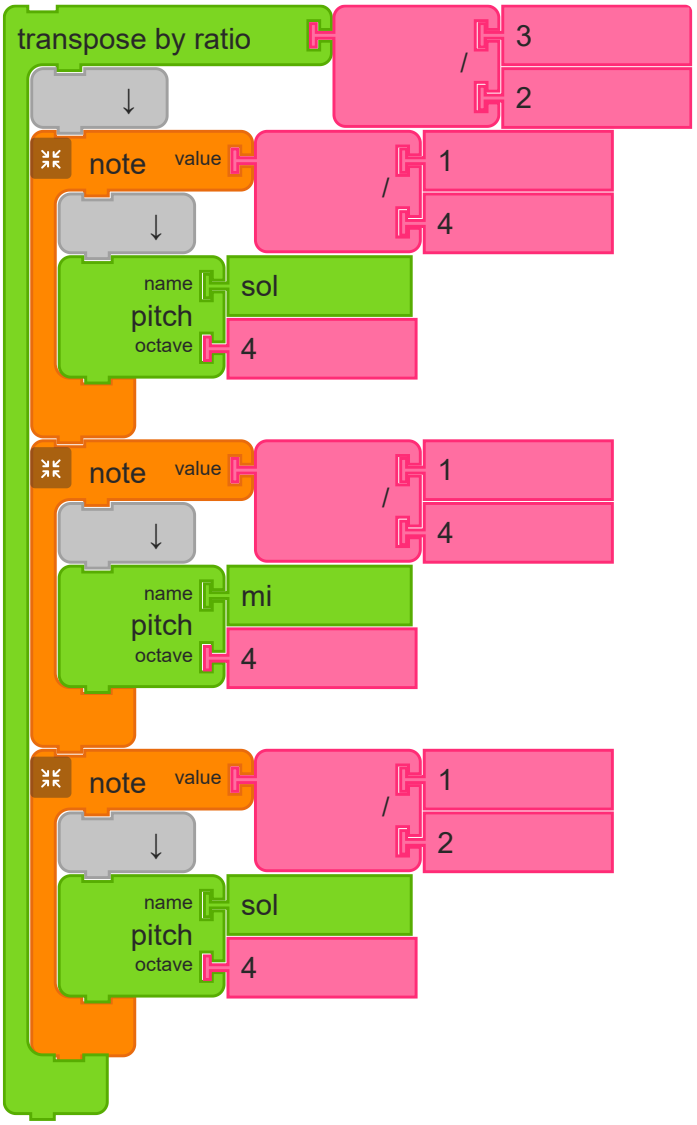
The *Accidental* block can be wrapped around *Pitch* blocks, *Note value* blocks, or chunks of notes inside of ***Action*** blocks. A sharp will raise the pitch by one half step. A flat will lower by one half step. In the example, on the left, just the *Pitch* block `re` is lowered by one half step; on the right, both *Pitch* blocks are raised by one half step. (You can also use a double-sharp or double-flat accidental.)

3.2.3 Adjusting Transposition



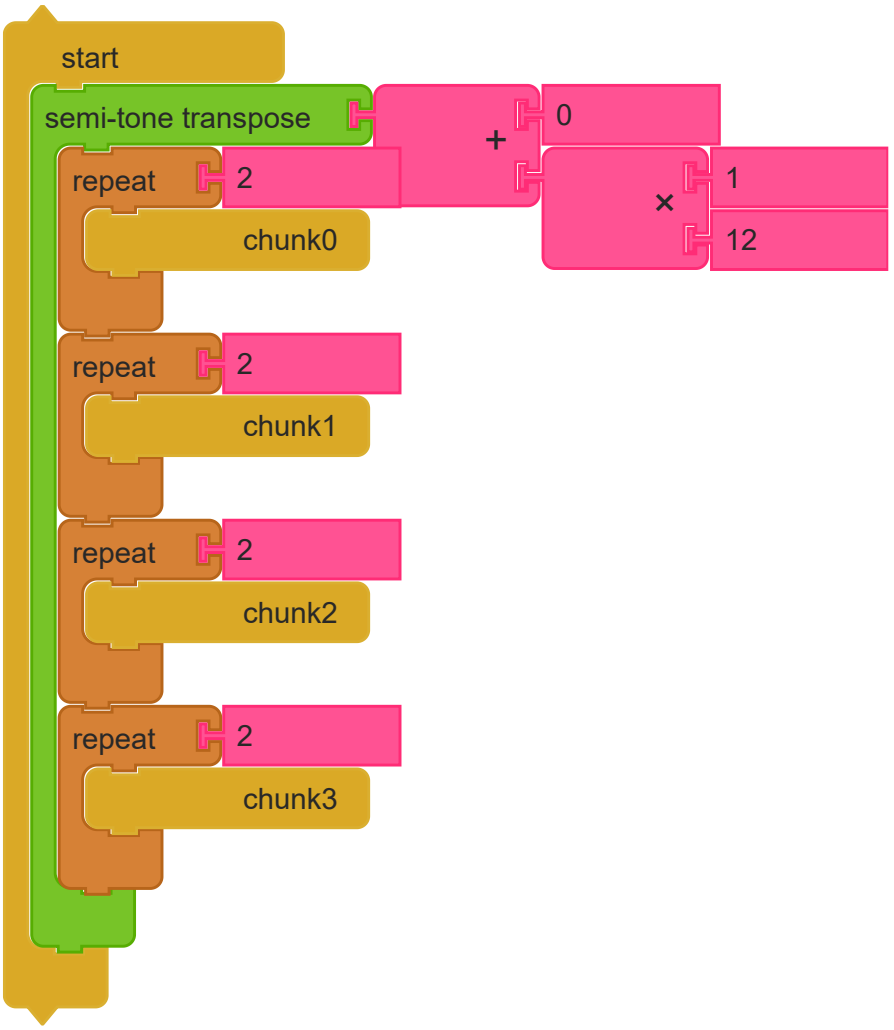
There are multiple ways to transpose a pitch: by semi-tone or scalar steps or by a ratio. The *Semi-tone-transposition* block (above left) can be used to make larger shifts in pitch in half-step units. A positive number shifts the pitch up and a negative number shifts the pitch down. The input must be a whole number. To shift up an entire octave, transpose by `12` half-steps. `-12` will shift down an entire octave.

The *Scalar-transposition* block (above right) shifts a pitch based on the current key and mode. For example, in `C Major`, a scalar transposition of `1` would transpose `C` to `D` (even though it is a transposition of `2` half steps). To transpose `E` to `F` is `1` scalar step (or `1` half step). To shift an entire octave, scalar transpose by the mode length up or down. (In major scales, the mode length is `7`.)

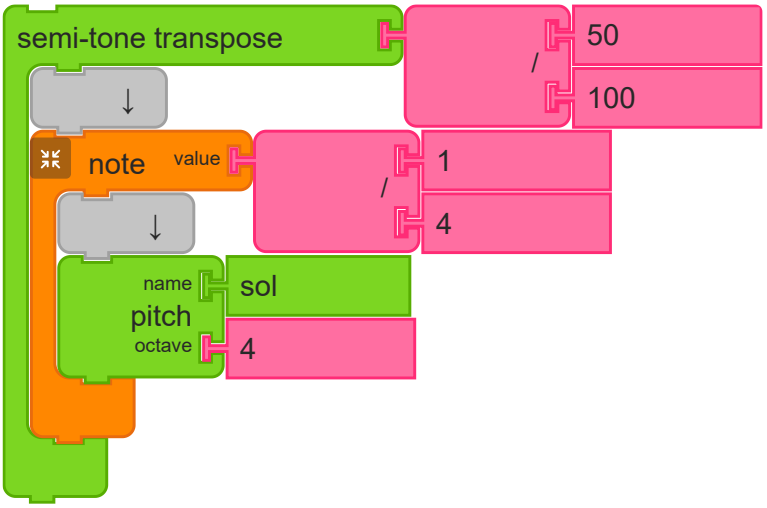


The *Transpose-by-ratio* block shifts a pitch based on a ratio. For example, a ratio of 2:1 would shift a pitch by an octave; a ratio of 3:2 would shift a pitch by a fifth.

As a convenience, a number of standard scalar transpositions are provided: *Unison*, *Second*, *Third*, ..., *Seventh*, *Down third*, and *Down sixth*, as well as a transposition for *Octave*.

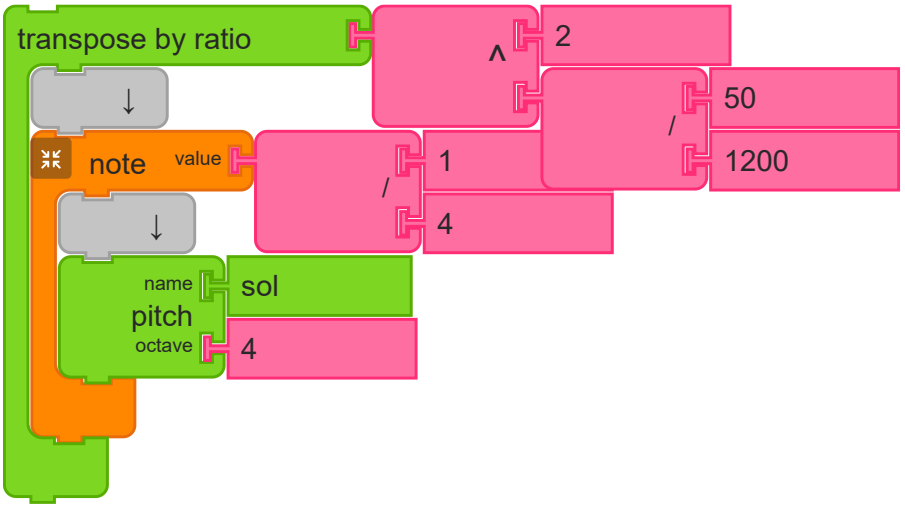


In the example above, we take the song we programmed previously and raise it by one octave.

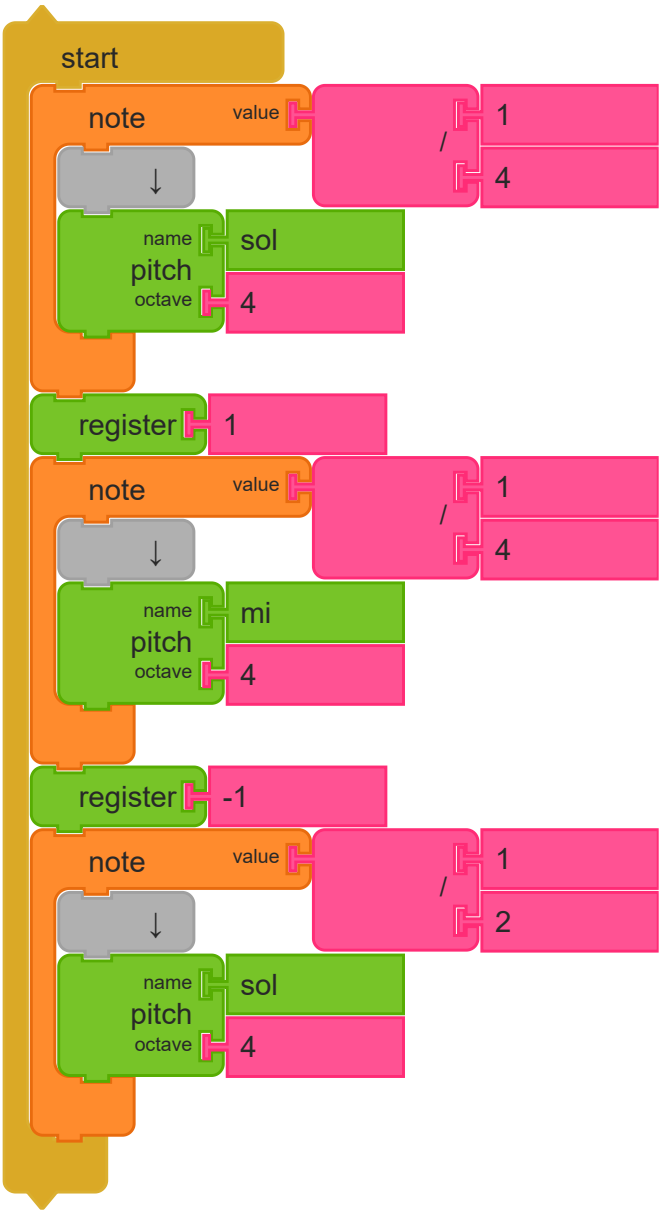


A cent is a unit of measure for the ratio between two frequencies. A semitone is defined as 100 cents. The frequency between two adjacent pitches would be 50 cents. You can use the *Semitone transpose* block to shift a pitch by cents.

In the example above, G4 + 50 cents is 403Hz. (Recall that G4 is 392Hz and G#4 is 415Hz).



You can also use the ratio block for cents, although the math is a bit more complicated.



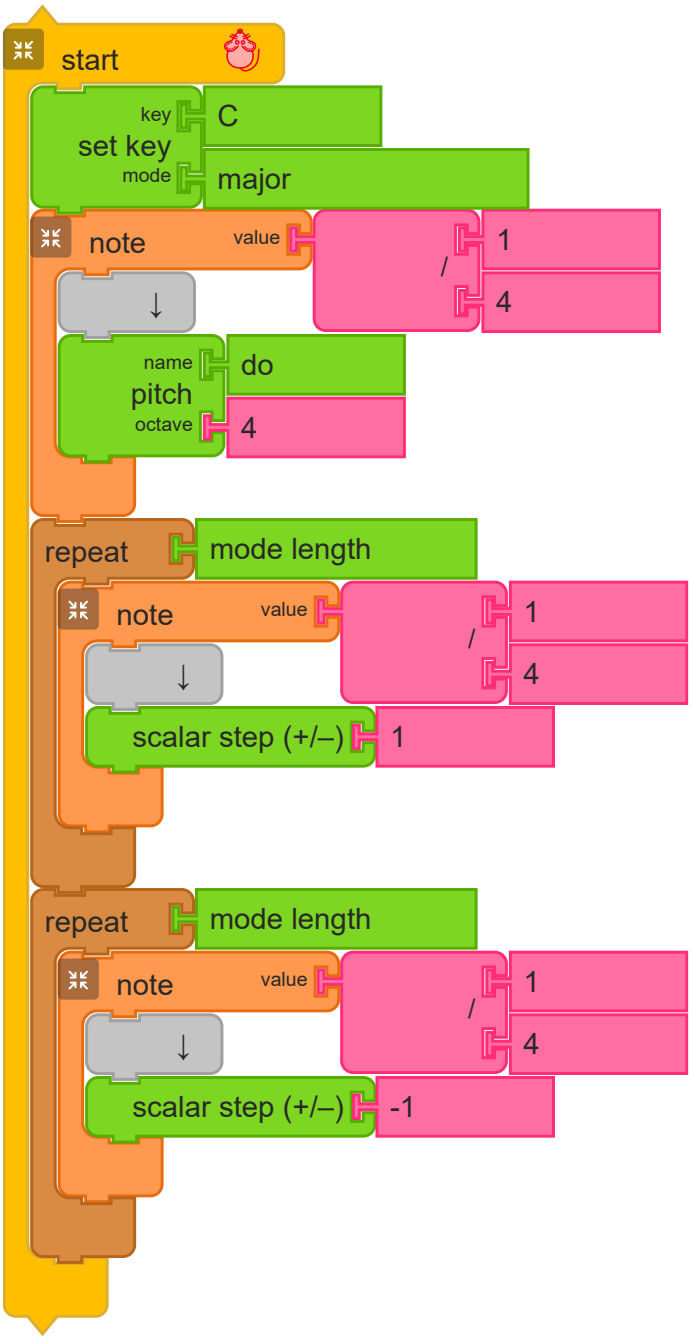
The *Register* block provides an easy way to modify the register (octave) of the notes that follow it. In the example above it is first used to bump the `Mi 4` note up by one octave and then to bump the `Sol 4` note down by one octave.

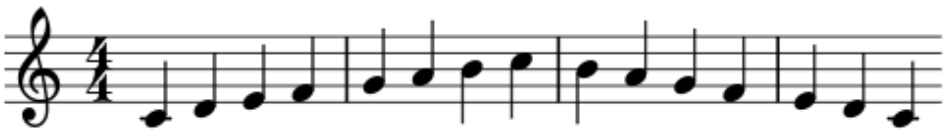
3.2.4 Summary of Pitch Movements

Representation	Pitch Movement	Properties
Scalar Step	scalar	0=no change
		1=next scalar pitch in current key and mode

Representation	Pitch Movement	Properties
		-1=previous scalar pitch in current key and mode
		If the argument to scalar step is positive, it moves up the scale; if it is negative, it moves down the scale.

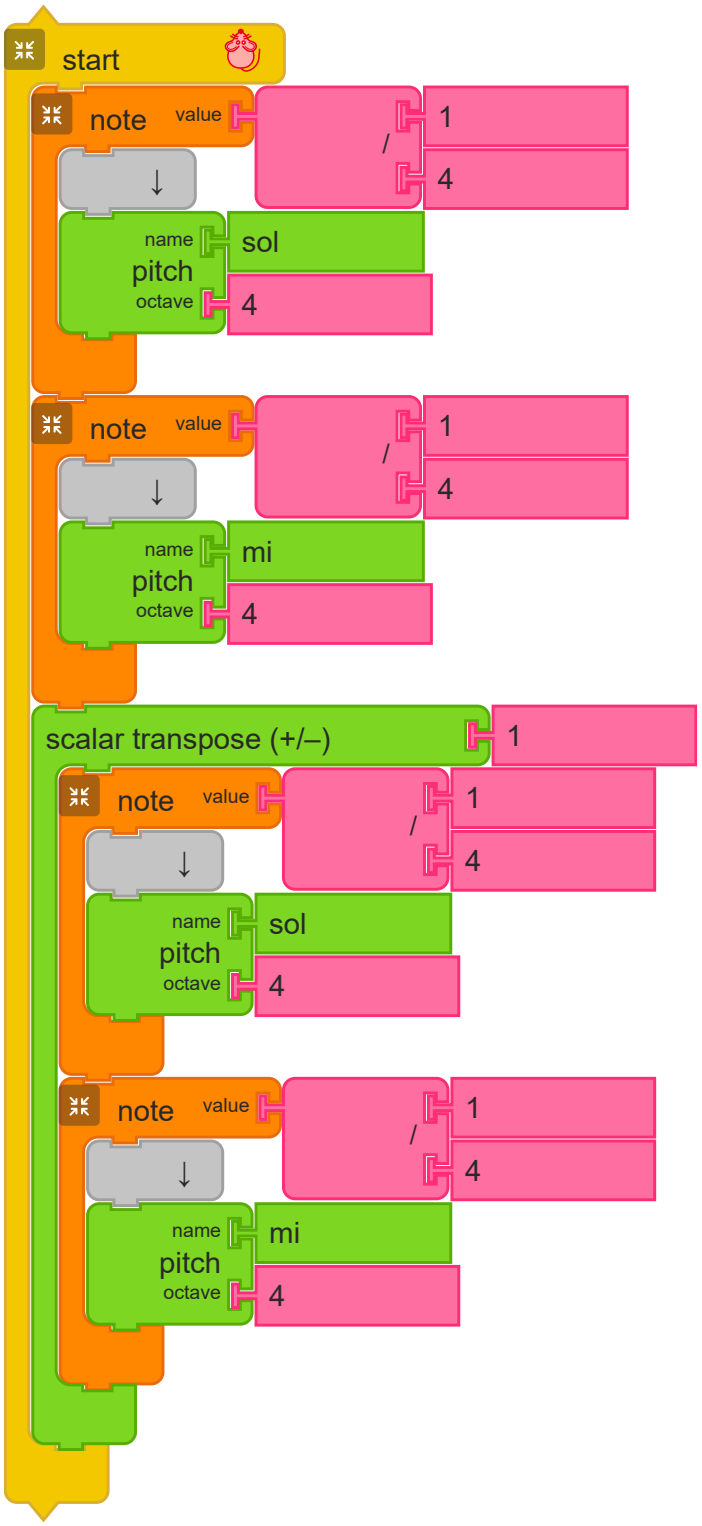
Music Blocks Code for Scalar Step

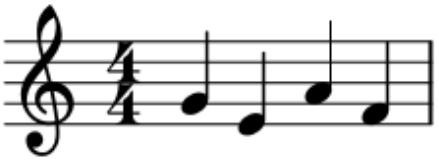


Music Blocks Code for Scalar Step
The example above demonstrates traveling up and down the major scale by moving an octave up from the starting note, do, one note at a time and then back down the same way.
Standard Notation with Scalar Step


Representation	Pitch Movement	Properties
Transposition	Semi-tone	Creates shifts in pitch by half-steps
		If the argument to transpose is positive, it will shift upwards in pitch; if it is negative, there will be a downwards shift.
		There are 12 half-steps shifts per octave.
		An argument of -12 will shift down one octave.
		An argument of zero will not change the pitch.

Music Blocks Code with Scalar Transpose



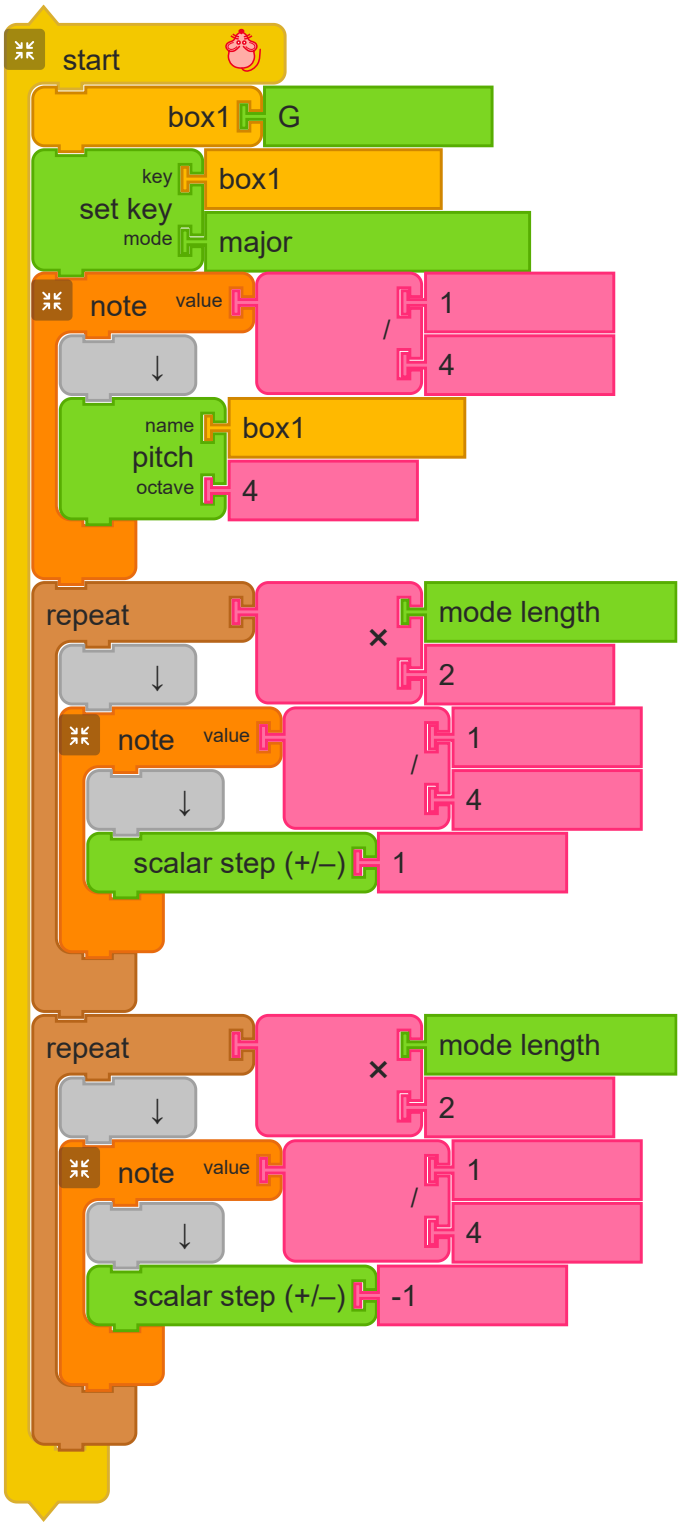
Standard Notation for Scalar Transpose		
		
Representation	**Pitch Movement**	**Properties**
Transposition	Scalar	Shifts the pitch based on the current key and mode
		Each number represents a scalar step.
		Scalar transposition can transform your original key to a new key by counting the notes between the keys.
		For example: Transposing C-D-E-F by 4 (fifth) will give us G-A-B-C
		To transpose an octave: shift by the mode length (7 in major scales) up or down.

3.2.5 Set Key

The *Set key* block is used to change both the mode and key of the current scale. (The current scale is used to define the mapping of Solfege [when set Movable Do = True] to notes and also the number of half steps take by the the *Scalar step* block.) For example, by setting the key to C Major, the scale is defined by starting at C (or Do) and applying the pattern of half steps defined by a Major mode. In this case, the pattern of steps skips past all of the sharps and flats. (On a piano, C Major is just the white keys).

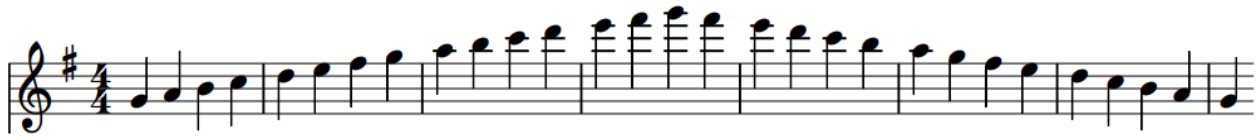
When using the *Set key* block, the mode argument is used to define the pattern of half steps and the key argument is used to define the starting position of the pattern. For example, when mode = "major" and key = "C", the pattern of half steps is 2 2 1 2 2 2 1 and the first note in the scale from which the pattern is applied is "C".

Set Key Example



Using the example above, one can modify the arguments to *Set key* in order to move up and down one octave in a scale. The example shows G Major scale, which has an F#, but it could be used for any combination of key and mode.

Standard Notation for Set Key Example



Various examples for Major modes are shown in the following table.

Key	Mode	Mode Pattern in Half Steps	Pitch Pattern
C	Major	2 2 1 2 2 2 1	C, D, E, F, G, A, B, C
G	Major	2 2 1 2 2 2 1	G, A, B, C, D, E, F#, G
D	Major	2 2 1 2 2 2 1	D, E, F#, G, A, B, C#, D
F	Major	2 2 1 2 2 2 1	F, G, A, B♭, C, D, E, F
B♭	Major	2 2 1 2 2 2 1	B♭, C, D, E♭, F, G, A, B♭

The next table is the same sets of various keys (starting pitches), but the mode is set to "Dorian" instead of Major.

Key	Mode	Mode Pattern in Half Steps	Pitch Pattern
C	Dorian	2 1 2 2 2 1 2	C, D, E♭, F, G, A, B♭, C
G	Dorian	2 1 2 2 2 1 2	G, A, B♭, C, D, E, F, G
D	Dorian	2 1 2 2 2 1 2	D, E, F, G, A, B, C, D
F	Dorian	2 1 2 2 2 1 2	F, G, A♭, B♭, C, D, E♭, F
B♭	Dorian	2 1 2 2 2 1 2	B♭, C, D♭, E♭, F, G, A♭, B♭

This last table is the same set of keys as the above two tables, but the mode is set to "Phrygian".

Key	Mode	Mode Pattern in Half Steps	Pitch Pattern
C	Phrygian	1 2 2 2 1 2 2	C, D♭, E♭, F, G, A♭, B♭, C
G	Phrygian	1 2 2 2 1 2 2	G, A♭, B♭, C, D, E♭, F, G

Key	Mode	Mode Pattern in Half Steps	Pitch Pattern
D	Phrygian	1 2 2 2 1 2 2	D, E♭, F, G, A, B♭, C, D
F	Phrygian	1 2 2 2 1 2 2	F, G♭, A♭, B♭, C, D♭, E♭, F
B♭	Phrygian	1 2 2 2 1 2 2	B♭, C♭, D♭, E♭, F, G♭, A♭, B♭

Notice how in all the examples, the sets with the same mode results in the same "Mode Pattern of Half Steps", but the resultant "Pitch Pattern" is different. Also, notice how G Dorian and F Major have the same set of pitches in "Pitch Pattern" (they both have B♭ and no other sharps or flats). C Dorian, D Phrygian, and B♭ Major all have the same set of pitches as well (all three have B♭ and E♭).

If these lists were expanded further, there would be many more such examples. These are because these modes (Major, Dorian, and Phrygian) all have essentially the same modal pattern; the starting point is just shifted slightly for each: Dorian could be thought of starting from the second scale degree of Major and Phrygian from the third, for example. Not all modes have this relationship to Major. The ones that do are: Ionian (Major), Dorian, Phrygian, Lydian, Myxolydian, Aeolian (Minor), and Locrian.

Set Key & Scalar Step

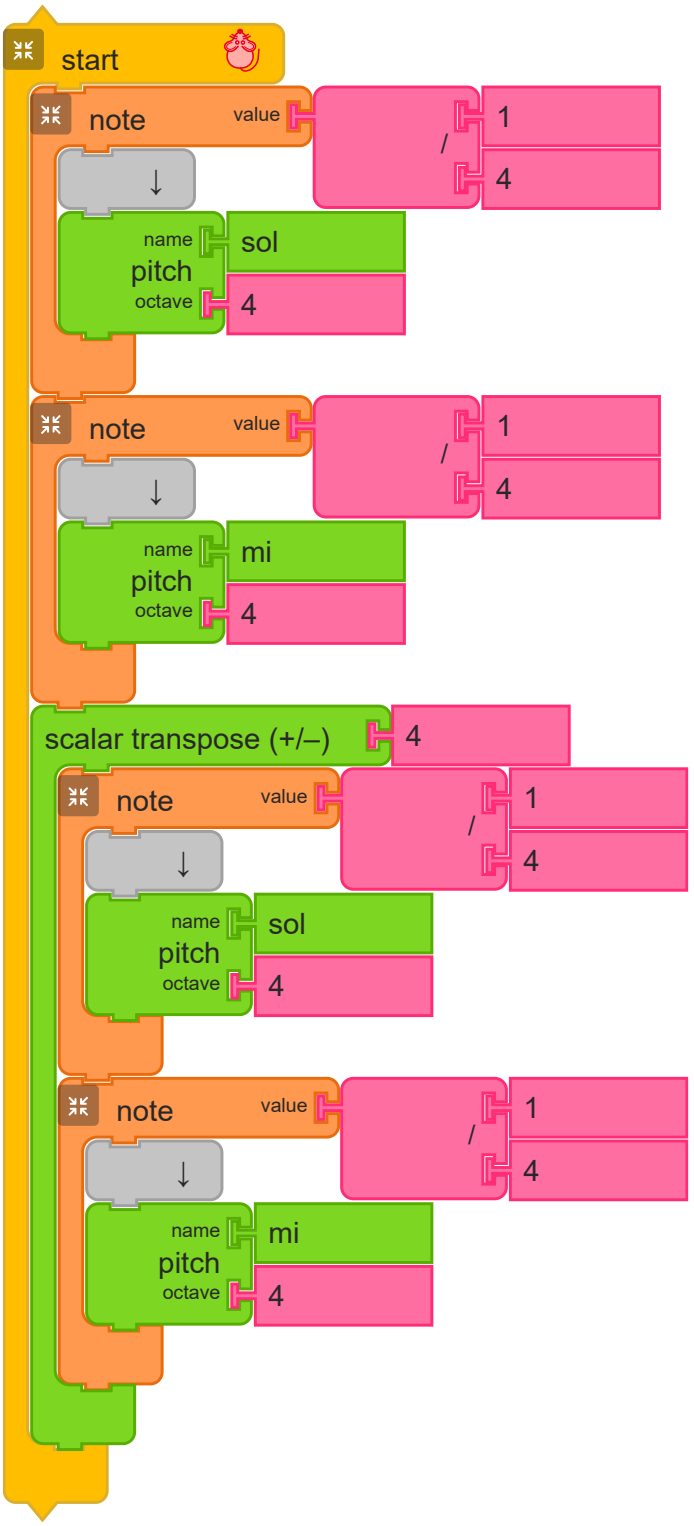
The *Set key* block is used to select a subset of notes in the given temperament. (By default, Music Blocks uses equal temperament of 12 equal divisions of the octave. The key and mode determine which of these notes will be used.)

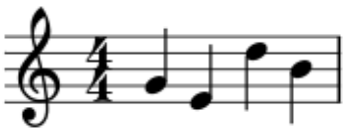
Set Key & Movable Do

The *Set Key* block will change the key and mode of the mapping between solfege, e.g., `Do`, `Re`, `Mi`, to note names, e.g., `F#`, `G#`, `A#`, when in F# Major. It only impacts the mapping of solfege when the *movable Do* block is set to True.

You can find the *Set key* block on the *Intervals* palette.

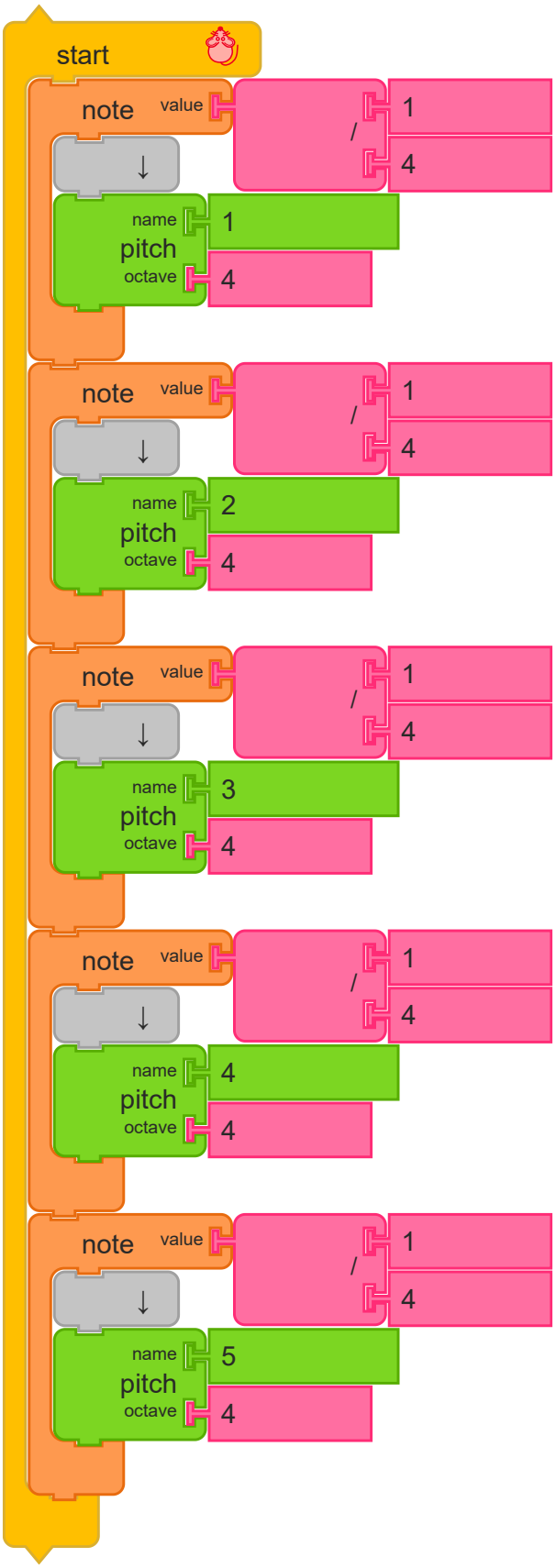
Music Blocks for Set Key and Movable Do

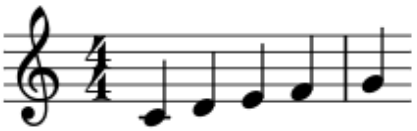


Standard Notation for Set Key and Movable Do		
		
Representation	**Pitch Movement**	**Properties**
Scale Degree	Scalar	The key block sets the key and mode.
		The scale degree blocks indicate which position the pitch is taking in the scale relative to the tonic which is "scale degree 1".

Music Blocks Code with Scale Degrees 1-5

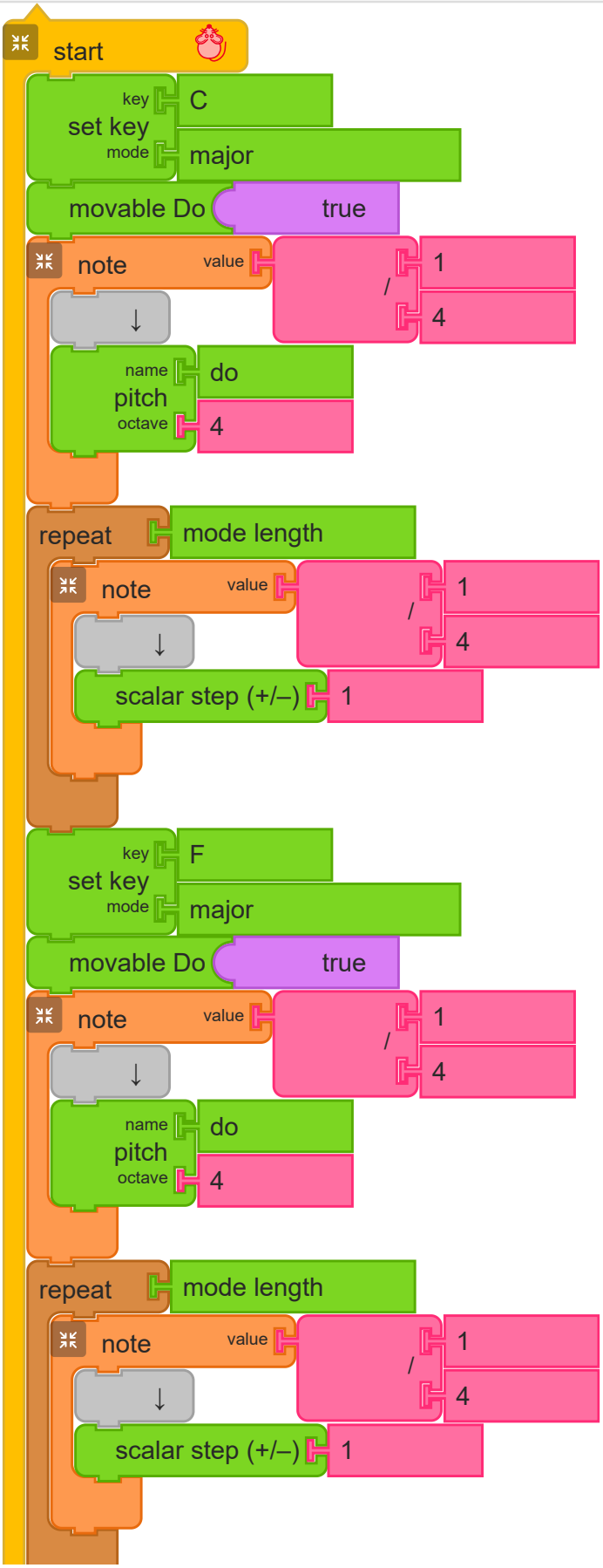
Music Blocks Code with Scale Degrees 1-5

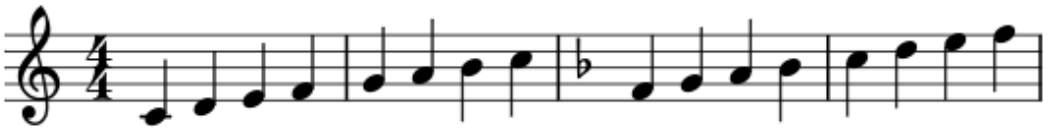


Standard Notation for Scale Degrees 1-5		
		
Representation	**Pitch Movement**	**Properties**
Movable “Do”	Advanced transposition by mode	Movable Do in combination with the Scale/Mode blocks will transpose sections of music in a nuanced way.
		The Set-key block allows you to change both the mode and key of how solfege is mapped to the notes.
		For example, in C major - Do is C, Re is D, Mi is E, etc.
		In F major - Do is F, Re is G, Mi is A

Music Blocks Code with Set Key and Movable Do

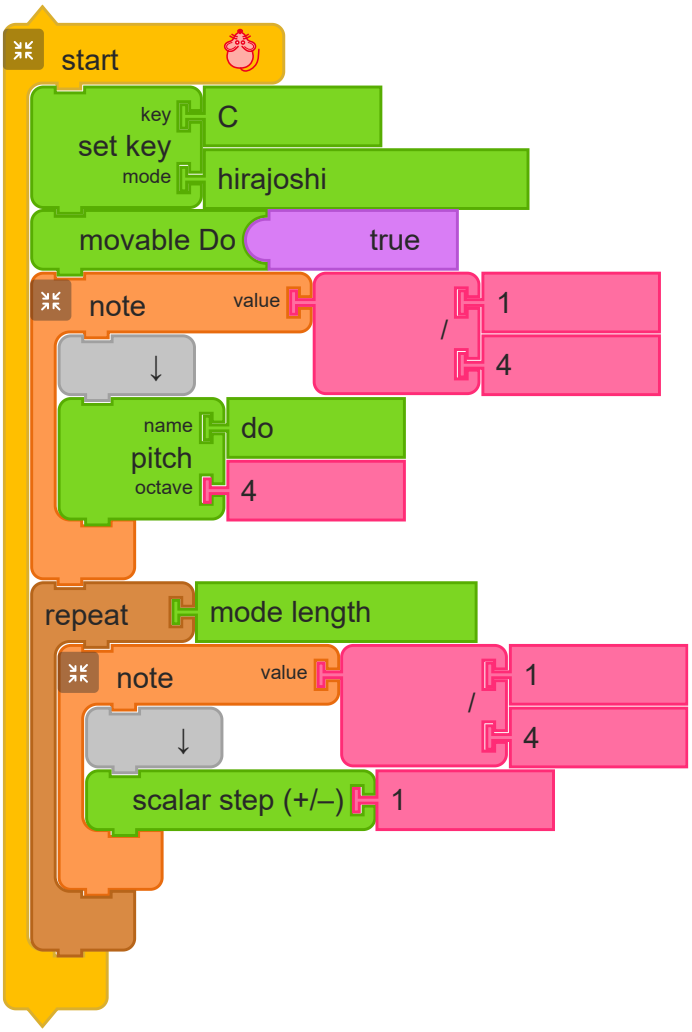
Music Blocks Code with Set Key and Movable Do



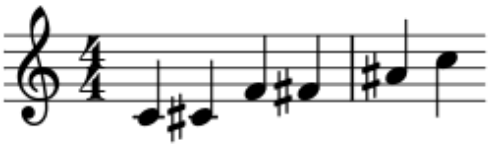
Standard Notation Code for Set Key and Movable Do


Representation	Pitch Movement	Properties
Movable “Do”	Advanced transposition by mode	You also have the option of changing the mode to Minor, Major, Chromatic, and many other exotic modes like hirajoshi, as shown in the example below.

Music Blocks for Set Key and Scalar Step



Standard Notation with Set Key and Scalar Step



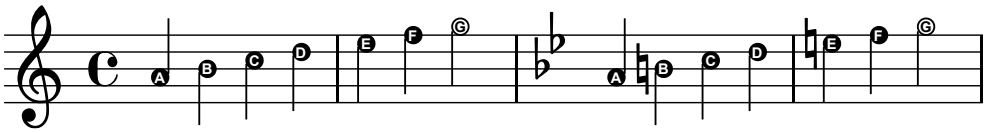
3.2.6 Fixed and Movable Pitch Systems

Music Blocks allows users to express and explore musical ideas in a variety of different systems. The main systems of expression are fixed and movable.

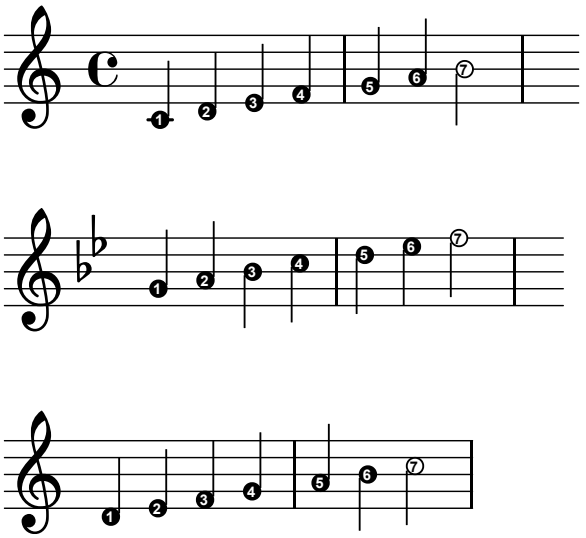
Fixed and Movable Systems

Fixed pitch systems represent pitches in an absolute way. Pitches in a fixed system do not change, regardless of a tonal context (such as key or mode). Movable systems, on the other hand, represent pitches in a relative way based on their tonal context.

An example of a fixed system is Alphabet Notation. Pitches are expressed as `A`, `B`, `C`, `D`, `E`, `F`, and `G`. Regardless of whether the key is C major or G minor, the pitch of `G` is the same. In Alphabet Notation, pitches are the same ("fixed") regardless of the context.

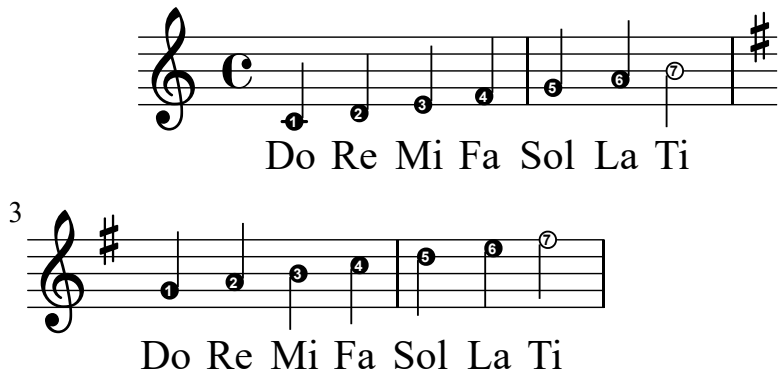


An example of a movable system is Scale Degree. Pitches are expressed as `1`, `2`, `3`, `4`, `5`, `6`, and `7`. For C major, these pitches are `C`, `D`, `E`, `F`, `G`, `A`, and `B`. For G (natural) minor, these pitches are `G`, `A`, `B♭`, `C`, `D`, `E♭`, and `F`. For D dorian, these pitches are `D`, `E`, `F`, `G`, `A`, `B`, and `C`. In all three examples, the pitches are determined by the tonal context.



Solfege is an example of a system that can be either fixed or movable; it can either be a fixed system (Fixed Solfege) or a movable system (Movable Solfege).

Fixed Solfege works like the alphabet system; `La` is `A`, `Ti` is `B`, `Do` is `C`, etc. Context does not affect the sounding pitch. Movable Solfege works like the Scale Degree system; for any major, `Do` is 1st scale degree, `Re` is 2nd, `Mi` is 3rd, `Fa` is 4th, etc. Hence, in Movable Solfege in the key of G (natural) minor, `Do` is `G`, `Re` is `A`, et al.



Music Blocks users can create and preview code in both Fixed Solfege and Movable Solfege. Teachers and learners may use either system (or both) to express their musical ideas as well as deepen their understanding of music.

Using Tonal Context with Movable Systems

For movable systems an important point of context is its key and mode. For "C Major", the key is "C" and the mode is "Major" (also called Ionian). Key and mode are important as they define the tonal framework, i.e., which pitches are "in" and which are "out". It also defines the function of the pitches within the framework. This is why for scale degrees `1`, `2`, `3`, `4`, and `5`, the expected result for C major is `C`, `D`, `E`, `F`, and `G` (skipping any sharps/flats), while those same scale degrees for D major are `D`, `E`, `F#`, `G`, and `A`. The set of pitches that make up C major have no sharps or flats, so they are skipped. D major has two sharps, `F#` and `C#`. The `F#` is the 3rd scale degree for D major.

Scale Degree with *Set Key* is a very powerful tool for expression. It is also very common in music pedagogy. However, because the number values 1-7 are hard wired into this system, it is a tool that works best to express seven-pitch tonal frameworks (e.g. major, minor, and other common seven pitch scales). For musical ideas where a more purely mathematical form of expression is required, Music Blocks offers the user the *nth Modal Pitch* block.

nth Modal Pitch is similar to *Scale Degree* in that it is a movable system that uses numbers to express pitches. However, unlike *Scale Degree*, *nth Modal Pitch* starts at `0`, allows for negative numbers, and is not restricted to a seven-pitch tonal framework. `0` is the first pitch of the mode, `1` is the next pitch, `2` is the pitch above that, etc. `-1` is the pitch before the first pitch of the mode. This tool is especially helpful for expressing a musical idea that requires computation as you can run computations directly on the number value. It is also helpful if you are, for example, creating music in a whole tone (six note) pitch space. In the case of *Set Key* set to "whole tone", `6` would be the octave above.

Pitch Number, MIDI, and Set Pitch Number Offset

Pitch Number is similar to *nth Modal Pitch* in that it is a zero-based, mathematical system to express pitches. However, unlike *nth Modal Pitch*, *Pitch Number* disregards any tonal framework. It is also chromatic by default, meaning that its pitch space includes the sharp/flat

pitches (black keys on piano) as well as the natural pitches (white keys on piano). By default, middle C (C_4) is `0`. The C major scale in the 4th octave is `0`, `2`, `4`, `5`, `7`, `9`, and `11`. `12` is the C an octave above middle C (C_5). This system is useful mathematically, but because it disregards key, it is difficult to control when creating music. That being said, fretted instruments such as ukulele and guitar use this system to express pitch, so it is a good system for expressing how these instruments work.

MIDI also uses a similar system to *Pitch Number* to express pitches, but the 0 is offset from Music Blocks' default. In order to change the sounding pitch of `0` for *Pitch Number*, use *set pitch number offset*. This makes *Pitch Number* blocks behave as a relative system as it transposes the pitches up or down accordingly (but has no effect on key).

Two Subsystems for Movable

For Movable Do, there exists yet two more systems. One system, which we call `Movable=Do`, allows the user to express solfege syllables in relation to the Major mode. Therefore, if a user were to specify A minor, then La would be A, the first scale degree in A Minor. The other system, which we call `Movable=La` allows the user to express solfege in relation to the particular mode specified. Therefore, if a user were to specify A Minor, then Do would be A. *Scale Degree* works like `Movable=La` by default such that `1` is always the first pitch of a given mode.

Because some users may want to explicitly spell out all of the pitches regardless of the chosen key, we allow them to use Scale Degree with the *Movable Do* block (remember, Scale Degree works like Movable=La by default). Please see this code (../../examples/2-spelling-systems-for-Scale-Degree.html) as an example.

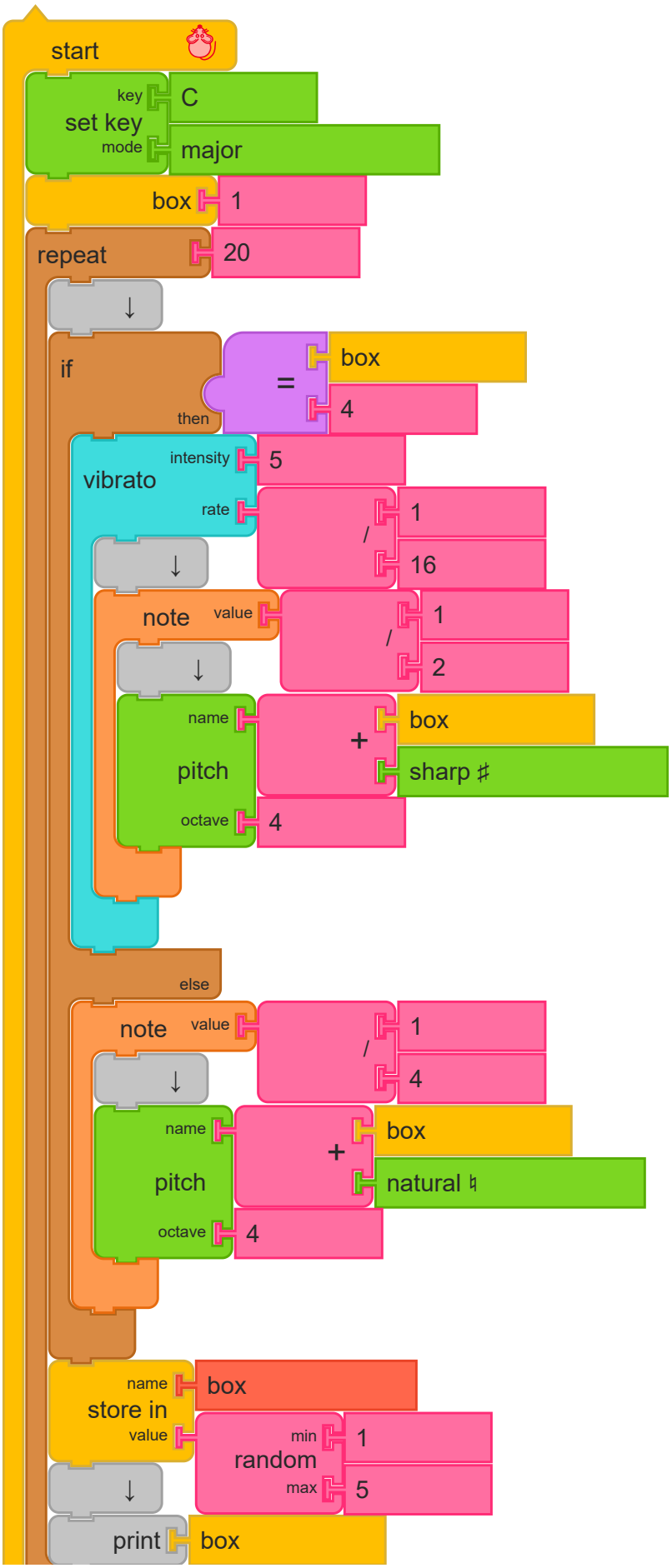
The following chart describes the behavior of different blocks depending on whether or not a *Movable Do* block is present.

Block(s)	**Fixed or Movable? (Do or La?)**	**Set Key Transformation?**
Alphabet Pitch	Fixed	No effect.
Solfege	Fixed by default	No effect.
Solfege and Movable=Do	Specified via "movable" block set to Do	Yes.

Block(s)	Fixed or Movable? (Do or La?)	Set Key Transformation?
Solfege and Movable=La	Specified via "movable" block set to La	Yes. Works like Scale Degree.
n^th modal pitch	Movable	Yes. Good for modes of any length.
Scale Degree	Movable	Yes. Most useful for 7 note systems. Works just like Movable=La for Solfege by default.
Scale Degree and Movable=Do	Movable	Yes. When preceded by Movable=Do, the user can be explicit in their spelling.
Scalar Step	Movable	Yes. Navigates up/down within *nth modal pitch* space.
Scalar Interval	Movable	Yes. Adds above/under within *nth modal pitch* space.
Scalar Inversion	Movable	Yes. Inversion around a specified axis within *nth modal pitch* space.
Pitch Number	Movable	No effect. Pitches can be transformed via Set Pitch Number Offset.

Illustrative example:

The following example demonstrates how the Scale Degree functionality combines math and musical modifiers. When combining numbers and accidentals, it recreates the same functionality as the *Scale Degree* block.


start
key
C
set key
mode
major
box
1
repeat
20
if
=
box
4
then
intensity
5
vibrato
rate
/
1
16
note
value
/
1
2
name
pitch
octave
+
box
sharp ♯
4
else
note
value
/
1
4
name
pitch
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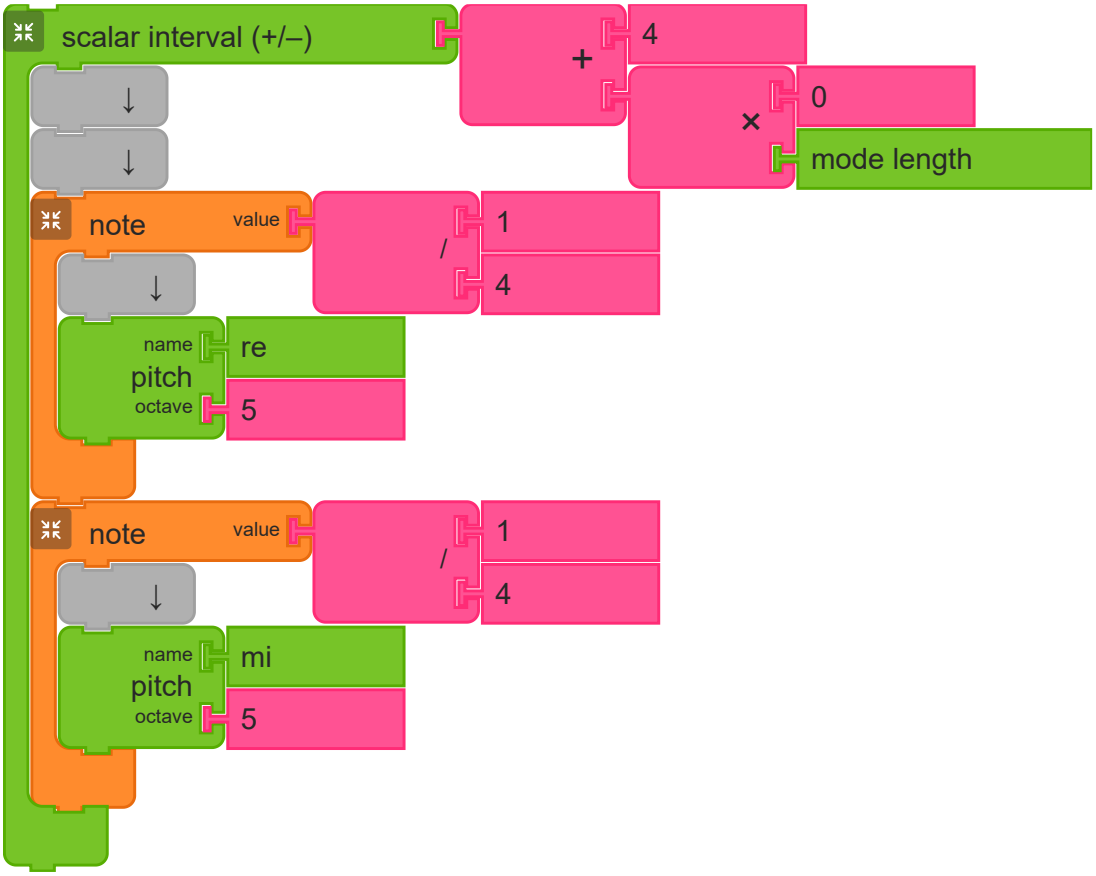
3.2.7 Intervals



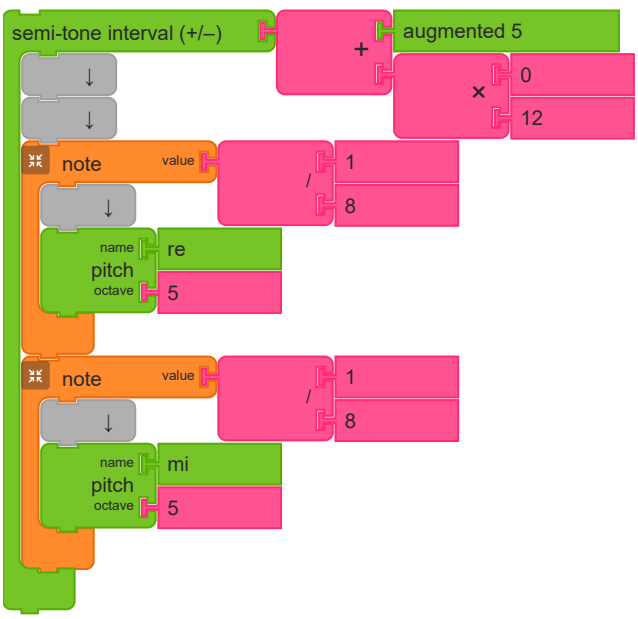
The *Scalar interval* block calculates a relative interval based on the current mode, skipping all notes outside of the mode. For example, a *fifth*, and adds the additional pitches to a note's playback. In the figure, we add `La` to `Re` and `Ti` to `Mi`.

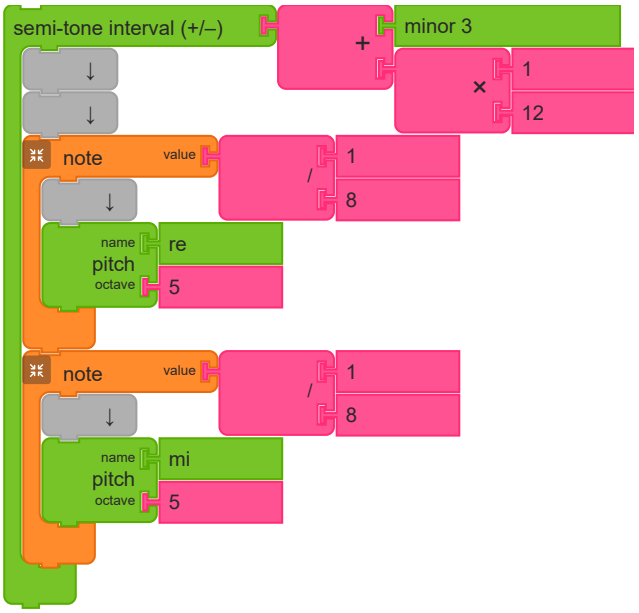
As a convenience, a number of standard scalar intervals are provided on the *Intervals* palette: *Unison*, *Second*, *Third*, ..., *Seventh*, *Down third*, and *Down sixth*.

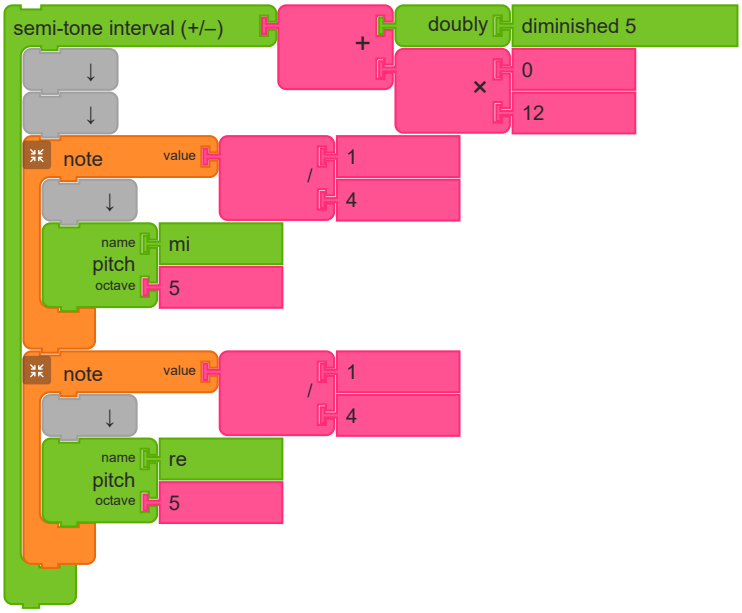
The *Scalar interval measure* block can be used to measure the number of scalar steps between two pitched.

3.2.7.1 Absolute Intervals

Absolute (or semi-tone) intervals are based on half-steps.







The *Augmented* block calculates an absolute interval (in half-steps), e.g., an augmented fifth, and adds the additional pitches to a note. Similarly, the *Minor* block calculates an absolute interval, e.g., a minor third. Other absolute intervals include *Perfect*, *Diminished*, and *Major*.

In the augmented fifth example above, a chord of `D5` and `A5` are played, followed by a chord of `E5` and `C5`. In the minor third example, which includes a shift of one octave, first a chord of `D5` and `F5` is played, followed by chord of `E5` and `G6`.

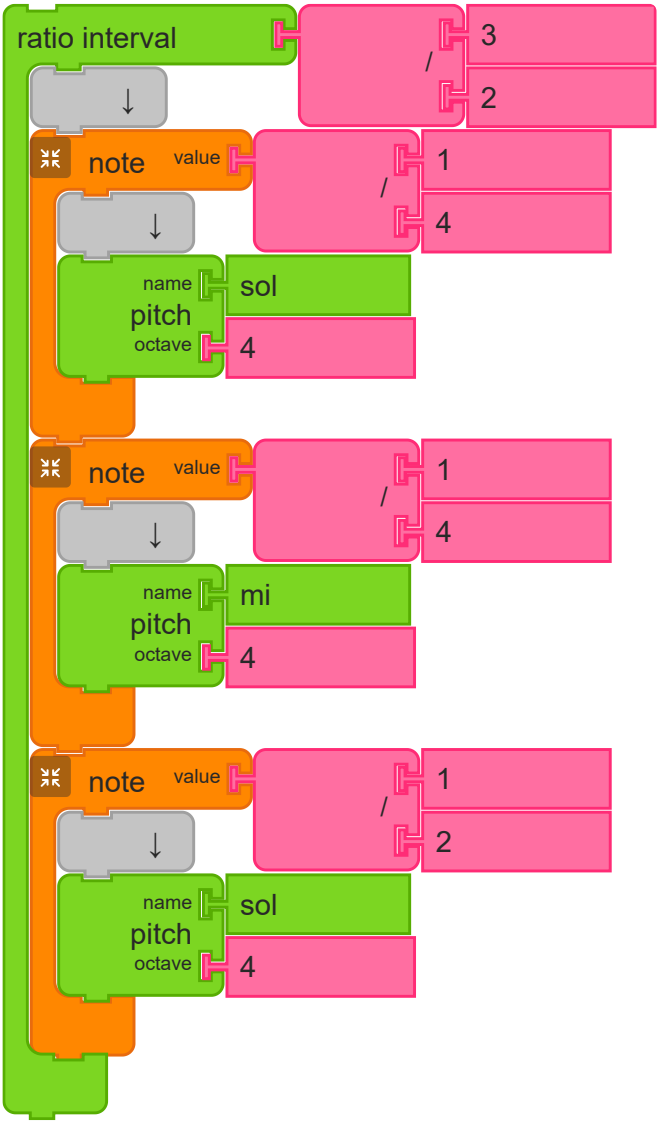
As a convenience, a number of standard absolute intervals are provided on the *Intervals* palette: *Major 2*, *Minor 3*, *Perfect 4*, *Augmented 6*, *Diminished 8*, et al.

The *Doubly* block can be used to create a double augmentation or double diminishment.

The *Semi-tone interval measure* block can be used to measure the number of half-steps between two pitches.

3.2.7.2 Ratio Intervals

Another way to think about intervals is in terms of ratios. For example, a ratio of 2:1 would be an octave shift up; 1:2 would be an octave shift down; 3/2 would be a fifth.

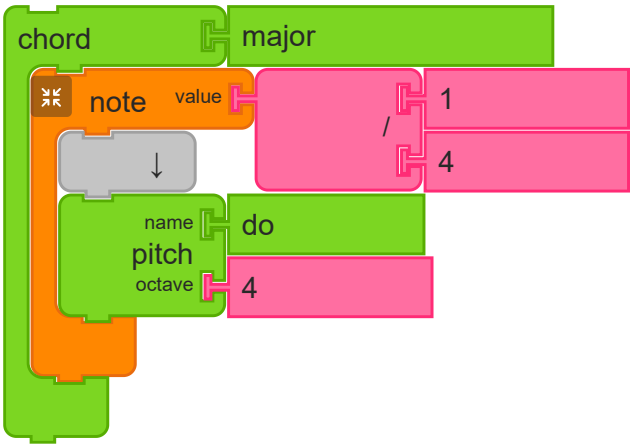


The *Ratio Interval* block lets you generate an interval based on a ratio.

3.2.8 Chords

A chord is a group of notes that are played together (often used for harmony in music). There are triads (three notes), tetrachords (four notes), and even five-, six-, and seven-note chords.

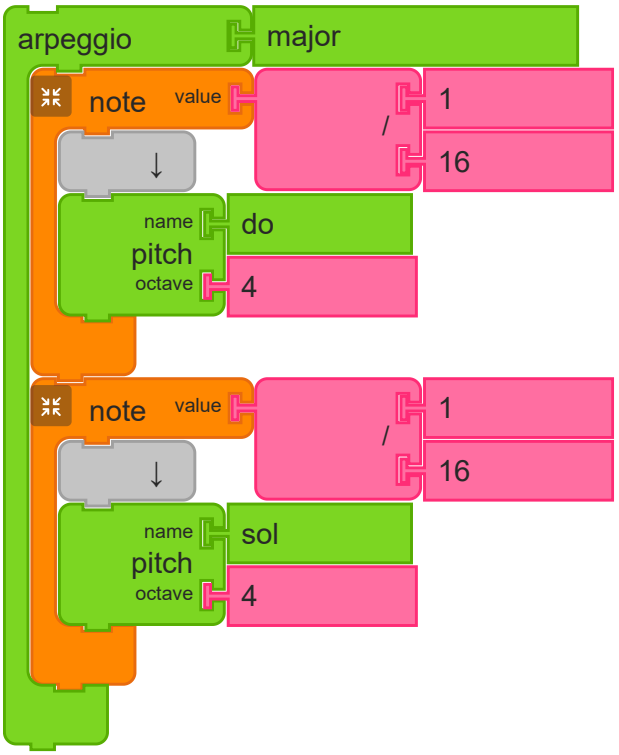
The *Chord* block builds a chord from a base note.



We support many basic chords:

chord	intervals	example
major	1 4 7	C major C - E - G
minor	1 3 7	C minor C - E♭ - G
dominant 7	1 4 7 10	C7 C - E - G - B♭
minor 7	1 3 7 10	Cmin7 C - E♭ - G - B♭
major 7	1 4 7 11	Cmaj7 C - E - G - B

The *Arpeggio* block also builds a chord from a base note, but rather than playing all of the pitches at once, each pitch is played in sequence.



In the example above, since the Major chord intervals are 1 4 7, the notes played are do, mi, sol, sol, ti, mi.

3.2.9 Inversion

The *Invert* block will rotate a series of notes around a target note. There are three different modes of the *Invert* block: *even*, *odd*, and *scalar*. In *even* and *odd* modes, the rotation is based on half-steps. In *even* and *scalar* mode, the point of rotation is the given note. In *odd* mode, the point of rotation is shifted up by a `1/4` step, enabling rotation around a point between two notes. In "scalar" mode, the scalar interval is preserved around the point of rotation.

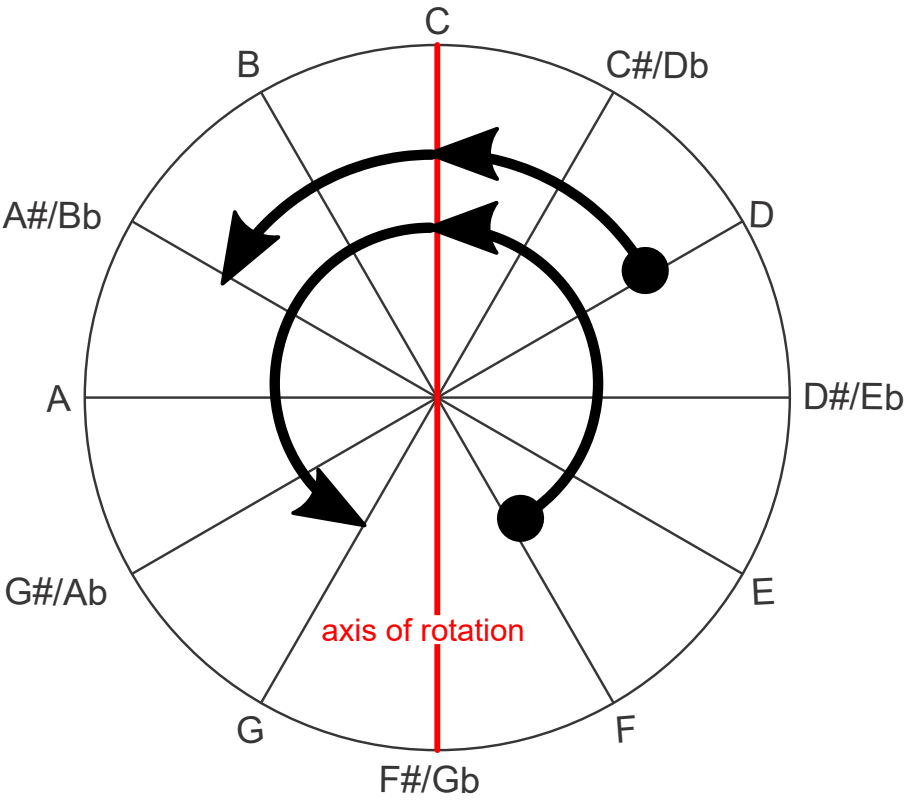
NOTE: The initial `C5` pitch (as a half note) remains unchanged (in all of the examples) as it is outside of the invert block.

The above example code has an *even* inversion for two notes `F5` and `D5` around the reference pitch of `C5`. We would expect the following results:

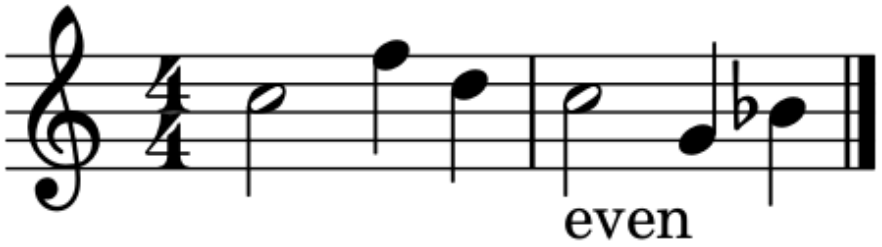
Even inversion

Starting pitch	Distance from C5	Inverse distance from C5	Ending pitch
F5	5 half steps *above*	5 half steps *below*	G4
D5	2 half steps *above*	2 half steps *below*	B♭4

This operation can also be visualized on a pitch clock. The arrows on the following diagram point from the starting pitch, around the axis of the reference pitch, to its destination ending pitch.



In standard notation the result of this *even* inversion operation is depicted in the second measure of the following example. The first measure is the original reference.

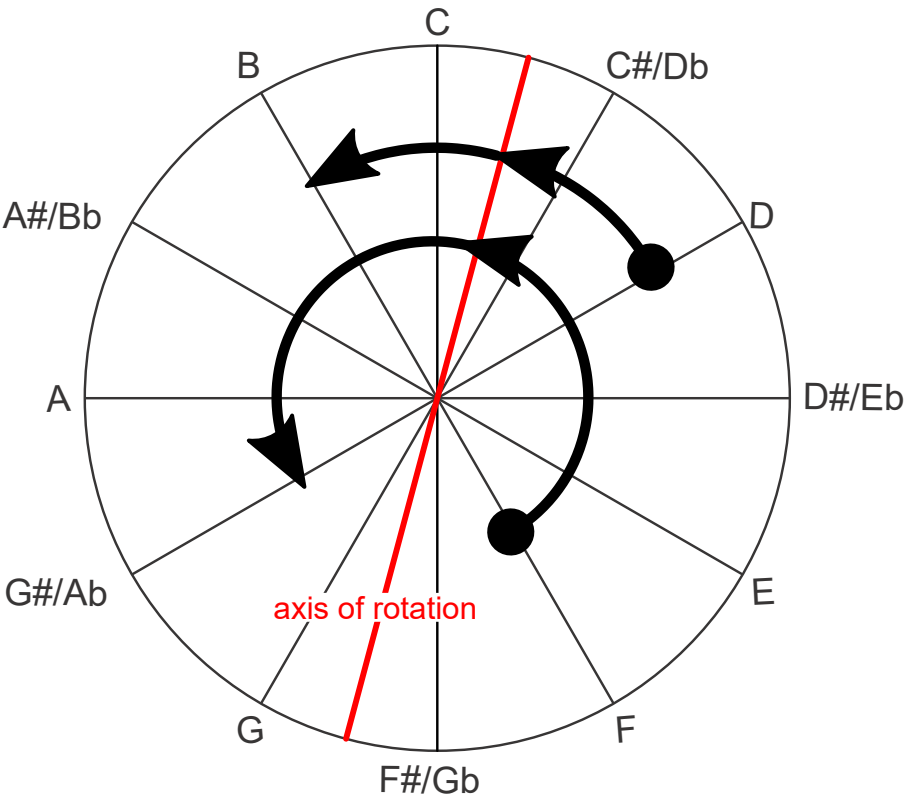


Underneath the *even* inversion in the example code is an *odd* inversion for the same two notes of `F5` and `D5` around the same reference pitch of `C5`. We would expect the following results:

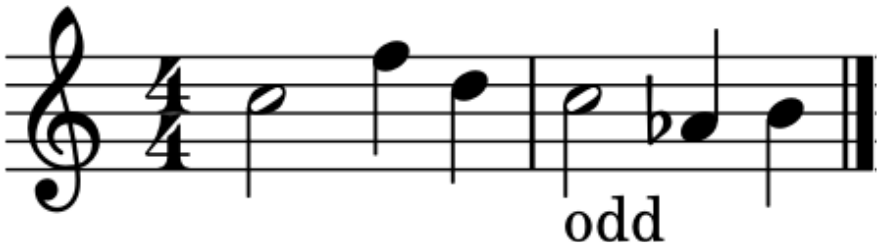
Odd inversion

Starting pitch	Distance from midway-point between `C5` and `C♯5`	Inverse distance from midway-point between `C5` and `C♯5`	Ending pitch
`F5`	4.5 half steps *above*	4.5 half steps *below*	`A♭4`
`D5`	1.5 half steps *below*	1.5 half steps *above*	`B4`

This operation can be visualized on a pitch clock similar to *even* inversion except offset in-between `C5` and `C♯5` (i.e. quarter step *above* `C5`).



In standard notation the result of this *odd* inversion operation is depicted in second measure of the following example. The first measure is the original reference. NOTE: The `C5` pitch remains unchanged as it is not operated upon in the example block code (above). If it were contained in the operation it would be changed to `C♯5` (i.e. `C5` is 0.5 half steps *below* the axis of rotation, so the result of an inversion around `C5` and `odd` would be 0.5 half steps *above* the axis of rotation).

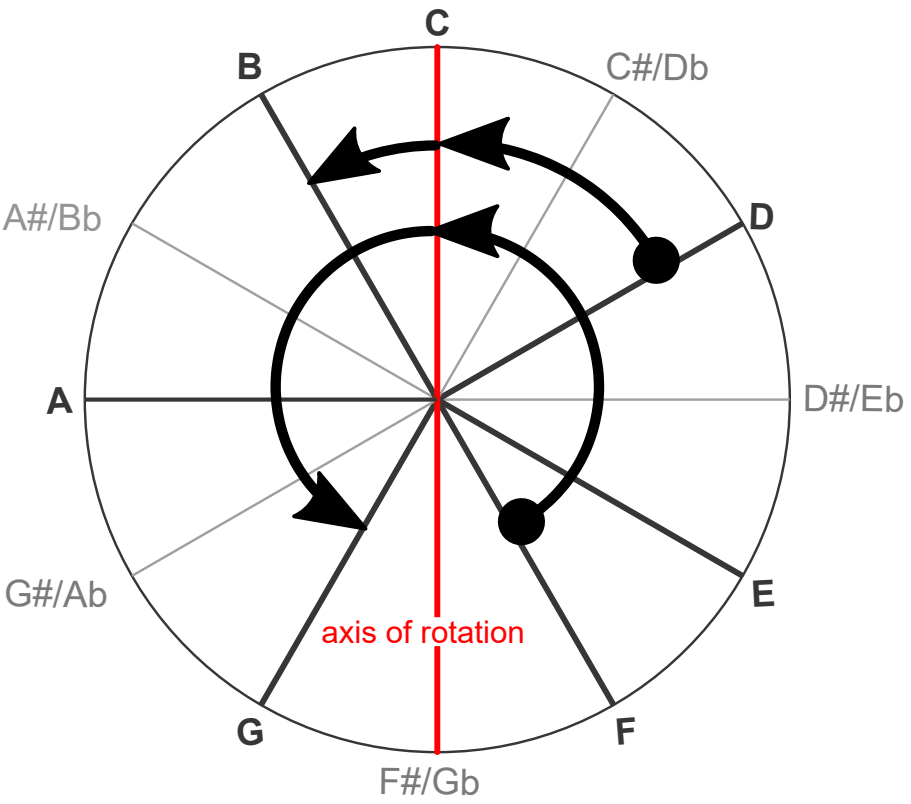


Scalar inversion

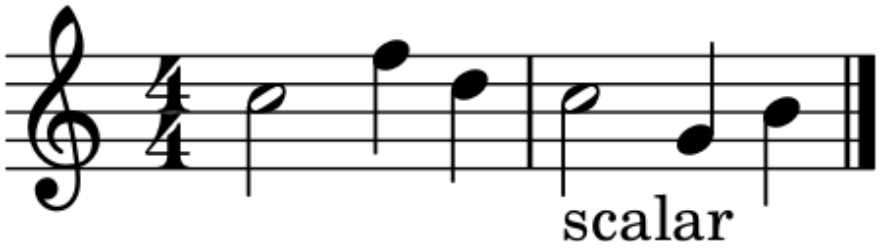
Underneath the *even* and *odd* inversion blocks in the example code is an inversion block set to *scalar*. We would expect the following results:

Starting pitch	Scalar distance from C5 (in steps)	Inverse scalar distance from C5 (in steps)	Ending pitch
F5	3 above (C5 --> D5 --> E5 --> F5)	3 below (C5 --> B4 --> A4 --> G4)	G4
D5	1 above (C5 --> D5)	1 below (C5 --> B4)	B4

This operation can be visualized on a pitch clock similar to *odd* and *even* except that all non-scalar pitches (i.e. pitches outside the chosen key) are skipped. NOTE: The scalar pitches are shown in bold in the following pitch clock diagram.



In standard notation the result of *scalar* inversion operation is depicted in the second measure of the following example. The first measure is the original reference.



In the *invert (even)* example above, notes are inverted around `C5` . In the *invert (odd)* example, notes are inverted around a point midway between `C5` and `C♯5` . In the *invert (scalar)* example, notes are inverted around `C5` , by scalar steps rather than half-steps.

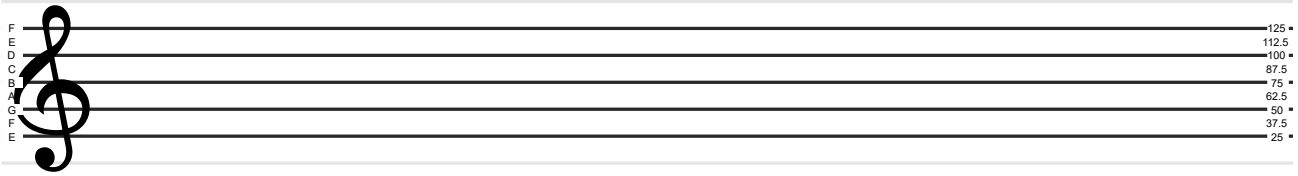
3.2.10 Converters

Converters are used to transform one form of inputs into other, more usable form of outputs. This section of the guide will talk about the various conversion options Music Blocks has to offer.

Generalized shape of a converter is:

where the right argument is converted accordingly, and output is received on the left side.

Note: Before an introduction of the different types of converters, a little introduction on Y staff in Music Blocks. Staff is a set of horizontal lines and spaces and different positions along Y axis represents different notes. [C, D, E, F, G, A, B]

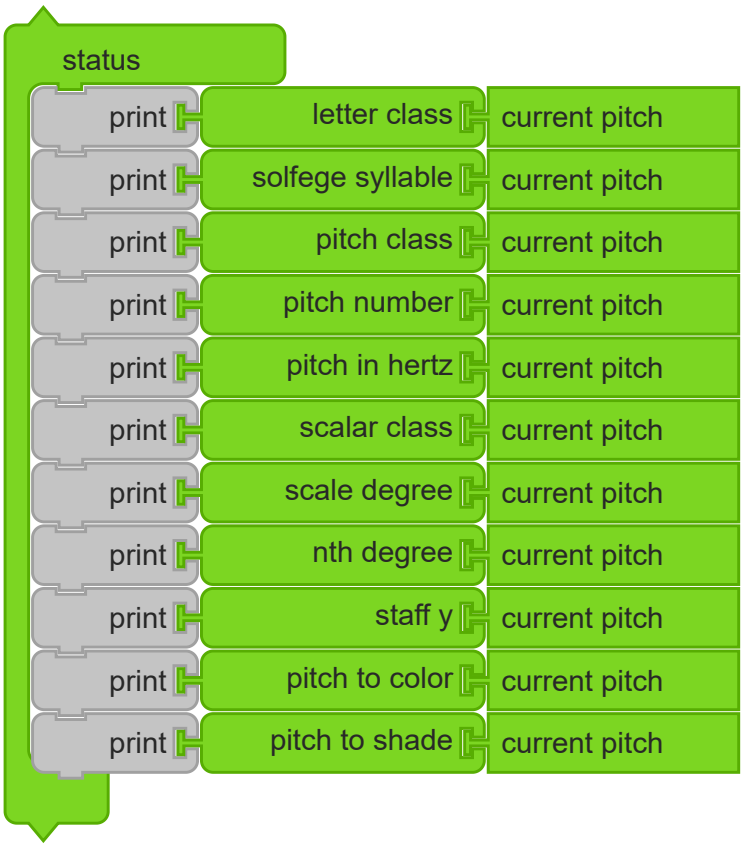


3.2.9.1 Y to Pitch

This converter takes input in the form of a number that represents Staff Y position in pixels, and processes the value such that it can be used with certain pitch blocks (pitch number, nth modal pitch, pitch) to produce notes corresponding to given Staff Y position as an argument.

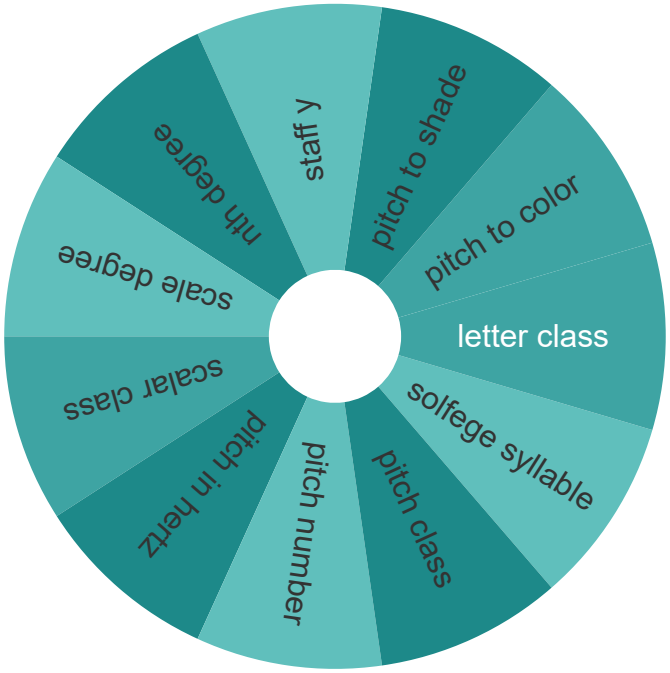
Additionally, the block can be plugged into a print block to view the converted note value.

3.2.9.2 Pitch converter



Pitch converter offers a range of options through a pie-menu based interface and it can potentially convert or extract info out of the current playing pitch using the current pitch block as an input. It can also take custom input in form or solfege, hertz, pitch number etc.

All these options are provided in the form of a pie-menu which can be accessed simply by clicking on the converter.



Below explained is the utility of every conversion option:

0. Alphabet:

Prints the alphabet data of the note being played e.g A, B, C, D, E, F, G, including accidentals.

1. Alphabet class:

Prints the alphabet data of the note being played e.g A, B, C, D, E, F, G. It doesn't print any info regarding accidentals.

2. Solfege Syllable:

Similar to Alphabet class, returns the data in form of solfege e.g do, re, mi. It too, gives no info regarding accidentals.

3. Pitch class:

Returns a number between 0 to 11, corresponding to the note played, where C is 0 and B is 11. Each increase in the number signifies an increase by one semitone.

4. Scalar class:

Returns a number between 1-7 corresponding to the scale degree of the note being played, with reference to the chosen mode. Provides no info regarding accidentals.

5. Scale Degree:

Intuitively, returns the scale degree of the note being played with reference to the chosen mode. It can also be thought of as Scalar class with accidentals.

6. N^th Degree:

Zero-based index of the degree of note being played in the chosen mode.

7. Pitch in Hertz:

Returns the value in hertz of the pitch of the note being currently played.

8. Pitch Number:

Value of the pitch of the note currently being played. It is different from Pitch class in the way that it can go below 0 and above 11 depending upon the octave.

9. Staff Y:

Returns the Y staff position of the note being played according to staff dimensions. It takes into account only the alphabet class, no accidental info is processed.

3.2.9.3 Number to Octave

This converter takes a numeric value which denotes pitch number and returns the octave corresponding to that pitch number.

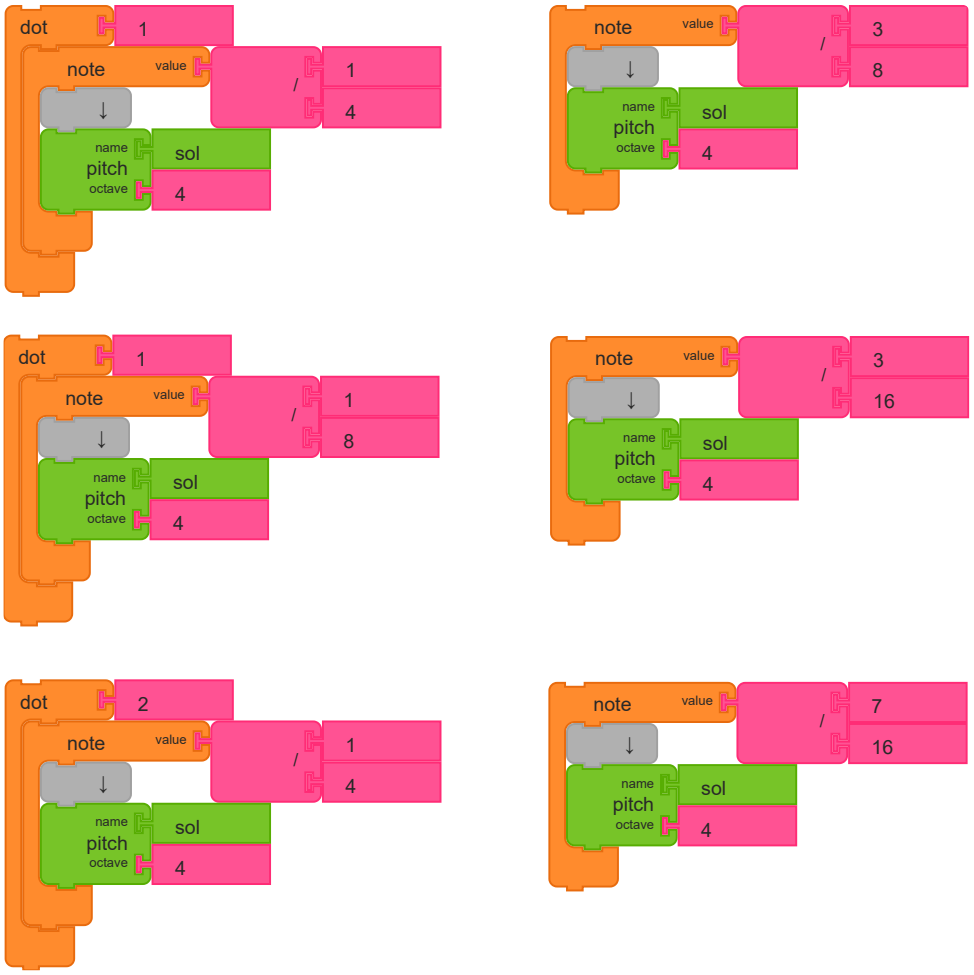
3.2.9.4 Number to Pitch

This converter takes a numeric value which denotes pitch number and returns the pitch name corresponding to that pitch number. No octave is inferred.

Converter Name	Description
alphabet	Converts pitch to letter (as defined above). G maps to G. G♯ maps to G#.
alphabet class	Converts pitch to letter (as defined above). G maps to G. G♯ also maps to G.
solfege syllable	Converts pitch to solfege (as defined above). G maps to sol.
solfege class	Converts pitch to solfege class (as defined above). G maps to sol. G♯ maps to sol.
pitch class	Converts pitch to pitch class (as defined above). G maps to 7.
scalar class	Converts pitch to scalar class (as defined above). G maps to 5.
scale degree	Converts pitch to scale degree (as defined above). G maps to 5.
nth degree	Converts pitch to nth degree (as defined above). G maps to 4.
staff y	Maps the current pitch to a y value that corresponds to a position on the staff. G4 maps to 50.
pitch number	Converts pitch to pitch number (as defined above). G maps to 7.
pitch in hertz	Converts pitch to hertz. G4 maps to 392Hz.
pitch to color	Converts pitch to a color value (0-100). C maps to 0, G maps to 58.3, etc.
pitch to shade	Coverts the octave value of the current pitch to a shade. Octave 4 maps to 50.

3.3 Note Value Transformations

3.3.1 Dotted Notes



You can "dot" notes using the *Dot* block. A dotted note extends the rhythmic duration of a note by 50%. E.g., a dotted quarter note will play for `3/8 (i.e. 1/4 + 1/8)` of a beat. A dotted eighth note will play for `3/16 (i.e. 1/8 + 1/16)` of a beat. A double dot extends the duration by `75% (i.e. 50% + [50% of 50%])`. For example, a double-dotted quarter note will play for `7/16 (i.e. 1/4 + 1/8 + 1/16)` of a beat (which is the same as `4/16 + 2/16 + 1/16 = 7/16`).

The dot block is useful as an expression of musical rhythm--it is convenient and helps to organize musical ideas (e.g. many melodies use dots as the basis of their rhythmic motifs), however you can achieve the same rhythmic result as dot by putting the calculation directly into note value as well. For example, indicating `3/8` instead of `1/4` will result in a dotted quarter note.

The chart below shows two common examples, dotted quarter and dotted eighth, and how to achieve them with either the dot block or by direct calculation into a note's note value.

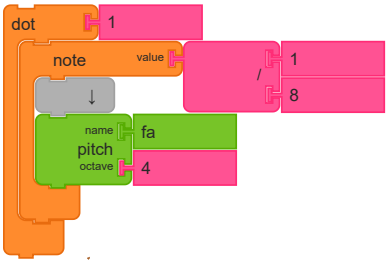
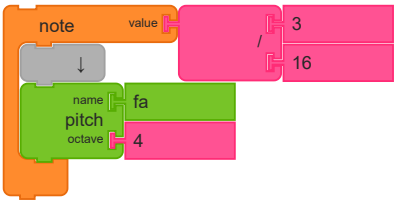
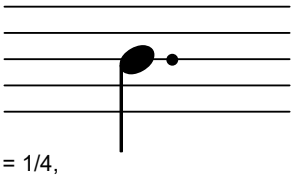
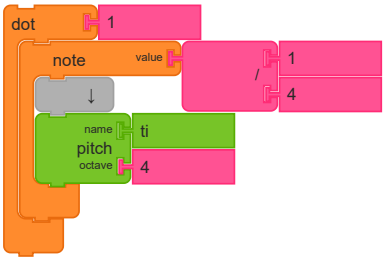
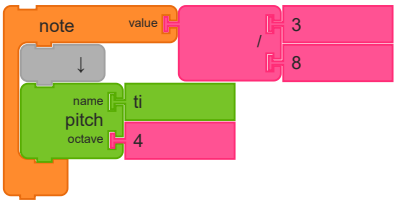
Using Dotted Notes

The dot increases the value
of a note by half of its value.

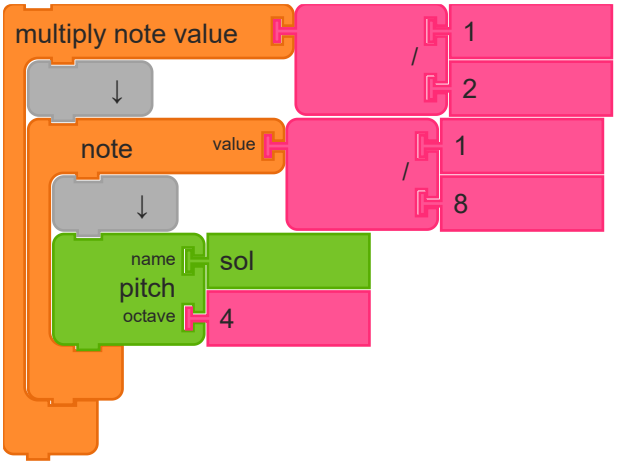
x= value of note

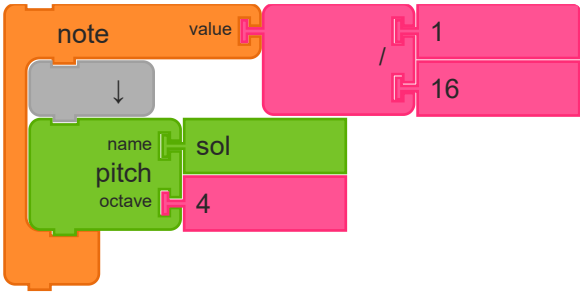
Formula: $x + \frac{x}{2} =$ value of dotted note

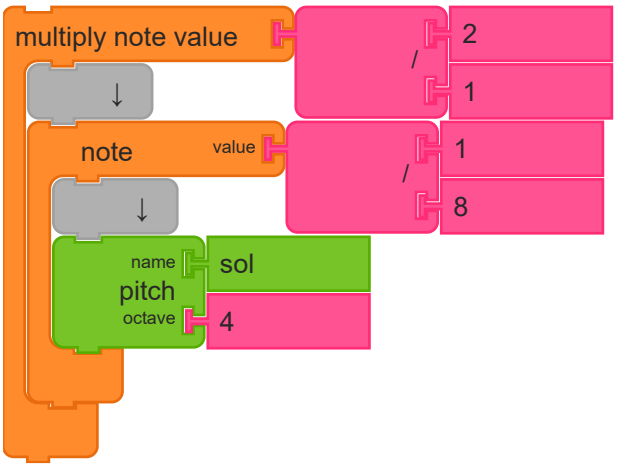
Examples:

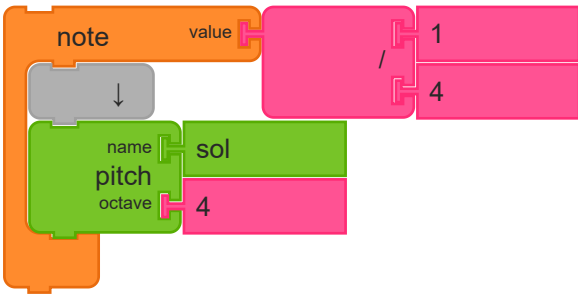
Western Notation	Music Blocks Notation with dot	Music Block Notation without dot
 For x = 1/8, $\frac{1}{8} + \frac{1}{(8*2)} = \frac{1}{8} + \frac{1}{16} = \frac{2}{16} + \frac{1}{16} = \boxed{\frac{3}{16}}$		
 For x = 1/4, $\frac{1}{4} + \frac{1}{(4*2)} = \frac{1}{4} + \frac{1}{8} = \frac{2}{8} + \frac{1}{8} = \boxed{\frac{3}{8}}$		

3.3.2 Speeding Up and Slowing Down Notes via Mathematical Operations

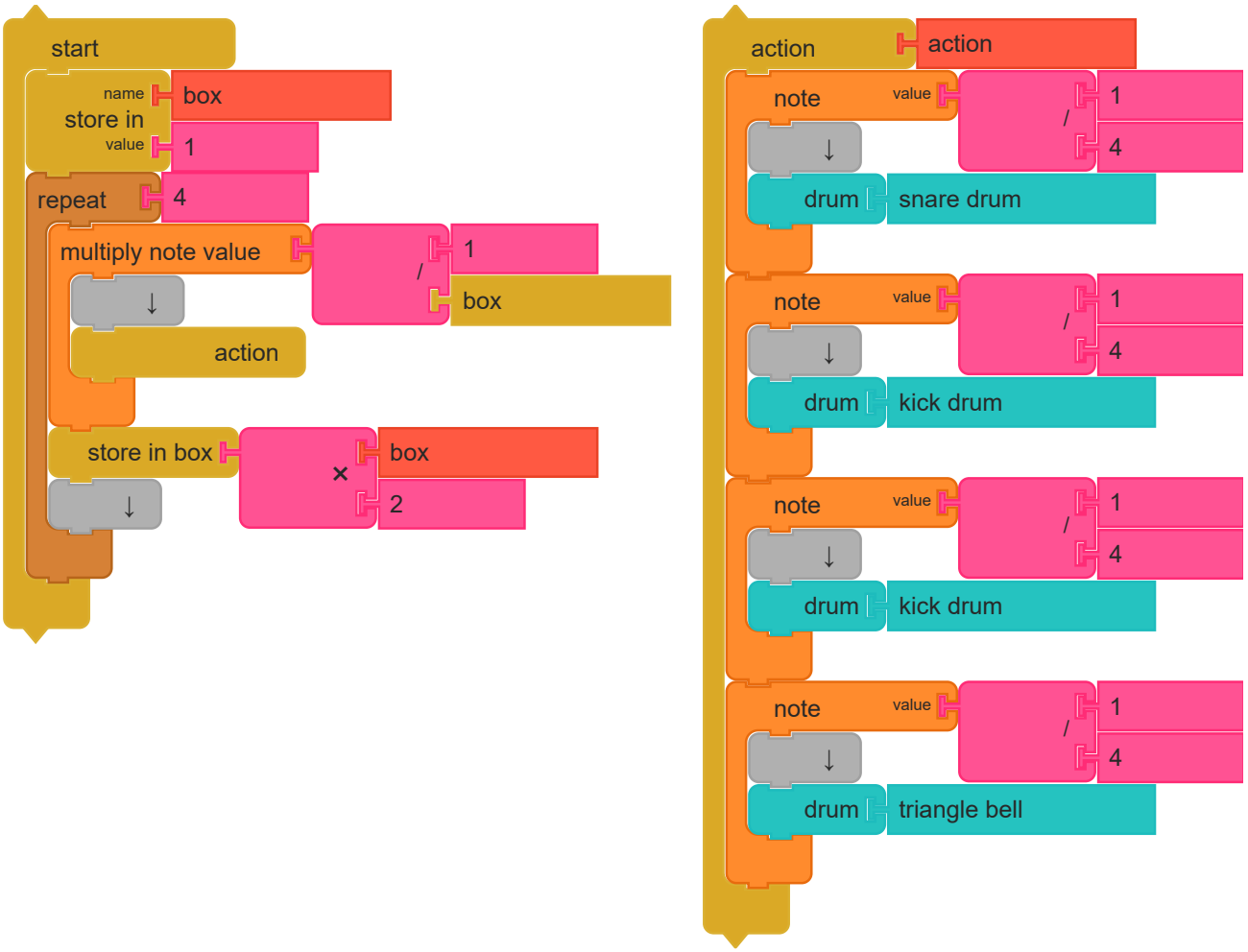






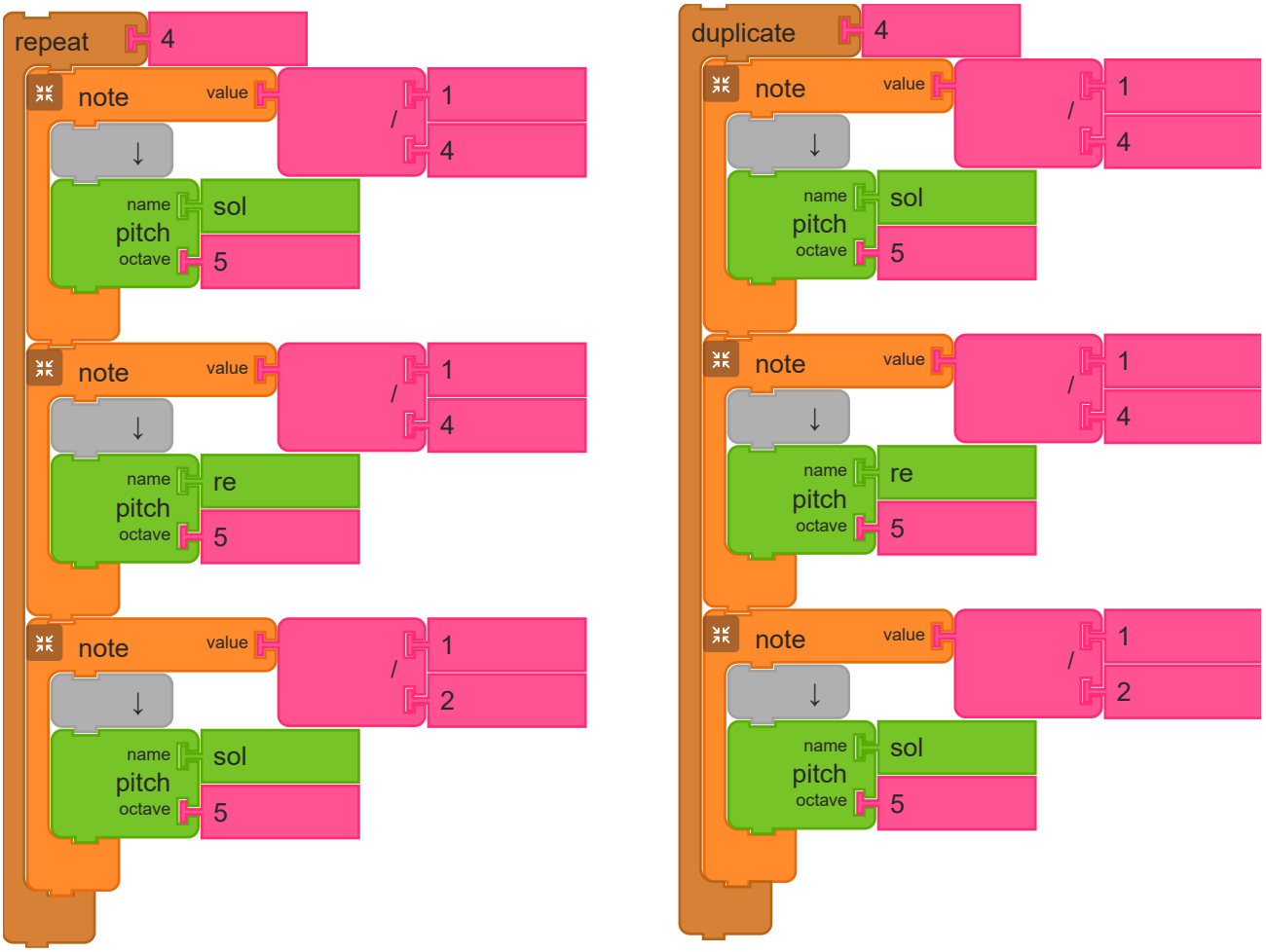


You can also multiply (or divide) the note value, which will change the duration of the notes by changing their note values. Multiplying the note value of an `1/8` note by `1/2` is the equivalent of playing a `1/16` note (i.e. `1/2 * 1/8 = 1/16`). Multiplying the note value of an `1/8` note by `2/1` (which has the effect of dividing by `1/2`) will result in the equivalent of a `1/4` note.



In the above example, the sequence of drum note values is decreased over time, at each repetition.

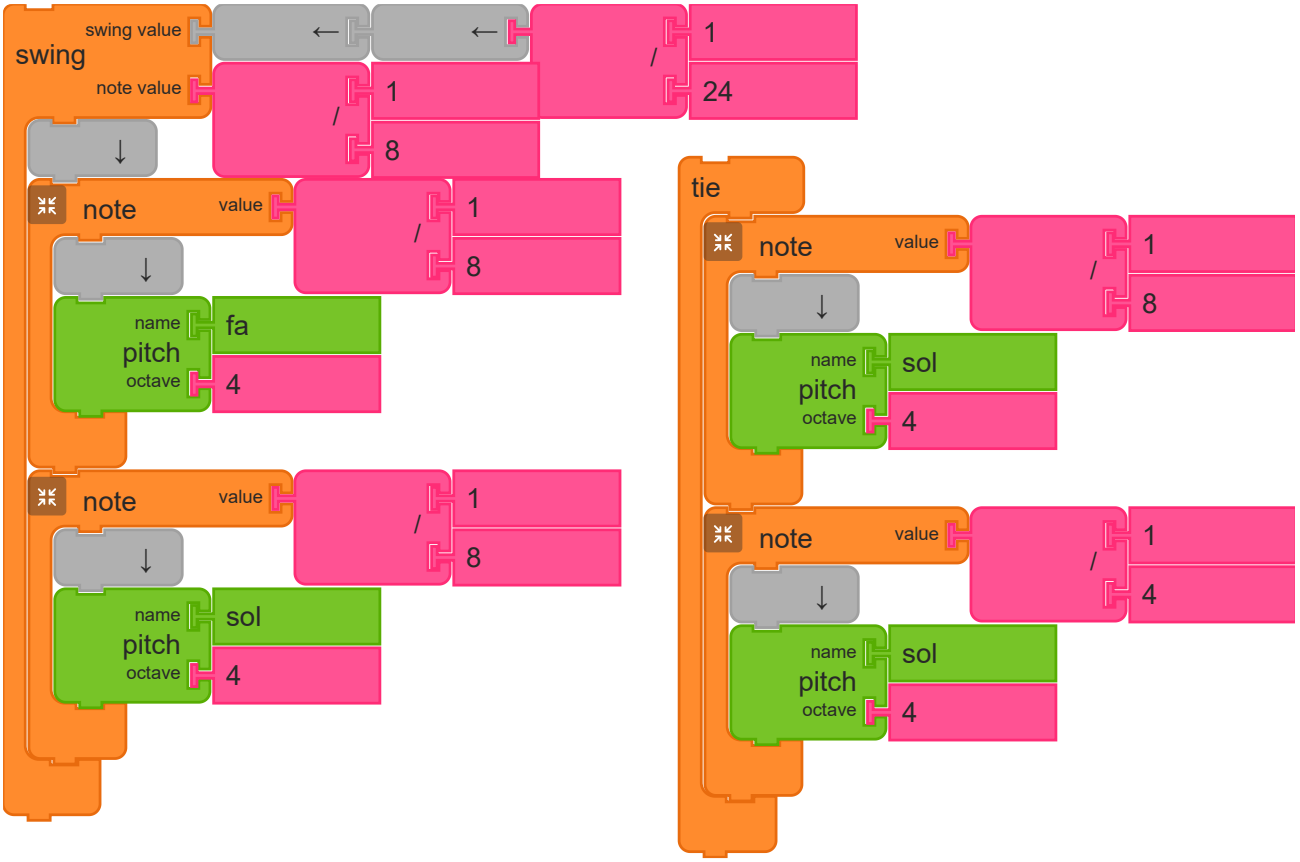
3.3.3 Repeating Notes



There are several ways to repeat notes. The *Repeat* block will play a sequence of notes multiple times; the *Duplicate* block will repeat each note in a sequence.

In the example, on the left, the result would be `Sol, Re, Sol, Sol, Re, Sol, Sol, Re, Sol, Sol, Re, Sol` ; on the right the result would be `Sol, Sol, Sol, Sol, Re, Re, Re, Re, Sol, Sol, Sol, Sol` .

3.3.4 Swinging Notes and Tied Notes



The *Swing* block works on pairs of notes (specified by note value), adding some duration (specified by swing value) to the first note and taking the same amount from the second note. Notes that do not match note value are unchanged.

In the example, `re5` would be played as a `1/6` note and `mi5` would be played as a `1/12` note (`1/8 + 1/24 === 1/6` and `1/8 - 1/24 === 1/12`). Observe that the total duration of the pair of notes is unchanged.

Tie also works on pairs of notes, combining them into one note. (The notes must be identical in pitch, but can vary in rhythm.)

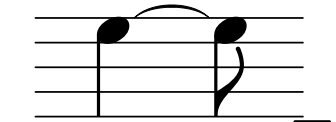
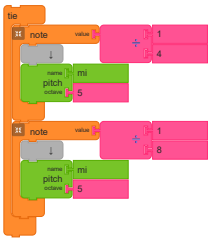
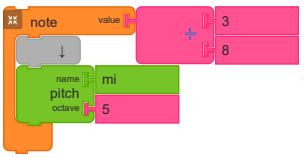
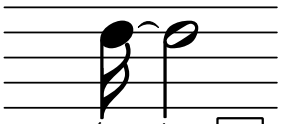
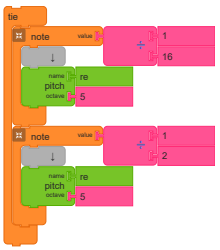
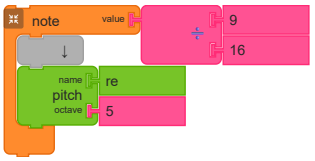
Using Notes with Ties

A tie connects two notes of the same pitch* and indicates that they are to be played as the sum of the two notes.

x= value of note 1 y= value of note 2

Formula: x + y = total value of notes contained within tie

Examples:

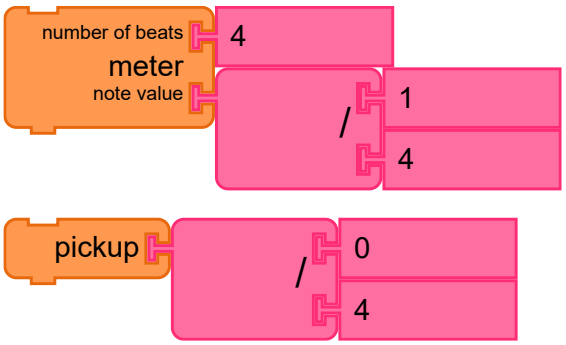
Western Notation	Music Blocks Notation with tie	Music Block Notation without tie
 $\frac{1}{4} + \frac{1}{8} = \boxed{\frac{3}{8}}$ Find common denominator: $x = \frac{1}{4}$ $y = \frac{1}{8}$ $2 * \frac{1}{4} = \frac{2}{8} + \frac{1}{8} = \frac{3}{8}$		
 $\frac{1}{16} + \frac{1}{2} = \boxed{\frac{9}{16}}$ Find common denominator: $x = \frac{1}{16}$ $y = \frac{1}{2}$ $8 * \frac{1}{2} = \frac{8}{16} + \frac{1}{16} = \frac{9}{16}$		

* Ties affect rhythm, not pitch. For tie to work, both pitches must be exactly the same. If not, it will be considered a slur.

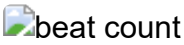
3.3.5 Beat

The beat of the music is determined by the *Meter* block (by default, it is set to 4:4).

The *Pickup* block can be used to accommodate any notes that come in before the beat.

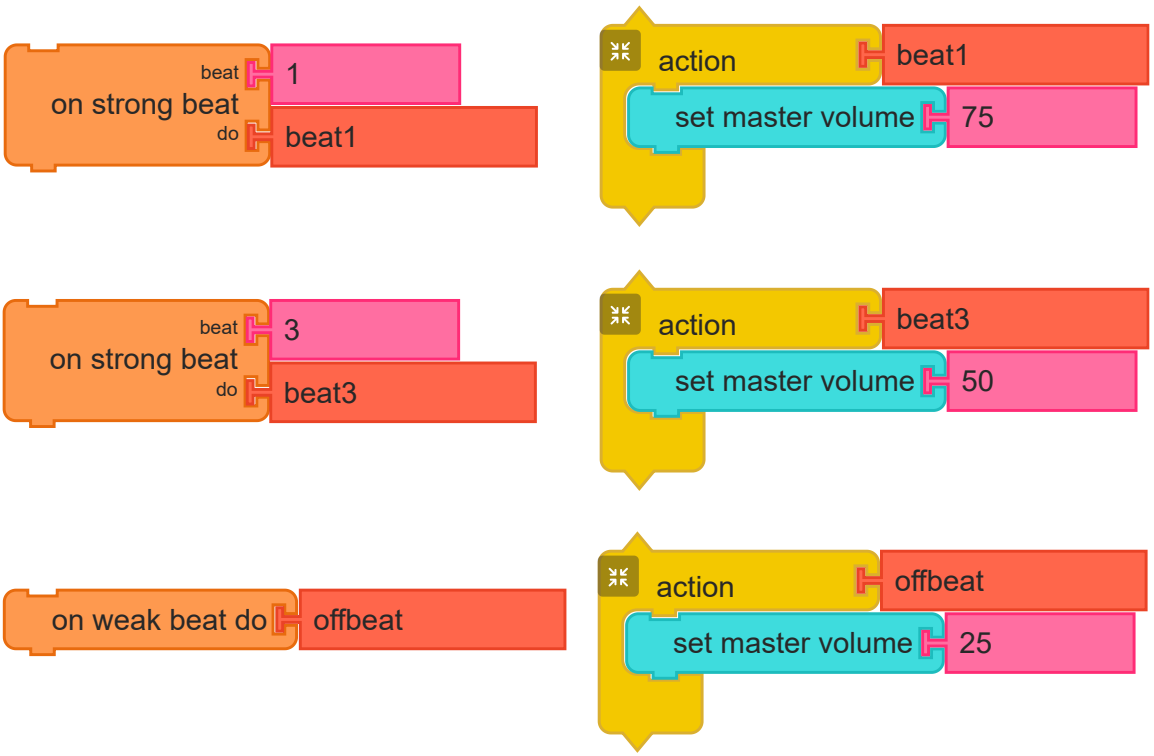


The Beat count block is the number of the current beat, eg 1, 2, 3, or 4. In the figure, it is used to take an action on the first beat of each measure.



The Measure count block returns the current measure.

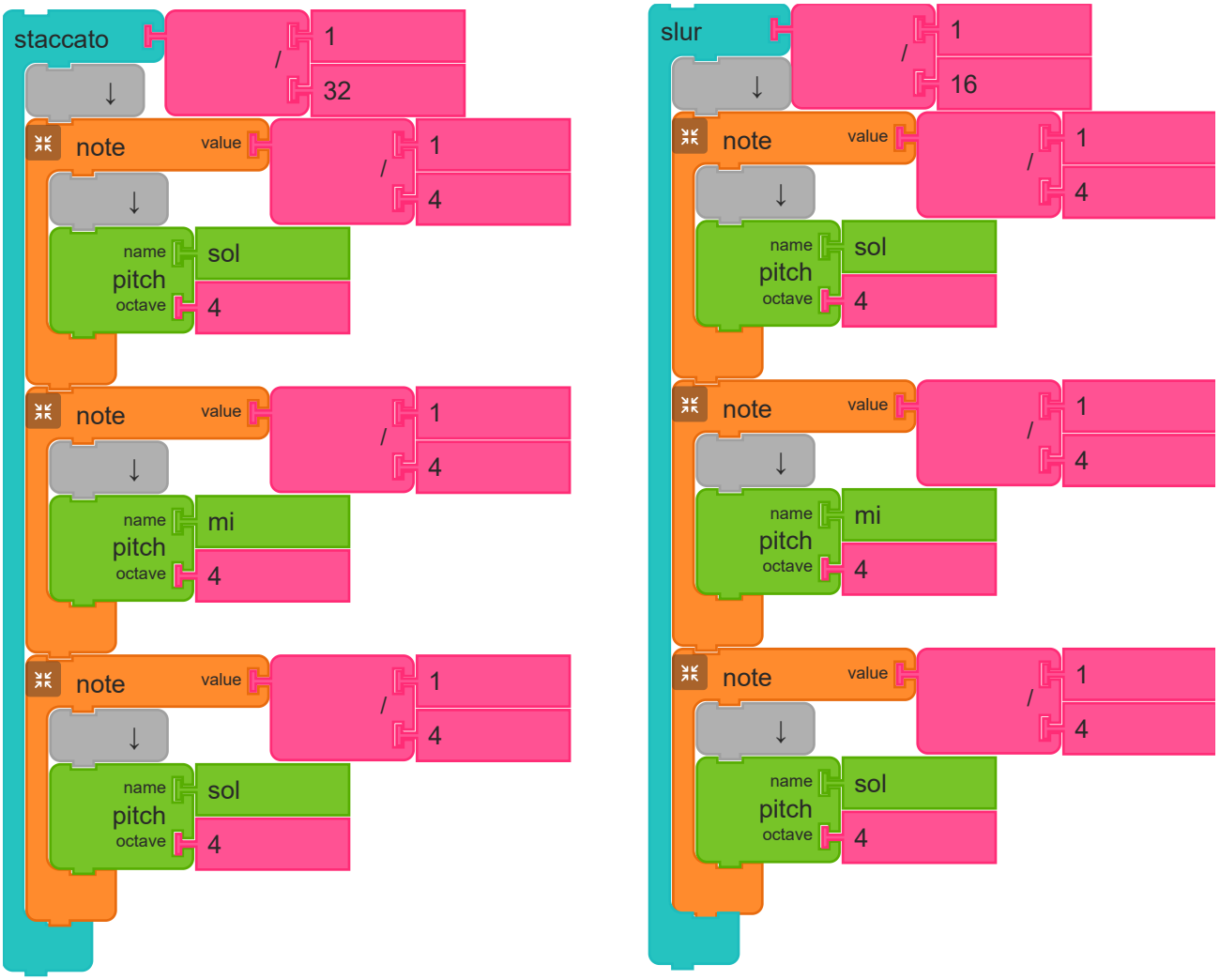
Specifying beat is useful in that you can have the character of a note vary depending upon the beat. In the example below, the volume of notes on Beat `1` and Beat `3` are increased, while the volume of off beats is decreased.



The *On-Beat-Do* and *Off-Beat-Do* blocks let you specify actions to take on specific beats. (Note that the action is run before any blocks inside the note block associated with the beat are run.)

More examples can be found in the Graphics section below.

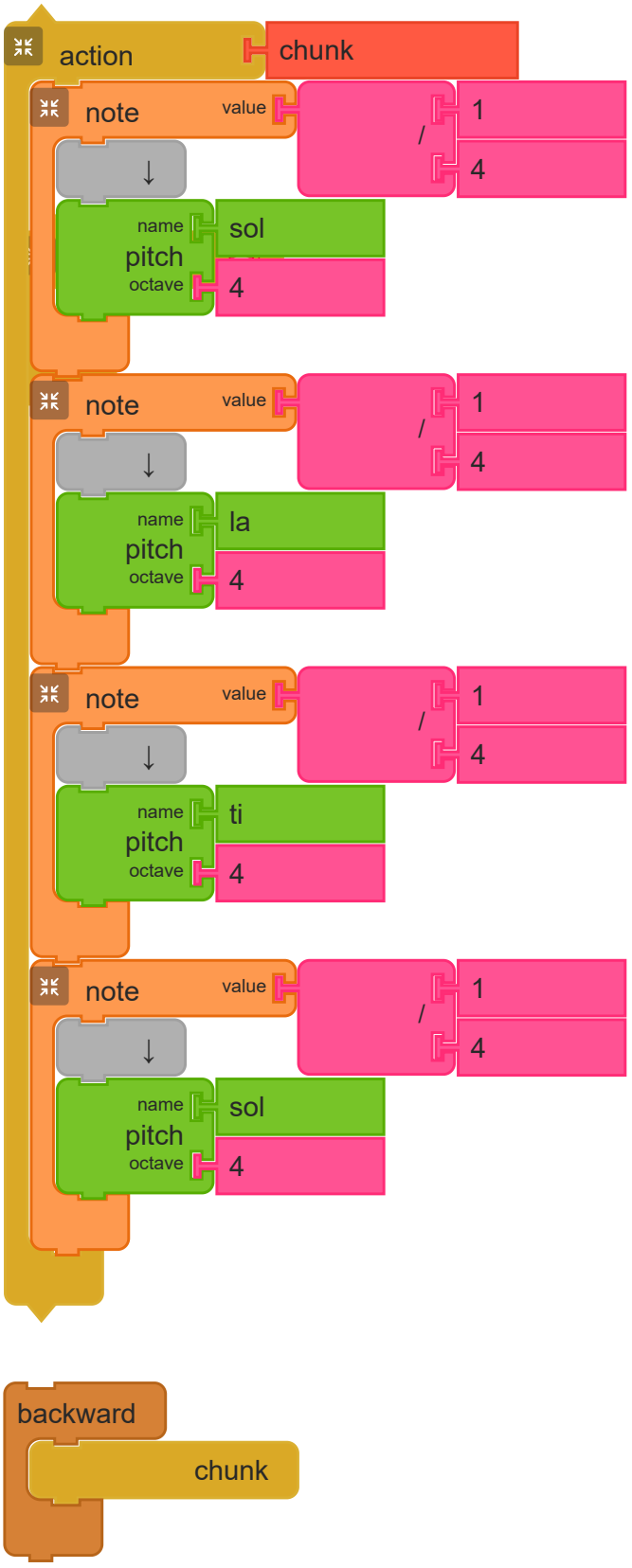
3.3.6 Staccato and Slur



The *Staccato* block shortens the length of the actual note—making them tighter bursts—while maintaining the specified rhythmic value of the notes.

The *Slur* block lengthens the sustain of notes—running longer than the noted duration and blending it into the next note—while maintaining the specified rhythmic value of the notes.

3.3.7 Backwards



The *Backward* block will play the contained notes in reverse order (retrograde). In the example above, the notes in `chunk` are played as `Sol`, `Ti`, `La`, `Sol`, i.e., from the bottom to the top of the stack.

An example from Bach is provided. In the example, there are two voices, one which plays the composition forward and one that plays the same composition backward.

Note that all of the blocks inside a *Backward* block are reverse, so use this feature with caution if you include logic intermixed with notes.

3.4 Other Transformations

3.4.1 Set Volume and Crescendo

The *Set master volume* block will change the master volume. The default is `50`; the range is `0` (silence) to `100` (full volume).

The *Set synth volume* block will change the volume of a particular synth, e.g., `violin`, `snare drum`, etc. The default volume is `50`; the range is `0` (silence) to `100` (full volume). In the example, the *synth name* block is used to select the current synth.

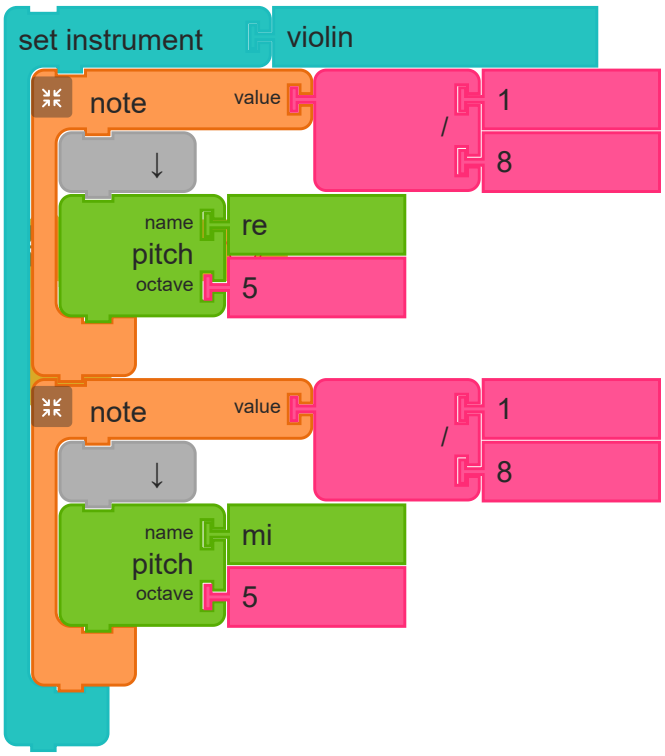
As a convenience, a number of standard volume blocks are provided: from loudest to quietest, there is *fff*, *ff f*, *mf*, *mp*, *p*, *pp*, and *ppp*. In musical terms "f" means "forte" or loud, "p" means "piano" or soft, and "m" means "mezzo" or middle.

The *Set Relative Volume* block modifies the clamped note's volume according to the input value of the block in an added (or subtracted when negative) percentage with respect to the original volume. For example, `100` would mean doubling the current volume.

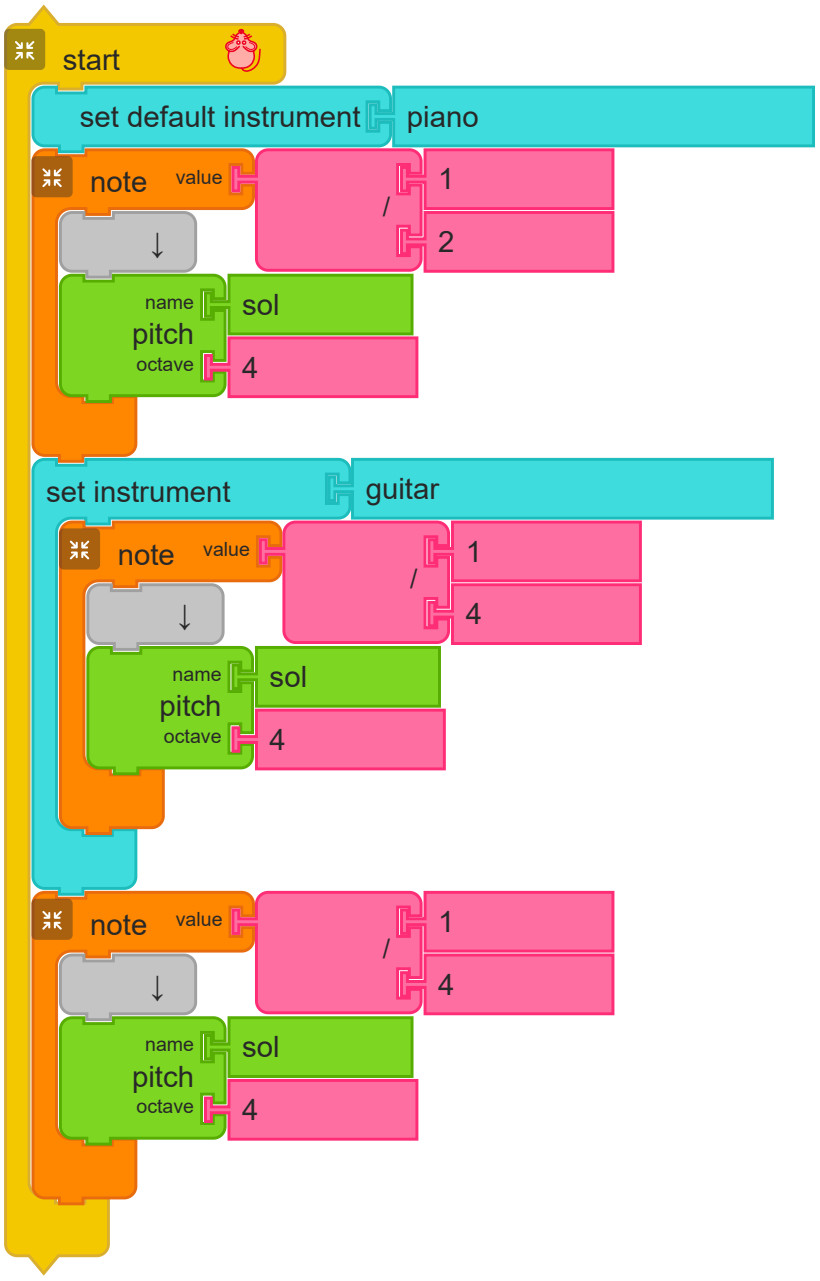
The *Crescendo* block will increase (or decrease) the volume of the contained notes by a specified amount for every note played. For example, if you have 3 notes in sequence contained in a *Crescendo* block with a value of `5`, the final note will be at 15% more than the original value for volume.

NOTE: The *Crescendo* block does not alter the volume of a note as it is being played. Music Blocks does not yet have this functionality.

3.4.2 Setting Instrument

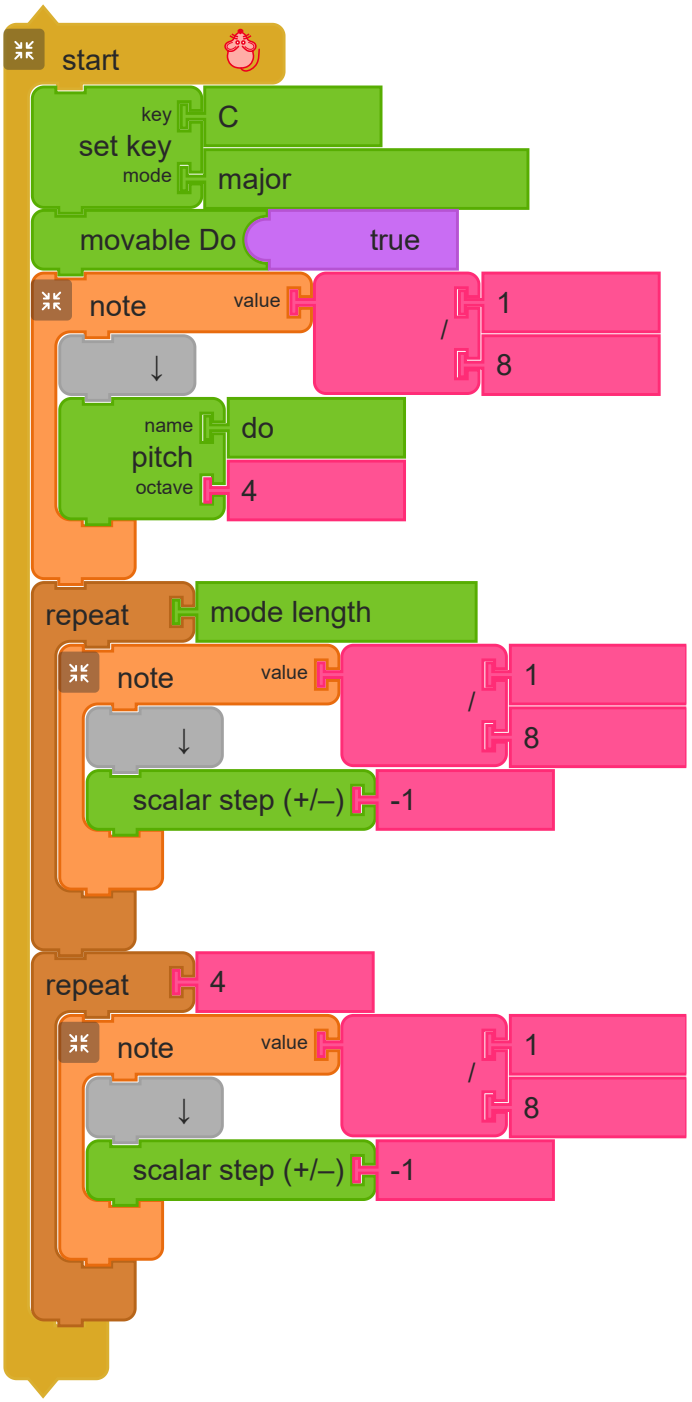


The default instrument is an electronic synthesizer, so by default, that is the instrument used when playing notes. You can override this default for a group of notes by using the *Set Instrument* block. It will select an instrument for the synthesizer for any contained blocks, e.g., violin.

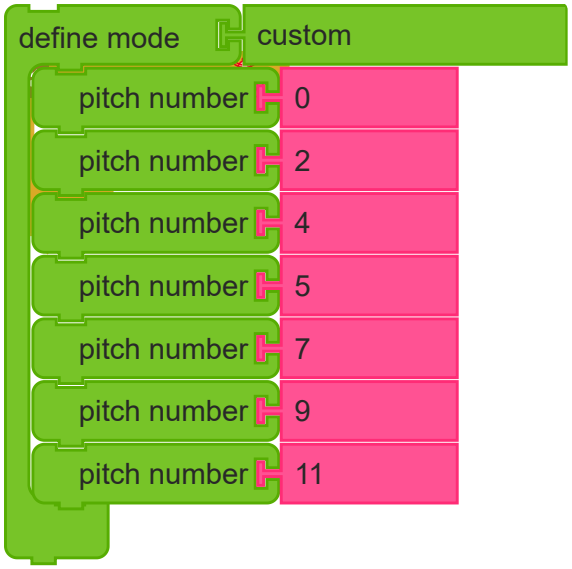


You can also override the default using the *Set default instrument* block. In the example above, the default instrument is set to piano, so any note that is not inside of a *Set instrument* block will be played using the piano synthesizer. The first note in this example is piano; the second note is guitar; and the third is piano.

3.4.3 Setting Key and Mode



The *Set Key* block will change the key and mode of the mapping between solfege, e.g., `Do`, `Re`, `Mi`, to note names, e.g., `C`, `D`, `E`, when in C Major. Modes include Major and Minor, Chromatic, and a number of more exotic modes, such as Bebop, Geez, Maqam, etc. This block allows users to access "movable Do" within Music Blocks, where the mapping of solfege to particular pitch changes depending on the user's specified tonality.



The *Define mode* block can be used to define a custom mode by defining the number and size of the steps within an octave. You can use your custom mode with the *Set key* block.

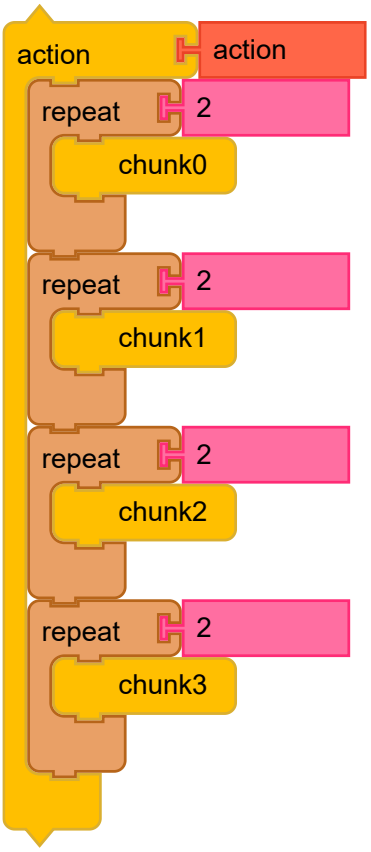
3.4.4 Vibrato, Tremelo, et al.

The *Vibrato* Block adds a rapid variation in pitch to any contained notes. The intensity of the variation ranges from `1` to `100` (cents), e.g. plus or minus up to one half step. The rate argument determines the rate of the variation.

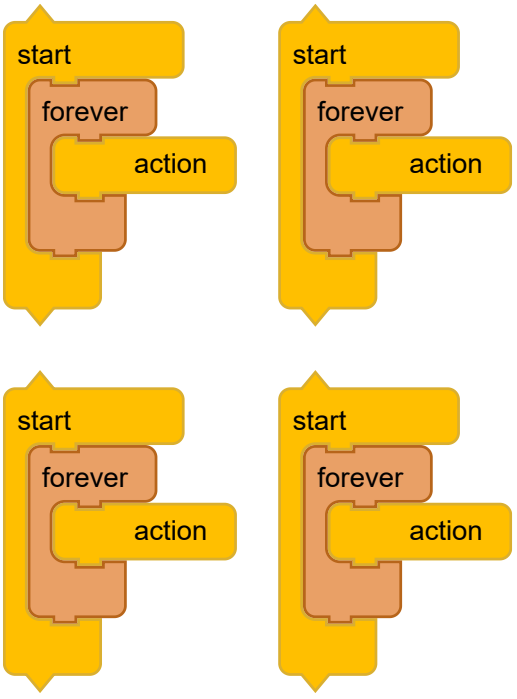
The other effects blocks also modulate pitch over time. Give them a try.

3.5 Voices

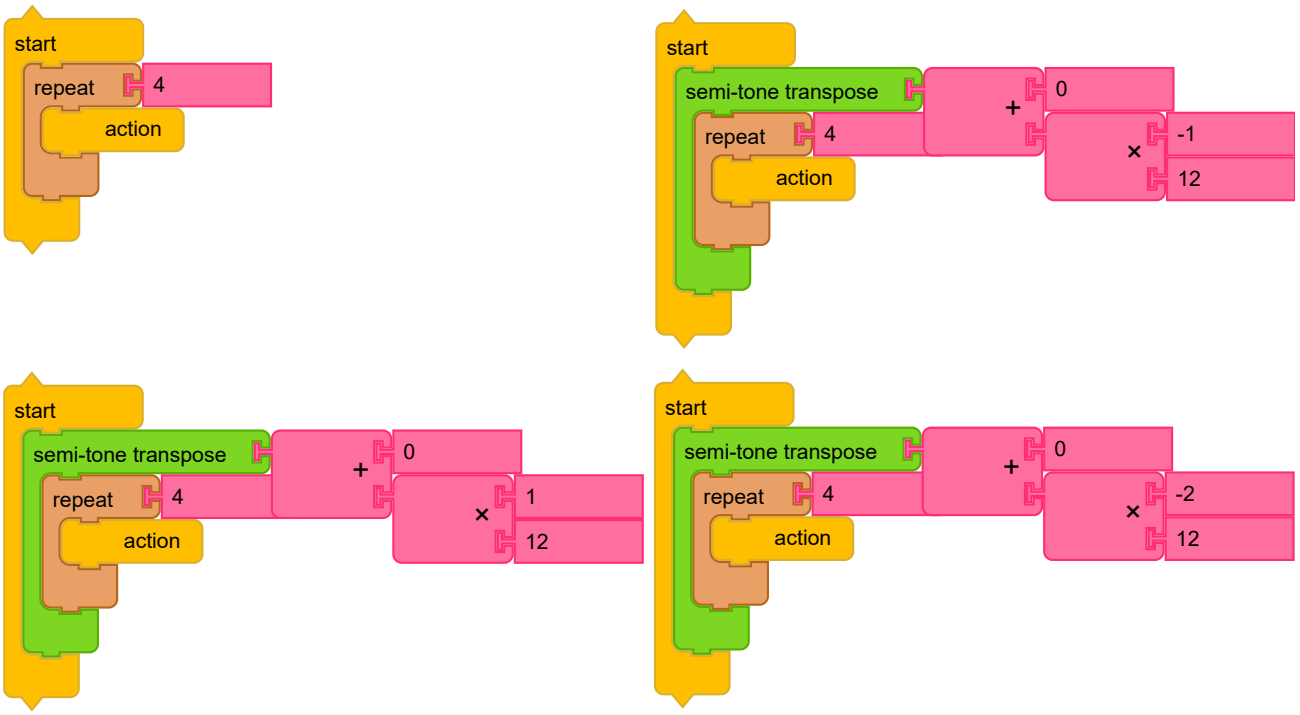
Each *Start* block runs as a separate voice in Music Blocks. (When you click on the Run button, all of the *Start* blocks are run concurrently.)



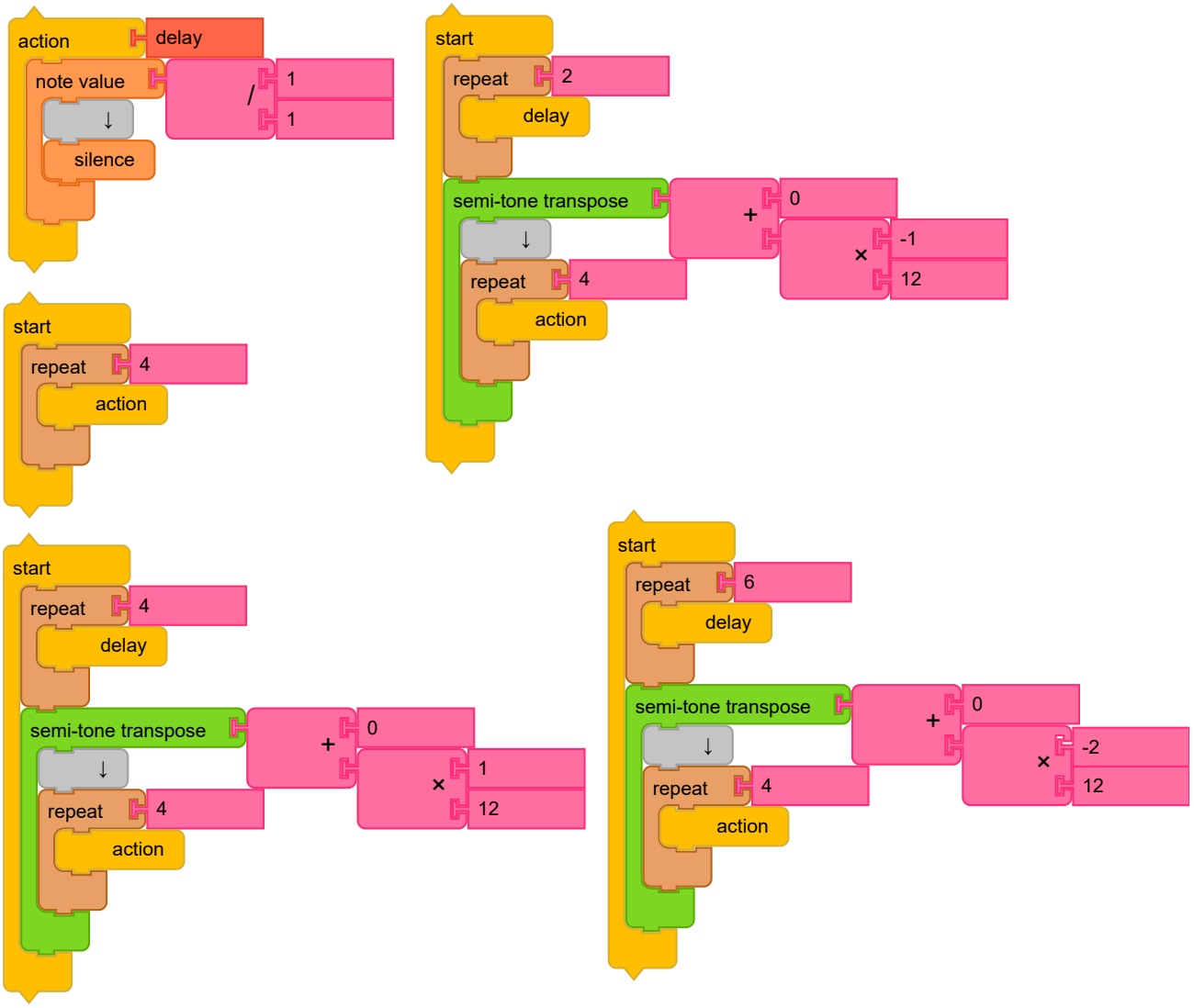
If we put our song into an action...



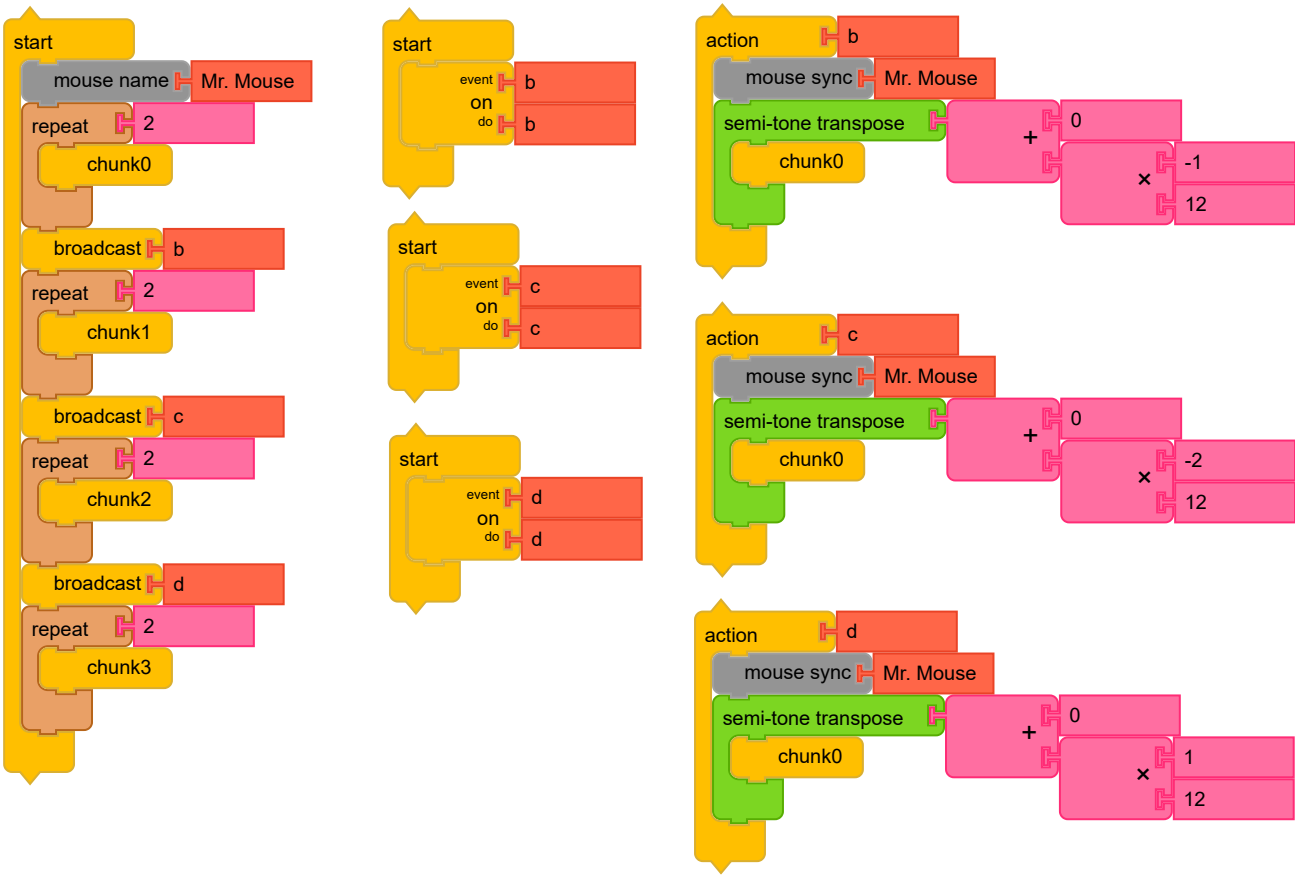
...we can run it from multiple *Start* blocks.



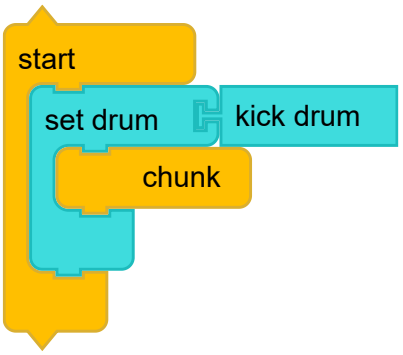
It gets more interesting if we shift up and down octaves.



And even more interesting if we bring the various voices offset in time.

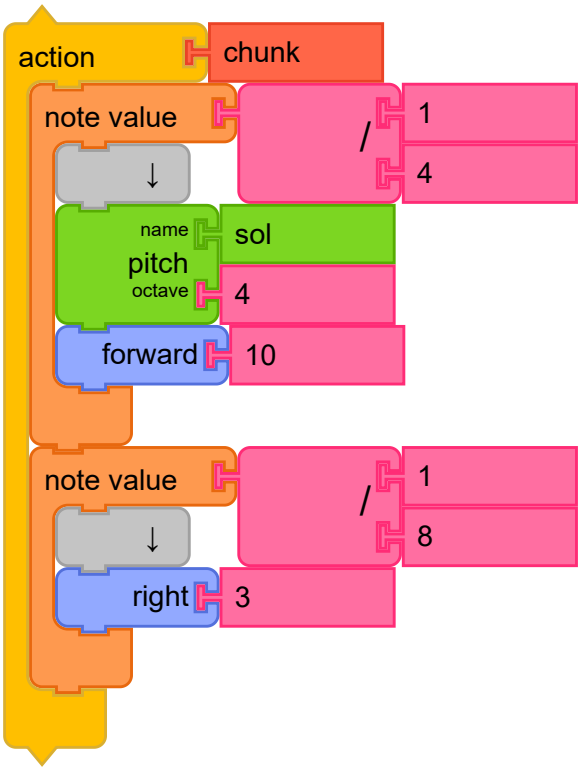


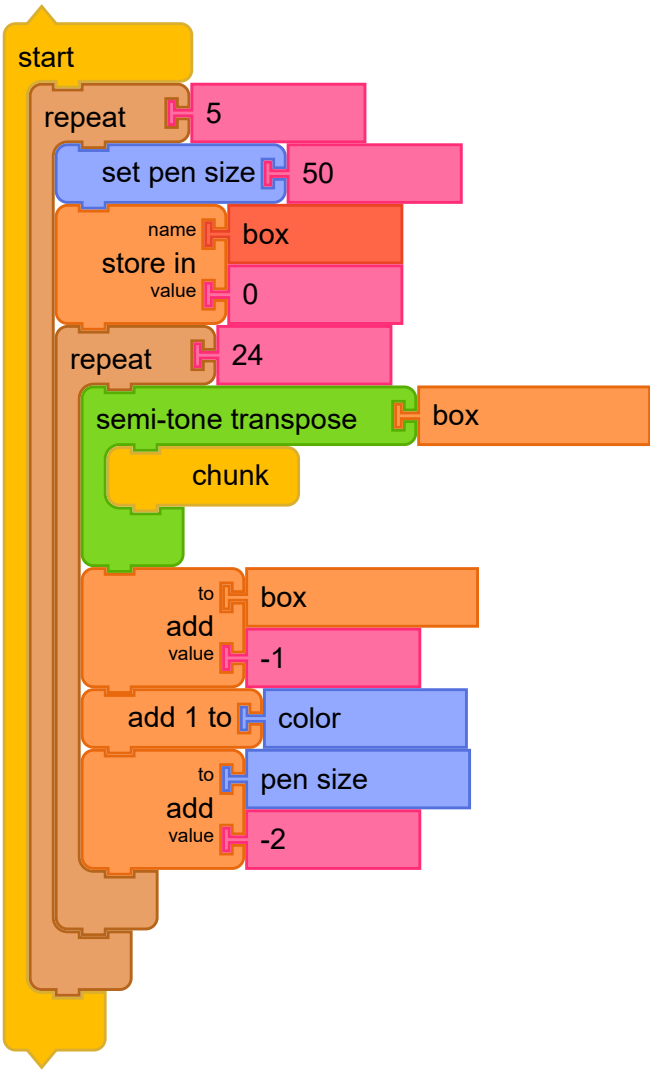
An alternative to use a preprogrammed delay is to use the *Broadcast* block to bring in multiple voices. In the example above, after each section of the song is played, a new event is broadcasted, bringing in a new voice. Note the use of the *Mouse Sync* block. This ensures that the multiple voices are synced to the same master clock.



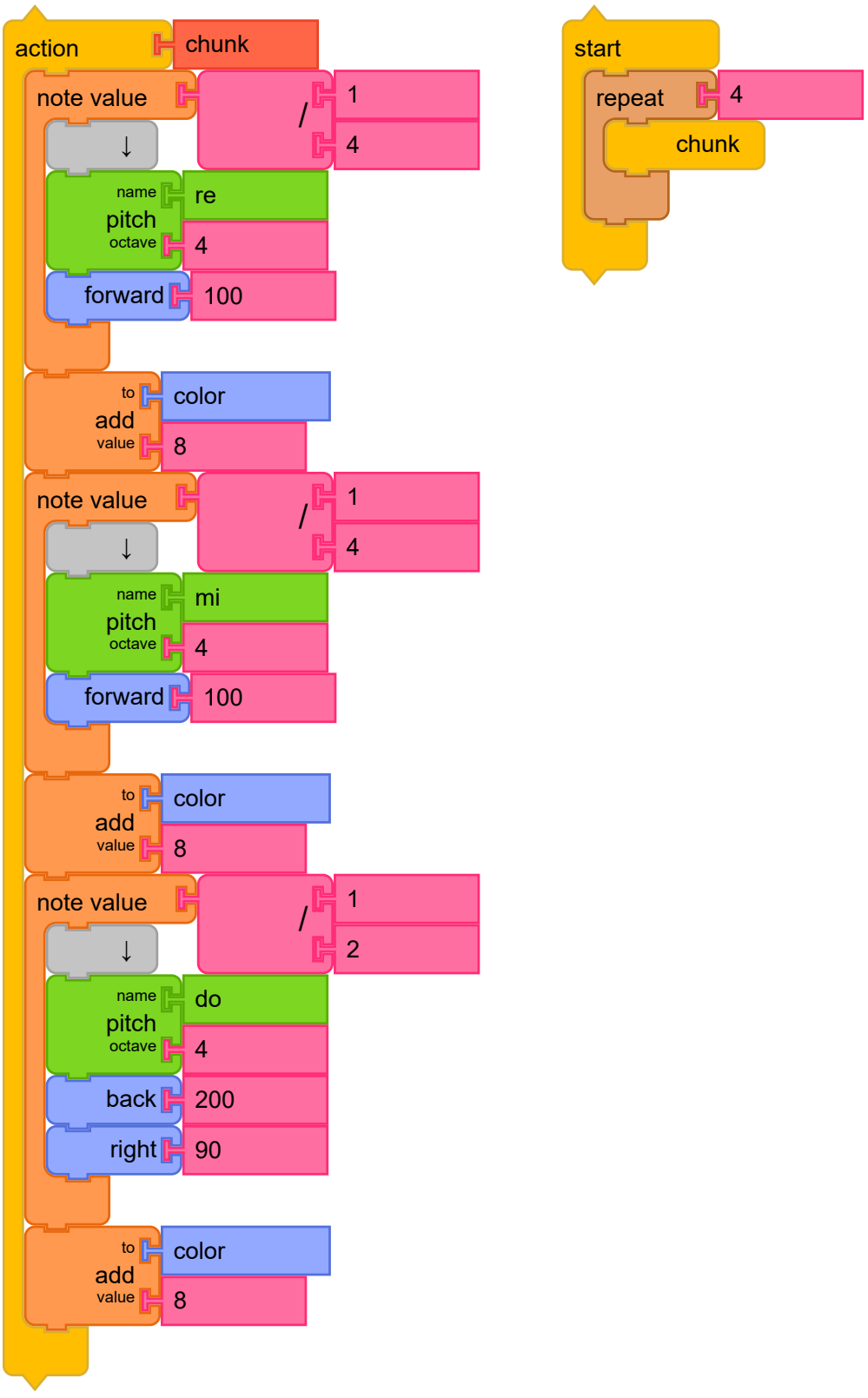
A special *Start drum* version of the *Start* block is available for laying down a drum track. Any *Pitch* blocks encountered while starting from a drum will be played as `C2` with the default drum sample. In the example above, all of the notes in `chunk` will be played with a kick drum.

3.6 Adding graphics

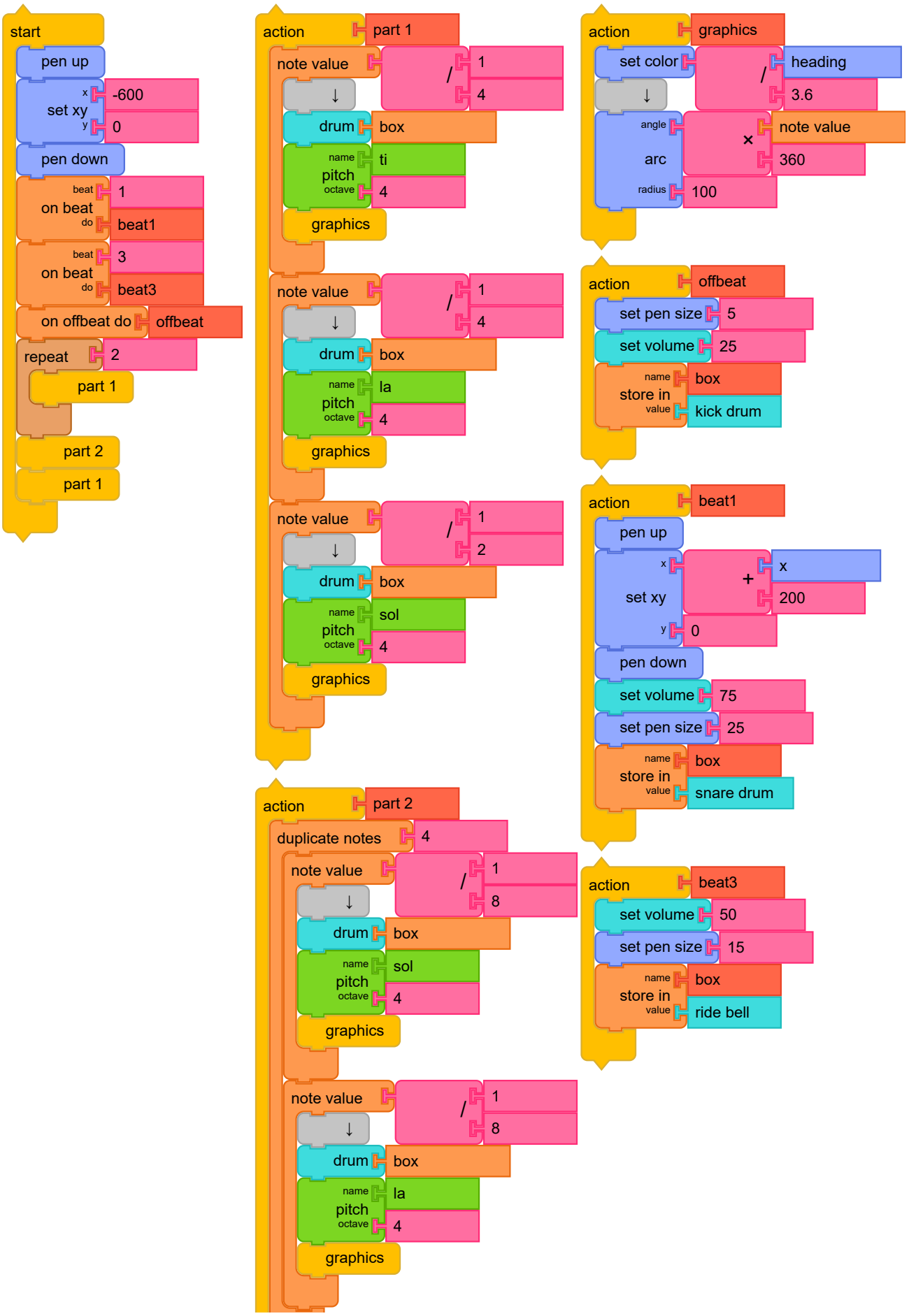




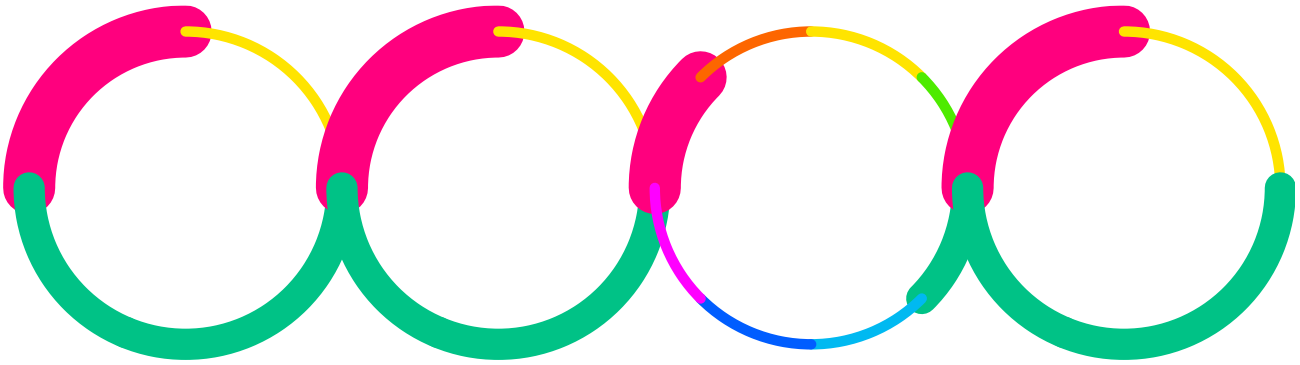
Turtle graphics can be combined with the music blocks. By placing graphics blocks, e.g., *Forward* and *Right*, inside of *Note value* blocks, the graphics stay in sync with the music. In this example, the turtle moves forward each time a quarter note is played. It turns right during the eighth note. The pitch is decreased by one half step, the pen size decreases, and the pen color increases at each step in the inner repeat loop.



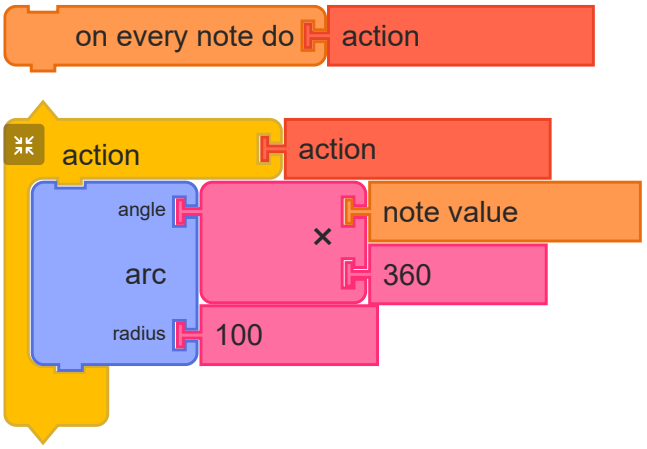
Another example of graphics synchronized to the music by placing the graphics commands inside of *Note value* blocks


start
pen up
set xy x -600 y 0
pen down
on beat beat 1 do beat1
on beat beat 3 do beat3
on offbeat do offbeat
repeat 2
part 1
part 2
part 1
action part 1
note value / 1 4
drum box
pitch name ti octave 4
graphics
note value / 1 4
drum box
pitch name la octave 4
graphics
note value / 1 2
drum box
pitch name sol octave 4
graphics
action part 2
duplicate notes 4
note value / 1 8
drum box
pitch name sol octave 4
graphics
note value / 1 8
drum box
pitch name la octave 4
graphics
action graphics
set color / heading 3.6
arc angle × note value 360 radius 100
action offbeat
set pen size 5
set volume 25
store in name box value kick drum
action beat1
pen up
set xy x + x 200 y 0
pen down
set volume 75
set pen size 25
store in name box value snare drum
action beat3
set volume 50
set pen size 15
store in name box value ride bell

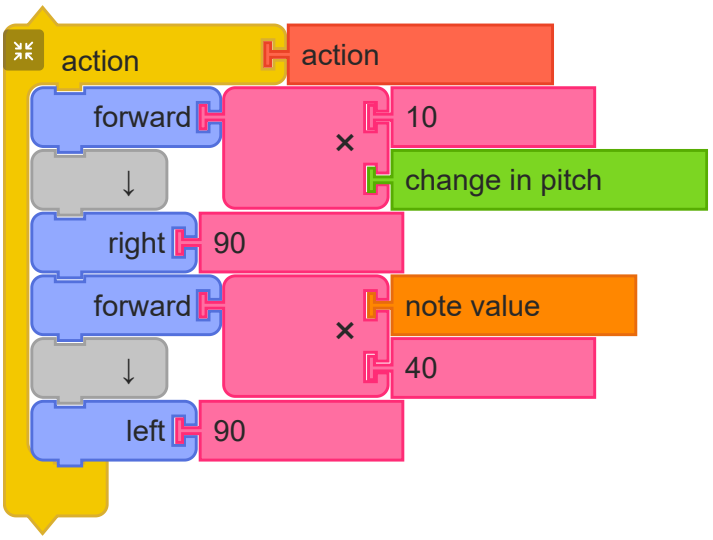
Another approach to graphics is to use modulate them based on the beat. In the example above, we call the same graphics action for each note, but the parameters associated with the action, such as pen width, are dependent upon which beat we are on. On Beat 1, the pen size is set to `50` and the volume to `75`. On Beat `3`, the pen size is set to `25` and the volume to `50`. On off beats, the pen size is set to `5` and the volumne to `5`. The resultant graphic is shown below.



The *On-Every-Note-Do* block lets you specify an action to take whenever a note is played. In the example above, the note value is used to determine the portion of an arc to draw, i.e., a 1/4 note draws a 1/4 circle, a 1/2 note draw 1/2 circle, and a whole note draws a full circle.



The *On-Every-Note-Do* block is found in the Crab Canon project on the Planet to "plot the music". The mouse moves up and down based on the change in pich between notes and to the right in proportion to the note value.



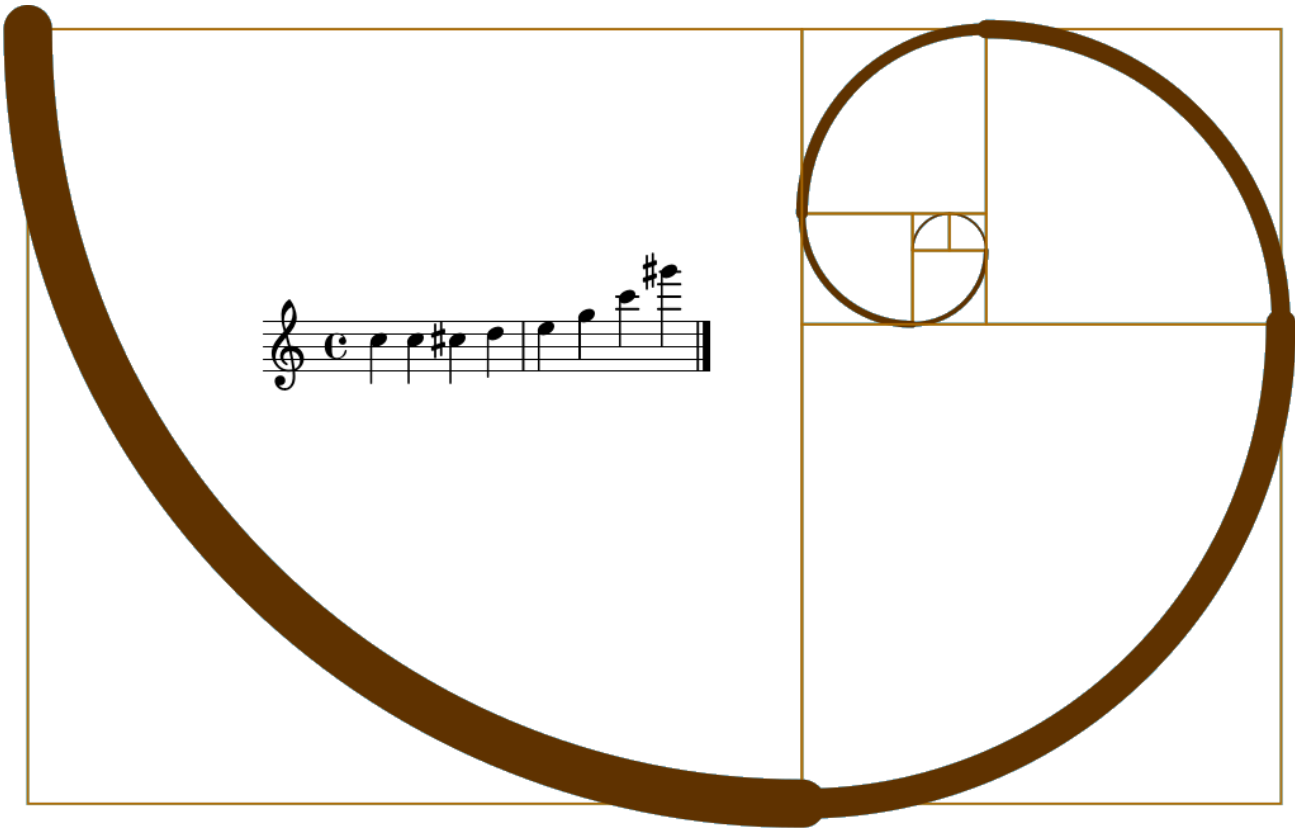
Music Blocks has an internal "conductor" maintaining the beat. When the Run button is clicked, the program begins and an internal master (or "conductor") clock starts up. All of the music tries to stay synced to that clock.

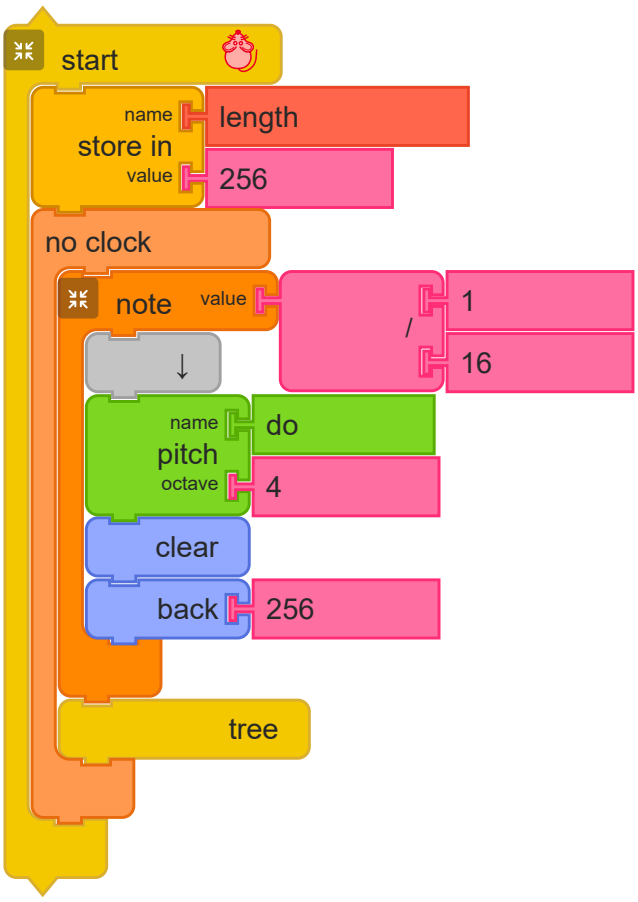
For example, if you have multiple voices (mice), they all share the same conductor in order to keep on the same beat. If a voice (mouse) is falling behind, Music Blocks tries to catch up on the next note by truncating it. If it is an 1/8 note behind and the next note is a 1/2 note, then only an 3/8 note would be played, so as to catch up. That is a somewhat extreme example—usually the timing errors are only very very small differences.

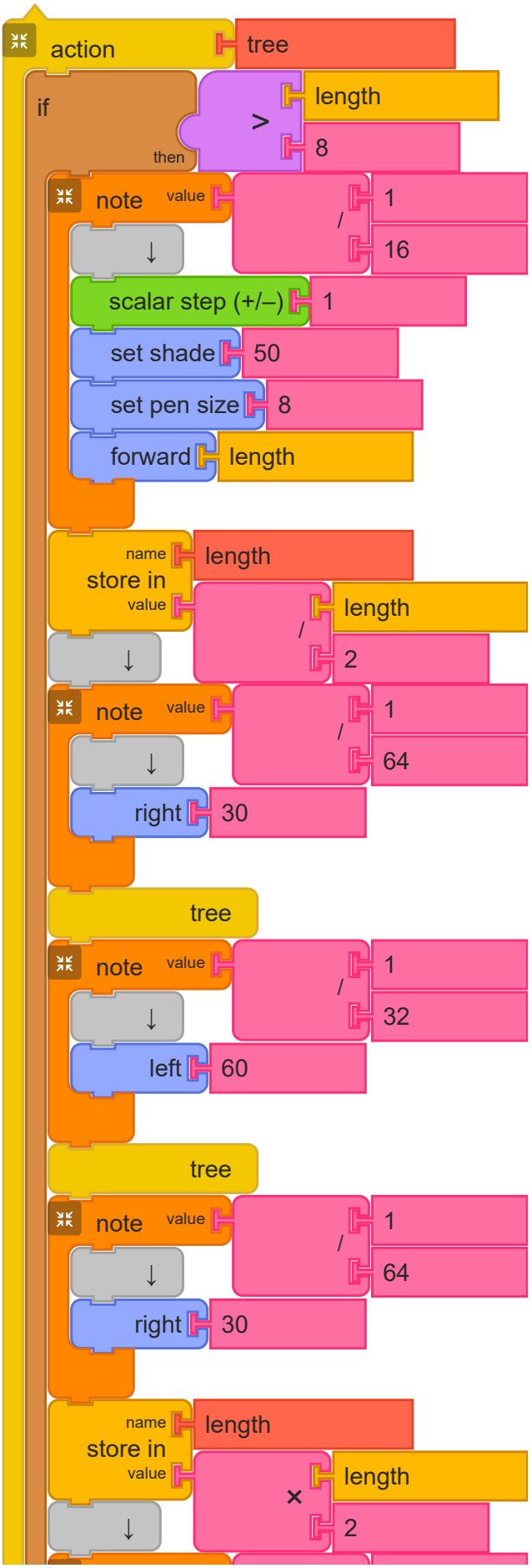
But in some situations, the timing errors can be very large. This is when the *No-clock* block is used.

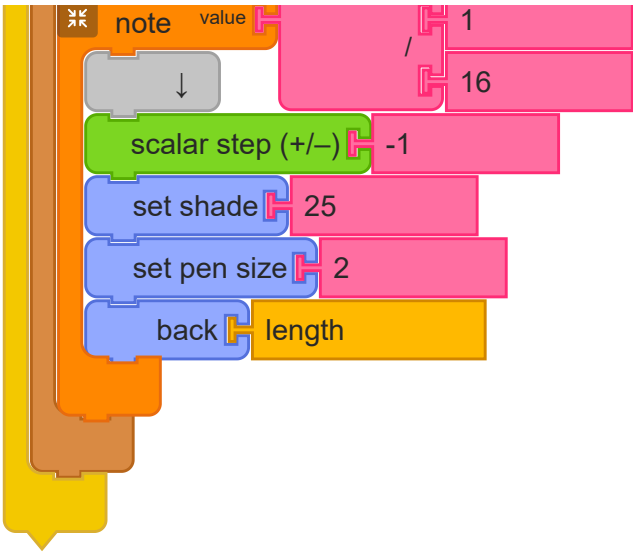
A typical problem is when the music is not played continuously. Imagine an interactive game where a hero is battling a monster. Our hero plays theme music whenever the monster is defeated. But that might occur at any time, hence it is not going to be in sync with the conductor. The offset could be tens of seconds. This would mean that all of the notes in the theme music might be consumed by trying to catch up with the conductor. The *No-clock* block essentially says, do your own thing and don't worry about the conductor.

In this example, because the computation and graphics are more complex, a *No-clock* block is used to decouple the graphics from the master clock. The "No-clock* block prioritizes the sequence of actions over the specified rhythm.

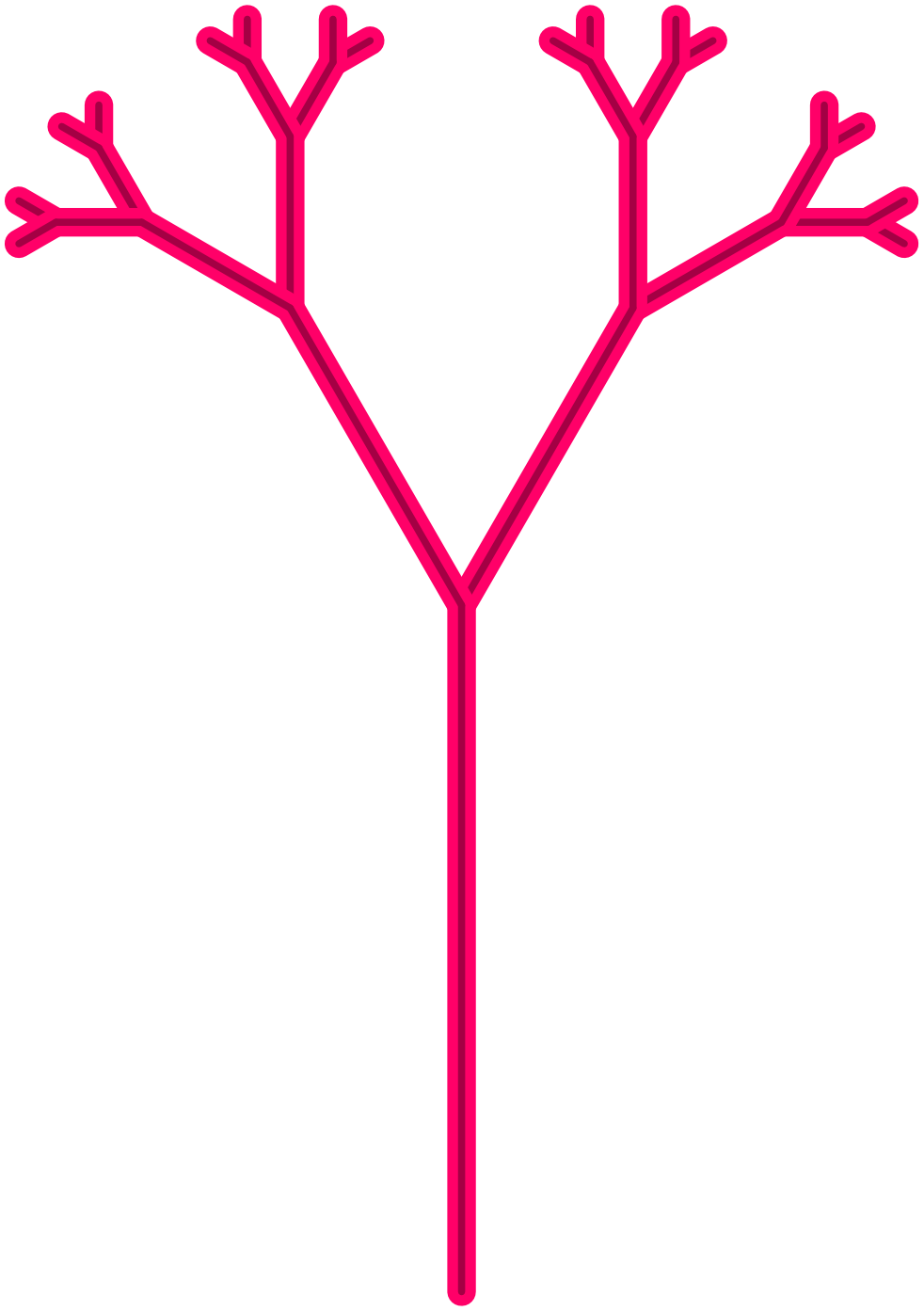



start
name
store in
value
length
256
no clock
note
value
1
/
16
name
pitch
octave
do
4
clear
back
256
tree


action
tree
if
then
>
length
8
note
value
1
/
16
scalar step (+/–)
1
set shade
50
set pen size
8
forward
length
name
store in
value
length
/
2
note
value
1
/
64
right
30
tree
note
value
1
/
32
left
60
tree
note
value
1
/
64
right
30
name
store in
value
length
×
length
2

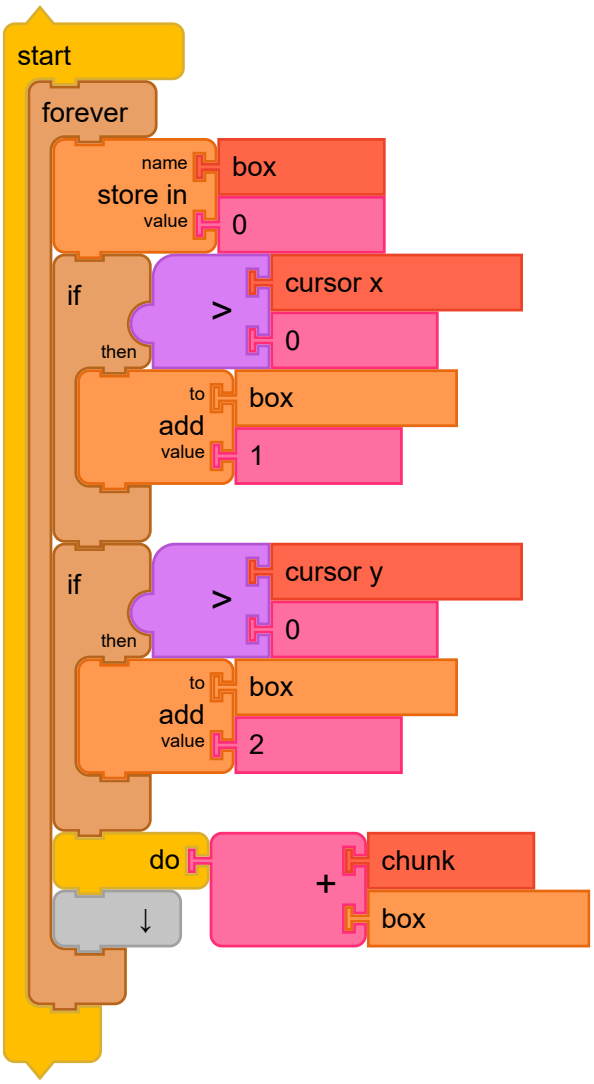


Another example of embedding graphics into notes: in case, a recursive tree drawing, where the pitch goes up as the branches ascend.

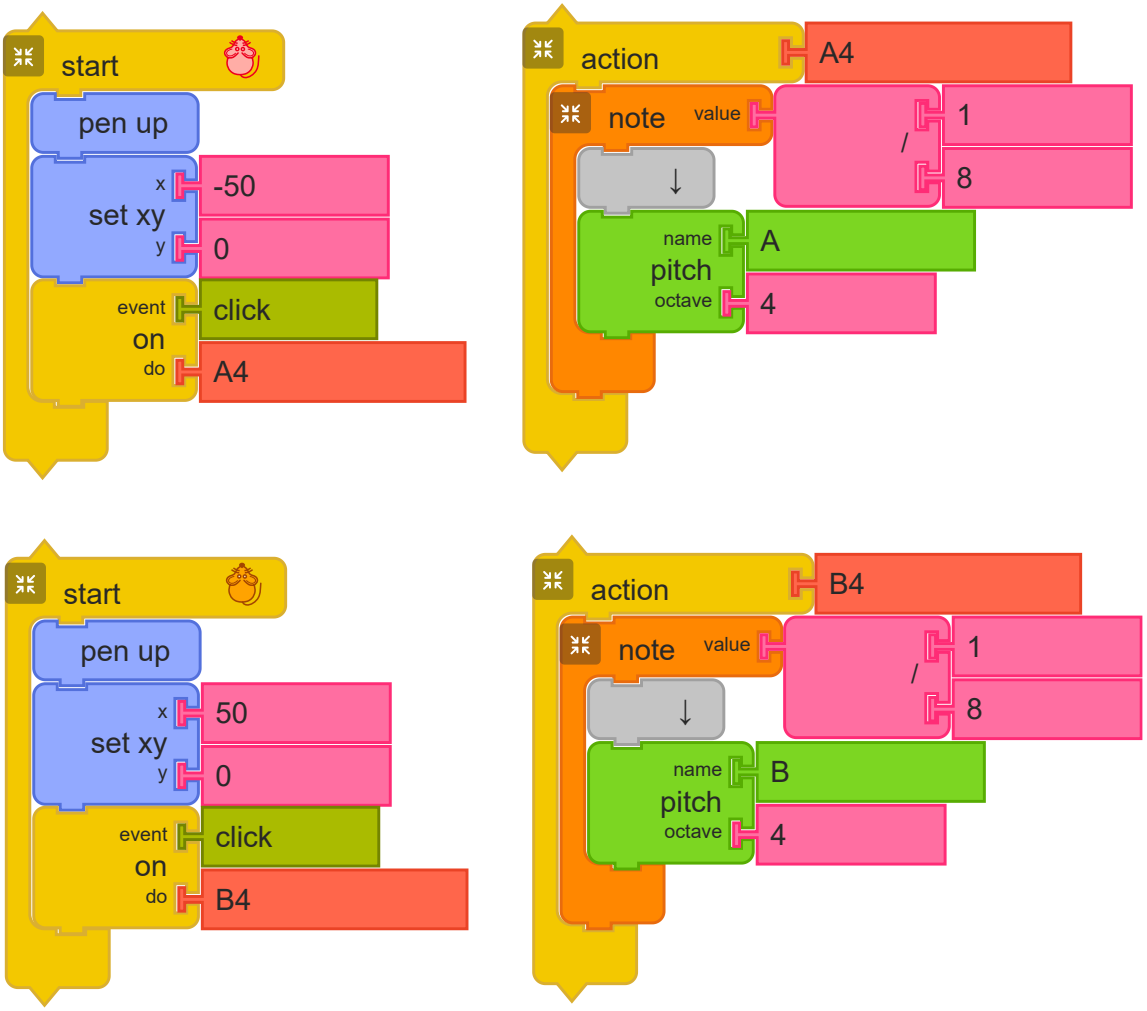


3.7 Interactions

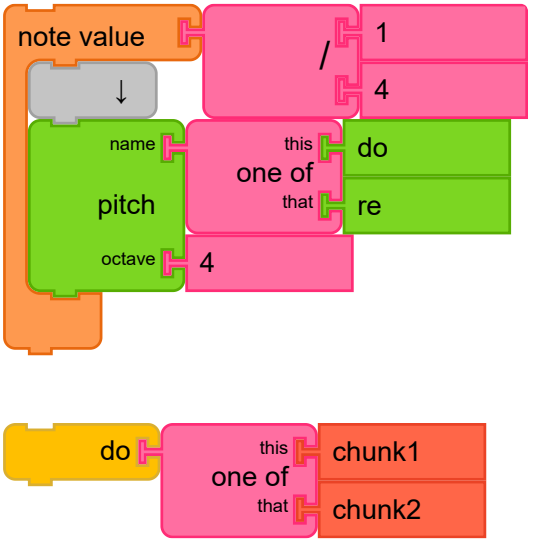
There are many ways to interactive with Music Blocks, including tracking the mouse position to impact some aspect of the music.



For example, we can launch the phrases (chunks) interactively. We use the mouse position to generate a suffix: `0`, `1`, `2`, or `3`, depending on the quadrant. When the mouse is in the lower-left quadrant, `chunk0` is played; lower-right quadrant, `chunk1`; upper-left quadrant, `chunk2`; and upper-right quadrant, `chunk3`.



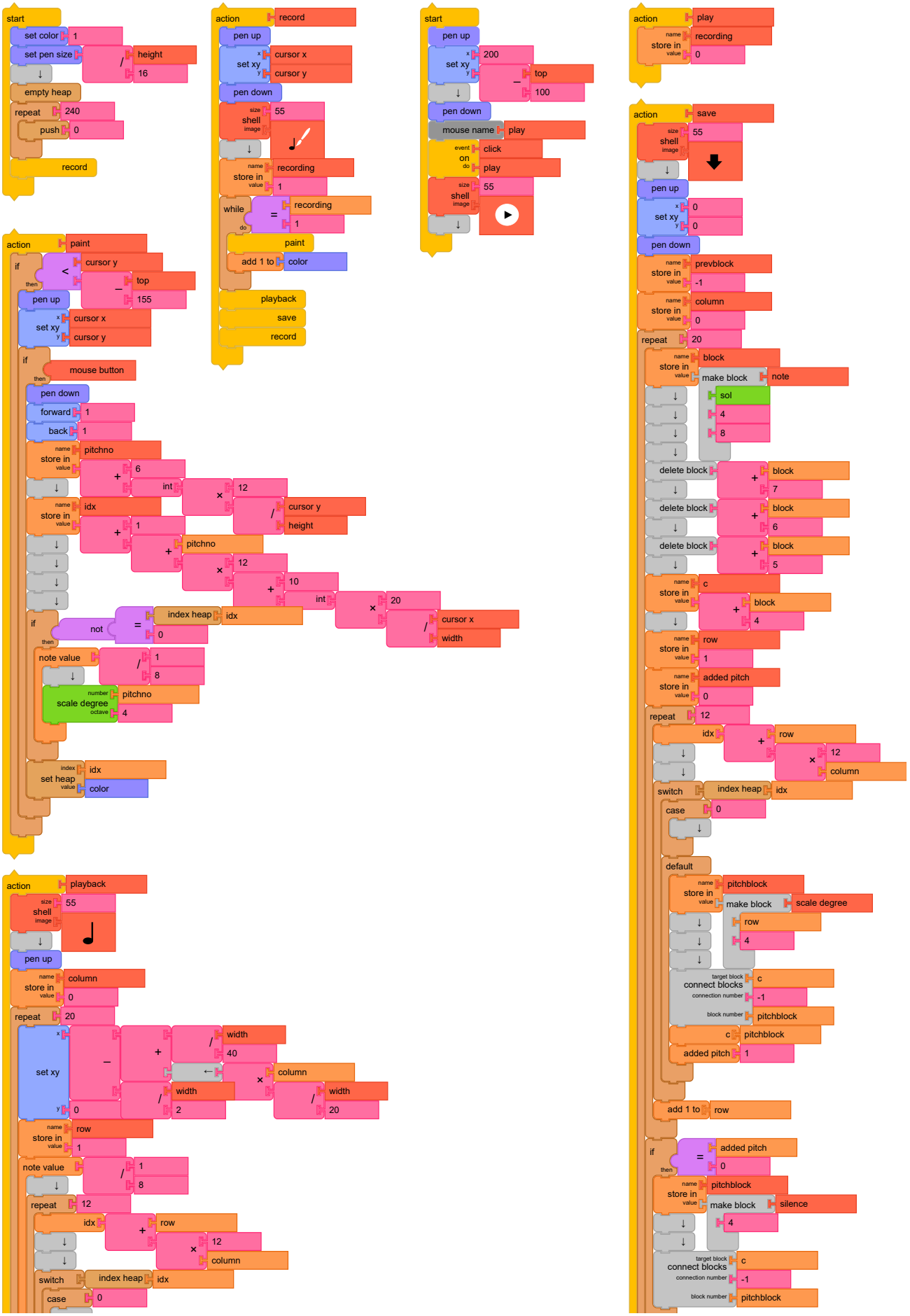
In the example above, a simple two-key piano is created by associating *click* events on two different turtles with individual notes. Can you make an 8-key piano?

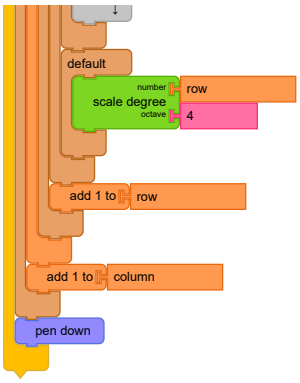


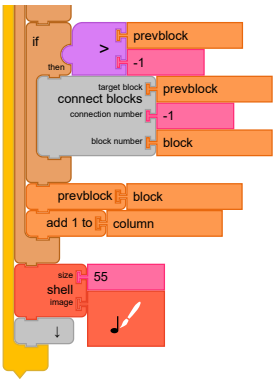
You can also add a bit of randomness to your music. In the top example above, the *One-of* block is used to randomly assign either `Do` or `Re` each time the *Note value* block is played. In the bottom example above, the *One-of* block is used to randomly select between `chunk1`

and `chunk2`.

Musical Paint has been a popular activity dating back to programs such as Dan Franzblau's *Vidsizer* (1979) or Morwaread Farbood's *Hyperscore* (2002). Music Blocks can be used to create musical paint as well. In the somewhat ambitious example below, we go a step further than the typical paint program in that you can not only paint music (a la Vidsizer) and playback your painting as a composition (a la Hyperscore), but also generate *Note* blocks from your composition.


start
set color 1
set pen size / height 16
empty heap
repeat 240
push 0
record
action record
pen up
set xy cursor x cursor y
pen down
shell 55
store in recording 1
while recording = 1
paint
add 1 to color
playback
save
record
start
pen up
set xy 200 top 100
pen down
mouse name play
on click
play
shell 55
action play
store in recording 0
action save
shell 55
pen up
set xy 0 0
pen down
store in prevblock -1
store in column 0
repeat 20
store in block make block note
sol 4 8
delete block block 7
delete block block 6
delete block block 5
store in c block 4
store in row 1
store in added pitch 0
repeat 12
idx row × 12 column
switch index heap idx
case 0
default
store in pitchblock make block scale degree
row 4
connect blocks target block c
connection number -1
block number pitchblock
c pitchblock
added pitch 1
add 1 to row
if = added pitch 0
store in pitchblock make block silence
4
connect blocks target block c
connection number -1
block number pitchblock
action paint
if cursor y < top 155
pen up
set xy cursor x cursor y
if mouse button
pen down
forward 1
back 1
store in pitchno + 6 int × 12 / cursor y height
store in idx + 1 + pitchno × 12 + 10 int × 20 / cursor x width
if not = index heap idx 0
note value / 1 8
scale degree number pitchno octave 4
set heap index idx value color
action playback
shell 55
pen up
store in column 0
repeat 20
set xy x – + / width 40 ← × column / width 20 y 0
store in row 1
note value / 1 8
repeat 12
idx + row × 12 column
switch index heap idx
case 0





The program works by first creating an array from the heap that corresponds to a 20x12 grid of notes on the screen: 20 columns, representing time from left to right; and 12 rows, corresponding to scalar pitch values, which increase in value from the bottom to the top.

The *record* action repeatedly calls the *paint* action until the *playback* button is clicked.

The *paint* action tracks the mouse (*Set XY* to *cursor x* and *cursor y*) and, if the mouse button is pressed, marks an entry in the array corresponding to that note, plays the note, and leaves behind a "drop of paint".

The *playback* action is invoked by clicking on the *play* mouse, which sets *recording* to `0`, thus breaking out of the paint "while loop". Playback scans each column in the array from left to right for pitches to play and generates a chord of pitches for each column.

Once the *playback* action is complete, the *save* action is invoked. Again each column in the array is scanned, but this time, instead of playing notes, the *Make Block* block is called in order to generate a stack of notes that correspond to the composition. This stack can be copied and pasted into another composition.

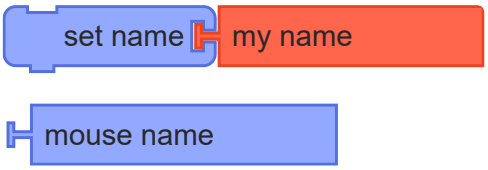
While a bit fanciful, this example, which can be run by clicking on the link below, takes musical paint in a novel direction.

3.8 Ensemble

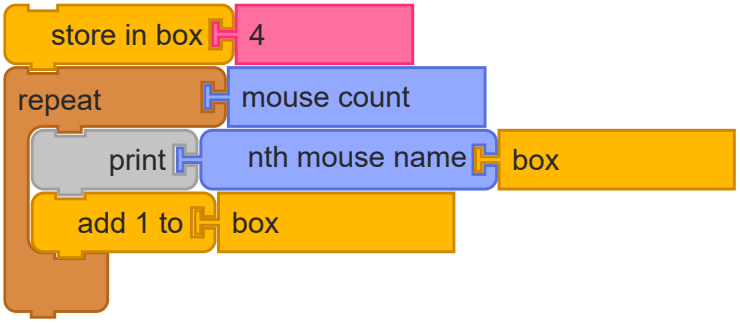
Much of music involves multiple instruments (voices or "mice" in Music Blocks) playing together. There are a number of special blocks that can be used to coordinate the actions of an ensemble of mice.

This section will guide about different ensemble blocks, which communicate the status of mice by name, including notes played, current pen color, pitch number, etc.

To use the ensemble blocks, you must assign a name to each mouse, as we will reference each mouse by its name.

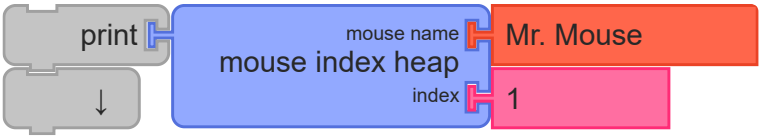


Use the *Mouse count* block in combination with the *Nth mouse name* block to iterate through all of the mice.

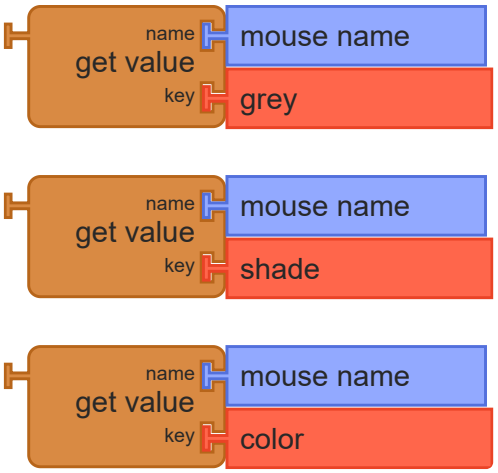


The *Mouse sync* block aligns the beat count between mice.

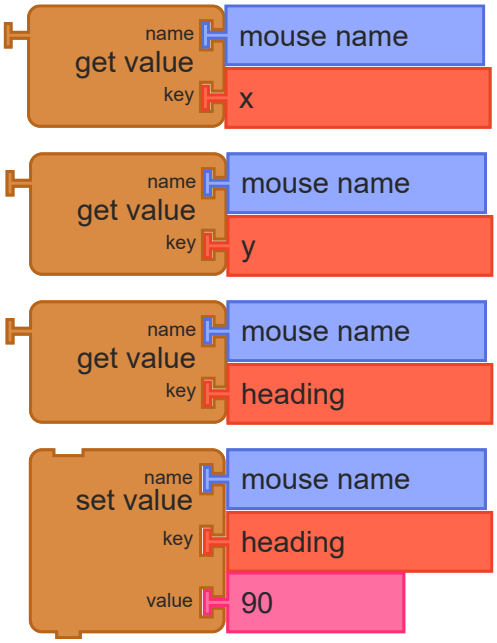
The *Mouse index heap* block returns a value in the heap at a specified location for a specified mouse.



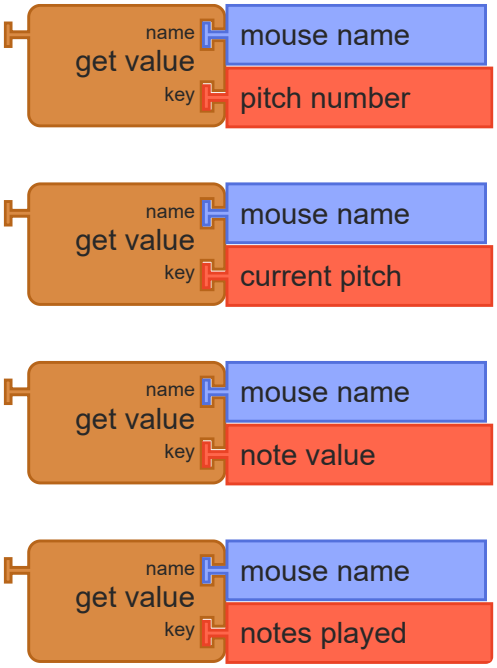
You can use the dictionary entries to data between mice. The *Get value* block lets you specify a mouse name and the value you want to access. For example, you can access a mouse's pen attributes, such as color, shade, and grey values.



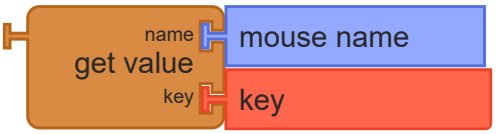
You can also access the mouse's graphics attributes, such as x, y, and heading. You can also set attributes of a mouse using the *Set value* block. In the example, a mouse's heading is set to 90.



Some music status is also available through the dictionary. You can access a mouse's "current pitch", "pitch number", "note value", the number of "notes played".



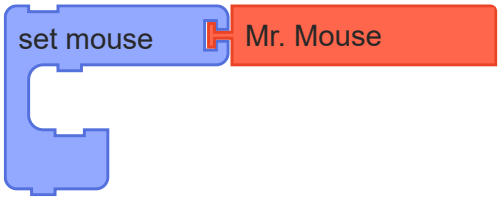
The dictionary can be used to share other things too. Just set a *key/value* pair with one mouse and access it from another.



Other Ensemble blocks include:

The *Found mouse* block will return true if the specified mouse can be found.

The *Set mouse* block sends a stack of blocks to be run by the specified mouse.



4. Widgets

Previous Section (3. Programming with Music) | Back to Table of Contents | Next Section (5. Beyond Music Blocks)

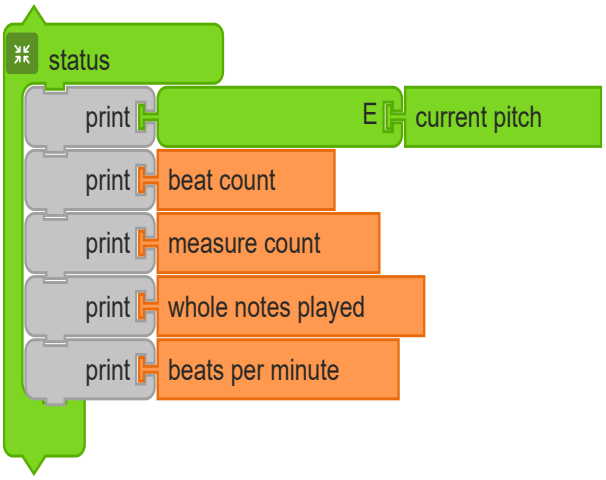
This section of the guide will talk about the various Widgets that can be used within Music Blocks to enhance your experience.

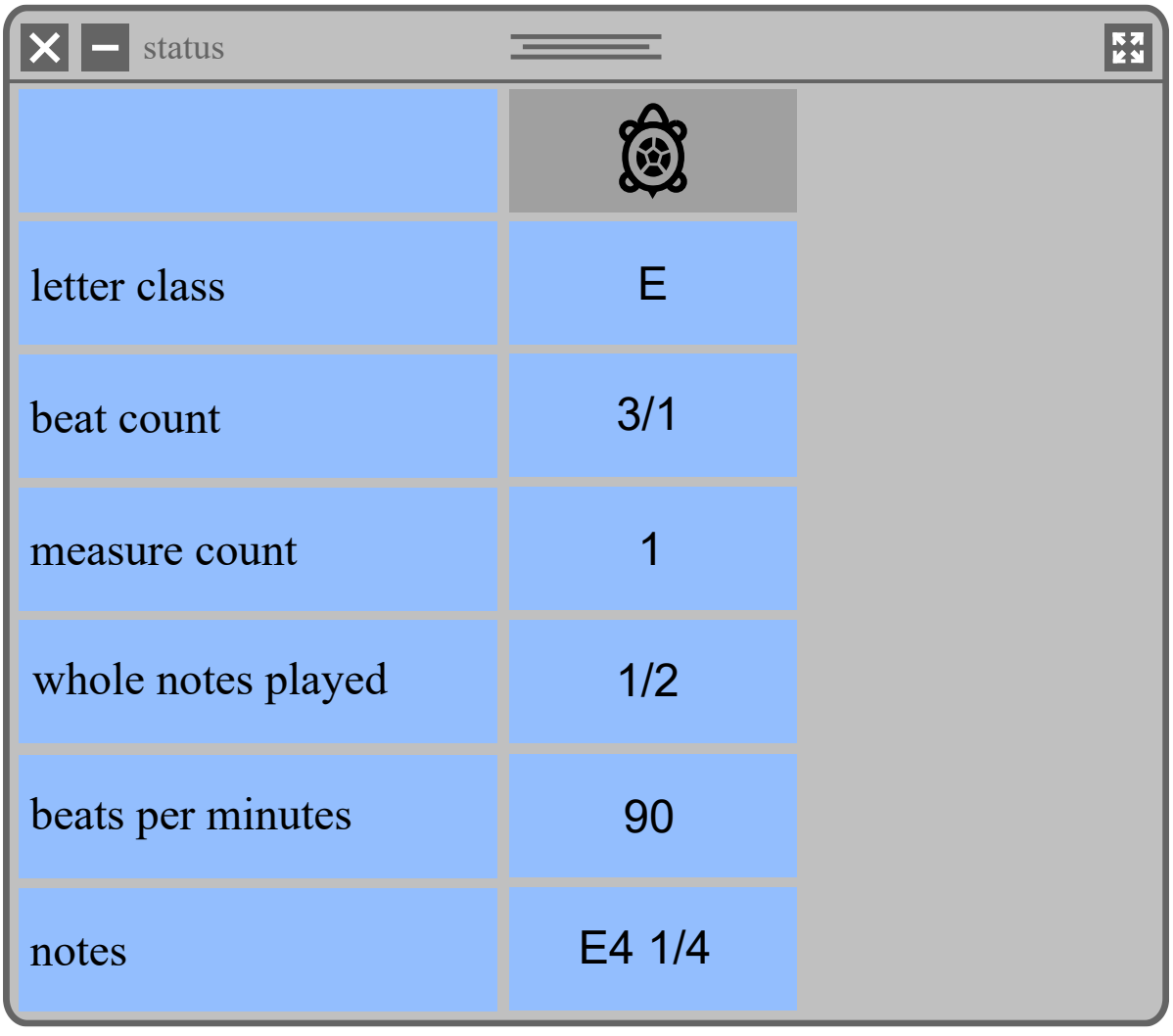
Every widget has a menu with at least two buttons.

You can hide the widget by clicking on the *Close* button.

You can move the widget by dragging its containing the window.

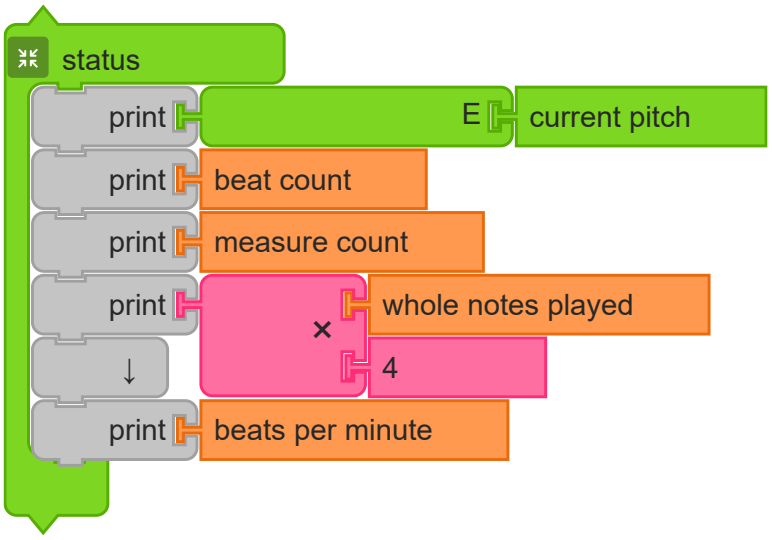
4.1 Status





The *Status widget* is a tool for inspecting the status of Music Blocks as it is running. By default, the key, BPM, and volume are displayed. Also, each note is displayed as it is played. There is one row per voice in the status table.

Additional *Print* blocks can be added to the *Status* widget to display additional music factors, e.g., duplicate, transposition, skip, staccato and slur, and graphics factors, e.g., x, y, heading, color, shade, grey, and pensize.

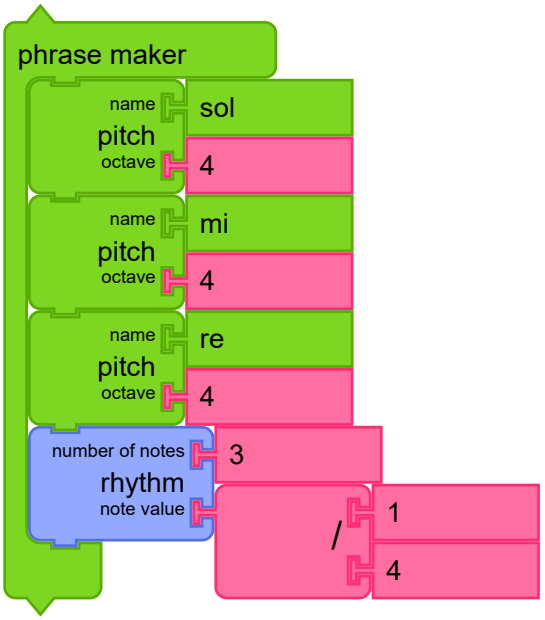


You can do additional programming within the status block. In the example above, `whole notes played` is multiplied by `4` (to calculate quarter notes played) before being displayed.

4.2 Generating Chunks of Notes

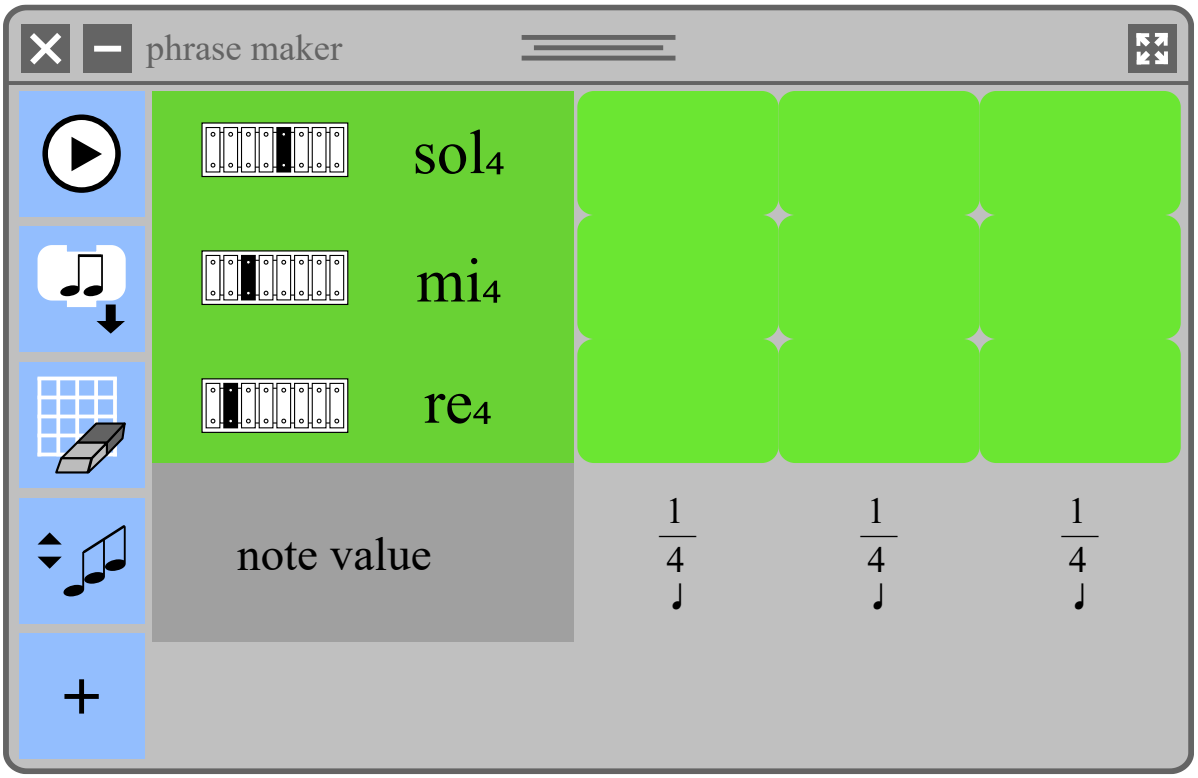
Using the Phrase Maker, it is possible to generate chunks of notes at a much faster speed.

4.2.1 The Phrase Maker



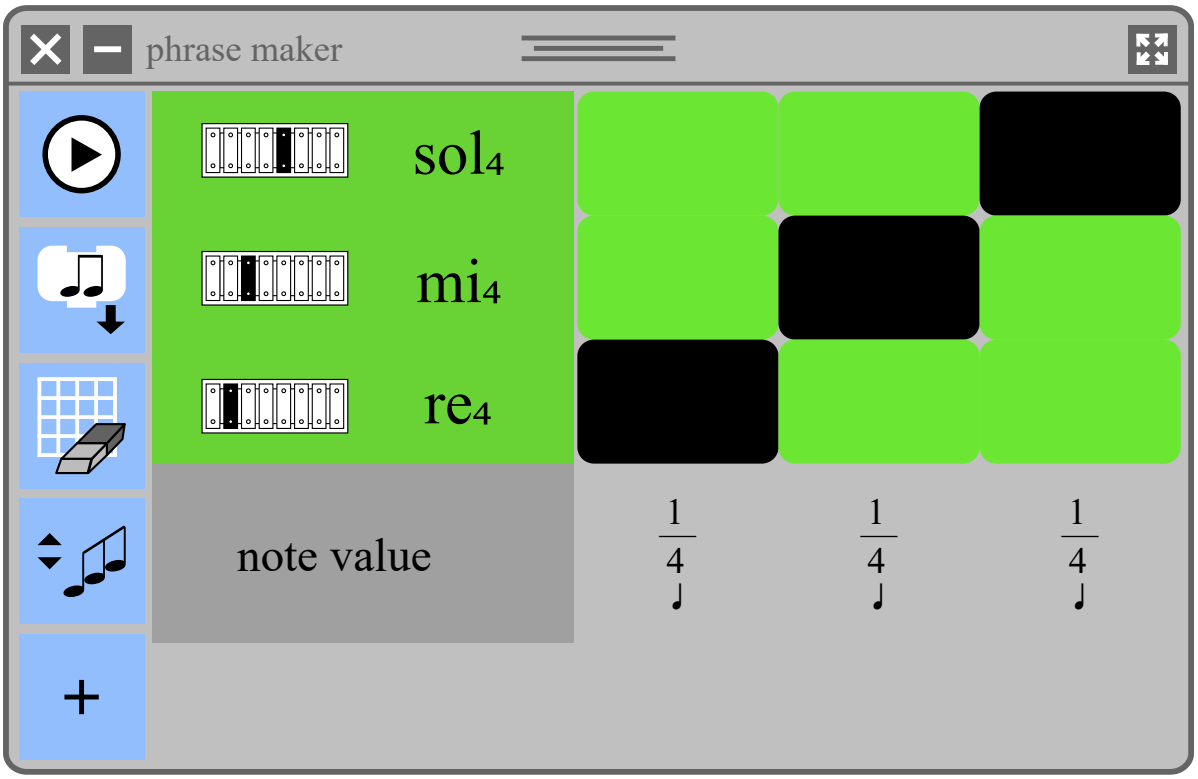
Music Blocks provides a widget, the *Phrase maker*, as a scaffold for getting started.

Once you've launched Music Blocks in your browser, start by clicking on the *Phrase maker* stack that appears in the middle of the screen. (For the moment, ignore the *Start* block.) You'll see a grid organized vertically by pitch and horizontally by rhythm.



The matrix in the figure above has three *Pitch* blocks and one *Rhythm* block, which is used to create a 3 x 3 grid of pitch and time.

Note that the default matrix has five *Pitch* blocks, one *Drum* block, and two *Mouse* (movement) blocks. Hence, you will see eight rows, one for each pitch, drum, and mouse (movement). (A ninth row at the bottom is used for specifying the rhythms associated with each note.) Also by default, there are two *Rhythm* blocks, which specifies six quarter `(1/4)` notes followed by one half `(1/2)` note.



By clicking on individual cells in the grid, you should hear individual notes (or chords if you click on more than one cell in a column). In the figure, three quarter notes are selected (black cells). First `Re 4`, followed by `Mi 4`, followed by `Sol 4`.

widget

If you click on the *Play* button (found in the top row of the grid), you will hear a sequence of notes played (from left to right): `Re 4`, `Mi 4`, `Sol 4`.

widget

Once you have a group of notes (a "chunk") that you like, click on the *Save* button (just to the right of the *Play* button). This will create a stack of blocks that can used to play these same notes programmatically. (More on that below.)

You can rearrange the selected notes in the grid and save other chunks as well.

widget

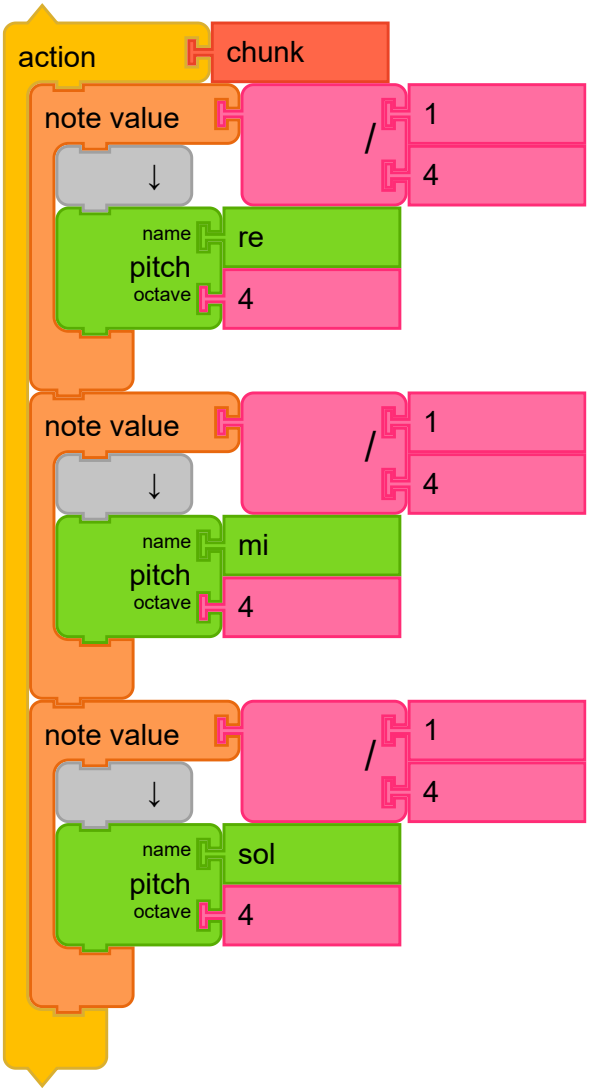
The *Sort* button will reorder the pitches in the matrix from highest to lowest and eliminate any duplicate *Pitch* blocks.

widget

There is also an Erase button that will clear the grid.

Don't worry. You can reopen the matrix at anytime (it will remember its previous state) and since you can define as many chunks as you want, feel free to experiment.

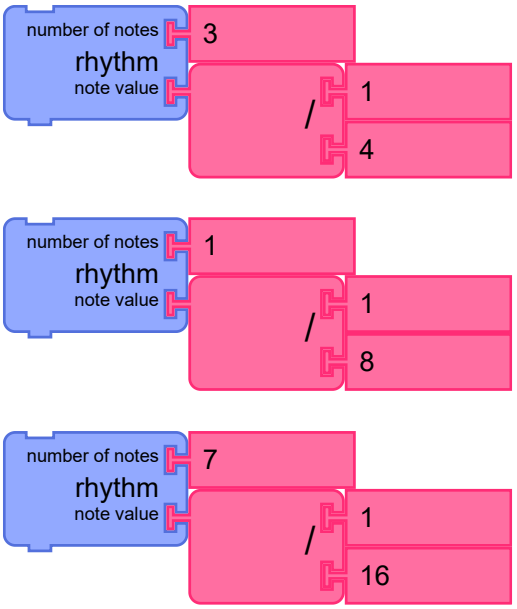
Tip: You can put a chunk inside a *Phrase maker* block to generate the matrix to corresponds to that chunk.



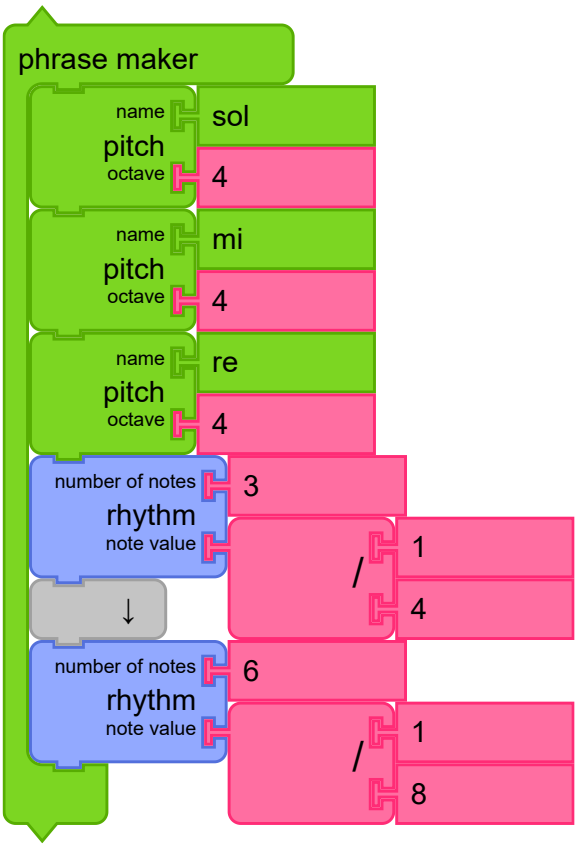
The chunk created when you click on the matrix is a stack of blocks. The blocks are nested: an *Action* block contains three *Note value* blocks, each of which contains a *Pitch* block. The *Action* block has a name automatically generated by the matrix, in this case, chunk. (You can rename the action by clicking on the name.). Each note has a duration (in this case 4, which represents a quarter note). Try putting different numbers in and see (hear) what happens. Each note block also has a pitch block (if it were a chord, there would be multiple *Pitch* blocks nested inside the Note block's clamp). Each pitch block has a pitch name (`Re` , `Mi` , and `Sol`), and a pitch octave; in this example, the octave is 4 for each pitch. (Try changing the pitch names and the pitch octaves.)

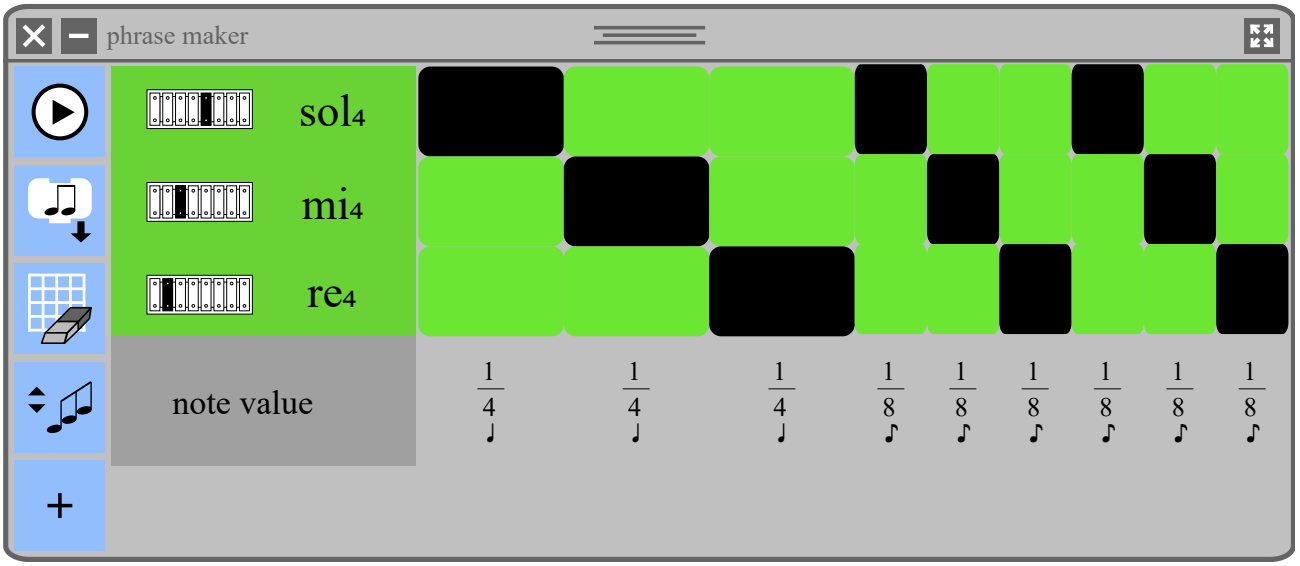
To play the chuck, simply click on the action block (on the word action). You should hear the notes play, ordered from top to bottom.

4.2.2 The Rhythm Block



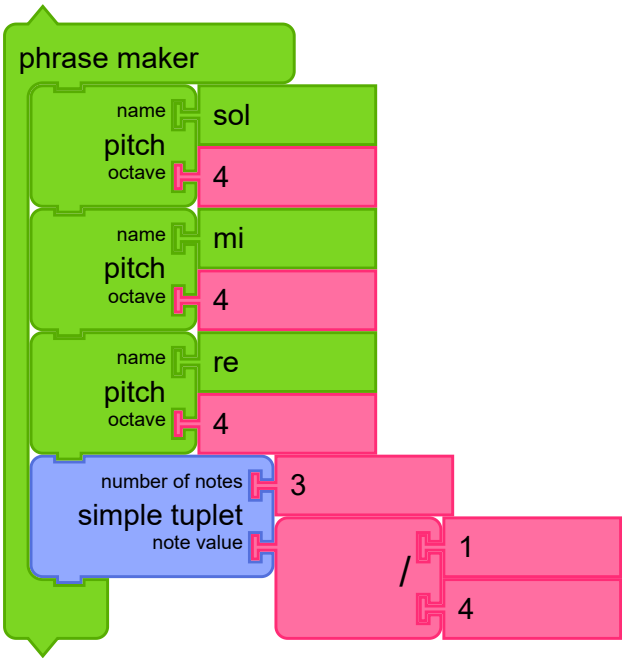
Rhythm blocks are used to generate rhythm patterns in the *Phrase maker* block. The top argument to the *Rhythm* block is the number of notes. The bottom argument is the duration of the note. In the top example above, three columns for quarter notes would be generated in the matrix. In the middle example, one column for an eighth note would be generated. In the bottom example, seven columns for 16th notes would be generated.

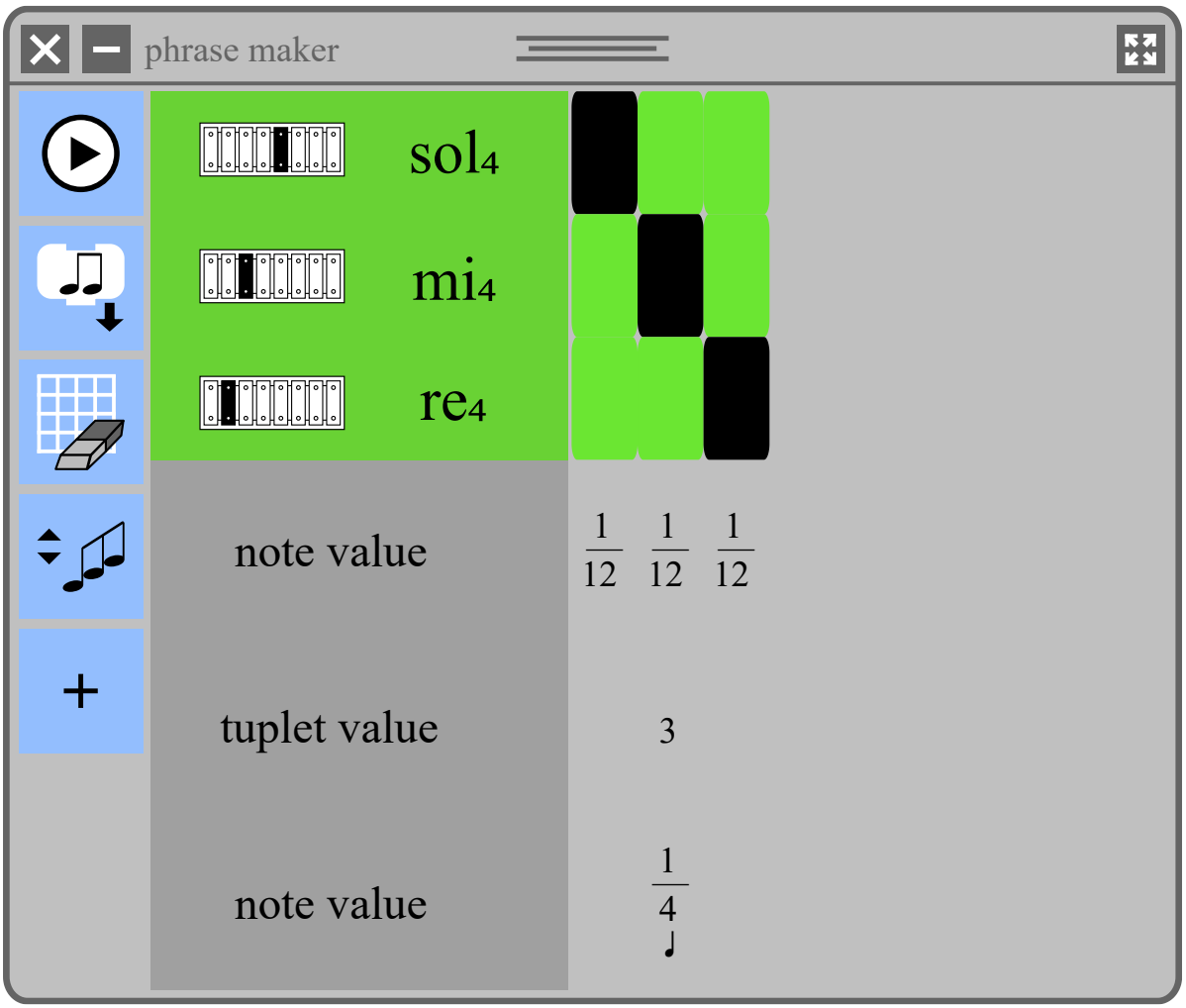




You can use as many *Rhythm* blocks as you'd like inside the *Phrase maker* block. In the above example, two *Rhythm* blocks are used, resulting in three quarter notes and six eighth notes.

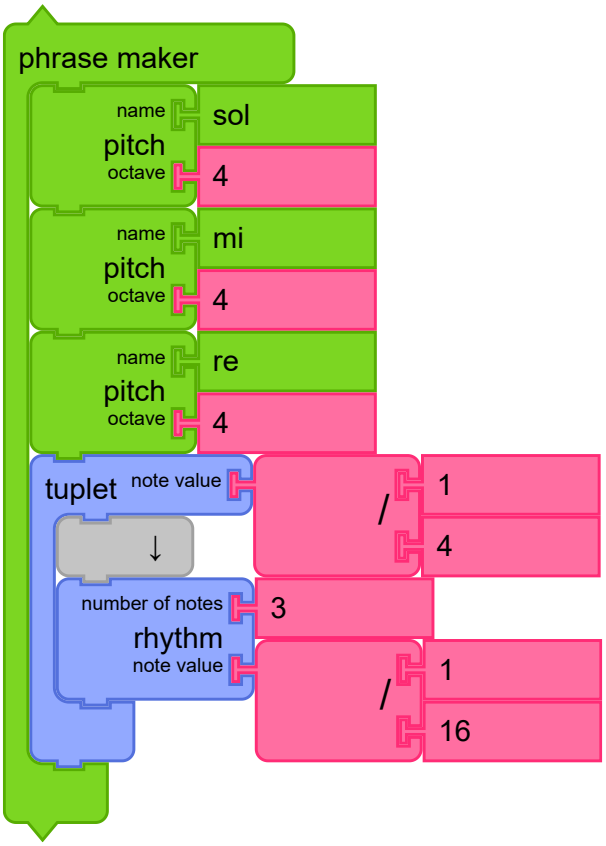
4.2.3 Creating Tuplets



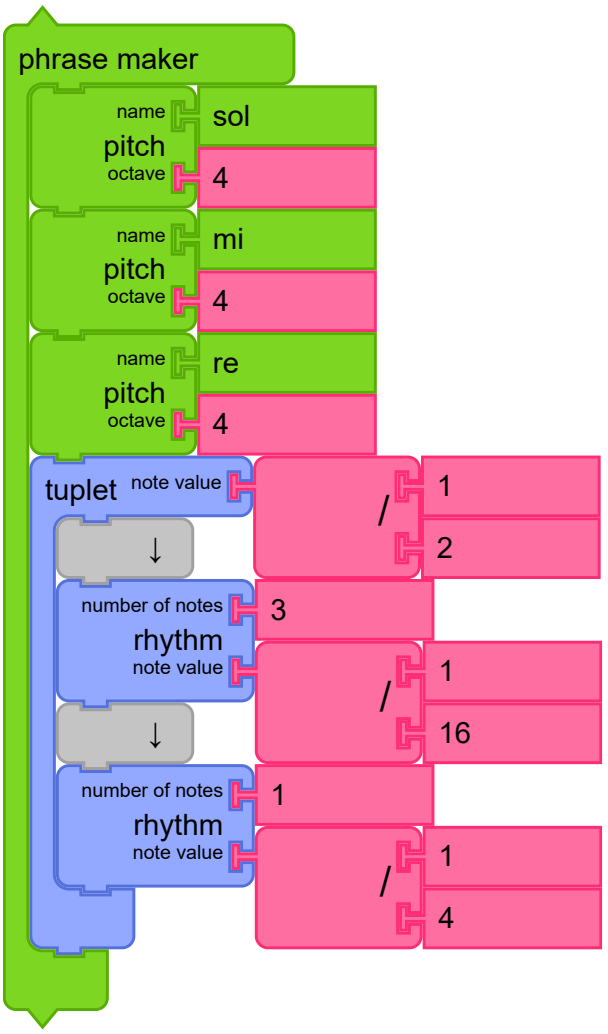


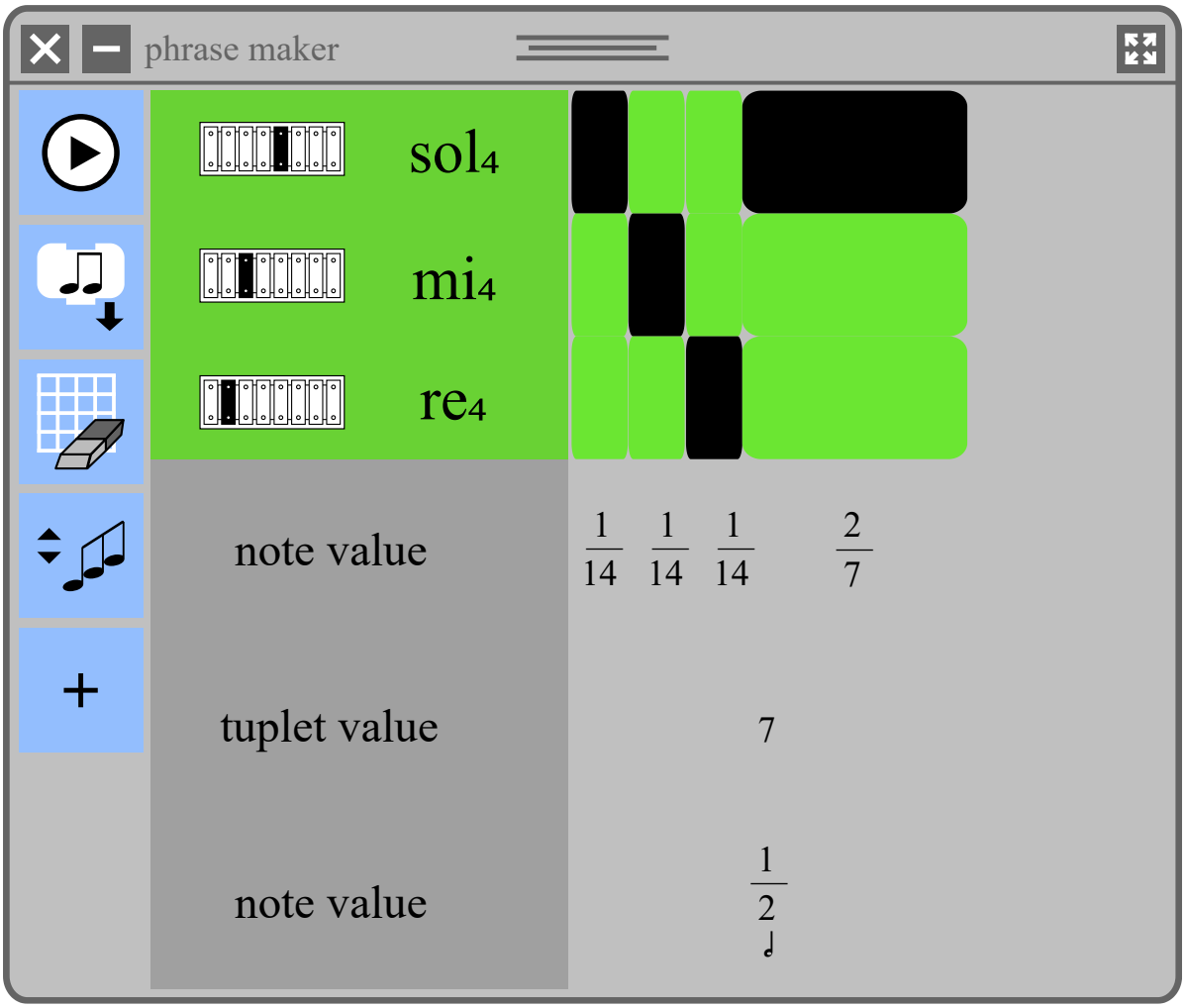
Tuplets are a collection of notes that get scaled to a specific duration. Using tuplets makes it easy to create groups of notes that are not based on a power of 2.

In the example above, three quarter notes—defined in the *Simple Tuplet* block—are played in the time of a single quarter note. The result is three twelfth notes. (This form, which is quite common in music, is called a *triplet*. Other common tuplets include a *quintuplet* and a *septuplet*.)



In the example above, the three quarter notes are defined in the *Rhythm* block embedded in the *Tuplet* block. As with the *Simple Tuplet* example, they are played in the time of a single quarter note. The result is three twelfth notes. This more complex form allows for intermixing multiple rhythms within single tuplet.


phrase maker
name
sol
pitch
octave
4
name
mi
pitch
octave
4
name
re
pitch
octave
4
tuplet
note value
/
1
2
number of notes
3
rhythm
note value
/
1
16
number of notes
1
rhythm
note value
/
1
4



In the example above, the two *Rhythm* blocks are embedded in the *Tuplet* block, resulting in a more complex rhythm.

Note: You can mix and match *Rhythm* blocks and *Tuplet* blocks when defining your matrix.

4.2.4 What is a Tuplet?

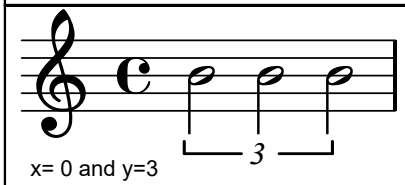
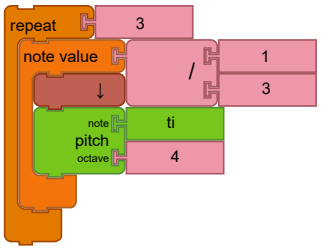
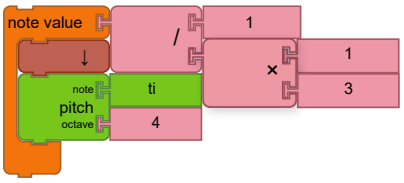
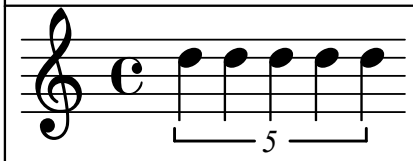
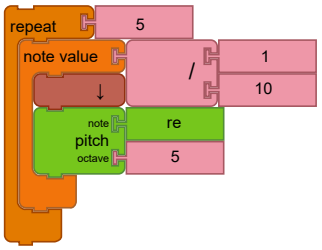
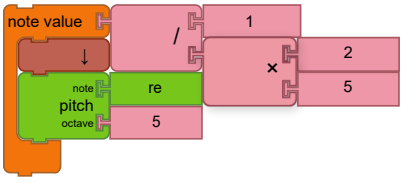
Using Tuplets

A tuplet is a specific group of notes played in a condensed amount of time.

x= power of the note* y= tuplet value

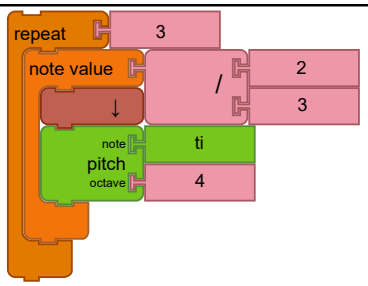
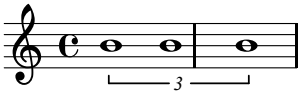
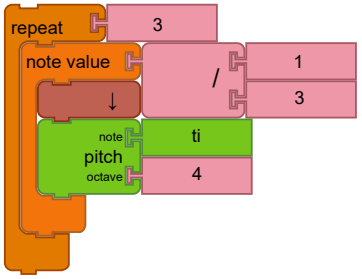
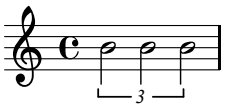
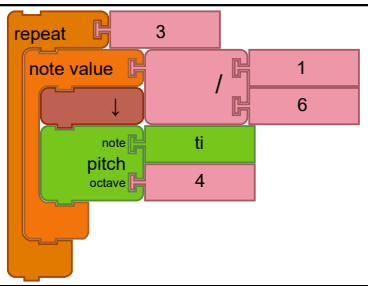
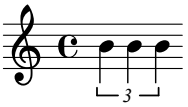
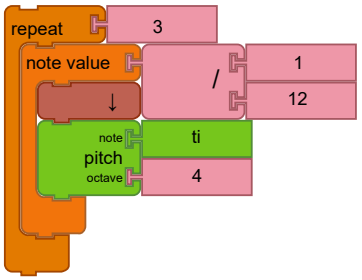
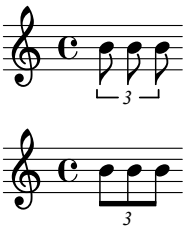
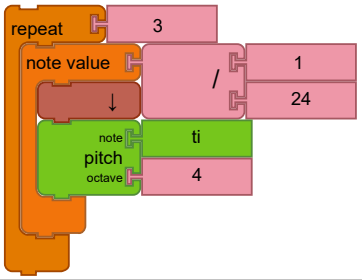
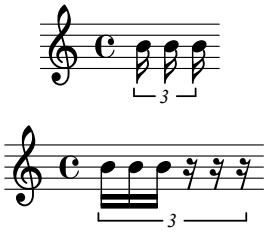
Formula: $\frac{1}{2^{x} * y} =$ resulting note value**

Examples:

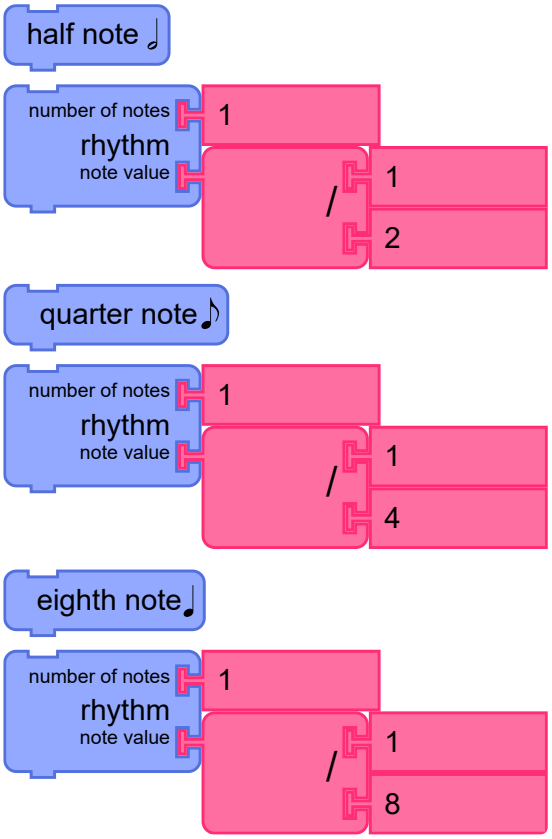
Western Notation	Music Blocks Tuplet	Music Block Math for Tuplet
 x= 0 and y=3 $\frac{1}{2^{0} \times 3} = \frac{1}{1 \times 3} = \frac{1}{3}$		
 x= 1 and y=5 $\frac{1}{2^{1} \times 5} = \frac{1}{2 \times 5} = \frac{1}{10}$		

*The power of the note occurs as follows:
longa= -3, breve= -2, whole= -1, half=0, quarter=1, eighth=2, sixteenth=3, thirty-second=4, and continues in this pattern.

**Different tuplet values produce different rhythmic qualities when mixed with note values of different tuplet values.

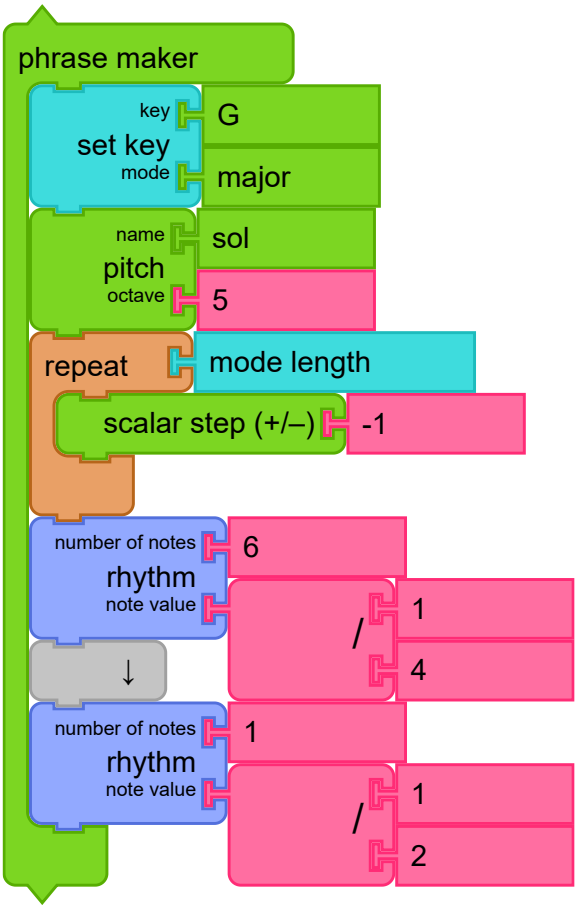
Power of Two	Music Blocks Tuplet	Tuplet in Western Notation
$\frac{1}{2^{-1} \times 3} = \frac{2}{3}$		
$\frac{1}{2^{0} \times 3} = \frac{1}{3}$		
$\frac{1}{2^{1} \times 3} = \frac{1}{6}$		
$\frac{1}{2^{2} \times 3} = \frac{1}{12}$		
$\frac{1}{2^{3} \times 3} = \frac{1}{24}$		

4.2.5 Using Individual Notes



You can also use individual notes when defining the grid. These blocks will expand into *Rhythm* blocks with the corresponding values.

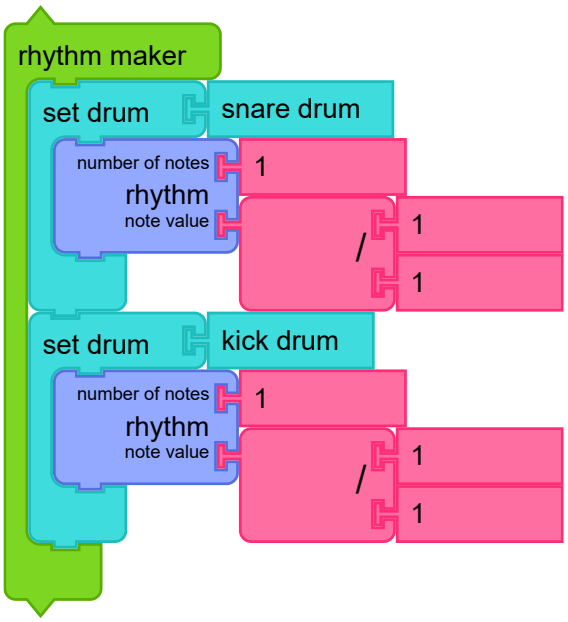
4.2.6 Using a Scale of Pitches



You can use the *Scalar step* block to generate a scale of pitches in the matrix. In the example above, the pitches comprising the G major scale in the 4th octave are added to the grid. Note that in order to put the highest note on top, the first pitch is the `Sol` in `Octave 5`. From there, we use `-1` as the argument to the *Scalar step* block inside the *Repeat*, working our way down to `Sol` in `Octave 4`. Another detail to note is the use of the *Mode length* block.

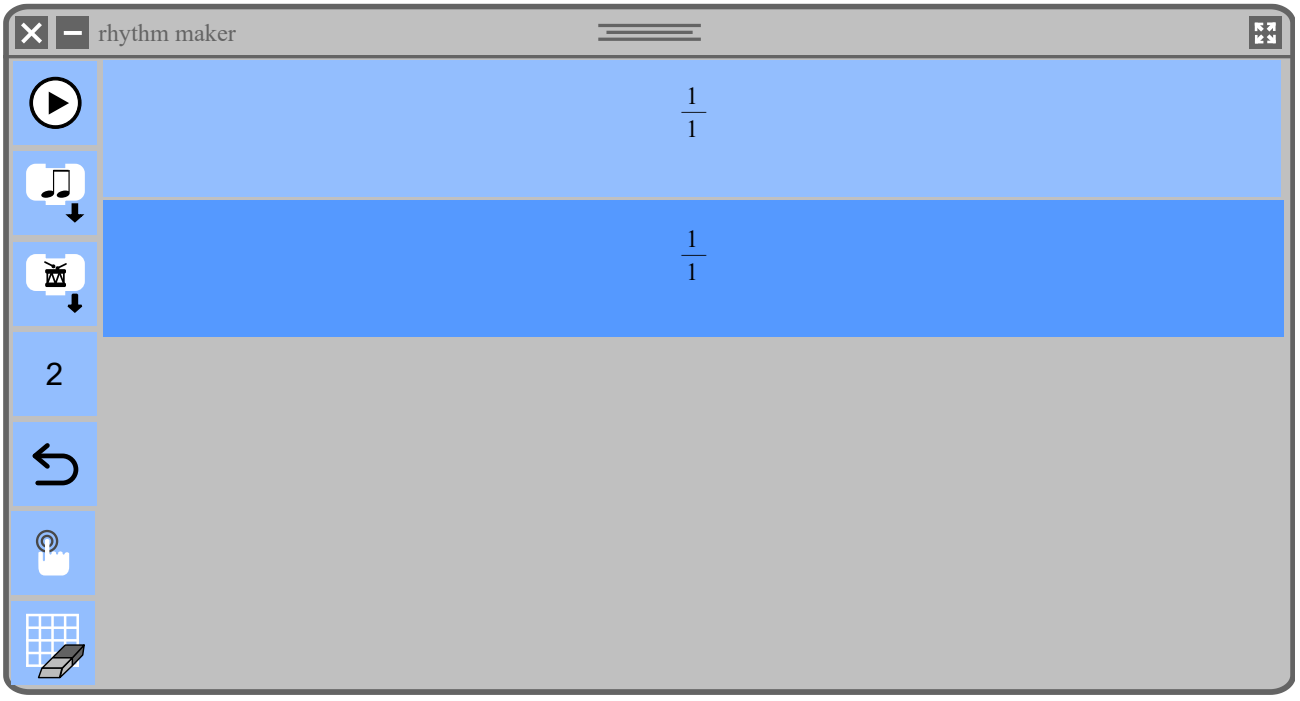
4.3 Generating Rhythms

The *Rhythm Maker* block is used to launch a widget similar to the *Phrase maker* block. The widget can be used to generate rhythmic patterns.

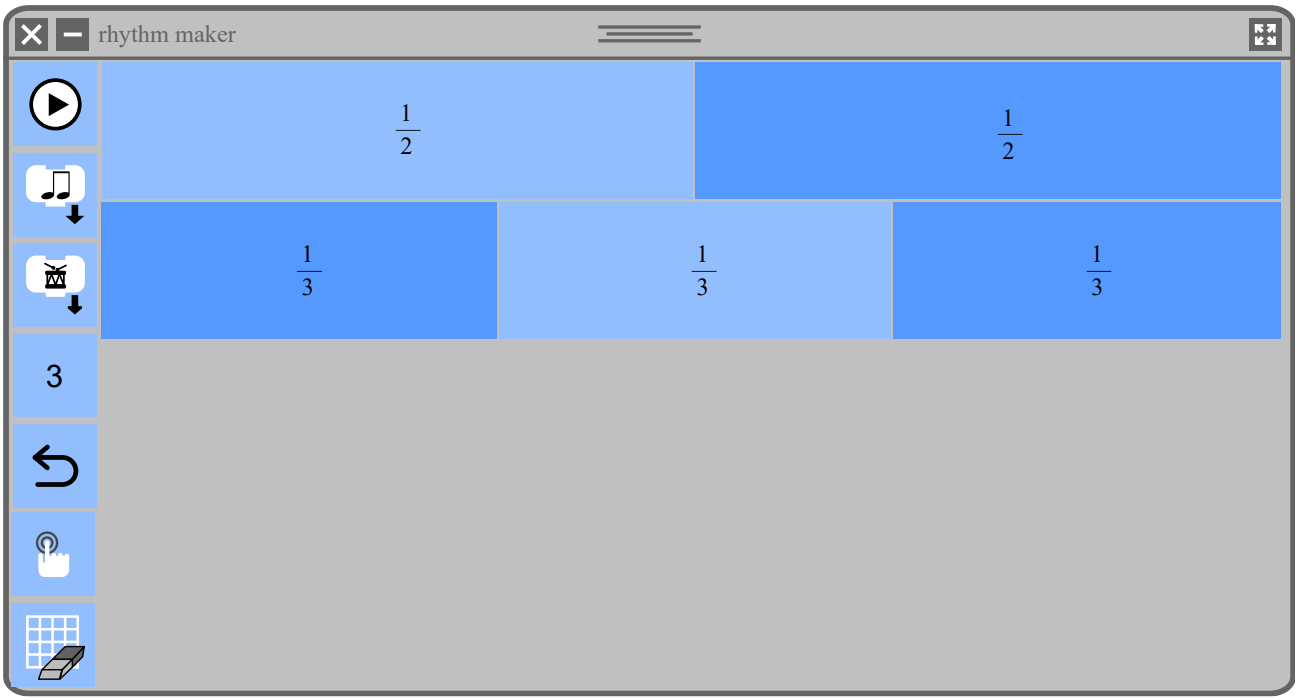


The argument to the *Rhythm Maker* block specifies the duration that will be subdivided to generate a rhythmic pattern. By default, it is 1 / 1, e.g., a whole note.

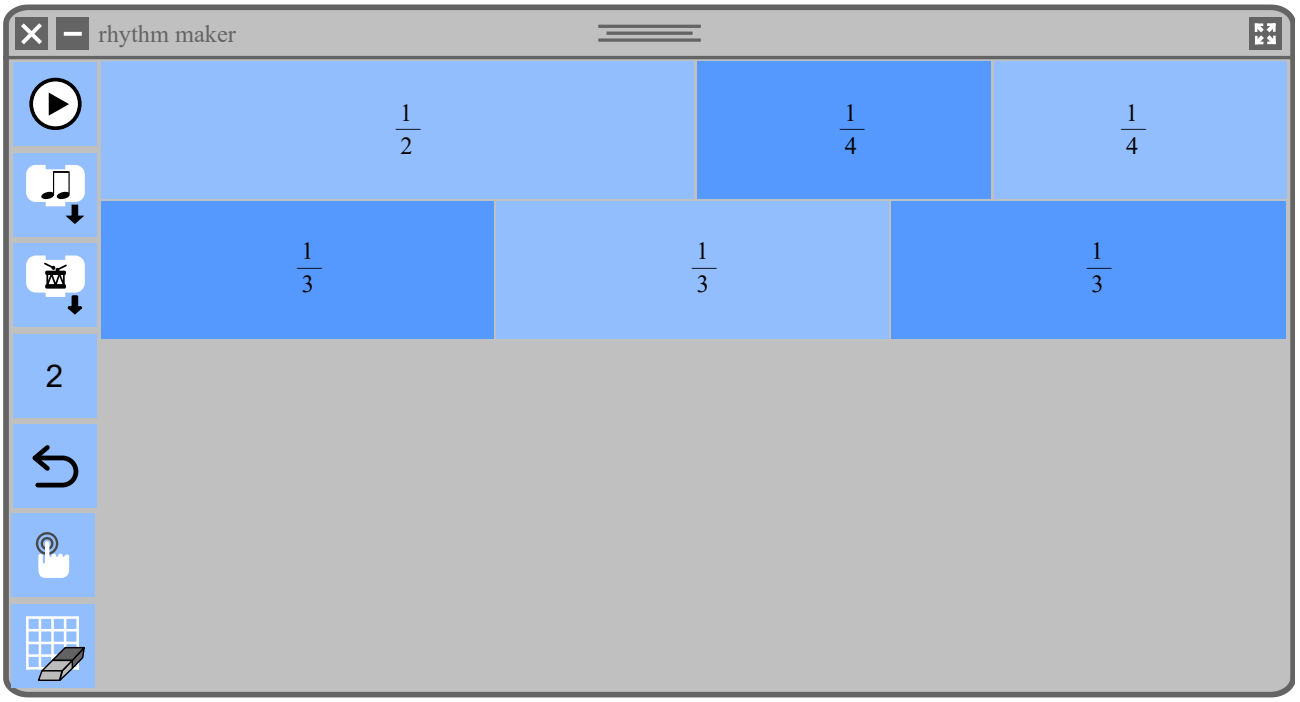
The *Set Drum* blocks contained in the clamp of the *Rhythm Maker* block indicates the number of rhythms to be defined simultaneously. By default, two rhythm "rulers" are defined. The embedded *Rhythm* blocks define the initial subdivision of each rhythm ruler.



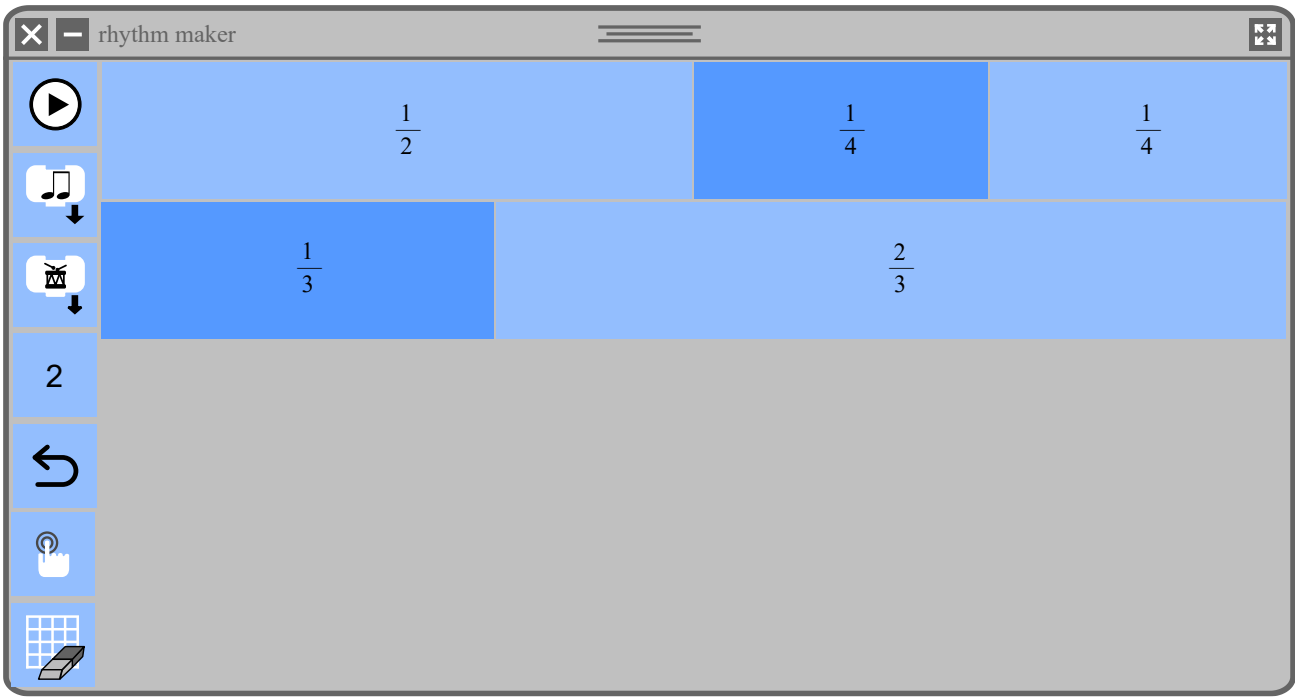
When the *Rhythm Maker* block is clicked, the *Rhythm Maker* widget is opened. It contains a row for each rhythm ruler. An input in the top row of the widget is used to specify how many subdivisions will be created within a cell when it is clicked. By default, 2 subdivisions are created.



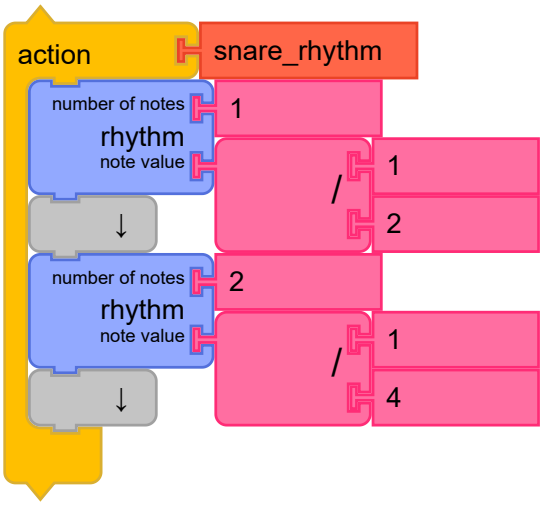
As shown in the above figure, the top rhythm ruler has been divided into two half-notes and the bottom rhythm ruler has been divided into three third-notes. Clicking on the *Play* button to the left of each row will playback the rhythm using a drum for each beat. The *Play-all* button on the upper-left of the widget will play back all rhythms simultaneously.

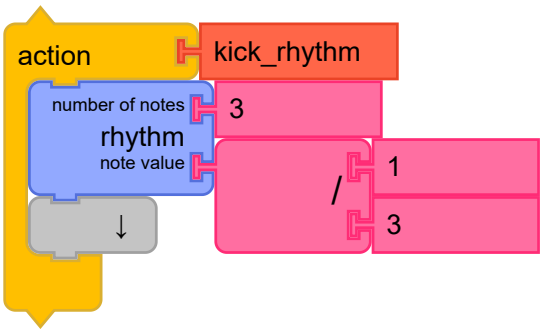


The rhythm can be further subdivided by clicking in individual cells. In the example above, two quarter-notes have been created by clicking on one of the half-notes.

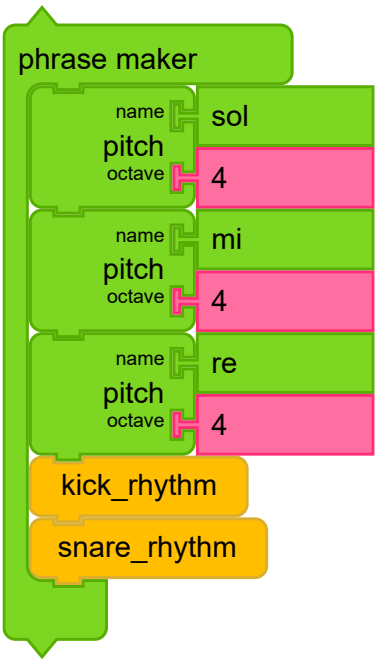


By dragging across multiple cells, they become tied. In the example above, two third-notes have been tied into one two-thirds-note.

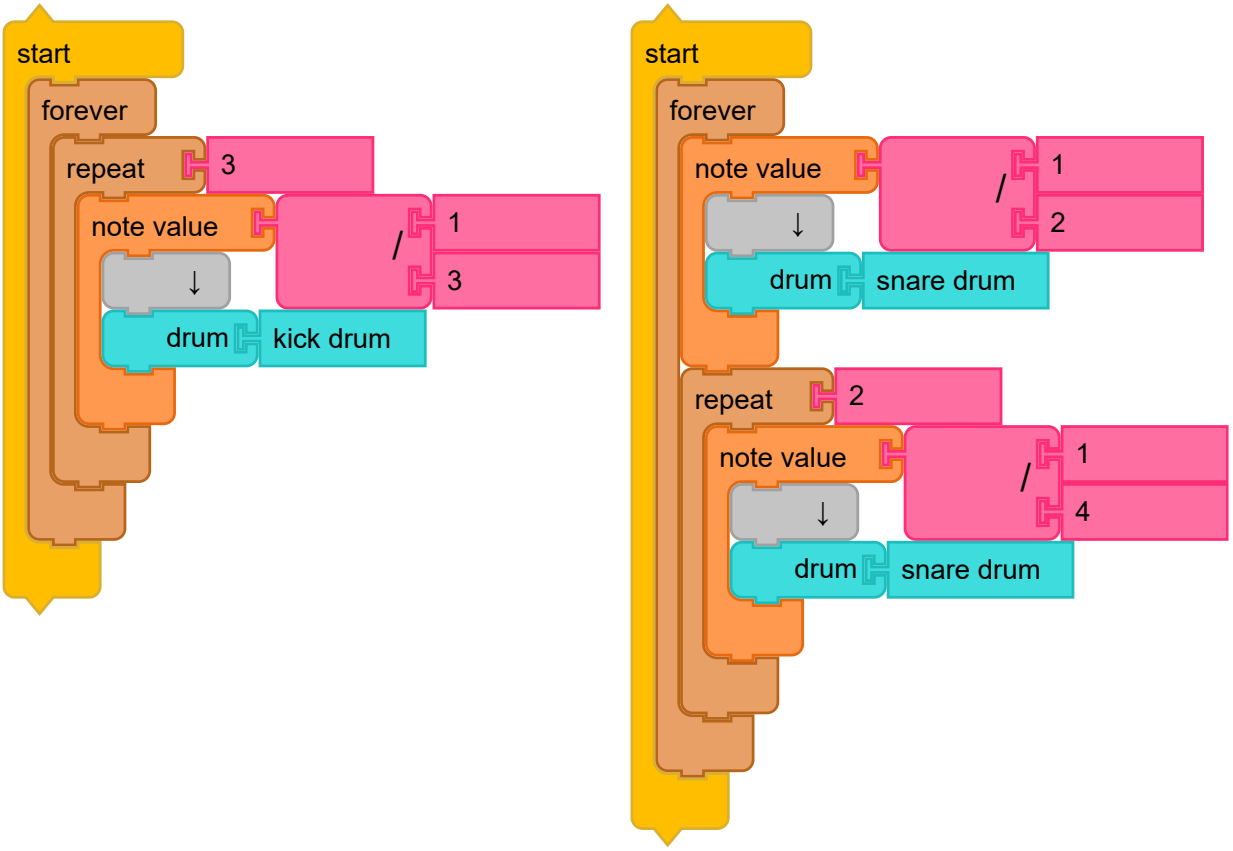




The *Save stack* button will export rhythm stacks.



These stacks of rhythms can be used to define rhythmic patterns used with the *Phrase maker* block.



The *Save drum machine* button will export *Start* stacks that will play the rhythms as drum machines.

Another feature of the *Rhythm Maker* widget is the ability to tap out a rhythm. By clicking on the *Tap* button and then clicking on a cell inside one of the rhythm rulers, you will be prompted (by four tones) to begin tapping the mouse button to divide the cell into sub-cells. Once the fourth tone has sounded, a progress bar will run from left to right across the screen. Each click of the mouse will define another beat within the cell. If you don't like your rhythm, use the *Undo* button and try again.

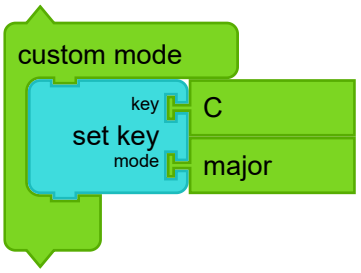
4.4 Musical Modes

Musical modes are used to specify the relationship between intervals (or steps) in a scale. Since Western music is based on 12 half-steps per octave, modes specify how many half steps there are between each note in a scale.

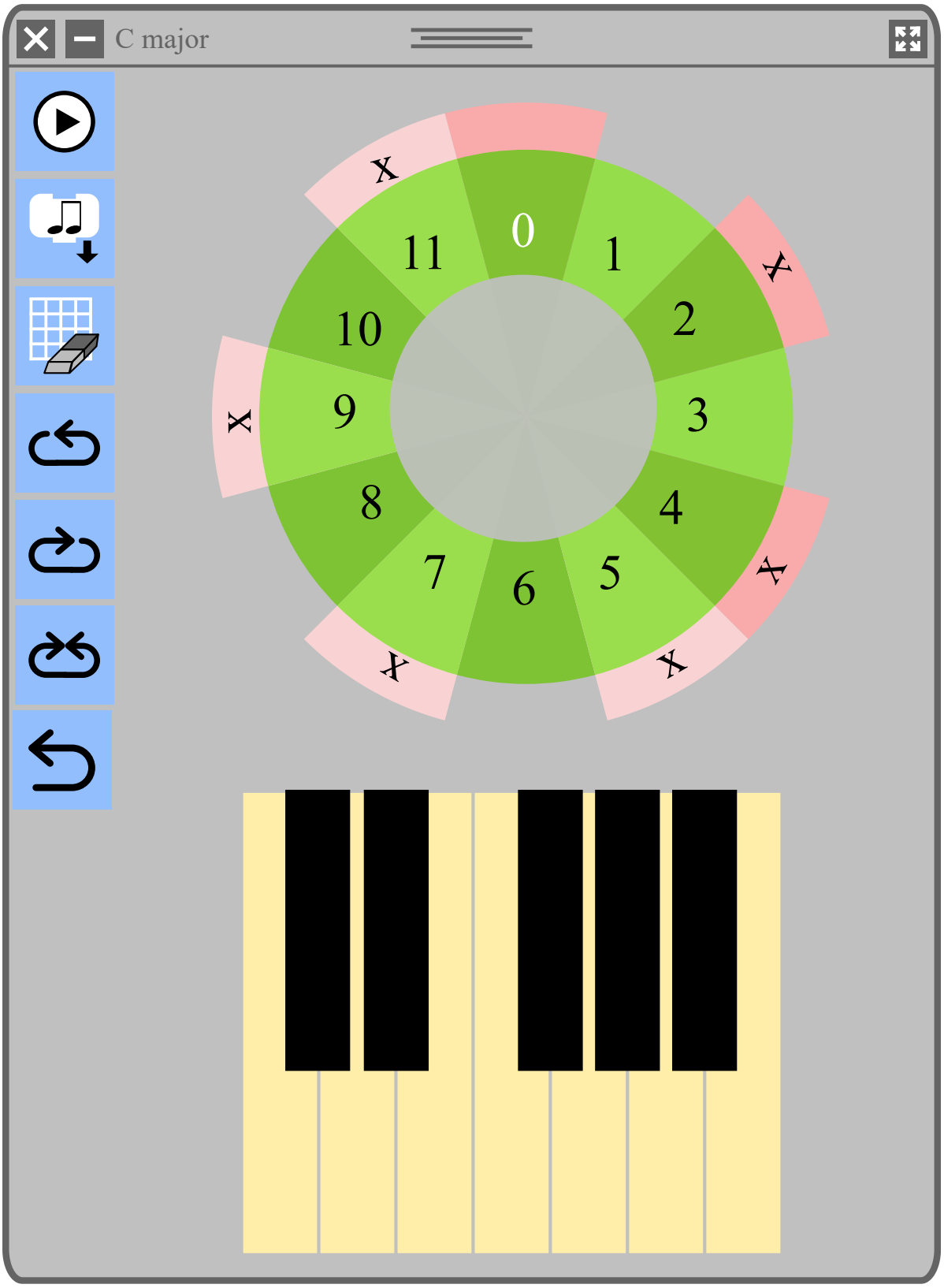
By default, Music Blocks uses the *Major* mode, which, in the Key of C, maps to the white keys on a piano. The intervals in the *Major* mode are `2, 2, 1, 2, 2, 2, 1`. Many other common modes are built into Music Blocks, including, of course, *Minor* mode, which uses `2, 1, 2, 2, 1, 2, 2` as its intervals.

Note that not every mode uses 7 intervals per octave. For example, the *Chromatic* mode uses 11 intervals: `1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1`. The *Japanese* mode uses only 5 intervals: `1, 4, 2, 3, 2],`. What is important is that the sum of the intervals in an octave is 12 half-steps.

The *Mode length* block will return the number of intervals (scalar steps) in the current mode.



The *Mode* widget lets you explore modes and generate custom modes. You invoke the widget with the *Custom mode* block. The mode specified in the *Set key* block will be the default mode when the widget launches.



In the above example, the widget has been launched with *Major* mode (the default). Note that the notes included in the mode are indicated by the protruding sectors with 'X's, which are arrayed in a circular pattern of twelve half-steps to complete the octave.

Since the intervals in the *Major* mode are `2, 2, 1, 2, 2, 2, 1`, the notes are `0`, `2`, `4`, `5`, `7`, `9`, `11`, and `12` (one octave above `0`).

The widget controls run along the toolbar at the top. From left to right are:

Play all, which will play a scale using the current mode;

Save, which will save the current mode as the *Custom* mode and save a stack of *Pitch* blocks that can be used with the *Phrase Maker* block;

Rotate counter-clockwise, which will rotate the mode counter-clockwise (See the example below);

Rotate clockwise, which will rotate the mode clockwise (See the example below);

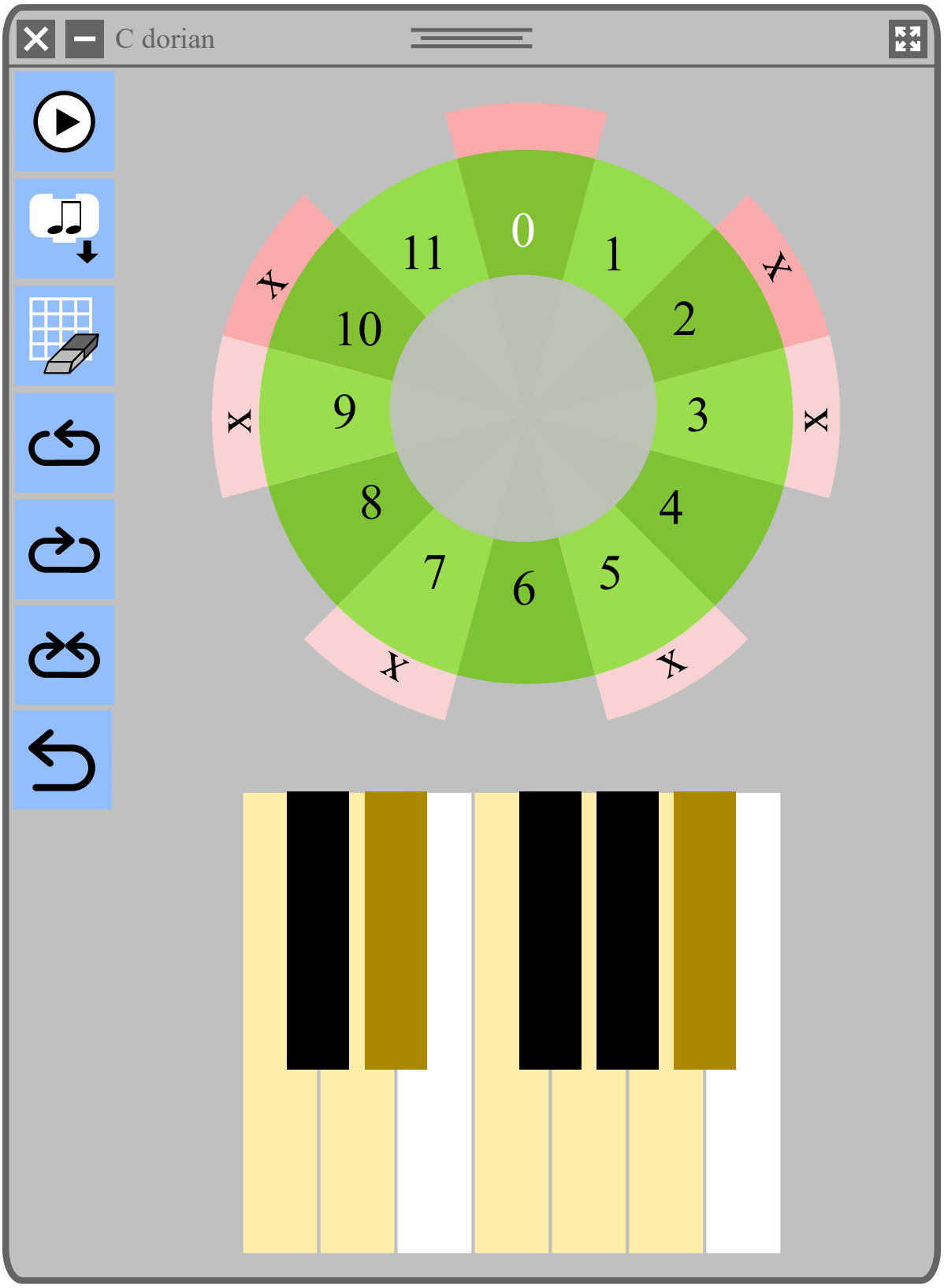
Invert, which will invert the mode (See the example below);

Undo, which will restore the mode to the previous version; and

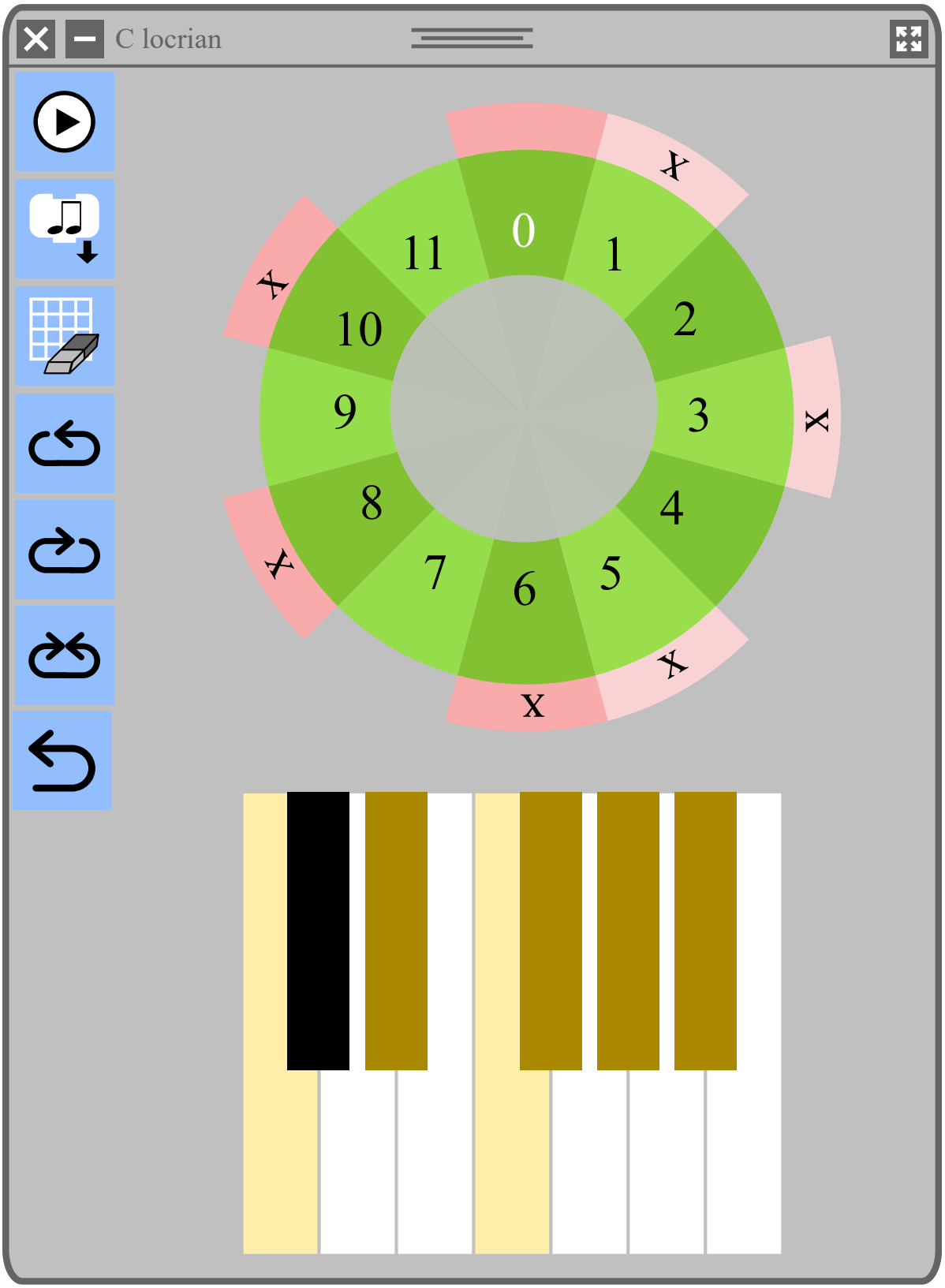
Close, which will close the widget.

You can also click on individual notes to activate or deactivate them.

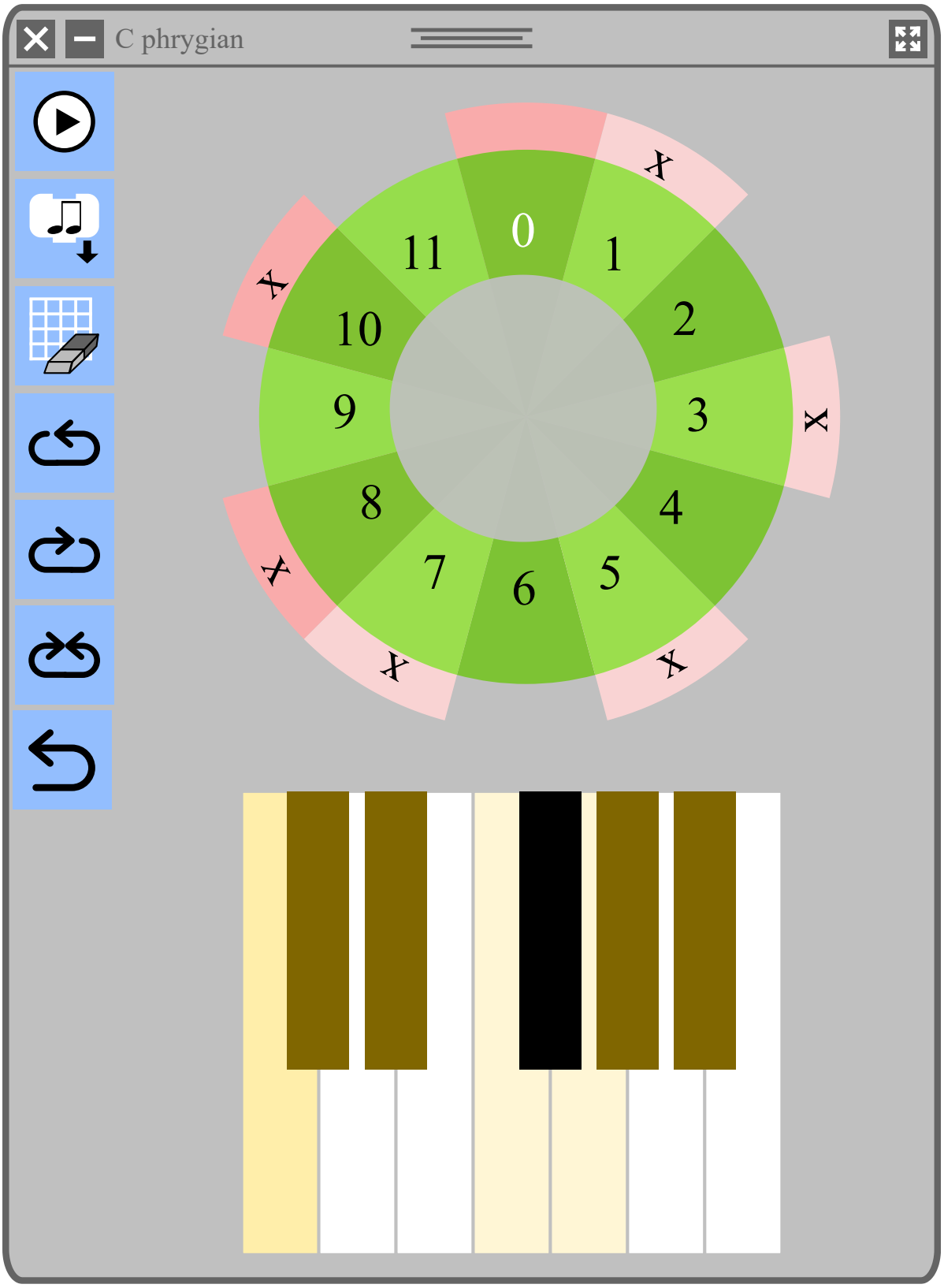
Note that the mode inside the *Custom mode* block is updated whenever the mode is changed inside the widget.



In the above example, the *Major* mode has been rotated counter-clockwise, transforming it into *Dorian*.

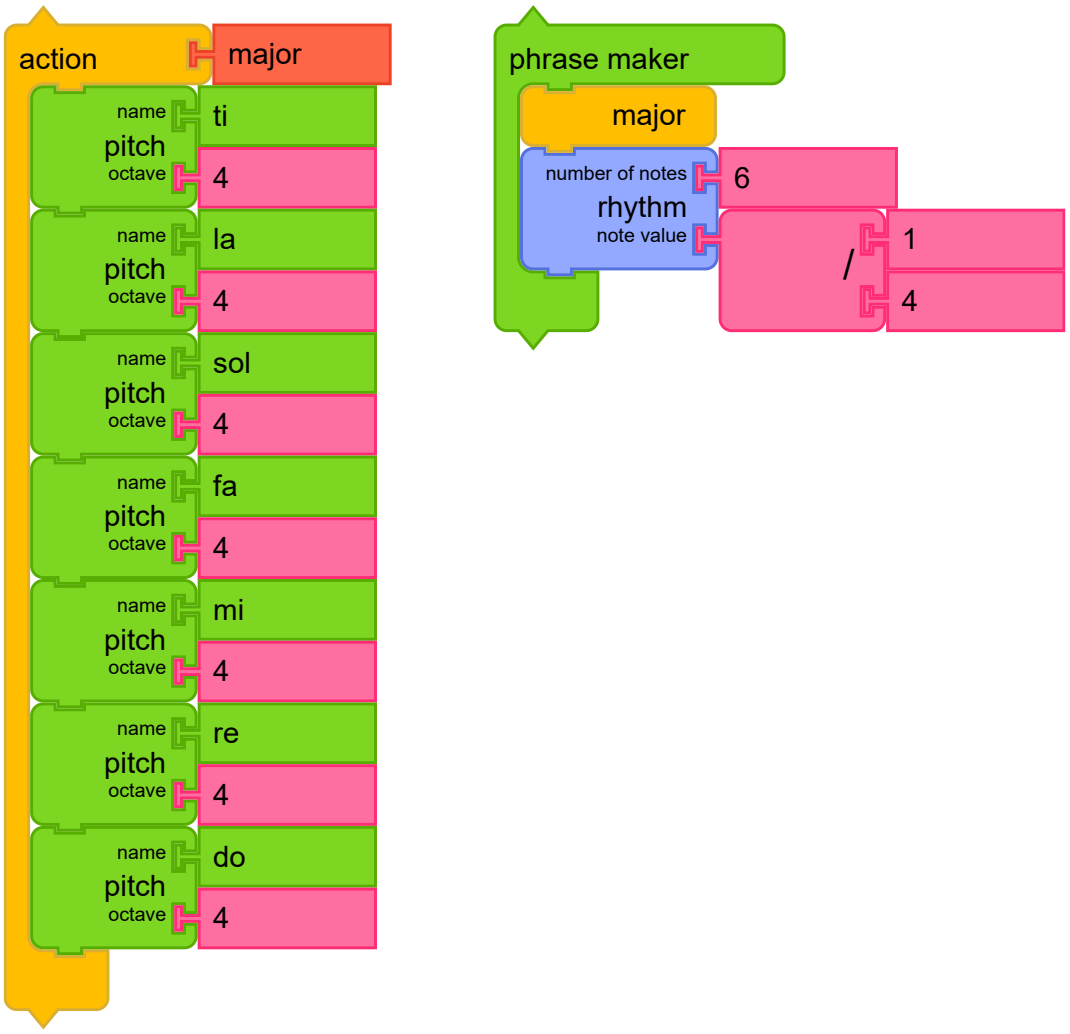


In the above example, the *Major* mode has been rotated clockwise, transforming it into *Locrian*.



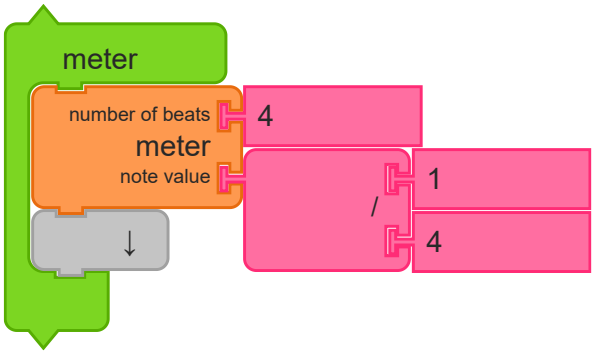
In the above example, the *Major* mode has been inverted, transforming it into *Phrygian*.

Note: The build-in modes in Music Blocks can be found in musicutils.js (https://github.com/sugarlabs/musicblocks/blob/master/js/utils/musicutils.js#L68).

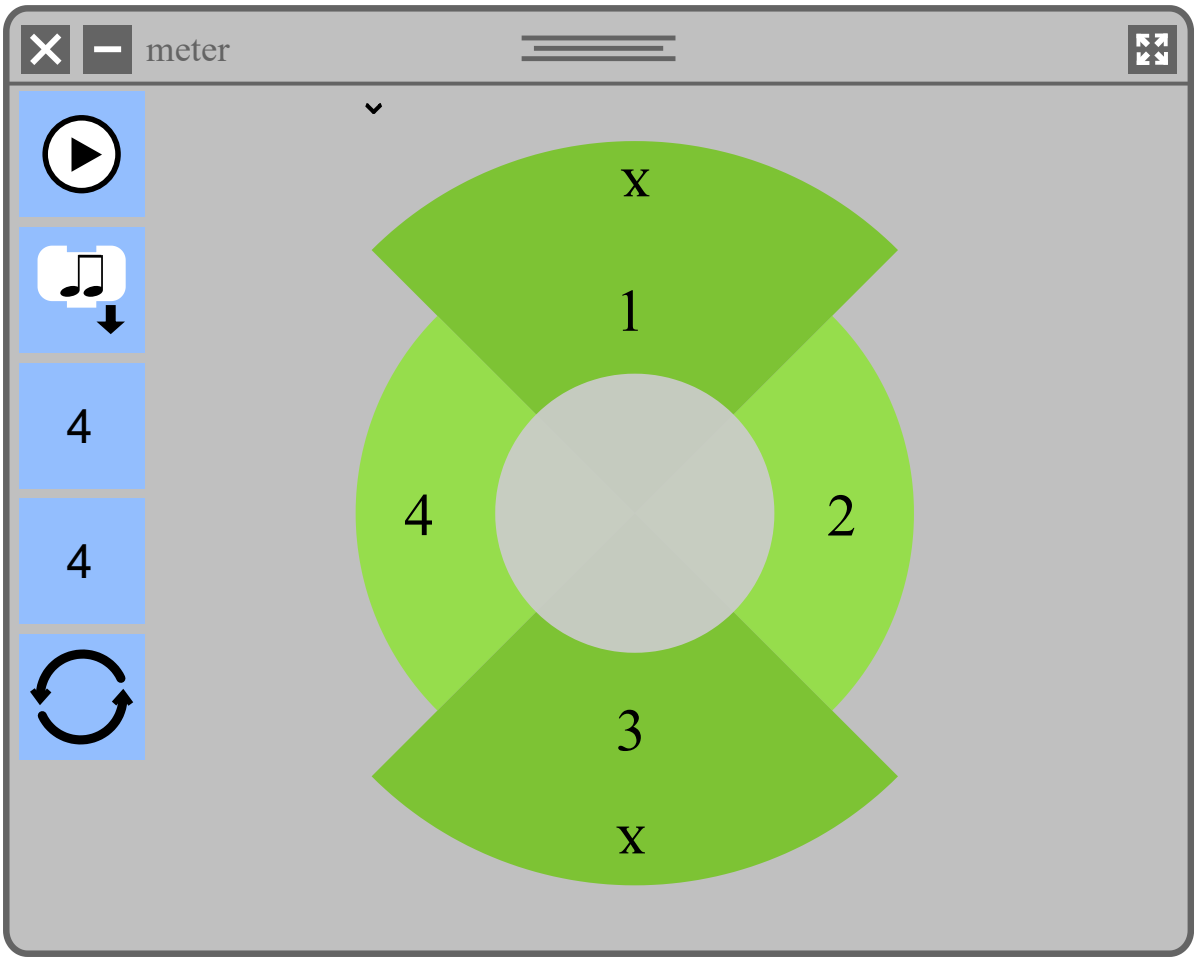


The *Save* button exports a stack of blocks representing the mode that can be used inside the *Phrase maker* block.

4.5 Meters

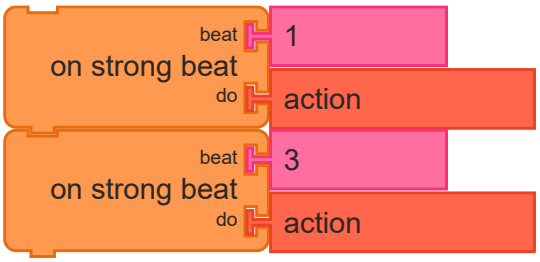


The *Meter Widget* block is used to explore strong and weak beats. Launch the widget with the meter you want to explore. (In the example, the meter is 4 beats per measure, where each beat is one quarter note.)



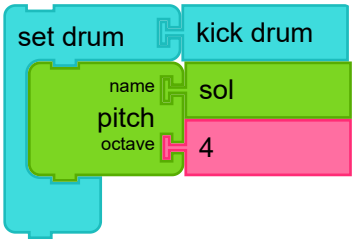
Inside the widget, you can click on a sector to indicate a strong beat. (Clicking on the *X* will revert the beat to a weak beat.) In the figure, the first and third beats are strong.

The *Play* button will play the beat, using a snare drum for strong beats and a kick drum for weak beats.

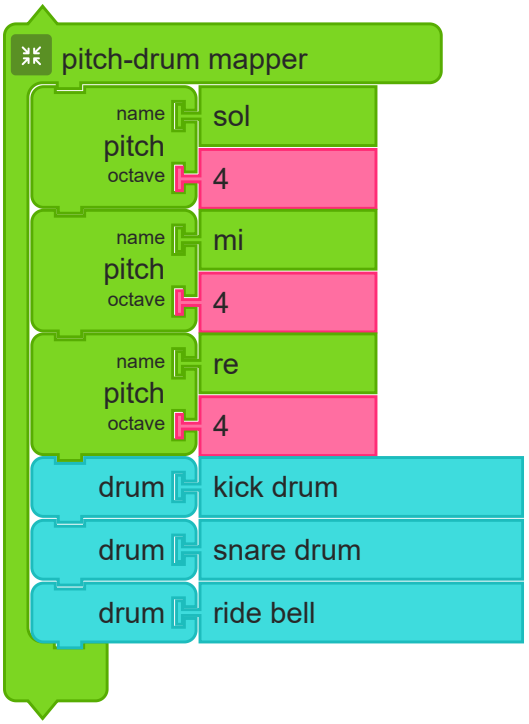


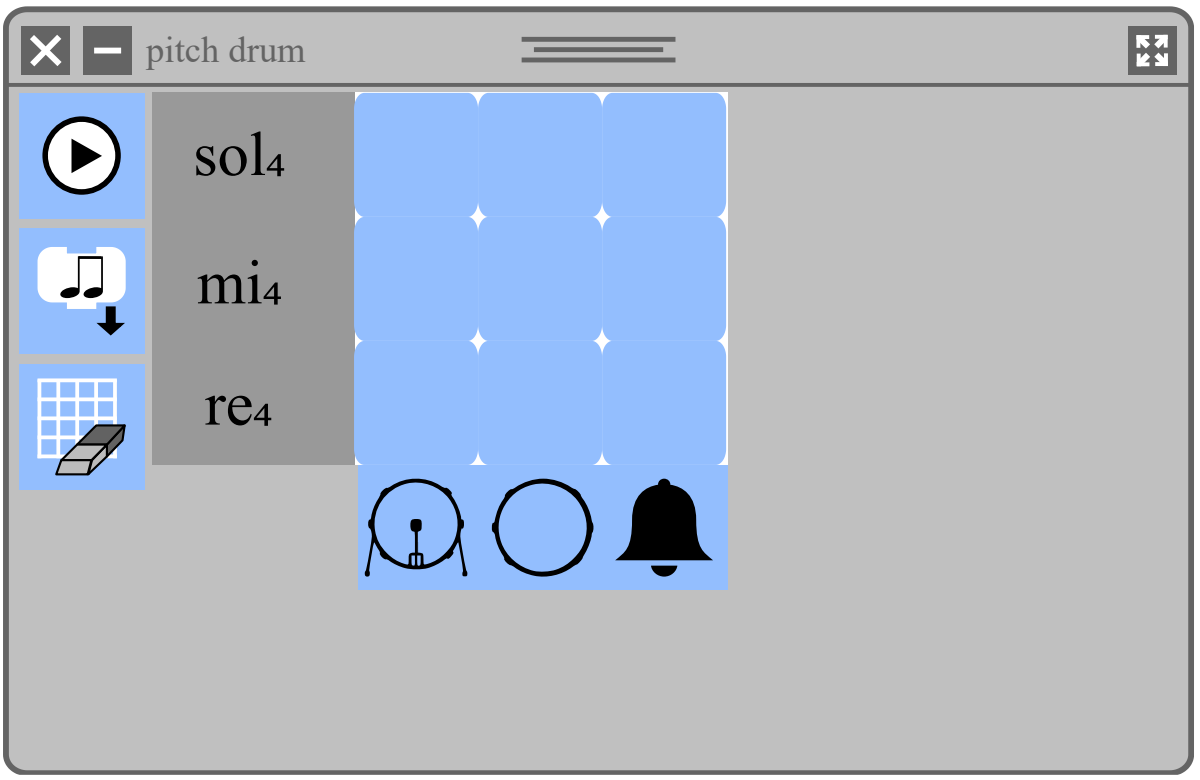
The *Save* button will export *On strong beat do* blocks for each strong beat.

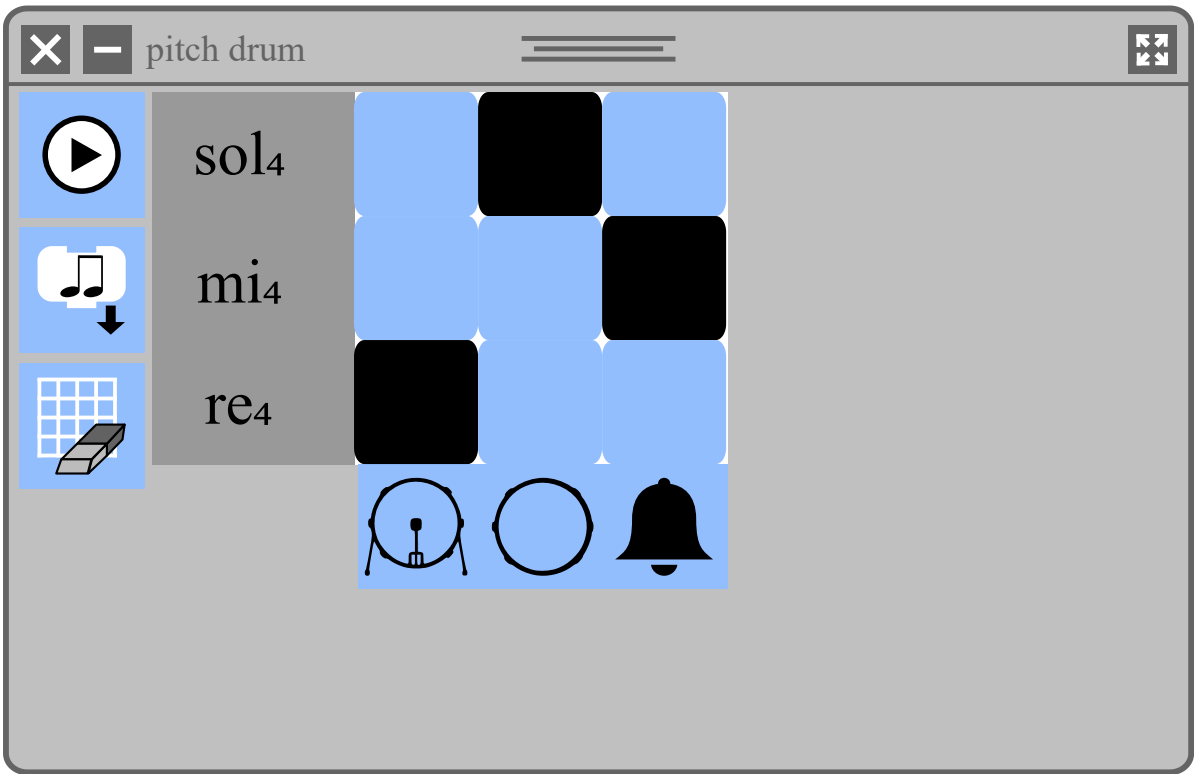
4.6 The Pitch-Drum Matrix

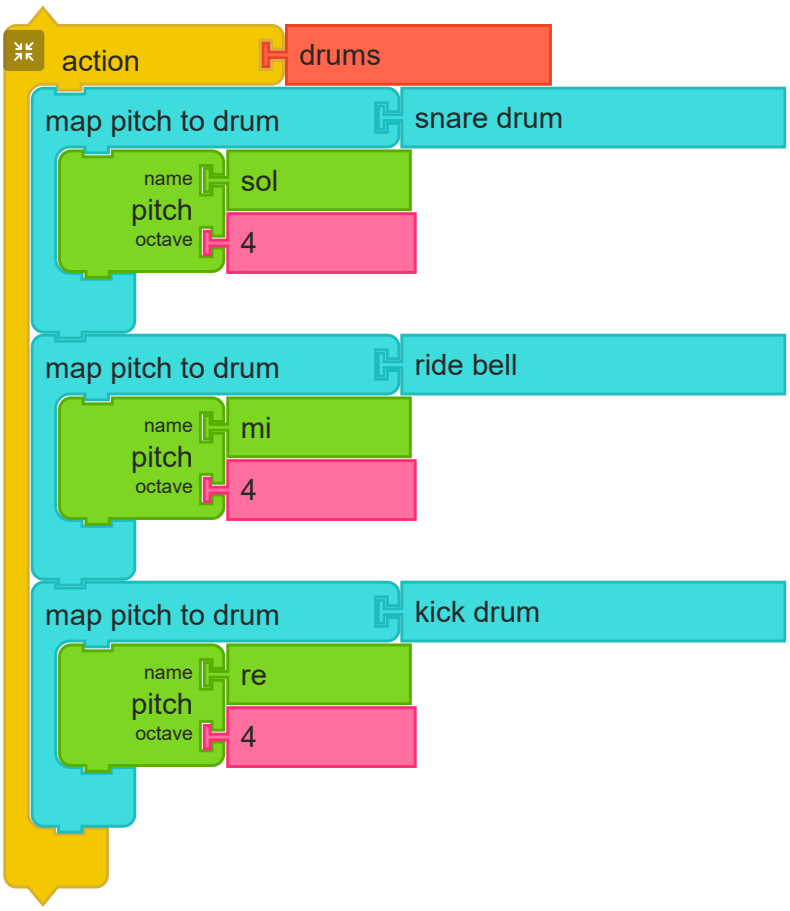


The *Set Drum* block is used to map the enclosed pitches into drum sounds. Drum sounds are played in a monopitch using the specified drum sample. In the example above, a `kick drum` will be substituted for each occurrence of a `Re 4`.




pitch drum
sol4
mi4
re4


pitch drum
sol4
mi4
re4

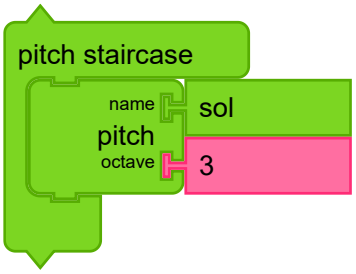


As an experience for creating mapping with the *Set Drum* block, we provide the *Drum-Pitch* Matrix. You use it to map between pitches and drums. The output is a stack of *Set Dum* blocks.

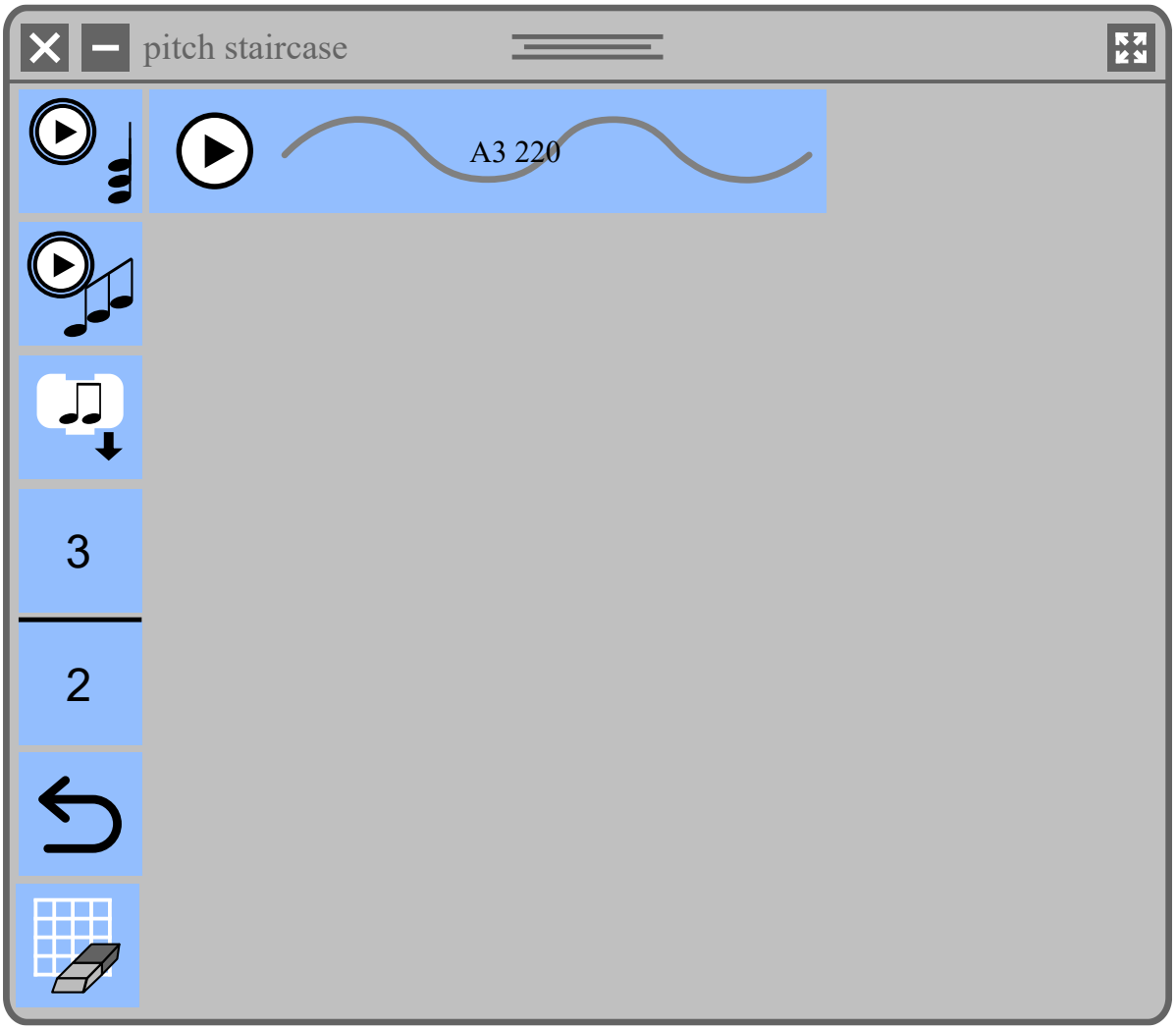
4.7 Exploring Musical Proportions

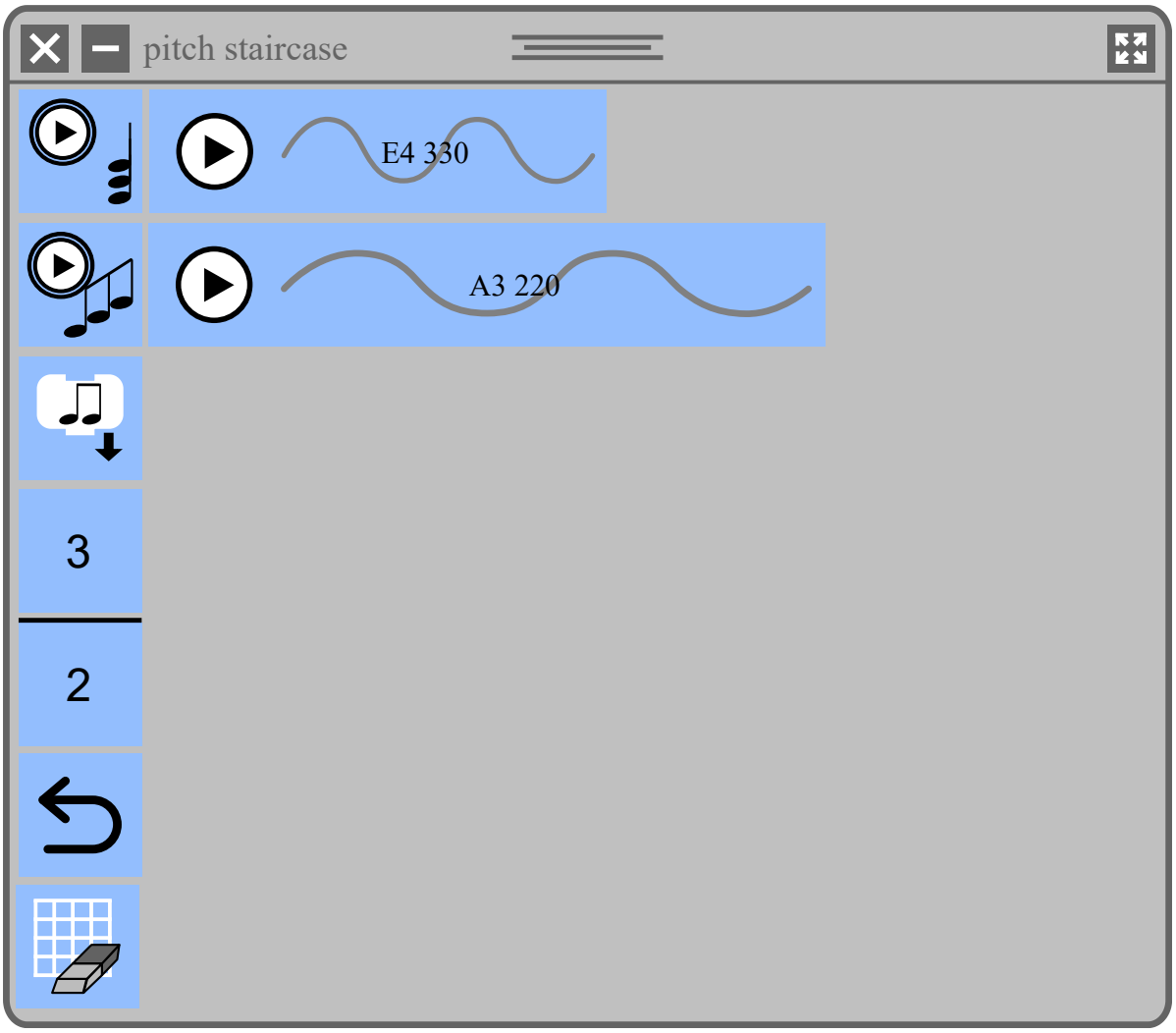
The *Pitch Staircase* block is used to launch a widget similar to the *Phrase maker*, which can be used to generate different pitches using a given pitch and musical proportion.

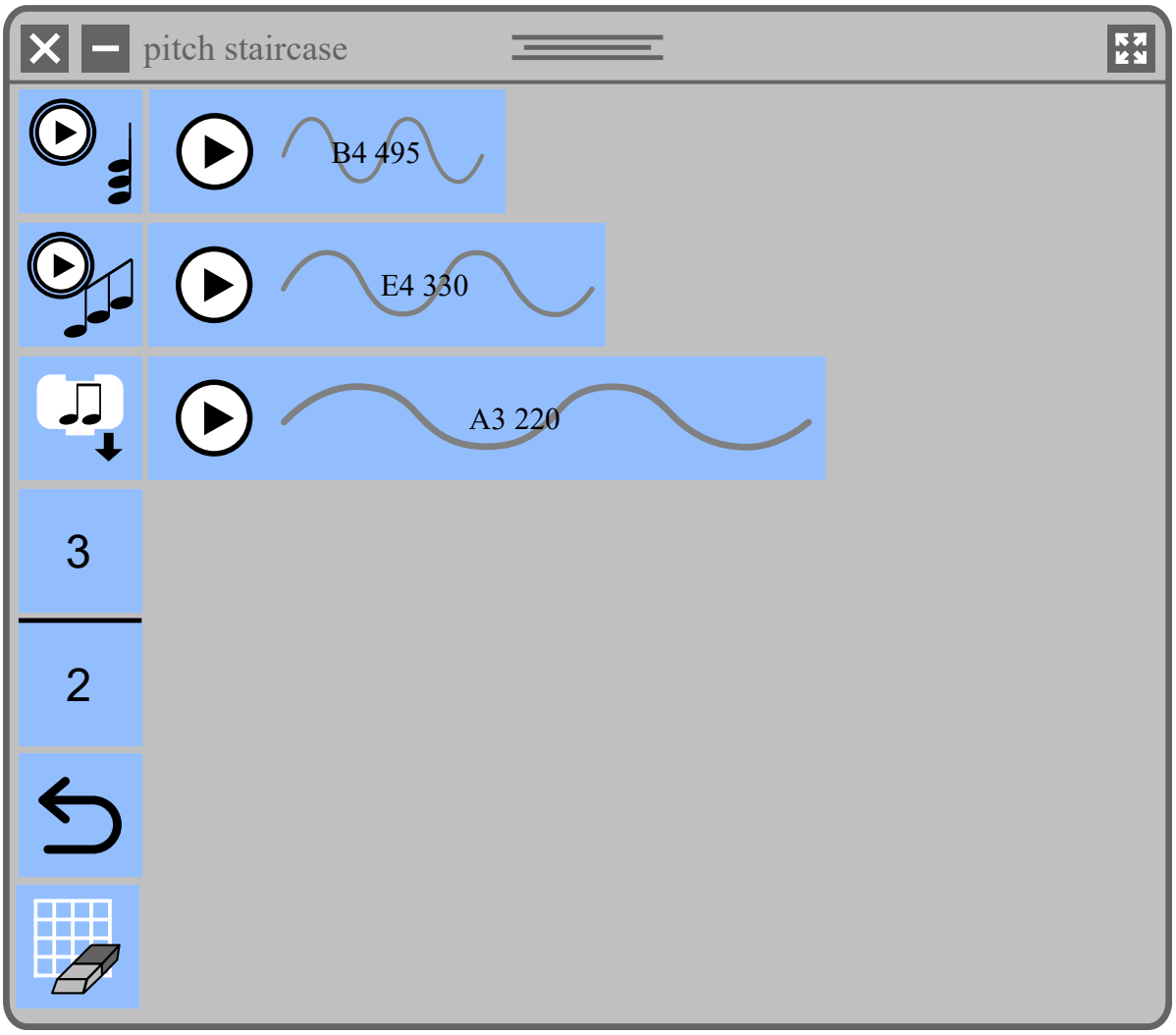
The *Pitch* blocks contained in the clamp of the *Pitch Staircase* block define the pitches to be initialized simultaneously. By default, one pitch is defined and it have default note "la" and octave "3".



When *Pitch Staircase* block is clicked, the *Pitch Staircase* widget is initialized. The widget contains row for every *Pitch* block contained in the clamp of the *Pitch Staircase* block. The input fields in the top row of the widget specify the musical proportions used to create new pitches in the staircase. The inputs correspond to the numerator and denominator in the proportion respectively. By default the proportion is 3:2.

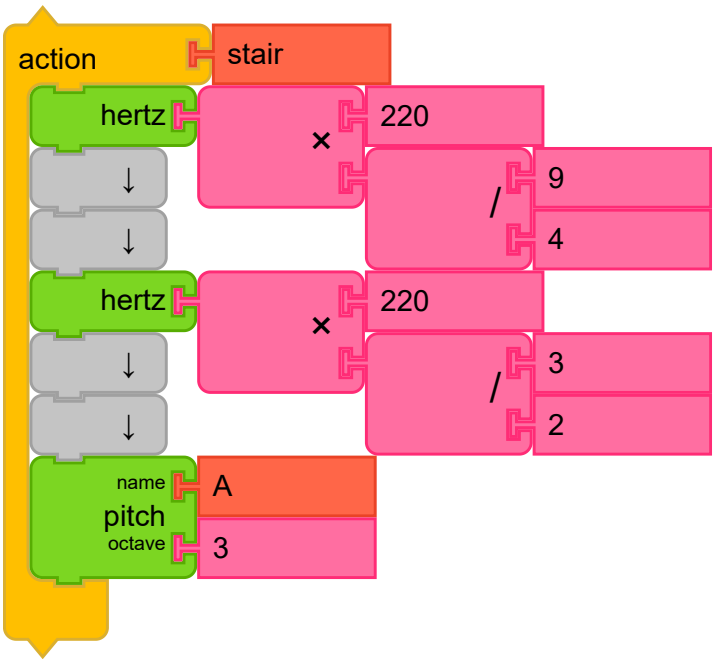



pitch staircase
E4 330
A3 220
3
2

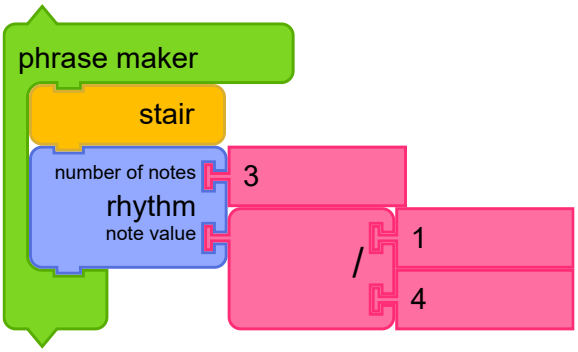


Clicking on the *Play* button to the left of each row will playback the notes associated with that step in the stairs. The *Play-all* button on the upper-left of the widget will play back all the pitch steps simultaneously. A second *Play-all* button to the right of the stair plays in increasing order of frequency first, then in decreasing order of frequency as well, completing a scale.

The *Save stack* button will export pitch stacks. For example, in the above configuration, the output from pressing the *Save stack* button is shown below:



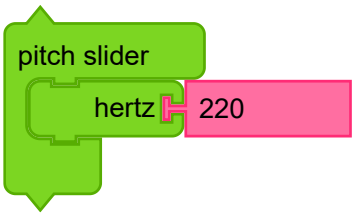
These stacks can be used with the *Phrase maker* block to define the rows in the matrix.

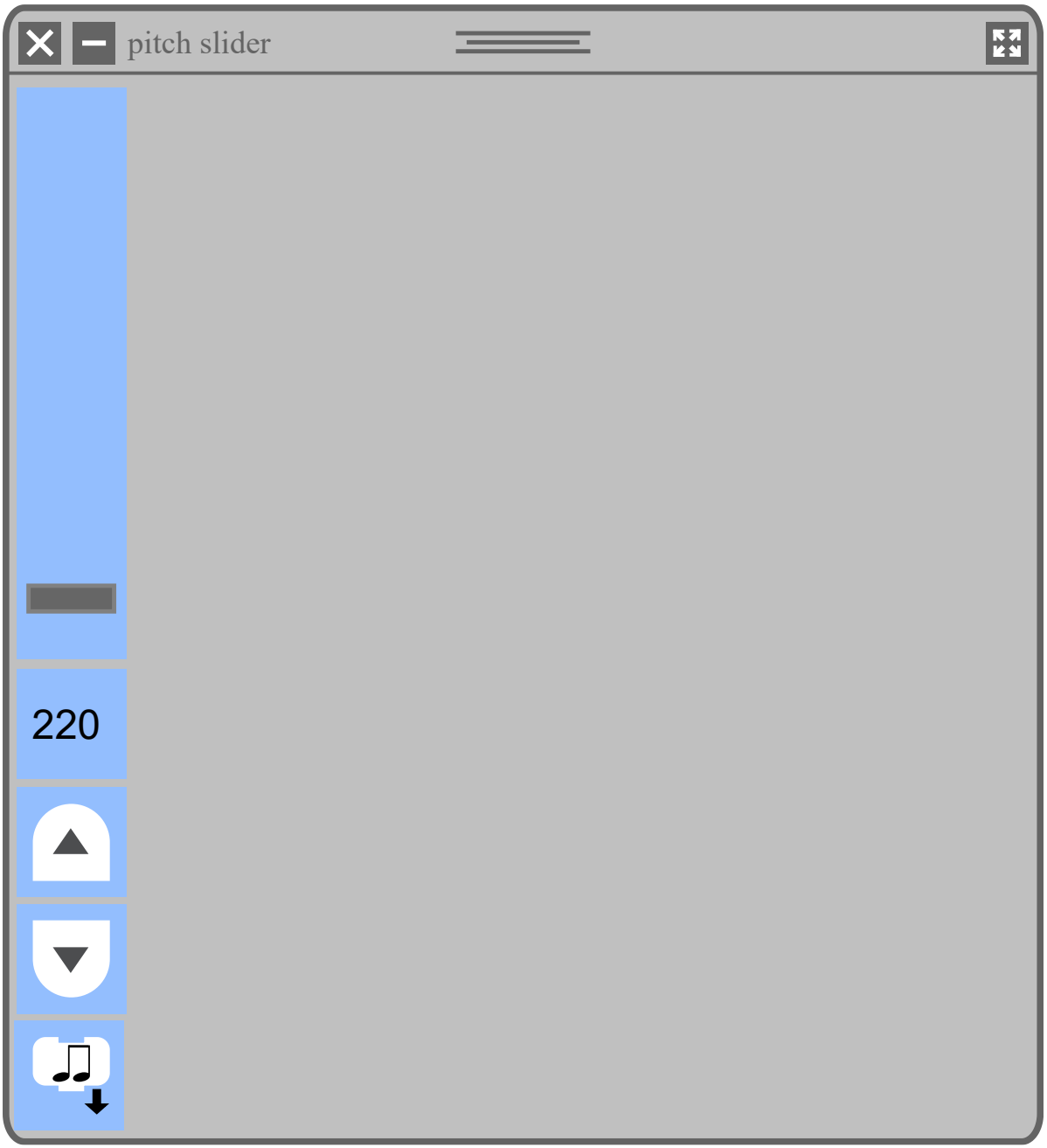


4.8 Generating Arbitrary Pitches

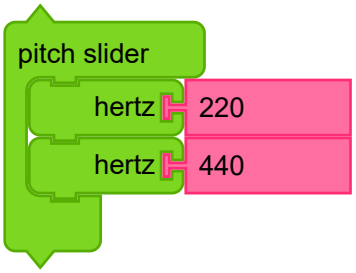
The *Pitch Slider* block is used to launch a widget that is used to generate arbitrary pitches. It differs from the *Pitch Staircase* widget in that it is used to create frequencies that vary continuously within the range of a specified octave.

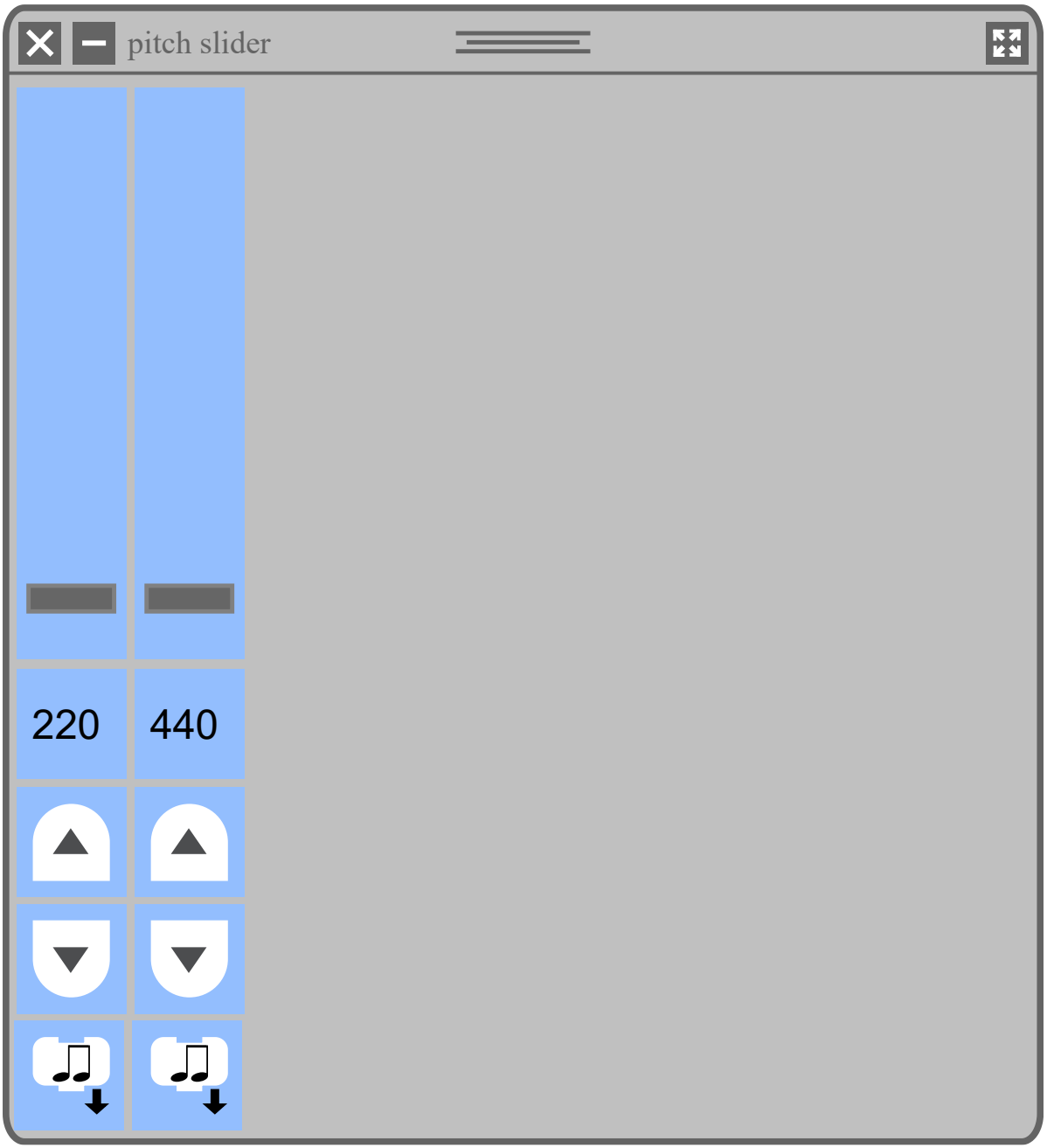
Each *Sine* block contained within the clamp of the *Pitch Slider* block defines the initial pitch for an octave.



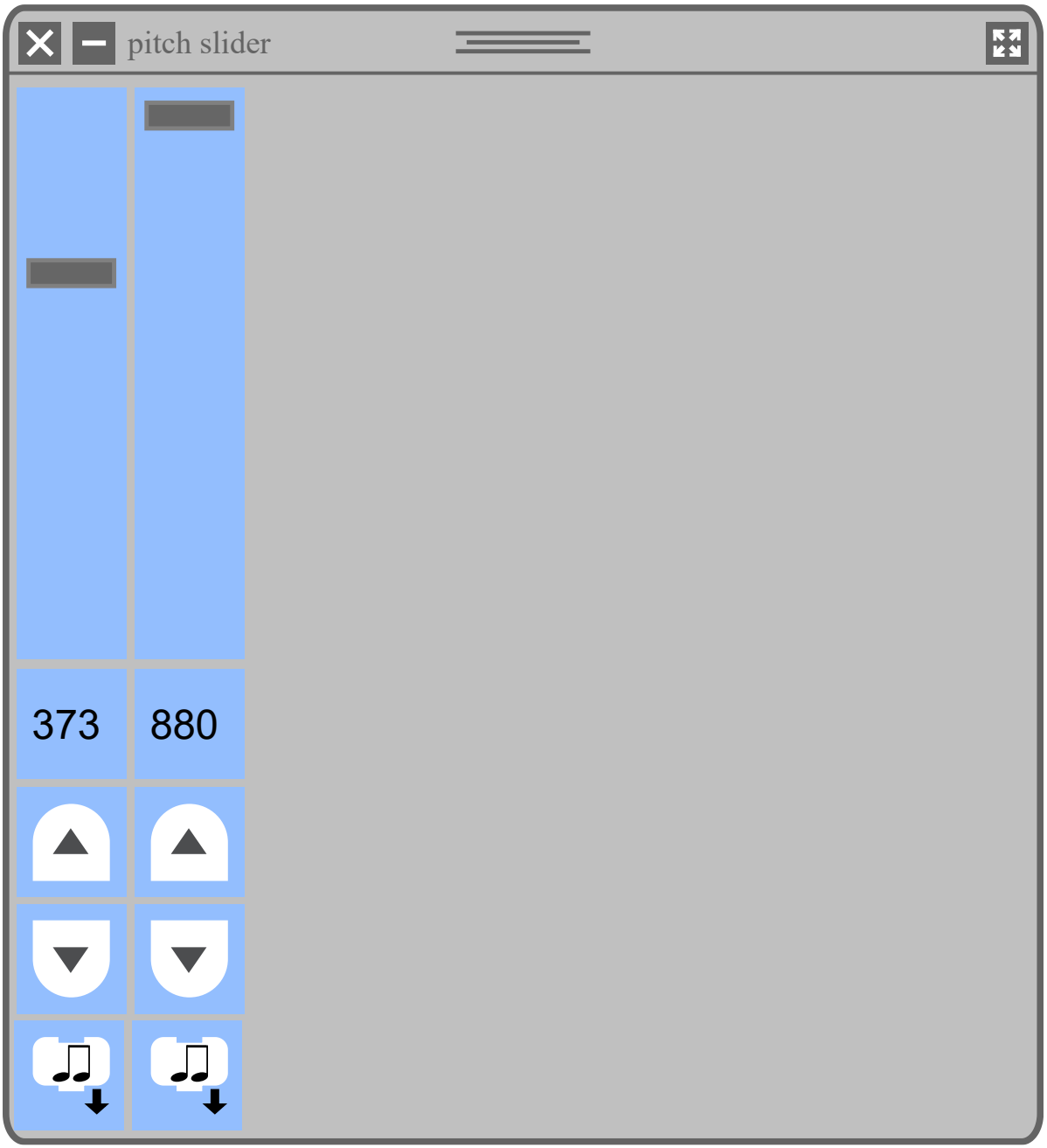


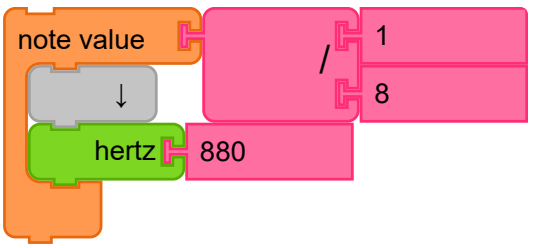
When the *Pitch Slider* block is clicked, the *Pitch Slider* widget is initialized. The widget will have one column for each *Sine* block in the clamp. Every column has a slider that can be used to move up or down in frequency, continuously or in intervals of 1/12th of the starting frequency. The mouse is used to move the frequency up and down continuously. Buttons are used for intervals. Arrow keys can also be used to move up and down, or between columns.

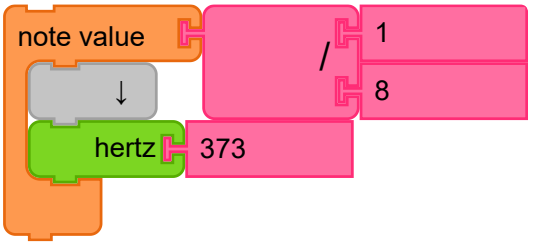




Clicking in a column will extract the corresponding *Note* blocks, for example:


pitch slider
373
880

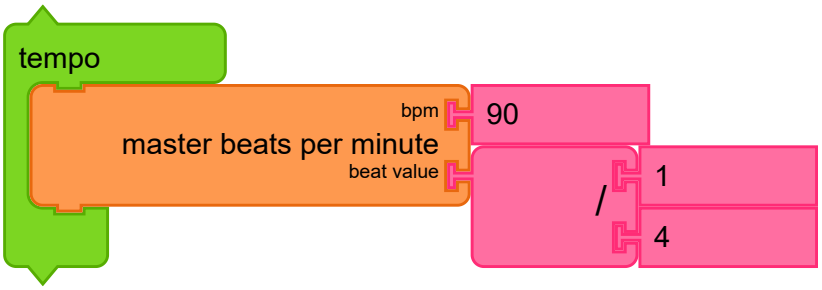

note value
/
1
8
hertz
880


note value
/
1
8
hertz
373

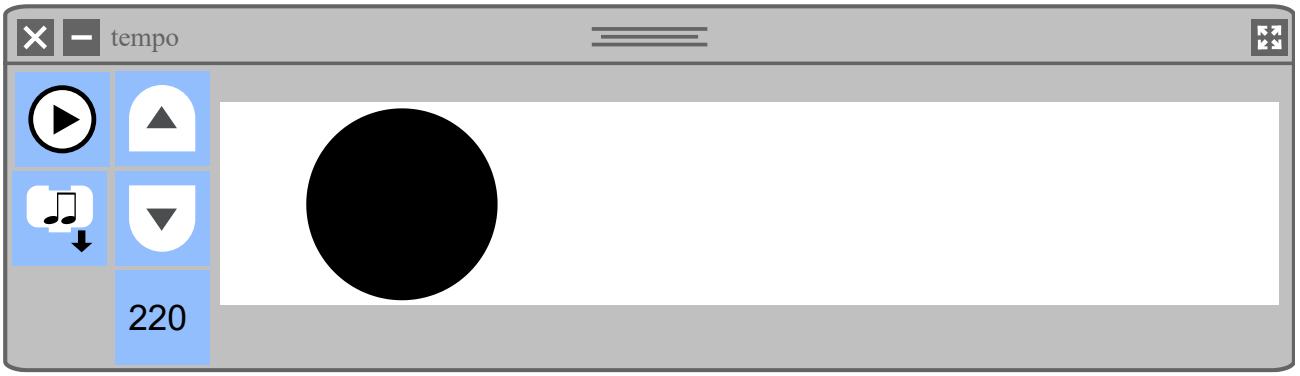
4.9 Changing Tempo

The *Tempo* block is used to launch a widget that enables the user to visualize Tempo, defined in beats per minute (BPM). When the *Tempo* block is clicked, the *Tempo* widget is initialized.

The *Master Beats per Minute* block contained in the clamp of the *Tempo* block sets the initial tempo used by the widget. This determines the speed at which the ball in the widget moves back and forth. If BPM is `60`, then it will take one second for the ball to move across the widget. A round-trip would take two seconds.



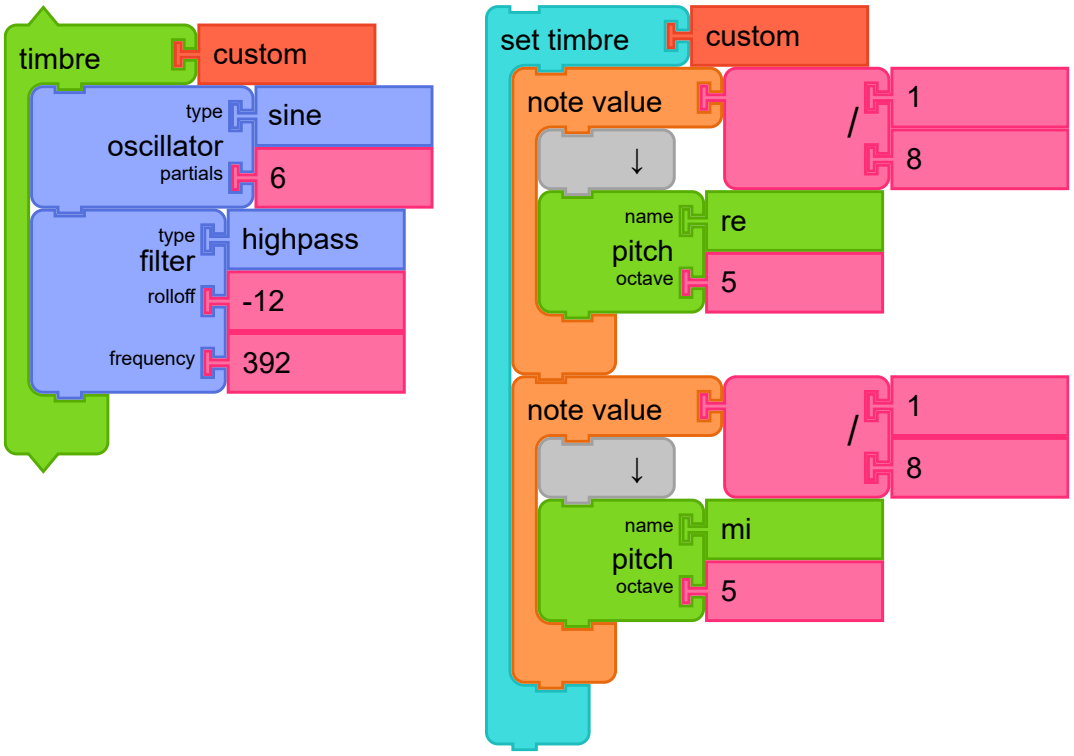
The top row of the widget holds the *Play/pause* button, the *Speed up* and *Slow down* buttons, and an input field for updating the Tempo.



You can also update the tempo by clicking twice in spaced succession in the widget: the new beats per minute (BPM) is determined as the time between the two clicks. For example, if there is `1/2` second between clicks, the new BPM will be set as `120`.

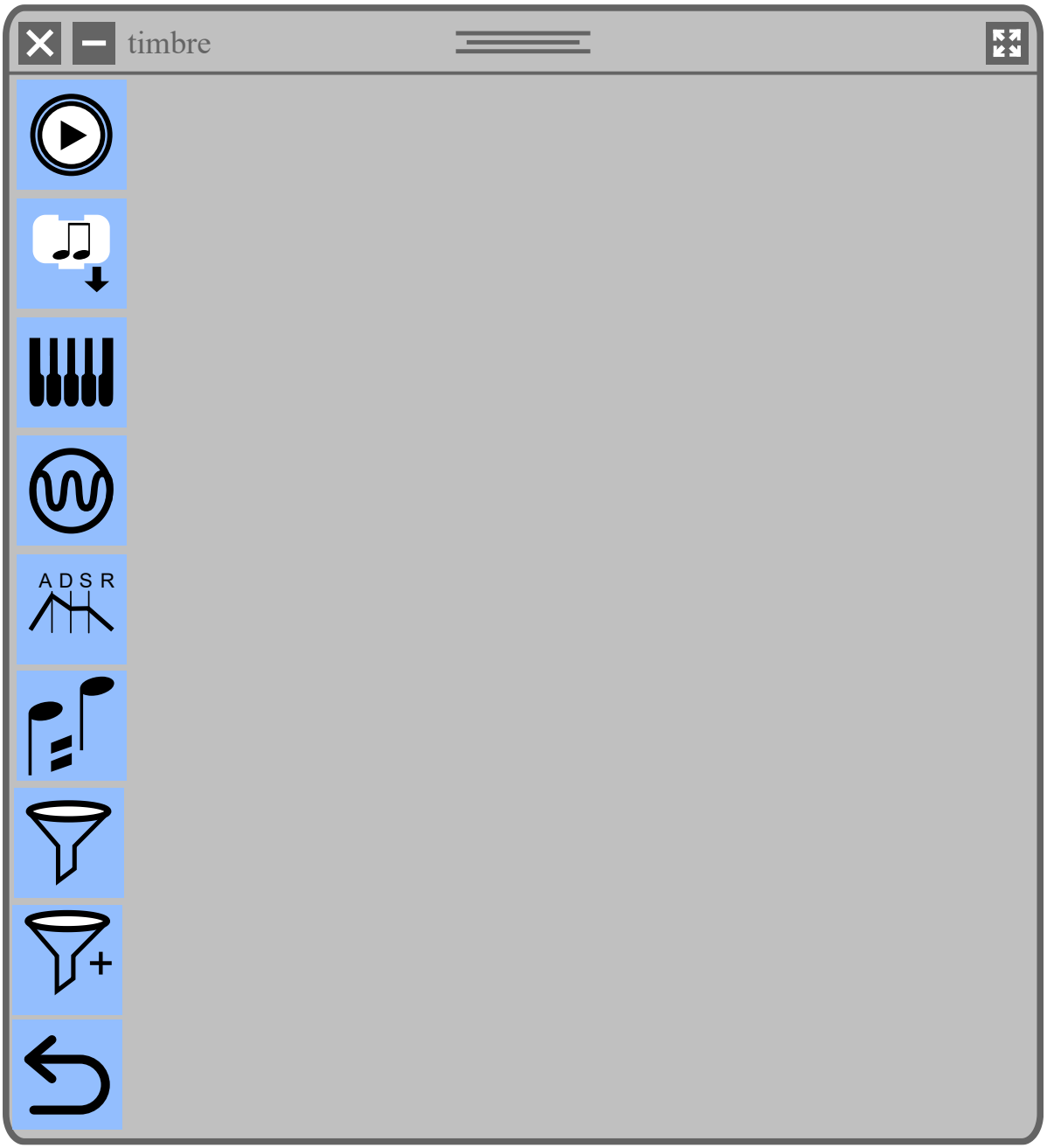
4.10 Custom Timbres

While Music Blocks comes with many built-in instruments, it is also possible to create custom timbres with unique sound qualities.



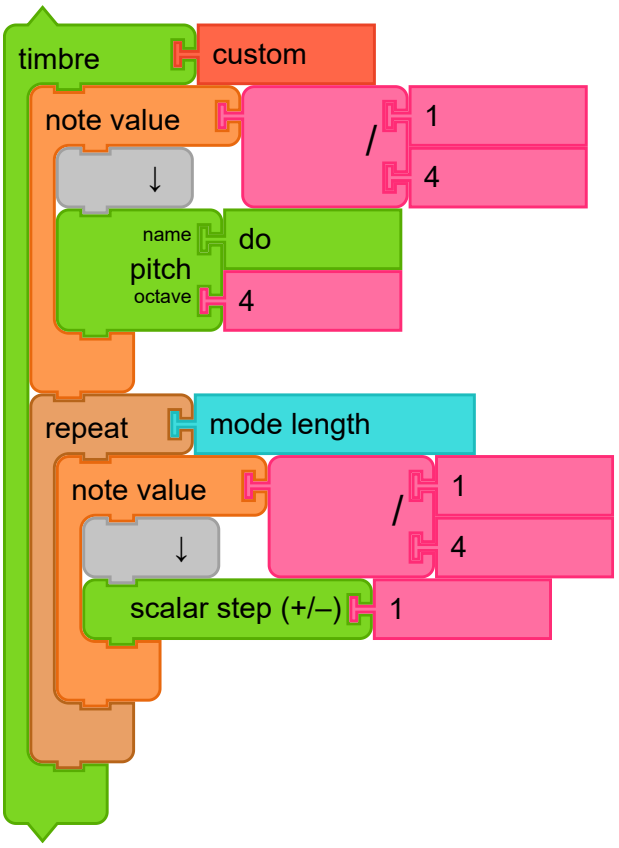
The *Timbre* block can be used to launch the *Timbre* widget, which lets you add synthesizers, oscillators, effects, and filters to create a custom timbre, which can be used in your Music Blocks programs.

The name of the custom timbre is defined by the argument passed to the block (by default, `custom`). This name is passed to the *Set timbre* block in order to use your custom timbre.



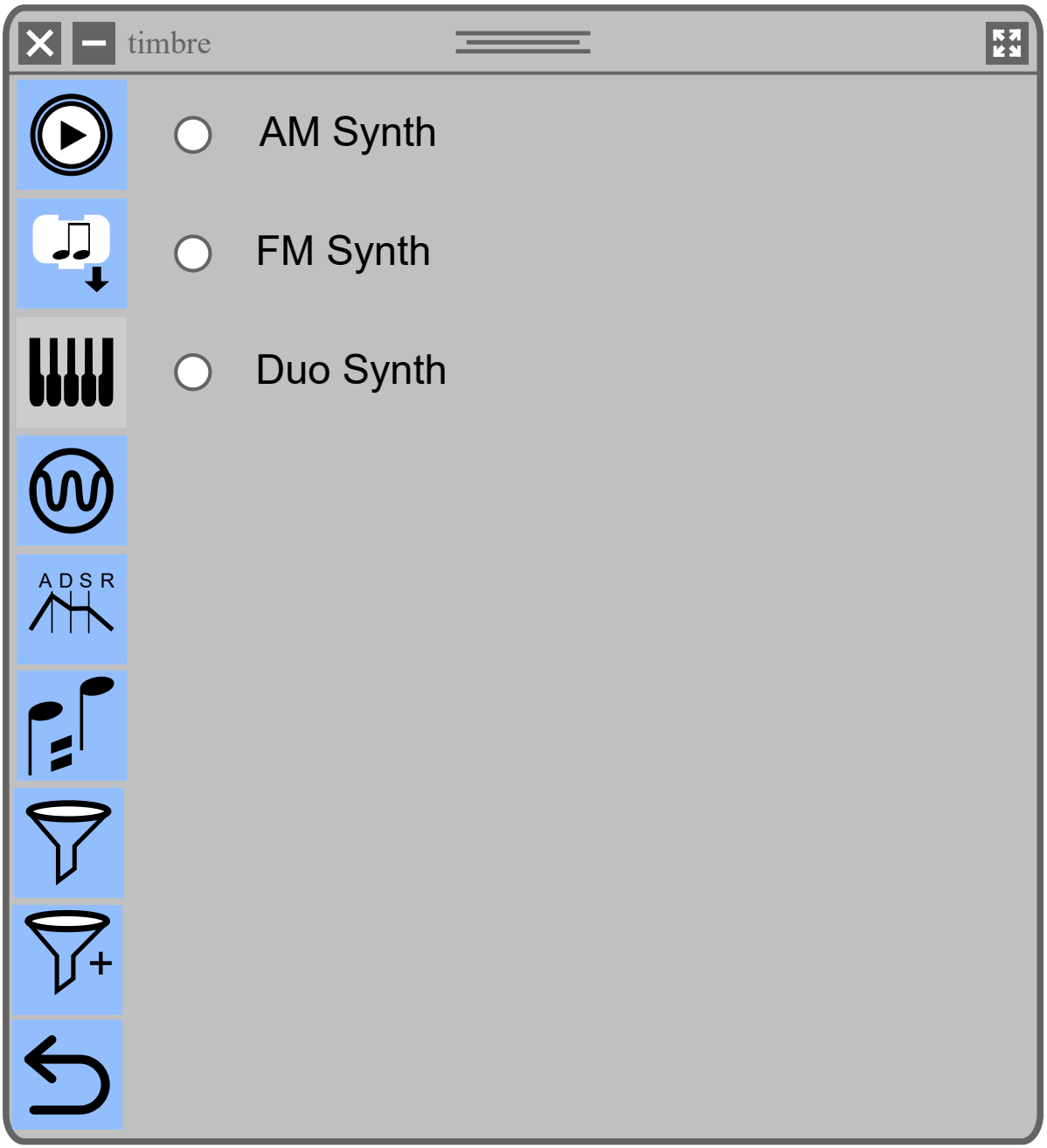
The *Timbre* widget has a number of different panels, each of which is used to set the parameters of the components that define your custom timbre.

7 The *Play* button, which lets you test the sound quality of your custom timbre. By default, it will play `Sol` , `Mi` , `Sol` using the combination of filters you define.

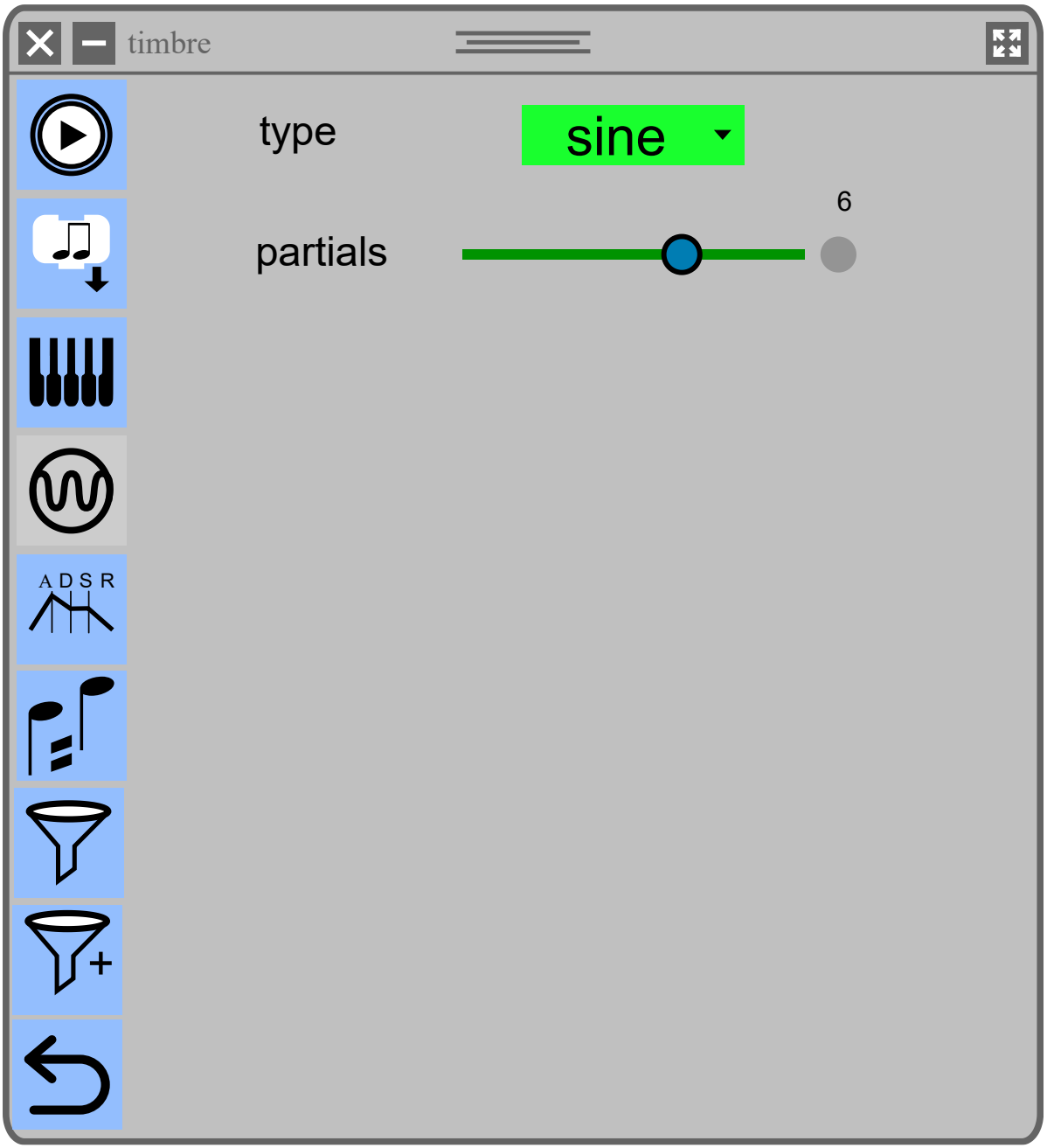


You can also put notes in the *Timbre* block to use for testing your sound. In the example above, a scale will be used for the test.

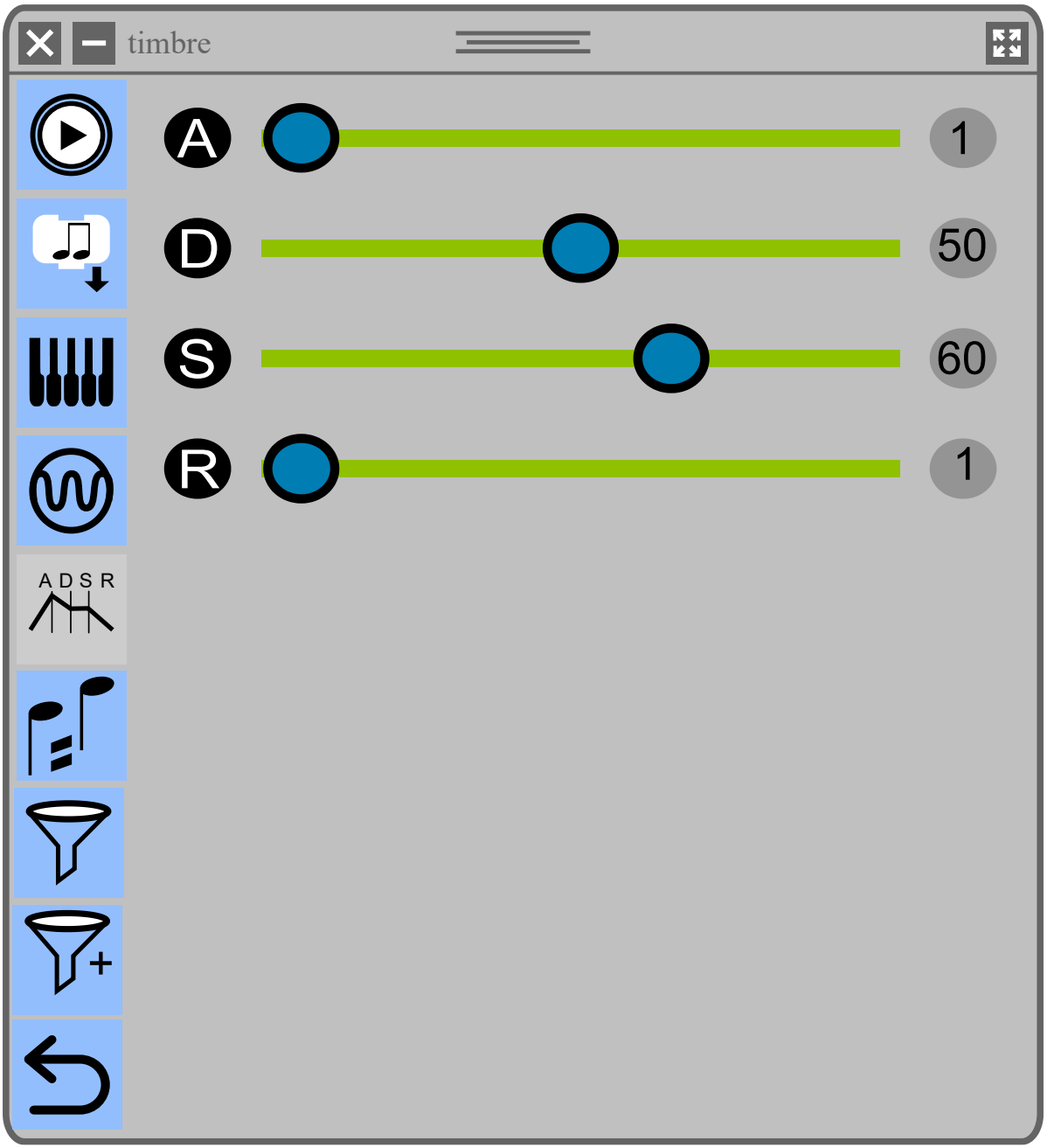
8 The *Save* button, which will save your custom timbre for use in your program.



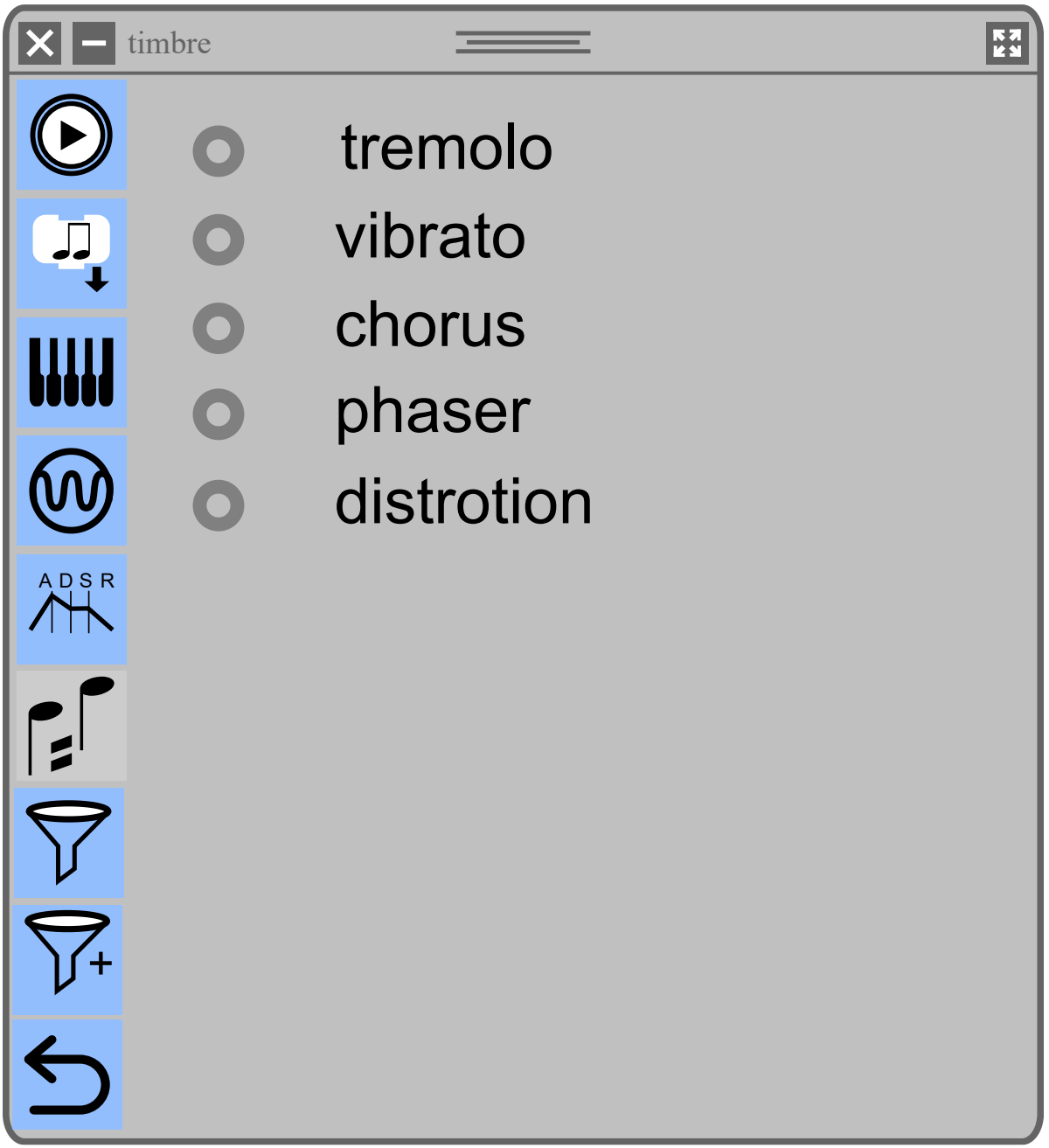
9 The *Synth* button, which lets you choose between an AM synth, a PM synth, or a Duo synth.

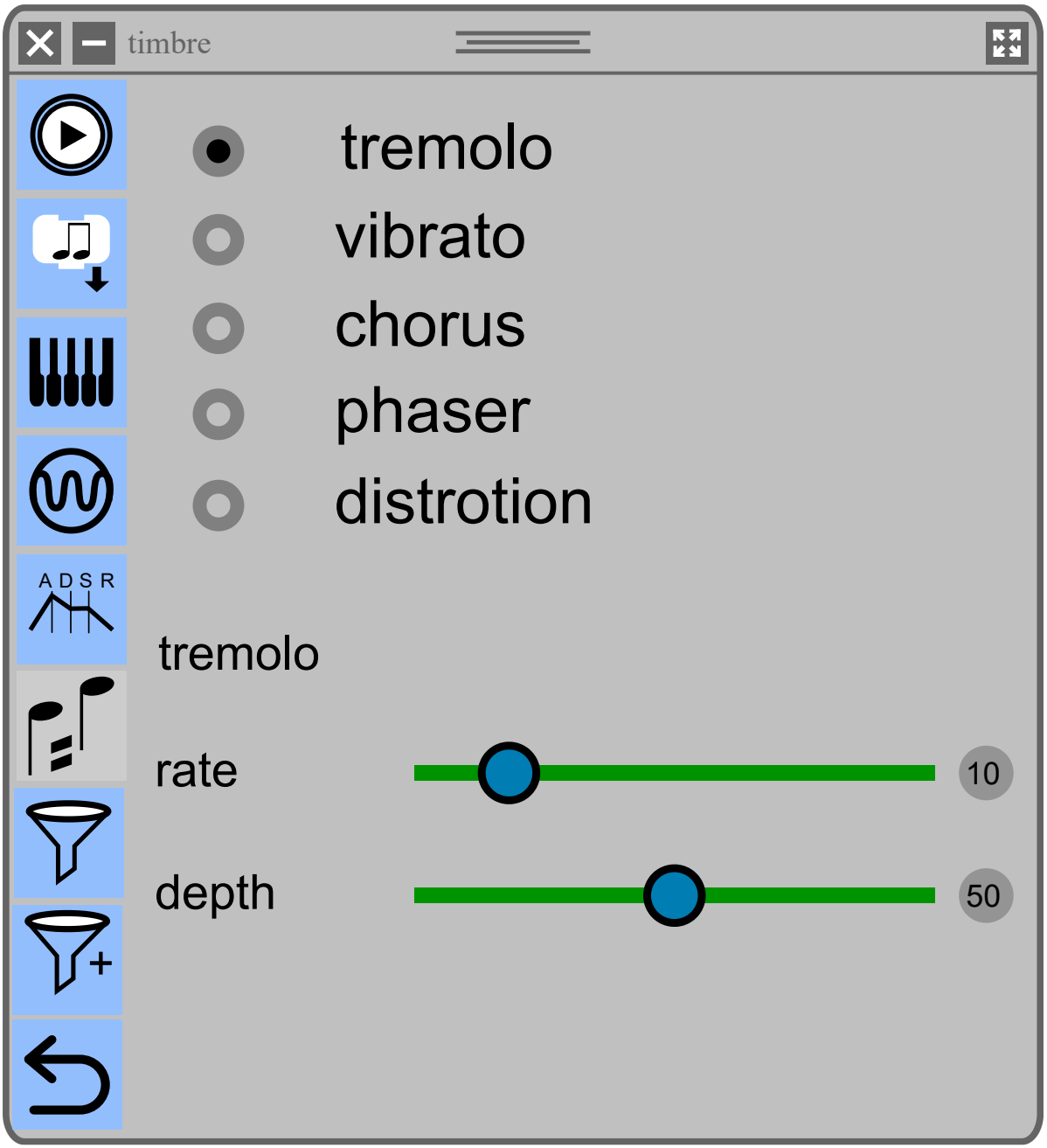


10 The *Oscillator* button, which lets you choose between a sine wave, square wave, triangle wave, or sawtooth wave. You can also change the number of partials.

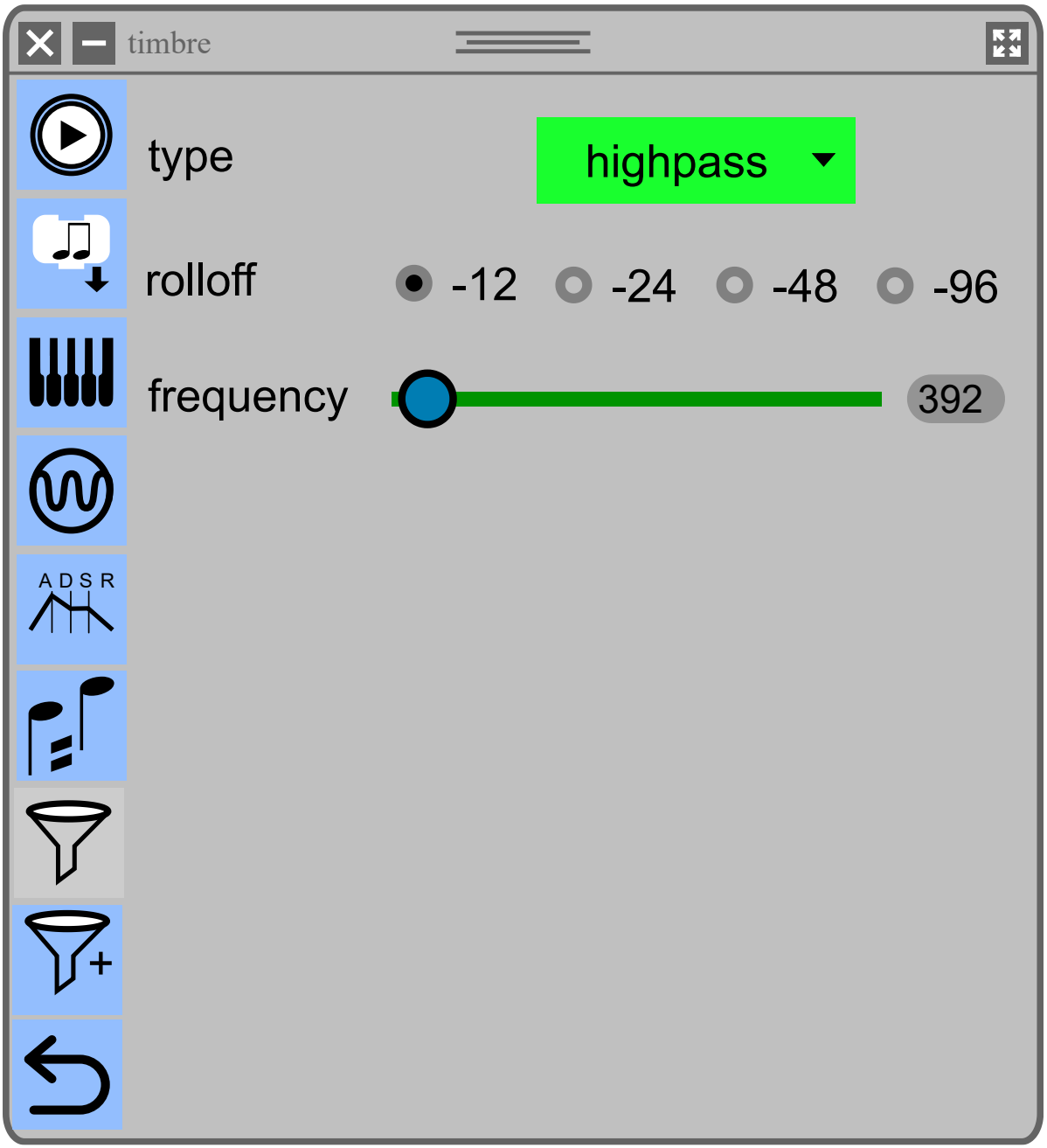


11 The *Envelope* button, which lets you change the shape of the sound envelope, with controls for attack, decay, sustain, and release.


timbre
tremolo
vibrato
chorus
phaser
distrotion
A D S R



12 The *Effects* button, which lets you add effects to your custom timbre: tremelo, vibrato, chorus, phaser, and distortion. When an effect is selected, additional controls will appear in the widget.



13

The *Filter* button, which lets you choose between a number of different filter types.

14

The *Add filter* button, which lets you add addition filters to your custom timbre.

15

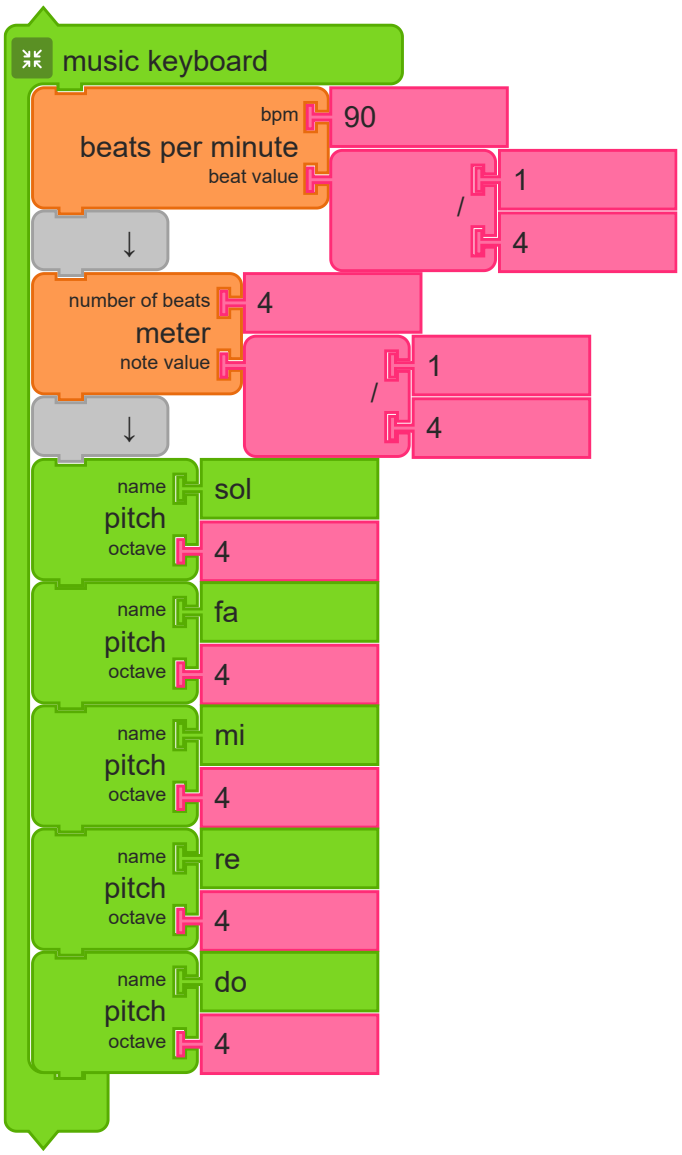
The *Undo* button.

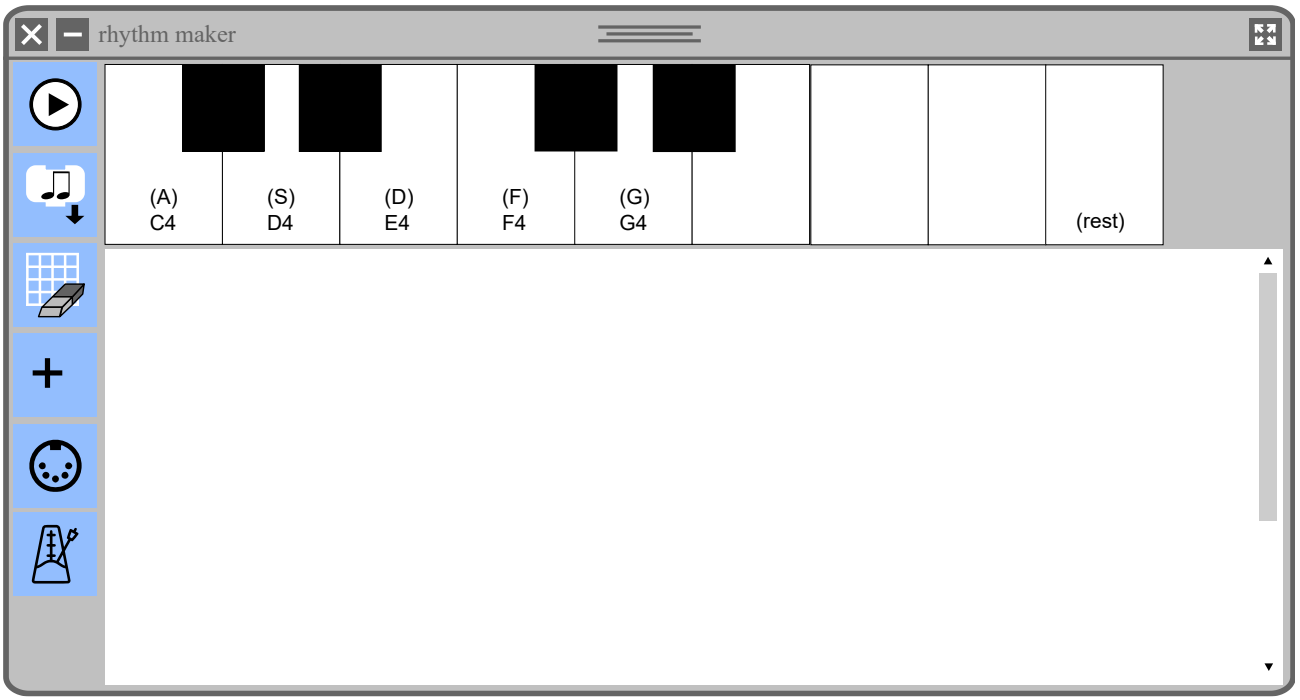
As you add synthesizers, effects, and filters with the widget, blocks corresponding to your choices are added to the *Timbre* block. This lets you reopen the widget to fine-tune your custom timbre.

4.11 The Music Keyboard

The Music Keyboard is used to generate notes by pressing keys of a virtual keyboard.

When there are no *Pitch* blocks inside the widget clamp, a keyboard with all keys between C4 and G5 is created.





When there are *Pitch* blocks inside the widget clamp, a keyboard with only those pitches is created.

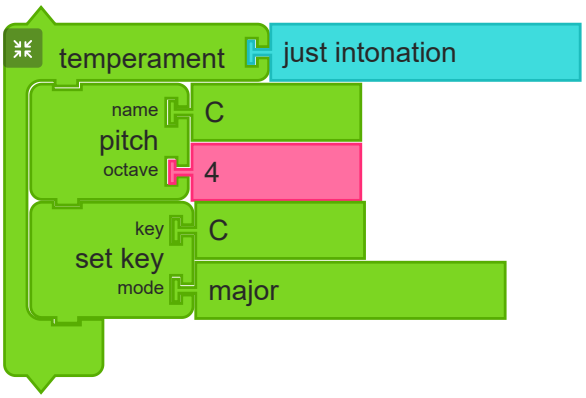
Click on the keys to hear sounds. Click on the Play button to playback all of the notes played. Click on the Save button to output code (a series of *Note* blocks). The Clear button is used to delete all keys pressed previously in order to start new.

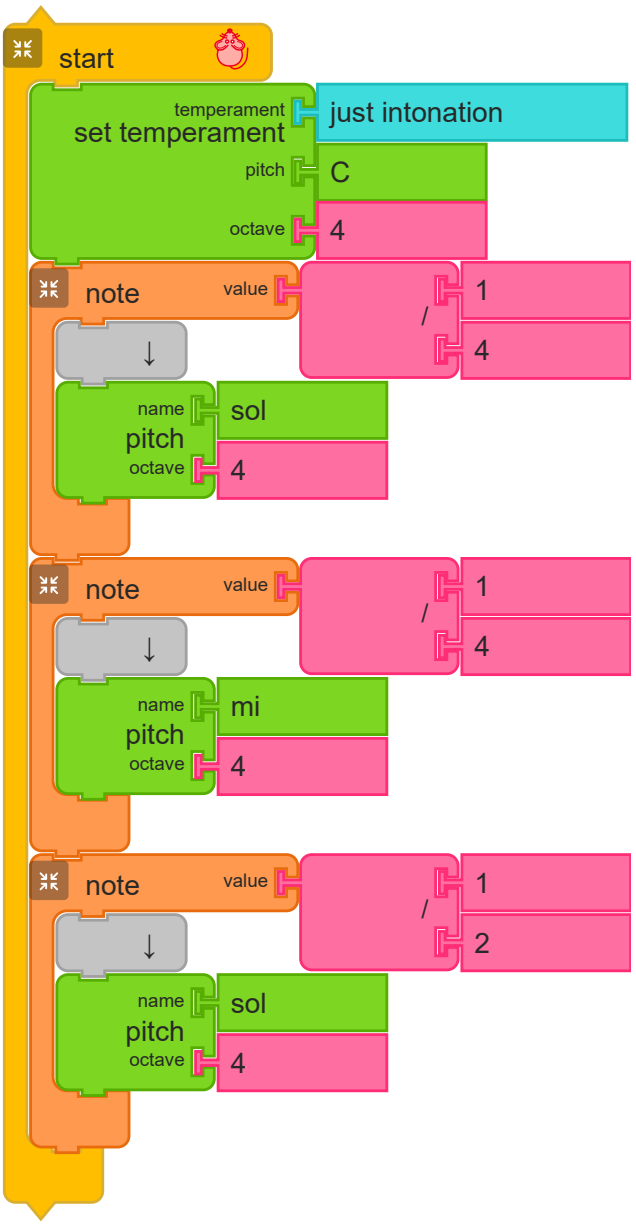
The MIDI input allows for a using a MIDI device to generate notes.

The metronome feature will generate a beat to enable candence.

4.12 Changing Temperament

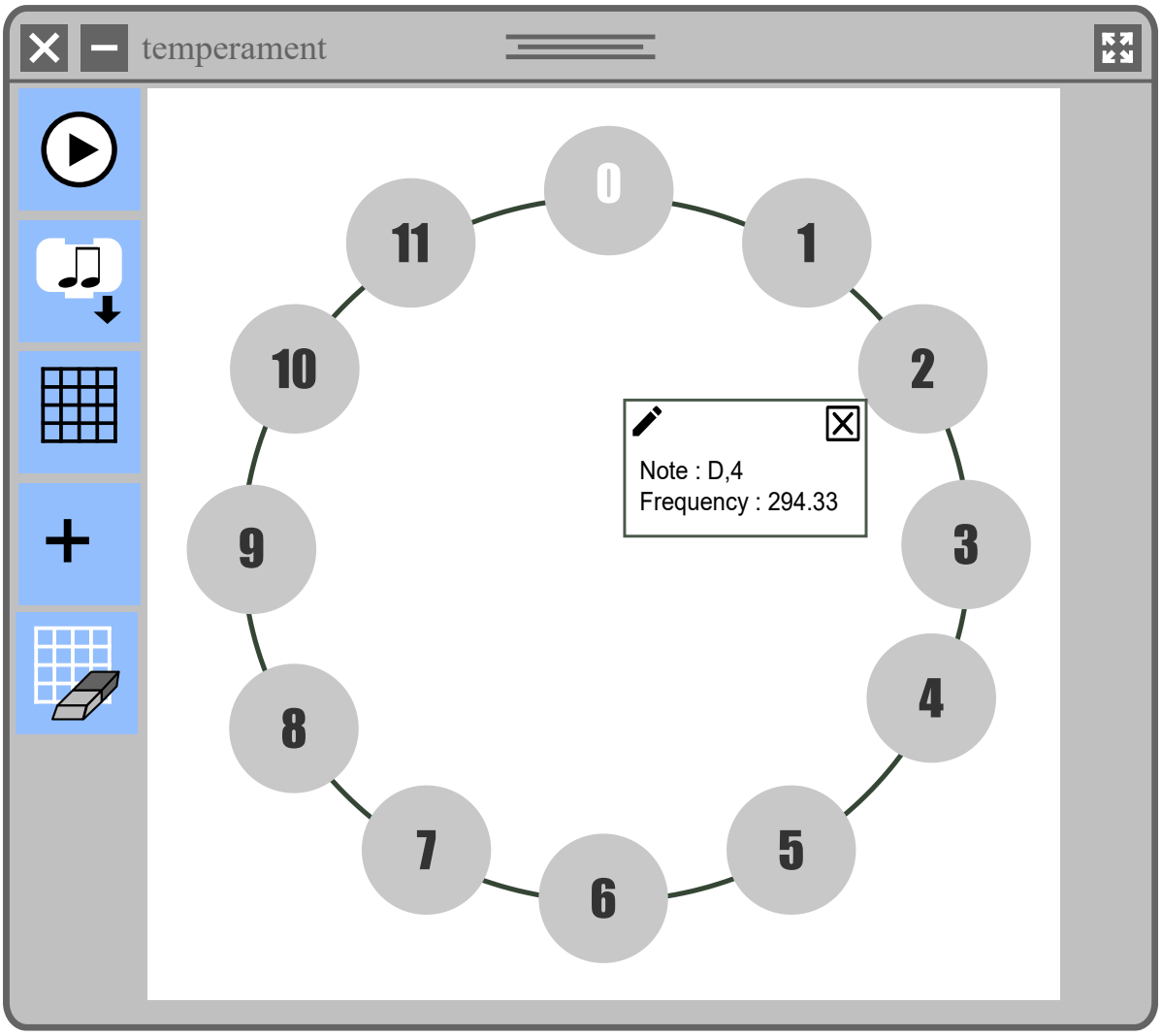
Tempering is the process of altering the size of an interval by making it narrower or wider than pure. It is also possible to change and create different tuning systems.





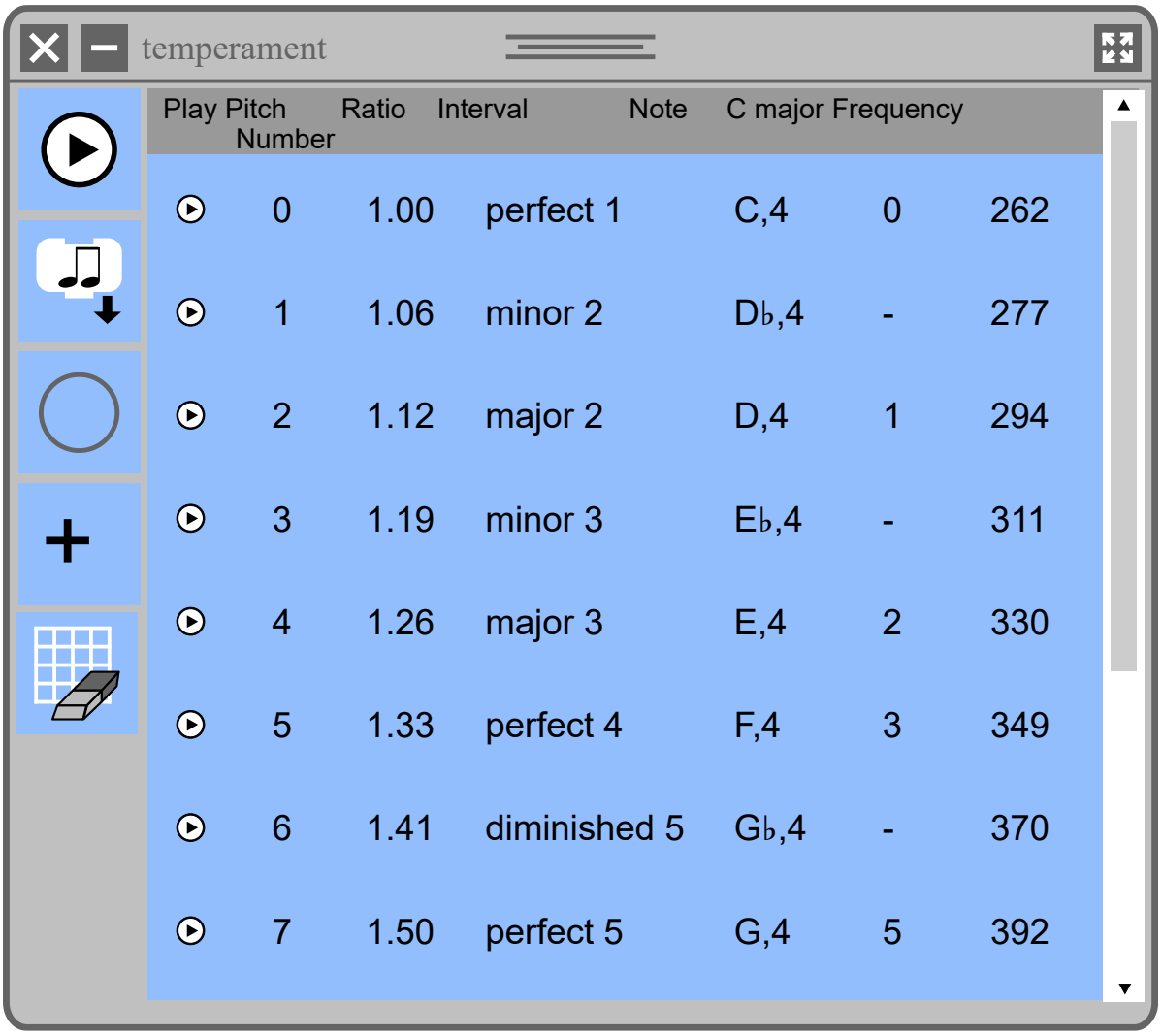
The *Temperament* block is used to launch a widget that enables the user to visualize and edit notes within an octave.

You can select a temperament system from the pie menu which is passed as an argument to the block. This name is passed to the *Set temperament* block in order to play the notes in selected temperament system. *Starting Pitch* is the argument of pitch block inside temperament block. In the above example, starting pitch is `C4` .



In the above example, selected temperament is *Just Intonation*. Notes within an octave can be viewed in the form of circle. These circles represent *pitch numbers*. Note that the pitches that are closer together in selected temperament system are visually closer and pitches that are farther apart looks farther.

The information regarding any note can be viewed by clicking on the respective circle. In the above example, circle (pitch number) `2` is `D4`. The frequency of note can be changed through edit button (left hand side corner of note information popup).



Information regarding notes can also be viewed in the form of a *table* as shown in the above example. The table will show all the information about pitches that lie within an octave. This information includes *pitch number*, *interval*, *ratio*, *note*, *frequency* and *mode*.

The frequency of any note is calculated by `Starting Pitch Frequency X Ratio`.

The widget controls are as follows:

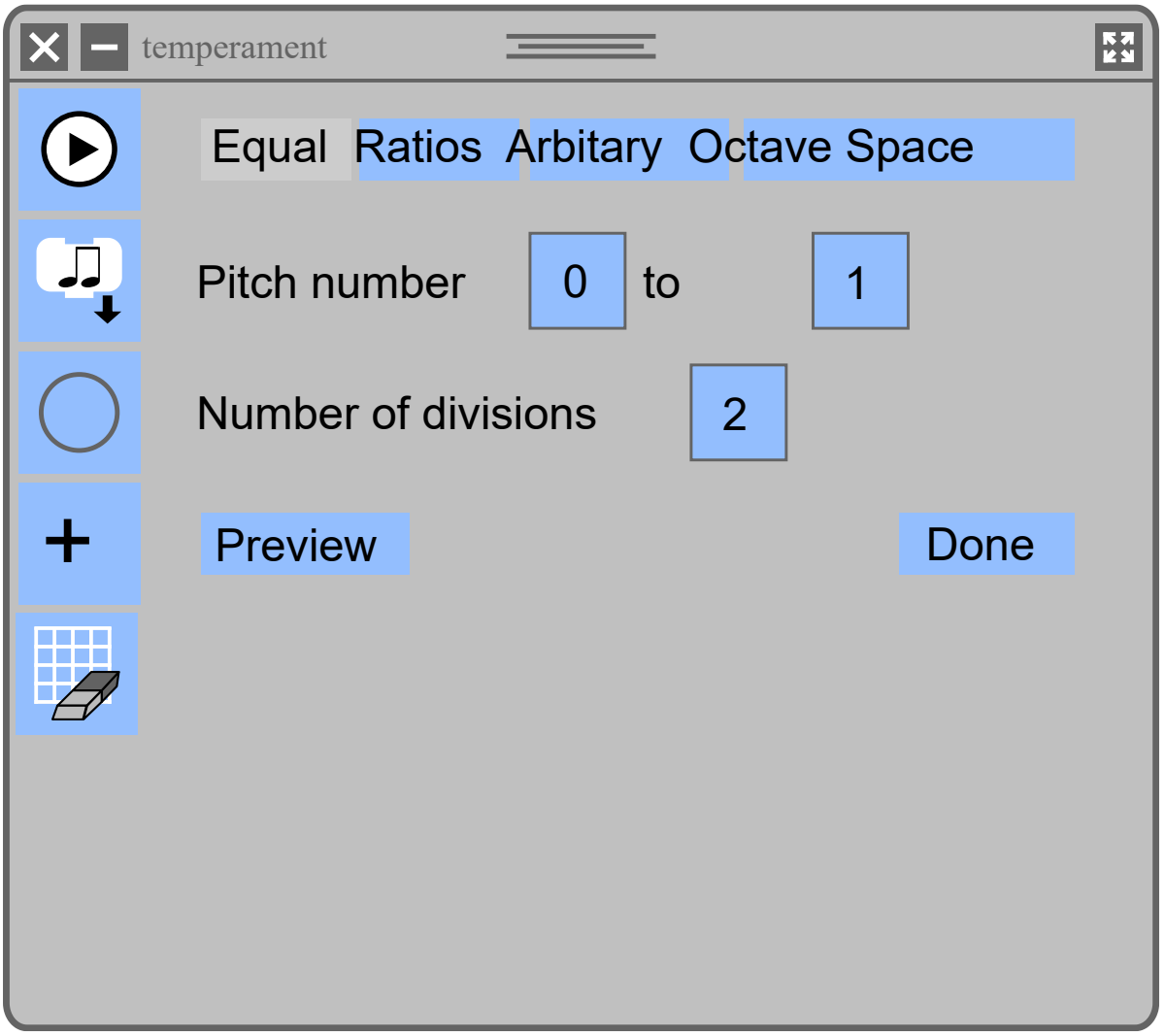
The *Clear* button at the bottom of the widget will clear all pitches except for a single `0` from which the user may add pitches.

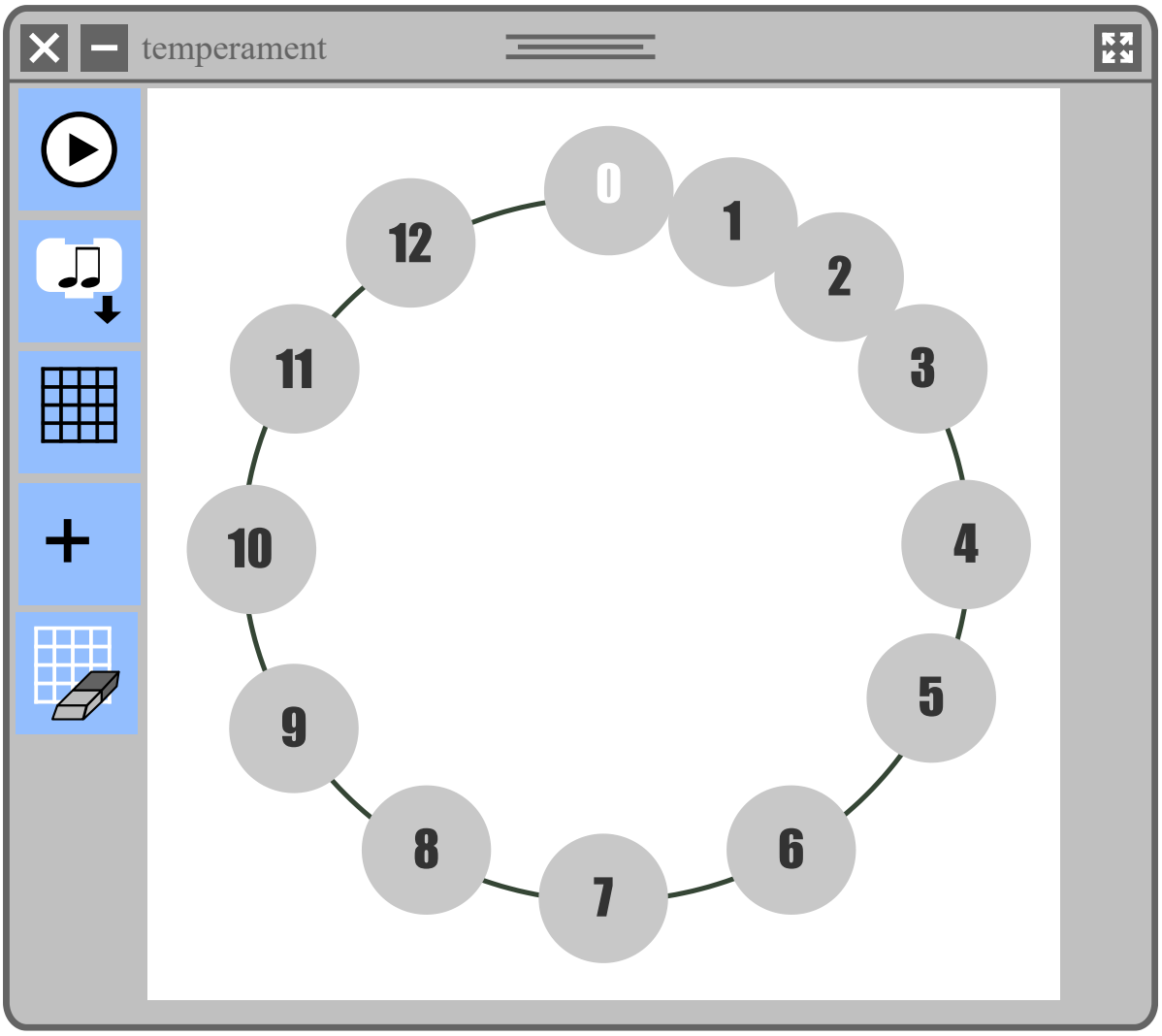
The *Play all* button will play through all the pitches in an octave and then it will play backwards down the pitches.

The *Save* button will save custom temperament for use in your program. It will create a *set temperament* block. This block will tune the notes attached to it according to the selected temperament.

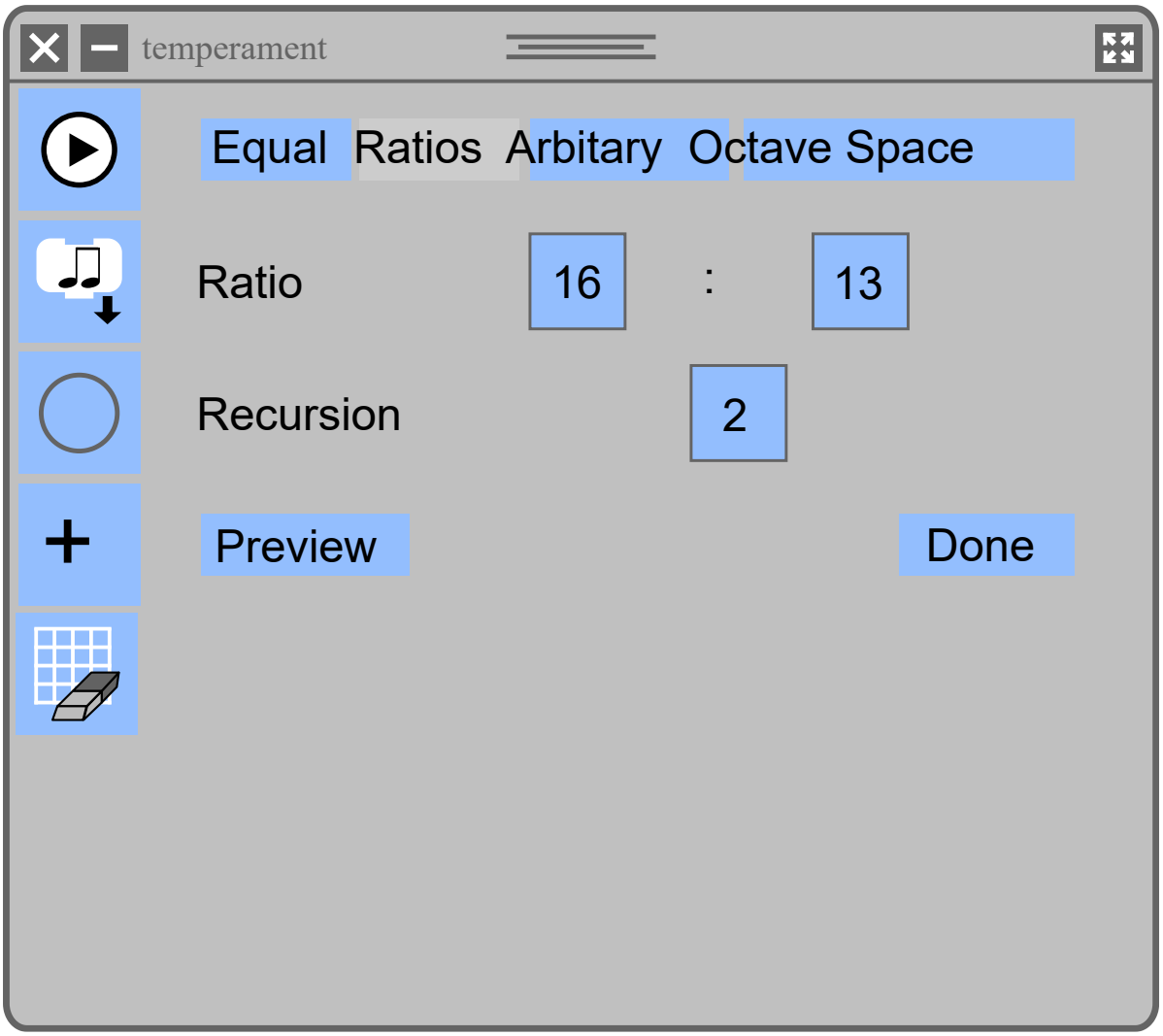
The *Table* button is used to toggle between circular and tabular representation of notes.

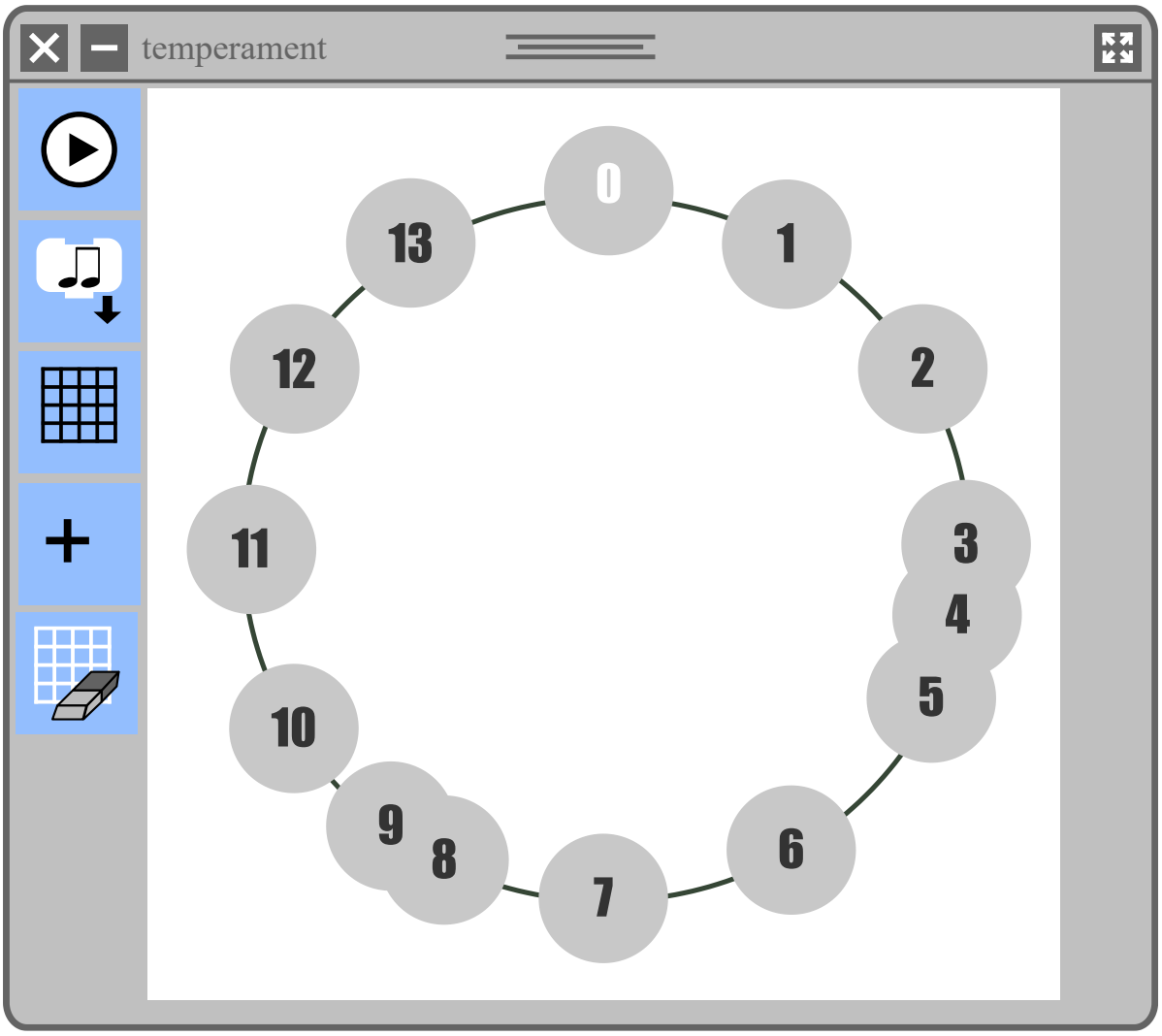
The *Add* button is used to edit notes through different tools:



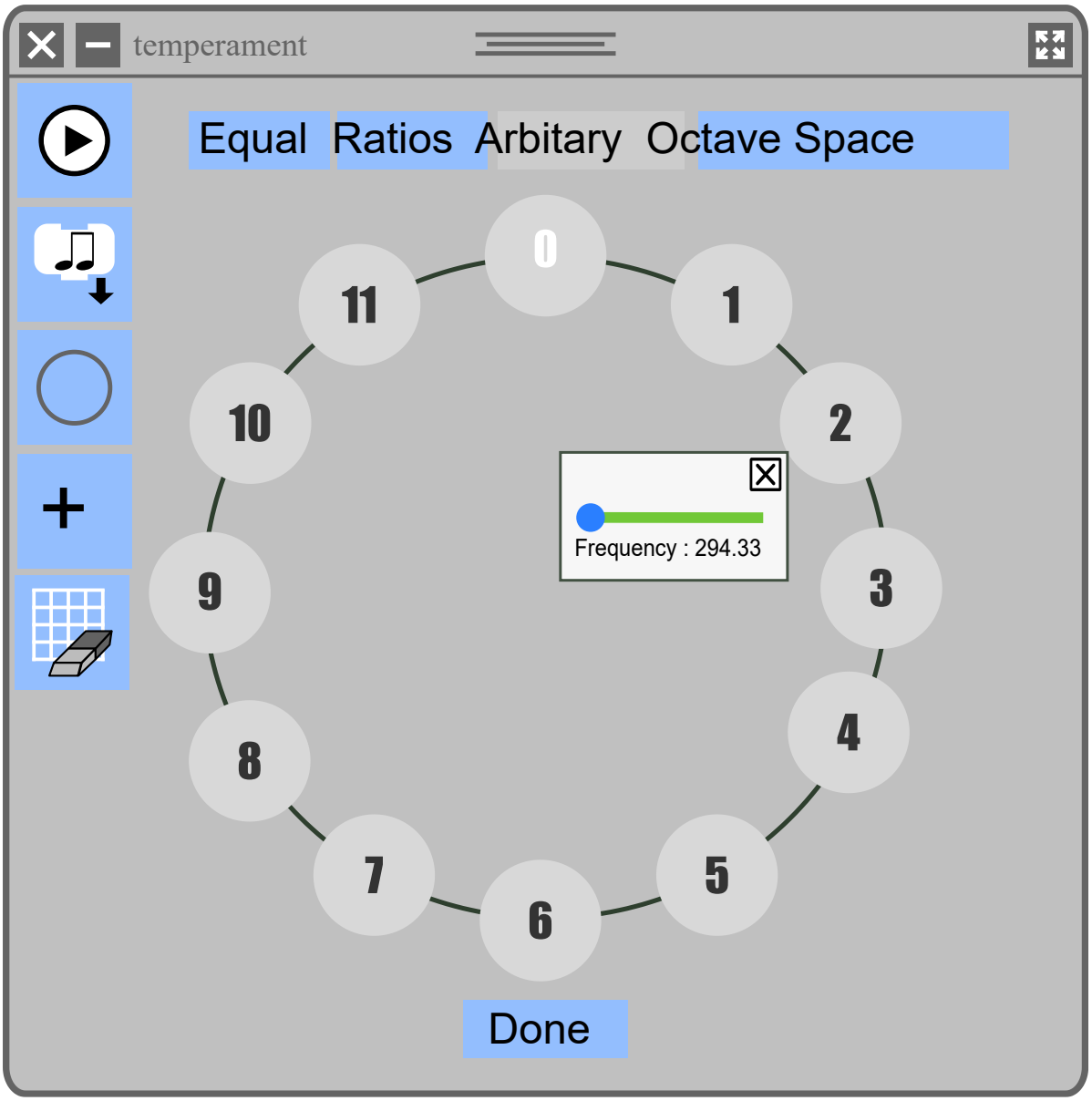


The `Equal` edit tool is used to make *equal divisions* between two pitch numbers. In the above example, two equal divisions are made between pitch numbers `0` and `1` and the resultant number of notes within an octave are changed from 12 to 13.

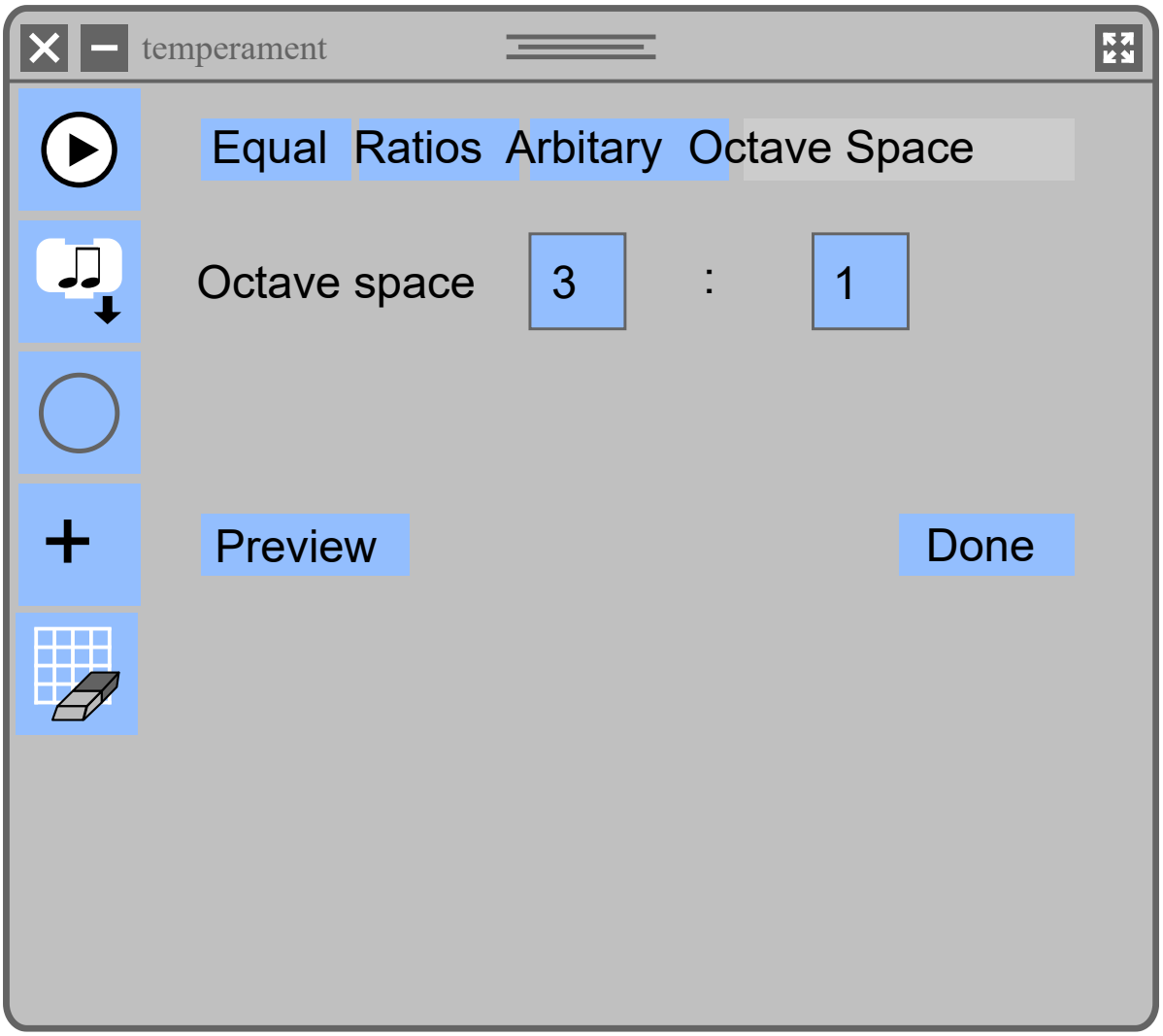

temperament
Equal
Ratios
Arbitary
Octave Space
Ratio
16
:
13
Recursion
2
Preview
Done



The `Ratio` tool is used to add notes of specified ratios in such a way that the resultant pitches wrap inside a single octave. Recursion represents the number of times notes ratio calculation is repeated. In the above example, 2 notes are added in pitch space and the resultant number of notes within an octave are changed from 12 to 14. Frequency of first pitch is (Starting Pitch Frequency) * (16/13) and second pitch is (Starting Pitch Frequency) * $(16/13)^2$.



The `Arbitrary` edit tool is used to add a note in an arbitrary position. In this panel, whenever the user hovers over the outer circle, a frequency-slider window pops up, allowing the user to add a note according to a chosen frequency. In the above example, a new note will be added somewhere between pitch numbers `2` and `3` by adjusting the frequency slider.



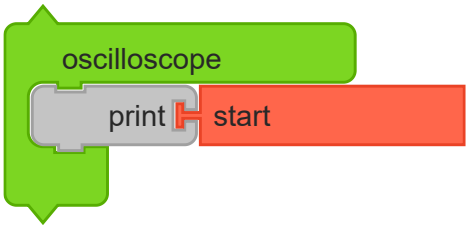
The `Octave Space` tool is used to edit the octave ratio. The standard octave space is 2:1. In the above example, octave space will be changed to 3:1 after clicking on `Done` .

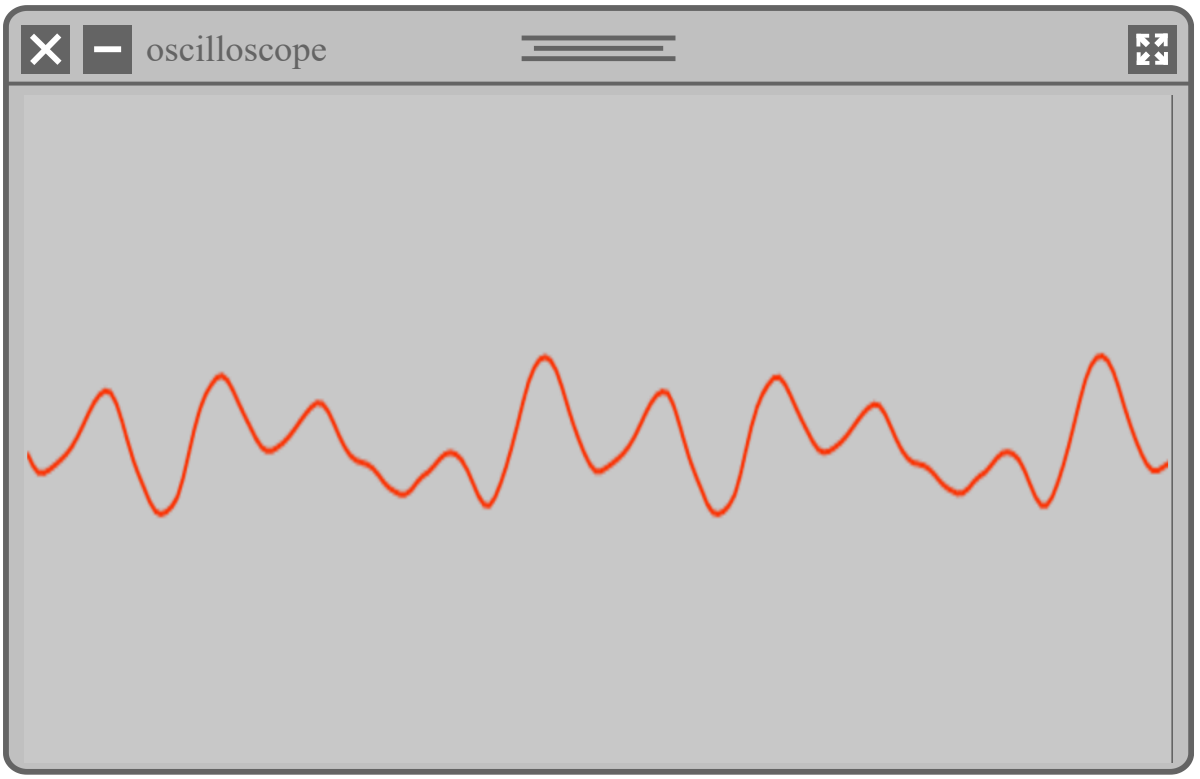
The *Drag* button will drag the widget.

The *Close* button will close the widget.

4.13 The Oscilloscope

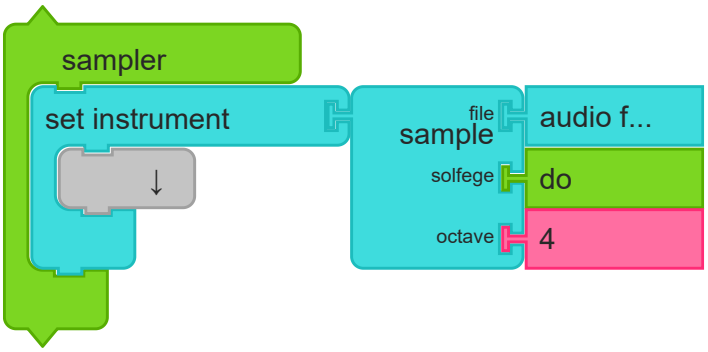
Music Blocks has an Oscilloscope Widget to visualize the music as it plays.



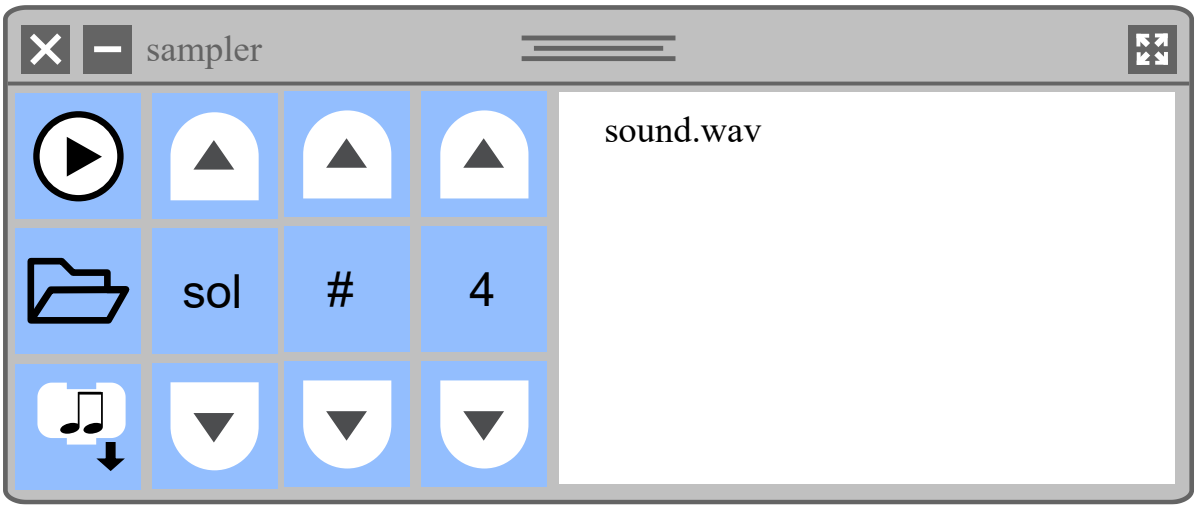


A separate wave will be displayed for each mouse.

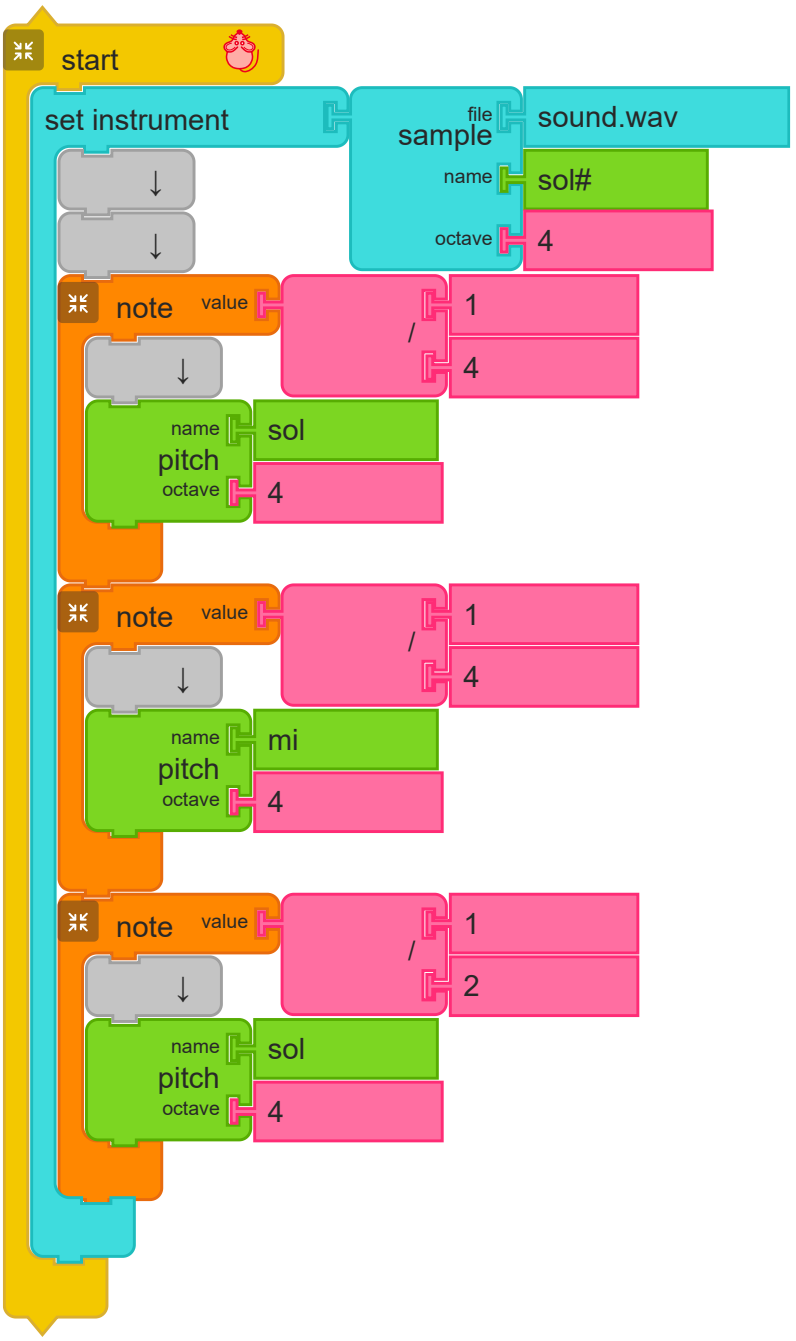
4.14 The Sampler



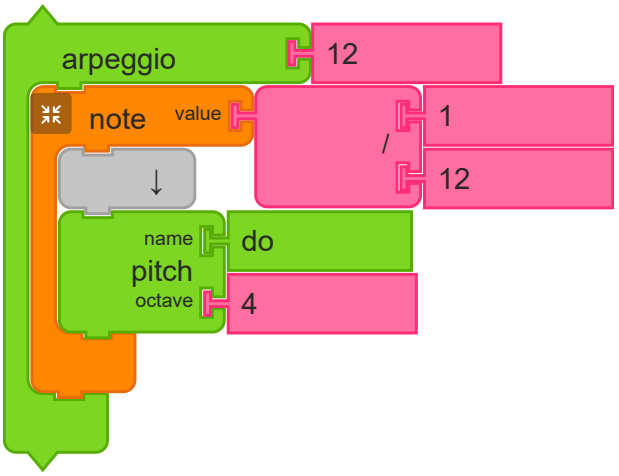
You can import sound samples (.WAV files) and use them with the *Set Instrument" block. The *Sampler* widget lets you set the center pitch of your sample so that it can be tuned.



You can then use the *Sample* block as you would any input to the *Set Instrument* block.

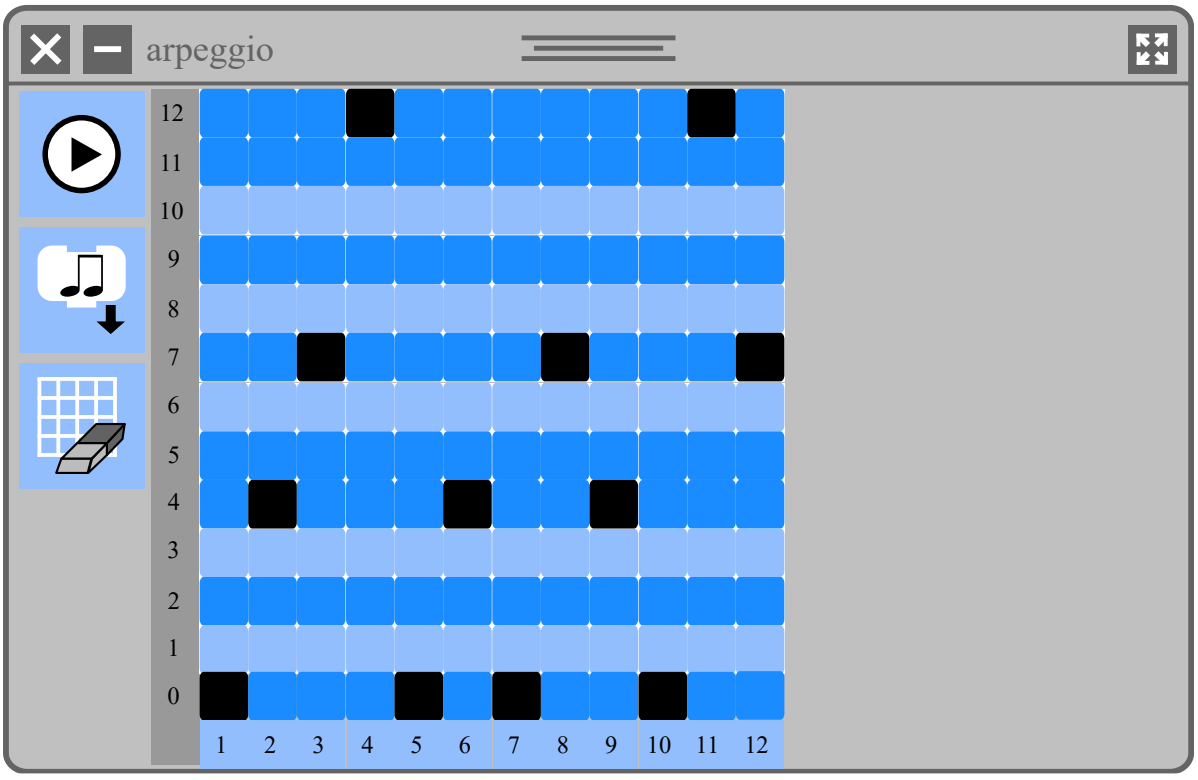

start
set instrument
file
sample
sound.wav
name
sol#
octave
4
note
value
/
1
4
name
pitch
octave
sol
4
note
value
/
1
4
name
pitch
octave
mi
4
note
value
/
1
2
name
pitch
octave
sol
4

4.15 Arpeggio



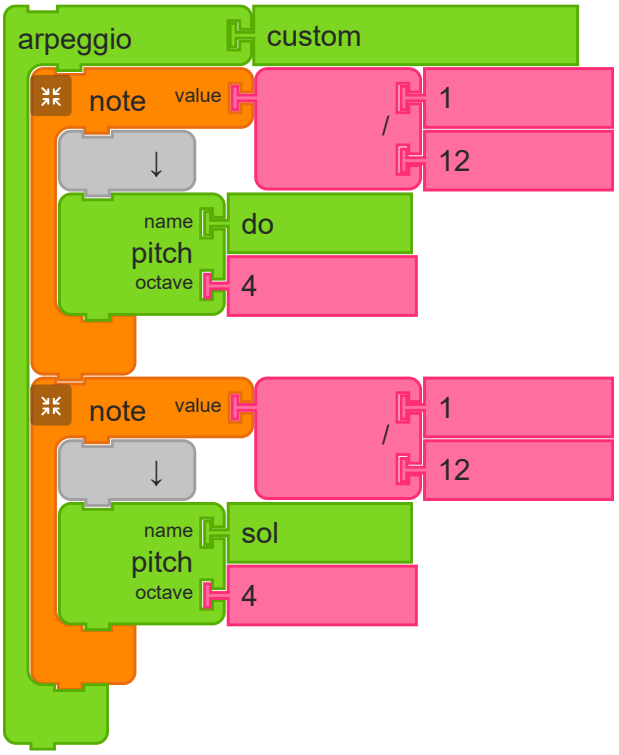
You can design custom sequences to use with the *Arpeggio* block using the *Arpeggio* widget. The widget lets you "paint" intervals that are then saved to a "custom" chord, which can be used with the *Arpeggio* block.

The numeric argument to the widget block, `12` in the figure above, designates the number of columns. The widget always provides a range of half-steps (one octave in the default a 12-step equal-temperament tuning). (If you are in a temperament with more notes per ocatve, the grid will expand.) The rows that represent notes in the current mode are highlighted.



The horizonal axis is time and the verical axis is half-step offsets from the base note.

The sequence in the pattern above is `do mi sol do do mi do sol mi do do sol`.



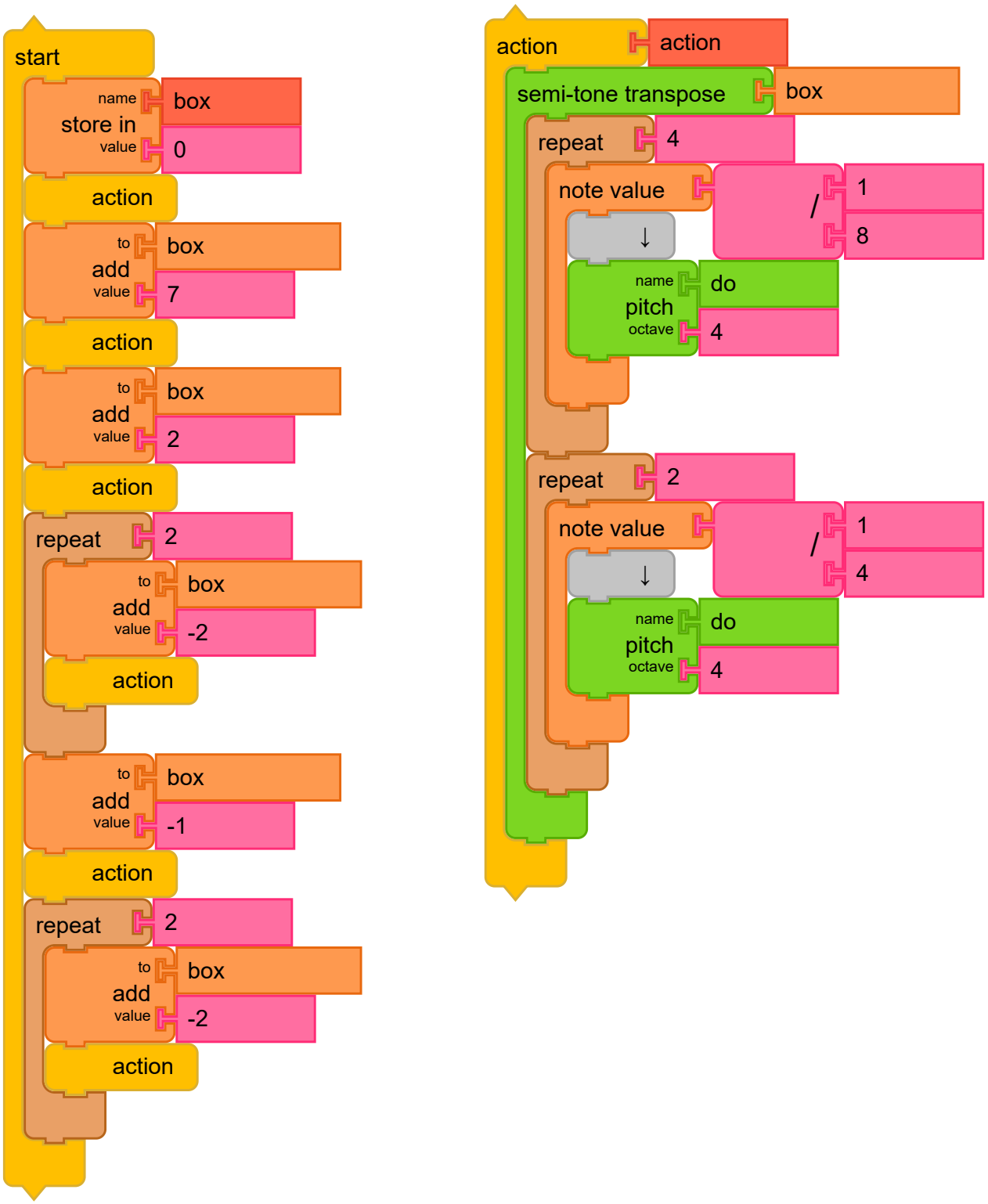
5. Beyond Music Blocks

Previous Section (4. Widgets) | Back to Table of Contents

Music Blocks is a waypoint, not a destination. One of the goals is to point the learner towards other powerful tools.

5.1 Lilypond

One such tool is Lilypond (http://lilypond.org), a music engraving program.



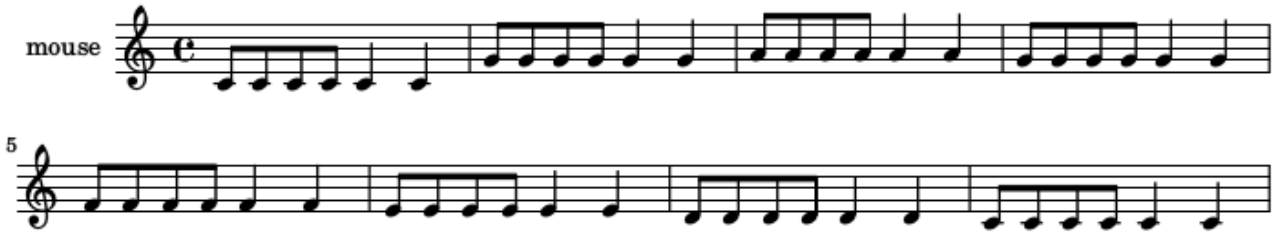
The *Save as Lilypond* option from the Save menu will transcribe your composition (Only available in Advanced Mode).

Note that if you use a *Print* block inside of a note, Lilypond will create a "markup" or annotation for that note. It is a simple way to add lyrics to your score.

```
\version "2.18.2"

mouse = {
c'8 c'8 c'8 c'8 c'4 c'4 g'8 g'8 g'8 g'8 g'4 g'4 a'8 a'8 a'8 a'8 a'4
a'4 g'8 g'8 g'8 g'8 g'4 g'4 f'8 f'8 f'8 f'8 f'4 f'4 e'8 e'8 e'8 e'8
e'4 e'4 d'8 d'8 d'8 d'8 d'4 d'4 c'8 c'8 c'8 c'8 c'4 c'4
}

\score {
<<
\new Staff = "treble" {
\clef "treble"
\set Staff.instrumentName = #"mouse" \mouse
}
>>
\layout { }
}
```



5.2 Other Exports

In addition to Lilypond, there are several other export formats supported, including ABC, MusicXML, WAV, SVG, and PNG.

ABC notation is a shorthand form of musical notation. In basic form it uses the letters A through G, letter notation, to represent the given notes, with other elements used to place added value on these – sharp, flat, the length of the note, key, ornamentation (See https://en.wikipedia.org/wiki/ABC_notation (https://en.wikipedia.org/wiki/ABC_notation)).

MusicXML is an XML-based file format for representing Western musical notation. The format is open, fully documented, and can be freely used under the W3C Community Final Specification Agreement (See https://en.wikipedia.org/wiki/MusicXML (https://en.wikipedia.org/wiki/MusicXML)).

WAV (Waveform Audio File Format) is an audio file format standard, developed by IBM and Microsoft, for storing an audio bitstream on PCs (See https://en.wikipedia.org/wiki/WAV (https://en.wikipedia.org/wiki/WAV)).

PNG (Portable Network Graphics) is a raster-graphics file format that supports lossless data compression (See https://en.wikipedia.org/wiki/Portable_Network_Graphics (https://en.wikipedia.org/wiki/Portable_Network_Graphics)). You can save your artwork as PNG.

SVG (Scalable Vector Graphics) is an Extensible Markup Language (XML)-based vector image format for two-dimensional graphics with support for interactivity and animation (See https://en.wikipedia.org/wiki/Scalable_Vector_Graphics (https://en.wikipedia.org/wiki/Scalable_Vector_Graphics)). You can also save your artwork as SVG.

Note that artwork saved as PNG or SVG can subsequently be imported into Music Blocks to be used with either the *Show* or *Avatar* blocks.

Help artwork

Note for translators: The artwork used by the help widget (and used in this README file) can be created by typing *Alt-H* into Music Blocks. Artwork for each block will be generated and saved by the browser.

5.3 The JavaScript Editor

There are practical limits to the size and complexity of Music Blocks programs. At some point we expect Music Blocks programmers to move on to text-based programming languages. To facilitate this transition, there is a JavaScript widget that will convert your Music Blocks program into JavaScript.

The JavaScript code is written and viewed on the **JavaScript Editor** widget which can be opened by pressing on the "*JavaScript Editor*" (<>) button in the auxilliary menu.

Example code

For the block stacks (and mouse art generated after running),


Example Project

the following code is generated:

```
let action = async mouse => {
    await mouse.playNote(1 / 4, async () => {
        await mouse.playPitch("do", 4);
        console.log(mouse.NOTEVALUE);
        return mouse.ENDFLOW;
    });
    let box1 = 0;
    let box2 = 360 / mouse.MODELENGTH;
    for (let i0 = 0; i0 < mouse.MODELENGTH * 2; i0++) {
        await mouse.playNote(1 / 4, async () => {
            if (box1 < mouse.MODELENGTH) {
                await mouse.stepPitch(1);
                await mouse.turnRight(box2);
            } else {
                await mouse.stepPitch(-1);
                await mouse.turnLeft(box2);
            }
            await mouse.goForward(100);
            return mouse.ENDFLOW;
        });
        box1 = box1 + 1;
    }
    return mouse.ENDFLOW;
};
new Mouse(async mouse => {
    await mouse.clear();
    await mouse.setInstrument("guitar", async () => {
        await mouse.setColor(50);
        await action(mouse);
        return mouse.ENDFLOW;
    });
    return mouse.ENDMOUSE;
});
MusicBlocks.run();
```

Here's the complete API (../js/js-export/samples/sample.js) of methods, getters, setters.

6. Appendix

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6.1 Beginner Palettes

Looking for a block? The tables below (one for beginner mode and one for advanced mode) list the blocks by the palette where they are found.

Beginner mode

Music			**Programming**			**Graphics**	
Palette	*Blocks*		*Palette*	*Blocks*		*Palette*	*Blocks*
Rhythm	note		**Flow**	repeat		**Graphics**	forward
	note value drum			forever			back
	silence			if then			left
	tie			if then else			right
	note value			backward			set xy
Meter	meter		**Action**	action			set heading
	beats per second			start			arc
	master beats per second			broadcast			scroll xy
	on every note do			on event do			x
	notes played			do			y
	beat count		**Boxes**	store in box1			heading
Pitch	pitch			box1		**Pen**	set color
	pitch G4			store in box2			set shade
	scalar step (+/-)			box2			set pen size
	pitch number			store in			pen down

Music			**Programming**			**Graphics**	
	hertz			box			pen up
	fourth			add			fill
	fifth			add 1 to			background
	pitch in hertz		**Number**	number			color
	pitch number			random		**Media**	print
	scalar change in pitch			one of this or that			text
	change in pitch			+			show
Interval	set key			-			avatar
	mode length			x			height
	movable do			/			width
	third		**Boolean**	=			bottom (screen)
	sixth			<			top (screen)
	chord I			>			left (screen)
	chord IV						right (screen)
	chord V					**Sensors**	mouse button
	set temperament						cursor x
Tone	set instrument						cursor y
	vibrato						click

Music			Programming			Graphics	
	chorus						loudness
	tremolo					**Ensemble**	set name
Ornament	staccato						mouse name
	slur						
	neighbor (+/-)						
Volume	crescendo						
	decrescendo						
	set master volume						
	set synth volume						
	set drum volume						
Drum	drum						
	sound effect						
	set drum						
Widget	status						
	phrase maker						
	C major scale						
	G major scale						
	rhythm maker						
	music keyboard						

Music			Programming			Graphics	
	pitch slider						
	tempo						
	custom mode						
	rhythm						
	simple tuplet						

6.2 Advanced Palettes

Music			Programming			Graphics	
Palette	*Blocks*		*Palette*	*Blocks*		*Palette*	*Blocks*
Rhythm	note value sol4		**Flow**	repeat		**Graphics**	forward
	note value G4			forever			back
	note value +1			if then			left
	note value 5 4			if then else			right
	note value 7			while			set xy
	note value 392 hertz			until			set heading
	dot			wait for			arc
	multiplicity note value			stop			bezier
	skipnotes			switch			control point 1

Music			Programming			Graphics	
	swings			case			control point 2
	milliseconds			default			clear
Meter	pickup			duplicate			scroll xy
	on strong beat			backward			wrap
	on weak beat do		**Action**	action			x
	no clock			start			y
	whole notes played			start drum			heading
	note counter			broadcast		**Pen**	set color
	measure count			on event do			set grey
	beat factor			do			set shade
	current meter			arg1			set hue
Pitch	scale degree			arg			set translucency
	sharp flat			calculate			set pen size
	accidental			do			pen down
	unison			calculate			pen up
	second			do			fill
	third			action			hollow line
	sixth			calculate			background

Music			Programming			Graphics	
	seventh			return to URL			set font
	down third			return			pen size
	down sixth		**Boxes**	store in box1			color
	octave			box1			shade
	semi-tone transpose			store in box2			grey
	register			box2			black
	invert			store in			white
	sol			store in box			red
	G			box			orange
	sargam			box			yellow
	accidental			add			green
	number of octave			add 1 to			blue
	number of pitch		**Number**	number			purple
	set pitch number offset			random		**Media**	text
	MIDI			one of this or that			show
Intervals	set key			+			avatar
	current key			-			note to frequency

Music			Programming			Graphics	
	current mode			-			hertz
	mode length			x			stop media
	movable Do			/			open file
	define mode			abs			height
	scalar interval (+/-)			sqrt			width
	semi tone interval (+/-)			^			bottom (screen)
	major 3			mod			top (screen)
	scalar interval measure			int			left (screen)
	semi-tone interval measure		**Boolean**	true			right (screen)
	interval name			=		**Sensors**	keyboard
	doubly			<			to ASCII
	set temperament			>			mouse bottom
Tone	set instrument			or			cursor x
	voice name			and			cursor y
	audio sample			not			time
	vibrato		**Heap**	push			pixel color

Music			Programming			Graphics	
	chorus			pop			red
	phaser			set heap			green
	tremolo			index heap			blue
	distortion			reverse heap			click
	harmonic			empty heap			loudness
	weighted partials			heap empty?		**Ensemble**	set name
	partial			heap length			mouse name
	FM synth			show heap			new mouse
	AM synth		**Dictionary**	get value			found mouse
	duo synth			set value			mouse sync
Ornament	staccato			get value by name			mouse note value
	slur			set value by name			mouse pitch number
	neighbor (+/-)			dictionary			mouse notes played
	neighbor (+/-)		**Extras**	print			mouse x
Volume	crescendo			comment			mouse y
	decrescendo			wait			set mouse

Music			Programming			Graphics	
	set relative volume			open project			mouse heading
	set master volume			hide blocks			mouse color
	set synth volume			show blocks			start mouse
	set drum volume			no background			stop mouse
	fff		**Program**	set heap			mouse index heap
	ff			load heap			
	f			save heap			
	mf			set dictionary			
	mp			load dictionary			
	p			save heap to App			
	pp			load heap from App			
	ppp			open palette			
	master volume			open project			
Drum	drum			make block			
	sound effect			connect blocks			

Music			Programming			Graphics	
	set drum			run blocks			
	map pitch to drum			move block			
	snare drum			delete block			
	kick drum						
	floor tom						
	cup drum						
	darbuka drum						
	hi hat						
	triangle drum						
	finger cymbals						
	ride bell						
	cow bell						
	crash						
	slap						
	clap						
	clang						
	chime						
	bubbles						
	bottle						

Music			Programming			Graphics	
	dog						
	cricket						
	cat						
	duck						
	noise						
	effect						
	drum						
	noisename						
	tom tom						
Widget	status						
	phrase maker						
	C major scale						
	G major scale						
	rhythm maker						
	pitch staircase						
	music keyboard						
	chromatic keyboard						
	pitch slider						

Music			Programming			Graphics	
	pitch-drum maker						
	audio sampler						
	tempo						
	meter						
	timbre						
	temperament						
	rhythm						
	simple tuplet						
	triplet						
	quintuplet						
	septuplet						
	tuplet						
	whole note						
	half note						
	quarter note						
	eighth note						
	1/16 note						
	1/32 note						
	1/64 note						
	custom mode						

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