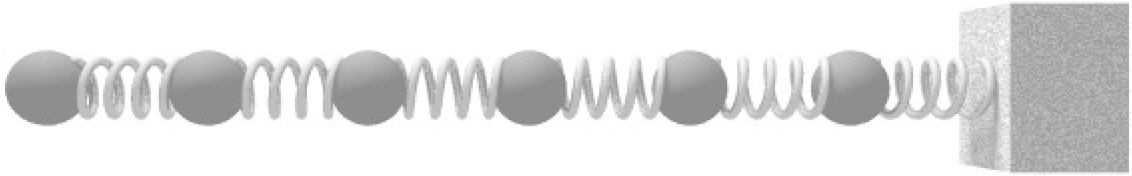
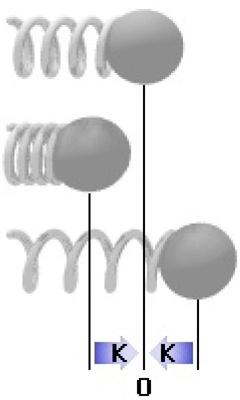


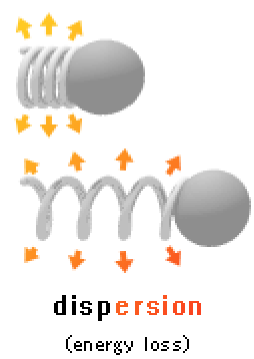
about mass-springs

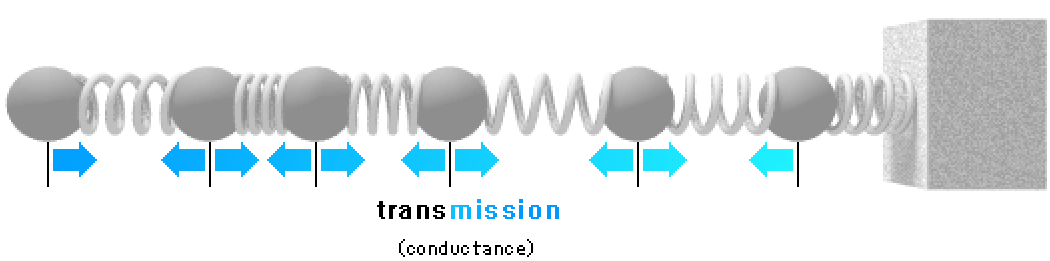
A spring is a system that potentiates force due to displacement. A first-order mass-spring model describes the motion of one point. Models can be cascaded for more complex simulation.



The variable **K** is used to indicate the spring constant, or how the spring reacts to displacement.

The variable **disp** indicates dispersion of energy, or how rapidly energy decays from the mass-spring.





The third variable is **trans** indicating transmission of the signal between cascaded mass-springs.

The ideal, or mathematically perfect 1st-order mass-spring has a sinusoidal response. When **trans** is increased, the frequencies of each order spread evenly around the center frequency, which is determined by **k**.

Effectively, a multi-order mass-spring model consisting of these coefficients can be used to generate a number of detunable sine waves in response to impulse signals. Altering the impulse will not effect the frequency of the sines, but will result in dynamic variation.

boundaries

To make these synthesizers more expressive, boundary conditions are applied to limit and reflect the first order. Separate upper and lower thresholds limit the signal like a compressor. The **hard** sliders set the amount of compression applied beyond the threshold.

Limiting the mass-spring oscillation simulates the vibrational medium and introduces timbral caustics. Increasing **refl**ection of energy on each axis adds to environmental definition.

Because this model describes a primary mode of vibration present in drums and other objects, it can synthesize timbres similar to some acoustic instruments and be applied to other emulative tasks. Many acoustic systems can be described in terms of mass-springs, including vibrating air.

In correlation with synthesis standards, the impulse envelope has positive polarity in consideration to the **LO** and **HI** thresholds. Setting the upper threshold to 0 will inhibit oscillation. Setting it close to 0 achieves a variety of timbres by propogating caustics caused by limiting and reflection.

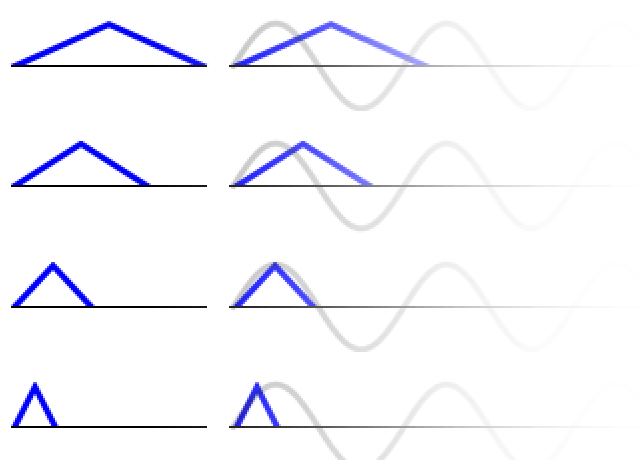
Note that the thresholds indicate the level where the softlimiting starts to take effect, and not the limit of the signal.

the impulse

The mass-spring network is induced into oscillation by applying a linear envelope to the first segment, representing a striking force.

In the same way as a tuned audio delay or other regenerative system, an input signal similar in frequency to the resonant frequency of the mass-spring will cause louder output. This harmonic effect is exaggerated by the elementary form of the model - an impulse envelope that corresponds to 180° of the mass-spring's harmonic frequency has significantly more volume and sustain, like playing harmonics correctly on a muted guitar string.

The effect of the impulse rate is also discernible in the timbre, and may sound softer or larger at slower rates. A wooden effect can be produced by using rates slower than the spring's frequency. Experiment and find the best modulation range for the impulse parameters.



impulse signals imposed on frequency cycle

mass-spring panel

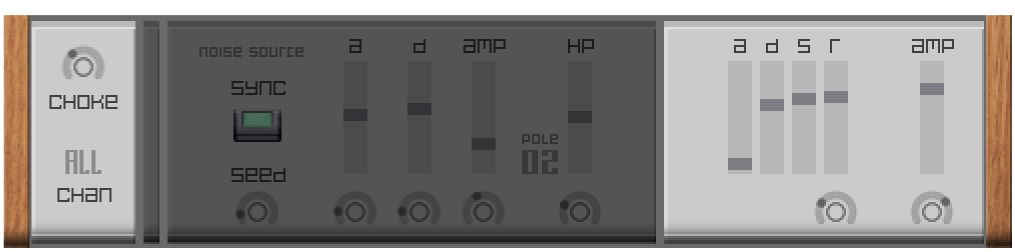
Both Cymbal and Mass have the same upper panel, although they are different internally.

The upper panel contains the parameters for the impulse, mass-spring, and boundaries. The mass-spring network can be **sync**ed to reinitialise on gate events for recallable output.

The mass-spring signal is run through a high pass and then may be mixed with a band peak filter. The high pass filter can be used for describing the size or proximity of the object.

Fine settings may be made by holding [ctrl] when dragging the mouse.

You should not use high trans values with high k values, this may require you to restart your host's audio engine. Fortunately this combination exceeds the range of timbral interest, ie. only sines around nyquist.

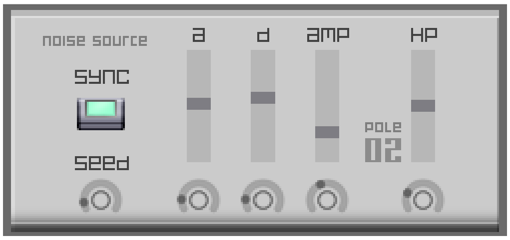


lower panel (shared)

Cymbal and Mass have different secondary components in their architecture, which are located in the center of the lower panel of each instrument.

Both instruments share a **choke** coefficient, which reduces a group of parameters on every other MIDI key. C, D, E, F#, G# and A# are unmuted. The **mod wheel** is routed to choke.

Unmarked knobs positioned directly under sliders are used to trim velocity responsivity of the parameter. The trimmer under the amplification envelope release also affects the decay rate.



noise source (cymbal)

Cymbal VST includes a separately enveloped and high pass filtered noise source to accentuate the high frequencies. Using the noise source to augment the short swell and sizzle of a cymbal adds detail and realism.

I generally found an attack value that delays the swell until after the initial impulse to be most suitable, so that the attack (say 30ms) is more realistic sounding (modeled) than random (noise source).

The mass-spring is a better option for modeling the decay and lower frequencies of cymbals because of it's modal characteristics.

The noise source has a seed parameter enabling recallable output.

reverb (mass)

Like the noise source for Cymbal, the reverb on Mass is intended for brief and subtle augmentation of the immediate decay of the mass-spring, and not as a discrete effect.

When emulating drums, the reverb can be used as an elementary simulation of a drum's acoustic body, or can add complexity to emulation of drum head timbres.

To complement the mass-spring, turn the gain and low pass filter up and sweep the size until it seems to match the object you wish to describe, then reduce then gain and lp settings.

The velocity trimmers for gain and low pass reduce the value of these coefficients.

patching techniques

These models are elementary mathematic forms that can be used to describe elementary behaviour in physical systems. To have a clear idea of the synthesis model, reduce the limiting effects (**LO** and **HI** at extremes, **hard** and **refl** at low settings) to audition the effect of the **K**, **disp** and **trans** settings.

Compare this to common idiophone synthesis techniques - the range of frequencies suggests the size of the object.

As you add the boundaries to the patch you will notice their effect on the timbre, and that various combinations are better for producing some textures than others.

When building an emulative patch, keep in mind that these models are much simpler than physical acoustic forms, and that coefficients based on real forms will produce less complex timbres and shorter decays. Modeled timbres can be made more complex abstractly (eg. by increasing **refl** or decreasing **disp**) until the best balance between sustain, complexity and realism is found.

patching (continued)

Perhaps a good image to keep in mind when patching the boundaries is something frying in a skillet. Pressing with the spatula will cause what is cooking to sizzle more. When you reduce the thresholds, the signal spends more time being shaped by the boundary conditions and creates more caustics.

High reflection values can increase the sustain and richness of the timbre. High hardness settings can reduce the effect of reflection by minimising the amount of time the signal spends past the threshold. Try creating different conditions for each axis.

license

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Cymbal and Mass VST are made with SynthEdit - http://www.synthedit.com

http://www.xoxos.net