

Reverse Gravity

for three retuned, computer-driven pianos

by Kyle Gann

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Technical Specifications

The 33-pitch tuning of the three pianos (the same in every octave) is as follows, given first in the number of cents above E-flat, and then as ratios to the nearest E-flat 1/1 below:

Piano	1		2		3	
D	1088	15/8	977	225/128	1044	117/64
Db	969	7/4	938	55/32	906	27/16
C	857	105/64	773	25/16	840	13/8
B	738	49/32	755	99/64	729	195/128
Bb	702	3/2	590	45/32	609	91/64
A	551	11/8	551	11/8	481	169/128
Ab	471	21/16	440	165/128	408	81/64
G	386	5/4	320	77/64	342	39/32
Gb	204	9/8	275	75/64	275	75/64
F	155	35/32	192	143/128	192	143/128
E	92	135/128	53	33/32	27	65/64
Eb	0	1/1	1103	121/64	1173	63/32

Note that no string needs to be raised higher than its natural tuning except for the B-flat on piano 1, which is 2¢ sharp (or if one prefers, 2¢ could be subtracted from all quantities).

For electronic realization of the piece, it can prove helpful to reconfigure the tuning as a reference pitch in cycles per second for each piano, and ratios derived from that standard:

Tuning pitch:	38.891 cps	36.7641 cps	38.2833 cps
D	15/8	225/121	13/7
Db	7/4	20/11	12/7
C	105/64	200/121	104/63
B	49/32	18/11	65/42
Bb	3/2	180/121	13/9
A	11/8	16/11	169/126
Ab	21/16	15/11	9/7
G	5/4	14/11	26/21
F#	9/8	150/121	25/21
F	35/32	13/11	143/126
E	135/128	12/11	65/63
Eb	1/1	1/1	1/1

In the configuration of certain tuning softwares, the following sequences might facilitate getting the required tuning:

Piano 1:

38.891 = Eb0

1/1, 135/128, 35/32, 9/8, 5/4, 21/16, 11/8, 3/2, 49/32, 105/64, 7/4, 15/8

Piano 2:

36.7641485 = Eb0

1/1, 12/11, 13/11, 150/121, 14/11, 15/11, 16/11, 180/121, 18/11, 200/121, 20/11, 225/121

Piano 3:

38.283333 = Eb0

1/1, 65/63, 143/126, 25/21, 26/21, 9/7, 169/126, 13/9, 65/42, 104/63, 12/7, 13/7

For purposes of analysis, the entire scale (which I refer to as my 8x8 scale) is given below, grouping its pitches into eight harmonic series' on the 1st, 3rd, 5th, 7th, 9th, 11th, 13th, and 15th harmonics of E-flat, and naming each pitch in a typographical equivalent of Ben Johnston's just-intonation notation:

Pitch name	Ratio	Cents	1/1	3/2	5/4	7/4	9/8	11/8	13/8	15/8
Db^^-	121/64	1103						11		
D	15/8	1088	15	5	3					1
Db13	117/64	1044					13		9	
C#+	225/128	977								15
Db7	7/4	969	7			1				
C^	55/32	938			11			5		
C+	27/16	906		9			3			
C7+	105/64	857				15				7
Cb13	13/8	840	13						1	
B	25/16	773			5					
Bb^	99/64	755					11	9		
Cb77+	49/32	738				7				
Bb13	195/128	729							15	13
Bb	3/2	702	3	1						
Bbb713	91/64	609				13			7	
A+	45/32	590		15	9		5			3
Ab^	11/8	551	11					1		
Abb1313	169/128	481							13	
Ab7+	21/16	471		7		3				
G^	165/128	440						15		11
G+	81/64	408					9			
G	5/4	386	5		1					
Gb13	39/32	342		13					3	
Gb7^	77/64	320				11		7		
F#+	75/64	275			15					5
F+	9/8	204	9	3			1			
Fb13^	143/128	192						13	11	
F7+	35/32	155			7	5				
E+	135/128	92					15			9
Eb^	33/32	53		11				3		
Eb13	65/64	27			13				5	
Eb	1/1	0	1							
Eb7+	63/32	1173				9	7			

In Johnston's notation, + raises a pitch by 81/80, # raises it by 25/24, b lowers it by 24/25, 7 lowers it by 35/36, ^ raises it by 33/32, 13 raises it by 65/64, and F-A-C, C-E-G, and G-B-D are all perfectly tuned 4:5:6 major triads.

Reverse Gravity

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♩ = 72

Piano 1

mf *mf*

p

Piano 2

♩ = 72

mf

Piano 3

p

4

♩ = 70

Pno1

mf *mf*

p

Pno2

p

Pno3

mf *mf*

p

2

6

$\text{♩} = 72$

Pno1

mf

3

Pno2

pp

$\text{♩} = 72$

Pno3

p

8

$\text{♩} = 71$

$\text{♩} = 73$

Pno1

mf

5

3

pp

pp

Pno2

5

3

Pno3

$\text{♩} = 71$

$\text{♩} = 73$

5

3

11 $\text{♩} = 74$ $\text{♩} = 75$ 3

Pno1

Pno2

Pno3

14 $\text{♩} = 72$

Pno1

Pno2

Pno3

Reverse Gravity

16 (b) $\text{♩} = 74$

Pno1

Pno2

Pno3

pp

$\text{♩} = 74$

The musical score is arranged in three systems, one for each piano (Pno1, Pno2, Pno3). Each system contains two staves (treble and bass clef). The score begins at measure 16, marked with a key signature of one flat (B-flat) and a tempo of quarter note = 74. Pno1 features a complex melodic line with triplets and slurs, while Pno2 and Pno3 provide harmonic support with chords and rhythmic patterns. Dynamics include piano (*pp*) and fortissimo (*ff*). The score concludes with a final measure in 4/4 time.

19 (b) $\text{♩} = 73$ $\text{♩} = 72$ $\text{♩} = 73$

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Pno1 features complex rhythmic patterns with dynamics like *ff* and *ffz*, and articulation such as slurs and accents. Pno2 has a more melodic line with slurs and a triplet. Pno3 includes dynamics like *ffz* and *ff*, and features a triplet in the bass line. The score is marked with a tempo of quarter note = 73 and includes a key signature change to B-flat major (indicated by a 'b' in a circle) at the beginning. The time signature changes from 3/4 to 4/4.

22 $\text{♩} = 74$ $\text{♩} = 75$ $\text{♩} = 76$

Pno1

Pno2

Pno3

$\text{♩} = 74$ $\text{♩} = 75$ $\text{♩} = 76$

p *11* *11* *11*

11

11 *11* *11*

The musical score is arranged in three systems, each for a different piano (Pno1, Pno2, Pno3). Each system contains three staves (treble, middle, and bass clefs). The score is divided into three measures. Measure 1 starts at measure 22 and has a tempo of 74. Measure 2 has a tempo of 75. Measure 3 has a tempo of 76. The time signature changes from 4/4 to 3/4 at the beginning of measure 3. Pno1 features a melodic line in the treble clef with slurs and dynamic markings, and a bass line in the bass clef. Pno2 has a complex melodic line in the treble clef with triplets and slurs, and a bass line. Pno3 has a simple melodic line in the treble clef and a bass line. Dynamic markings include *p* and *11* (fortissimo). The score concludes with a final chord in the bass clef of each system.

25 $\text{♩} = 77$ $\text{♩} = 78$ $\text{♩} = 79$

Pno1

Pno2

Pno3

28 $\text{♩} = 72$

Pno1

Pno3

♩ = 70

31

Pno1

Pno2

Pno3

The musical score consists of three staves labeled Pno1, Pno2, and Pno3. The tempo is marked as ♩ = 70. The score is divided into two measures by a 3/4 time signature change. Pno1 has a complex melodic line with slurs and ornaments. Pno2 has a simple bass line with chords. Pno3 has sparse accompaniment with slurs and ornaments. The score includes various musical notations such as slurs, ornaments, and dynamic markings.

33 $\text{♩} = 72$

Pno1

Pno2

$\text{♩} = 72$

Pno3

p



35

Pno1

Pno2

pp

p

37 $\text{♩} = 75$

Pno1

p *mf* *mf*

3 11 5:3

Pno2

p *mf*

3 11 5:3

Pno3

p *mf*

11 5:3

The image displays a musical score for three piano parts, labeled Pno1, Pno2, and Pno3. The score is written in treble clef and includes various musical notations such as notes, rests, and dynamic markings. The first measure of Pno1 is marked with the number 39. The score is divided into two systems, each containing two measures. Pno1 features melodic lines with slurs and dynamic markings like *mf*. Pno2 includes a bass line with chords and a treble line with notes and rests. Pno3 has a treble line with notes and rests, and a bass line with notes and rests. The score is presented in a clean, black-and-white format.

41 $\text{♩} = 77$

The musical score is divided into three systems, each for a different piano part (Pno1, Pno2, Pno3).
- **Pno1:** Starts in 3/4 time at measure 41. It features a rest in the first measure, followed by a note with a slur and a fermata. The second measure has a rest, and the third measure has a note with a slur and a fermata. The time signature changes to 4/4 in the fourth measure, where it plays a series of notes with a slur and a fermata. The dynamic marking *mf* is present.
- **Pno2:** Starts in 3/4 time. It has a rest in the first measure, followed by a note with a slur and a fermata. The second measure has a rest, and the third measure has a note with a slur and a fermata. The time signature changes to 4/4 in the fourth measure, where it plays a series of notes with a slur and a fermata. The dynamic marking *mf* is present.
- **Pno3:** Starts in 3/4 time. It has a rest in the first measure, followed by a note with a slur and a fermata. The second measure has a rest, and the third measure has a note with a slur and a fermata. The time signature changes to 4/4 in the fourth measure, where it plays a series of notes with a slur and a fermata. The dynamic marking *mf* is present.

44 $\text{♩} = 75$

The musical score is divided into two systems. The first system contains measures 44 and 45. Pno1 (bass clef) starts in 3/4 time with a half note chord, then changes to 4/4 time with a quarter note chord. Pno2 (treble and bass clefs) has a 3-measure rest in 3/4 time, followed by a triplet of eighth notes in 4/4 time marked *mf*. Pno3 (treble and bass clefs) has a 3-measure rest in 3/4 time, followed by a triplet of eighth notes in 4/4 time. The second system contains measures 46 and 47. Pno1 (bass clef) has a 4-measure rest in 4/4 time. Pno2 (treble and bass clefs) has a 4-measure rest in 4/4 time. Pno3 (treble and bass clefs) has a 4-measure rest in 4/4 time. The tempo marking $\text{♩} = 75$ is present at the beginning of each system.

The musical score consists of three systems, each for a different piano part:

- Pno1:** Starts at measure 46. The upper staff features a complex melodic line with slurs and a dynamic marking of *mf*. The lower staff provides a rhythmic accompaniment with a consistent eighth-note pattern. A tempo marking of $\text{♩} = 74$ is present.
- Pno2:** Features a melodic line in the upper staff with slurs and a triplet of eighth notes. The lower staff has a few notes in the first measure before remaining silent.
- Pno3:** The upper staff has a few notes in the first measure before remaining silent. The lower staff continues with a rhythmic accompaniment similar to Pno1.

Throughout the score, there are various musical notations including slurs, accents, and fingering numbers (5, 3, 5). The key signature includes one sharp (F#) and one flat (Bb).

49 $\text{♩} = 73$ $\text{♩} = 72$ $\text{♩} = 70$

Pno1

Pno2

Pno3

p

p

p

p

52 $\text{♩} = 68$

Pno1

Pno2

Pno3

ff

f

ff

ff

54

The musical score consists of three systems, each for a different piano (Pno1, Pno2, Pno3). The first system (Pno1) features a complex melodic line with dynamics ranging from *ff* to *f*, including slurs, accents, and fingerings (11, 3). The second system (Pno2) is mostly silent, with a final chord marked *ff* and a triplet. The third system (Pno3) has a rhythmic accompaniment in the bass clef and a melodic line in the treble clef with dynamics *ff* and *f*, including slurs and fingerings (11, 3). The piece is in a key with two flats and a 7/8 time signature.

57

ff

ff

ff

$\text{♩} = 71$

$\text{♩} = 71$

The musical score consists of three systems, each for a different piano (Pno1, Pno2, Pno3).
- **Pno1:** The first system starts at measure 57. The right hand features a complex rhythmic pattern with triplets (marked '3') and a quintuplet (marked '5'). The left hand has a melodic line with slurs and a dynamic marking of *ff*.
- **Pno2:** The right hand is mostly silent, with a few notes in the second measure. The left hand has a few notes in the second measure, including a dynamic marking of *ff*.
- **Pno3:** The right hand has a melodic line with slurs and a dynamic marking of *ff*. The left hand has a few notes in the first measure and rests in the second.
- **Tempo:** A tempo marking of $\text{♩} = 71$ is present at the top right and bottom right of the score.

59 $\text{♩} = 68$

The musical score is divided into three systems, each for a different piano part:

- Pno1:** Features a complex melodic line in the right hand with slurs and ornaments, and a bass line with a triplet in the second measure.
- Pno2:** Provides harmonic support with chords in the right hand and single notes in the left hand.
- Pno3:** Features a melodic line in the right hand with slurs and ornaments, and a bass line with chords.

The score includes a tempo marking of $\text{♩} = 68$ and a measure number of 59. The time signature changes from 5/4 to 4/4 between the first and second measures of each system.

61

Pno1

Pno2

Pno3

5

11 3 3

11

11

5

5

3/4

3/4

3/4

64

Pno1

Pno2

Pno3

mf

66 $\text{♩} = 72$

Pno1

mp

Pno2

mp

mp mp

Pno3

$\text{♩} = 72$

mp

mp

mp

69

Pno1

Pno2

Pno3

mp mp

The musical score is for three pianos (Pno1, Pno2, Pno3) in 5/4 time, starting at measure 69. The score is divided into two systems. The first system (measures 69-70) features Pno1 with a complex chordal structure in the right hand and a rhythmic pattern in the left hand. Pno2 and Pno3 have more active parts, with Pno2 featuring a triplet in the right hand. The second system (measures 71-72) continues the development of these parts, with Pno1 playing sustained chords and Pno2/Pno3 featuring more melodic and rhythmic activity. Dynamics are marked as *mp* (mezzo-piano) in the second system.

71

$\text{♩} = 72$

Pno1

Pno2

Pno3

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). The first system (Pno1) starts in 5/4 time and changes to 4/4. It features complex melodic lines in the right hand and bass lines in the left hand, with dynamic markings of 11 and 9. The second system (Pno2) also starts in 5/4 and changes to 4/4, with similar melodic and bass line structures and dynamic markings. The third system (Pno3) is in 4/4 time and features simpler melodic lines and bass lines, also with dynamic markings of 11 and 9. A tempo marking of quarter note = 72 is indicated at the top of the score.

74

The musical score is divided into three systems, each for a different piano (Pno1, Pno2, Pno3). Each system consists of two staves (treble and bass clef). The first system (Pno1) starts in 5/4 time and changes to 4/4 time at the second measure. The second system (Pno2) also starts in 5/4 time and changes to 4/4 time. The third system (Pno3) starts in 5/4 time and changes to 4/4 time. The score includes various musical notations such as notes, rests, and dynamic markings like '11' and '9'. The first system (Pno1) has a treble staff with notes and rests, and a bass staff with notes and rests. The second system (Pno2) has a treble staff with notes and rests, and a bass staff with notes and rests. The third system (Pno3) has a treble staff with notes and rests, and a bass staff with notes and rests.

76

Pno1

Pno2

Pno3

11 11

3 9 9

11 11

9

26

77

$\text{♩} = 67$ $\text{♩} = 64$ $\text{♩} = 59$ $\text{♩} = 55$ $\text{♩} = 50$ $\text{♩} = 45$ $\text{♩} = 38$ $\text{♩} = 64$

Pno1

Pno2

Pno3

p p

p

79

Pno1

Pno2

Pno3

p

p

82 $\text{♩} = 67$ 27

Pno1

Pno2

Pno3

85 $\text{♩} = 64$

Pno1

Pno2

Pno3

5 5

p *p*

3

p

11 *pp*

p *pp* 9 9 9 11 *pp*

89

Pno1

Pno2

Pno3

The musical score consists of three parts: Pno1, Pno2, and Pno3. Pno1 is written for two staves (treble and bass). The treble staff begins at measure 89 with a triplet of eighth notes (F#4, G4, A4) followed by a half note (Bb4) and a quarter note (A4). The bass staff has a half note (Bb3) and a quarter note (A3) in measure 89, and a half note (Bb3) and a quarter note (A3) in measure 90. Pno2 is written for two treble staves. The upper staff has a half note (F#4) and a quarter note (G4) in measure 89, and a half note (F#4) and a quarter note (G4) in measure 90. The lower staff has a half note (F#4) and a quarter note (G4) in measure 89, and a half note (F#4) and a quarter note (G4) in measure 90. Pno3 is written for one treble staff. It has a half note (F#4) and a quarter note (G4) in measure 89, and a half note (F#4) and a quarter note (G4) in measure 90. The score ends at measure 91 with a 3/4 time signature.

The musical score is for three pianos (Pno1, Pno2, Pno3) in 4/4 time, starting at measure 92. The key signature is two sharps (F# and C#). Measure 92 features Pno1 with a mezzo-piano (*mp*) melody in the right hand and a piano (*p*) accompaniment in the left hand. Pno2 has a piano (*p*) accompaniment in the left hand and a mezzo-piano (*mp*) accompaniment in the right hand. Pno3 is silent in measure 92. Measure 93 shows Pno1 with a piano (*p*) accompaniment in the left hand and a mezzo-piano (*mp*) accompaniment in the right hand. Pno2 has a piano (*p*) accompaniment in the left hand and a piano (*p*) accompaniment in the right hand. Pno3 remains silent. Measure 94 features Pno1 with a mezzo-piano (*mp*) accompaniment in the left hand and a mezzo-piano (*mp*) accompaniment in the right hand. Pno2 has a piano (*p*) accompaniment in the left hand and a piano (*p*) accompaniment in the right hand. Pno3 remains silent. Measure 95 shows Pno1 with a mezzo-piano (*mp*) accompaniment in the left hand and a mezzo-piano (*mp*) accompaniment in the right hand. Pno2 has a piano (*p*) accompaniment in the left hand and a piano (*p*) accompaniment in the right hand. Pno3 has a piano (*p*) accompaniment in the left hand and a mezzo-piano (*mp*) accompaniment in the right hand. Tempo markings of 66 bpm and 64 bpm are indicated above the staves.

96

Pno1

Pno2

Pno3

The musical score consists of three systems, each for a piano (Pno1, Pno2, Pno3). Each system has a grand staff with a treble and bass clef. Measure 96 is marked at the beginning. Pno1 features a triplet of eighth notes in the treble clef, followed by a slur over a quarter note and a half note. Pno2 has a quarter note in the treble clef and a quarter note in the bass clef. Pno3 has a quarter note in the treble clef and a quarter note in the bass clef. Dynamic markings include 'pp' (pianissimo) and 'ff' (fortissimo). There are also slurs and accents throughout the score.

The image shows a musical score for three pianos, labeled Pno1, Pno2, and Pno3. The score is written in treble clef with a key signature of one flat (B-flat). Pno1 starts at measure 99 with a dynamic marking of 99. Pno2 has a dynamic marking of 11. The score includes various musical notations such as slurs, ties, and fingering numbers (7 and 11). The piece concludes with a double bar line.

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