



An Ear for Music



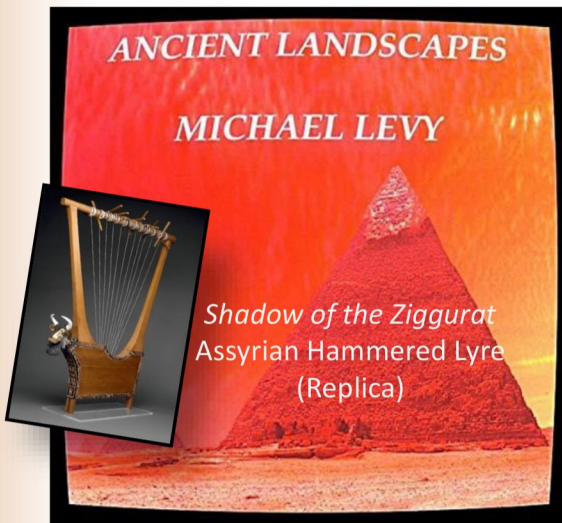
Session 5 Musical Instruments: Strings and Others

OLLI at Illinois
Spring 2024

D. H. Tracy



An Ear for Music



Session 6 Musical Instruments: Strings and Others

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Course Outline



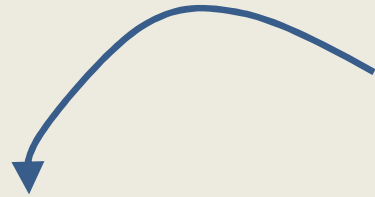
1. Building Blocks: Some basic concepts
2. Resonance: Building Complex Sounds
3. Hearing and the Ear
4. Musical Scales
- 5. Musical Notation; String Instruments**
6. Timbre and Pipe Instruments
7. Human Voice and Singing
8. Harmony and Dissonance; Chords

MIDI

81	880		A 5
80	830.6		G#/Ab 5
79	784.0		G 5
78	740.0		F#/Gb 5
77	698.5		F 5
76	659.3		E 5
75	622.3		D#/Eb 5
74	587.3		D 5
73	554.4		C#/Db 5
72	523.3		C 5
71	493.9		B 4
70	466.2		A#/Bb 4
69	440		A 4
68	415.3		G#/Ab 4
67	392.0		G 4
66	370.0		F#/Gb 4
65	349.2		F 4
64	329.6		E 4
63	311.1		D#/Eb 4
62	293.7		D 4
61	277.2		C#/Db 4
60	261.6		C 4
59	246.9		B 3
58	233.1		A#/Bb 3
57	220		A 3
56	207.7		G#/Ab 3
55	196.0		G 3
54	185.0		F#/Gb 3
53	174.6		F 3
52	164.8		E 3
51	155.6		D#/Eb 3
50	146.8		D 3
49	138.6		C#/Db 3
48	130.8		C 3
47	123.5		B 2
46	116.5		A#/Bb 2
45	110		A 2
44	103.8		G#/Ab 2
43	98.0		G 2

ca. 500 AD

Naming the Notes



≈Tenor Range

Notes on the Diatonic C Major Scale



Boëthius (Roman Philosopher, 477-524)
[Sainted 1883]



Naming the Notes

MIDI

81	880		A 5	
80	830.6		G#/Ab 5	
79	784.0		G 5	aa
78	740.0		F#/Gb 5	
77	698.5		F 5	ff
76	659.3		E 5	ee
75	622.3		D#/Eb 5	
74	587.3		D 5	dd
73	554.4		C#/Db 5	cc
72	523.3		C 5	
71	493.9		B 4	bb
70	466.2		A#/Bb 4	
69	440		A 4	aa
68	415.3		G#/Ab 4	
67	392.0		G 4	O g
66	370.0		F#/Gb 4	N f
65	349.2		F 4	M e
64	329.6		E 4	
63	311.1		D#/Eb 4	L d
62	293.7		D 4	
61	277.2		C#/Db 4	K c
60	261.6		C 4	I b
59	246.9		B 3	
58	233.1		A#/Bb 3	H a
57	220		A 3	
56	207.7		G#/Ab 3	G g
55	196.0		G 3	F f
54	185.0		F#/Gb 3	E e
53	174.6		F 3	
52	164.8		E 3	D d
51	155.6		D#/Eb 3	
50	146.8		D 3	C c
49	138.6		C#/Db 3	B b
48	130.8		C 3	A a
47	123.5		B 2	
46	116.5		A#/Bb 2	
45	110		A 2	
44	103.8		G#/Ab 2	
43	98.0		G 2	G

ca. 500 AD



Boëthius

(Roman Philosopher, 477-524)

≈Tenor
Range

Notes on the
Diatonic
C Major
Scale

MIDI

MIDI	Freq.	Scale	Note	Symbol
81	880		A 5	
80	830.6		G#/Ab 5	
79	784.0		G 5	aa
78	740.0		F#/Gb 5	
77	698.5		F 5	ff
76	659.3		E 5	ee
75	622.3		D#/Eb 5	
74	587.3		D 5	dd
73	554.4		C#/Db 5	cc
72	523.3		C 5	
71	493.9		B 4	bb
70	466.2		A#/Bb 4	aa
69	440		A 4	
68	415.3		G#/Ab 4	
67	392.0		G 4	O g
66	370.0		F#/Gb 4	
65	349.2		F 4	N f
64	329.6		E 4	M e
63	311.1		D#/Eb 4	
62	293.7		D 4	L d
61	277.2		C#/Db 4	
60	261.6		C 4	K c
59	246.9		B 3	I b
58	233.1		A#/Bb 3	b
57	220		A 3	H a
56	207.7		G#/Ab 3	
55	196.0		G 3	G G
54	185.0		F#/Gb 3	
53	174.6		F 3	F F
52	164.8		E 3	E E
51	155.6		D#/Eb 3	
50	146.8		D 3	D D
49	138.6		C#/Db 3	
48	130.8		C 3	C C
47	123.5		B 2	B B
46	116.5		A#/Bb 2	B
45	110		A 2	A A
44	103.8		G#/Ab 2	
43	98.0		G 2	G

Naming the Notes

ca. 500 AD

B flat was the first note beyond the Diatonic C Major subscale to be added

Organized by Octaves



Boëthius

(Roman Philosopher, 477-524)



MIDI

81	880	A 5			
80	830.6	G#/Ab 5			
79	784.0	G 5	gg		g'
78	740.0	F#/Gb 5			
77	698.5	F 5	ff		f'
76	659.3	E 5	ee		e'
75	622.3	D#/Eb 5			
74	587.3	D 5	dd		d'
73	554.4	C#/Db 5	cc		
72	523.3	C 5			c'
71	493.9	B 4	bb		b'
70	466.2	A#/Bb 4	bb		
69	440	A 4	aa		a'
68	415.3	G#/Ab 4			
67	392.0	G 4	O	g	g'
66	370.0	F#/Gb 4			
65	349.2	F 4	N	f	f'
64	329.6	E 4	M	e	e'
63	311.1	D#/Eb 4			
62	293.7	D 4	L	d	d'
61	277.2	C#/Db 4			
60	261.6	C 4	K	c	c'
59	246.9	B 3	I	b	b'
58	233.1	A#/Bb 3			
57	220	A 3	H	a	a'
56	207.7	G#/Ab 3			
55	196.0	G 3	G	G	g
54	185.0	F#/Gb 3			
53	174.6	F 3	F	F	f
52	164.8	E 3	E	E	e
51	155.6	D#/Eb 3			
50	146.8	D 3	D	D	d
49	138.6	C#/Db 3			
48	130.8	C 3	C	C	c
47	123.5	B 2	B	B	b
46	116.5	A#/Bb 2			
45	110	A 2	A	A	a
44	103.8	G#/Ab 2			
43	98.0	G 2		G	G

Naming the Notes

ca. 500 AD



Boëthius

(Roman Philosopher, 477-524)

Organized by Octaves



Ear for Music 5

Naming the Notes

MIDI

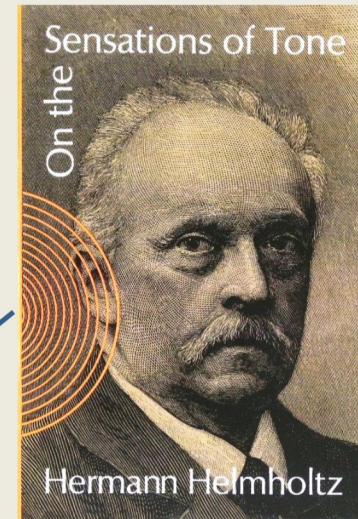
81	880	A 5			
80	830.6	G#/Ab 5			
79	784.0	G 5	aa	g''	
78	740.0	F#/Gb 5			
77	698.5	F 5	ff	f''	
76	659.3	E 5	ee	e''	
75	622.3	D#/Eb 5			
74	587.3	D 5	dd	d''	
73	554.4	C#/Db 5	cc		
72	523.3	C 5		e''	
71	493.9	B 4	bb	b'	
70	466.2	A#/Bb 4	bb		
69	440	A 4	aa	a'	
68	415.3	G#/Ab 4			
67	392.0	G 4	O	g	g'
66	370.0	F#/Gb 4			
65	349.2	F 4	N	f	f'
64	329.6	E 4	M	e	e'
63	311.1	D#/Eb 4			
62	293.7	D 4	L	d	d'
61	277.2	C#/Db 4			
60	261.6	C 4	K	c	c'
59	246.9	B 3	I	b	b
58	233.1	A#/Bb 3		b	
57	220	A 3	H	a	a
56	207.7	G#/Ab 3			
55	196.0	G 3	G	G	g
54	185.0	F#/Gb 3			
53	174.6	F 3	F	F	f
52	164.8	E 3	E	E	e
51	155.6	D#/Eb 3			
50	146.8	D 3	D	D	d
49	138.6	C#/Db 3			
48	130.8	C 3	C	C	c
47	123.5	B 2	B	B	B
46	116.5	A#/Bb 2		B	
45	110	A 2	A	A	A
44	103.8	G#/Ab 2			
43	98.0	G 2		G	G

ca. 500 AD



Boëthius

Organized by Octaves, but starting at C instead of A!



Ear for Music 5

MIDI

81	880	A 5			A5
80	830.6	G#/Ab 5			G#5
79	784.0	G 5	gg	g''	G5
78	740.0	F#/Gb 5			F#5
77	698.5	F 5	ff	f''	F5
76	659.3	E 5	ee	e''	E5
75	622.3	D#/Eb 5			D#5
74	587.3	D 5	dd	d''	D5
73	554.4	C#/Db 5			C#5
72	523.3	C 5			C5
71	493.9	B 4	bb	b'	B4
70	466.2	A#/Bb 4	bb		A#4
69	440	A 4	aa	a'	A4
68	415.3	G#/Ab 4			G#4
67	392.0	G 4	O	g	G4
66	370.0	F#/Gb 4			F#4
65	349.2	F 4	N	f	F4
64	329.6	E 4	M	e	E4
63	311.1	D#/Eb 4			D#4
62	293.7	D 4	L	d	D4
61	277.2	C#/Db 4			C#4
60	261.6	C 4	K	c	C4
59	246.9	B 3	I	b	B3
58	233.1	A#/Bb 3			A#3
57	220	A 3	H	a	A3
56	207.7	G#/Ab 3			G#3
55	196.0	G 3	G	g	G3
54	185.0	F#/Gb 3			F#3
53	174.6	F 3	F	f	F3
52	164.8	E 3	E	e	E3
51	155.6	D#/Eb 3			D#3
50	146.8	D 3	D	d	D3
49	138.6	C#/Db 3			C#3
48	130.8	C 3	C	c	C3
47	123.5	B 2	B	B	B2
46	116.5	A#/Bb 2			A#2
45	110	A 2	A	A	A2
44	103.8	G#/Ab 2			G#2
43	98.0	G 2		G	G2

Naming the Notes

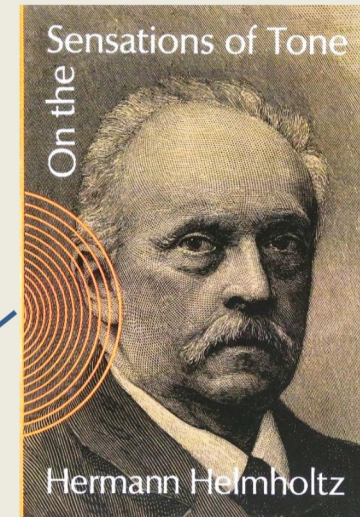
ca. 500 AD



Boëthius

Scientific Notation System (20th Century)

Also Organized by Octaves, starting at C



Ear for Music 5



MIDI

81	880	A 5			A5	La
80	830.6	G#/Ab 5			G#5	Si
79	784.0	G 5	gg	g''	G5	Sol
78	740.0	F#/Gb 5			F#5	Fi
77	698.5	F 5	ff	f''	F5	Fa
76	659.3	E 5	ee	e''	E5	Mi
75	622.3	D#/Eb 5			D#5	Ri
74	587.3	D 5	dd	d''	D5	Re
73	554.4	C#/Db 5	cc		C#5	Di
72	523.3	C 5		e''	C5	Do
71	493.9	B 4	bb	b'	B4	Ti
70	466.2	A#/Bb 4	bb		A#4	Li
69	440	A 4	aa	a'	A4	La
68	415.3	G#/Ab 4			G#4	Si
67	392.0	G 4	O	g	G4	Sol
66	370.0	F#/Gb 4			F#4	Fi
65	349.2	F 4	N	f	F4	Fa
64	329.6	E 4	M	e	E4	Mi
63	311.1	D#/Eb 4			D#4	Ri
62	293.7	D 4			D4	Re
61						Di
60						Do
59						Ti
58						Li
57						La
56						Si
55						Sol
54						Fi
53						Fa
52						Mi
51						Ri
50						Re
49						Di
48						Do
47						Ti
46						Li
45						La
44						Si
43						Sol
42						Fi
41						Fa
40						Mi
39						Ri
38						Re
37						Di
36						Do
35						Ti
34						Li
33						La
32						Si
31						Sol
30						Fi
29						Fa
28						Mi
27						Ri
26						Re
25						Di
24						Do
23						Ti
22						Li
21						La
20						Si
19						Sol
18						Fi
17						Fa
16						Mi
15						Ri
14						Re
13						Di
12						Do
11						Ti
10						Li
9						La
8						Si
7						Sol
6						Fi
5						Fa
4						Mi
3						Ri
2						Re
1						Di

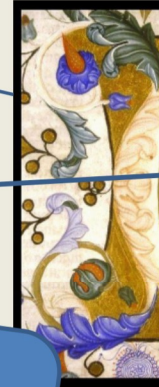
Naming the Notes

ca. 500 AD

Solfège

Scientific Notation System (20th Century)

Organized by Octaves, starting at C



Hermann Helmholtz

Ut Queant Laxis (Hymn to St. John the Baptist)

Guido of Arezzo (circa 991-1033)

Do que - ant la - xis, Re so - na - re fi - bris, Mi - ra

ges - to - rum Fa mu - li tu - o - rum, Sol - ve pol -

lu - ti, La bi - i re - a - tum, Sanc - te Jo - han - nes.

Ear for Music 5

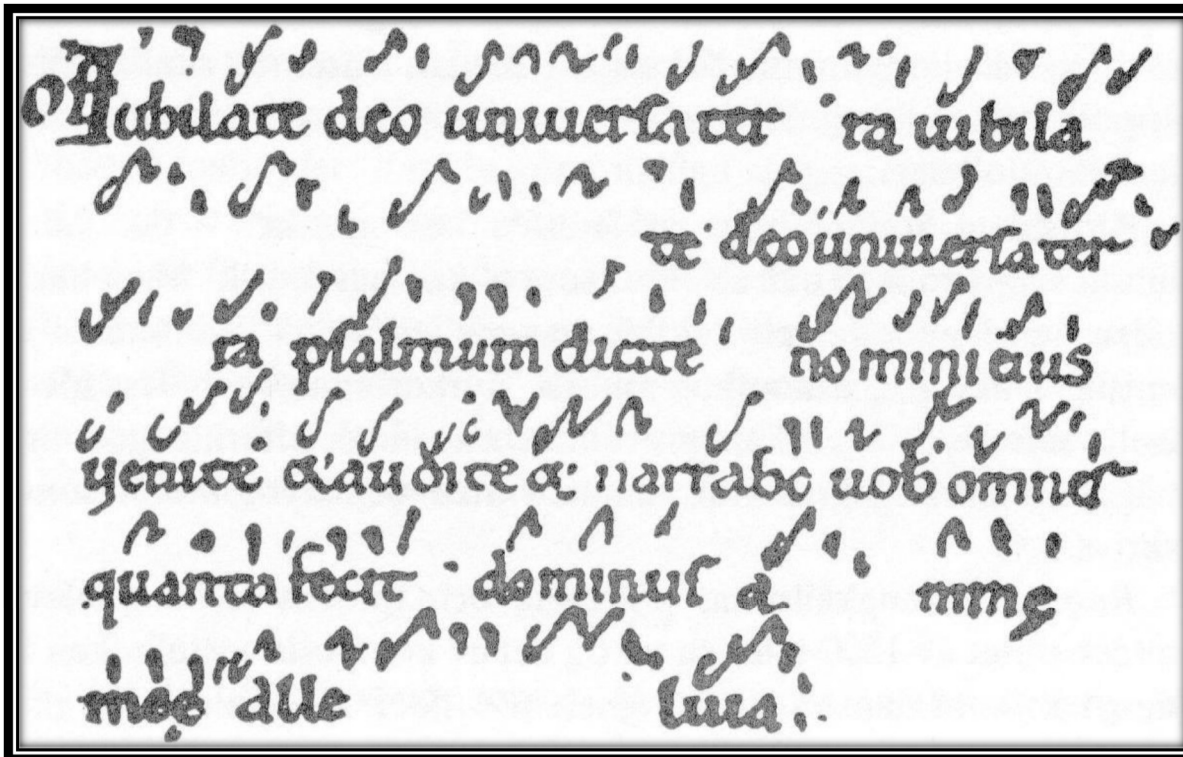


Musical Notation

Writing Down Music



Neumes: Pre-modern Notation

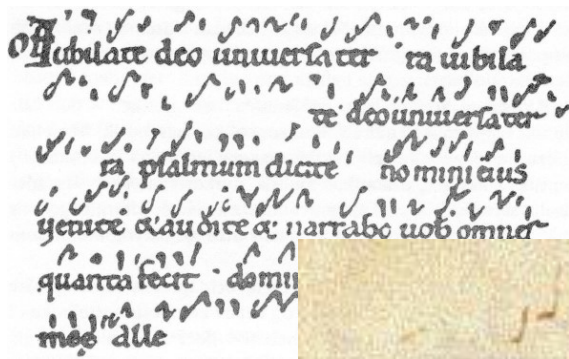


These kinds of tone 'hints' began to appear in the West as early as 800 AD, starting around Metz

Wikipedia



Neumes

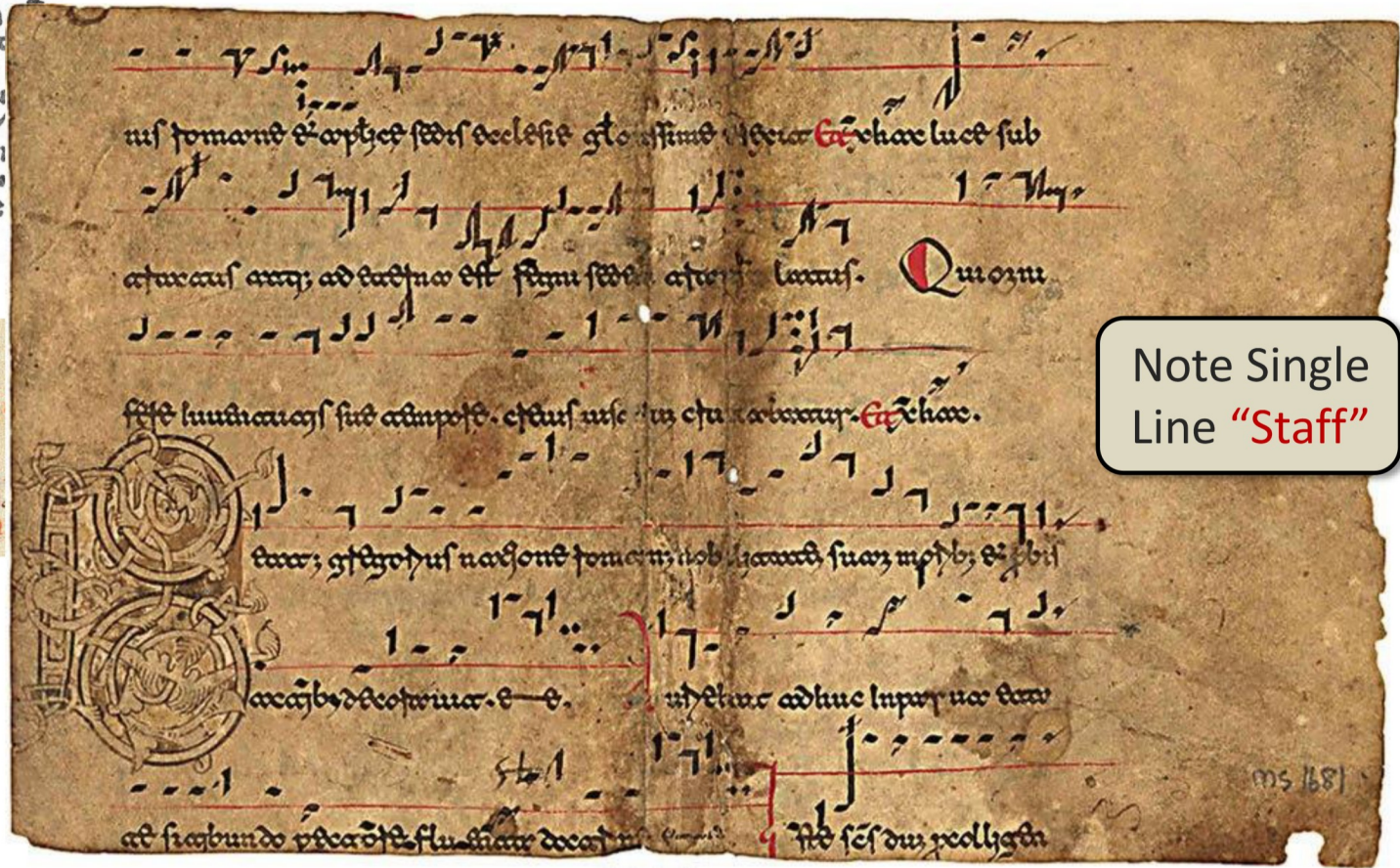
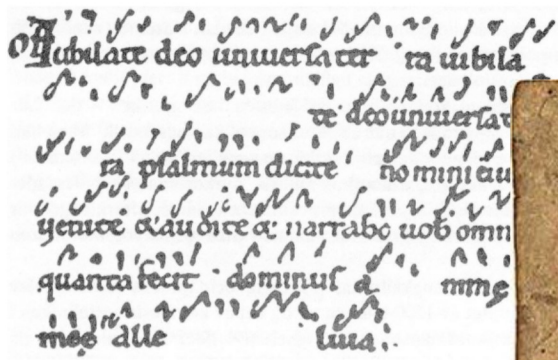


Wikipedia

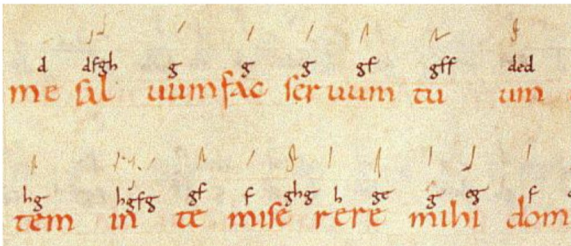
Digraphic Neume (11th Century manuscript from Saint-Bénigne de Dijon)



Neumes

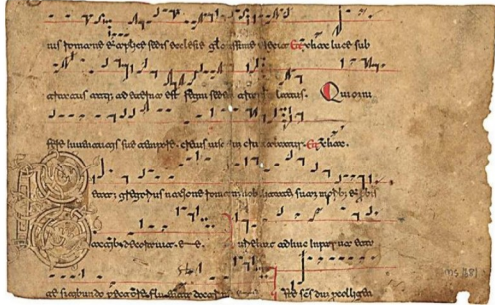
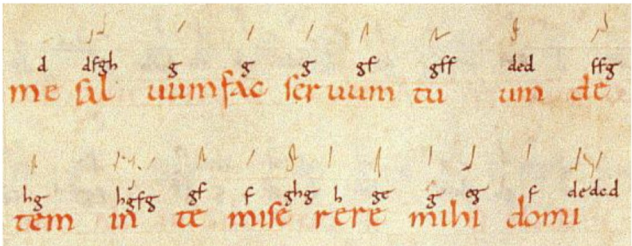
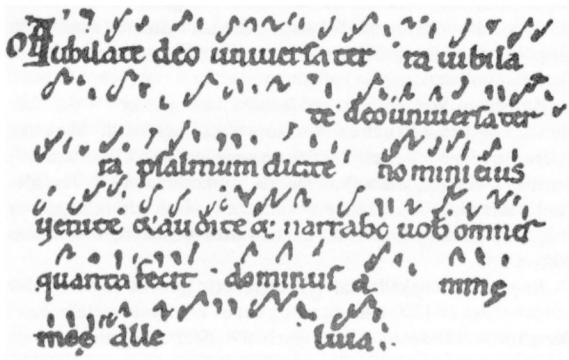


Note Single Line "Staff"



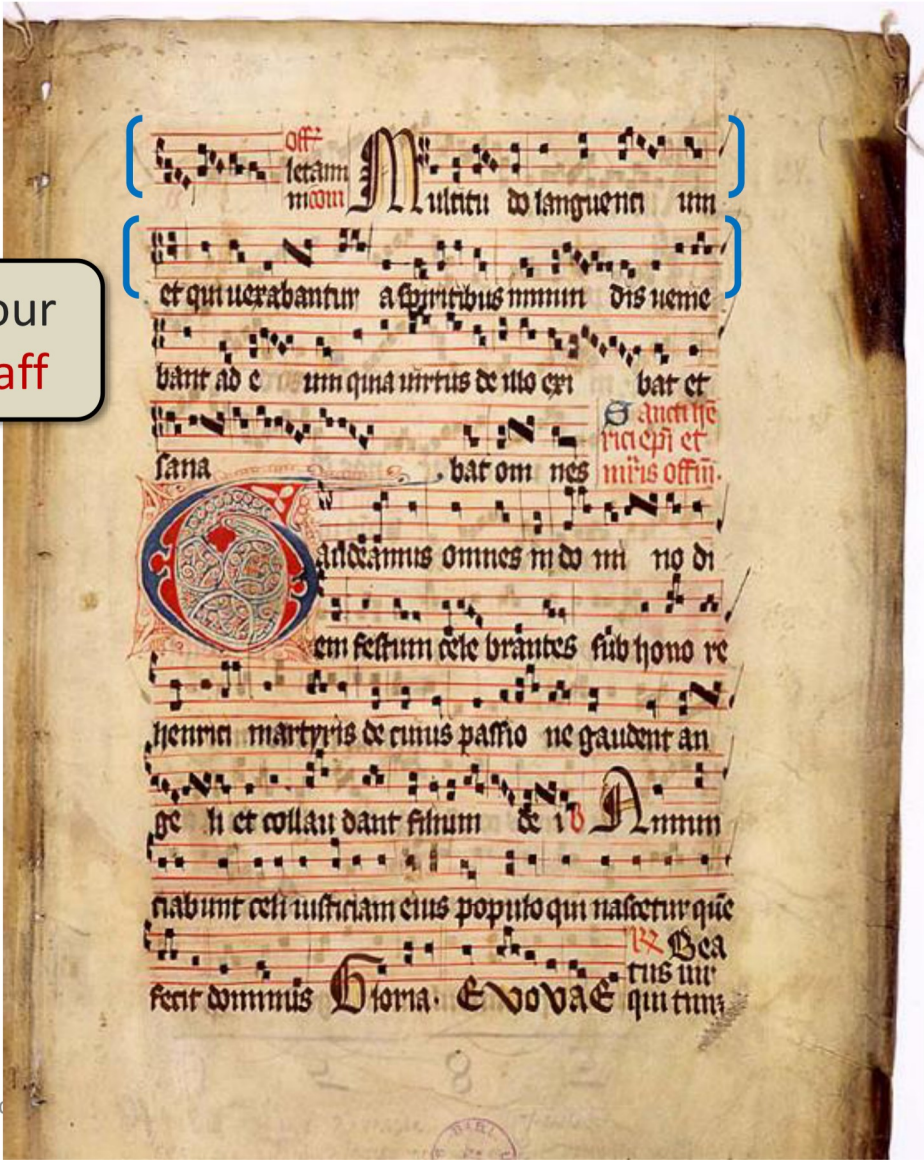
Example of Beneventon Script
14th Century
Southern Italy

Neumes

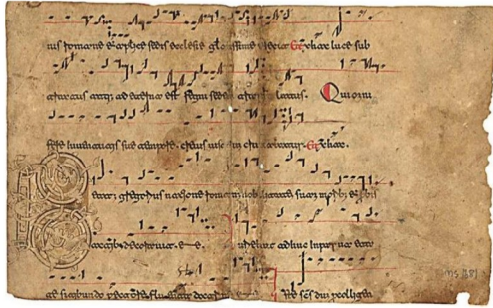
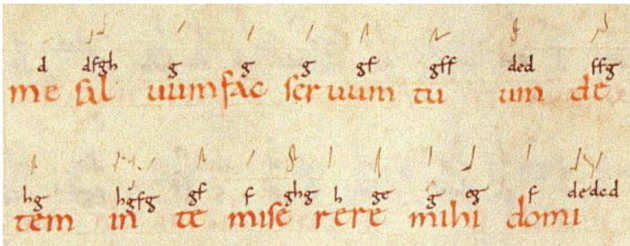
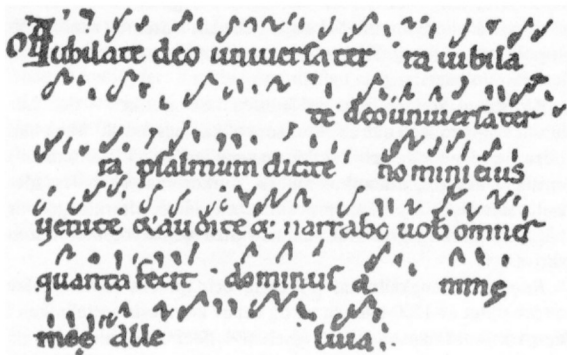


Note Four
Line Staff

from
Graduale
Aboense
Hymn Book of
Turku, Finland
14th-15th century
Gregorian Chant

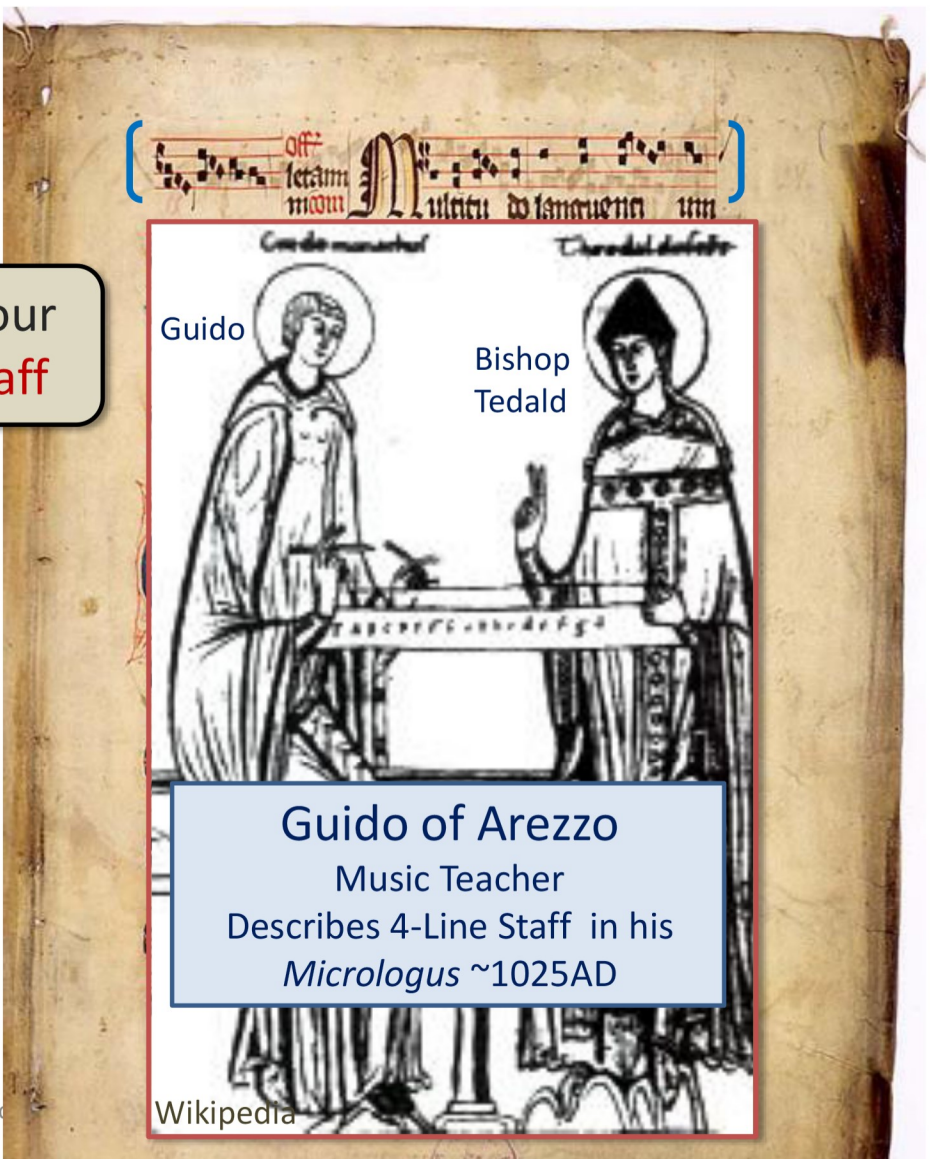


Neumes



Note Four
Line Staff

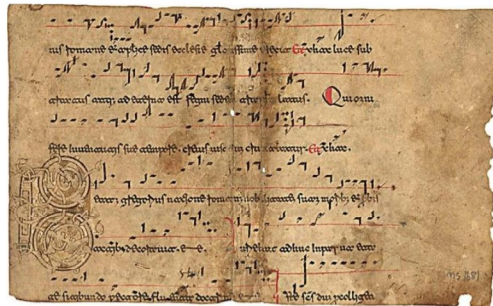
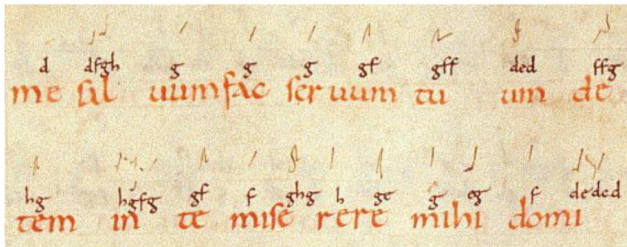
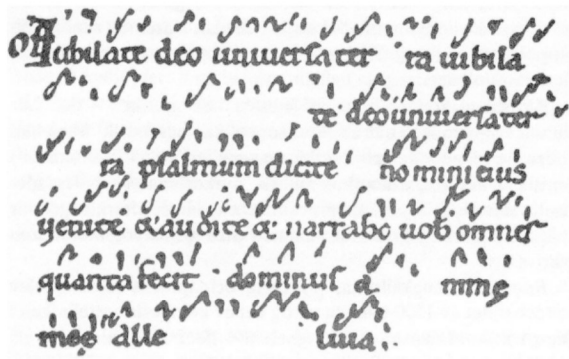
from
Graduale
Aboense
Hymn Book of
Turku, Finland
14th-15th century
Gregorian Chant



Guido of Arezzo
Music Teacher
Describes 4-Line Staff in his
Micrologus ~1025AD



Neumes



Modern Version on Four Line Staff

1. 

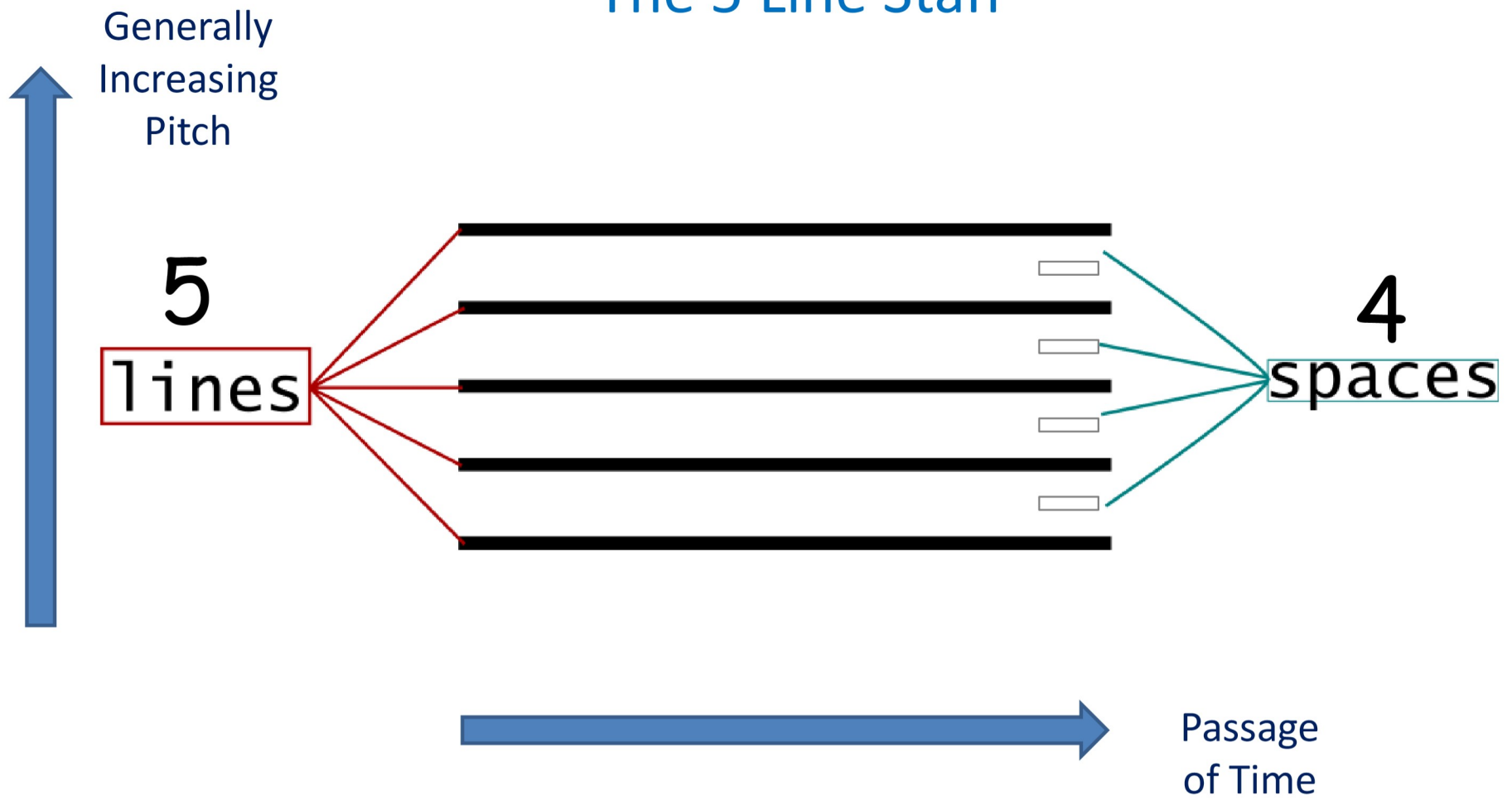
K Y-ri- e * e- lé- i-son.

Orbis Factor
(Kyrie XI)
A Gregorian Chant

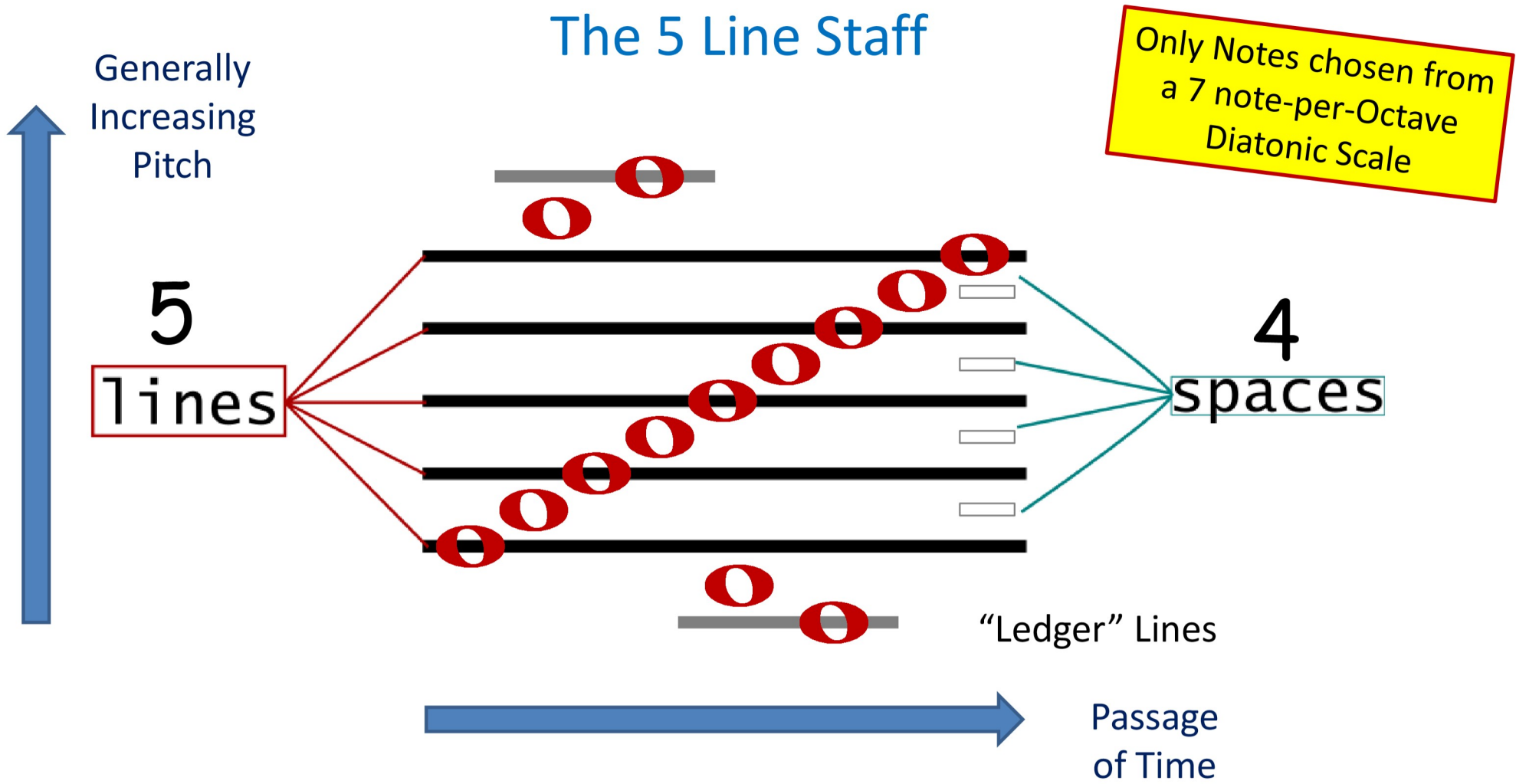
Wikipedia



The 5 Line Staff



The 5 Line Staff

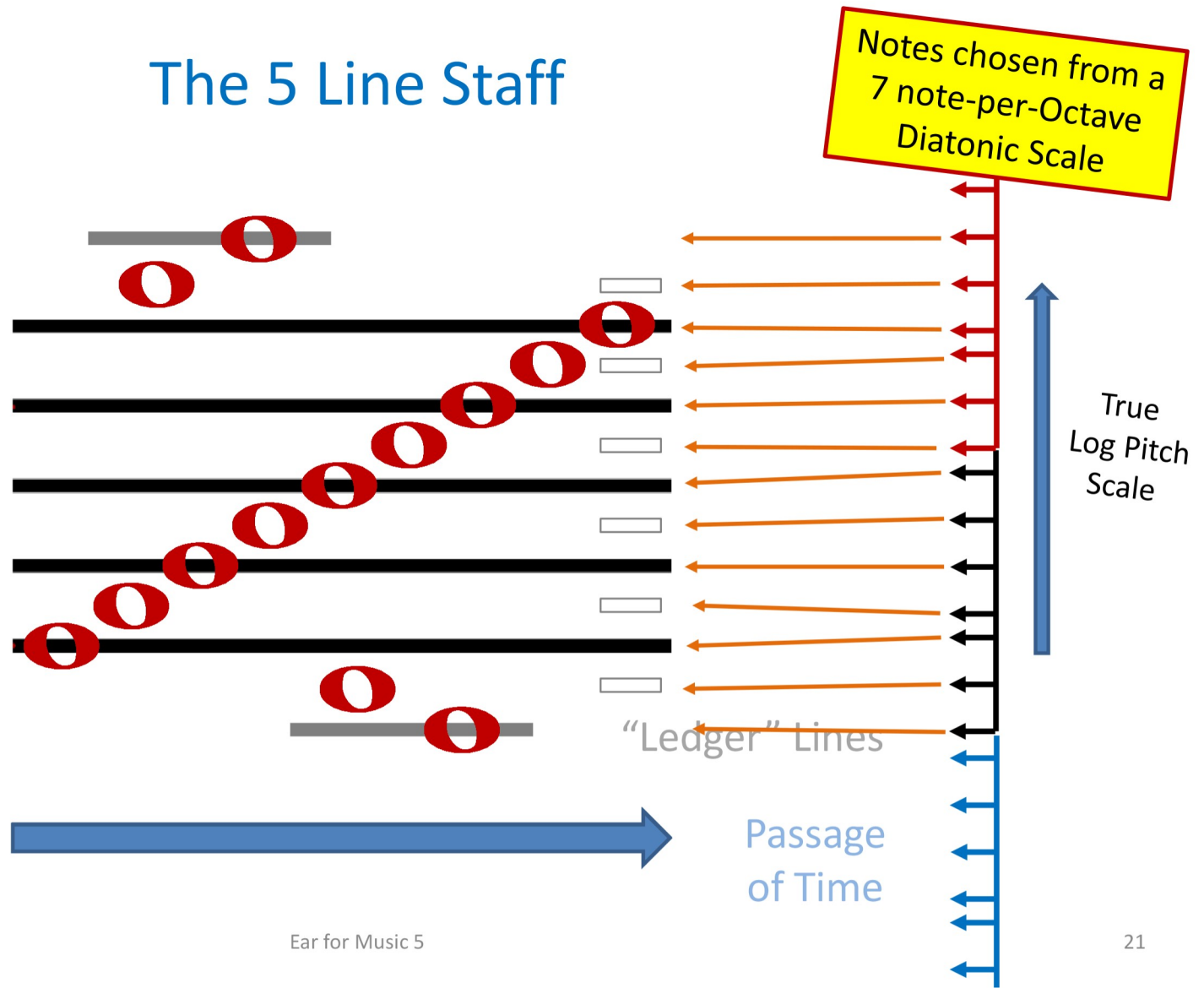


The 5 Line Staff

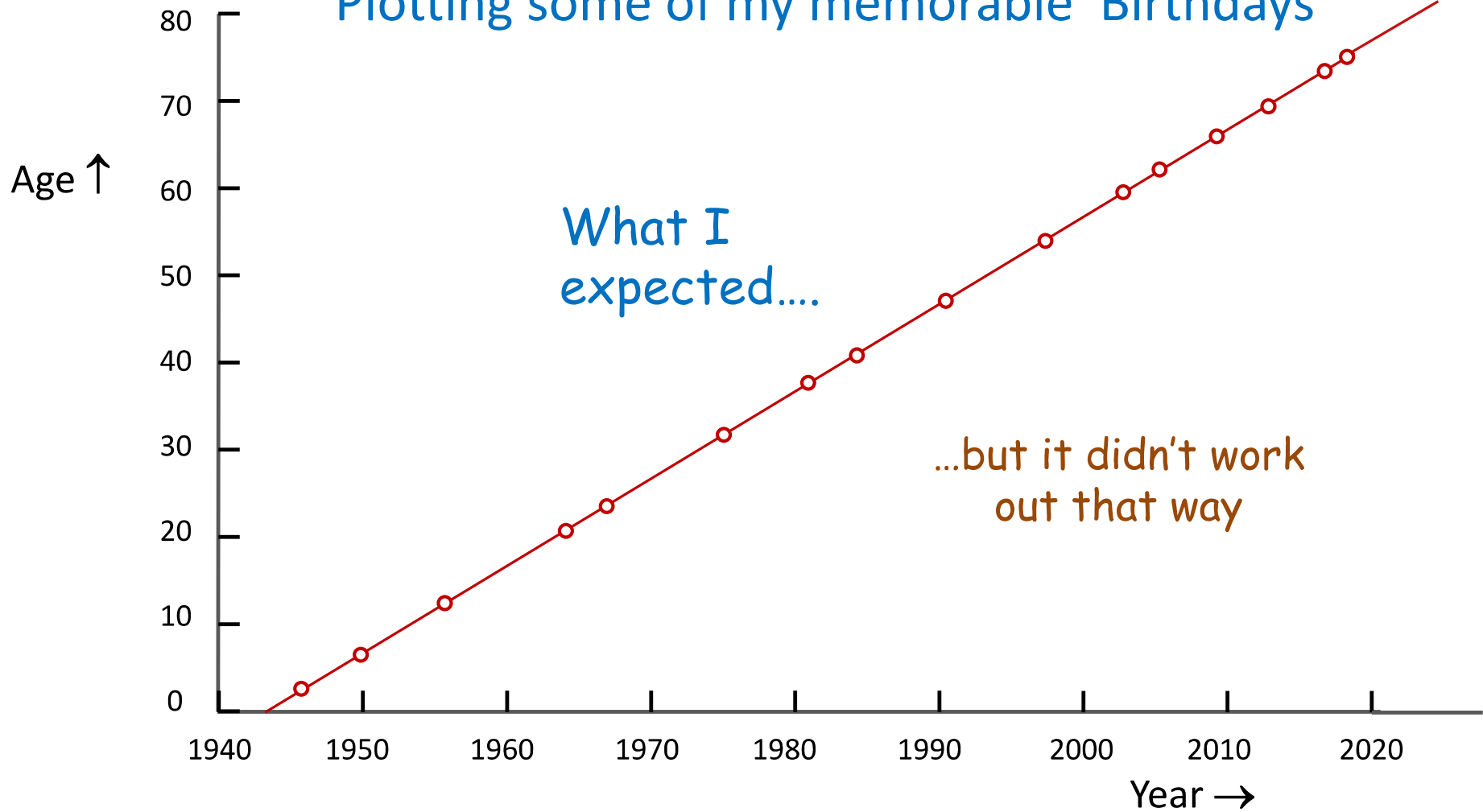


Generally Increasing Pitch

Erratic "Sorta-Log" Pitch Scale

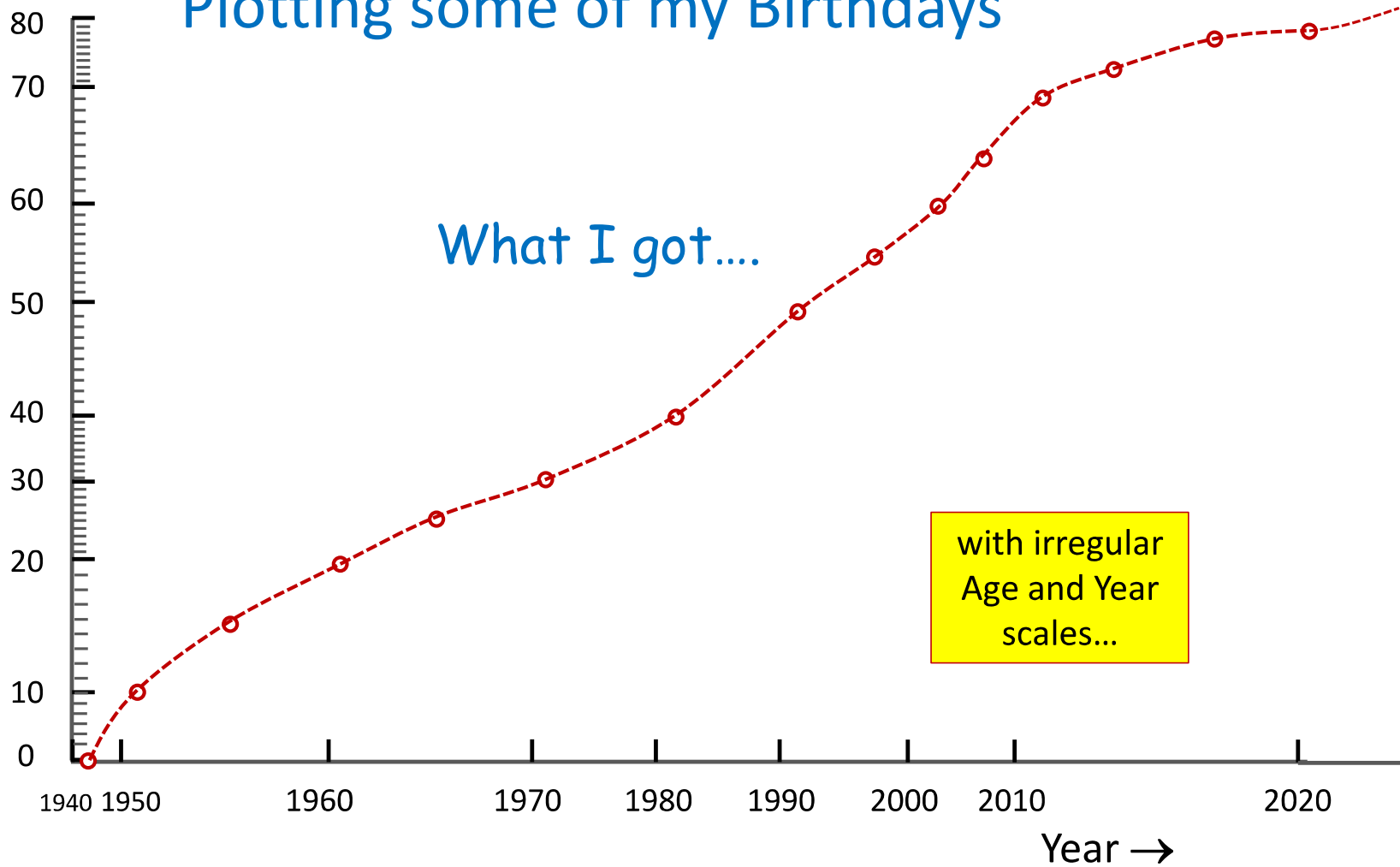


Plotting some of my memorable Birthdays



Plotting some of my Birthdays

Age ↑



The 5 Line Staff

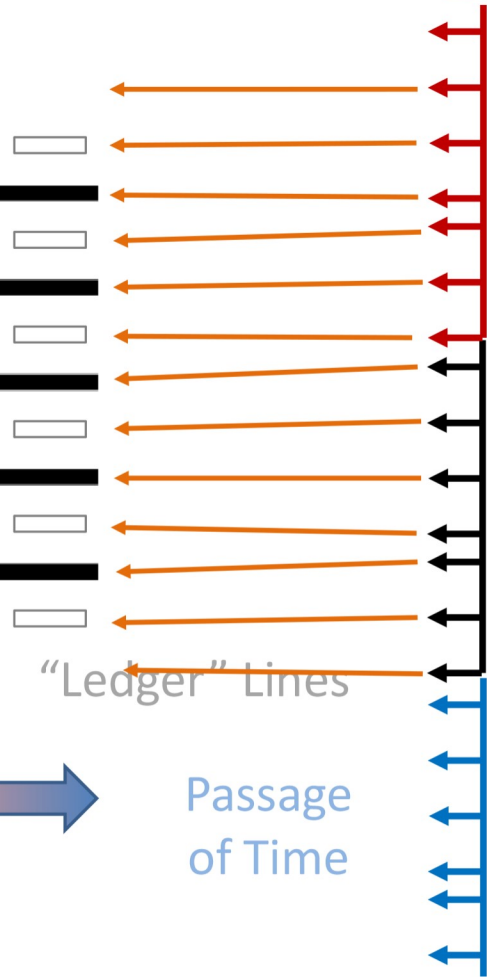
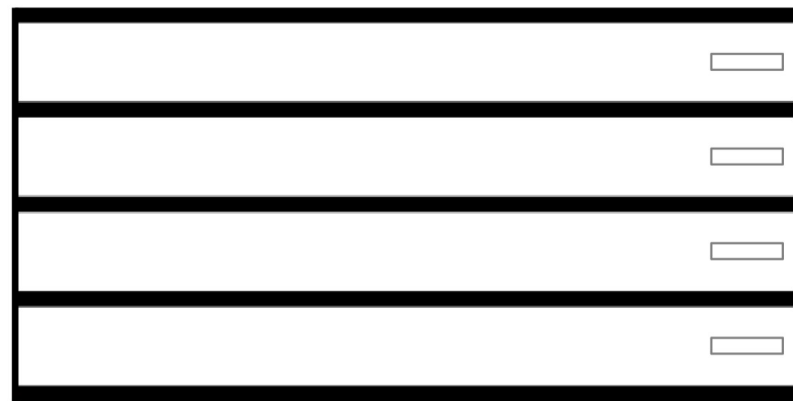
Generally

Q: How do we know which staff *line* corresponds to which note/frequency?

Notes chosen from a 7 note-per-Octave Diatonic Scale



Erratic "Sorta-Log" Pitch Scale



True Log Pitch Scale

C Major Scale

Passage of Time



The 5 Line Staff

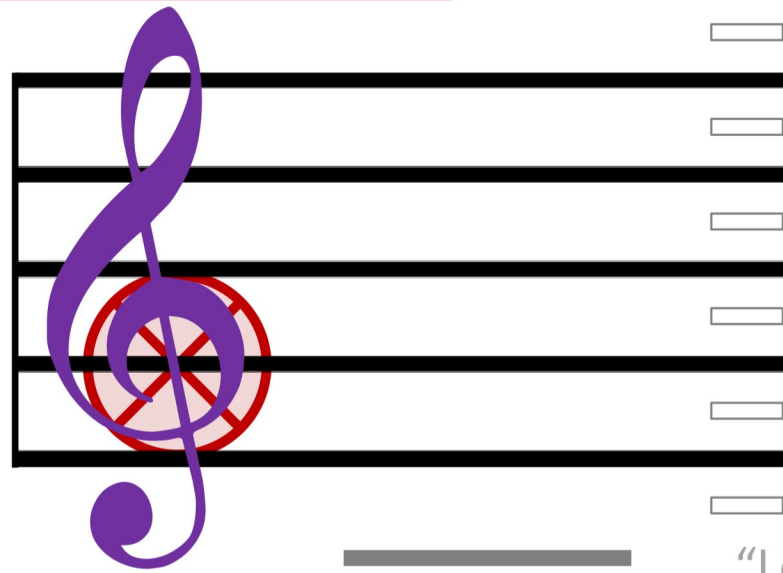
Generally

Q: How do we know which staff *line* corresponds to which note/frequency?

A: With a Clef Symbol

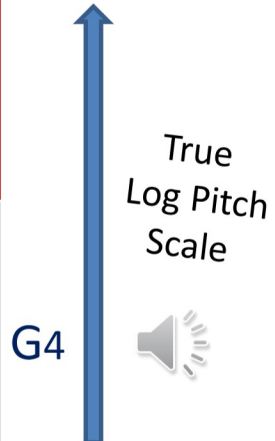
Erratic
"Sorta-Log"
Pitch Scale

Example:
The **G-Clef** or
Treble Clef:
Bullseye on G4



"Ledge" Lines

Notes chosen from a
7 note-per-Octave
Diatonic Scale



G4

C Major Scale

Passage of Time



The 5 Line Staff

Generally

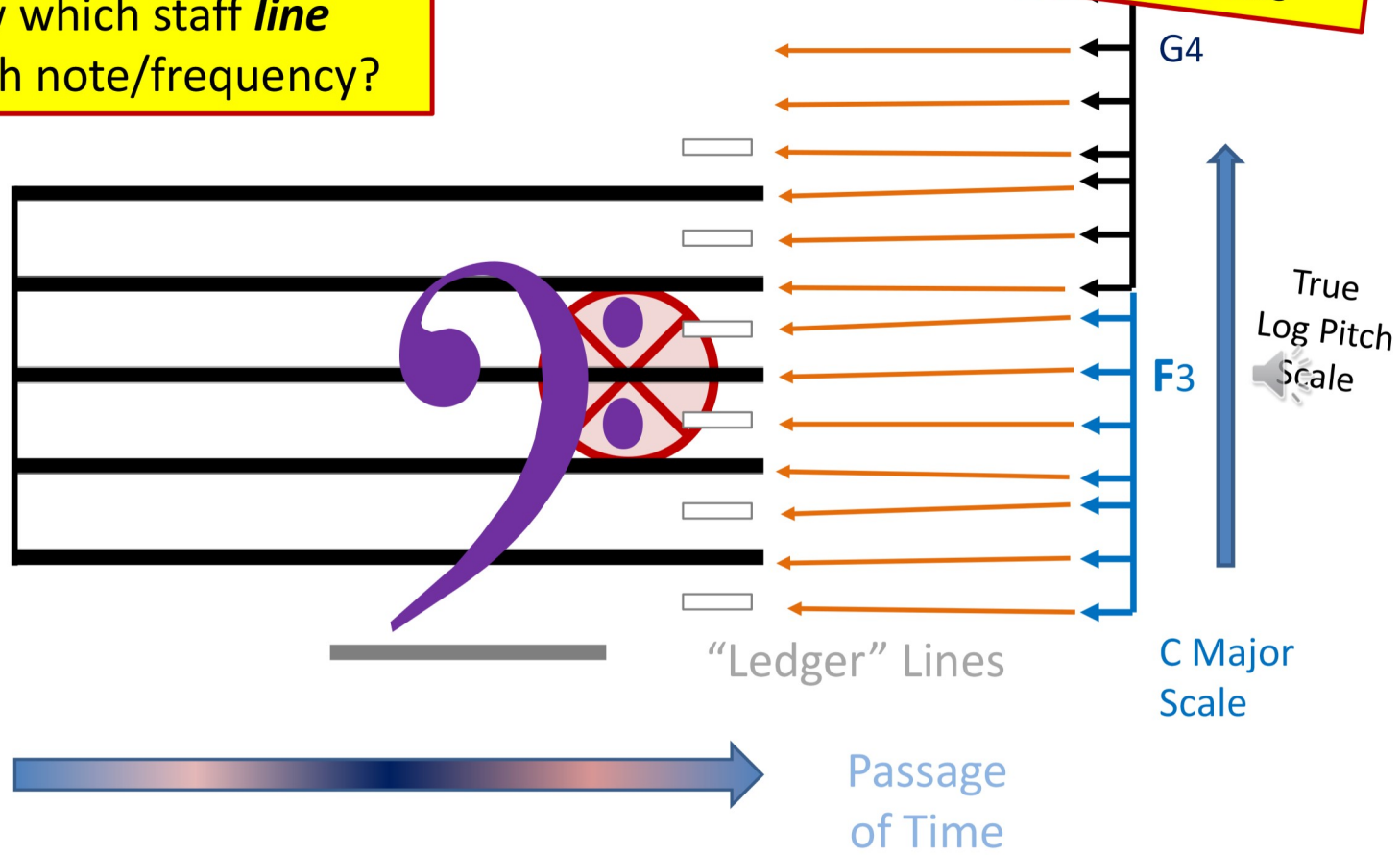
Q: How do we know which staff *line* corresponds to which note/frequency?

A: With a Clef Symbol

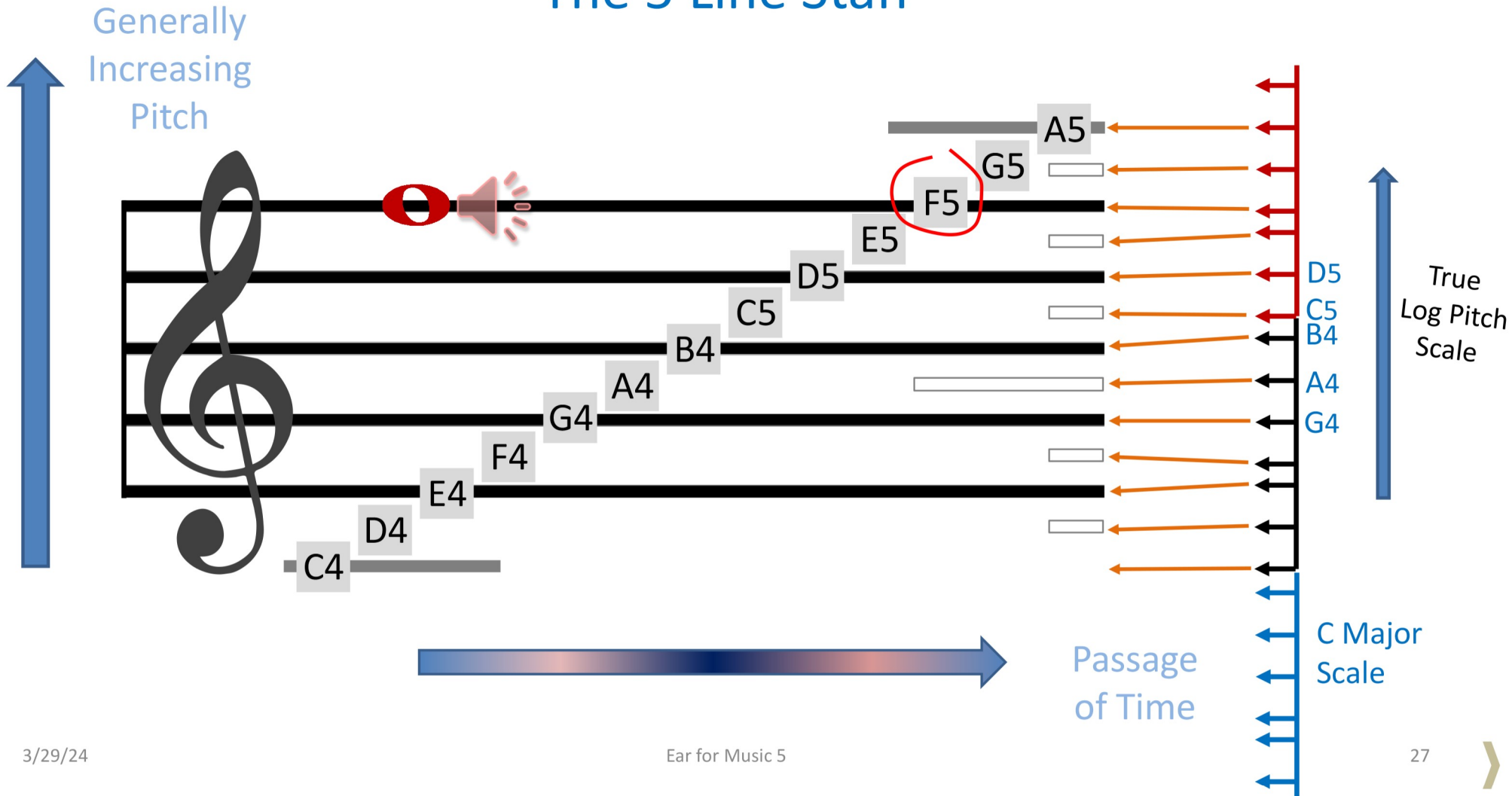
Erratic
"Sorta-Log"
Pitch Scale

Another Example:
The **F-Clef** or
Bass Clef:
Bullseye on **F3**

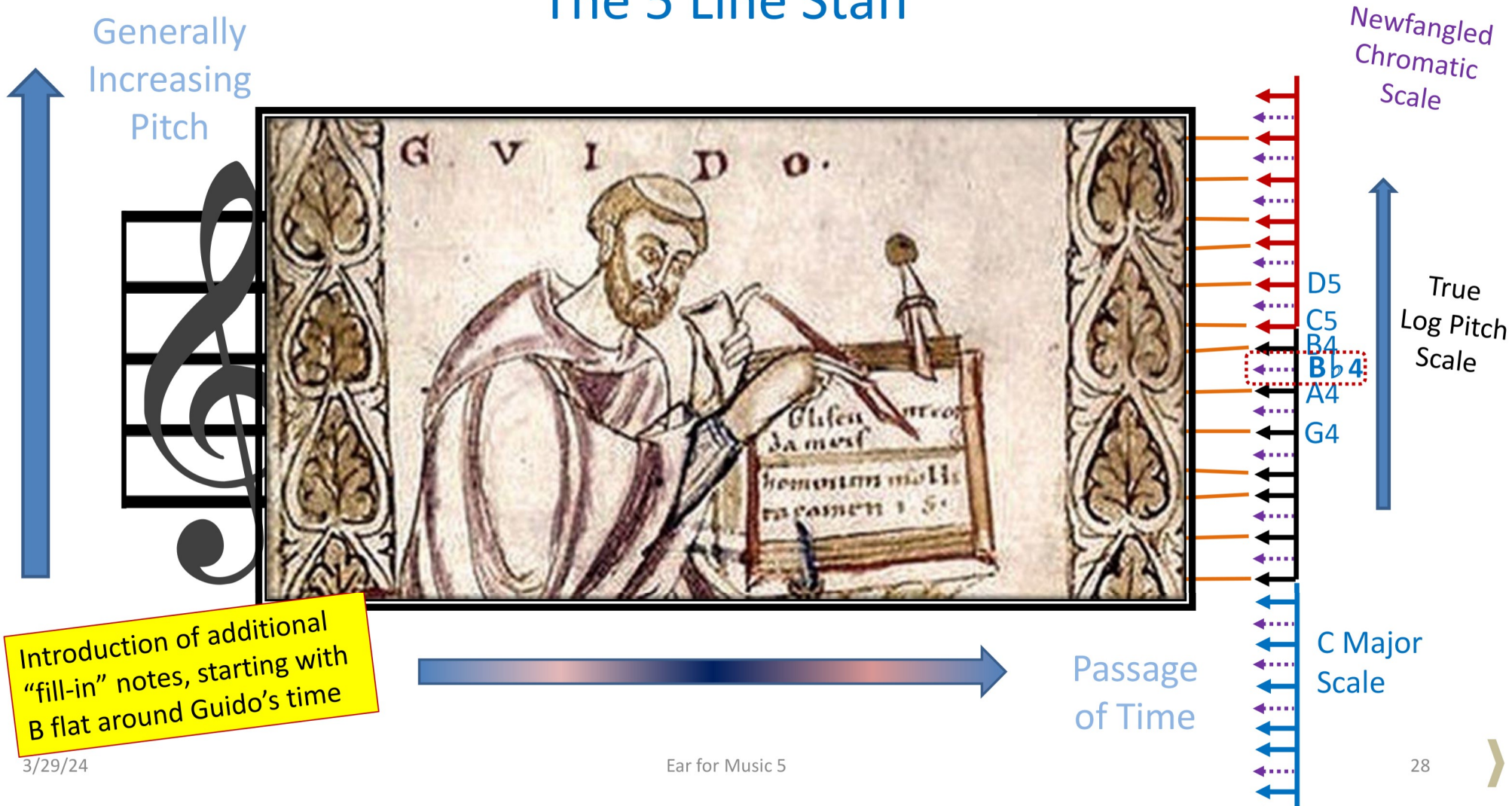
Notes chosen from a
7 note-per-Octave
Diatonic Scale



The 5 Line Staff



The 5 Line Staff



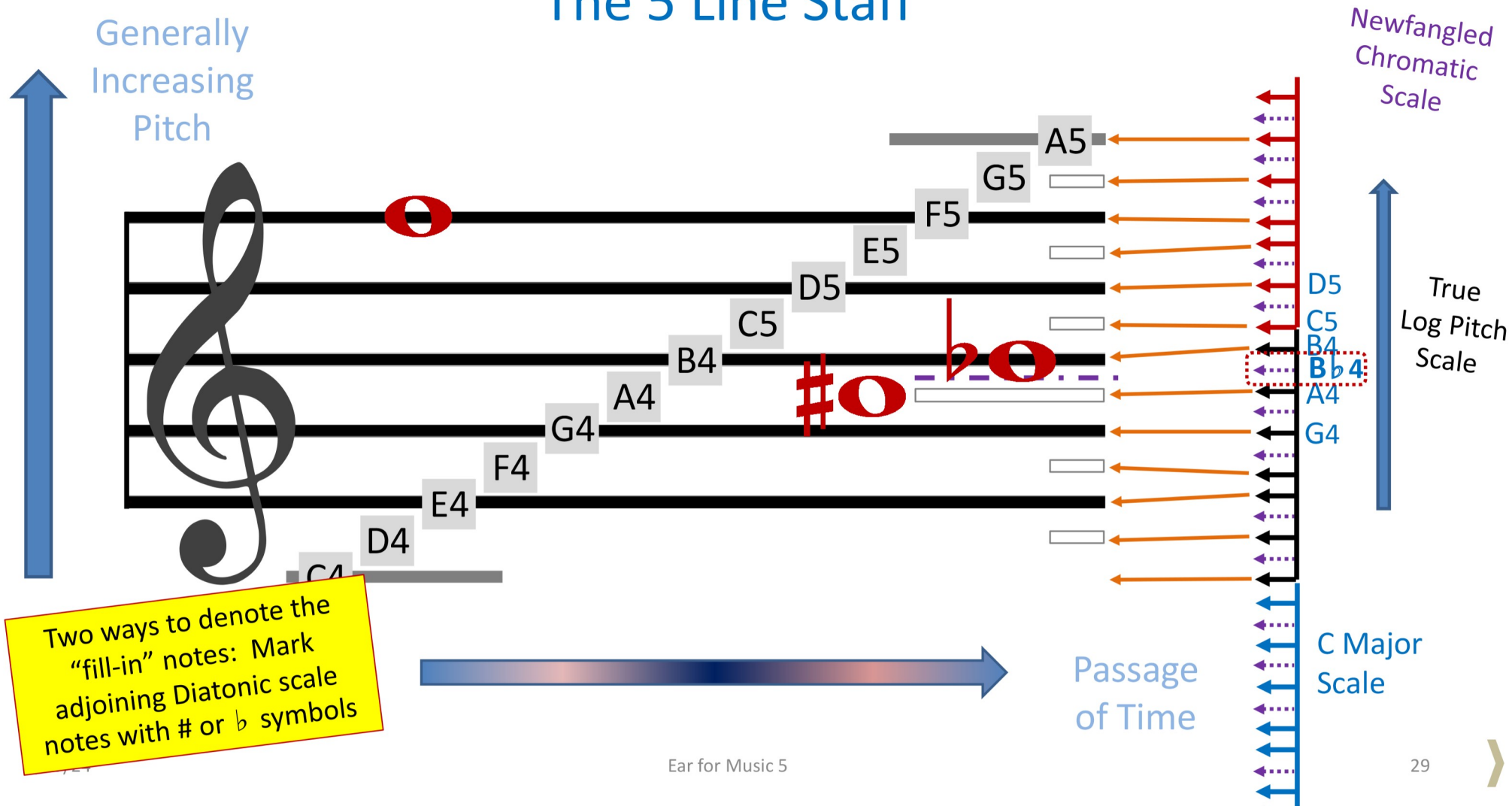
Introduction of additional "fill-in" notes, starting with B flat around Guido's time

3/29/24

Ear for Music 5

28

The 5 Line Staff



Two ways to denote the "fill-in" notes: Mark adjoining Diatonic scale notes with # or *b* symbols

Music in Keys Other than C Major or A minor

A musical staff with a treble clef. The middle line is labeled C5 and the first line is labeled G4. A yellow callout box above the staff contains the text "What if we have a lot of these intruders?". The staff contains a sequence of notes: a whole note on the C5 line, followed by five sharp notes (F#4, G#4, A#4, B#4, C#5) on the space between G4 and C5, then a whole note on the C5 line, followed by two sharp notes (D#5, E#5) on the space between C5 and the next line above.



Passage
of Time



Music in Keys Other than C Major or A minor

Shortcut: Mark the whole line (or space) as defaulting to #, then mark exceptions with Natural symbol

Natural Symbol

C5

G4

C4

Passage of Time

The diagram shows a musical staff with a treble clef. A vertical blue arrow on the left points upwards. A yellow box contains the text 'Shortcut: Mark the whole line (or space) as defaulting to #, then mark exceptions with Natural symbol'. A purple sharp symbol (#) is placed on the C5 line. A purple natural symbol (♮) is placed on the G4 line. Red oval notes are placed on the C5 line and the G4 line. A horizontal blue arrow at the bottom points to the right, labeled 'Passage of Time'. Below the staff, a grey line with a red oval note is labeled 'C4'.



Aside

If the Romans Forgot to Give Us Vowels...

[w="a", q="e", j="i", k="o", g="u". Underscore= 'no change']

i.e. w means simply w



Aside

If the Romans Forgot to Give Us Vowels...

[w="a", q="e", j="i", k="o", g="u". Underscore= 'no change']

Jt wws thq bqst kf tjmq_s, jt wws thq wkrst kf tjmq_s, jt wws thq
wgq kf wjsdkm, jt wws thq wgq kf fkkljshnq_{ss}, jt wws thq qpkch
kf bqljqf, jt wws thq qpkch kf jncrqdgljty, jt wws thq sqwskn kf
Ljght, jt wws thq sqwskn kf Dwrknq_{ss}, jt wws thq sprjng kf hkpq,
jt wws thq wjntqr kf dqspwjr.

Kinda works,
but what a pain!


Chwrlqs Djckqns

W Twlq kf Twk Cjtjqs (1859)



Transposing a Melody from Key of D to B_b (4 pitch steps down)

D →



Example from Heinrich Koch's
"Musikalisches Lexikon" (via Wikipedia)

Transposing a Melody from Key of D to B_b (4 pitch steps down)

D

↓
C#
↓
C
↓
B
↓
B_b

One of several ways it could be written....

All pitches reduced to 79.4% of originals

Example from Hei...
"Musikalisches Lex...

Very complex process, hard for music students to learn...

The Full Chromatic Scale on the 5 Line Staff



C4 C# D D# E F F# G G# A A# B4 C5

C5 B4 Bb A Ab G Gb F E Eb D Db C4

Two ways to notate each non-Diatonic note



The Full Chromatic Scale on the 5 Line Staff

C₄ C[#] D D[#] E F F[#] G G[#] A A[#] B₄ C₅
 C₅ B₄ B^b A A^b G G^b F E E^b D D^b C₄

Note durations

	Whole Note		Half Note		Quarter Note		Eighth Note		16th Note						
2	1½	1	7/8	¾	½	7/16	3/8	¼	3/16	1/8	3/64	1/16	1/32	1/64	1/128 ...



Für sechs Streichinstrumente

1. Geige

Arnold Schönberg, Op. 4

Sehr langsam

2 1. Bratsche

pp

immer leise

pp

trmn

immer leise

pp

trmn

cresc.

espress.

3

rit.

A

f

accel.

f

p

B

rit. steigernd

1

1

2

2. Geige

VERKLAERTE NACHT

(Transfigured Night)

Opus 4, for String Sextet (1899)

After a Poem by RICHARD DEHMEL

VIOLIN I

ARNOLD SCHOENBERG

(1875-1951)

Sehr langsam.

immer leise

2 1. Bratsche. *pp* *pp* *tr* *immer leise* *cresc.* *espress.* *rit.* **B** *rit. steigernd* 2

The image shows the first five staves of the Violin I part of Arnold Schoenberg's 'Verklärte Nacht'. The music is in 3/4 time and begins with a dynamic marking of *pp*. The first staff includes the tempo marking 'Sehr langsam.' and the instruction 'immer leise'. The second staff also has 'immer leise'. The third staff features a section marked 'A' and a dynamic marking of *pp*. The fourth staff includes 'cresc.' and 'espress.'. The fifth staff starts with 'rit.' and 'B', followed by 'rit. steigernd' and a final '2' marking. The score includes various musical notations such as slurs, accents, and dynamic markings.

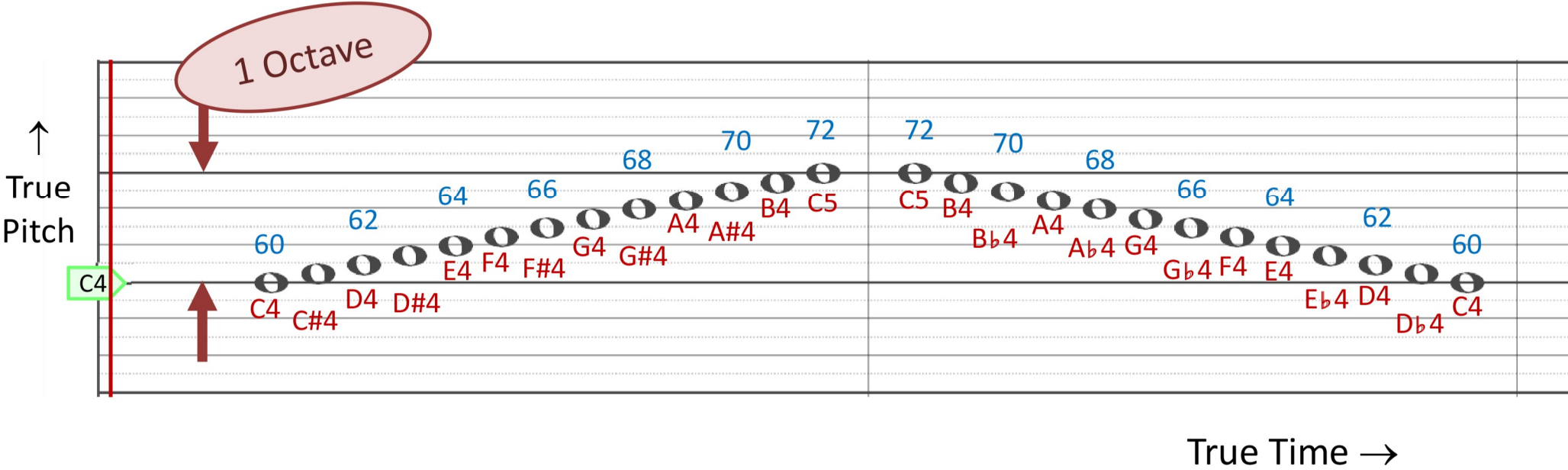
12 Note Per Octave Equal Tempered Scale: The Chromatic Scale

MIDI	<i>f</i>		Note	Pitch Class	Solfège
85	1108.7		C#/D \flat 6	1	Di
84	1046.5		C 6	0	Do
83	987.8		B 5	11	Ti
82	932.3		A#/B \flat 5	10	Li
81	880		A 5	9	La
80	830.6		G#/A \flat 5	8	Si
79	784.0		G 5	7	Sol
78	740.0		F#/G \flat 5	6	Fi
77	698.5		F 5	5	Fa
76	659.3		E 5	4	Mi
75	622.3		D#/E \flat 5	3	Ri
74	587.3		D 5	2	Re
73	554.4		C#/D \flat 5	1	Di
72	523.3		C 5	0	Do
71	493.9		B 4	11	Ti
70	466.2		A#/B \flat 4	10	Li
69	440		A 4	9	La
68	415.3		G#/A \flat 4	8	Si
67	392.0		G 4	7	Sol
66	370.0		F#/G \flat 4	6	Fi
65	349.2		F 4	5	Fa
64	329.6		E 4	4	Mi
63	311.1		D#/E \flat 4	3	Ri
62	293.7		D 4	2	Re
61	277.2		C#/D \flat 4	1	Di
60	261.6		C 4	0	Do
59	246.9		B 3	11	Ti
58	233.1		A#/B \flat 3	10	Li
57	220		A 3	9	La



A Modest Proposal

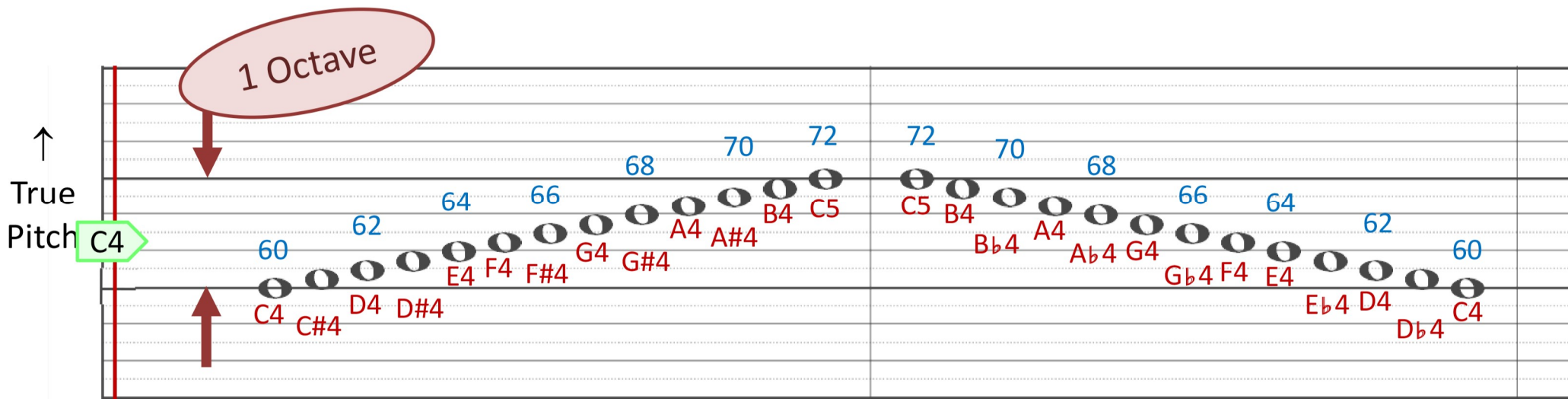
Chromatic Scale with *OLLI* • Staff



Chromatic Scale with *OLLI* • Staff



A Modest Proposal



	Key Transposition?
--	--------------------



Simply move the "Clef" Indicator... or else just shift all the notes up or down as desired. Dead Simple.

True Time →



Scott Joplin: The Entertainer on *OLLI*•staff



The Entertainer
NewNotation 1.11.xlsm



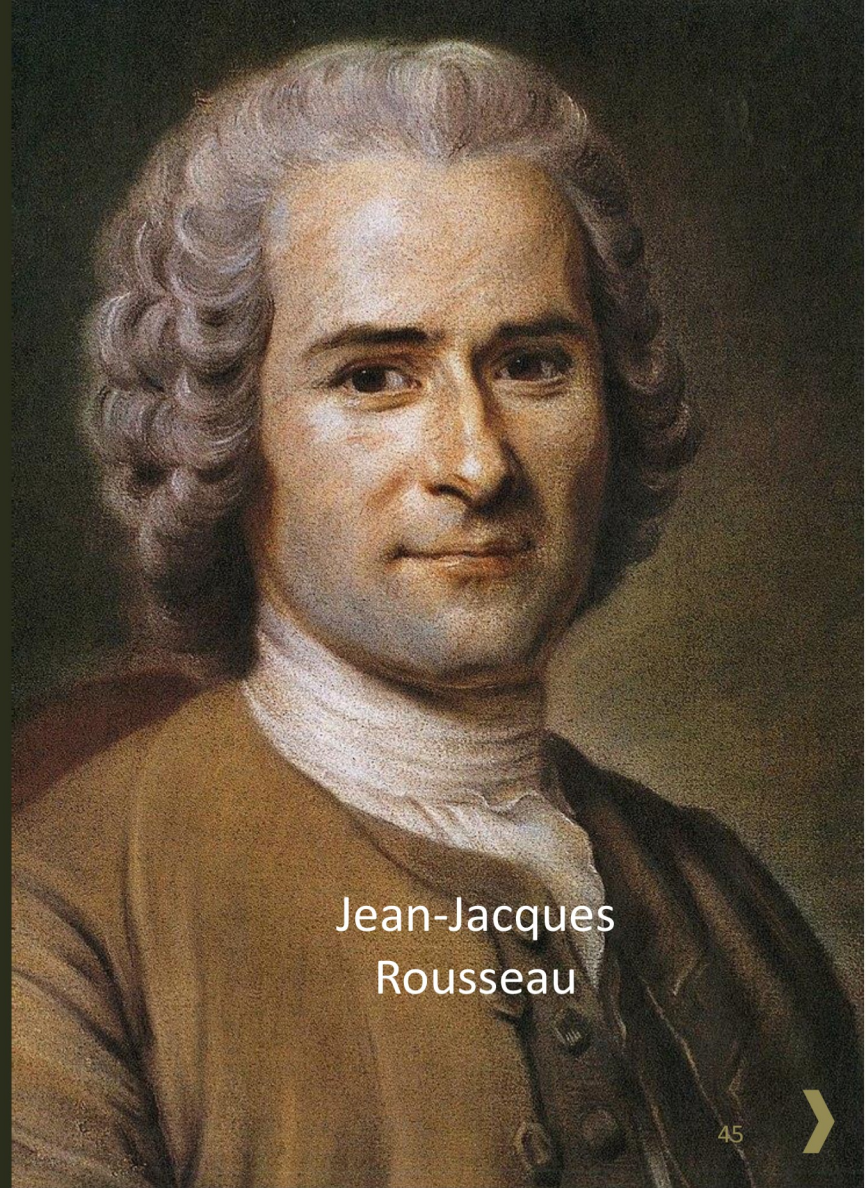
1742 Proposal to the French Academy of Sciences for a Numerical Notation System

REJETÉ

Also published in his *Dissertation on Modern Music* (1743)

Handwritten musical notation in 4/4 time, consisting of two systems of numbers separated by bar lines. The first system has three measures: the first measure contains '1112333', the second '22231 1', and the third '3 3 5 55'. The second system has two measures: the first contains '44453 0 | i 1 7 77 | 66665 0 |' and the second contains '1112333 | 22231 0 ||'. The word 'Phil' is partially visible at the bottom left of the page.

Long history of attempts to
rationalize musical notation



Jean-Jacques
Rousseau



Dozens of Current Alternative Notation Schemes

- See *e.g.*
The Music Notation Project
www.MusicNotation.org



SCOOPED

Dodeka System



Jacques-Daniel Rochet
(Swiss)

The Dodeka Project
www.DodekaMusic.com

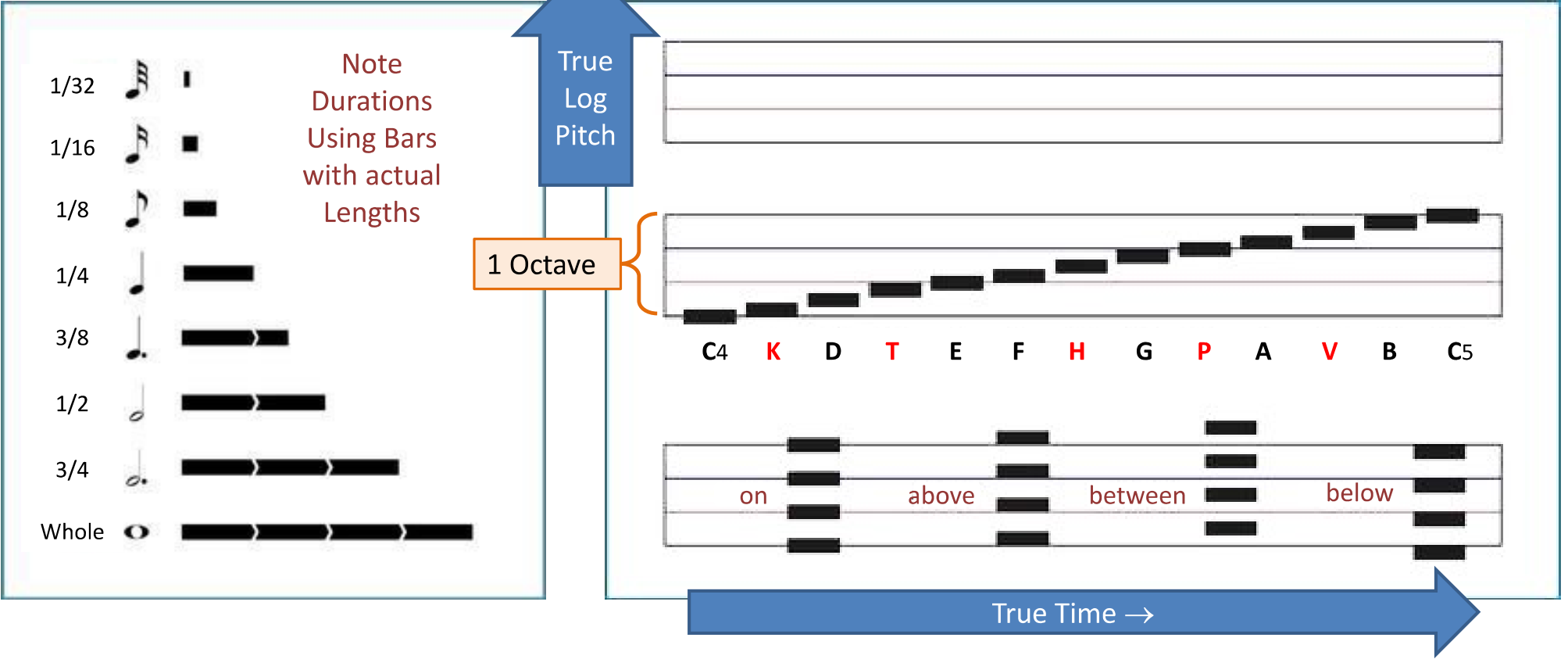
Note Durations Using Bars with actual Lengths

1/32		
1/16		
1/8		
1/4		
3/8		
1/2		
3/4		
Whole		



SCOOPED

Dodeka System



Music notation tools...

Single score

Speed = 60
Intensity
Nuances
Pedal
End
Tone
Additional line
Change
Repetitions
Return

The diagram shows a single musical staff with various notation elements. A tempo marking of 60 is shown. Dynamic markings include 'Intensity' with a box and 'Nuances' with a wedge. A 'Pedal' marking is shown as a grey oval. The staff contains notes, rests, and articulation marks. A 'Change' section is marked with a diamond and a circled '4'. 'Repetitions' are shown with circled '2's. A 'Return' section is marked with a vertical line and a double-headed arrow. An 'End' section is marked with a double bar line and a circled '5'. A 'Zoom sound' section is marked with a vertical line and a double-headed arrow.

Triple scores

Tempo
Notes
Expression
Mesure
Time zoom
Landmarks
Zoom sound
Triplet
Expression
Repeat

The diagram shows a triple score with three staves. The top staff has a tempo marking of 4. The middle staff has a 'Triplet' marking. The bottom staff has a 'Repeat' marking. The score includes notes, rests, and articulation marks. A 'Time zoom' section is marked with a vertical line and a double-headed arrow. 'Landmarks' are marked with vertical lines and double-headed arrows. A 'Zoom sound' section is marked with a vertical line and a double-headed arrow. The score is divided into measures by vertical lines.

Some of the extensive Dodeka notation

Notes	
	N. value: 16-32x <i>According to the duration of the note</i>
	Note value: 8 x Double whole note <i>Short notation (4x)</i> <i>Linear notation</i>
	Value: 4 x Whole note <i>Short notation (4x)</i> <i>Linear notation</i>
	Note value: 2 x Half note <i>Short notation (4x)</i> <i>Linear notation</i>
	Reference note value: 1 x Quarter note
	Note value: 1/2 Eighth note
	Note value: 1/4 Sixteenth note
	Note value: 1/8 Thirty-second note
	1/16 1/32 1/64 Zoom 4x
	Beamed notes Arrow
	Dotted note Links
	Ghost note x xx xxx Depending on the duration

Rests	
	Time : 16-32x <i>Duration according to the number</i>
	R. value: 16x R. value: 8 x
	R. value: 4x <i>Short notation (4x)</i> <i>Linear notation</i>
	Rest value: 2x <i>Short notation (4x)</i> <i>Linear notation</i>
	Reference rest value: 1 x
	Rest value: 1/2
	Rest value: 1/4
	Rest value: 1/8
	Rest value: 1/16
	1/32 1/64 Zoom 4x + 1/4 1/8
	Breath mark
	Caesura

Navigation controls: back, play, metronome icon, title "Lullaby", tempo slider set to 120, and eye icon.

A musical score for 5 staves. The score is divided into measures by vertical lines. A large orange vertical highlight covers the third and fourth measures. The notes are color-coded: black, green, blue, purple, and brown. A large number '3' is written on the fourth staff in the first measure. A metronome icon is visible in the background.

A horizontal timeline bar at the bottom of the interface. It features a play button on the right and several black rectangular markers along the timeline, indicating specific points in the music.

Dodeka can handle any kind of music



Fur Elise
In A minor. For keyboards

Ludwig van Beethoven
Excerpt of the opus WoO 59, 1810

The image displays a three-system musical score for the piece 'Fur Elise' by Ludwig van Beethoven. The score is written for keyboard and includes several annotations for the Dodeka software:

- System 1:** Features a circled '3' in the first measure, indicating a triplet. Fingerings (1-5) are shown above the notes. A double-headed arrow points to a specific interval.
- System 2:** Includes a circled 'A' and a circled 'B' with arrows pointing to specific notes, likely marking repeat or branch points.
- System 3:** Starts with a circled 'B' and ends with three dots, indicating a continuation of the piece.



Question Time

- Naming Notes
- Musical Notation
 - Traditional
 - Alternative



- Zoomland
- In Person





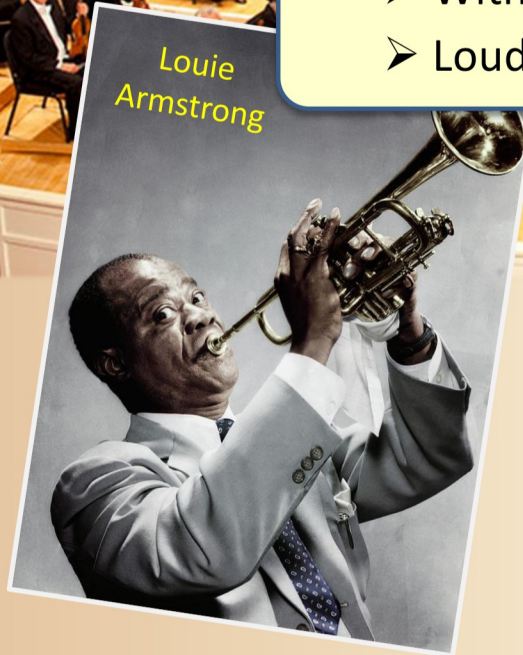
Chicago Symphony
Orchestra (2015)





Basic Role of Musical Instruments is:

- Rendering Musical Notes or Rhythmic Beats
 - With pleasing Timbres
 - Loudly enough to be heard





We have a few to get through...

540

The Chart of
MUSICAL INSTRUMENTS

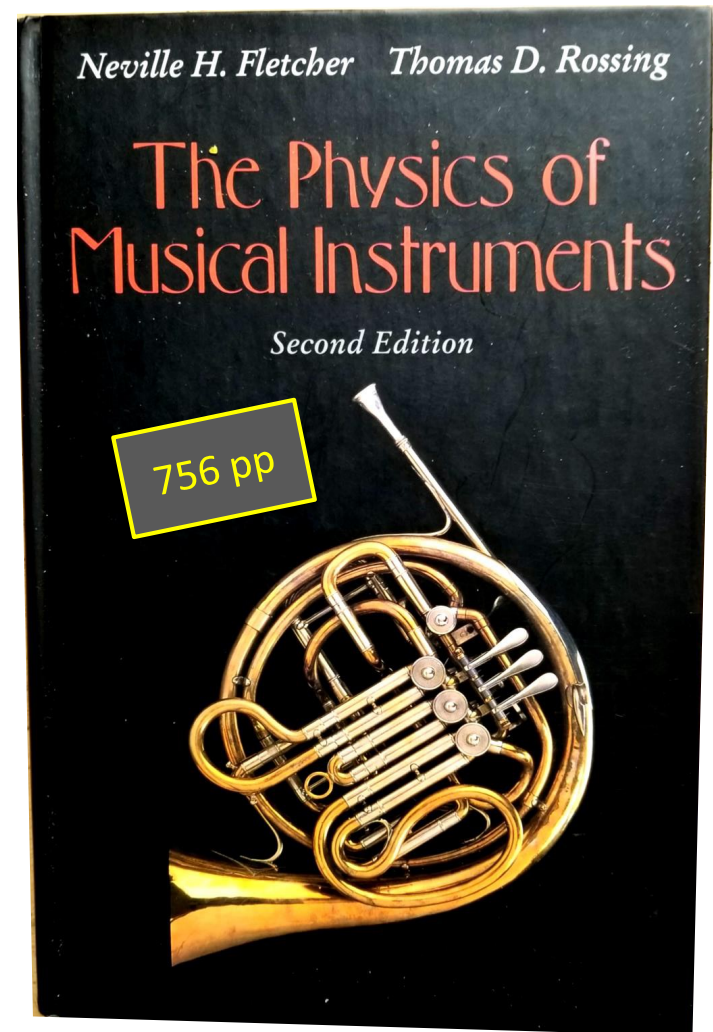
3/29/24

Pop Chart Lab

For for Music 5...

What Do We Know About How Musical Instruments Work?

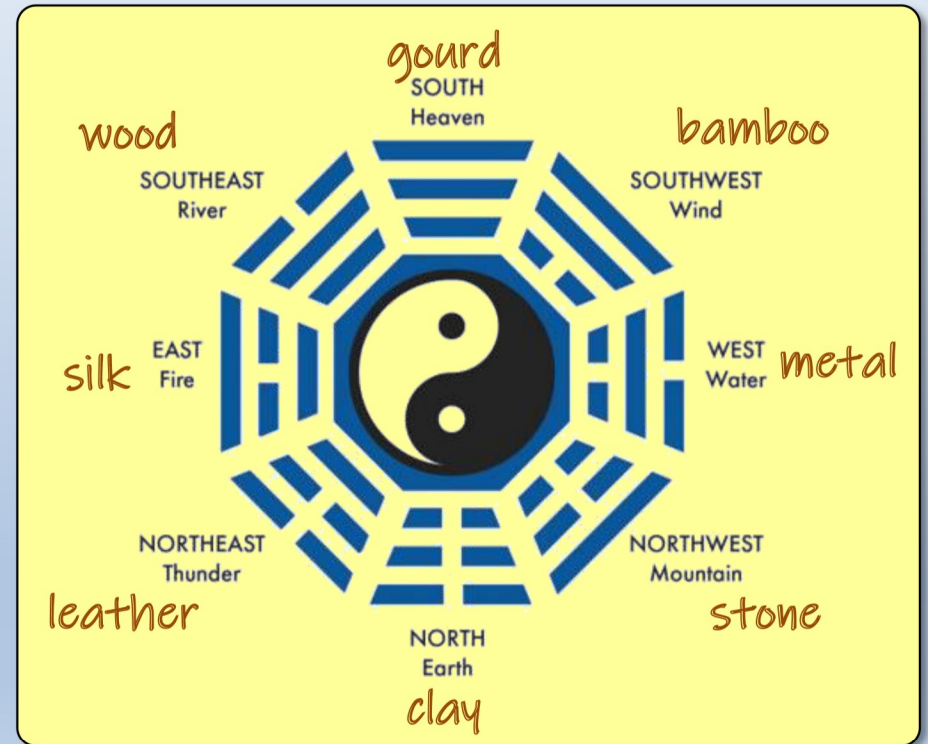
- Not that much
- Good general understanding
 - Lots of interesting details
 - but not enough to design one from scratch
 - Lots of poorly understood aspects
- Existing instruments basically evolved over centuries
 - largely by trial and error
 - but often with informed insight



Classifying Musical Instruments

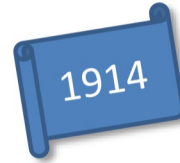
Chinese “8 Winds” Classification (~ Han Dynasty)

- Traditionally
 - Strings
 - Brasses
 - Woodwinds
 - Percussion



Hornbostel-Sachs Classification System

The “Dewey Decimal System” of Musical Instruments



Erich von Hornbostel
(1877-1935)



Curt Sachs
(1881-1959)

① Idiophones

② Membranophones

③ Chordophones

④ Aerophones

⑤ Electrophones



Hornbostel-Sachs Classification System

The “Dewey Decimal System” of Musical Instruments

1914



Erich von Hornbostel
(1877-1935)



Curt Sachs
(1881-1959)

① Idiophones



② Membranophones



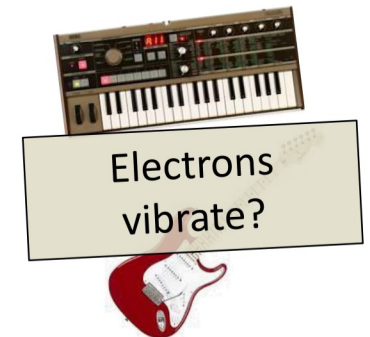
③ Chordophones



④ Aerophones



⑤ Electrophones



Hornbostel-Sachs: Family Tree of the African Thomo

Example



JEUNE FILLE PAÏENNE JOUANT DU THOMO

3 Chordophones

31 Simple chordophones or zithers

311 Bar zithers

311.1 Musical bows

311.12 Heterochord musical bows

311.121 Mono-heterochord musical bows

311.121.2 With resonator

311.121.22 With resonator attached

311.121.221 Without tuning noose *S. Africa (hade, thomo)*

www.MIMO-International.com

Explore the world collections of musical instruments

Welcome to the world's largest freely accessible database for information on musical instruments held in public collections. Our database now contains the records of 64259 instruments.

64,250 Instruments

Another ~~My~~ Scheme

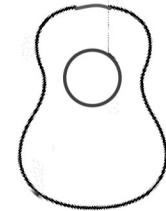
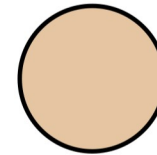
- 1 Dimensional Resonators

- Strings
- Pipes



- 2 Dimensional Resonators

- Drums
- Parts of some string instruments (e.g. guitars, pianos)



- 3 Dimensional Resonators

- Bars (e.g. xylophones)
- Bells

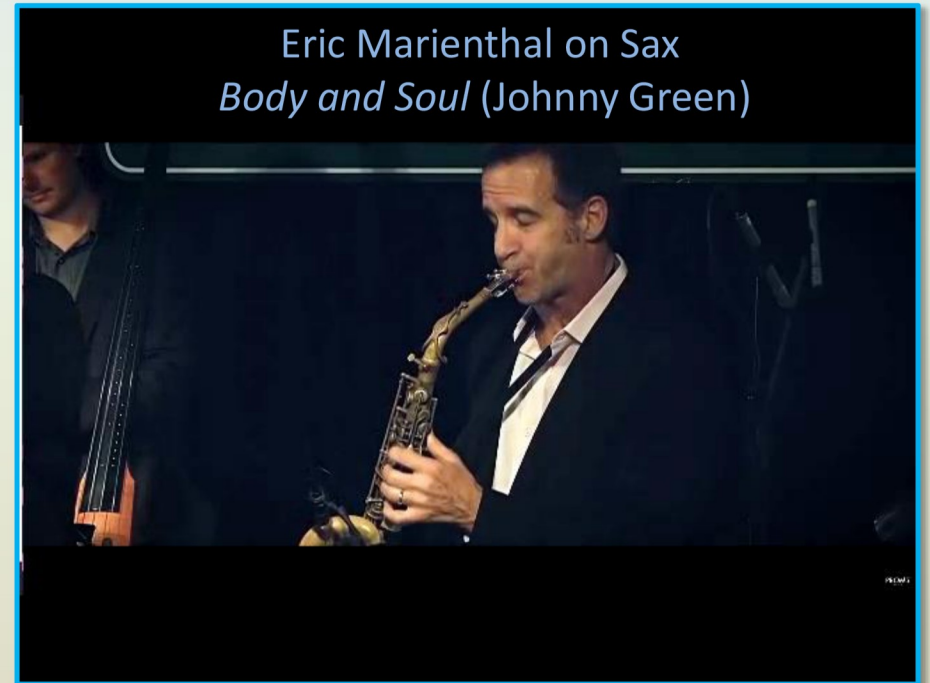


Why are there so many kinds of Instruments?



Instrument Differentiators

1. Timbre



Instrument Differentiators

1. Timbre

2. Frequency Range

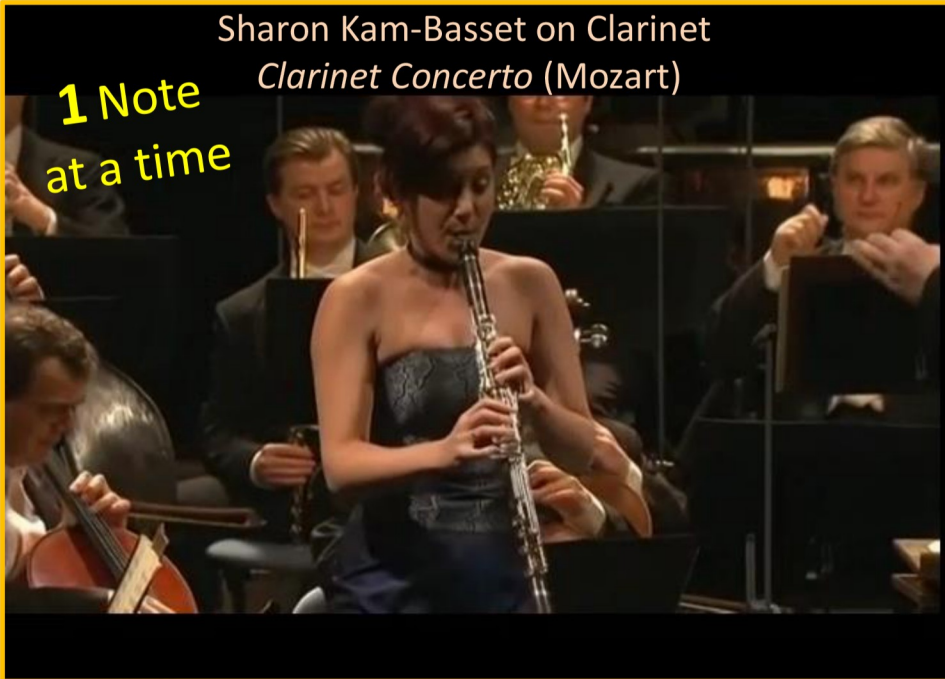


Instrument Differentiators

1. Timbre
2. Range
- 3. Chord Capability**
Simultaneous Notes

Sharon Kam-Basset on Clarinet
Clarinet Concerto (Mozart)

1 Note
at a time



Richard Elliott on Salt Lake Tabernacle Pipe Organ
Bach Toccata in D Minor

10 or more
Notes at a
time



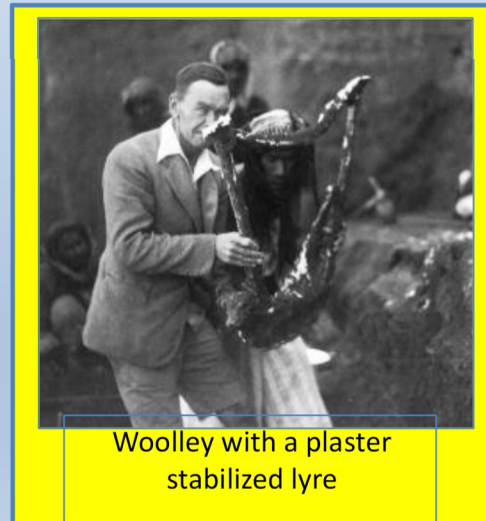
Strings

Mesopotamian Strings: Golden Lyre of Ur

- From “Royal Tombs” at Ur, Sumeria (~2600 BC)
- Excavated ~1929
 - British Museum/U Penn Expedition
 - Led by Leonard Woolley
- 4 Excellent Lyres found
- Best : **The Queen’s Golden Lyre**
Iraq Museum, Baghdad (Restored)



3 Lyres as excavated



Woolley with a plaster stabilized lyre

Postscript: Golden Lyre Damaged in 2003 Looting of the Iraq National Museum



Iraq National Museum,
Baghdad (2008)



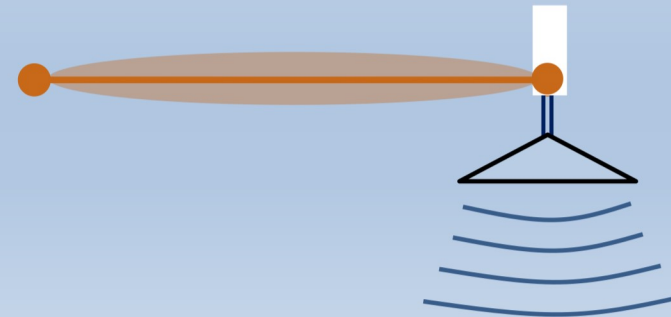
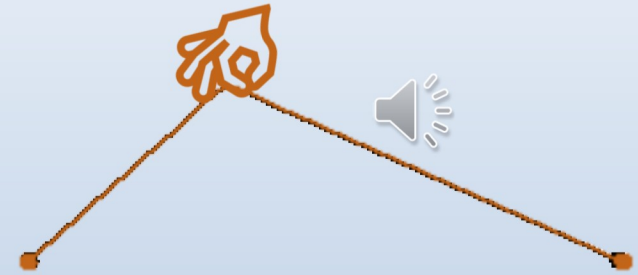
Remains of Golden Lyre
found in parking lot:
Minus ancient parts

Strings

String Instruments

Three main problems:

1. Excitation
 - How to get the string vibrating
2. Frequency Control
 - Playing desired notes
3. Getting Sound Out
 - Coupling string vibrations to sound waves

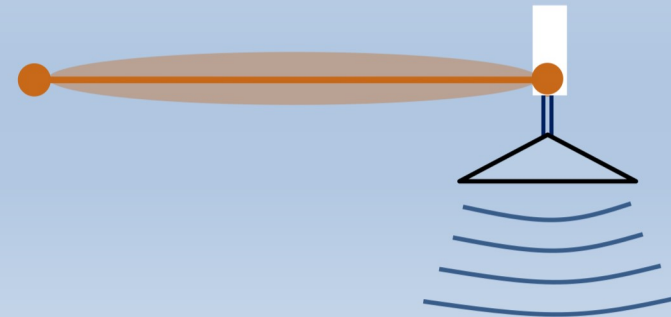
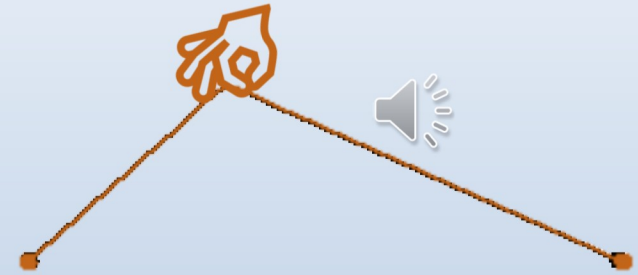


Strings

String Instruments

Three main problems:

1. Excitation **EASY**
 - How to get the string vibrating
2. Frequency Control **EASY**
 - Playing desired notes
3. Getting Sound Out **HARD**
 - Coupling string vibrations to sound waves

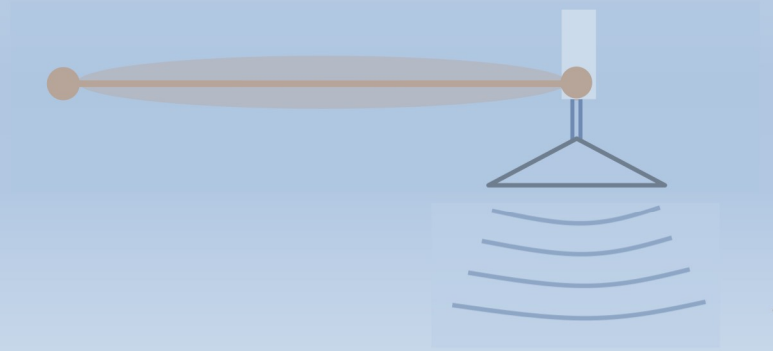
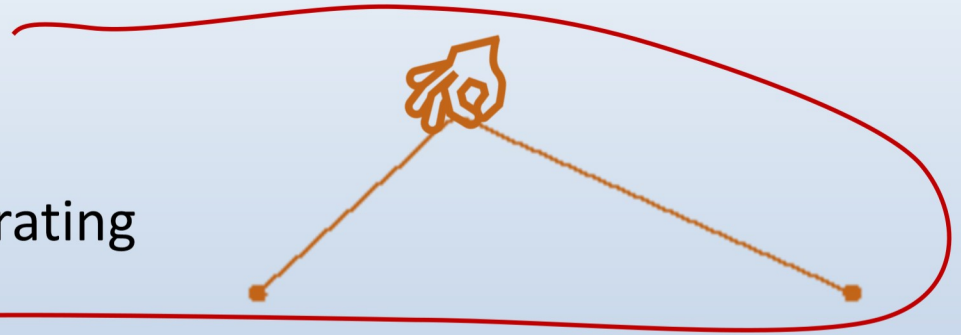


Strings

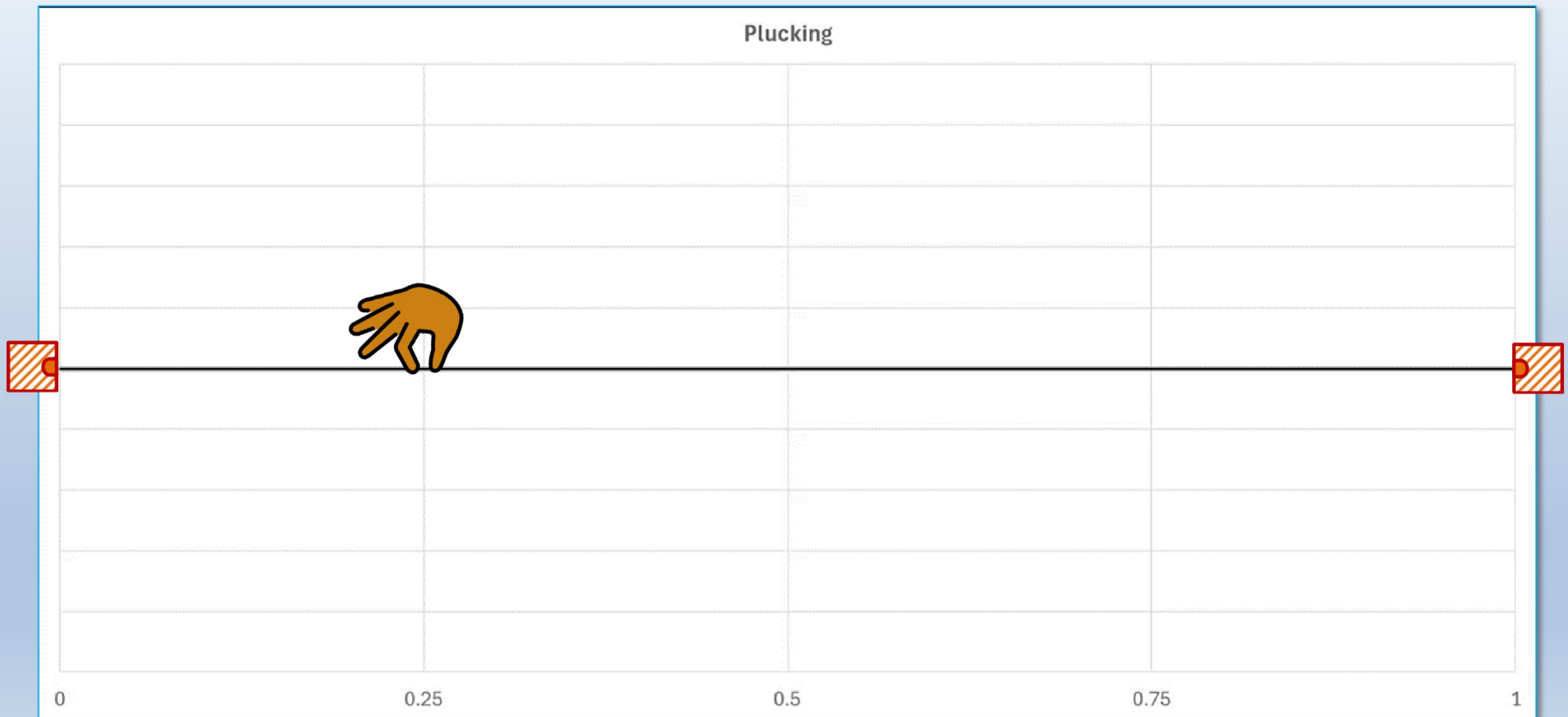
String Instruments

Three main problems:

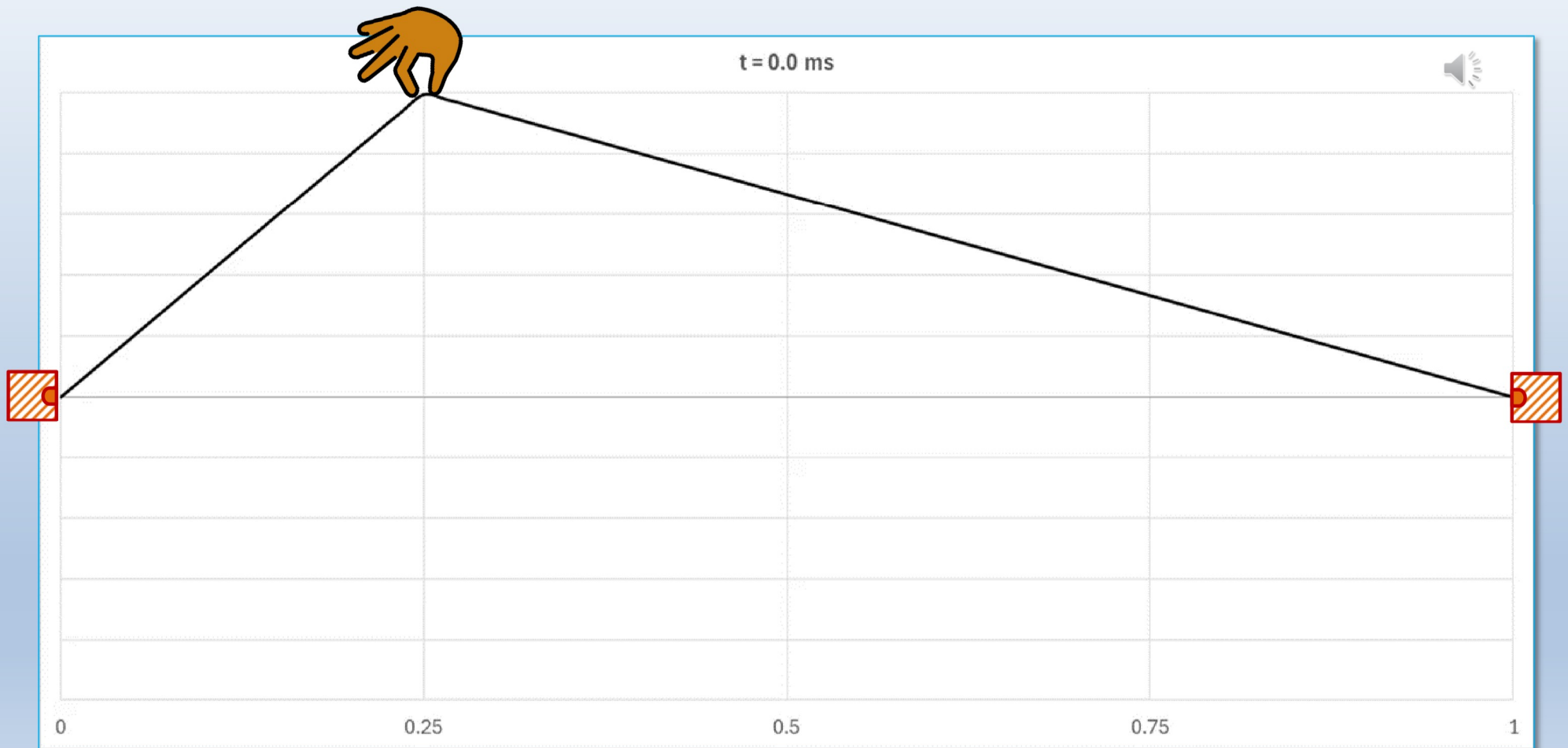
1. Excitation **EASY**
 - How to get the string vibrating
2. Frequency Control **EASY**
 - Playing desired notes
3. Getting Sound Out **HARD**
 - Coupling string vibrations to sound waves



Plucking a Guitar String



Plucking a Guitar String



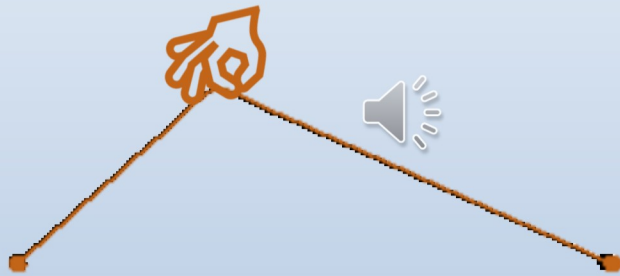
Plucking a Guitar String



$t = 3.1 \text{ ms}$



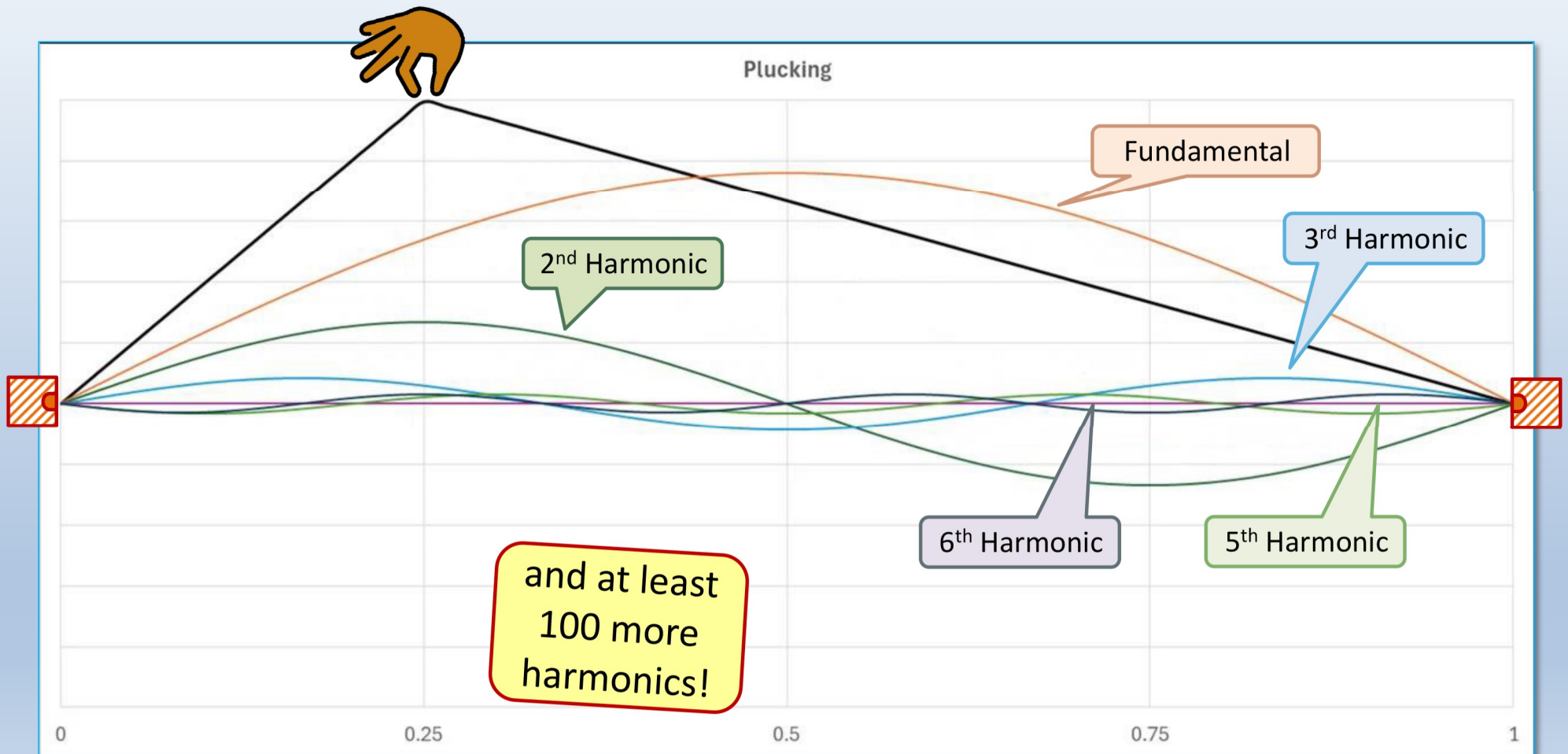
Is that what a Plucked String Really Looks Like?



Slow Motion

Bass Guitar
Cruikshank, University of St. Andrews

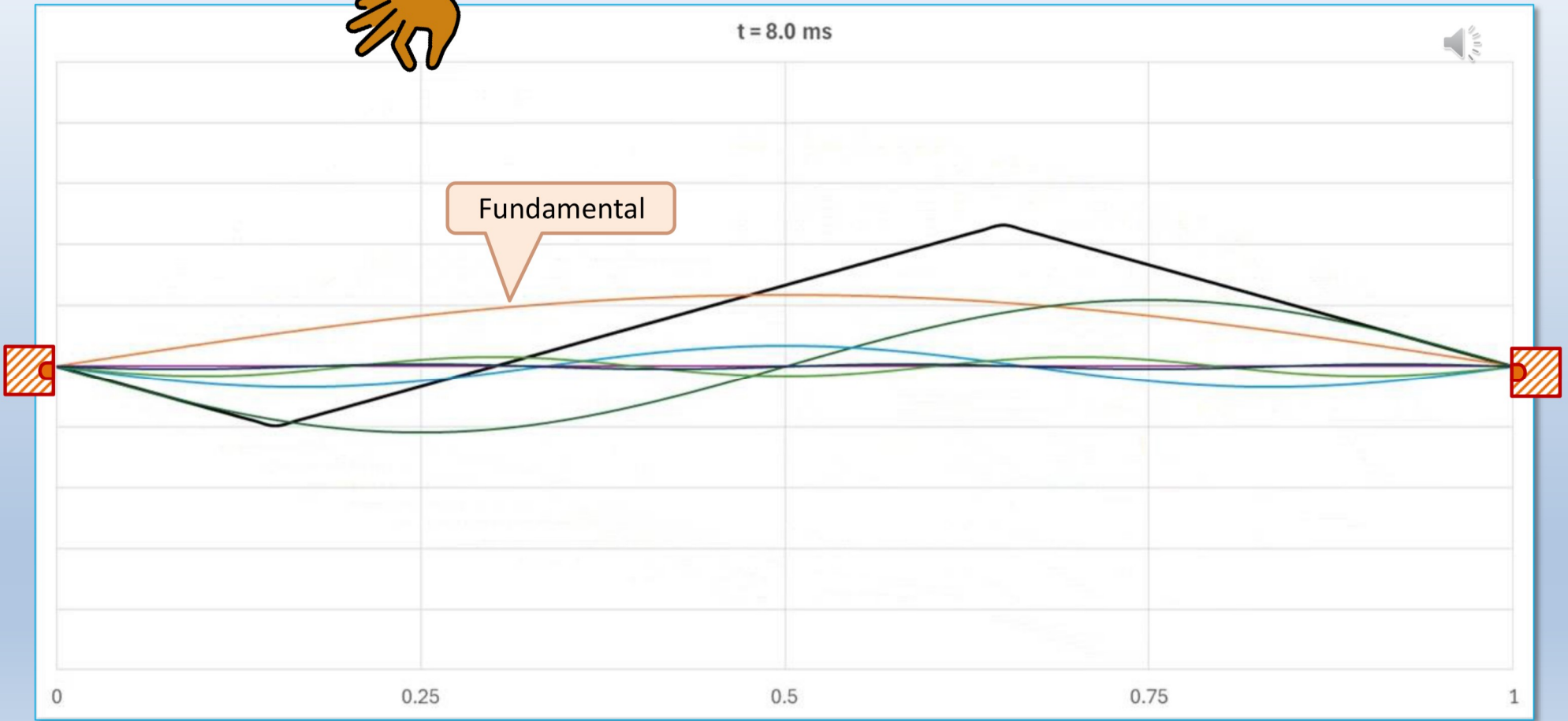
Plucking a Guitar String: The Vibration Modes Adding Up to the Triangle



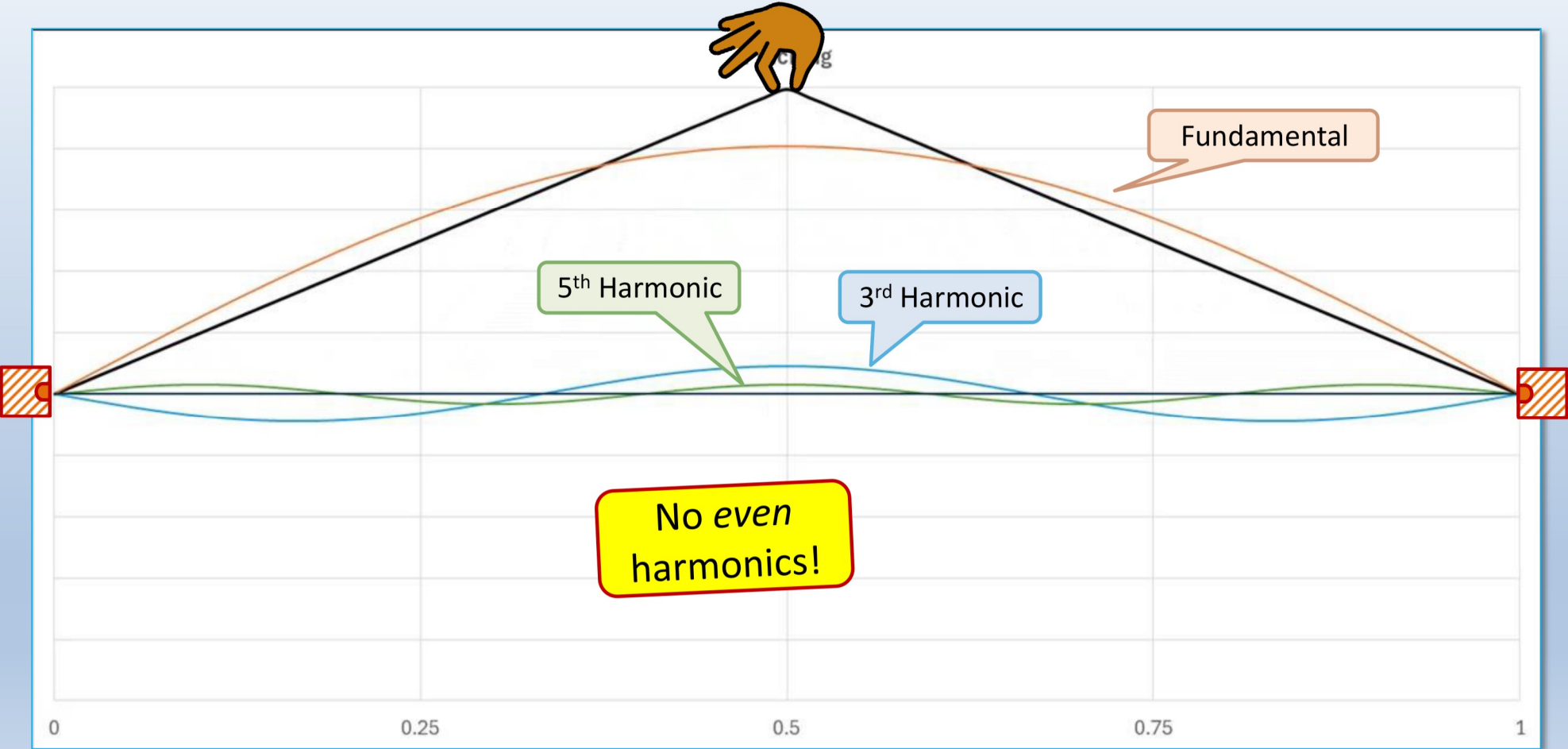
Plucking a Guitar String



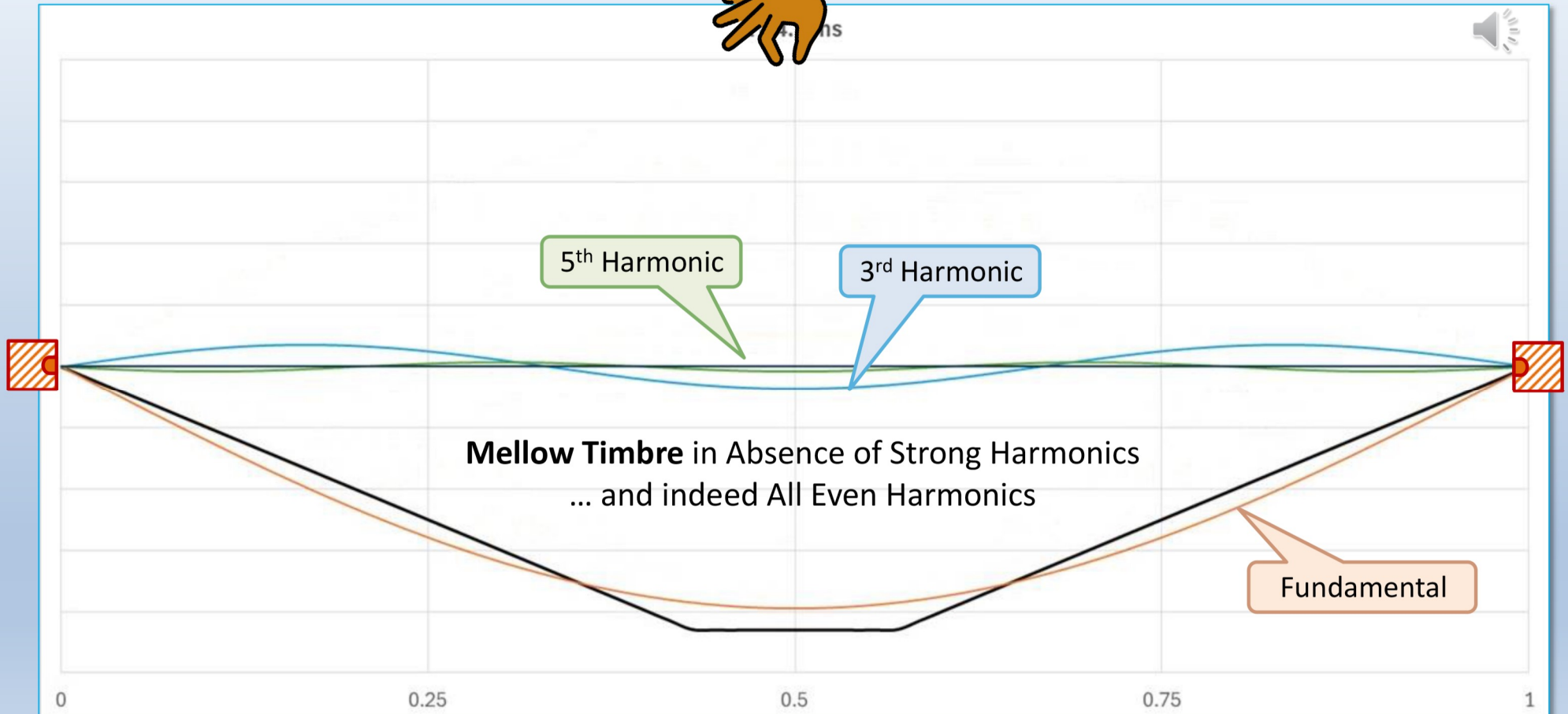
t = 8.0 ms



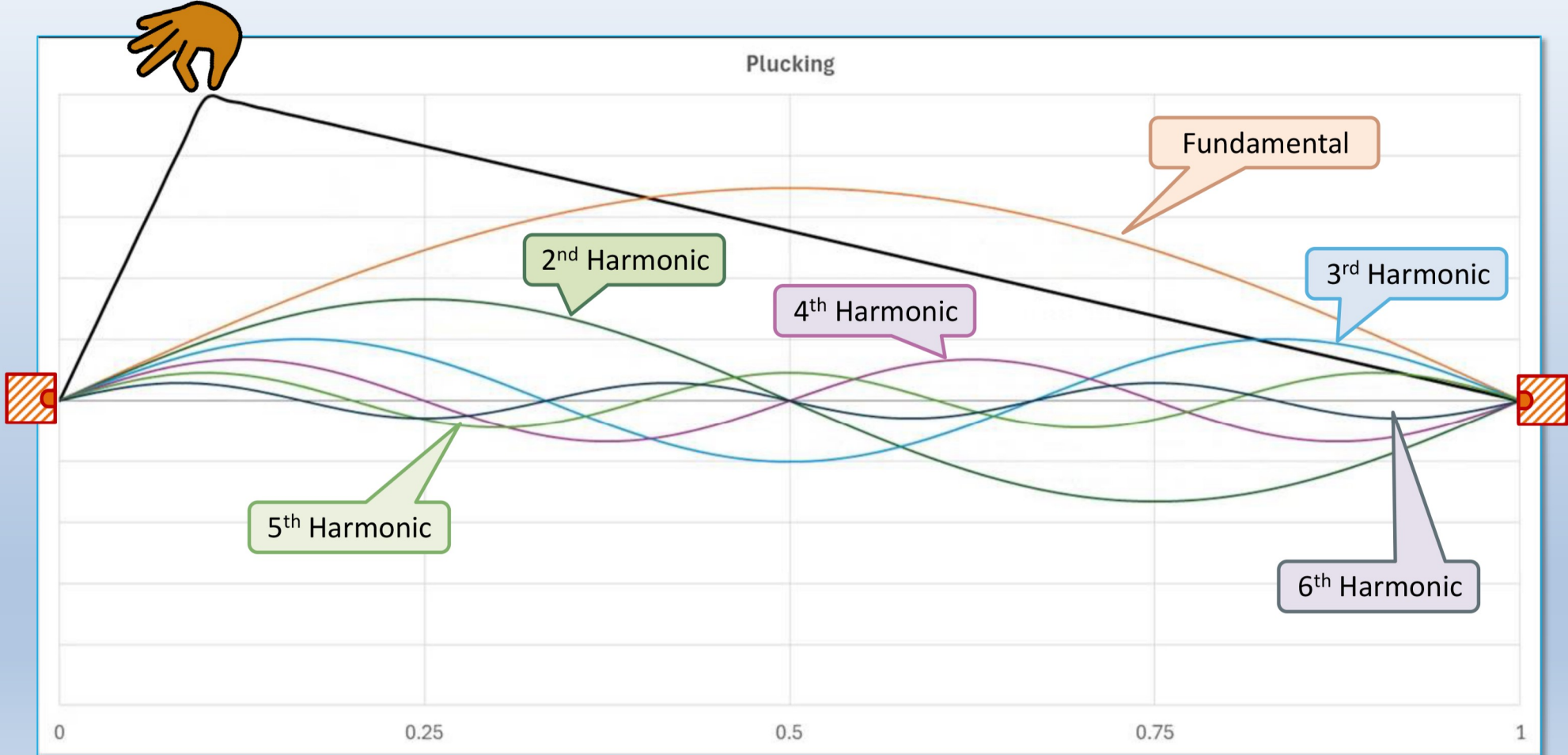
Plucking a Guitar String: What if we pluck the middle?



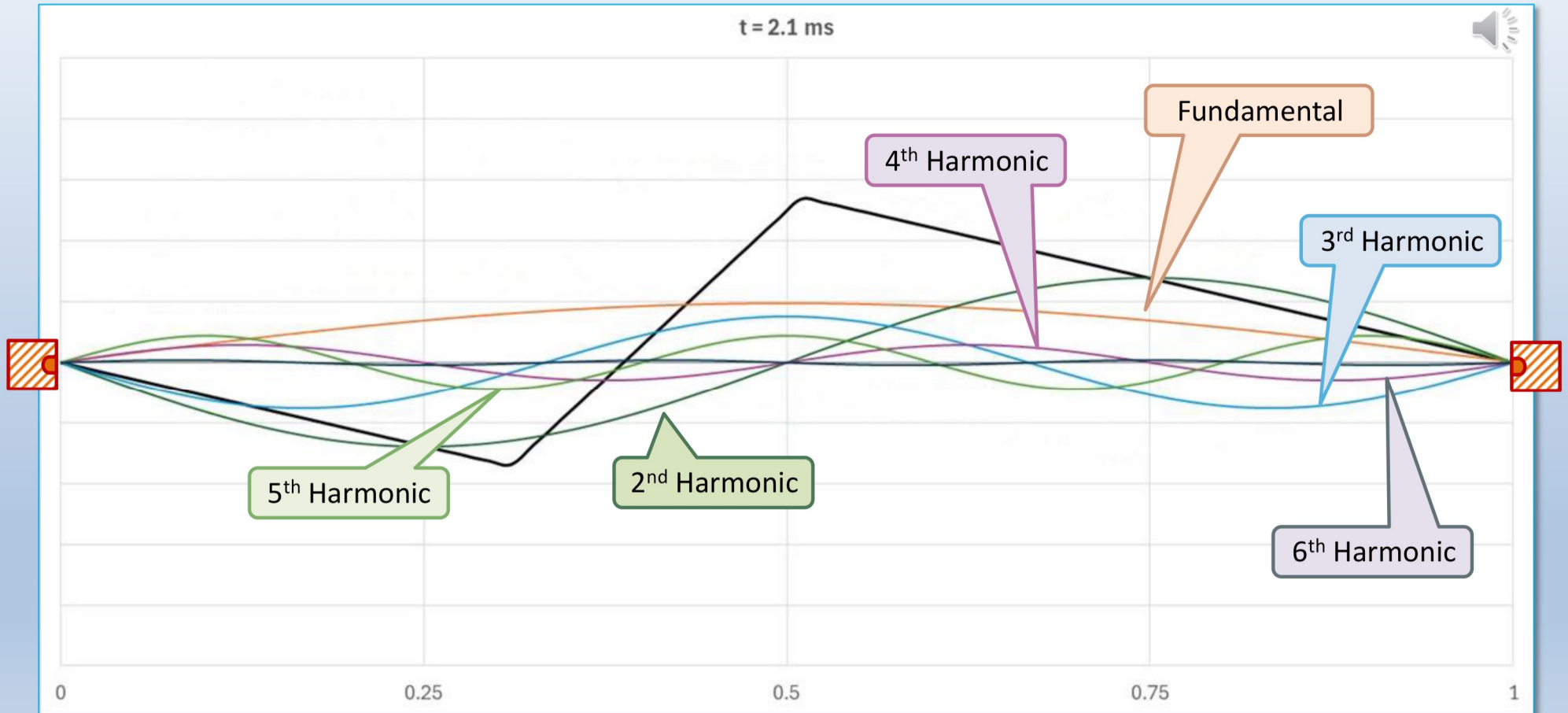
Plucking a Guitar String in the middle



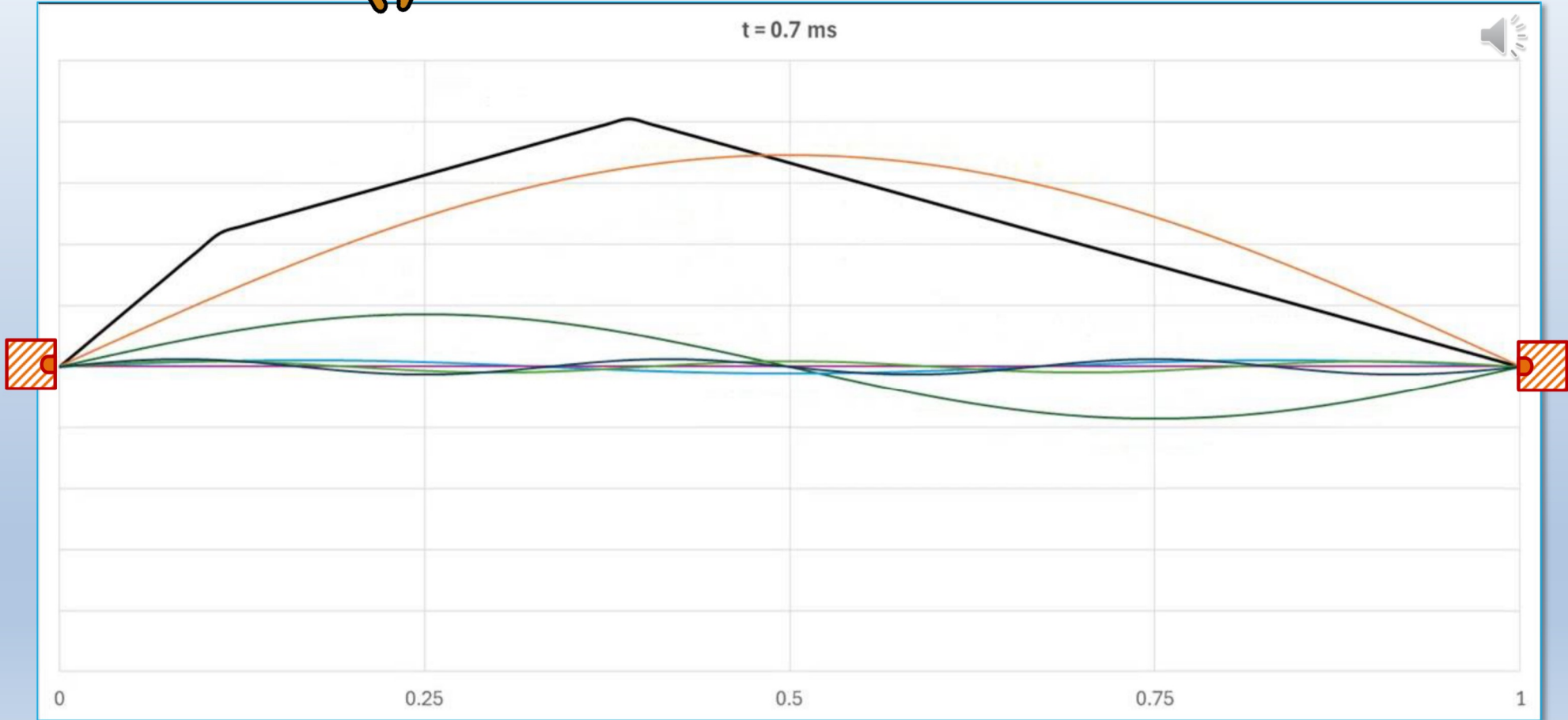
Plucking a Guitar String: What if we pluck at one end?



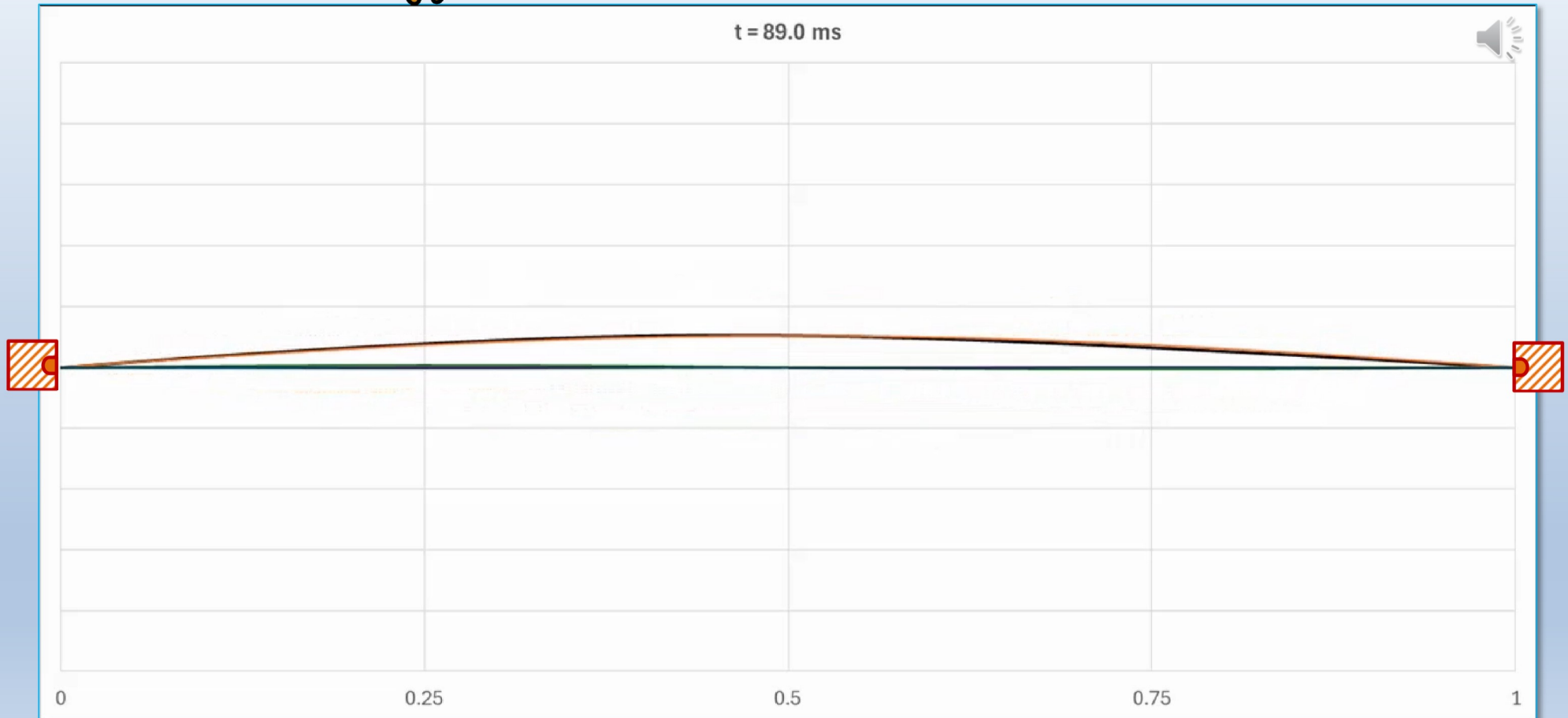
Plucking a Guitar String near the end



Plucking a Guitar String: Higher Harmonics Decay Faster



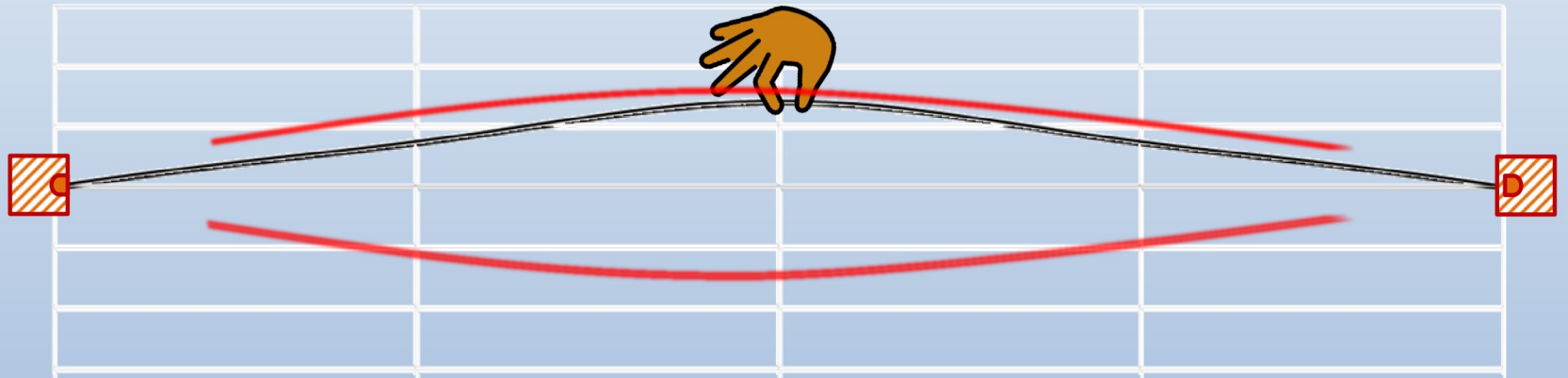
Plucking a Guitar String: Higher Harmonics Decay Faster



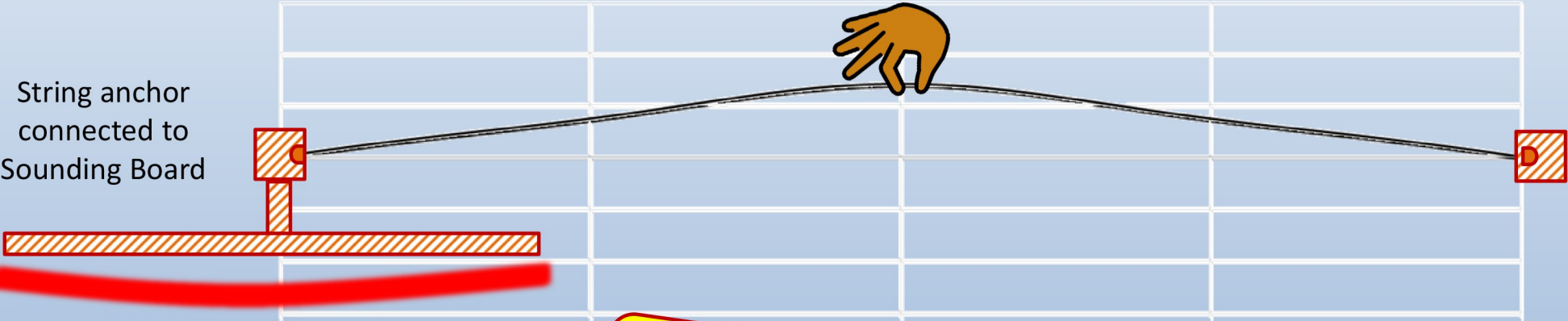
Plucking a Guitar String: Making it Heard



Strings couple weakly to air



Plucking a Guitar String: Making it Heard



String anchor connected to Sounding Board

With Sounding Board, string can couple strongly to air

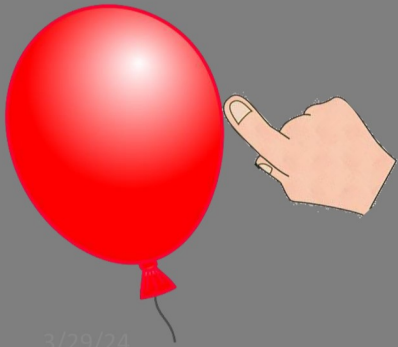


Strings

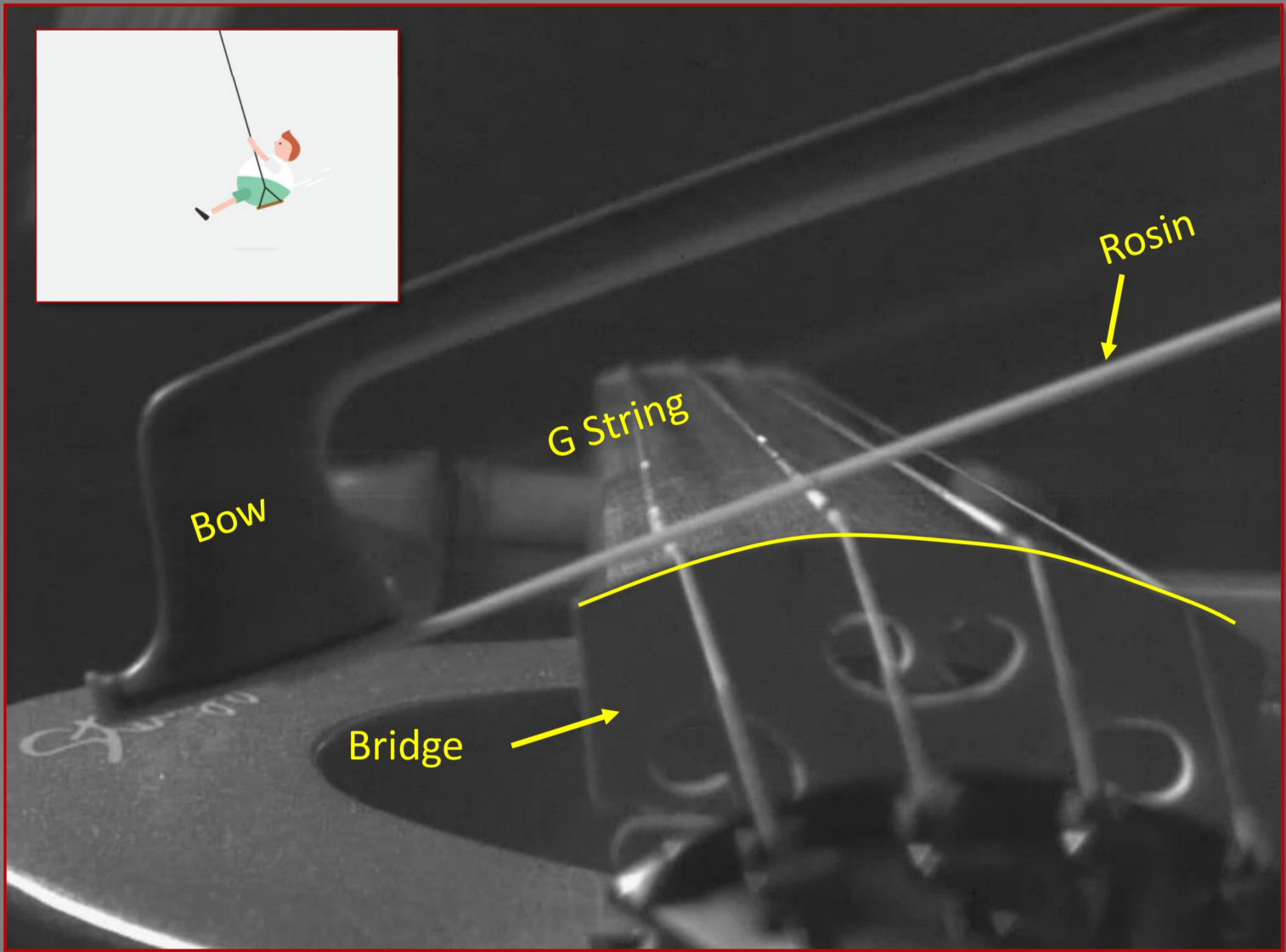


Exciting the String:
Bowling

Stick-Slip
Friction



3/29/24



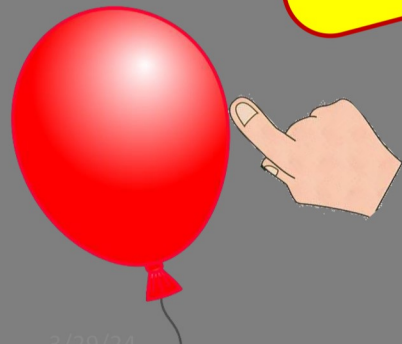
Strings



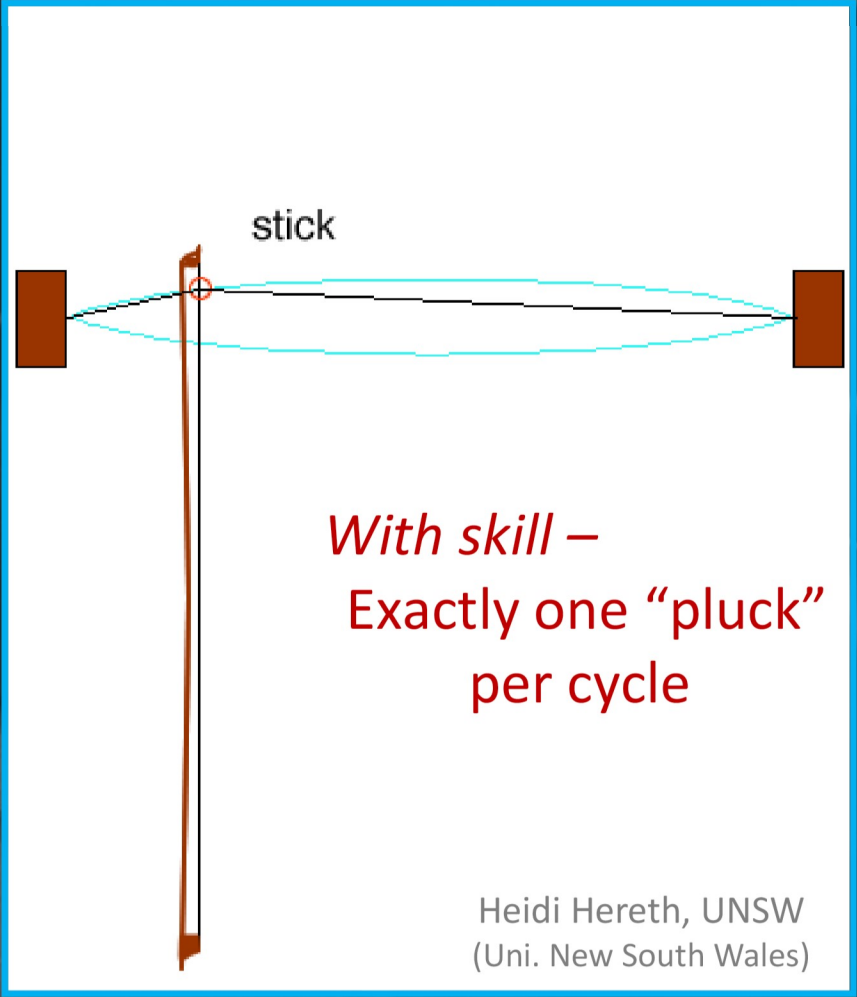
Exciting the String: Bowing

Stick-Slip
Friction

Result:
High Harmonics have
no time to decay.
Brilliant Timbre



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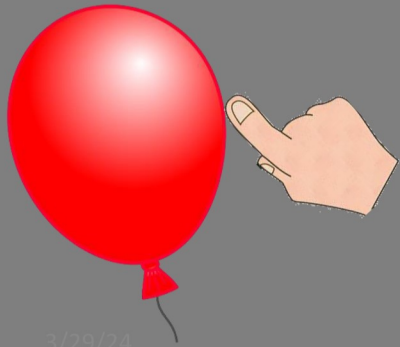


Strings

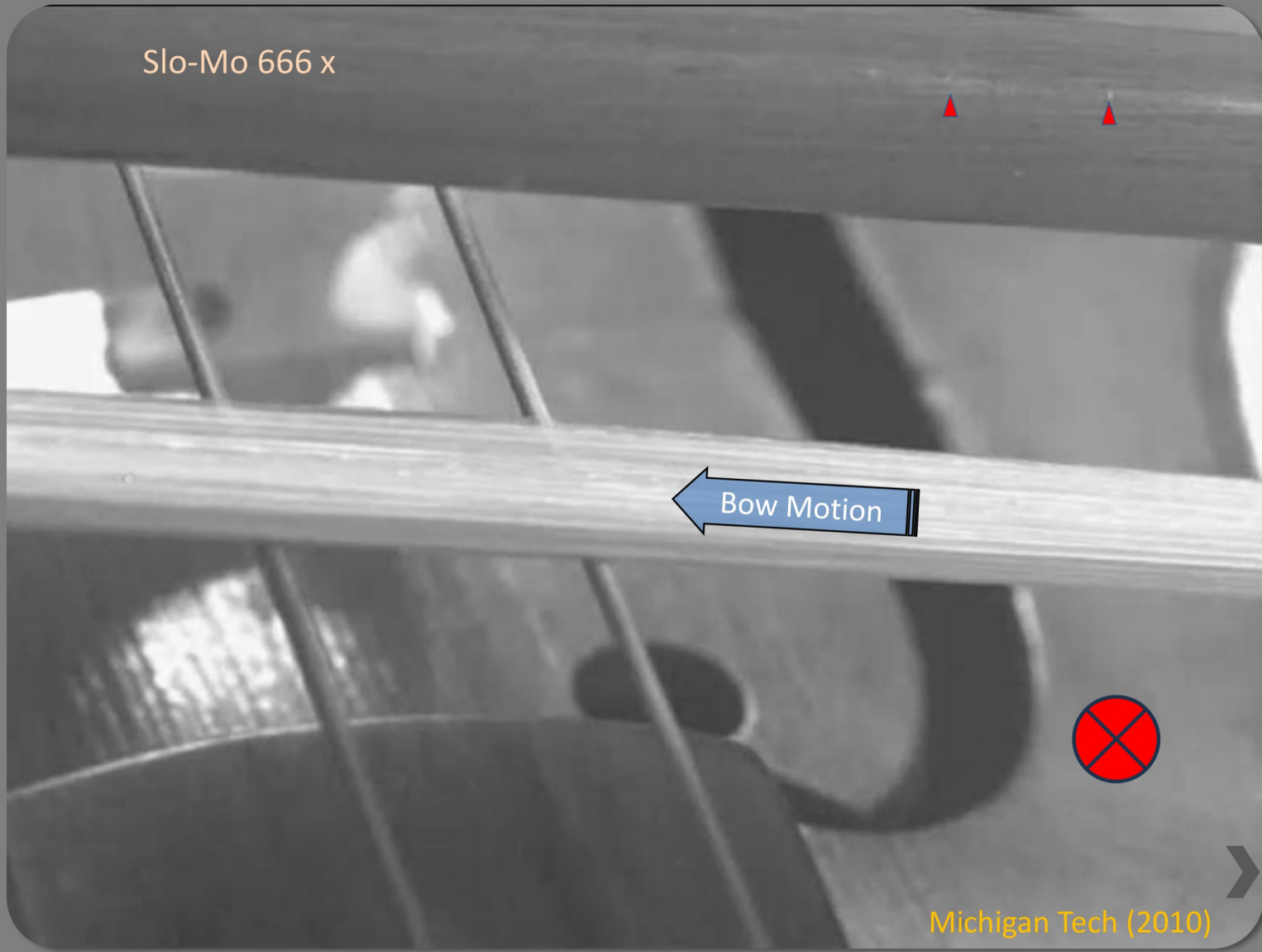


Exciting the String:
Bowling

Stick-Slip
Friction



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Strings

Exciting the Strings: Sympathetic Vibration



Sitar

6 Played Strings

12 or more Sympathetic Strings



Viola d'Amore
(1760)

6-7 Played Strings

Equal Number Sympathetic

Not directly plucked or bowed. Instead pick up vibes from other strings tuned similarly.



Aliquot Strings
(Blüthner 1873)



Strings

String Instruments

Three main problems:

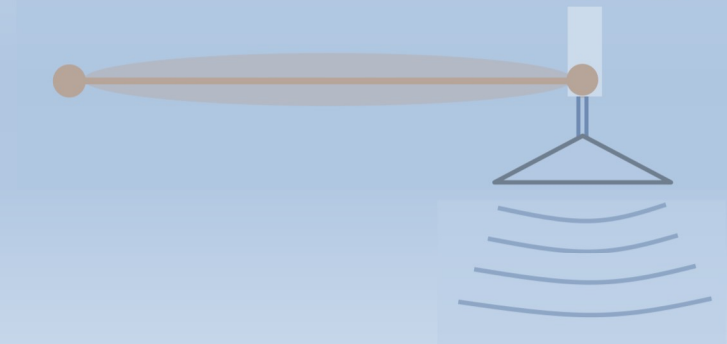
1. Excitation **EASY**
 - How to get the string vibrating



2. Frequency Control **EASY**
 - Playing desired notes

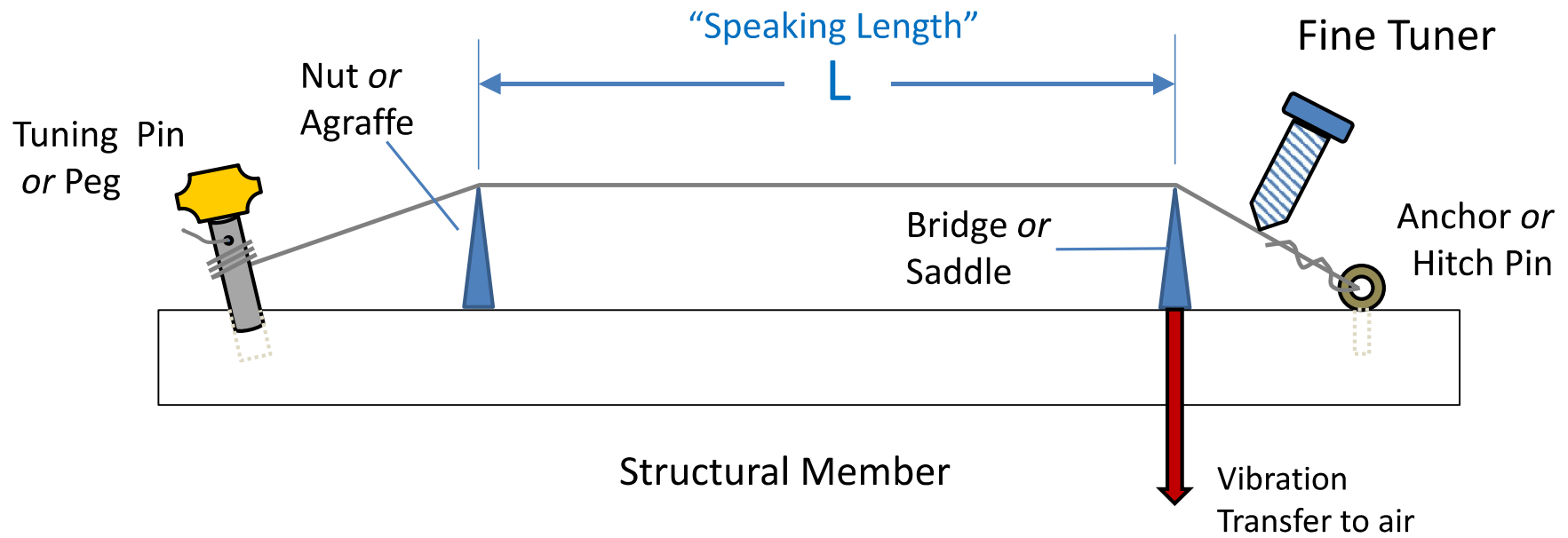


3. Getting Sound Out **HARD**
 - Coupling string vibrations to sound waves



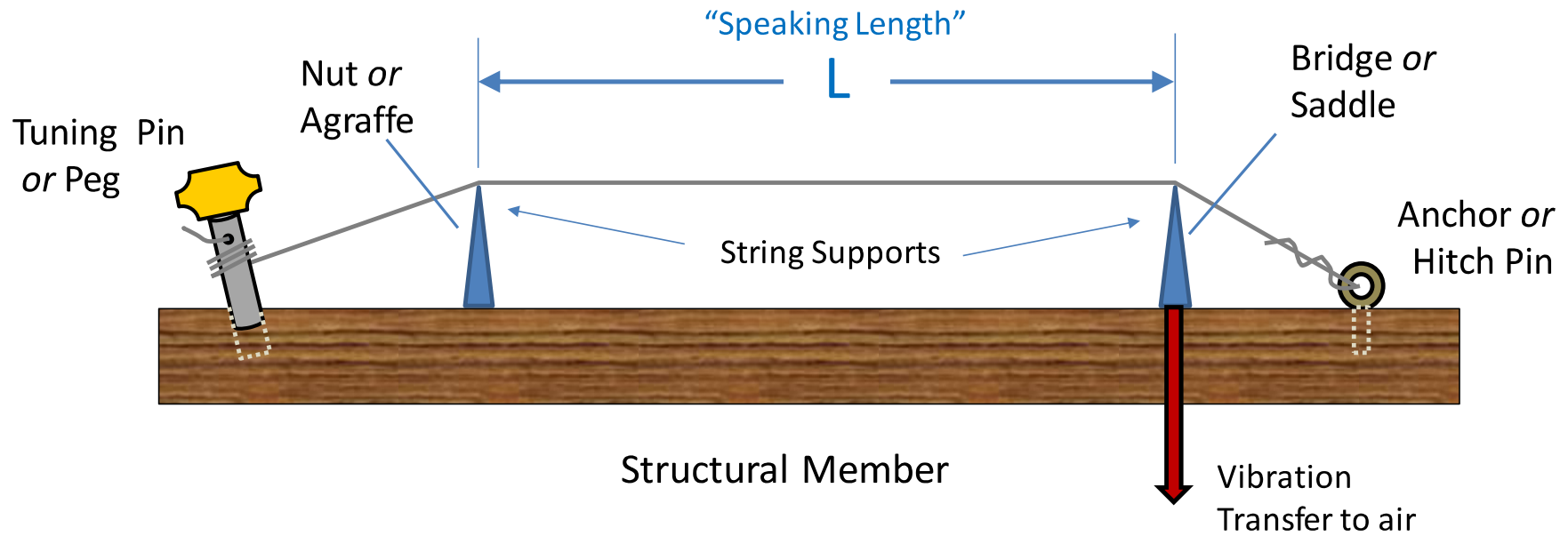
Strings

Generic String: Fixed Frequency



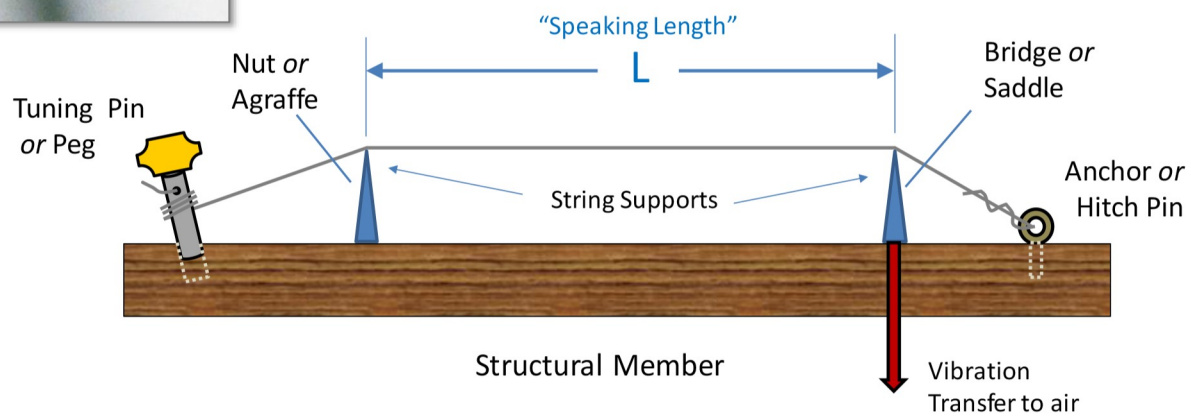
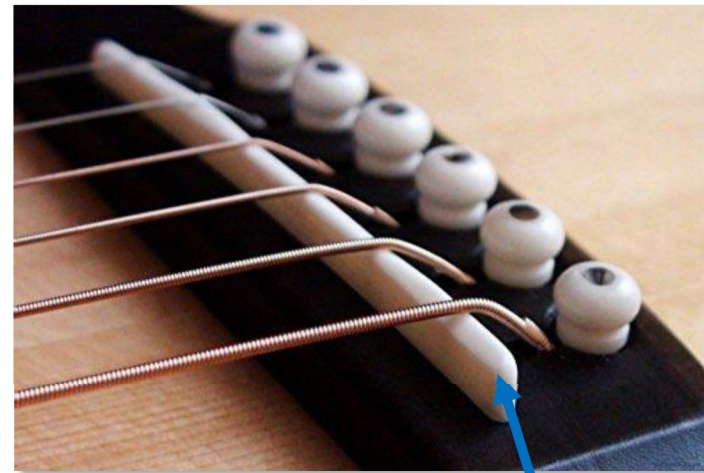
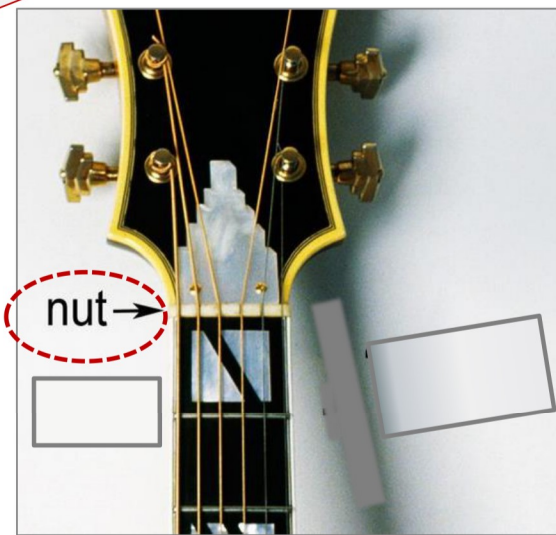
Strings

Generic String: Fixed Frequency



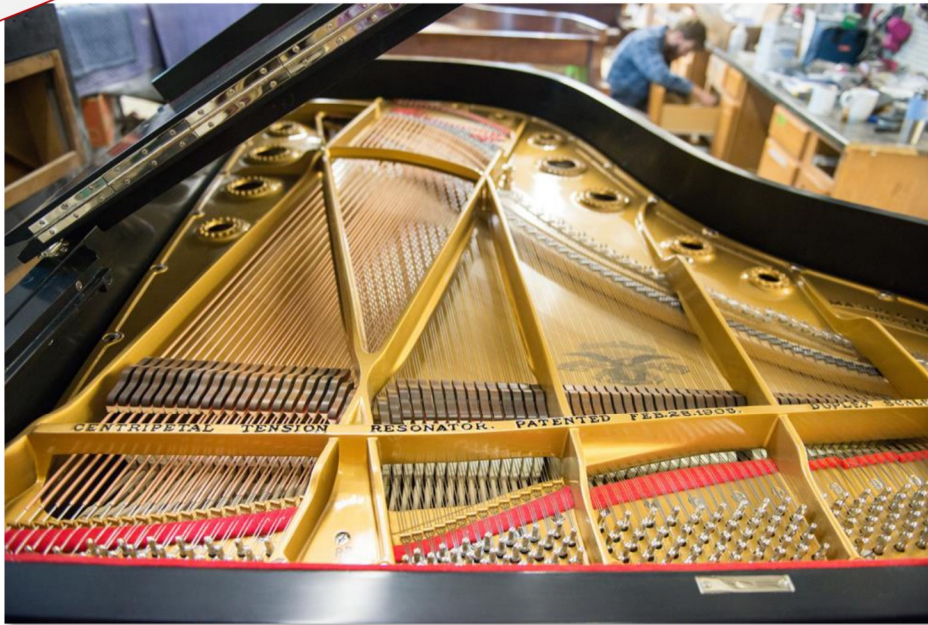
Strings

Generic String: Fixed Frequency

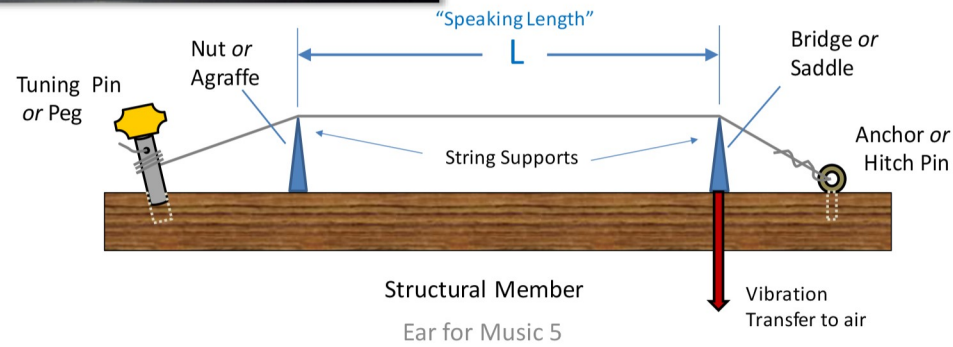


Strings

Instruments Using Fixed Frequencies



Piano



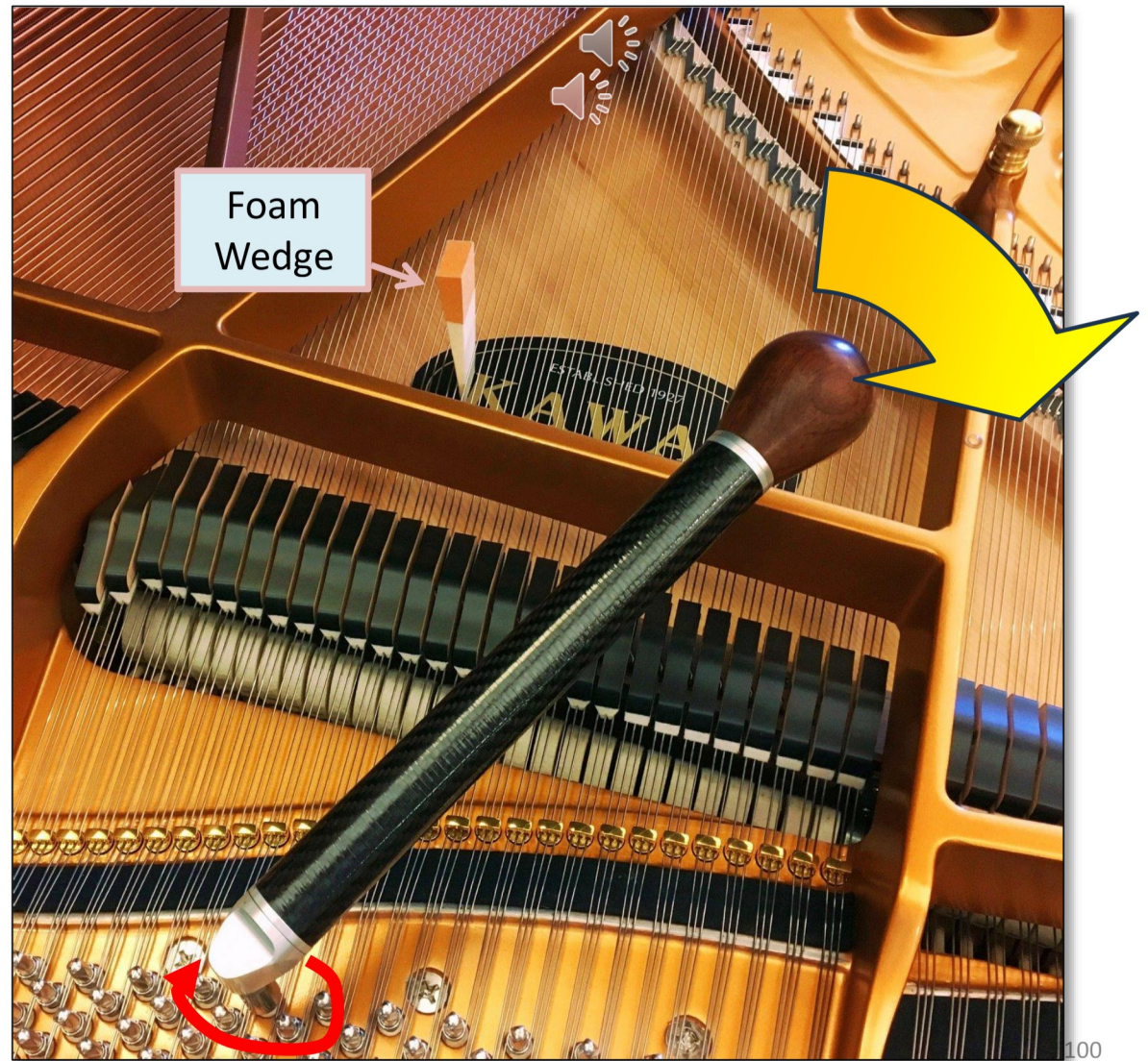
Strings

Tuning a Piano

- String Lengths are Fixed
- Tensions are Varied to Adjust Frequencies

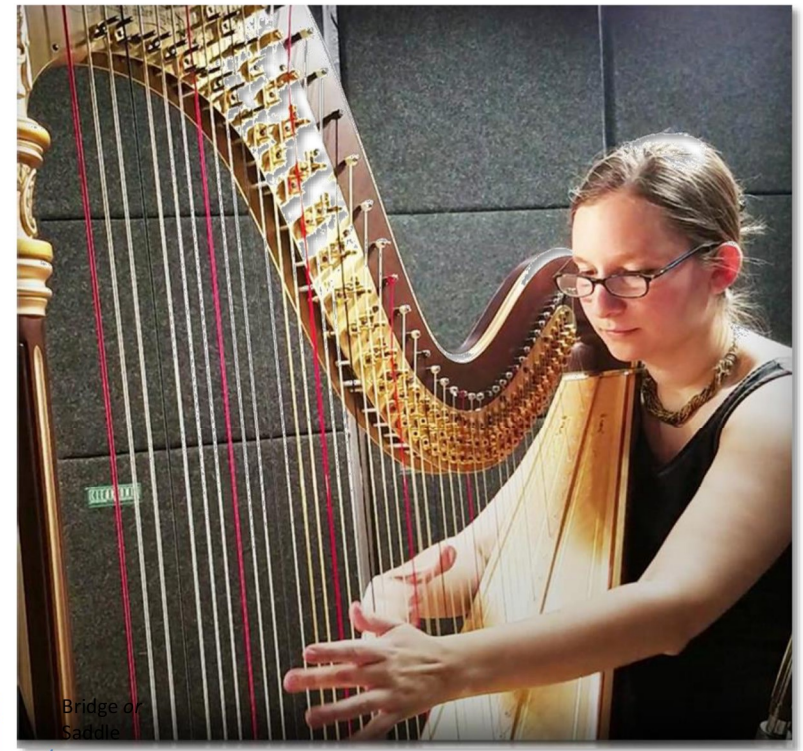
Piano

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Strings

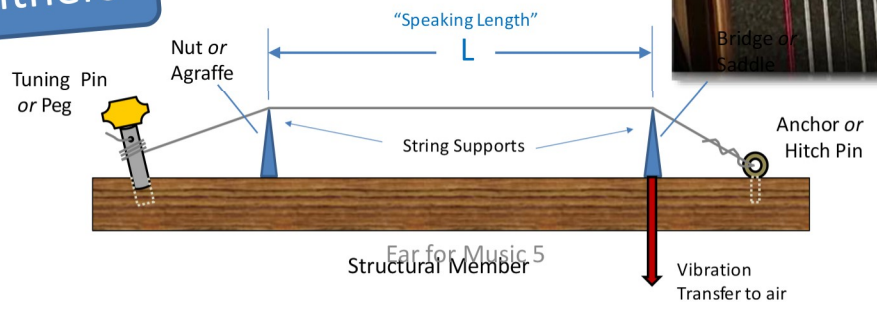
Instruments Using Fixed Frequencies



Zithers

Ukrainian Bandura

Harps



Strings

Instruments Using Variable Frequencies (*Length Change*)



Guitar



Banjo



Sitar



Violin

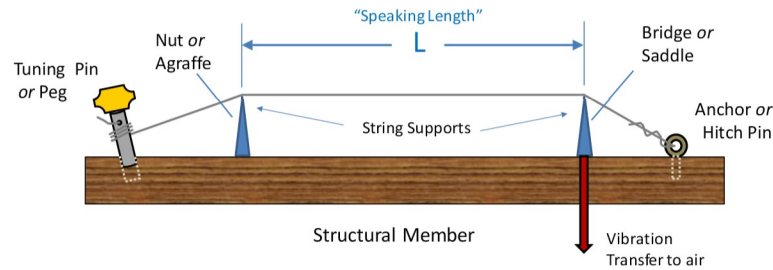


Cello



Double Bass

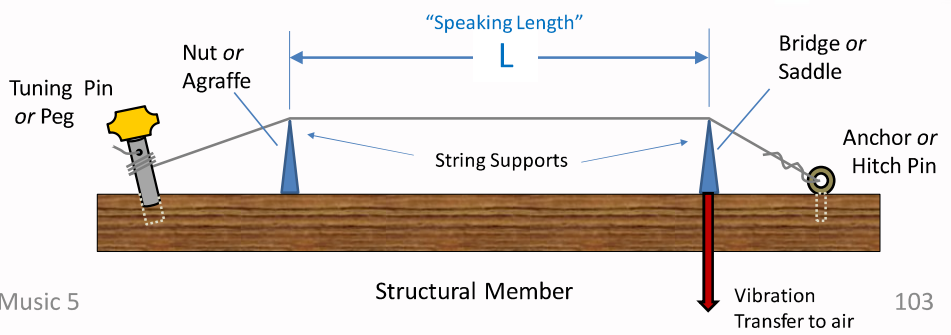
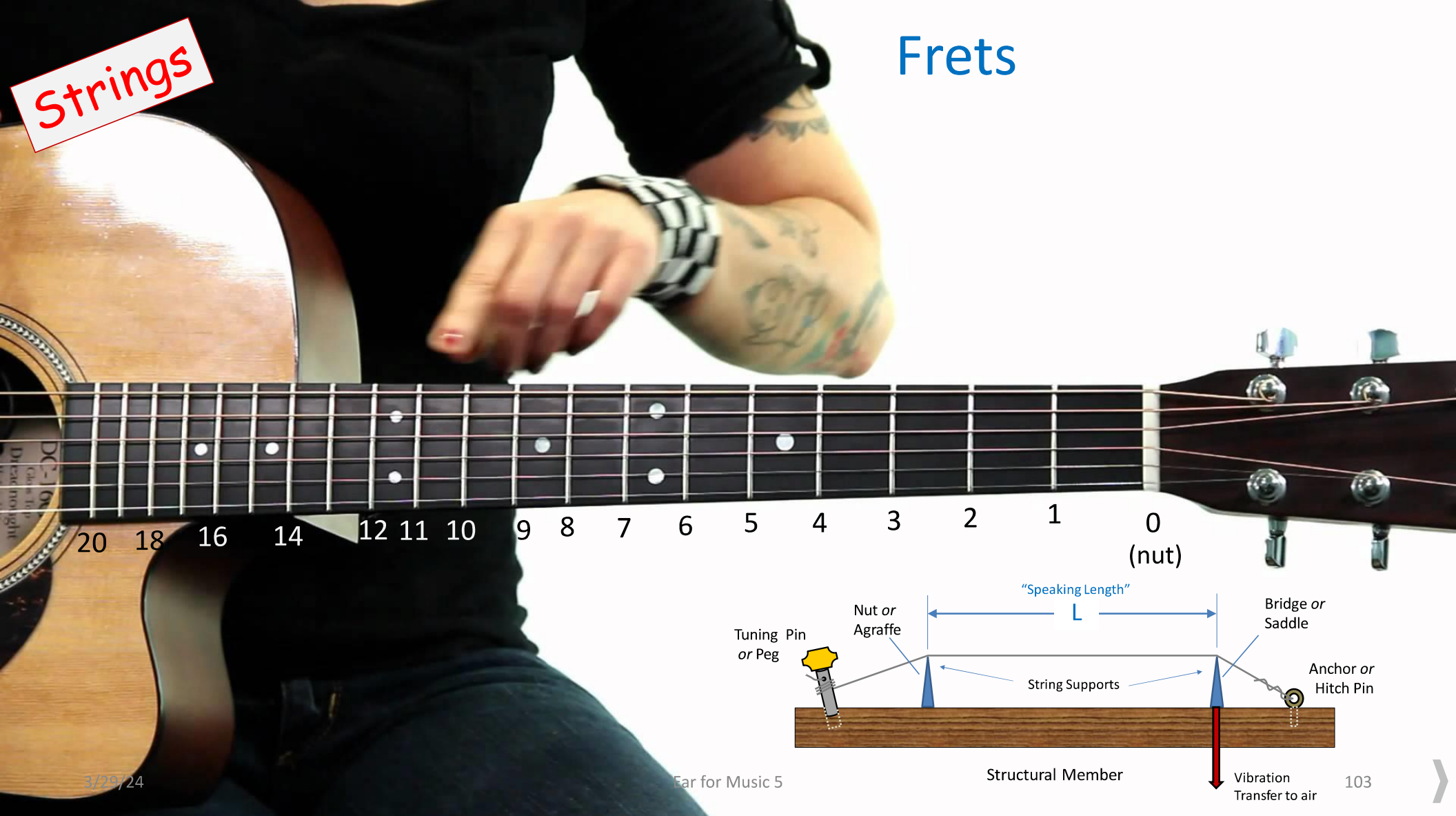
Fretted Instruments



Unfretted

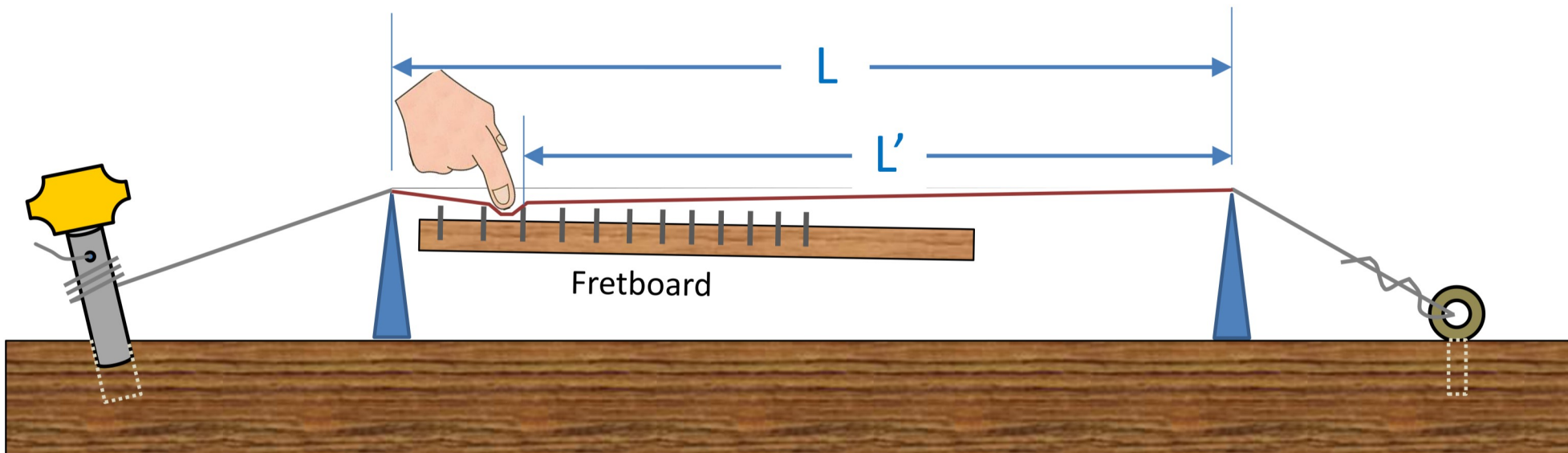
Strings

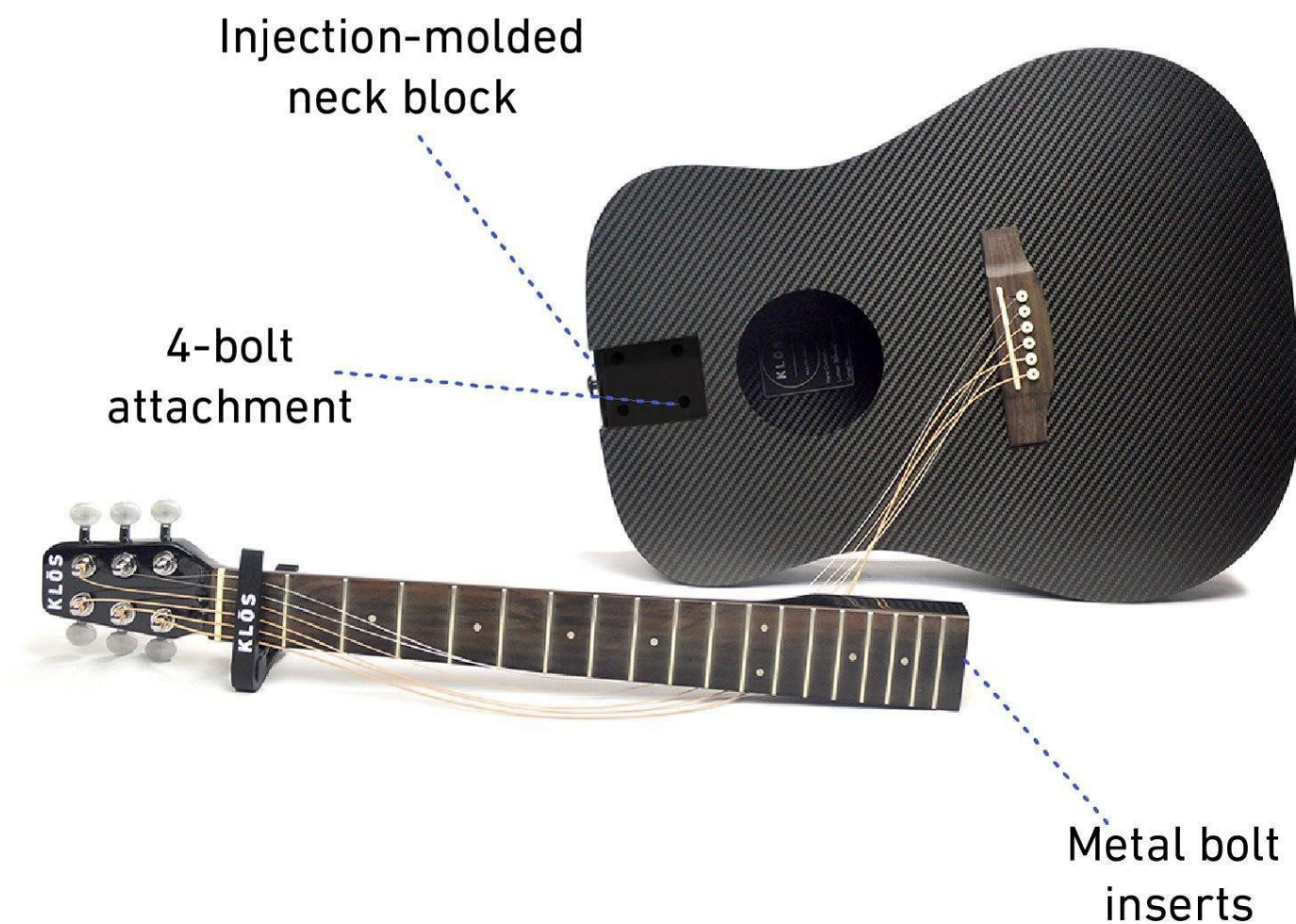
Frets



Strings

Frets





Injection-molded neck block

4-bolt attachment

Metal bolt inserts

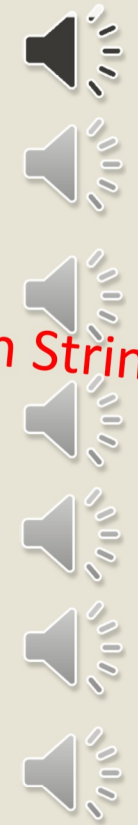
6 String Guitar Standard Tuning

Piano	MIDI	<i>f</i>	Chromatic Scale	Note		
45	65	349.2	—————	F 4		
44	64	329.6	—————	E 4	E4	} 5 steps
43	63	311.1	—————	D#/Eb 4		
42	62	293.7	—————	D 4		
41	61	277.2	—————	C#/Db 4		
40	60	261.6	—————	C 4		
39	59	246.9	—————	B 3	B3	} 4 steps
38	58	233.1	—————	A#/Bb 3		
37	57	220	—————	A 3		
36	56	207.7	—————	G#/Ab 3		
35	55	196.0	—————	G 3	G3	} 5 steps
34	54	185.0	—————	F#/Gb 3		
33	53	174.6	—————	F 3		
32	52	164.8	—————	E 3		
31	51	155.6	—————	D#/Eb 3		
30	50	146.8	—————	D 3	D3	} 5 steps
29	49	138.6	—————	C#/Db 3		
28	48	130.8	—————	C 3		
27	47	123.5	—————	B 2		
26	46	116.5	—————	A#/Bb 2		
25	45	110	—————	A 2	A2	} 5 steps
24	44	103.8	—————	G#/Ab 2		
23	43	98.0	—————	G 2		
22	42	92.5	—————	F#/Gb 2		
21	41	87.3	—————	F 2		
20	40	82.4	—————	E 2	E2	} 5 steps
19	39	77.8	—————	D#/Eb 2		

≈ 5:4

≈ 4:3

Open Strings



Strings

Frets

Demo

E2	82.4 Hz
A2	110.0
D3	146.8
G3	196.0
B3	246.9
E4	329.6 Hz

