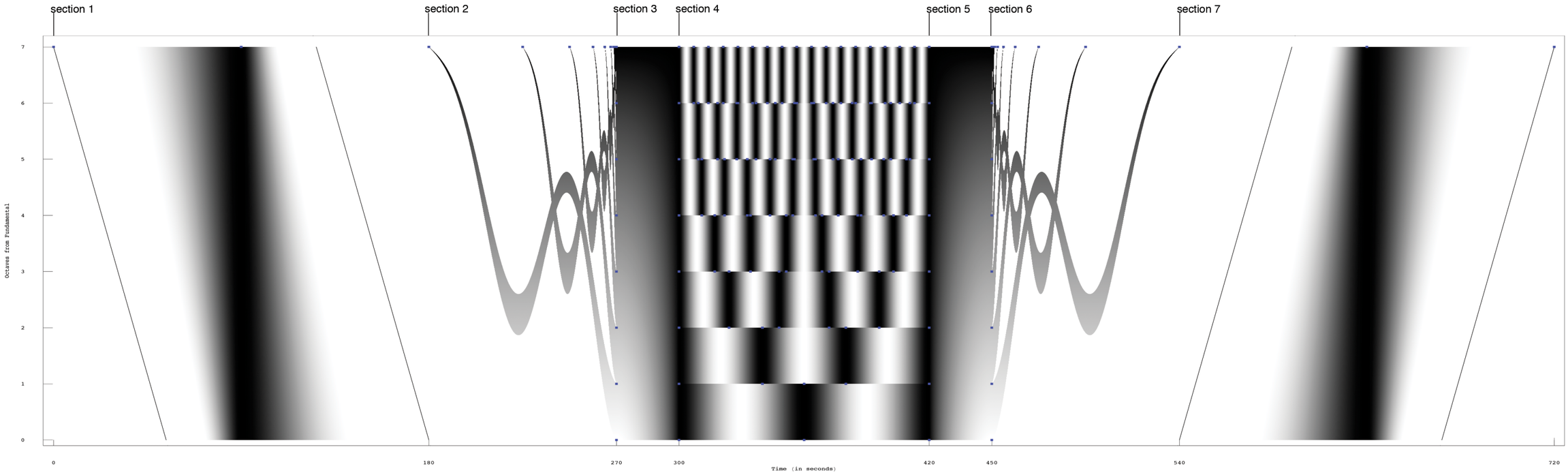
# nothing... I


section 1
section 2
section 3
section 4
section 5
section 6
section 7
Octaves from Fundamental
0
1
2
3
4
5
6
7
0
180
270
300
420
450
540
720
Time (in seconds)

# nothing… I

## for percussion, sine tones, and one or more acoustic, sustaining-tone instruments… preferably more.

michael benjamin winter (2006 - vienna, austria)

## Notes

**For all instruments except for percussion**

- Most individual tones should enter and exit as imperceptibly as possible with a dynamic contour of a Gaussian function/envelope. However, when a series of tone durations are very short, performers may slur sets of successive tones, enter and exit the conglomerate line as imperceptibly as possible, and, throughout the slur, follow the general contour of the peak amplitudes of the individual tones. A performance of the piece should sound very fluid in that every component contributes equally to the conglomerate sound.

**For percussion**

- The gong, which sounds throughout the first and last section, should be rolled, enter and exit as imperceptibly as possible, and should follow the dynamic contour of a Gaussian Envelope from beginning to end of the roll.
- The other percussion instruments should be struck as loud as possible and let vibrate for as long as possible.

**Dynamic relationships**

- There are general correlations between tone duration and peak dynamic. Longer tones have lower peak dynamics and shorter tone have higher peak dynamics. Given dynamics are relative to the entire ensemble. Except for the percussion, the peak loudness played by any instrument should never be louder than the peak dynamic of any other instrument. This also holds true for the gong. The peak amplitude in the middle of the first and last section should be as loud as the conglomerate sound from the other instruments. The rest of the percussion should be as loud as possible with as strong an attack as possible. The sine tone accompaniment should be just slightly softer than the ensemble (see **Electronic Accompaniment Application Notes**).

**Miscellaneous information**

- Since the generating algorithm of the piece (see **Meta-Score**) is choosing timestamps, durations, and pitches on continuums with practically no quantization, performers should try to play every tone chosen to be played as accurately as possible in both the pitch and time domain (see **Personal Statement** which addresses the difficulties in this work and underlines the possibilities). All instruments should play without vibrato.

**Choosing an ensemble and "Preferred Type"**

- Though the piece can be played with one or more players, the more the merrier. Each instruments is assigned a preferred type of 1, 2, or 3. Each type, which is the conglomerate timbre of a set of instruments of the given type, should be as dissimilar as possible relative to the other two types. For example, type 1 may be composed of strings, type 2 may be woodwinds, and type 3 may be brass. You may also combine instruments of different timbres to create a type so long as the types remain unique relative to the others. For example, type 1 may be composed of woodwinds/strings, type 2 of brass/woodwinds, and type 3 of strings/brass. These are just examples using the traditional orchestra choir paradigm, but how an ensemble chooses the instruments that compose a type does not matter so long as there is a significant timbral difference between the preferred types. The number of instruments assigned to a preferred type 1, 2, or 3, should optimally be in a ratio of 3:2:2 respectively. When choosing a preferred type, one should take into consideration that Preferred Type 1 spans the greatest range from C-1 to C-8, then Type 2 from C-2 to C-7, and then Type 3 from C-3 to C-6.
- The chosen gong should be low and should get quassi-noisy at the peak amplitude of the ensemble. All the other percussion instruments should have the characteristic of a long decay time and a sharp attack. For example, glockenspiel, vibraphone, and piano. These instruments only play C's from C-1 to C-8 with no cent deviations. Sometimes all the octaves are presented together, sometimes in pairs, and sometimes alone. It will probably take several players to cover all the tones.

## Interpretation of the Provided Notation

- The provided notation is a very strict space-equals-time notation. The position of a stem (equal to the very beginning of the notehead on the left-hand side) on the horizontal represents the beginning of a tone in time and the length of the beam represent the duration of the tone. A space that does not have a beam running through it represents a rest. Above each note is a cent deviation (one-hundredth of a tempered semitone) from the closest tempered pitch. To avoid any collisions and to preserve the strict space-equals-time presentation, clef changes and accidentals that do not fit in the space between the note to which the change applies and the prior note are placed above the note that the change applies to. Clef signs hold to the next clef change and accidentals only apply to the tone that it proceeds or is placed above. A cautionary clef is given for the first note of each staff in each staff system. All dynamic information is presented in the white to black color gradient that fills the beams. White represents playing as imperceptibly as possible and black represents the maximum dynamic of the ensemble. This gradient is a Gaussian function for every note suggesting that each tone should enter and exit as imperceptibly as possible. However, as stated above, slurring sets of notes is allowed. It is the darkest part of the gradient for each note that provides a visual representation of the peak amplitude contour for the set of tones under a slur.
- In the percussion part, which is presented on one staff with one line, only the gong has a stem connected to a beam representing the dynamic contour of the roll (above the notehead the word "Gong" is written). With the beginning of each gong roll is also a C-8 to be played by one of the other percussion instruments with a short attack and long decay. "C-8" is written above the word "Gong" (only one notehead is given and the stem applies only to the gong). All the other notes or chords only have one notehead and a list of pitches written above the notehead. It is assumed that these tones are played with a hard attack and allowed to vibrate as long as possible. Since there are chords that span a seven-octave range, the pitch or pitches of a tone or chord are listed above the notehead in *letter/number* form (letter equals pitch class and number equals octave placement) instead of being distributed with noteheads on a "proper" staff.

- The score package includes a hard copy score. Also, the score generator and electronic accompaniment computer applications written in Java are either included or can be obtained.

  -The hard copy score is a set of parts labeled by preferred type. A performer may extract tones from the entire score excluding notes that are out of range or physically impossible. Especially with a larger ensemble, individual performer should try to extract tones from staffs labeled with their preferred type and the ensemble should try to play a similar amount of notes in each staff. There should never be a doubling of any tone in any part other than the percussion. If the percussionists choose to double a tone, they must strike the tone together. No tones in the percussion part may be omitted.

  - The preferred method for creating parts is using the score generator. Which has a user interface that allows one to enter as many instruments as desired as well as the characteristics of each instrument such as name, preferred type, and range. You can then render a version specific to the input characteristics. See the **Score Generator Application Notes** for detailed user information.

# Computer Applications Notes

Please check for updates at www.sonicism.net. Also, any bugs and upcoming changes will be listed in the "read-me" file provided with the application.

## Score Generator Application Notes

**The Score Frame**

Displays the rendered score and has a scrollable interface for navigation.

**The Tool Frame**

**- Save** and **Open** buttons – Self-explanatory.
**- Render** button – This button renders all tone information from which the final score will be produced**.** It generates 70 lines based on **Tone Information Algorithm** documented in the **Meta-Score**. Pressing this button will automatically update the score and if not saved, the previously rendered version is lost.
**- Update Score** button – After pressing this button, parts for each instrument are extracted to generate a score specific to the input characteristics in the **Instrument Frame.** Important difference! – Rendering the score changes the tone information from with the final score draws from, updating the score always draws from tone information created in the most recent rendering. For almost all parameter changes in the **Tool Frame** and the **Instrument Frame** the user must press enter and then **Update Score** to witness the changes.
**- Print** button – Self Explanatory.
**- Back/Forth** and **Zoom In/Out** buttons – Basic navigation tools.
**-** Page Set Up Information (**Measures per System, Page Width/Height/Margin**) – allows the user to tailor the score size to their liking. The program has been optimized to scale the score to the input page size and to avoid any collisions, but is not completely fool proof. When changing the page size, one must match the page size in the page setup dialog that opens when you try to print for a proper print.
**- Override** Systems:Page – By default. The application automatically calculates the number of systems per page. By checking this button, entering a number in the neighboring text field, and updating score, the user can determine the parameter of the score layout.

**The Instrument Frame**

- Allows the user to add and remove instruments based on the chosen ensemble. All parameters changes require that you press enter and then the **Update Score** button in the **Tool Frame** to witness the changes.
-All instrument panels are the same except the percussion panel, which, except for creating parts, is un-editable. The ordering of the instruments on the score is always the same as the ordering in the score frame from top to bottom and the percussion part is always presented last.
- Here is an overview of the input fields:
**- Staff Name** – Name displayed on the staff.
**- Preferred Type** – Set the preferred type for the instrument (as explained in the **Notes**).
**- Minimum/Maximum Frequency** – Enter the frequencies in Hertz limiting the part to extract pitches within the instrument's range.
**- Transpose** – Allows for transposing instruments to be displayed "as written".
**- Clef Preference** – Sets a clef preference scheme that, for the most part, changes clefs past two ledger lines to conserve space. B/S only does not display Tenor or Alto clefs and switches clefs at C-4. B/T/S prefers Bass Clef over Tenor Clef and Tenor Clef over Treble Clef (best suited for instruments like Contrabass and Bassoon). B/A/S prefers Alto Clef over all others (best suited for instruments like Viola).
**- Insert Before, Insert After,** and **Remove** buttons – Utilities for adding and removing instruments.
**- Solo for Parts** - Allows the user to update the score displaying only the instruments set to solo mode. Once all the information is set, use these and update score to print parts.

**- Important Note! –** Changing the preferred type or frequency range in one instrument effects which tones are extracted from the rendered tone information in all instruments. Do not create parts without having all input information finalized or change parameters after distributing scores for a particular performance. Read the **Meta-Score** section on **Part Extraction** for more information.

## Electronic Accompaniment Application Notes

Plays a rendering of the electronic part for the performance. Also gives a visual metronome so that the ensemble will always be synchronized with the electronic accompaniment. The user interface has basic **Start** and **Stop** functions and allows changing the starting measure for rehearsals. Pressing the **Render** button regenerates the electronic accompaniment based on the algorithm described in the **Meta-Score**. Since the electronics should not be any louder than the acoustic instruments, an **Amplitude Scalar** slider is given so that the user may match the levels. After starting the accompaniment the program gives a measure for nothing.

## Personal Statement

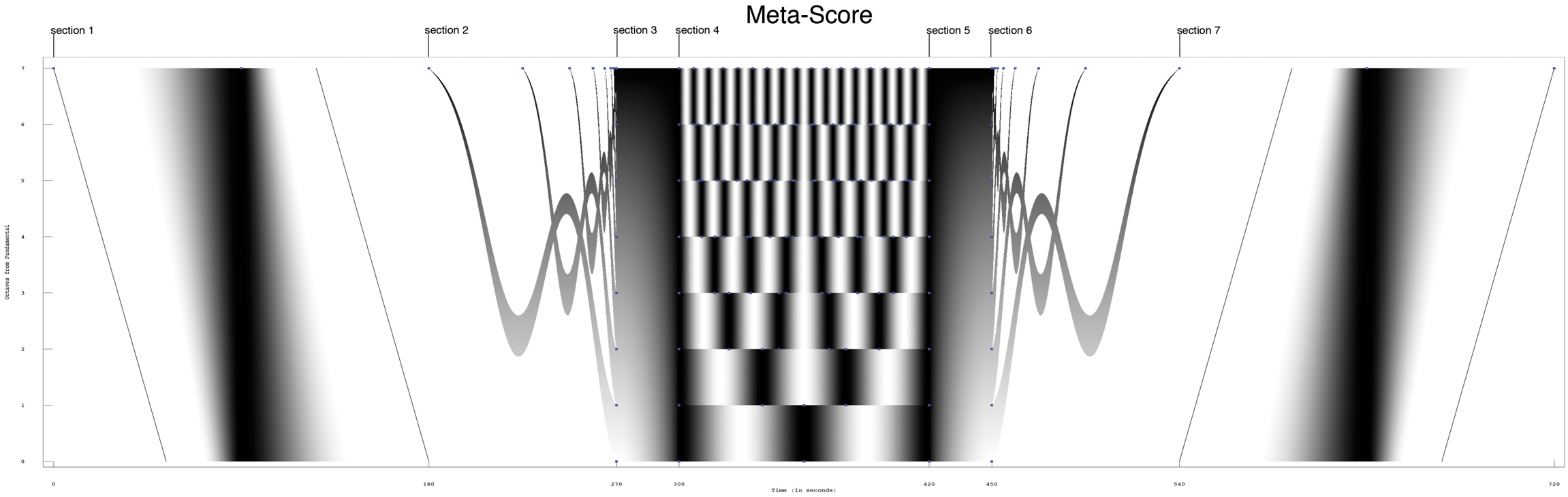
First off, I would like to acknowledge the difficulties that inhere in realizing this piece. For example, having to generate a score and learn a new notation system. However, certain, more archaic protocols like some traditional notation paradigms are not effective for this type of piece and the ideas presented in it. In a certain way, I have chosen to abandon making certain concrete decisions to ensure that the piece can be realized in an infinite number of ways. It is the output of the algorithm, merely a list of numbers, that gives instructions for rendering the piece, and any step past that should be viewed as a realization of sorts, which is exactly what the included score generator is - a realization of the tone information from the algorithm documented in a more readable way for musicians with the functionality of creating a score for any instruments.

When exploring the algorithm implemented in this work, I have limited myself to output basic tone information, i.e. timestamp, frequency, amplitude, and duration. Many of the other parameters have been homogenized to, in essence, take them out of the equation and to make such a characteristic as little a factor as possible in the perception of the different parts and voices of the work. The best example of this is the alleviation of the attack and decay differences from tone to tone in all instruments either than percussion by imposing Gaussian envelopes on all tones or requesting that the performers enter and exit any sound as imperceptibly as possible.

With this said, I would like to address a few compositional issues that I was confronted while working on **nothing… I**.

1) **Infinite Possibilities and Perception of Form**: Ultimately, the choice to use random numbers within algorithmically determined bounds and to keep the piece open to any set of sustaining instruments led to the decision of including a detailed mathematical notation of the piece, a re-renderable score generator, and a re-rendable electronic accompaniment. In **nothing… I**, the constants from performance to performance are the form, structure, and inherent relationships at a macro level. Within the bounds of the algorithm, there has been no human choice made on a micro level. It is my hopes that one will be able to perceive and remember larger gestalts despite the radical difference in the "inner fabric." Two analogies that come to mind is the difference between the micro and macro realms in physics, and our ability to attribute similarities to gestalts despite certain differences and vise-versa. The first analogy is related to the ability of understanding and "seeing" larger objects despite the fact that they are made of an incomprehensible chaotic stew that could never be understood as in the case with heavenly bodies like stars and planets, i.e. recognition comes from a global perspective. However, the second example deals with our ability and enjoyment of seeing and hearing the differences without feeling like one is in another "place", or piece of music. This is similar to viewing a building. When viewing two buildings, we are given general cues that suggest that it is a building. Cues such as its frame, its material, etc. But even though we can relate two buildings as the same general thing, our interest and fascination is created by how they are unique and different from each other even though they are both classified as buildings. In keeping with this, I have made quite an effort to ensure the exploration of such ideas by providing the tools that I have. However, as I wrote before, the algorithm is ultimately what one really needs to realize the piece.
2) **Spectral Differentiation**: One of the decisions that I have decided not to set in stone is timbre for the acoustic instruments. What I am emphasizing is that there be a *difference* when requested. Though writing for specific instruments/timbre is a very powerful thing, I found myself wanting most anything to be able to realize the piece. This decision was also based on the ever changing and evolving resources. Instruments are being improved and advancements in robotic technologies are taking huge leaps. For this particular piece, a successful realization can be created with many combinations of instruments.
3) **Continuums**: the tone information algorithm outputs non-quantized values, meaning that the possible timestamps, durations, and pitches are not discrete sets. It is my hopes that players do the best they can by accurately interpreting the information and it is understood that this task comes with great difficulty. Again, advancements in instrument techniques and mechanical improvements will hopefully help relieve some of the physical burdens that inhere.

**I would like to thank Nick Didkovsky** (fantastic composer, creator of JMSL – the computer language that made the score generator possible, and all around great person) and **Larry Polansky** (fantastic composer, creator of HMSL – the computer language that was the predecessor to JMSL), and also an all around great person) for their help with this piece.




- The **Meta-Score** for this piece is the following algorithm. All the tools provided for realizing this piece such as the score generator and the electronic accompaniment are simply ports of this algorithm into a computer language for sonification and a readable documentation of the work. That is to say, the algorithm provides all the tone information. From the documentation of the Meta-Score alone, the piece could be realized and I encourage such exploration.
- The algorithm is a repeated process that outputs tone parameters (timestamp, frequency, amplitude, and duration) in a set of 70 monophonic lines. For the electronic accompaniment, *all* the tone information is sonified, that is to say, no exception is "thrown."
- Since the piece is also for any set of acoustic, sustaining-tone instruments, an additional process/algorithm is implement to extract parts from all the generated tone information based on the physical limitations of the instruments. For example, pitch range.

**Tone Information Algorithm** (numbers correspond to the numbers on the following pages containing a more mathematical form of the algorithm)**:**

1) The following process is iterated 70 times (by a for loop) generating monophonic lines that comprise the entire piece.
2) Choose a random number (R) between 0 and .3 based on a uniform distribution.
3) Instantiate *x* to 180 * R (x is basically time in seconds).
4) Instantiate *v* to iteration%7 (*v* stands for which of the 7 textural voices this monophonic line is part of and eventually assigns a Preferred Type to the line (see **Part Extraction Algorithm**)).
5) Start a while loop that lasts until *x* is incremented past 720 – 180*R. For every iteration of the loop, the calculations will determine the parameters of a tone.
6) Choose a random number (Y) based on a uniform distribution between an upper limit (*u*) and a lower limit (*l*). *u* and *l* are functions of *x* and *v* expressed by the given piecewise equations. Y is directly related to pitch and is later used to calculate the frequency of the tone information generated by this iteration of the while loop. (Note that the symbols *u* and *l* are repeatedly used to represent upper and lower limits and that the symbol *x* used repeatedly for the Probability Distribution Functions (PDF = …) is *not* the *x* correlated to the time in seconds used in the algorithm.
7) Calculate a *z* value. The *z* value is a function of *x* and Y expressed by the given piecewise equation. *z* will later be used to calculate many of the parameters of the tone information generated by this iteration of the while loop (The provide graph is a visualization of this equation for all possible Y values).
8) Choose a random number (A) based on a uniform distribution between an upper limit (*u*) and a lower limit (*l*). *u* and *l* are functions of *z* and *x* expressed by the given piecewise equations. The amplitude of the tone generated by this iteration of the while loop is later set to A.
9) Choose a random number (D) based on a uniform distribution between an upper limit (*u*) and a lower limit (*l*). *u* and *l* are functions of *z*, *x*, and *v* expressed by the given piecewise equations. The duration of the tone generated by this iteration of the while loop is later set to D.
10) For each iteration of the while loop, tone information is generated for a tone that will be sounding in the piece. The timestamp is set to *x*, the frequency is set to 2^Y* 32.70317, the amplitude is set to A, and the duration is set to D.
11) Calculate a value to *increment x* by before the start of the next iteration of the while loop. *increment* is a function of *x* and *v* expressed by the given piecewise equation.
12) Increment *x* and return to beginning of while loop. If *x* + *increment* is greater than 720 – R, then the while loop is terminated and the next iteration of the for loop is initiated until the for loop has run 70 times.

**Part Extraction Algorithm** (only presented here)**:**

For each set of tone parameters (Step 10 of the Tone Information Algorithm):

1) Throw any instruments that cannot play that frequency or has already been assigned a tone that coincides with the tone currently trying to be assigned.
2) Of the available instruments in the ensemble, priority for the tone in question is ranked as follows:
    a. Instruments with the same preferred type of the monophonic line. (See step 4 of the Tone Information Algorithm. Preferred Type of *v* = 0, 3, or 6 is Type 1. Preferred Type of *v* = 1, 5 is Type 2. Preferred Type of *v* = 2, 4 is Type 3.)
    b. The instruments that have already been assigned a tone, i.e. keep an instruments staff empty as long as possible.
    c. The instrument who's nearest pre-assigned tone in time *before* the tone currently being assigned is also closest in Pitch to the tone currently being assigned.
3) If no instruments are available, throw the exception.

# Meta-Score

1) FOR(int $iteration = 0;\ iteration < 70;\ iteration{+}{+})\ \{$

2) $$\text{PDF(R)} = \begin{cases} 0 & x < 0 \\ \frac{1}{.3} & 0 \le x \le .3 \\ 0 & x > .3 \end{cases};$$

3) $$x = 180\,\text{R};$$

4) $$v = iteration\ \%7;$$

5) WHILE($x < 720 - 180\,R$) {

6) $$\text{Y such that } u = \begin{cases} 7 & x < 126 \\ 7 - \frac{7\left(\frac{x}{180} - .7\right)}{.3} & 126 \le x < 180 \\ .25\left(-2\left(\frac{x-180}{90} - \frac{2^v-1}{2^v}\right)2^v + \cos\left(3\pi\left(\frac{x-180}{90} - \frac{2^v-1}{2^v}\right)2^v\left(\left(\frac{x-180}{90} - \frac{2^v-1}{2^v}\right)2^v\right)^{0.4}\right) + 3\right)(6-v) + v + 1 & 180 \le x < 270 \\ 7 & 270 \le x < 300 \\ v + 1 & 300 \le x < 420 \\ 7 & 420 \le x < 450 \\ .25\left(-2\left(\left|\frac{x-540}{90}\right| - \frac{2^v-1}{2^v}\right)2^v + \cos\left(3\pi\left(\left|\frac{x-540}{90}\right| - \frac{2^v-1}{2^v}\right)2^v\left(\left(\left|\frac{x-540}{90}\right| - \frac{2^v-1}{2^v}\right)2^v\right)^{0.4}\right) + 3\right)(6-v) + v + 1 & 450 \le x < 540 \\ \frac{7\,(x-540)}{54} & 540 \le x < 594 \\ 7 & x \ge 594 \end{cases} \bigwedge$$

$$l = \begin{cases} 7 - \frac{7x}{54} & x < 54 \\ 0 & 54 \le x < 180 \\ .25\left(-2\left(\frac{x-180}{90} - \frac{2^v-1}{2^v}\right)2^v + \cos\left(3\pi\left(\frac{x-180}{90} - \frac{2^v-1}{2^v}\right)2^v\left(\left(\frac{x-180}{90} - \frac{2^v-1}{2^v}\right)2^v\right)^{0.4}\right) + 3\right)(7-v) + v & 180 \le x < 270 \\ 0 & 270 \le x < 300 \\ v + 1 & 300 \le x < 420 \\ 0 & 420 \le x < 450 \\ .25\left(-2\left(\left|\frac{x-540}{90}\right| - \frac{2^v-1}{2^v}\right)2^v + \cos\left(3\pi\left(\left|\frac{x-540}{90}\right| - \frac{2^v-1}{2^v}\right)2^v\left(\left(\left|\frac{x-540}{90}\right| - \frac{2^v-1}{2^v}\right)2^v\right)^{0.4}\right) + 3\right)(7-v) + v & 450 \le x < 540 \\ 0 & 540 \le x < 666 \\ \frac{7\left(\frac{x-540}{180} - .7\right)}{.3} & x \ge 666 \end{cases} \bigwedge \text{PDF(Y)} = \begin{cases} 0 & x < l \\ \frac{1}{u-l} & l \le x \le u; \\ 0 & x > u \end{cases}$$

7) $$z = \begin{cases} \begin{cases} 1 & x < 180\left(.4 - \frac{.2\,Y}{7}\right) \\ .5\cos\left(\frac{\pi\left(\frac{x}{180} - \left(.2\left|\frac{Y}{7} - 1\right| + .2\right)\right)}{\frac{.2\,Y}{7} + .1}\right) + .5 & 180\left(.4 - \frac{.2\,Y}{7}\right) \le x < 90 \\ .5\cos\left(\frac{\pi\left(\frac{x}{180} - \left(\frac{.2\,Y}{7} + .2\right)\right)}{.2\left|\frac{Y}{7} - 1\right| + .1}\right) + .5 & 90 \le x < 180\left(.6 + .2\left|\frac{Y}{7} - 1\right|\right) \\ 1 & x \ge 180\left(.6 + .2\left|\frac{Y}{7} - 1\right|\right) \end{cases} & x < 180 \\ \left|\frac{Y}{7} - 1\right| & 180 \le x < 270 \\ \left|\frac{Y}{7} - 1\right|\left|\left(\frac{x-270}{30} - 2\right)^2 - 1\right| & 270 \le x < 300 \\ \begin{cases} .5\left(\cos\left(4\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & Y < 1 \\ .5\left(\cos\left(6\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & 1 \le Y < 2 \\ .5\left(\cos\left(10\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & 2 \le Y < 3 \\ .5\left(\cos\left(14\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & 3 \le Y < 4 \\ .5\left(\cos\left(22\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & 4 \le Y < 5 \\ .5\left(\cos\left(26\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & 5 \le Y < 6 \\ .5\left(\cos\left(34\left(\frac{x-300}{120}\right)\pi - \pi\right) + 1\right) & Y \ge 6 \end{cases} & 300 \le x < 420\,; \\ \left|\frac{Y}{7} - 1\right|\left|\left|\frac{x-420}{30}\right|^2 - 1\right| & 420 \le x < 450 \\ \left|\frac{Y}{7} - 1\right| & 450 \le x < 540 \\ \begin{cases} 1 & x < 540 + 180\left(.4 - .2\left|\frac{Y}{7} - 1\right|\right) \\ .5\cos\left(\frac{\pi\left(\frac{x-540}{180} - \left(\frac{.2\,Y}{7} + .2\right)\right)}{.2\left|\frac{y}{7} - 1\right| + .1}\right) + .5 & 540 + 180\left(.4 - .2\left|\frac{Y}{7} - 1\right|\right) \le x < 630 \\ 0.5\cos\left(\frac{\pi\left(\frac{x-540}{180} - \left(0.2\left|\frac{Y}{7} - 1\right| + 0.2\right)\right)}{\frac{0.2\,Y}{7} + 0.1}\right) + 0.5 & 630 \le x < 540 + 180\left(.6 + \frac{.2\,Y}{7}\right) \\ 1 & x \ge 540 + 180\left(.6 + \frac{.2\,Y}{7}\right) \end{cases} & x \ge 540 \end{cases}$$

**8)**

$$\text{A such that } u = \begin{cases} (.75\,z + .05) + (.16\,z + .04) & x < 180 \\ (.4\,z + .4) + (.1\,z + .1) & 180 \le x < 300 \\ (.7\,z + .1) + (.15\,z + .05) & 300 \le x < 420 \\ (.4\,z + .4) + (.1\,z + .1) & 420 \le x < 540 \\ (.75\,z + .05) + (.16\,z + .04) & x \ge 540 \end{cases} \bigwedge l = \begin{cases} (.75\,z + .05) - (.16\,z + .04) & x < 180 \\ (.4\,z + .4) - (.1\,z + .1) & 180 \le x < 300 \\ (.7\,z + .1) - (.15\,z + .05) & 300 \le x < 420 \\ (.4\,z + .4) - (.1\,z + .1) & 420 \le x < 540 \\ (.75\,z + .05) - (.16\,z + .04) & x \ge 540 \end{cases} \bigwedge \text{PDF(A)} = \begin{cases} 0 & x < l \\ \frac{1}{u-l} & l \le x \le u; \\ 0 & x > u \end{cases}$$

**9)**

$$\text{D such that } u = \begin{cases} (7.8\,z + .2) + \left(\left(2 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & x < 180 \\ (3.8\,z + .2) + \left(\left(1 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & 180 \le x < 300 \\ \left(\left(\frac{8}{v+1} - .2\right) z + .2\right) + \left(\left(\frac{2}{v+1} - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & 300 \le x < 420 \\ (3.8\,z + .2) + \left(\left(1 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & 420 \le x < 540 \\ (7.8\,z + .2) + \left(\left(2 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & x \ge 540 \end{cases} \bigwedge$$

$$l = \begin{cases} (7.8\,z + .2) - \left(\left(2 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & x < 180 \\ (3.8\,z + .2) - \left(\left(1 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & 180 \le x < 300 \\ \left(\left(\frac{8}{v+1} - .2\right) z - .2\right) + \left(\left(\frac{2}{v+1} - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & 300 \le x < 420 \\ (3.8\,z + .2) - \left(\left(1 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & 420 \le x < 540 \\ (7.8\,z + .2) - \left(\left(2 - \left(.2 - \frac{1}{7}\right)\right) z + \left(.2 - \frac{1}{7}\right)\right) & x \ge 540 \end{cases} \bigwedge \text{PDF(D)} = \begin{cases} 0 & x < l \\ \frac{1}{u-l} & l \le x \le u; \\ 0 & x > u \end{cases}$$

**10)**

timestamp = $x$ (seconds);
frequency = $2^{Y} * 32.70317$;
peak amplitude = $A$;
duration = D;

**11)**

$$increment = \begin{cases} \text{D} & x + \text{D} < 180 - 180\,\text{R} \\ 270 - 90\,(.5^{v}) - x & 180 - 180\,\text{R} \le x + \text{D} < 270 - 90\,(.5^{v}) \\ \text{D} & 270 - 90\,(.5^{v}) \le x + \text{D} < 420 + 90\,(.5^{v}) \\ 540 + 180\,R - x & 420 + 90\,(.5^{v}) \le x + \text{D} < 540 + 180\,R \\ \text{D} & x \ge 540 + 180\,R \end{cases};$$

**12)**

$x = x + increment;$
}
}

**The above process is run twice. Once for the electronic accompaniment and then another time for part extraction for the part extraction of the acoustic instruments (see Part Extraction Algorithm which is not notated here). Finally, a percussion part is added to highlight parts of the piece. The tone information for the percussion part is listed below.**

**Added Percussion Tones**

**{0.0, 180.0, gong}, {540.0, 180.0, gong}, {0.0, C-8}, {90.0, C-8}, {180.0, C-8}, {225.0, C-8}, {247.5, C-8}, {258.75, C-8}, {264.375, C-8}, {267.1875, C-8}, {268.59375, C-8}, {540.0, C-8}, {495.0, C-8}, {472.5, C-8}, {461.25, C-8}, {455.625, C-8}, {452.8125, C-8}, {451.40625, C-8}, {270.0, C-1}, {270.0, C-2}, {270.0, C-3}, {270.0, C-4}, {270.0, C-5}, {270.0, C-6}, {270.0, C-7}, {270.0, C-8}, {300.0, C-1}, {300.0, C-2}, {300.0, C-3}, {300.0, C-4}, {300.0, C-5}, {300.0, C-6}, {300.0, C-7}, {300.0, C-8}, {420.0, C-1}, {420.0, C-2}, {420.0, C-3}, {420.0, C-4}, {420.0, C-5}, {420.0, C-6}, {420.0, C-7}, {420.0, C-8}, {450.0, C-1}, {450.0, C-2}, {450.0, C-3}, {450.0, C-4}, {450.0, C-5}, {450.0, C-6}, {450.0, C-7}, {450.0, C-8}, {360.0, C-1}, {360.0, C-2}, {340.0, C-2}, {340.0, C-3}, {380.0, C-2}, {380.0, C-3}, {324.0, C-3}, {324.0, C-4}, {348.0, C-3}, {348.0, C-4}, {372.0, C-3}, {372.0, C-4}, {396.0, C-3}, {396.0, C-4}, {317.14285714285717, C-4}, {317.14285714285717, C-5}, {334.2857142857143, C-4}, {334.2857142857143, C-5}, {351.42857142857144, C-4}, {351.42857142857144, C-5}, {368.57142857142856, C-4}, {368.57142857142856, C-5}, {385.7142857142857, C-4}, {385.7142857142857, C-5}, {402.8571428571429, C-4}, {402.8571428571429, C-5}, {310.90909090909093, C-5}, {310.90909090909093, C-6}, {321.8181818181818, C-5}, {321.8181818181818, C-6}, {332.72727272727275, C-5}, {332.72727272727275, C-6}, {343.6363636363636, C-5}, {343.6363636363636, C-6}, {354.54545454545456, C-5}, {354.54545454545456, C-6}, {365.45454545454544, C-5}, {365.45454545454544, C-6}, {376.3636363636364, C-5}, {376.3636363636364, C-6}, {387.27272727272725, C-5}, {387.27272727272725, C-6}, {398.1818181818182, C-5}, {398.1818181818182, C-6}, {409.0909090909091, C-5}, {409.0909090909091, C-6}, {309.2307692307692, C-6}, {309.2307692307692, C-7}, {318.46153846153845, C-6}, {318.46153846153845, C-7}, {327.6923076923077, C-6}, {327.6923076923077, C-7}, {336.9230769230769, C-6}, {336.9230769230769, C-7}, {346.15384615384613, C-6}, {346.15384615384613, C-7}, {355.38461538461536, C-6}, {355.38461538461536, C-7}, {364.61538461538464, C-6}, {364.61538461538464, C-7}, {373.8461538461538, C-6}, {373.8461538461538, C-7}, {383.0769230769231, C-6}, {383.0769230769231, C-7}, {392.3076923076923, C-6}, {392.3076923076923, C-7}, {401.53846153846155, C-6}, {401.53846153846155, C-7}, {410.7692307692308, C-6}, {410.7692307692308, C-7}, {307.05882352941177, C-7}, {307.05882352941177, C-8}, {314.11764705882354, C-7}, {314.11764705882354, C-8}, {321.1764705882353, C-7}, {321.1764705882353, C-8}, {328.2352941176471, C-7}, {328.2352941176471, C-8}, {335.29411764705884, C-7}, {335.29411764705884, C-8}, {342.3529411764706, C-7}, {342.3529411764706, C-8}, {349.4117647058824, C-7}, {349.4117647058824, C-8}, {356.47058823529414, C-7}, {356.47058823529414, C-8}, {363.52941176470586, C-7}, {363.52941176470586, C-8}, {370.5882352941177, C-7}, {370.5882352941177, C-8}, {377.6470588235294, C-7}, {377.6470588235294, C-8}, {384.70588235294116, C-7}, {384.70588235294116, C-8}, {391.7647058823529, C-7}, {391.7647058823529, C-8}, {398.8235294117647, C-7}, {398.8235294117647, C-8}, {405.88235294117646, C-7}, {405.88235294117646, C-8}, {412.94117647058823, C-7}, {412.94117647058823, C-8}, {540.0, C-8}, {630.0, C-8}, {720.0, C-8};**

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Percussion

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Percussion

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Percussion

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Percussion

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Percussion

**25** **of nothing**

101

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Percussion

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Percussion

**27 of nothing**

109

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Percussion

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Percussion

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Percussion

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Percussion

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Percussion

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Percussion