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Residual Ramifications: A Collection of Etudes Composed Using Residue Cycles
of Fibonacci Series Modulo m as Serial Tools

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Abstract

Residual Ramifications: A Collection of Etudes Composed Using Residue Cycles
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This dissertation contains sixteen original pieces of music written for a wide variety of ensembles, with representatives from every instrumental family (including electronics). Each short piece in the collection is an intense compositional study using a range of new serial methods. The basis for all serial techniques employed in the dissertation derives from Fibonacci series. In its natural state, the Fibonacci series of numbers $(0, 1, 1, 2, 3, 5, 8, \dots, F_{n-1} + F_{n-2})$ is limited in musical usefulness due to its rapid growth toward extremely large numbers (e.g., $F_{12} = 144$ and $F_{24} = 46368$). A more practical set of numbers emerges, however, by reducing each integer in the series to its residue (i.e., by taking modulus m , the remainder after division by m). As a rule, these residues form a repeating cycle of integers no matter how large the Fibonacci numbers become. Residue cycles can be derived from any general Fibonacci series (starting with any two positive integers less than m) for all positive integers m , thus providing a profusion of useful number sets. As demonstrated in this

dissertation, each $\text{Fib}(\text{mod } m)$ cycle, rich in mathematical relations, has the potential to create a particular musical persona. Traditional twelve-tone serialism has been avoided in favor of new alternatives for mapping numbers to musical parameters. The goal of this dissertation was to compose a set of pieces, ultimately accessible, rooted in rigorous serial schemes.

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INTRODUCTION

This collection of sixteen original pieces contains music composed for a wide variety of ensembles, with representatives from every instrumental family:

- I – piano solo
- II – ensemble (four or more players – see performance notes)
- III – computer-realized sound (quadraphonic – see performance notes)
- IV – double woodwind quintet (4 fl., 2 ob., 2 cl., 2 bsn.)
- V – viola sextet
- VI – counter-tenor, tenor, baritone
- VII – ensemble (four or more players – see performance notes)
- VIII – flute, glockenspiel, vibraphone, piano
- IX – piano solo and live electronics (see performance notes)
- X – guitar duet
- XI – flute, glockenspiel, vibraphone, piano
- XII – counter-tenor, tenor, baritone
- XIII – trombone quintet
- XIV – double woodwind quintet (4 fl., 2 ob., 2 cl., 2 bsn.)
- XV – guitar duet
- XVI – ensemble (four or more players – see performance notes)

Performance notes are included for the two pieces involving electronics (III and IX) and for the three open ensemble pieces (II, VII, and XVI). Etude III is written for computer-realized sound and therefore has no physical score. Instead, the page of performance notes (Performance Notes for III on page 13) explains the use of the sound files and other files found on the Pocket Material CD. The Pocket Material CD also contains the necessary computer programs for the piano and live electronics piece (see Performance Notes for IX on page 81).

This collection of short pieces is the result of extensive research into the mathematical properties and musical potential of Fibonacci series modulo m . All sixteen pieces were composed using a variety of new serial techniques based

on cycles of integers that arise from taking the modulus of a series of Fibonacci numbers. These integer cycles have been called residue cycles since each number in a cycle is the residue (or remainder after division by m) of each number in a Fibonacci series.

Due to the recursive definition of a Fibonacci series (i.e., the next number in the series equals the sum of the previous two numbers, or $F_n = F_{n-1} + F_{n-2}$), consecutive integers grow rapidly to extremely large numbers. For example, $F_{12} = 144$ whereas, just twelve integers later, $F_{24} = 46368$. When reducing a Fibonacci series to its residue cycle by taking modulus m of each integer, the series becomes, as a rule, a repeating cycle no matter how large the Fibonacci numbers grow. This special property increases the utility of Fibonacci series as serial tools for music composition. Residue cycles, moreover, can be derived from any general Fibonacci series (starting with any two positive integers less than m) for all positive integers m , thus providing a profusion of useful number sets.

Rich in mathematical relations, the order of numbers within a residue cycle provides the main inspiration for various serial schemes throughout the collection. While traditional twelve-tone serialism has been avoided, new methods of mapping numbers to musical parameters are used to create pieces that encapsulate particular personae exhibited by the residue cycles and are ultimately accessible.

I

for M.P.N.

 $\text{♩} = \text{ca } 160$

Piano

The first system of the musical score consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The music begins with a dynamic marking of *mf*. The first measure contains a chord with a sharp sign above it. The second measure has a dynamic marking of *p*. The third measure has a dynamic marking of *mf* and a flat sign below the bass staff. The fourth measure has a dynamic marking of *p*. The system ends with a final chord in the upper staff.

9

The second system of the musical score consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The music begins with a dynamic marking of *mf*. The first measure has a sharp sign above the bass staff. The second measure has a dynamic marking of *p*. The third measure has a dynamic marking of *mp*. The fourth measure has a dynamic marking of *mf*. The fifth measure has a dynamic marking of *p*. The sixth measure has a dynamic marking of *f*. The system ends with a final chord in the upper staff.

17

The third system of the musical score consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The music begins with a dynamic marking of *mf*. The first measure has a flat sign above the bass staff. The second measure has a dynamic marking of *p*. The third measure has a dynamic marking of *mf*. The fourth measure has a dynamic marking of *p*. The fifth measure has a dynamic marking of *mf*. The sixth measure has a dynamic marking of *p*. The system ends with a final chord in the upper staff.

24

The fourth system of the musical score consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The music begins with a dynamic marking of *mf*. The first measure has a sharp sign above the bass staff. The second measure has a dynamic marking of *p*. The third measure has a dynamic marking of *mf*. The fourth measure has a dynamic marking of *p*. The fifth measure has a dynamic marking of *mf*. The sixth measure has a dynamic marking of *p*. The system ends with a final chord in the upper staff.

32

Musical score for measures 32-39. The system consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The key signature has one sharp (F#). The music features a mix of eighth and sixteenth notes, with some slurs and accents. Measure 32 starts with a treble clef and a sharp sign, followed by a series of eighth notes in both staves. The piece concludes with a double bar line at the end of measure 39.

40

Musical score for measures 40-48. The system consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The key signature has one sharp (F#). The music continues with eighth and sixteenth notes, including slurs and accents. Measure 40 begins with a treble clef and a sharp sign. The system ends with a double bar line at the end of measure 48.

49

Musical score for measures 49-57. The system consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The key signature has one sharp (F#). The music continues with eighth and sixteenth notes, including slurs and accents. Measure 49 begins with a treble clef and a sharp sign. The system ends with a double bar line at the end of measure 57.

58

Musical score for measures 58-65. The system consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The key signature has one sharp (F#). The music continues with eighth and sixteenth notes, including slurs and accents. Measure 58 begins with a treble clef and a sharp sign. The system ends with a double bar line at the end of measure 65.

66

Musical score for measures 66-73. The system consists of two staves. The upper staff is in treble clef and the lower staff is in bass clef. The key signature has one sharp (F#). The music continues with eighth and sixteenth notes, including slurs and accents. Measure 66 begins with a treble clef and a sharp sign. The system ends with a double bar line at the end of measure 73.

II

5"

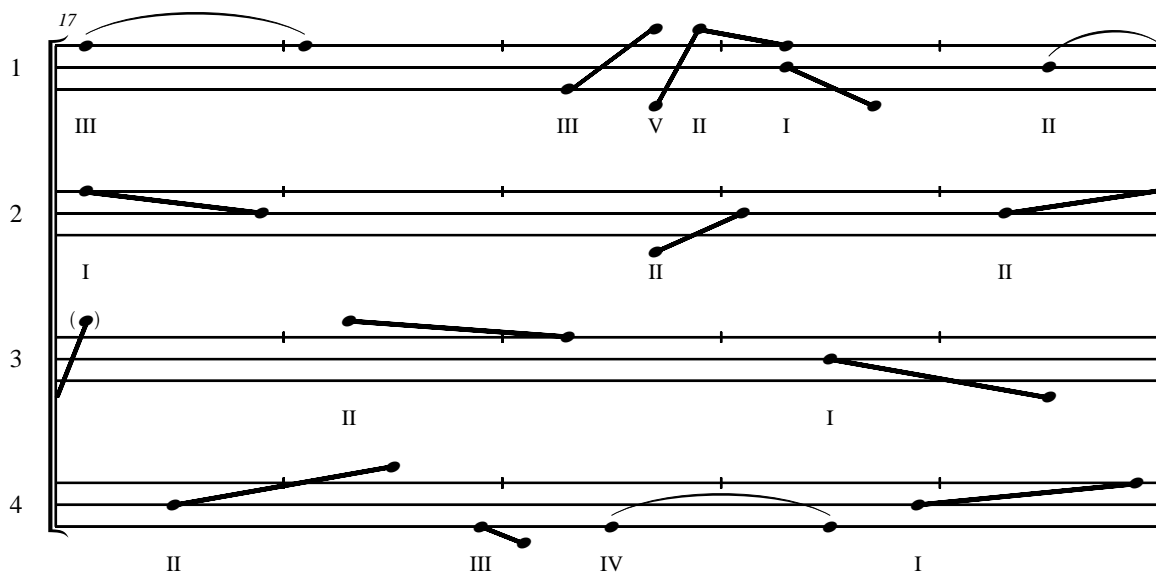
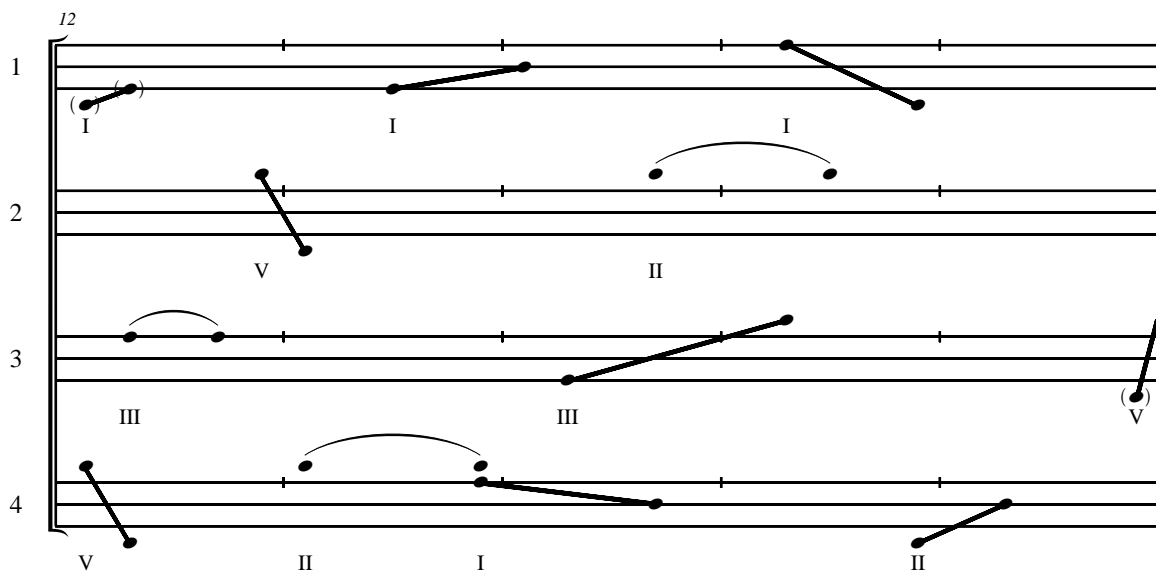
Part 1
Part 2
Part 3
Part 4

This musical score consists of four staves labeled Part 1, Part 2, Part 3, and Part 4. A bracket above the first measure indicates a width of 5 inches. The notation includes various note values, stems, and beams. Roman numerals 'I' are placed below the notes in several measures. Part 1 has notes on the top staff with stems pointing down. Part 2 has notes on the second staff with stems pointing up and down. Part 3 has notes on the third staff with stems pointing up and down. Part 4 has notes on the bottom staff with stems pointing up and down.

7

1
2
3
4

This musical score consists of four staves labeled 1, 2, 3, and 4. A bracket above the first measure indicates a width of 7 measures. The notation includes various note values, stems, and beams. Roman numerals 'I' and 'III' are placed below the notes in several measures. Staff 1 has notes on the top staff with stems pointing down. Staff 2 has notes on the second staff with stems pointing up and down. Staff 3 has notes on the third staff with stems pointing up and down. Staff 4 has notes on the bottom staff with stems pointing up and down.



Performance Notes for II

- This piece is written for at least four players, playing any instrument(s) capable of performing glissandos across the entire range of the instrument. When there are more than four players, the ensemble should distribute the parts as uniformly as possible.
- Each line on the three-lined staff represents three midpoints of the instrument's frequency range: the top line represents the midpoint of the high range; the middle line represents the midpoint of the entire range; and the bottom line represents the midpoint of the low range. Hence, if a figure begins above the top line and ends below the bottom line, the player will have traversed the entire range of the instrument from the highest extremity to the lowest extremity.
- The Roman numerals (I-V) should be predetermined by each player to correspond to five distinct timbral aspects the instrument is capable of producing. For example, a vocalist might choose to sing on five distinct syllables.
- Throughout the piece, a notehead signals the beginning and end of a glissando (two noteheads connected by a downward or upward sloping line) or a sustained note (two tied noteheads). Glissandos with noteheads in parentheses should be produced by an alternate means (e.g., whistling) not related to the instrument.

- The progress of time is indicated by “ticks” through the top line of each staff, each tick marking the passage of five seconds. Glissandos should be performed as a continuous change in frequency from the beginning to the end of a figure. Thus, the speed of the glissando is determined by the slope of the line.

Performance Notes for III

- This piece is written for quadraphonic computer-realized sound, thus there is no physical score. It has been composed in the computer music programming languages CSound and Common Music.
- The Pocket Material CD includes, in the “Residual-3” folder, four separate monophonic audio files (*Residual-3-1.wav*, *Residual-3-2.wav*, *Residual-3-3.wav*, and *Residual-3-4.wav*) and two source code files (*Residual-3.csd* and *Residual-3.lisp*).
- The four *.wav* files are for each of the four speaker channels: 1, the front left channel; 2, the front right channel; 3, the back left channel; and 4, the back right channel. These audio files can be used directly to perform the piece (recommended).
- The *.csd* file can be used to render the piece in real-time (or to a file) in an appropriate CSound environment (see <http://csounds.com>). *Residual-3.lisp* is the Common Music lisp code that generates the notes in the score file for the CSound code and has been included for reference purposes. These source code files may need to be opened in a text editor and copied to a new project.

Score in C

IV

♩ = 152

The musical score for measures 14-17 is arranged in a system of ten staves. The instruments and their parts are as follows:

- Flute 1A:** Active in measures 14-17. Dynamics: *mf* (measures 14-15), *f* (measure 16), *mf* (measure 17). Includes a crescendo hairpin from measure 16 to 17 and an accent (>) on the final note of measure 17.
- Flute 2A:** Silent throughout.
- Oboe A:** Active in measures 14-17. Dynamics: *mf* (measures 14-15), *f* (measure 16), *mf* (measure 17). Includes a crescendo hairpin from measure 16 to 17 and an accent (>) on the final note of measure 17.
- Clarinet in B♭ A:** Silent throughout.
- Bassoon A:** Active in measures 14-17. Dynamics: *mf* (measures 14-15), *f* (measure 16), *mf* (measure 17). Includes a crescendo hairpin from measure 16 to 17 and an accent (>) on the final note of measure 17.
- Flute 1B:** Silent throughout.
- Flute 2B:** Silent throughout.
- Oboe B:** Silent throughout.
- Clarinet in B♭ B:** Silent throughout.
- Bassoon B:** Silent throughout.

5

Ob. A *mf* *f*

B♭ Cl. A *mf* *f*

Ob. B *mf* *f* *mf*

10

Ob. A *mf*

B♭ Cl. A *mf*

Fl. 1B *mp* *f*

Ob. B *mp* *f* *mp*

Bsn. B *mp* *f* *mp*

14

Fl. 2A

Ob. A

Fl. 1B

Ob. B

Bsn. B

19

Fl. 1A

Fl. 2A

Ob. A

Bsn. A

Ob. B

23

Fl. 1A

Ob. A

Bsn. A

Ob. B

ff *p* *ff* *p*

Detailed description: This system covers measures 23 to 27. Fl. 1A (treble clef) has a melodic line with dynamics *ff* at measure 24 and *p* at measure 27. Ob. A (treble clef) is silent. Bsn. A (bass clef) has a rhythmic accompaniment with dynamics *ff* at measure 24 and *p* at measure 27. Ob. B (treble clef) has a melodic line with dynamics *ff* at measure 24 and *p* at measure 27. Slurs and accents are present throughout.

28

Fl. 1A

Ob. A

Bsn. A

Ob. B

B♭ Cl. B

f *mp* *f* *mp* *mp* *mf*

Detailed description: This system covers measures 28 to 32. Fl. 1A (treble clef) has a melodic line with dynamics *f* at measure 28 and *mp* at measure 30. Ob. A (treble clef) is silent until measure 29, then has a melodic line with dynamics *mp* at measure 30. Bsn. A (bass clef) has a rhythmic accompaniment with dynamics *f* at measure 28. Ob. B (treble clef) has a melodic line with dynamics *f* at measure 28 and *mp* at measure 30. B♭ Cl. B (bass clef) has a melodic line with dynamics *mp* at measure 30 and *mf* at measure 32. Slurs and accents are present throughout.

V

for C.T.A.

$\text{♩} = 58$ when necessary, change strings as imperceptibly as possible

The musical score consists of six staves, each labeled Viola 1 through Viola 6. The time signature is 4/4. The key signature has one flat (B-flat). The dynamic marking *ppp* is present at the beginning of each staff. The notation includes various note values, rests, and slurs. Viola 1 and 2 are in alto clef, Viola 3 is in soprano clef, and Viola 4, 5, and 6 are in soprano clef. Viola 5 has a unique articulation with a horizontal line under each note. Viola 4 has a double bar line in the middle of the staff.

9

Vla. 1
Vla. 2
Vla. 3
Vla. 4
Vla. 5
Vla. 6

The image shows a musical score for six violas, labeled Vla. 1 through Vla. 6. The score is organized into six staves, each with a clef and a key signature of one flat (B-flat). A measure number '9' is positioned at the top left. The music consists of a series of notes and rests across six measures. Vla. 1 and Vla. 2 are in bass clef, while Vla. 3, Vla. 4, Vla. 5, and Vla. 6 are in treble clef. The notes are connected by slurs, and there are various rests throughout the piece. The notation includes eighth notes, quarter notes, and half notes, with some notes beamed together. The overall structure is a single melodic line for each instrument, with some overlapping notes between adjacent staves.

16

Vla. 1

Vla. 2

Vla. 3

Vla. 4

Vla. 5

Vla. 6

Detailed description of the musical score: The score consists of six staves, each labeled from Vla. 1 to Vla. 6. Vla. 1 is in bass clef and begins with a measure rest, then plays a series of notes with slurs and ties. Vla. 2-6 are in treble clef. Vla. 2 has a staccato marking on its first note. Vla. 3-6 have various melodic lines with slurs and ties. The music is written in a common time signature, and the key signature has one flat. The score is a page from a larger work, as indicated by the measure number 16 at the top left.

23

Vla. 1

Vla. 2

Vla. 3

Vla. 4

Vla. 5

Vla. 6

The image displays a musical score for six violas, labeled Vla. 1 through Vla. 6. The score is written on six staves, each with a treble clef. The music begins at measure 23, indicated by a small '23' above the first staff. The notation includes various note values (quarter, eighth, and sixteenth notes), rests, and slurs. Vla. 1 starts with a half note G4, followed by a quarter rest, then a quarter note G4, and a half note G4. Vla. 2 starts with a quarter note G4, followed by a quarter note G4, a quarter note F4, and a quarter note E4. Vla. 3 starts with a quarter note G4, followed by a quarter note G4, a quarter note F4, and a quarter note E4. Vla. 4 starts with a quarter note G4, followed by a quarter note G4, a quarter note F4, and a quarter note E4. Vla. 5 starts with a quarter note G4, followed by a quarter note G4, a quarter note F4, and a quarter note E4. Vla. 6 starts with a quarter note G4, followed by a quarter note G4, a quarter note F4, and a quarter note E4. The score continues for several measures, with each staff showing a different melodic line. The notation is clear and professional, typical of a printed musical score.

VI

$\text{♩} = 76$

Counter-Tenor
ze - ro four four four four twen-ty - one

Tenor
ze - ro four four four four eigh-teen eight five

Baritone
ze - ro four four four four six-teen se - ven five four

CTen.
nine four four four four twen-ty - one nine four four four

T
four four four four eigh-teen eight five four four four four

B
four four four six-teen se - ven five four four four four

CTen.
four nine - teen eight five four four four four

T
ten three five four four four four eight

B
four - teen eight five four four four four two three

17 *f*

C.Ten. *f* *f*

se-ven-teen nine four four four four thir-teen eight five four four

T *f*

five four four four four two three five four four four

B *f*

five four four four four twelve six three five four four

23 *f* *f* *f*

C.Ten. *f* *f* *f*

four four se-ven five four four four four three five

T *f* *f* *f*

four six three five four four four four four four

B *f* *f* *f*

four four ten three five four four four four twen-ty -

29 *f* *f* *f*

C.Ten. *f* *f* *f*

four four four four nine-teen eight five four four four four

T *f* *f* *f*

four four ten three five four four four four four-teen

B *f* *f* *f*

two nine four four four four four-teen eight five four four

VII

♩ = 169 - 200

Part 1

Part 2

Part 3

Part 4

sfz f sfz f

sfz f sfz f

sfz f sfz f

sfz f sfz f

P1

P2

P3

P4

3 sfz f sfz f long

sfz f sfz f long

sfz f sfz f long

sfz f sfz f long

5

P1

sempre f

P2

sempre f

P3

sempre f

P4

sempre f

This musical system covers measures 5 and 6. Part P1 (top) begins with a fermata over a dotted quarter note, followed by eighth-note chords. Part P2 (second) starts with a quarter rest, then eighth-note chords. Part P3 (third) starts with a quarter rest, then eighth-note chords. Part P4 (bottom) plays a continuous eighth-note accompaniment throughout both measures. The dynamic marking *sempre f* is present in each part.

7

P1

P2

P3

P4

This musical system covers measures 7 and 8. Part P1 (top) starts with a quarter rest, then eighth-note chords. Part P2 (second) plays a continuous eighth-note accompaniment in measure 7, then eighth-note chords in measure 8. Part P3 (third) begins with a fermata over a dotted quarter note, followed by eighth-note chords. Part P4 (bottom) starts with a quarter rest, then eighth-note chords. The dynamic marking *sempre f* is present in each part.

Performance Notes for VII

- This piece is written for at least four players, playing any instrument(s) capable of making four separate sounds. When there are more than four players, the ensemble should distribute the parts as uniformly as possible.
- Each space on the five-lined staff represents one of four sounds a player can make. These sounds should be different in at least one aspect (e.g., pitch, timbre, instruments, etc.) aside from volume, which should be *forte* throughout unless otherwise marked.
- The top space on a player's staff should represent the "highest" (in some aspect) of the four sounds; the bottom space on a player's staff should represent the "lowest" (in some aspect) of the four sounds; and so on.
- If using instruments that can be ranked from "highest" to "lowest" (in some aspect): Part 1 should be played by the "highest" of the four instruments; Part 4 should be played by the "lowest" of the four instruments; and so on.
- Examples of sound combinations:
 - Two violins, viola, and 'cello each playing, in its respective clef, *pizzicato* pitches as if notated on a traditional five-lined staff.
 - Flute, oboe, clarinet, and bassoon each playing pitches in their high to extreme-high range (for the top-space notes), medium to high range (for the second-space notes), low to medium range (for the third-space notes), and extreme-low to low range (for the bottom-space notes).
 - Electronic instruments using four different types of sound synthesis.

VIII

Flute

$\text{♩} = 96$

p *expressively*

Glockenspiel

$\text{♩} = 96$

p

Vibraphone

Piano

$\text{♩} = 96$

p

Fl.

8

Glk.

8

Vib.

8

Pno.

8

Musical score for measures 16-24, featuring Flute (Fl.), Glockenspiel (Glk.), Vibraphone (Vib.), and Piano (Pno.). The score is in 3/4 time and includes a key signature change to one flat (B-flat) at measure 16. The dynamics are marked *mf* (mezzo-forte) throughout. The Flute part begins with a whole note chord at measure 16, followed by a melodic line starting at measure 17. The Glockenspiel and Vibraphone parts enter at measure 17 with rhythmic patterns. The Piano part provides harmonic support with chords and arpeggiated figures.

Musical score for measures 25-28, featuring Flute (Fl.), Glockenspiel (Glk.), Vibraphone (Vib.), and Piano (Pno.). The score is in 4/4 time and includes a key signature change to one flat (B-flat) at measure 25. The dynamics are marked *f sempre* (fortissimo sempre) throughout. The Flute part begins with a whole note chord at measure 25, followed by a melodic line starting at measure 26. The Glockenspiel and Vibraphone parts enter at measure 26 with rhythmic patterns. The Piano part provides harmonic support with chords and arpeggiated figures.

30

Fl.

Glk.

Vib.

Pno.

32

Fl.

Glk.

Vib.

Pno.

IX

for T.S.

Piano

f (long) *sempre p*

$\text{♩} = 54$

8^{vb}-----
Red. (to mm. 76)

7

14

22

30

Musical notation for measures 30-36. The system consists of a grand staff with a treble clef on the upper staff and a bass clef on the lower staff. The treble staff contains mostly whole rests. The bass staff contains a sequence of notes: a whole note C2, followed by a half note G2, a half note F2, a half note E2, a half note D2, a half note C2, a half note B1, and a half note A1. A slur is placed under the G2, F2, and E2 notes.

37

Musical notation for measures 37-44. The system consists of a grand staff with a treble clef on the upper staff and a bass clef on the lower staff. The treble staff contains mostly whole rests. The bass staff contains a sequence of notes: a half note B1, a half note A1, a half note G1, a half note F1, a half note E1, a half note D1, a half note C1, and a half note B0. A slur is placed under the G1, F1, and E1 notes.

45

Musical notation for measures 45-52. The system consists of a grand staff with a treble clef on the upper staff and a bass clef on the lower staff. The treble staff contains a sequence of notes: a half note B2, a half note A2, a half note G2, a half note F2, a half note E2, a half note D2, a half note C2, and a half note B1. A slur is placed under the B2, A2, and G2 notes. The bass staff contains a sequence of notes: a half note B1, a half note A1, a half note G1, a half note F1, a half note E1, a half note D1, a half note C1, and a half note B0. A slur is placed under the B1, A1, and G1 notes.

53

Musical notation for measures 53-60. The system consists of a grand staff with a treble clef on the upper staff and a bass clef on the lower staff. The treble staff contains a sequence of notes: a half note B2, a half note A2, a half note G2, a half note F2, a half note E2, a half note D2, a half note C2, and a half note B1. A slur is placed under the B2, A2, and G2 notes. The bass staff contains a sequence of notes: a half note B1, a half note A1, a half note G1, a half note F1, a half note E1, a half note D1, a half note C1, and a half note B0. A slur is placed under the B1, A1, and G1 notes.

61

Musical notation for measures 61-68. The system consists of a grand staff with a treble clef on the upper staff and a bass clef on the lower staff. The treble staff contains a sequence of notes: a half note B2, a half note A2, a half note G2, a half note F2, a half note E2, a half note D2, a half note C2, and a half note B1. A slur is placed under the B2, A2, and G2 notes. The bass staff contains a sequence of notes: a half note B1, a half note A1, a half note G1, a half note F1, a half note E1, a half note D1, a half note C1, and a half note B0. A slur is placed under the B1, A1, and G1 notes.

69

(long)

f (long)

8^{vb}-----

L'istesso Tempo ♩ = 108 detached (except where marked)

77

sempre p

* (no pedal)

83

88

94

Performance Notes for IX

- This piece is written for piano and live electronics. The piano is to be prepared with small piezo sensors attached to the strings with poster clay. There are sixteen sensors total which should be applied to the following notes:



- The sensors act as triggers inside a computer music program written in Max/MSP. The Pocket Material CD includes, inside the “Residual-9” folder, all the necessary components to run the program. The file *Residual-9.pat* is the main program to be run in the Max/MSP environment (see <http://cycling74.com>). Be sure to change the File Preferences in Max/MSP so that it is directed to the “Residual-9” folder.
- At the time of this writing, Teleo hardware modules (one “Analog In” module, and one “Multi I/O” module) were used as the interface for transmitting sensor information to the computer. Currently, the makers of Teleo (see <http://makingthings.com>) have discontinued the product, so obtaining the modules in the future may be difficult. The Max/MSP program can be easily modified, however, to accommodate other compatible sensor interfaces.

- *Residual-9.pat* is quite demanding on the computer's processor during operation. At the time of this writing, the piece is performable from a Macintosh MacBook Pro laptop computer running Mac OS X, v. 10.4.8, with a 2.16 GHz Intel Core 2 Duo processor and 2 GB of SDRAM memory.

- Notes about the piano score:
 - Diamond shaped noteheads indicate prepared notes. This serves merely to inform the performer, and treatment of these notes should not be modified in any way.
 - Sensor 0 (attached to the C below middle-C) triggers the beginning, the end, and switches between sections in the middle of the piece.
 - The B section of the piece should be rhythmically coordinated with the electronic sounds. This can be achieved by adjusting the object labeled "B section tempo" (in pink) in the main program.

- Be sure to adjust all pink colored objects inside *Residual-9.pat* to appropriate levels for the intended sound system. If repeat performances with the same sound system are planned, the patches *drone~.pat*, *play-palms.pat*, *back-bank[1-5]-select.pat*, and *play[3, 4, 5, etc.].pat*, in addition to the master faders and B section tempo, can be modified to have specific settings loaded when the program is opened.

X

♩ = 60

8^{va}-----

Guitar 1

mp

Guitar 2

A.H.-----

mp

Guitar 1

T
A
B

<2> <6> <14> <2>

<8>

A.H.-----

Guitar 2

T
A
B

<2> <8> <14>

<6>

6

Gtr. 1

Gtr. 2

mf

Gtr. 1

Gtr. 2

18 18 18 18 18 18 14 14 14

16 16 16 12 12 6 6 6 6 18 18 18

3 3 3

4 4 4

9 ^{8va}-----

Gtr. 1

Gtr. 2

Gtr. 1

Gtr. 2

mp

A.H.-----

12 ^(8va)----- ^{8va}-----

Gtr. 1

Gtr. 2

Gtr. 1

Gtr. 2

A.H.-----

A.H.-----

(8^{va})-----

16

Gtr. 1

f

Gtr. 2

A.H.-----

Gtr. 1

Gtr. 2

20

Gtr. 1

f

Gtr. 2

f

Gtr. 1

Gtr. 2

XI

for R.W.

$\text{♩} = 92$

breathe (drop notes) when necessary

Flute

mp

Glockenspiel

mp

Vibraphone

p

Piano

f

Rec. throughout

Fl.

mf *f*

Glk.

mf

Vib.

mp *mf*

Pno.

f *mp*

f

6

Fl. *mf*

Glk. *f*

Vib. *mp*

Pno. *f*

7

Fl. *mp*

Glk. *mf*

Vib. *mf*

Pno. *mp*

f

Musical score for measures 8-9. The score is for Flute (Fl.), Glockenspiel (Glk.), Vibraphone (Vib.), and Piano (Pno.).

- Fl.:** Measure 8: 8-measure rest, then a melodic line starting on G4, moving up stepwise to D5. Measure 9: Continuation of the melodic line, ending on G4. Dynamics: *f*.
- Glk.:** Measure 8: 8-measure rest. Measure 9: Melodic line starting on G4, moving up stepwise to D5. Dynamics: *mf*.
- Vib.:** Measure 8: Sixteenth-note triplet pattern (G4, A4, B4) repeated six times. Dynamics: *mf*. Measure 9: 8-measure rest, then a chord (G4, B4, D5) in measure 9. Dynamics: *f*.
- Pno.:** Measure 8: 8-measure rest. Measure 9: Melodic line starting on G4, moving up stepwise to D5. Dynamics: *f*. The bass line has a chord (G4, B4, D5) in measure 9. Dynamics: *mf*.

Musical score for measures 10-11. The score is for Flute (Fl.), Glockenspiel (Glk.), Vibraphone (Vib.), and Piano (Pno.).

- Fl.:** Measure 10: Melodic line starting on G4, moving up stepwise to D5. Measure 11: Continuation of the melodic line, ending on G4. Dynamics: *f*.
- Glk.:** Measure 10: 8-measure rest. Measure 11: Melodic line starting on G4, moving up stepwise to D5. Dynamics: *f*.
- Vib.:** Measure 10: Sixteenth-note triplet pattern (G4, A4, B4) repeated six times. Dynamics: *mf*. Measure 11: Continuation of the triplet pattern. Dynamics: *mf*.
- Pno.:** Measure 10: 8-measure rest. Measure 11: Melodic line starting on G4, moving up stepwise to D5. Dynamics: *f*. The bass line has a chord (G4, B4, D5) in measure 11. Dynamics: *mf*.

Musical score for measures 11-12. The score is in 3/4 time and features four staves: Flute (Fl.), Glockenspiel (Glk.), Vibraphone (Vib.), and Piano (Pno.).

- Flute (Fl.):** Measure 11 begins with a first ending bracket (11) over a series of eighth notes. A flat (b) is placed below the first note. The melody continues through measure 12, ending with a fermata.
- Glockenspiel (Glk.):** Measure 11 begins with a first ending bracket (11) over a series of eighth notes, with a flat (b) below the first note. The pattern continues through measure 12, ending with a fermata.
- Vibraphone (Vib.):** Measure 11 is a whole rest. Measure 12 features a chord with a flat (b) and a dynamic marking of *f*, followed by a fermata.
- Piano (Pno.):** Measure 11 begins with a first ending bracket (11) and a piano part starting at measure 8. The piano part consists of a series of eighth notes in triplets, with a dynamic marking of *mf*. Measure 12 features a chord with a flat (b) and a dynamic marking of *f*, followed by a fermata.

Musical score for measures 12-13. The score is in 3/4 time and features four staves: Flute (Fl.), Glockenspiel (Glk.), Vibraphone (Vib.), and Piano (Pno.).

- Flute (Fl.):** Measure 12 begins with a first ending bracket (12) over a series of eighth notes in triplets, with a dynamic marking of *mp*. Measure 13 continues with the triplet pattern, ending with a fermata.
- Glockenspiel (Glk.):** Measure 12 is a whole rest. Measure 13 features a chord with a dynamic marking of *mp*, followed by a fermata.
- Vibraphone (Vib.):** Measure 12 is a whole rest. Measure 13 is a whole rest.
- Piano (Pno.):** Measure 12 begins with a first ending bracket (12) and a piano part starting at measure 8. Measure 12 features a chord with a dynamic marking of *mp*. Measure 13 features a chord with a dynamic marking of *p*, followed by a fermata.

XII

for P.A.F.

$\text{♩} = 92$

f

Counter-Tenor

8

boh coh coh doh foh loh____ poh_

f

Tenor

8

boh coh coh doh foh loh____ poh_

f

Baritone

8

boh coh coh doh foh loh____ poh____ toh

⁶

CTen.

8

____ toh joh zoh hoh goh moh poh voh koh coh loh

T

8

____ toh joh zoh hoh goh moh poh voh koh coh loh

B

8

joh zoh hoh goh moh poh voh koh coh loh moh

¹³

CTen.

8

moh roh yoh____ qoh poh____ boh bay pay

T

8


moh roh yoh____ qoh poh____ boh


B


8

roh yoh____ qoh poh____ boh bay pay pay yay


19

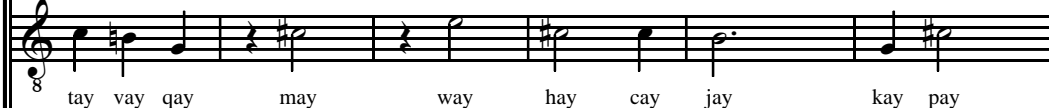
CTen.  pay yay nay may say cay tay vay qay may


T  bay pay pay yay nay may say cay

B  nay may say cay tay vay qay may way


25


CTen.  way hay cay jay kay pay say hay xay


T  tay vay qay may way hay cay jay kay pay

B  hay cay jay kay pay say hay xay day zay


31


CTen.  day zay cay pee qee yee ree mee lee

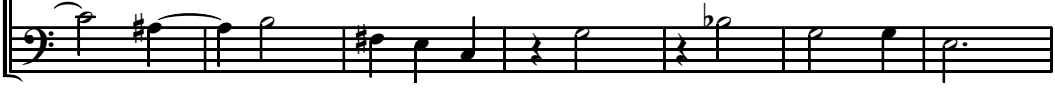
T  say hay xay day zay cay pee qee yee ree

B  cay pee qee yee ree mee lee


38

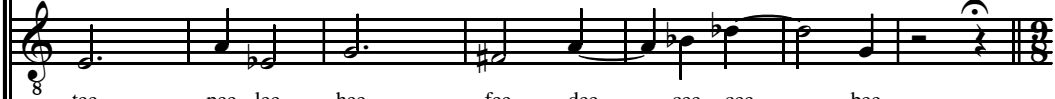
CTen. 
 _ cee_ kee vee pee mee gee hee zee jee tee


T 
 mee lee_ cee_ kee vee pee mee gee hee zee jee

B 
 _ cee_ kee vee pee mee gee hee zee jee tee

45

CTen. 
 pee lee hee fee dee_ cee cee_ bee_

T 
 tee pee lee hee fee dee_ cee cee_ bee

B 
 pee lee hee fee dee_ cee cee_ bee_

$\text{♩} = 132$

52

CTen. 
sing on doo

T 
sing on doo

B 

54

CTen.

T

B

sing on doo

56

CTen.

T

B

58

CTen.

T

B

XIII

for B.R.S.

♩ = 60

Musical score for Trombone 1 through Trombone 5, and Tbn. 1 through Tbn. 5. The score is in 2/4 time and marked *f* (forte). The tempo is indicated as ♩ = 60. The score is divided into two systems. The first system contains staves for Trombone 1 through Trombone 5. The second system contains staves for Tbn. 1 through Tbn. 5. Trombone 5 has a 5-measure rest at the beginning of the second system.

Trombone 1
f

Trombone 2
f

Trombone 3
f

Trombone 4
f

Trombone 5
f

Tbn. 1
5

Tbn. 2

Tbn. 3

Tbn. 4

Tbn. 5

8

Tbn. 1

Tbn. 2

Tbn. 3

Tbn. 4

Tbn. 5

12

Tbn. 1

Tbn. 2

Tbn. 3

Tbn. 4

Tbn. 5

16

Tbn. 1

Tbn. 2

Tbn. 3

Tbn. 4

Tbn. 5

19

Tbn. 1

Tbn. 2

Tbn. 3

Tbn. 4

Tbn. 5

4

Fl. A1
Ob. A
B♭ Cl. A
Bsn. A
Ob. B
Bsn. B

f

f

f

f

f

f

Detailed description: This block contains the musical notation for measures 4, 5, and 6. It features six staves: Fl. A1, Ob. A, B♭ Cl. A, Bsn. A, Ob. B, and Bsn. B. Measures 4 and 5 are mostly rests for all instruments. In measure 6, the Flute A1 and Oboe A parts enter with a melodic line marked *f*. The Bassoon A part also enters with a melodic line marked *f*. The Oboe B and Bassoon B parts have melodic lines starting in measure 4, also marked *f*. The B♭ Clarinet A part has a melodic line starting in measure 6, marked *f*. The dynamic *f* is written below the first notes of the Flute A1, Oboe A, and Bassoon A parts.

7

B♭ Cl. A
Bsn. A
Ob. B
B♭ Cl. B

p

f

p

Detailed description: This block contains the musical notation for measures 7, 8, and 9. It features four staves: B♭ Cl. A, Bsn. A, Ob. B, and B♭ Cl. B. In measure 7, the B♭ Clarinet A and Bassoon A parts have long, sustained notes marked *p*. The Oboe B part has a melodic line starting in measure 8, marked *p*. The B♭ Clarinet B part has a melodic line starting in measure 7, marked *f*. The dynamic *p* is written below the notes of the B♭ Clarinet A and Oboe B parts, and *f* is written below the notes of the B♭ Clarinet B part.

9

FL. A1

FL. A2

B \flat Cl. A

9

FL. B1

FL. B2

Ob. B

B \flat Cl. B

Bsn. B

f

f

f

f

mf

f

p

f

Detailed description: This page of a musical score, numbered 127, contains measures 9, 10, and 11. The score is for a woodwind section and is divided into two systems. The first system includes parts for Flute A1, Flute A2, and Bass Clarinet A. The second system includes parts for Flute B1, Flute B2, Oboe B, Bass Clarinet B, and Bassoon B. Measure 9 is marked with a '9' above the first staff. Dynamics include *f* (forte) and *mf* (mezzo-forte). Flute A1 and A2 have accents (>) on notes in measures 9 and 10. Bass Clarinet A has a crescendo hairpin in measure 9. Flute B1 has a *f* dynamic in measure 10. Flute B2 has a *f* dynamic in measure 9 and a *p* (piano) dynamic in measure 11. Oboe B has a *mf* dynamic in measure 9. Bass Clarinet B and Bassoon B have *f* dynamics in measure 9. Flute B2 has a crescendo hairpin in measure 11. The key signature has two flats, and the time signature is 4/4.

12

Fl. A2

p

Ob. A

p

B♭ Cl. A

p *mf*

Bsn. A

p

12

Fl. B1

f

Fl. B2

mp *p*

B♭ Cl. B

p

p

Detailed description: This page of a musical score, numbered 128, contains measures 12 through 14. The score is arranged in two systems of staves. The first system includes Flute A2, Oboe A, Clarinet A (B-flat), and Bassoon A. The second system includes Flute B1, Flute B2, and Clarinet B (B-flat). Measure 12 shows the Flute A2 and Clarinet A parts with a dynamic of *p*. The Clarinet A part has a crescendo from *p* to *mf*. The Bassoon A part is silent. In measure 13, the Flute B1 part enters with a dynamic of *f*, and the Flute B2 part has a dynamic of *mp*. The Oboe A part has a dynamic of *p*. In measure 14, the Flute B2 part has a dynamic of *p*, and the Clarinet B part has a dynamic of *p*. The Flute A2 part is silent in measure 14.

XV

♩ = 100 (aggressively)

Guitar 1

Guitar 2

f *ff* *p*

f *ff* *p*

Gtr. 1

Gtr. 2

f *ff* *p*

f *ff* *p*

Gtr. 1

Gtr. 2

mf *ff* *mp*

mf *ff* *mp*

Gtr. 1

Gtr. 2

ff *mf* *mf*

f *ff* *mf*

Gtr. 1

Gtr. 2

ff *f* *mf*

ff *f* *mf*

Gtr. 1

Gtr. 2

ff

ff

$\bullet = 92$ (calmly)

Gtr. 1

Gtr. 2

p *mf* *l.v.*

mf

Gtr. 1

Gtr. 2

mf *l.v.*

p

XVI

for R.E.M.

 $\bullet = 120$

Part 1 *p*

Part 2 *p*

Part 3 *p*

Part 4 *p*

Detailed description: This block contains the first two measures of a four-part musical score. Each part is on a five-line staff with a treble clef and a 6/8 time signature. The music consists of eighth notes and rests. Part 1 starts with a quarter rest followed by eighth notes on G4, A4, B4, and C5. Part 2 starts with a quarter rest followed by eighth notes on E4, F4, G4, and A4. Part 3 starts with a quarter rest followed by eighth notes on C4, D4, E4, and F4. Part 4 starts with a quarter rest followed by eighth notes on G3, A3, B3, and C4. A vertical bar line separates the two measures.

1

2

3

4

Detailed description: This block contains the next two measures of the four-part musical score. The notation continues from the previous block. Part 1 has eighth notes on G4, A4, B4, and C5. Part 2 has eighth notes on E4, F4, G4, and A4. Part 3 has eighth notes on C4, D4, E4, and F4. Part 4 has eighth notes on G3, A3, B3, and C4. A vertical bar line separates the two measures. A '3' above the first measure of this block indicates a triplet.

5

Musical score for measures 5 and 6, consisting of four staves (1-4). Measure 5 is marked with a '5' and a brace. The notation includes stems, beams, and flags. Measure 6 features a double bar line and contains two sets of slurs over the staves.

7

Musical score for measures 7 and 8, consisting of four staves (1-4). Measure 7 is marked with a '7' and a brace. The notation includes stems, beams, and flags. Measure 8 continues the notation across the four staves.

9

1 $\frac{6}{4}$ *f*

2 $\frac{6}{4}$ *f*

3 $\frac{6}{4}$ *f*

4 $\frac{6}{4}$ *f*

Detailed description: This block contains the musical notation for measures 9 through 11. It is organized into four staves, numbered 1 to 4. At the beginning of measure 9, there is a fermata over the first staff. The time signature is 6/4. The dynamic marking *f* (forte) is present in each staff. The notation includes various rhythmic values such as eighth and sixteenth notes, rests, and slurs. The first staff has a long horizontal line with a slur underneath it. The second and third staves have similar horizontal lines with slurs. The fourth staff has a long horizontal line with a slur underneath it. The notation continues through measure 11.

12

1

2

3

4

Detailed description: This block contains the musical notation for measures 12 through 14. It is organized into four staves, numbered 1 to 4. The time signature is 6/4. The notation includes various rhythmic values such as eighth and sixteenth notes, rests, and slurs. The first staff has a long horizontal line with a slur underneath it. The second and third staves have similar horizontal lines with slurs. The fourth staff has a long horizontal line with a slur underneath it. The notation continues through measure 14.

16

1 *mp*

2 *mp*

3 *mp*

4 *mp*

20

1

2

3

4

Performance Notes for XVI

- This piece is written for at least four players, playing any instrument(s) capable of being breathed through (string players, percussionists, and anyone else may join the vocalists and perform by simply breathing through their mouths). When there are more than four players, the ensemble should distribute the parts as uniformly as possible.
- The alternative noteheads indicate the following:



Inhalation and exhalation is also denoted by the direction of stems: a down-stem equals an exhale; and an up-stem equals an inhale.

- Breathing is to be performed such that all air passes through the instrument, creating a comfortably audible sound even at the quietest dynamic (this may require a larger or smaller volume of air depending upon the instrument). As the dynamics become louder, a player's instrument (or mouth, or voice) may respond to the sharp blasts of air by squeaking or otherwise. This is to be expected and welcomed.

- While rehearsing this piece, players should be aware of their lung capacity and plan moments to inaudibly replenish or expel extra air in order to avoid having too little air in the lungs when needing to exhale, or too much air in the lungs when needing to inhale (Part 2 should pay particular attention to this from m. 28 to the end).

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VITA

Jonathan Haek (b. 1977) is originally from Portland, Oregon. He has earned a Music Theory Certificate from the University of Washington (2005), an M.M. degree in Composition from the University of Oklahoma (2002), a B.A. degree in Flute Performance from Oregon State University (2000), and a B.S. degree in Mathematical Sciences with a minor in Computer Science from Oregon State University (2000). At the time of this writing, Haek's article "Serial Composition Using Residue Cycles of $\text{Fib}(\text{mod } m)$," an examination of techniques used to compose his dissertation, has been accepted by the journal *Perspectives of New Music* for forthcoming publication. Having collaborated extensively with choreographers at the University of Washington, Haek's music has been performed at various venues in and out of the Seattle area including the Velocity Mainspace Theater, Western Washington University at the American College Dance Festival's Northwest Regional Competition, and most recently at the University of Southern Mississippi. On the CD titled ">3" (Maritime fist glee club 2001), Haek performs free improvisation on the flute and piccolo. This recording emerged from weekly jam sessions with Christian Asplund and Michael Lee, a collaboration called >3 happening from 2000-02. Stemming from an interest in creating graphical user interfaces (GUIs) for exploring new musical territories, Haek has programmed a GUI which simulates a 15-stringed kithara useful for hearing and exploring Ancient Greek Tuning Systems, and another GUI which calculates residue cycles of $\text{Fib}(\text{mod } m)$ and displays various aspects of their structure. An ongoing interest of his is in interactive and computer music composition using Lisp, Common Music, CSound, Max/MSP, Teleo hardware modules, and various non-linear digital editing programs. From 2005-06, Haek served as Visiting Instructor at the University of Oklahoma teaching composition and a variety of music technology courses. Haek has studied composition with John Rahn, Joël-François Durand, and Christian Asplund.