

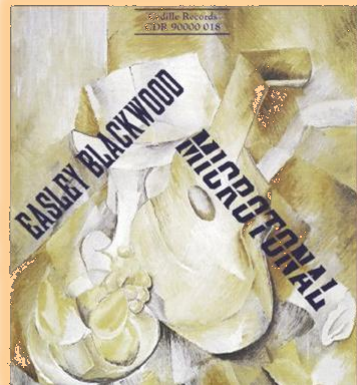


Sound of Music

How It Works

Session 4

Musical Scales: Foundations of Music



Easley Blackwood
*Suite for Guitar in 15-
note Equal Tuning, Op. 33*
Jeffrey Kust, guitarist
(1990)

Prelude (Allegro)

OLLI at Illinois
Spring 2020

D. H. Tracy





Sound of Music

How It Works

Session 4

Musical Scales: Foundations of Music

OLLI at Illinois

Spring 2020

D. H. Tracy

Course Outline



1. Building Blocks: Some basic concepts
2. Resonance: Building Sounds
3. Hearing and the Ear
- 4. Musical Scales**
5. Musical Instruments
6. Singing and Musical Notation
7. Harmony and Dissonance; Chords
8. Combining the Elements of Music



Sound Familiar?



- Listen carefully to 4 notes
 - 2 are “real”, 2 are “bogus”

- In isolation, it makes little difference...
 - but in the context of a musical piece it may matter

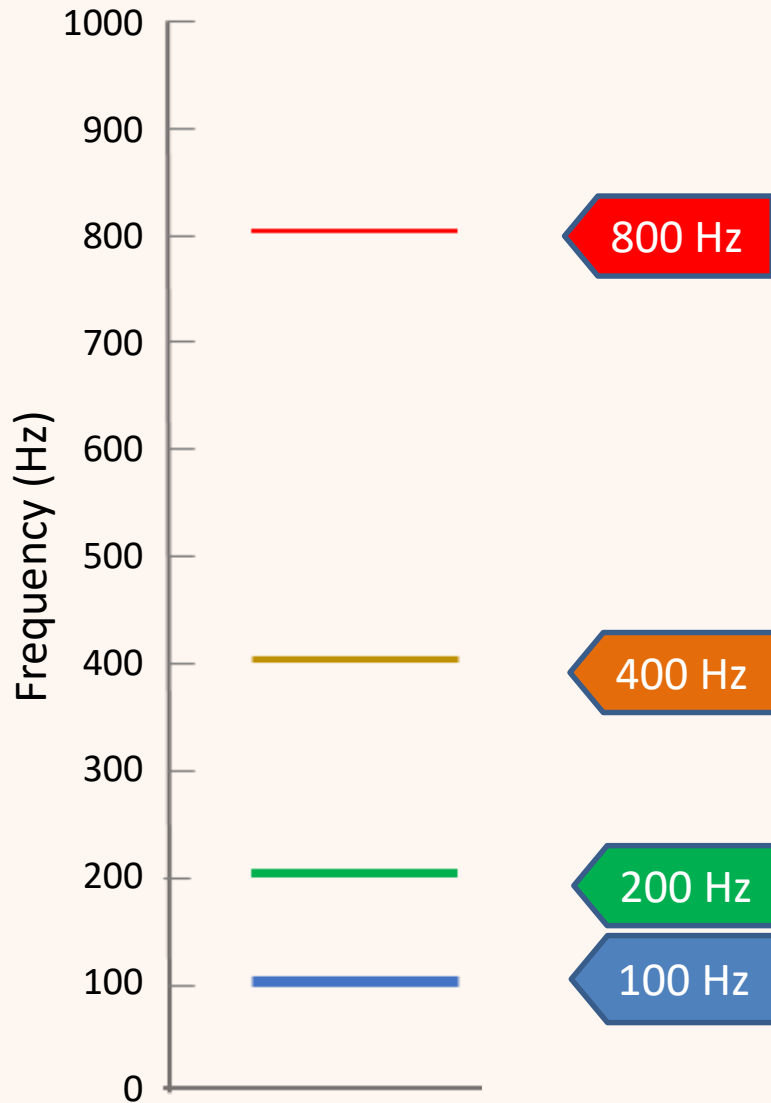
Music is Made with Notes Having Different Frequencies

- But how are these frequencies chosen?
- Example using Fixed Frequencies... 
- But what if we used random frequencies? 
 - Each note frequency chosen at *random*
 - (within a small range)
- ***Music can be made with non-fixed frequencies***



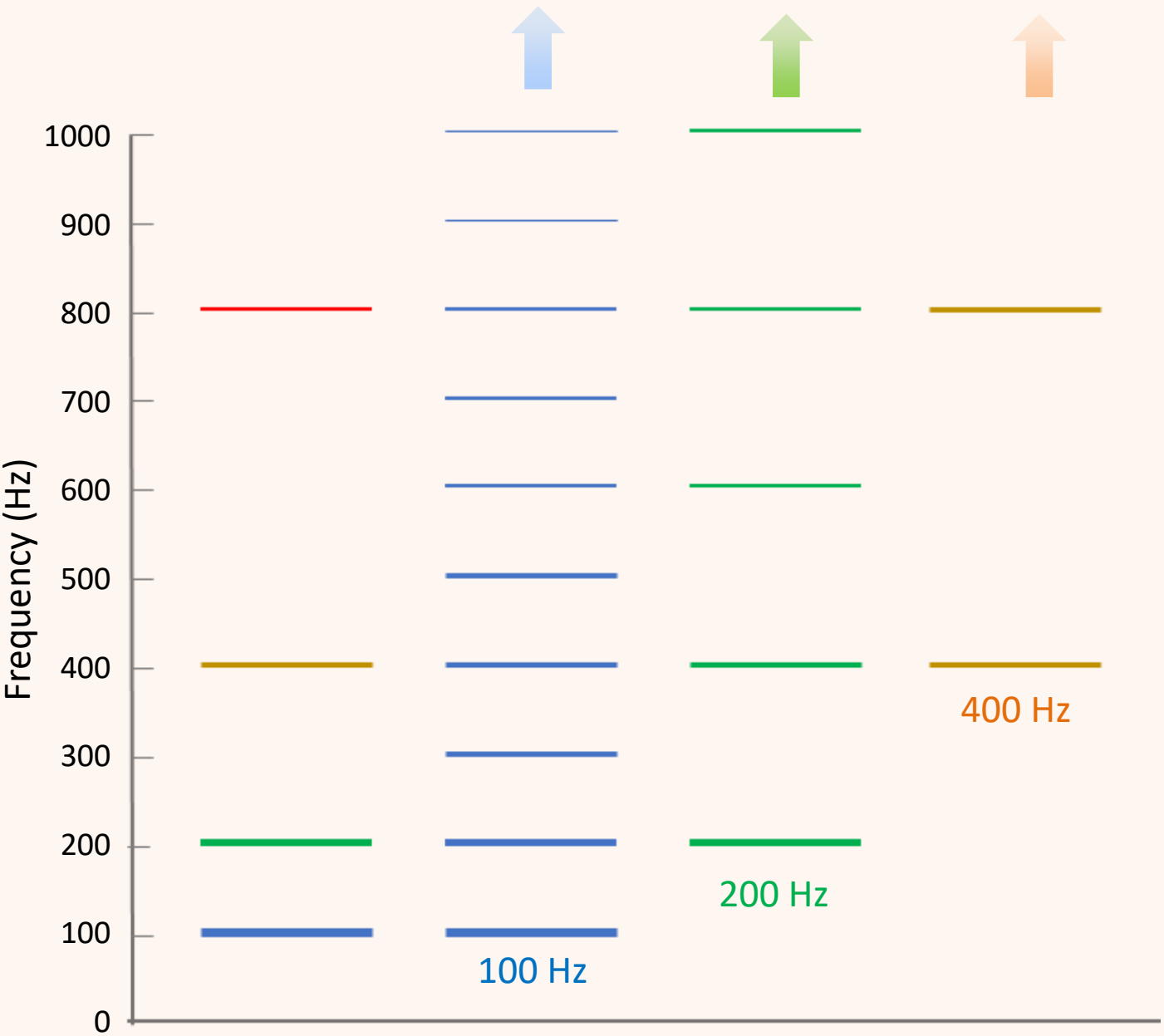
Sound of Music 4

The Octave As the Universal Frequency Interval *2x*

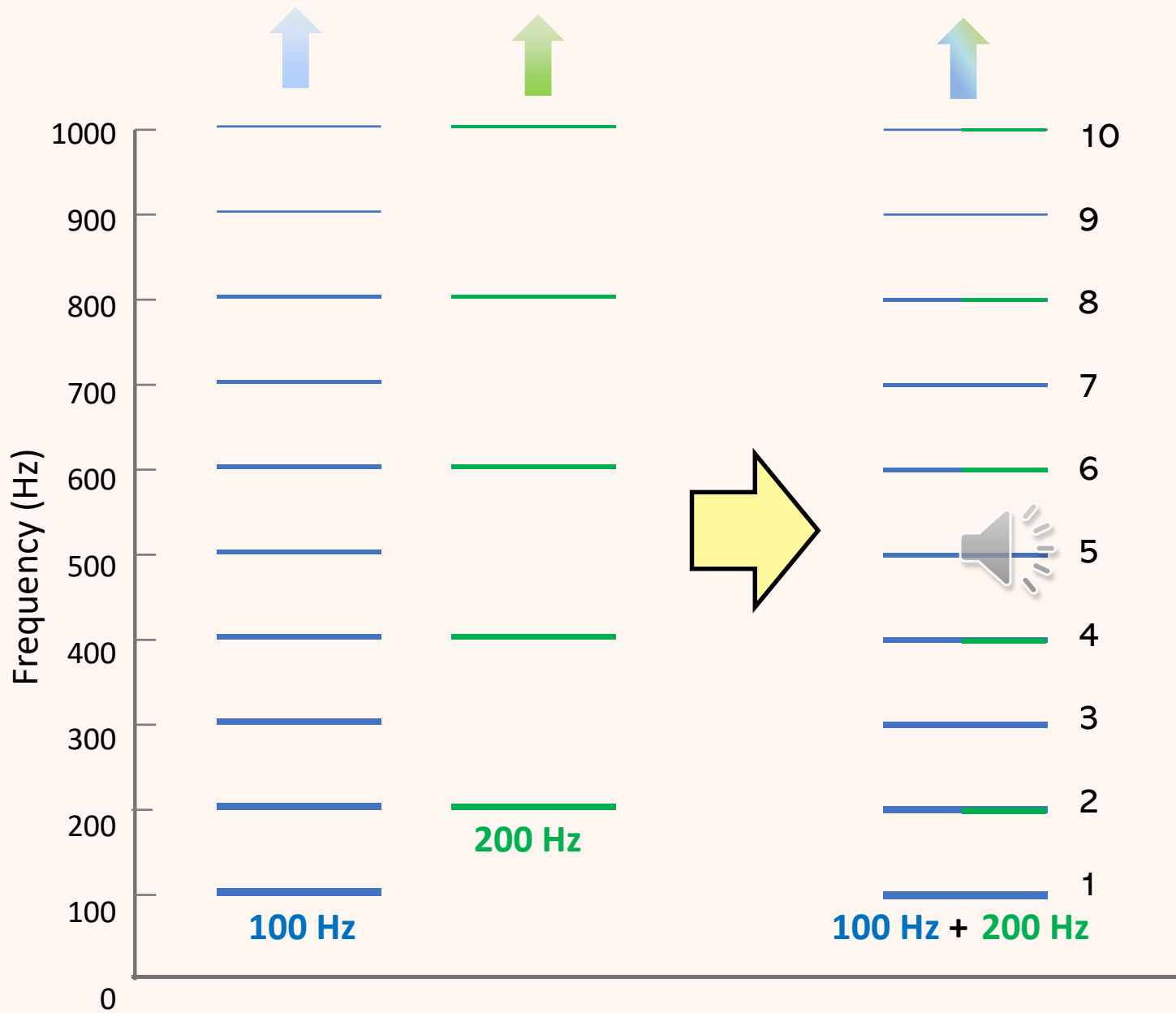


But these were
Complex Tones
with 16 Harmonics....

The Octave As the Universal Frequency Interval $2x$



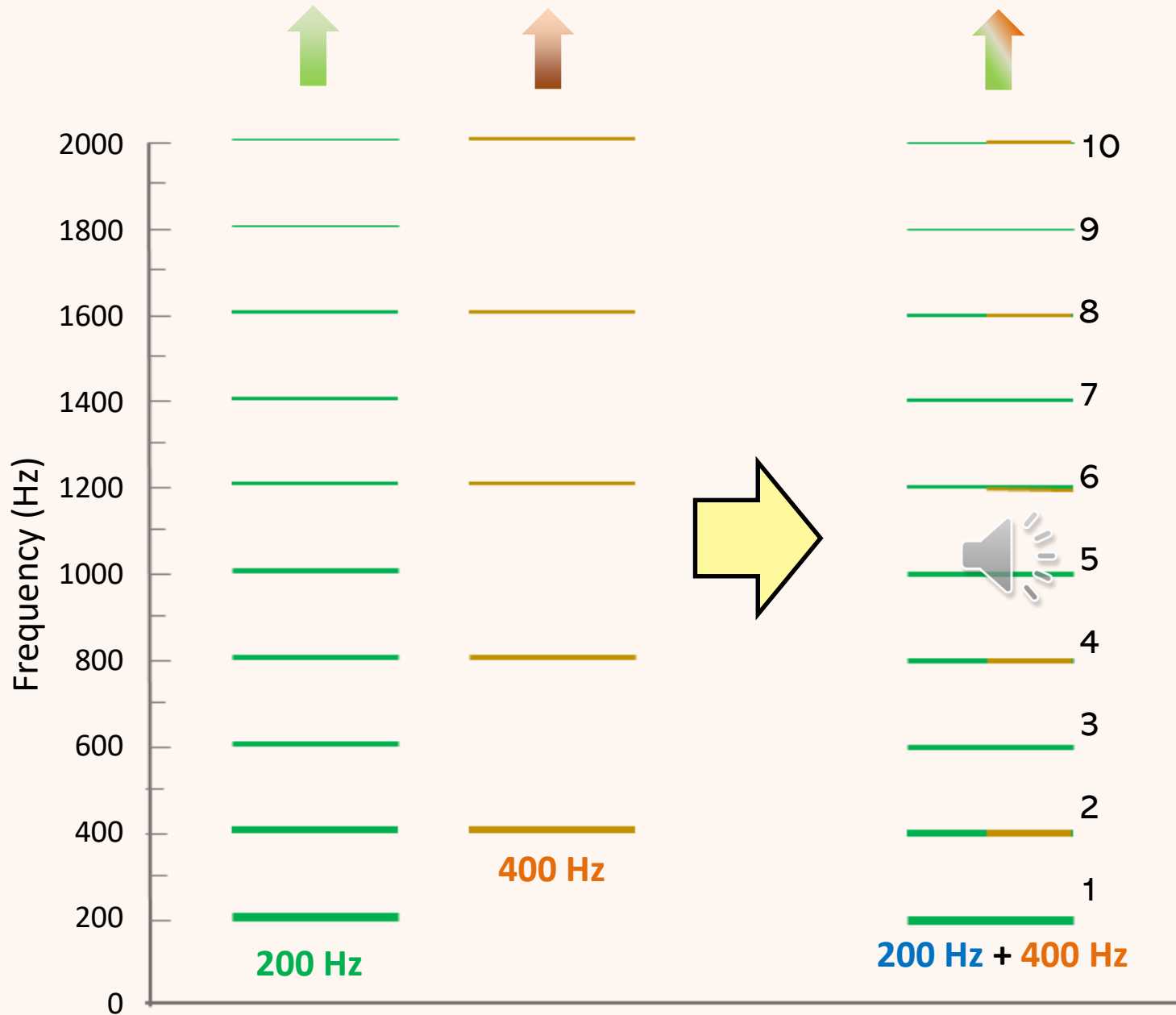
Higher Octaves Contain NO additional frequencies!



The Octave As the Universal Frequency Interval $2x$

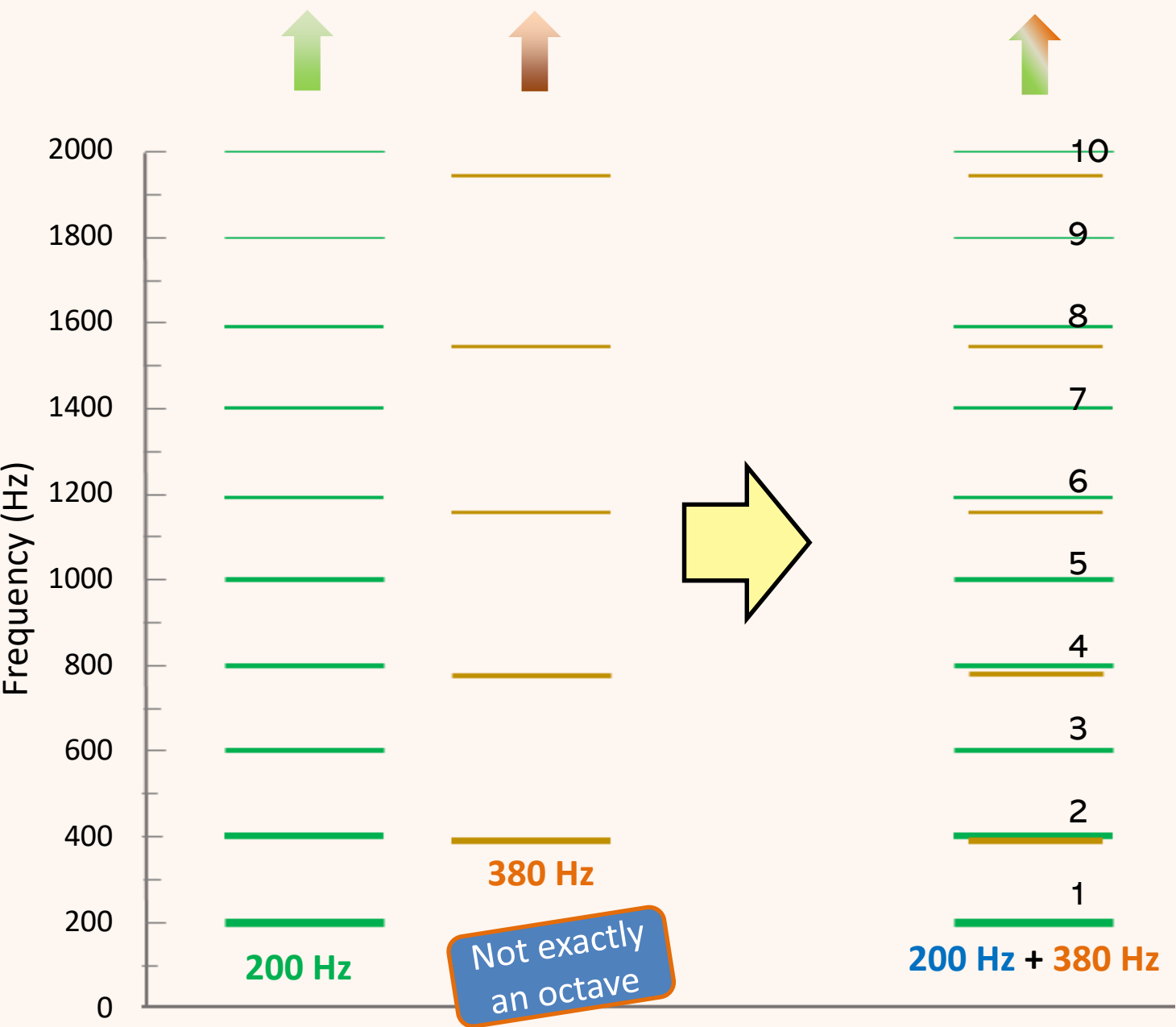
- The Combination of f and its octave sounds good
- The Combination $f + 2f$ sounds a lot like f alone

The Octave As the Universal Frequency Interval $2x$



- Again, the Combination of f and its octave sound good
- The Combination $f + 2f$ sounds somewhat like f alone

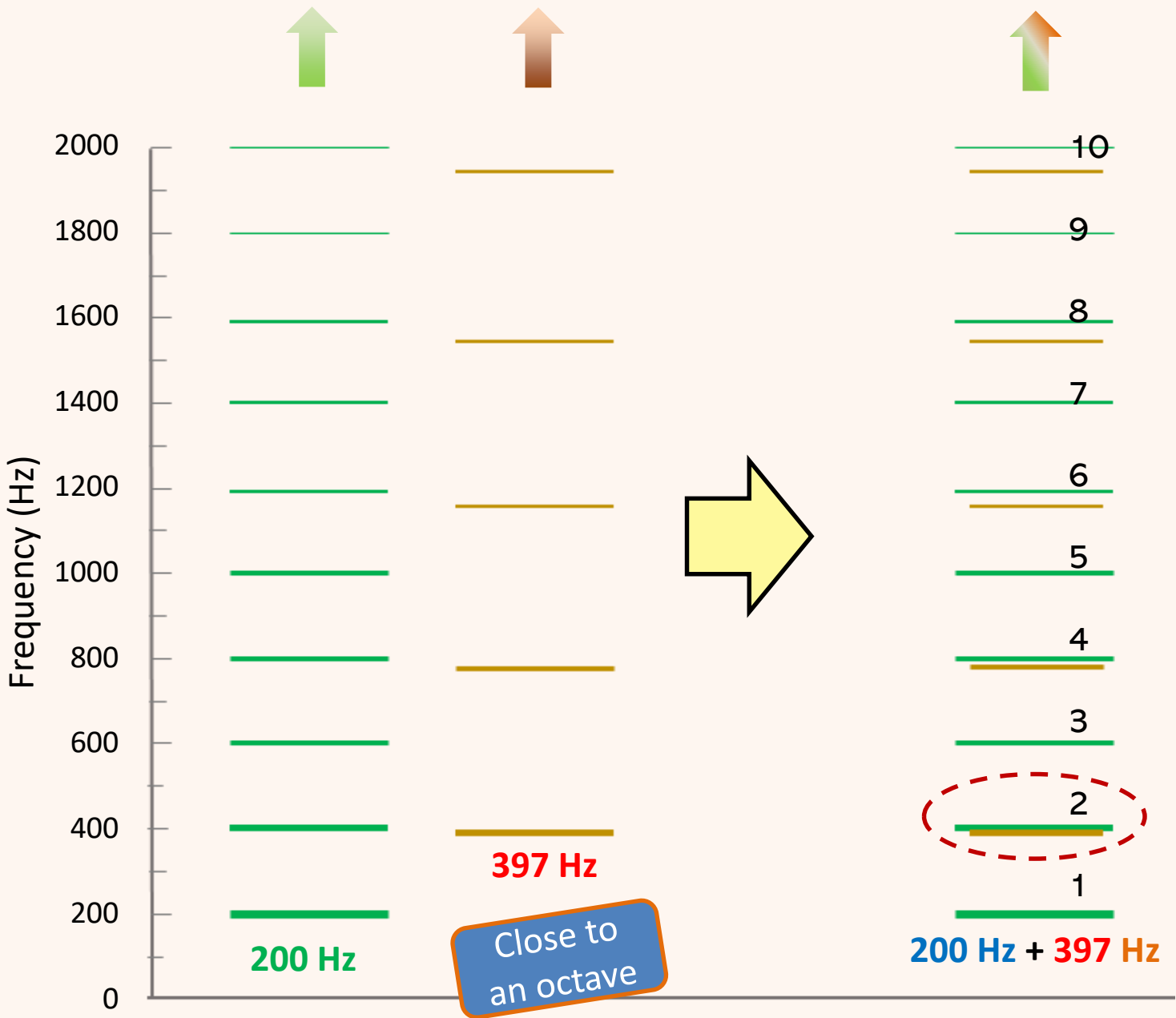
The Octave As the Universal Frequency Interval $2x$



- The Combination of f and its not-quite-octave sounds terrible



The Octave As the Universal Frequency Interval $2x$

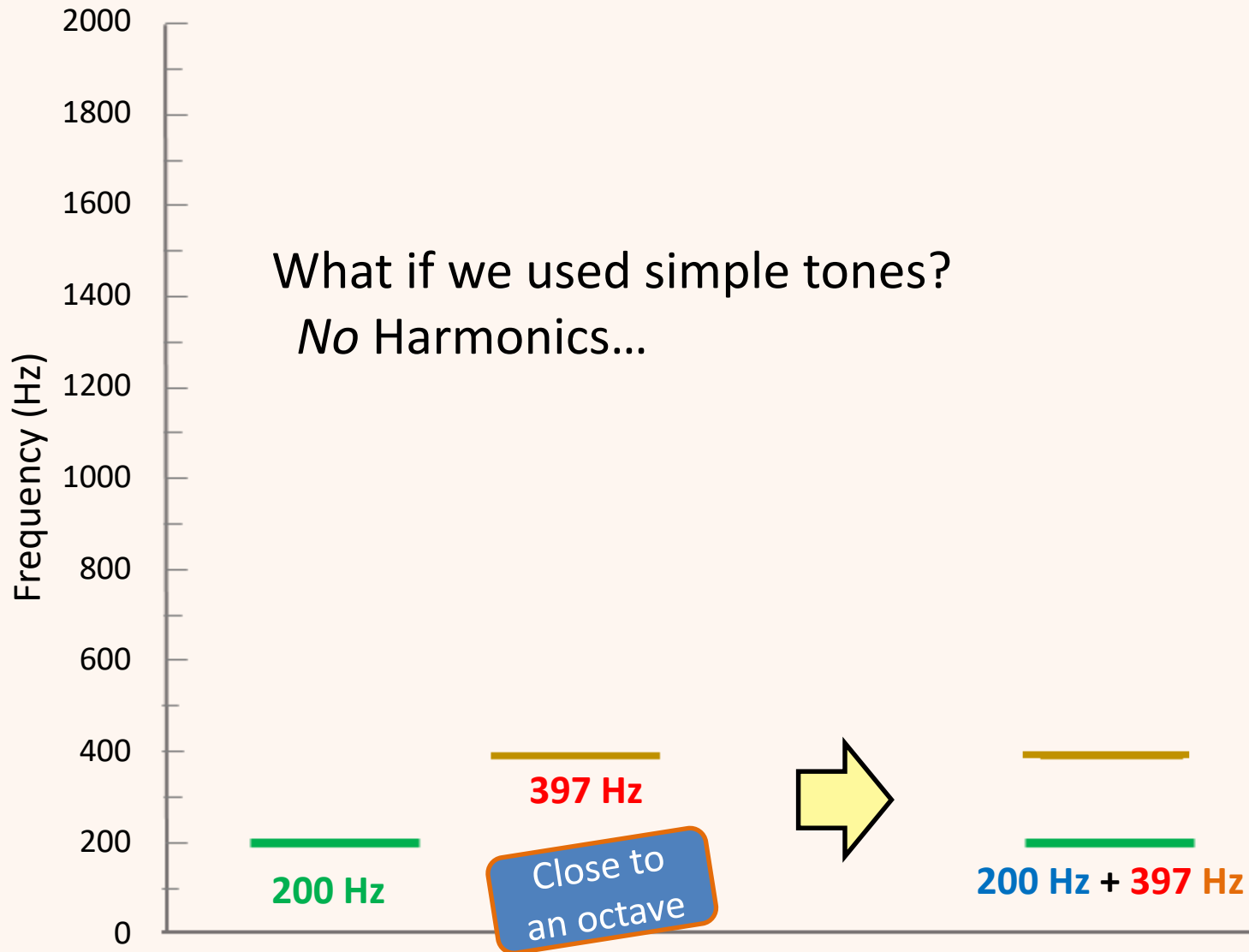


- If we are close to an Octave, we can hear the beats



The Octave As the Universal Frequency Interval $2x$

What if we used simple tones?
No Harmonics...

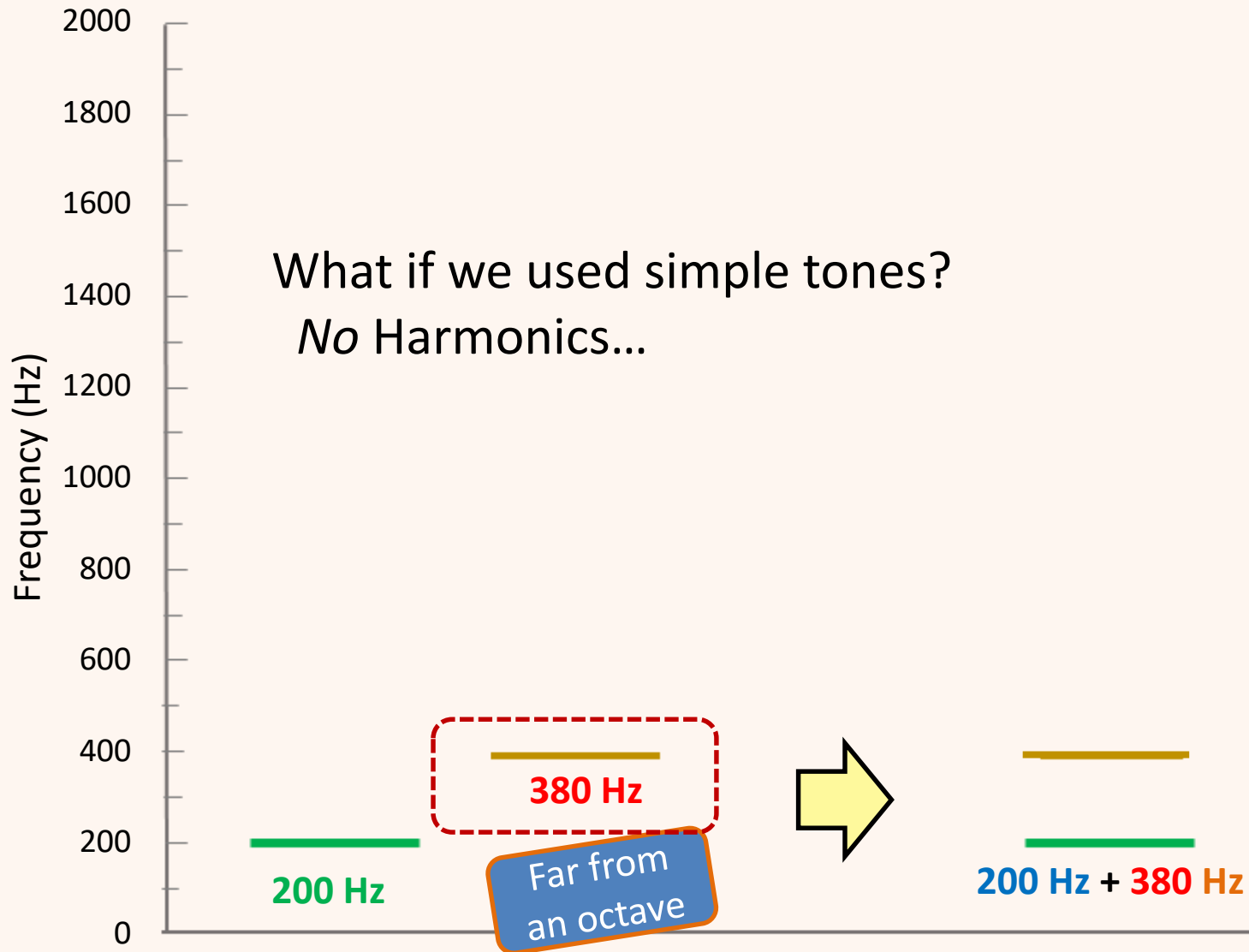


- Without Harmonics, Nothing so special about the Octave



The Octave As the Universal Frequency Interval $2x$

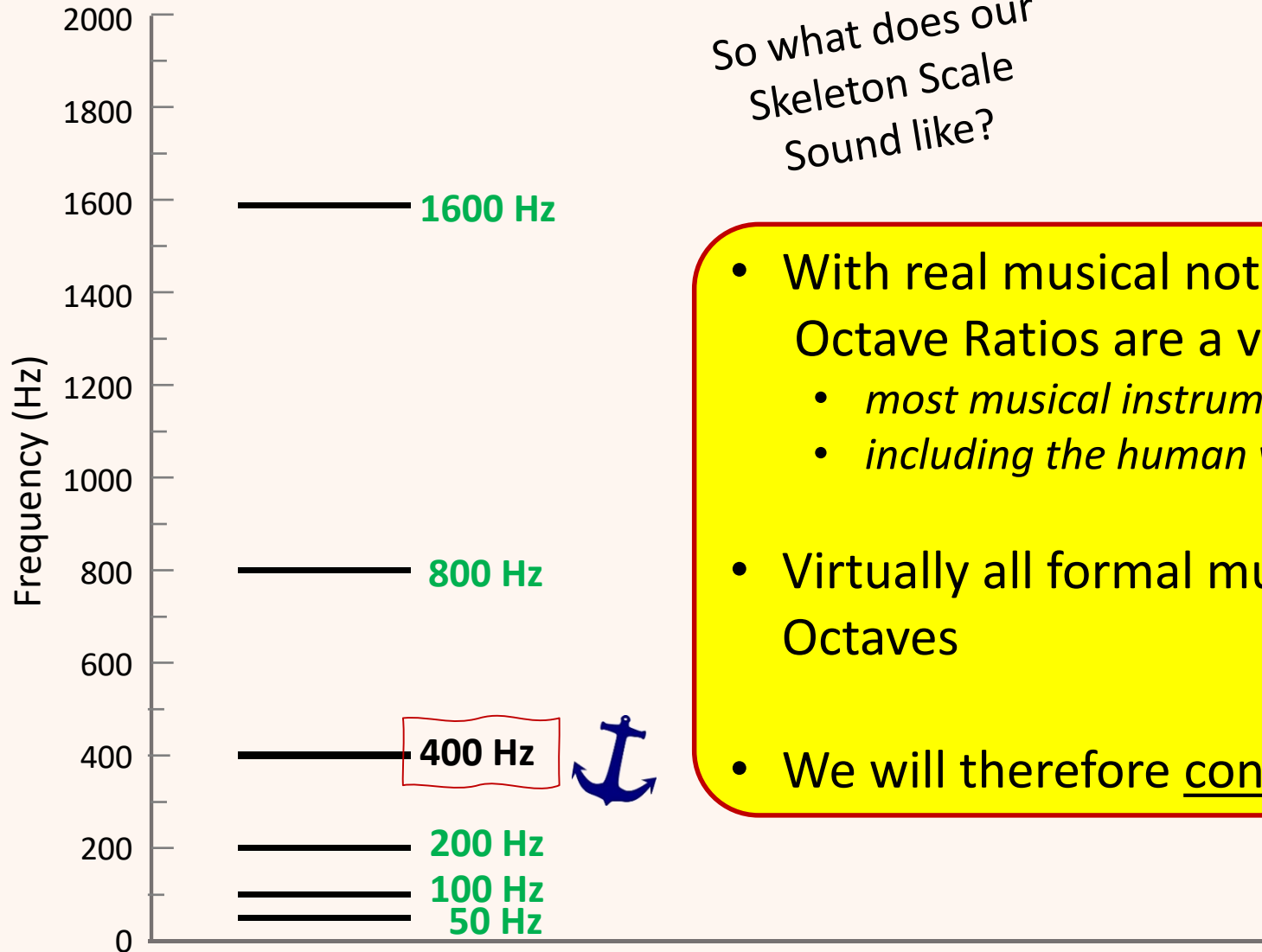
What if we used simple tones?
No Harmonics...



- Again, without Harmonics, Nothing really special about the octave



The Octave As the Universal Frequency Interval $2x$



So what does our Skeleton Scale Sound like?

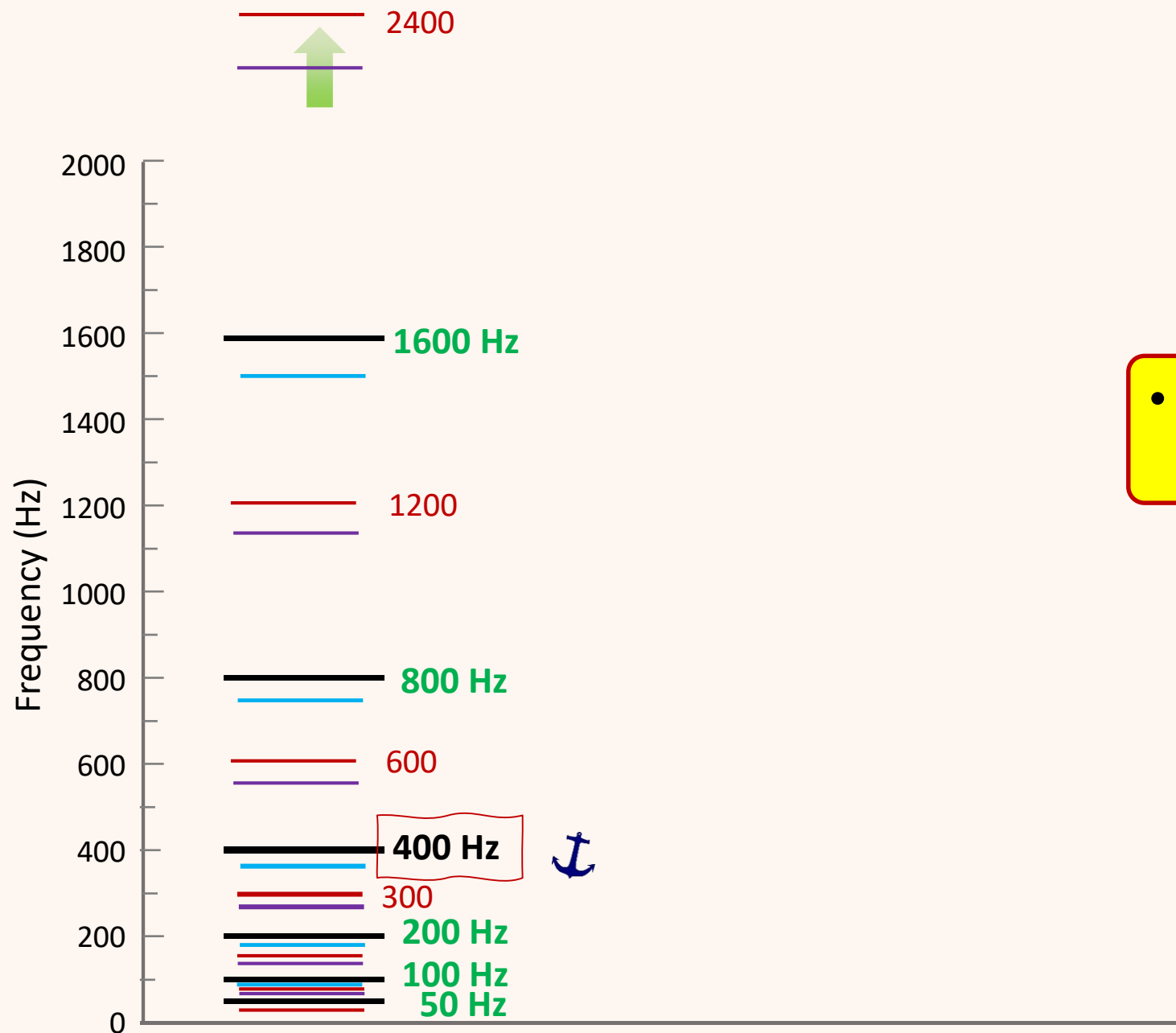
- With real musical notes having harmonics, Octave Ratios are a very good thing
 - *most musical instruments are rich in harmonics*
 - *including the human voice*
- Virtually all formal musical traditions organize scales by Octaves
- We will therefore construct Scales based on Octave Ratios



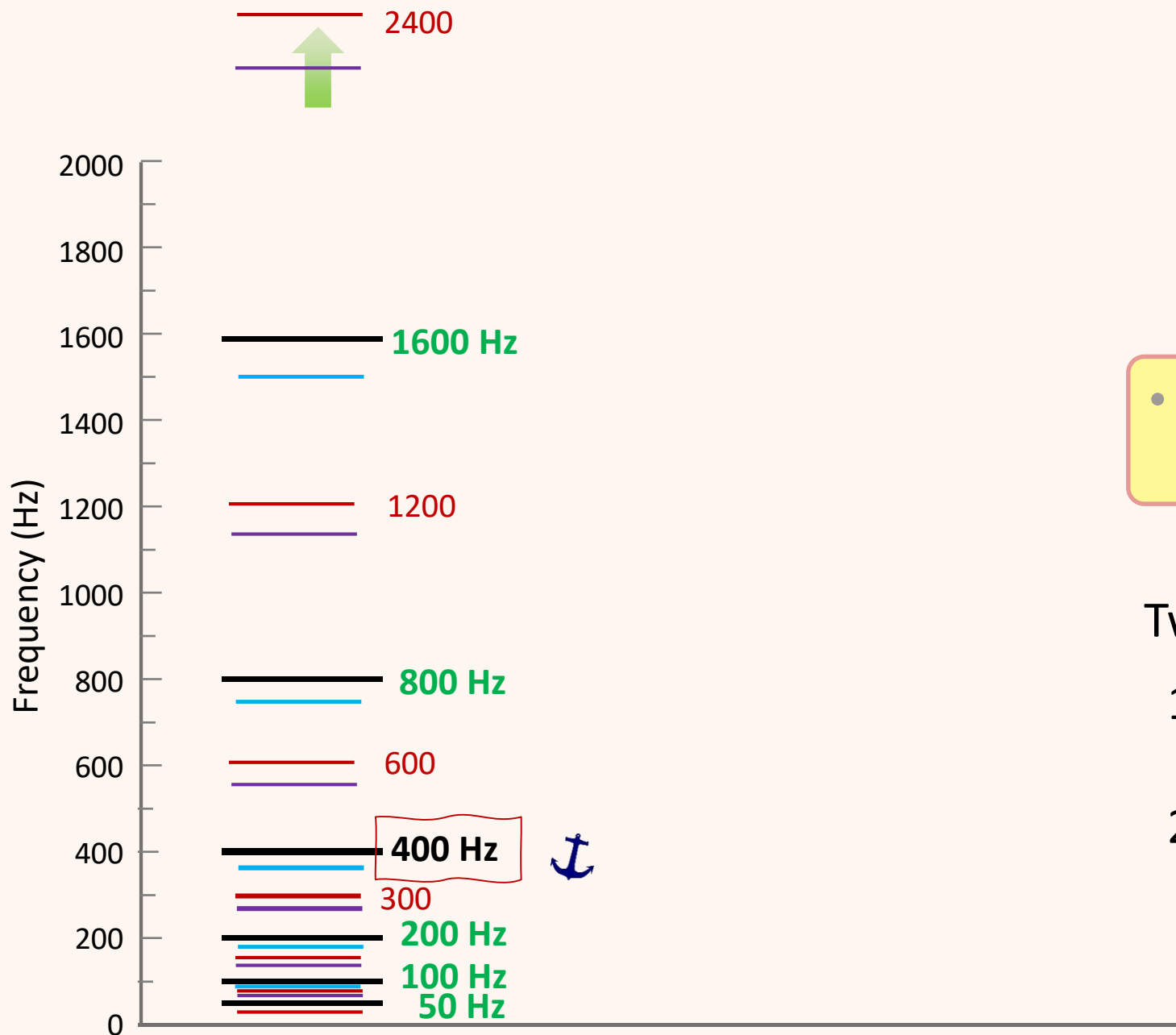
“Intervals”
in Musical Lingo

Constructing Scales based on Octaves

- If we add a note in one Octave, we need to add it in *all* Octaves.



Constructing Scales based on Octaves



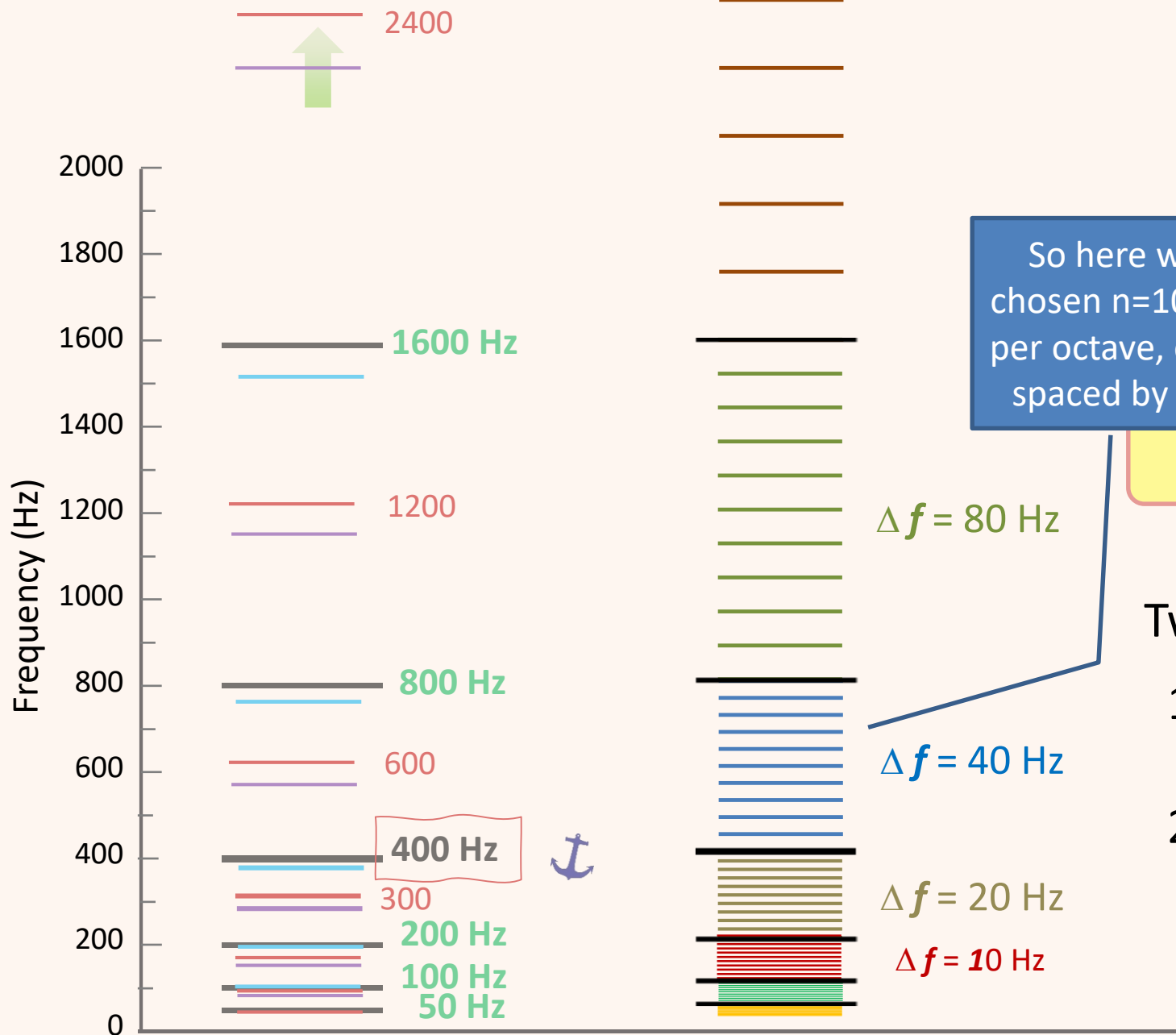
• If we add a note in one Octave, we need to add it in *all* Octaves.

Two Choices to Make:

1. How many notes per Octave?
2. How should they be distributed?
- i.e., exactly what frequencies?

TEMPERAMENT

Constructing Scales based on Octaves

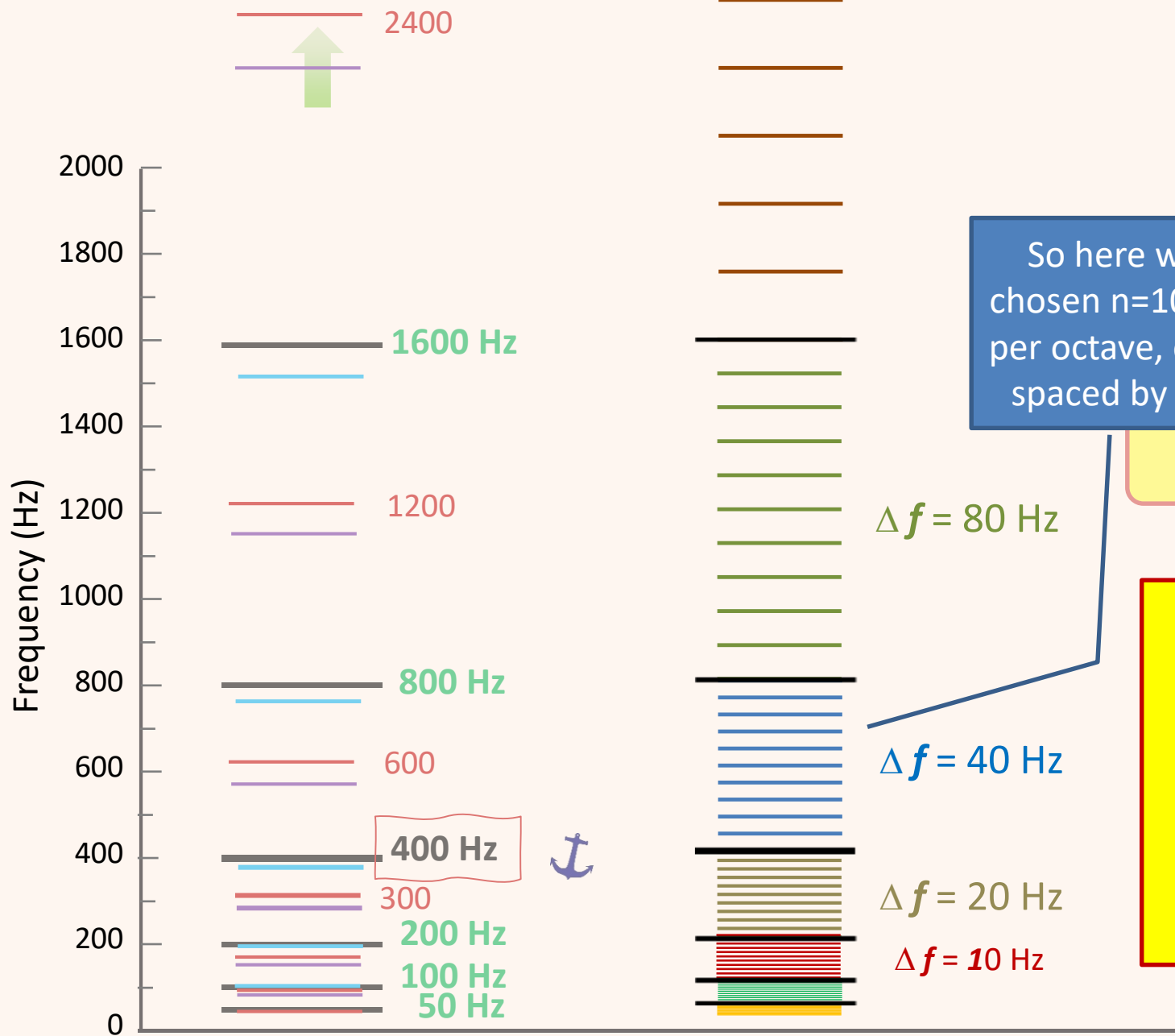


Two Choices to Make:

1. How many notes per Octave?
2. How should they be distributed?
- i.e., exactly what frequencies?

TEMPERAMENT

Constructing Scales based on Octaves

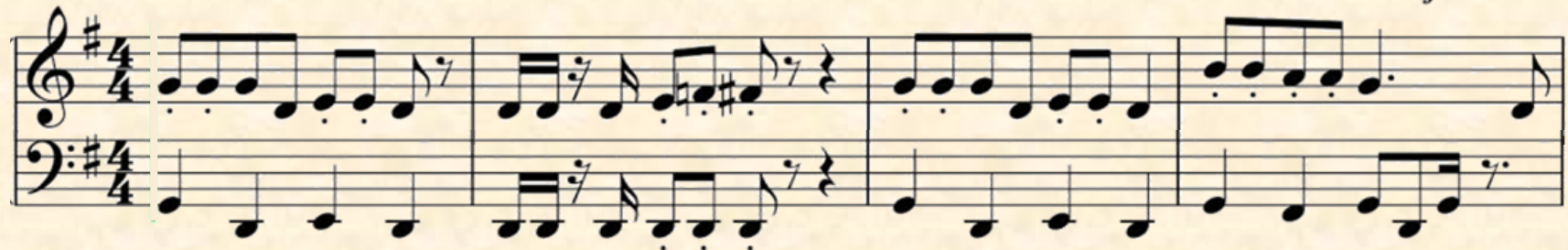


A monk* came up with an answer 1000 years ago...

Old MacDonald Had A Farm

Anonymous
Arr: Raif Husicic

$\text{♩} = 110$

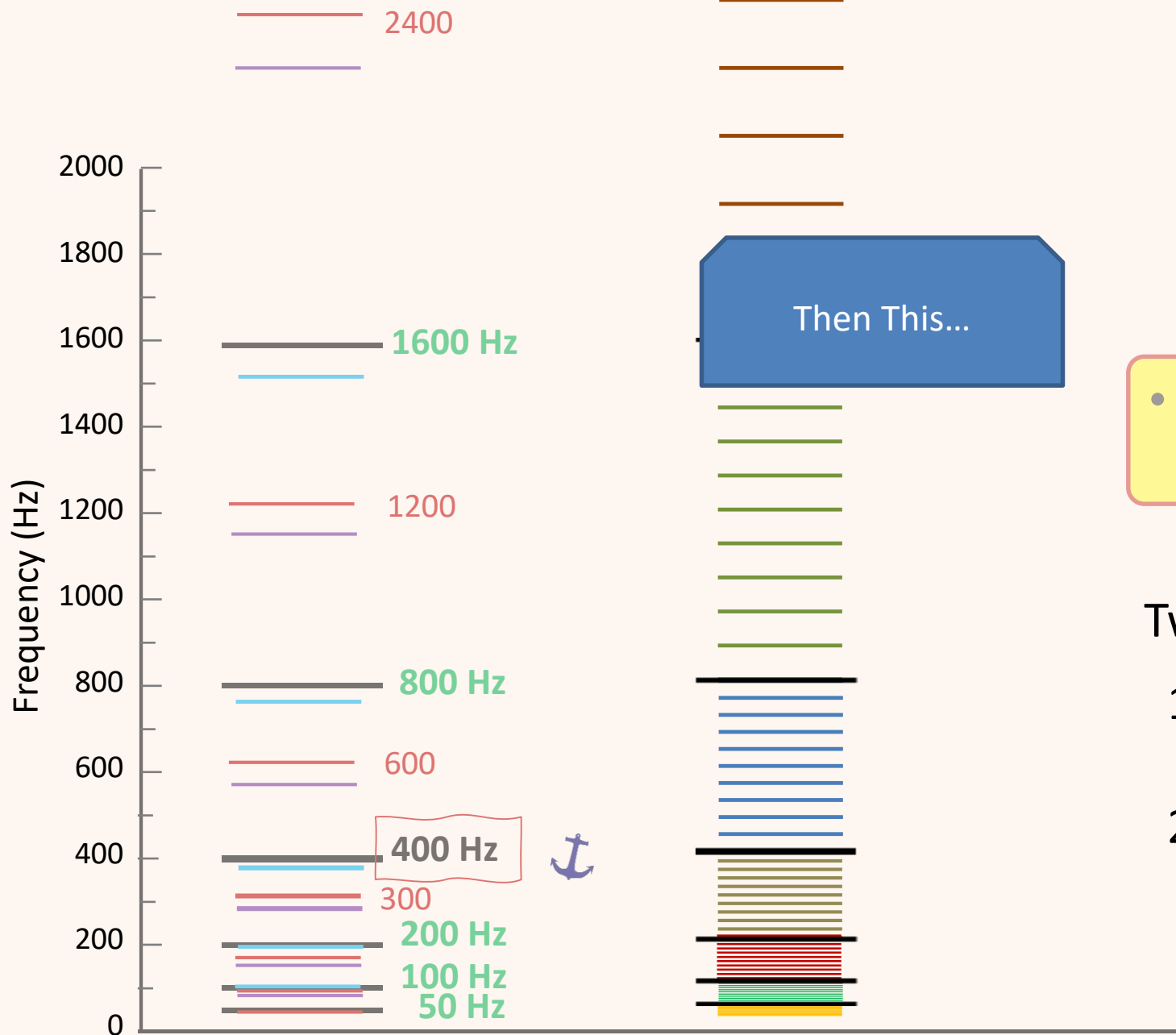


Log of Frequency
(Approximately)

Use a compressed
Logarithmic
Frequency Scale

*Guido of Arezzo 1025

Constructing Scales based on Octaves

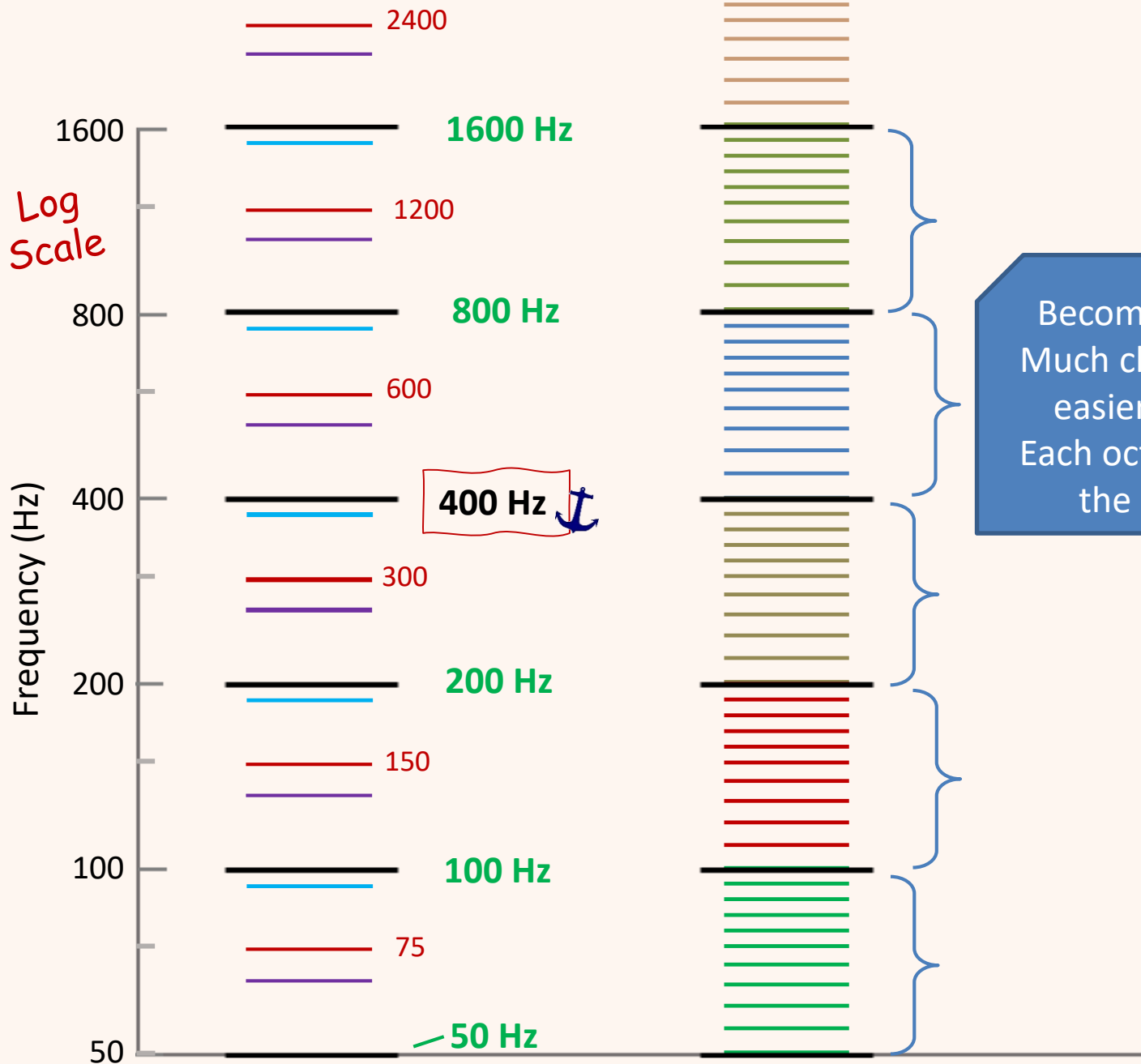


- If we add a note in one Octave, we need to add it in *all* Octaves.

Two Choices to Make:

1. How many notes per Octave?
2. How should they be distributed?
- i.e., exactly what frequencies?

TEMPERAMENT



Constructing Scales based on Octaves

Becomes This...
 Much clearer and easier to see.
 Each octave looks the same!

To add a note in one Octave, we have to add it in *all* Octaves.

Two Choices to Make:

1. How many notes per Octave?
2. How should they be distributed?
 - i.e., exactly what frequencies?

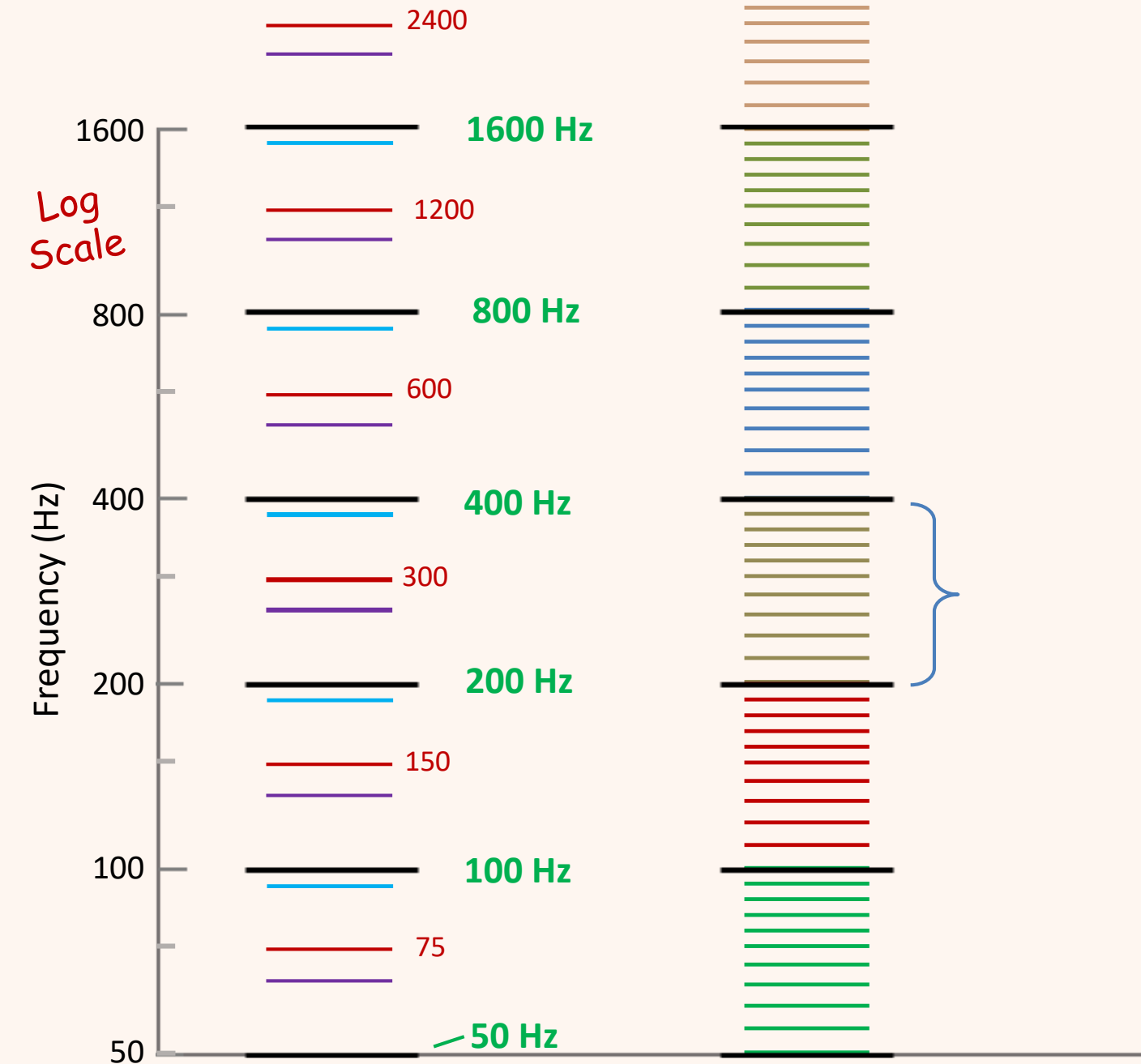
TEMPERAMENT

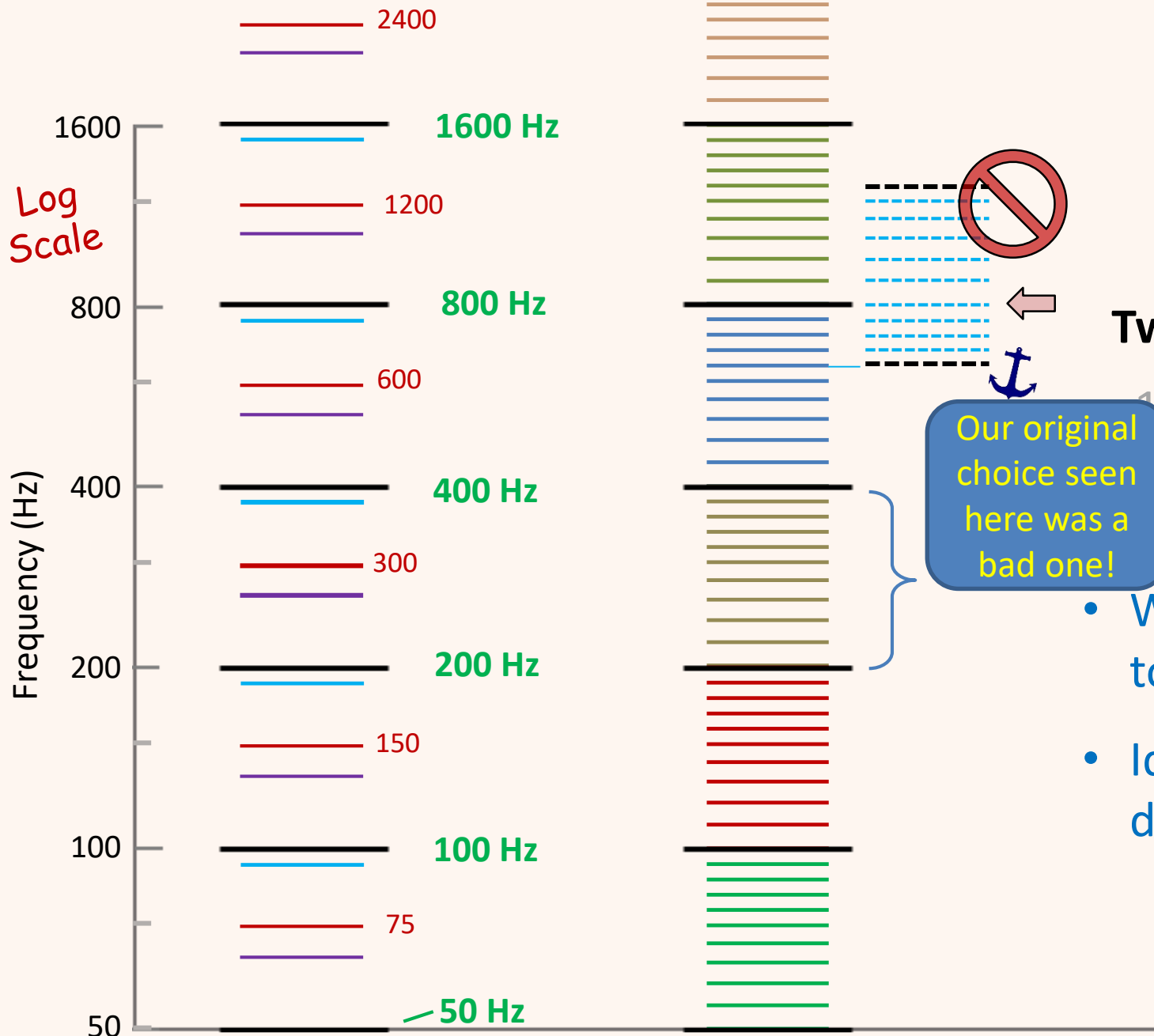
Constructing Scales based on Octaves

Two Choices to Make:

1. How many notes per Octave?

- *Enough* to make interesting music but...
- Not *too* many, lest we
 - Over-complicate Instruments
 - Confuse listeners
 - Burden Composers
- **Actual scales use from 5 to 24 notes/octave**

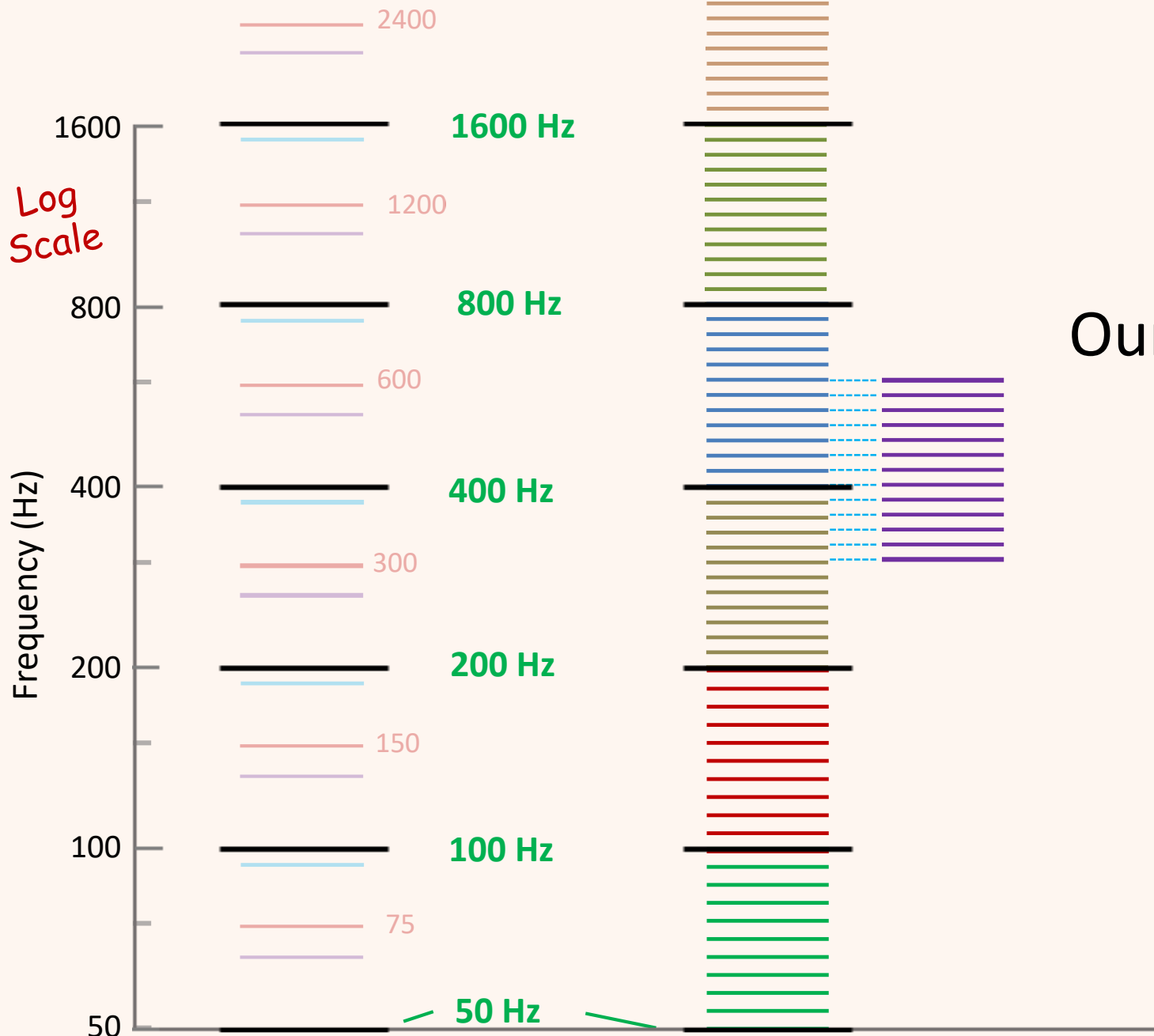




Constructing Scales based on Octaves

Two Choices to Make:

1. How many notes per Octave?
 How should they be distributed?
 - i.e., exactly what frequencies?
- We want to choose notes that play well together for melody and harmony
 - Ideally, we'd like a smooth, regular distribution
 - Better yet, so regular that we could anchor an octave at any note!



Constructing Scales based on Octaves

Our Focus: ~~“Mother Scale”~~ ?
Great-great Granddaughter

- 12 Notes Per Octave
- Equal Spacing (on Log Scale)
 - Clean
 - Simple
 - Elegant

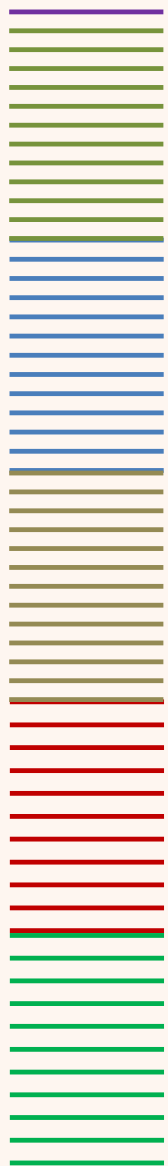
... but not musically ideal 😞



So What Is This Mother Scale?

Log Scale

Frequency $f \rightarrow$



Octave

12	200 Hz
11	188.8
10	178.2
9	168.2
8	158.7
7	149.8
6	141.42136
5	133.5
4	126.0
3	118.9
2	112.2
1	105.9 Hz
0	100 Hz



- 12 Notes Per Octave
- Equal Spacing (on Log Scale)
 - Equal Ratios of Adjacent Frequencies
 - Ratio = **1.05946...**
 - Each note \approx 6% Higher

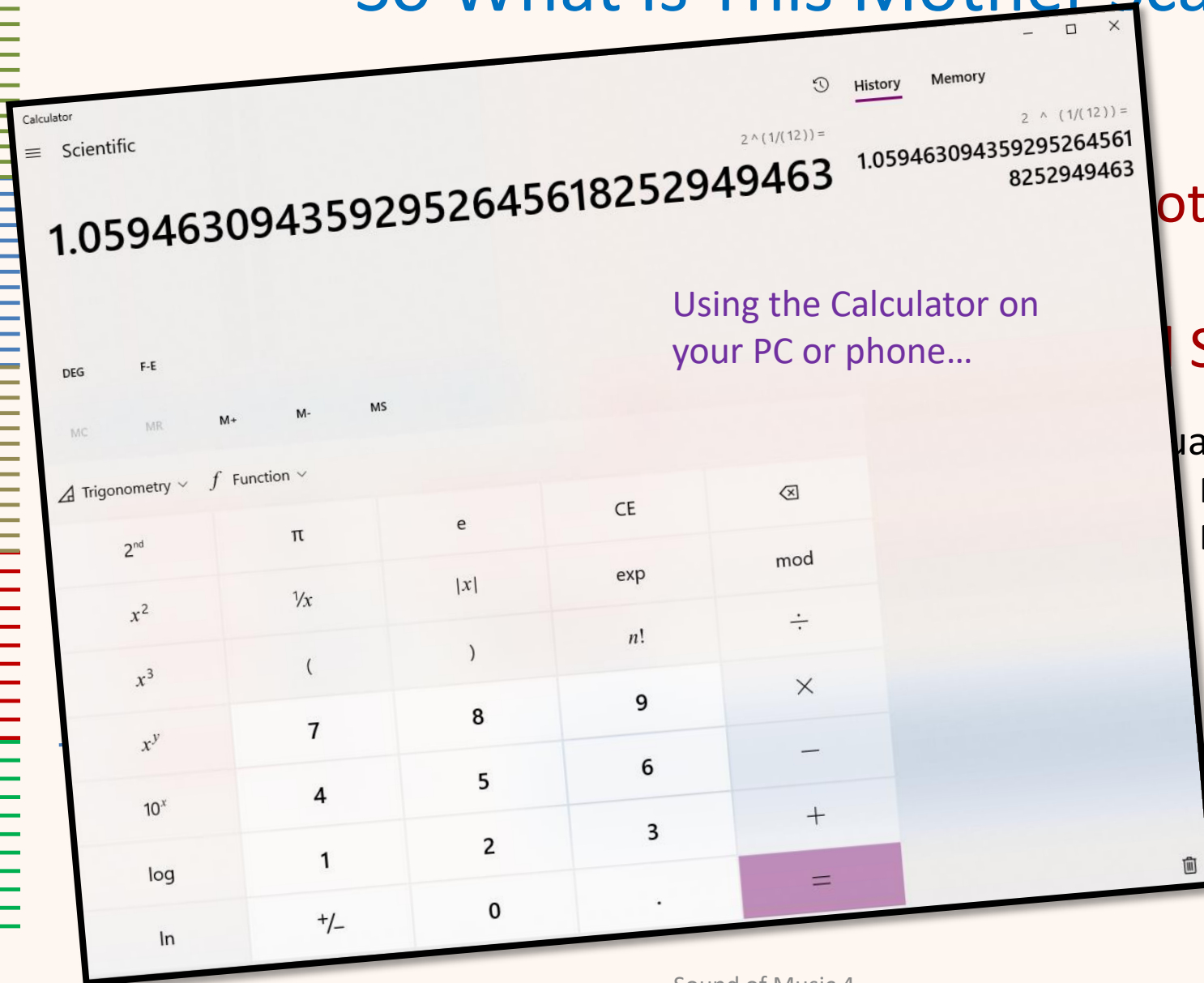
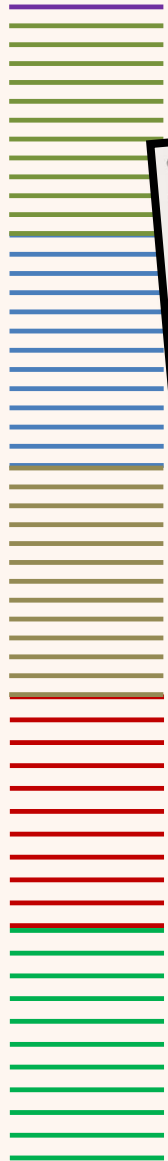
$$\sqrt[12]{2}$$

Compound Interest:
At 5.9% you will
Double Your Money
in 12 years

So What Is This Mother Scale?

Log Scale

Frequency $f \rightarrow$



Using the Calculator on your PC or phone...

$$\sqrt[12]{2}$$

Notes Per Octave

Spacing (on Log Scale)

Equal Ratios of Adjacent Frequencies

Ratio = **1.05946...**

Each note \approx 6% Higher

Compound Interest:
At 5.9% you will
Double Your Money
in 12 years

So What Is This Mother Scale?

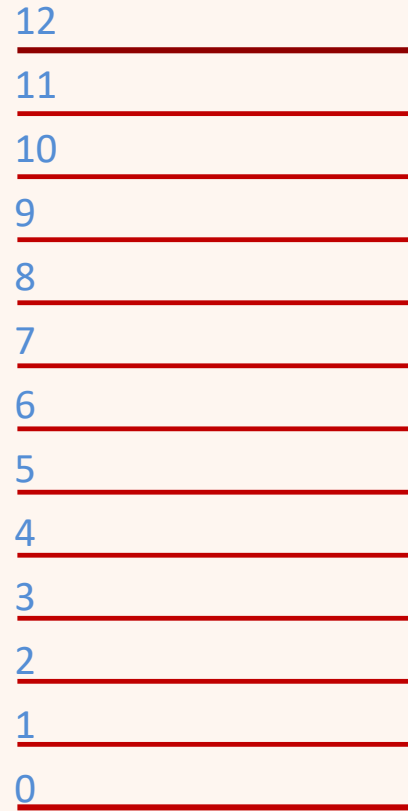
Log Scale

Frequency $f \rightarrow$

- 12 Notes Per Octave

- Equal Spacing (on Log Scale)

Octave



~~100 Hz~~

130.81 Hz

A Particular Example of such a 12-tone Equal Tempered scale is...

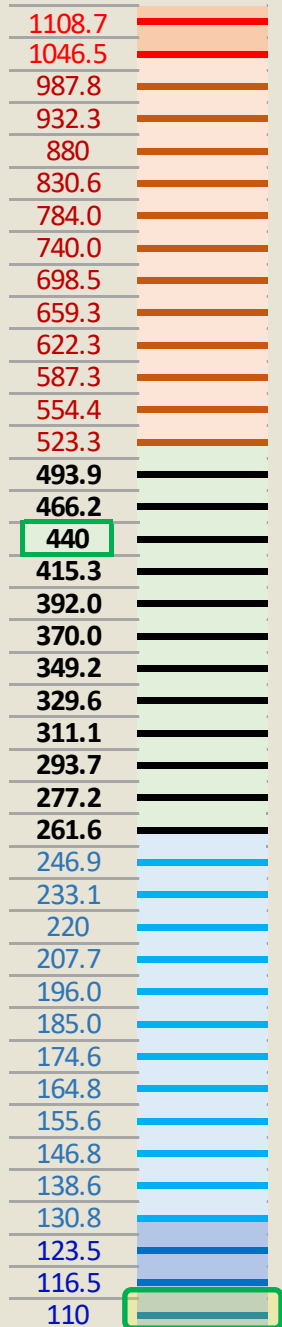
...

“The 12 Tone Chromatic Scale”



Piano

f



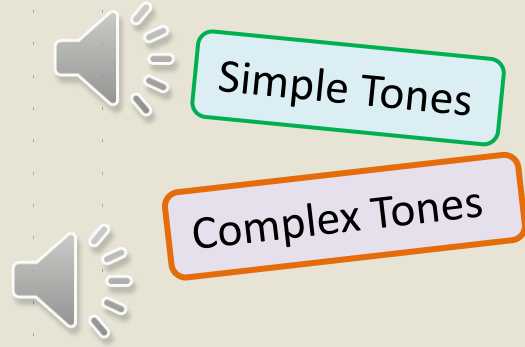
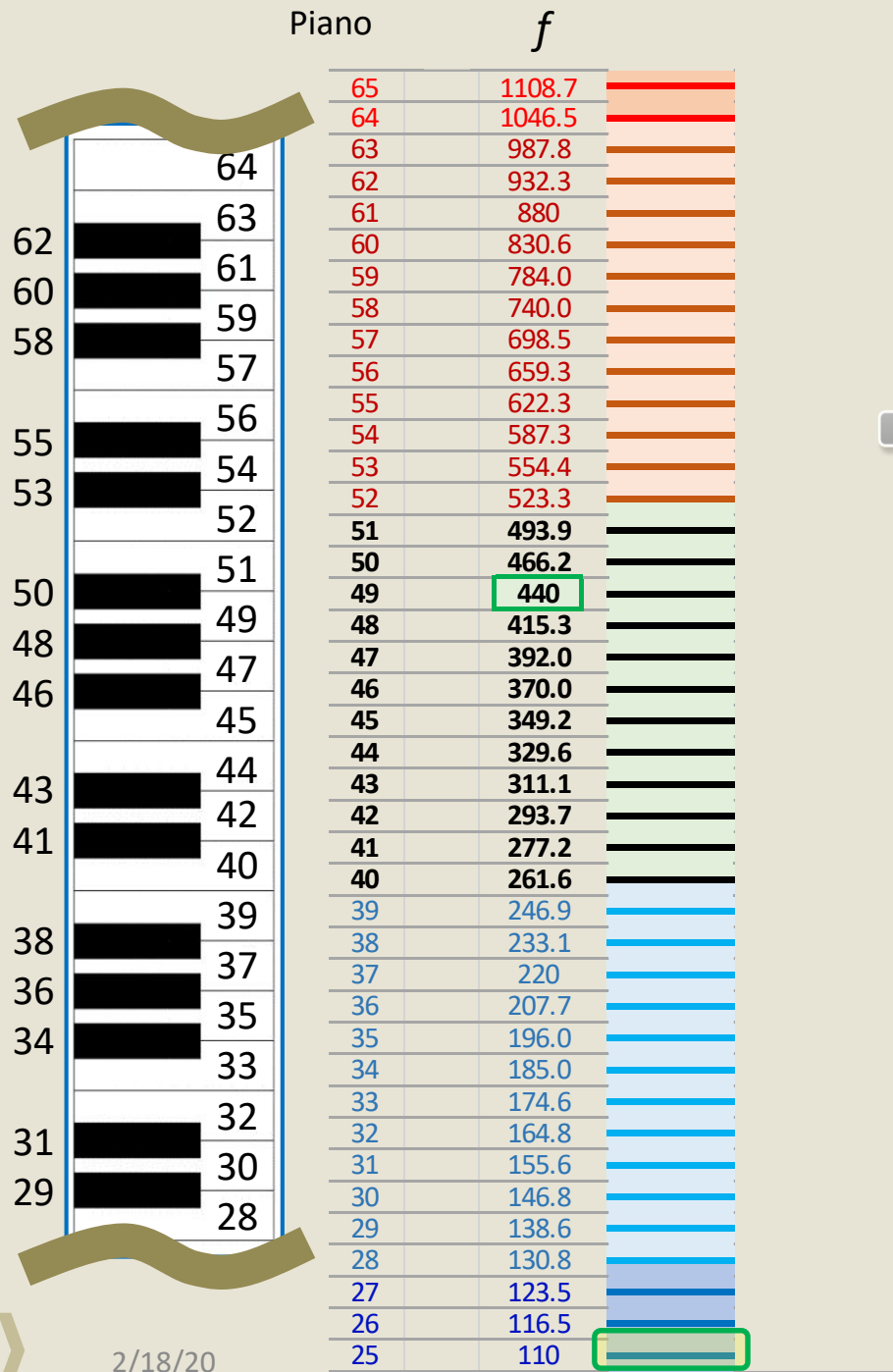
Simple Tones



Complex Tones

12 Note Per Octave Equal Tempered Scale: The Chromatic Scale

12 Note Per Octave Equal Tempered Scale: The Chromatic Scale



12 Note Per Octave Equal Tempered Scale: The Chromatic Scale

Piano *MIDI* *f*

	65	85	1108.7
	64	84	1046.5
	63	83	987.8
	62	82	932.3
	61	81	880
	60	80	830.6
62	61	59	784.0
60	59	58	740.0
58	57	57	698.5
	56	76	659.3
	55	75	622.3
55	54	74	587.3
53	53	73	554.4
	52	72	523.3
	51	71	493.9
	50	70	466.2
50	49	69	440
48	48	68	415.3
46	47	67	392.0
	46	66	370.0
	45	65	349.2
	44	64	329.6
43	43	63	311.1
41	42	62	293.7
	41	61	277.2
	40	60	261.6
	39	59	246.9
38	38	58	233.1
36	37	57	220
	36	56	207.7
34	35	55	196.0
	34	54	185.0
	33	53	174.6
31	32	52	164.8
29	31	51	155.6
	30	50	146.8
	29	49	138.6
	28	48	130.8
	27	47	123.5
	26	46	116.5
	25	45	110

Simple Tones

Complex Tones

We can label these notes by Piano key # or MIDI note code numbers, which are piano key+20



MIDI* Data

* Musical Instrument Digital Interface

12 Note Per Octave Equal Tempered Scale: The Chromatic Scale

MIDI	f		Pitch Class
85	1108.7		C#/D \flat 6
84	1046.5		C 6
83	987.8		B 5
82	932.3		A#/B \flat 5
81	880		A 5
80	830.6		G#/A \flat 5
79	784.0		G 5
78	740.0		F#/G \flat 5
77	698.5		F 5
76	659.3		E 5
75	622.3		D#/E \flat 5
74	587.3		D 5
73	554.4		C#/D \flat 5
72	523.3		C 5
71	493.9		B 4
70	466.2		A#/B \flat 4
69	440		A 4
68	415.3		G#/A \flat 4
67	392.0		G 4
66	370.0		F#/G \flat 4
65	349.2		F 4
64	329.6		E 4
63	311.1		D#/E \flat 4
62	293.7		D 4
61	277.2		C#/D \flat 4
60	261.6		C 4
59	246.9		B 3
58	233.1		A#/B \flat 3
57	220		A 3
56	207.7		G#/A \flat 3
55	196.0		G 3
54	185.0		F#/G \flat 3
53	174.6		F 3
52	164.8		E 3
51	155.6		D#/E \flat 3
50	146.8		D 3
49	138.6		C#/D \flat 3
48	130.8		C 3
47	123.5		B 2
46	116.5		A#/B \flat 2
45	110		A 2

All the C notes belong to Pitch Class Zero

Similarly, all the D notes belong to Pitch Class 2

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

Solfege syllables used for singer training, and also as the Names of Notes in France, Spain, Italy, Russia etc.

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



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



Note that many notes are left out of Julie Andrews' Song...



Alternate Scales with $n \neq 12$: “Microtonal Scales”



Easley Blackwood, Jr.
(1933-)
Former music professor at
U. of Chicago

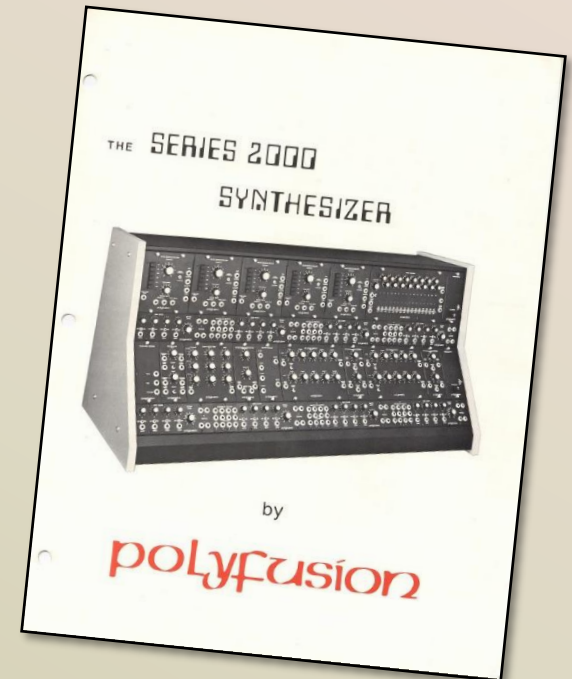
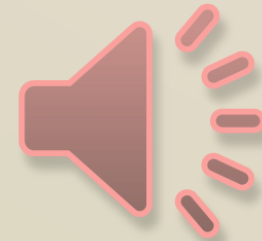
Example:

Fanfare in 19-note Equal Tuning, Op. 28a
(Blackwood, Polyfusion Synthesizer)



Cedille Records 1994

Compositions in
n-Tone Equal
Temperament:
13-tone
To
24-tone Scales
(Synthesizer
and
Modified Guitar)



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

Subscales of The Chromatic Scale

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

- Most Western music genres do **not** use the whole Chromatic Scale
 - Instead, they use smaller Subscales
- Such Subscale music includes:
 - Almost all pre-1910 music
 - Traditional
 - Classical
 - Liturgical
 - Pop music
 - Rock
 - Country and Bluegrass
- Music using the Chromatic Scale includes:
 - Modern “atonal” music (post-1910)
 - Much Jazz

Warning:
It's not quite as simple as this...

Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

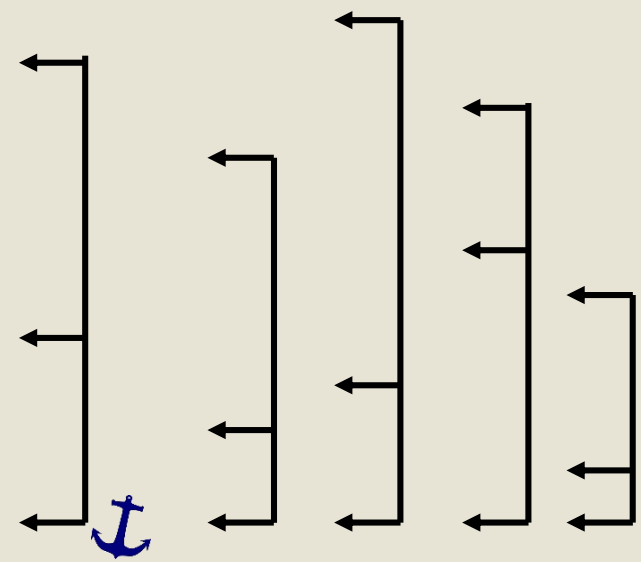
How many Subscales are there?

Examples for m = 3-note Subscales

All together, 55 Patterns like these for m=3

But each Pattern could be anchored at 12 different notes within an Octave

So there are $12 \times 55 = 660$ m=3 Subscales



Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Traditional Country Music Blues

Classical Pop Rock

Pentatonic
Heptatonic
(Includes Diatonic)

Used for Jazz?

m Notes	Patterns	Keys	Total Scales
1	1	12	12
2	11	12	132
3	55	12	660
4	165	12	1980
5	330	12	3960
6	462	12	5544
7	462	12	5544
8	330	12	3960
9	165	12	1980
10	55	12	660
11	11	12	132
12	1	12	12

Only a tiny fraction are of use!

The Pentatonic (5 note) Subscales of The Chromatic Scale

There are **330** m=5 Patterns...

But most are dumb like this

Reasonable rules:

1. Avoid gap of 4 or more
2. Avoid adjacent gaps of 3

With these rules, there are **just 5 Patterns possible!**

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	



The Pentatonic (5 note) Subscales of The Chromatic Scale

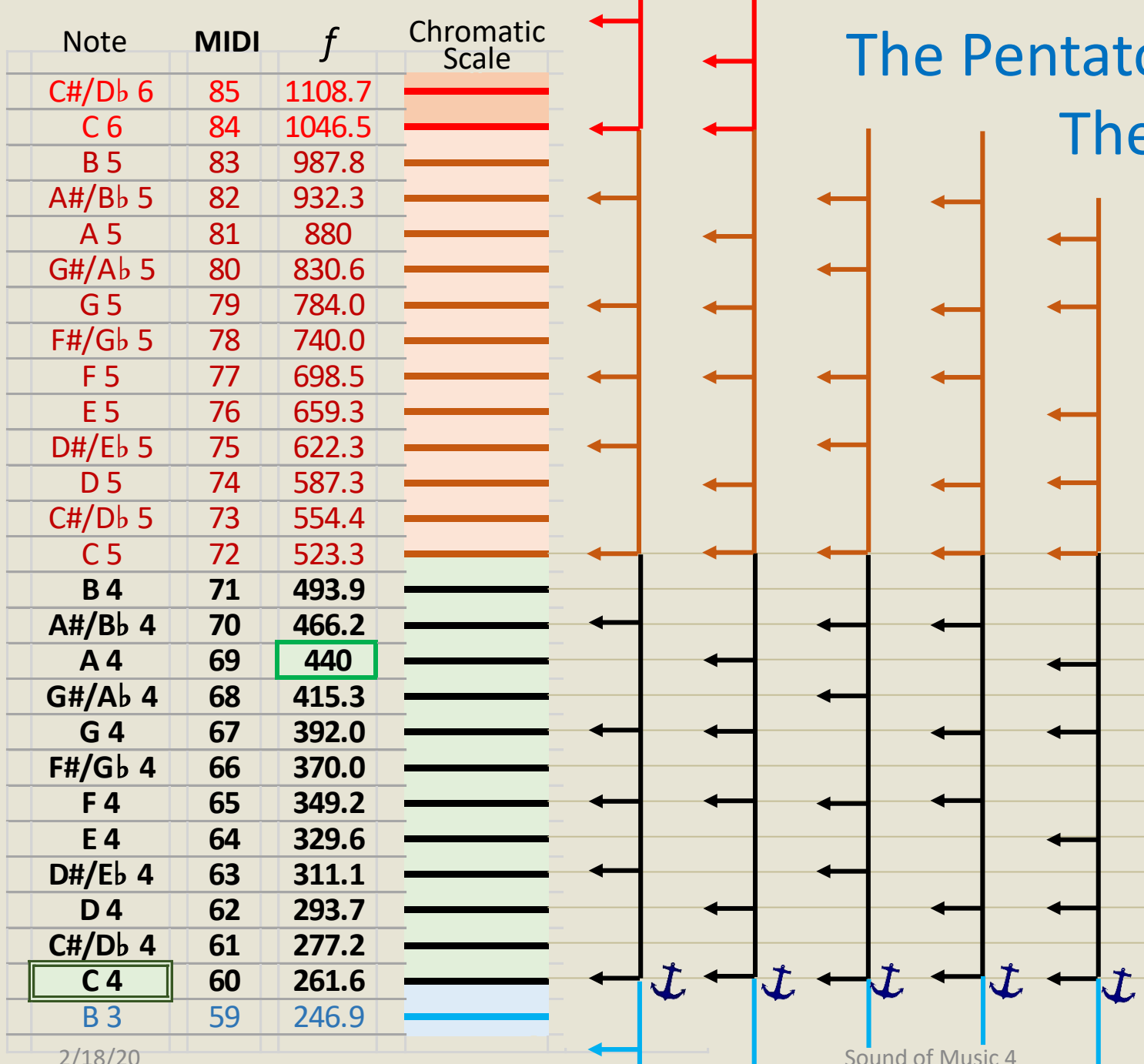
There are **330** m=5 Patterns...

Reasonable rules:

1. Avoid gap of 4 or more
2. Avoid adjacent gaps of 3

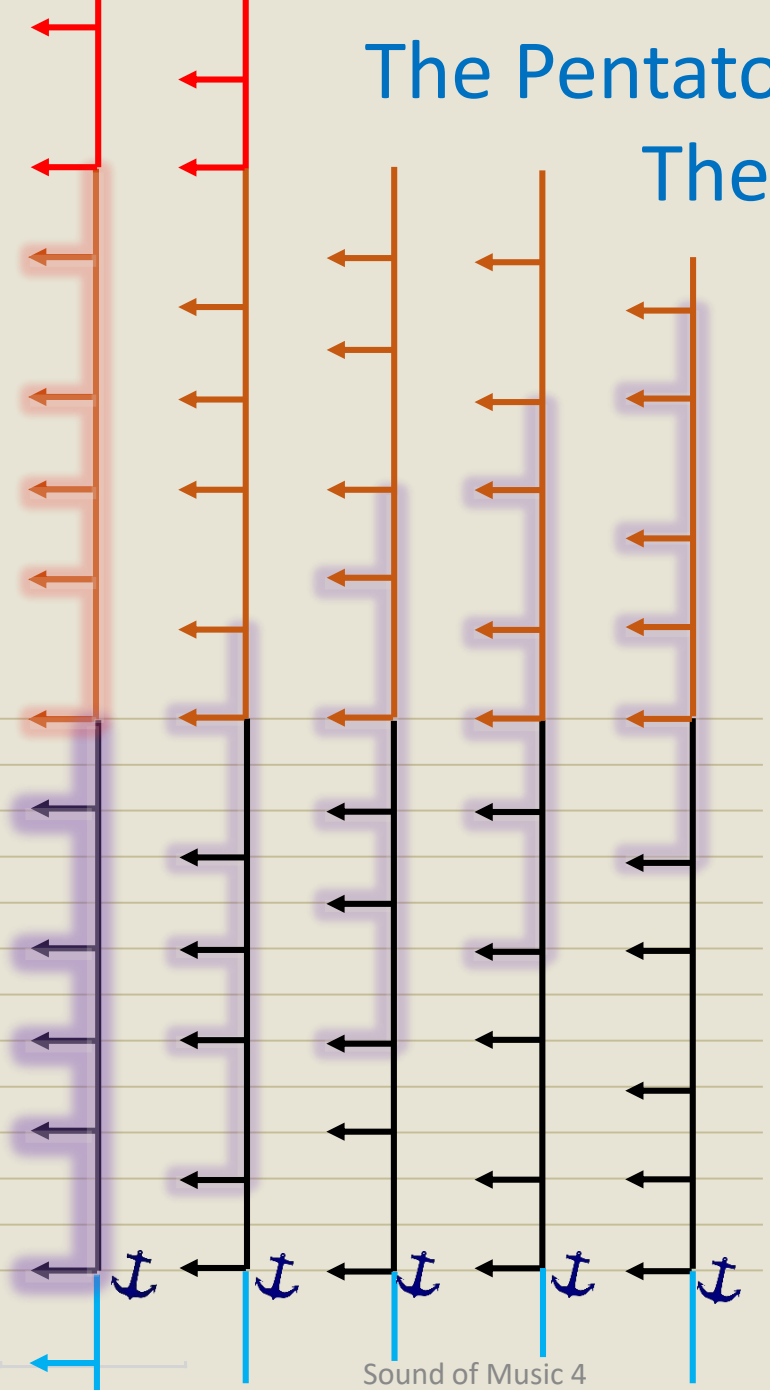
With these rules, there are **just 5 Patterns possible!**

^
these



The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	



There are **330** m=5 Patterns...

Reasonable rules:

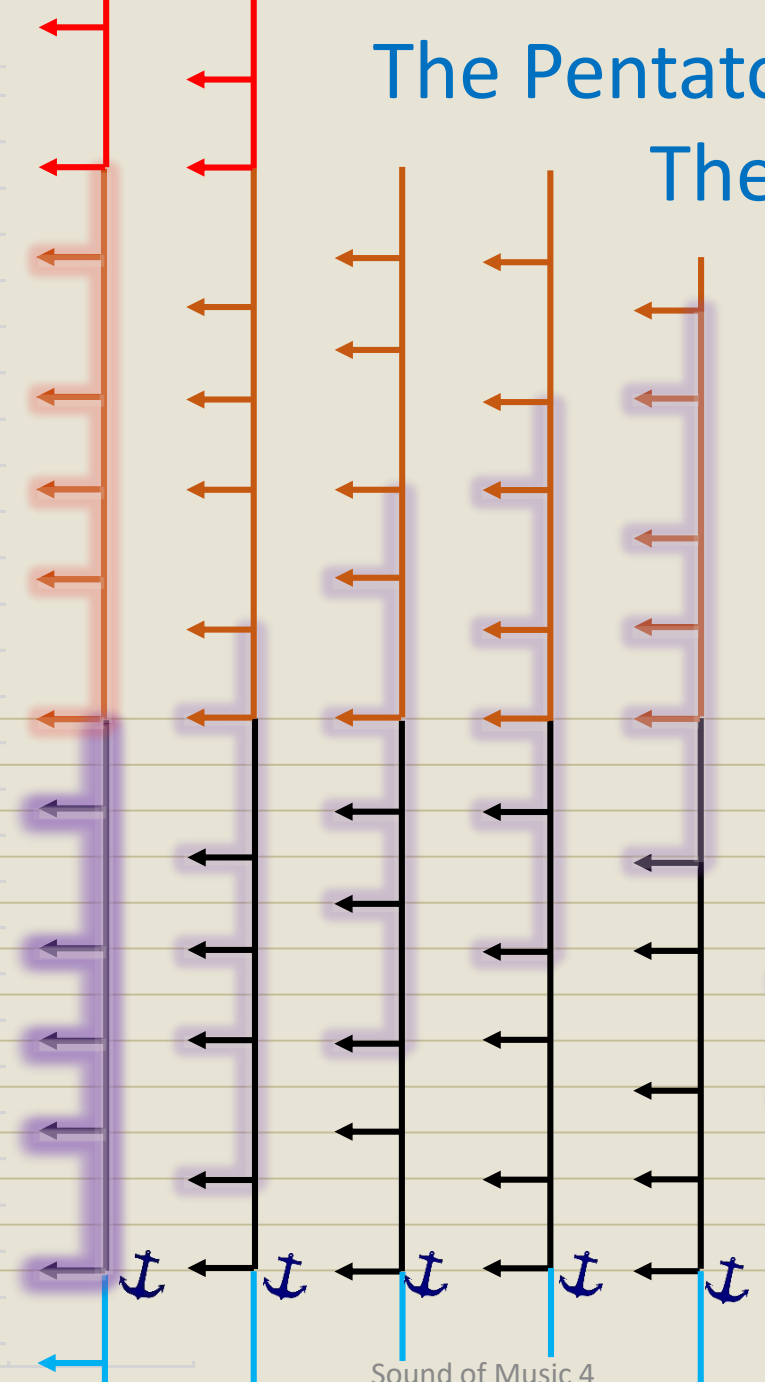
1. Avoid gap of 4 or more
2. Avoid adjacent gaps of 3

With these rules, there are **just 5 Patterns possible!**

But they all have the same family pattern – just shifted

The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

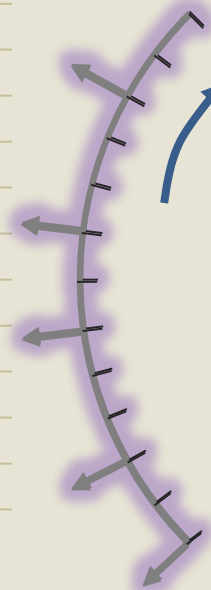


There are **330** $m=5$ Patterns...

Reasonable rules:

1. Avoid gap of 4 or more
2. Avoid adjacent gaps of 3

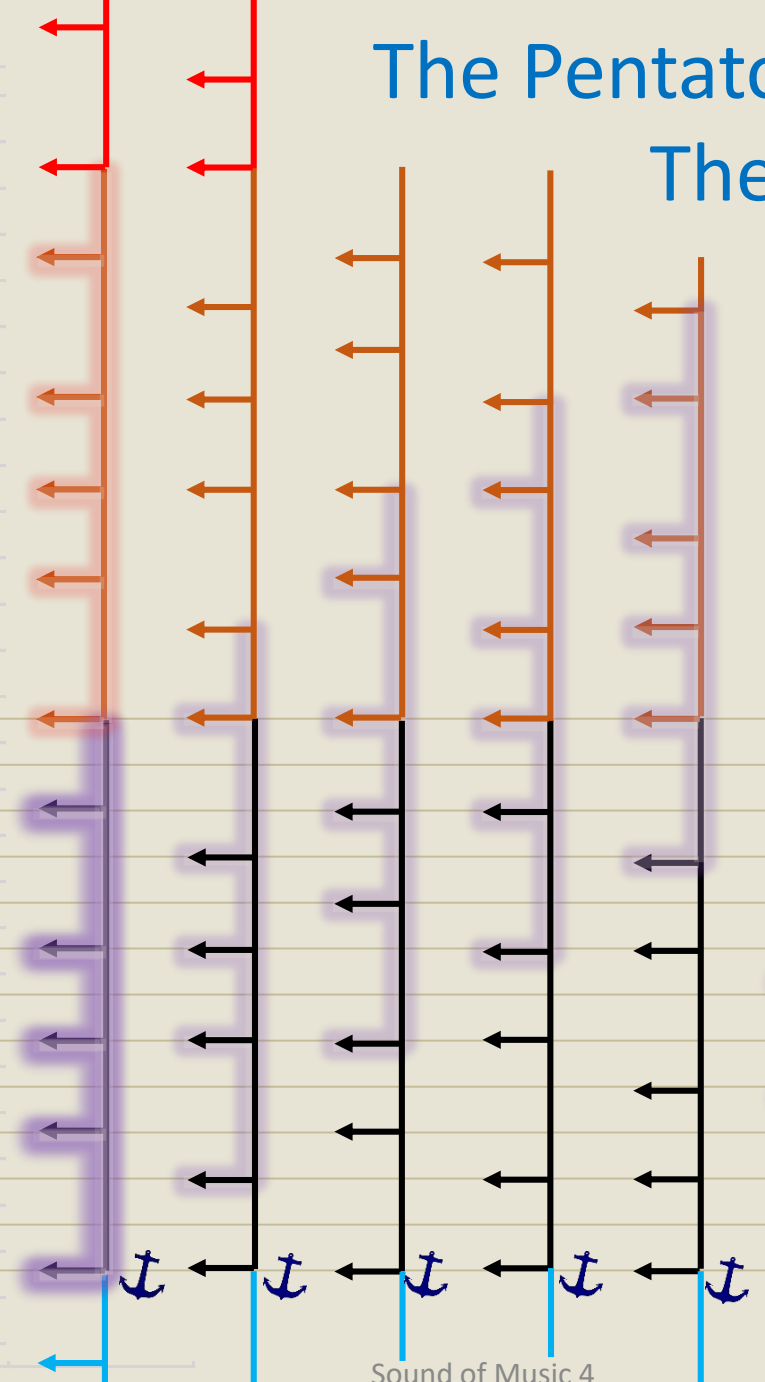
With these rules, there are **just 5 Patterns possible!**



Take the basic pattern and wrap it into a circle..

The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

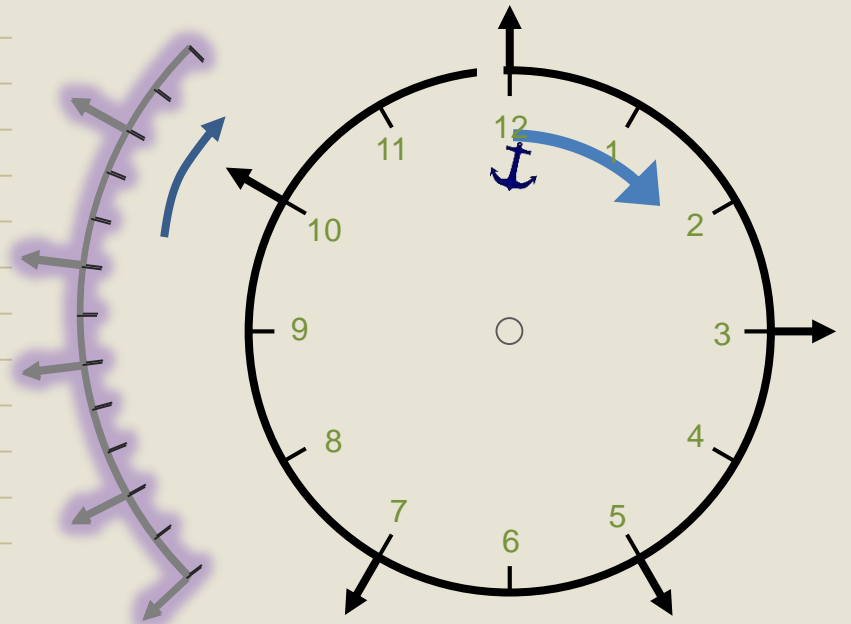


There are **330** $m=5$ Patterns...

Reasonable rules:

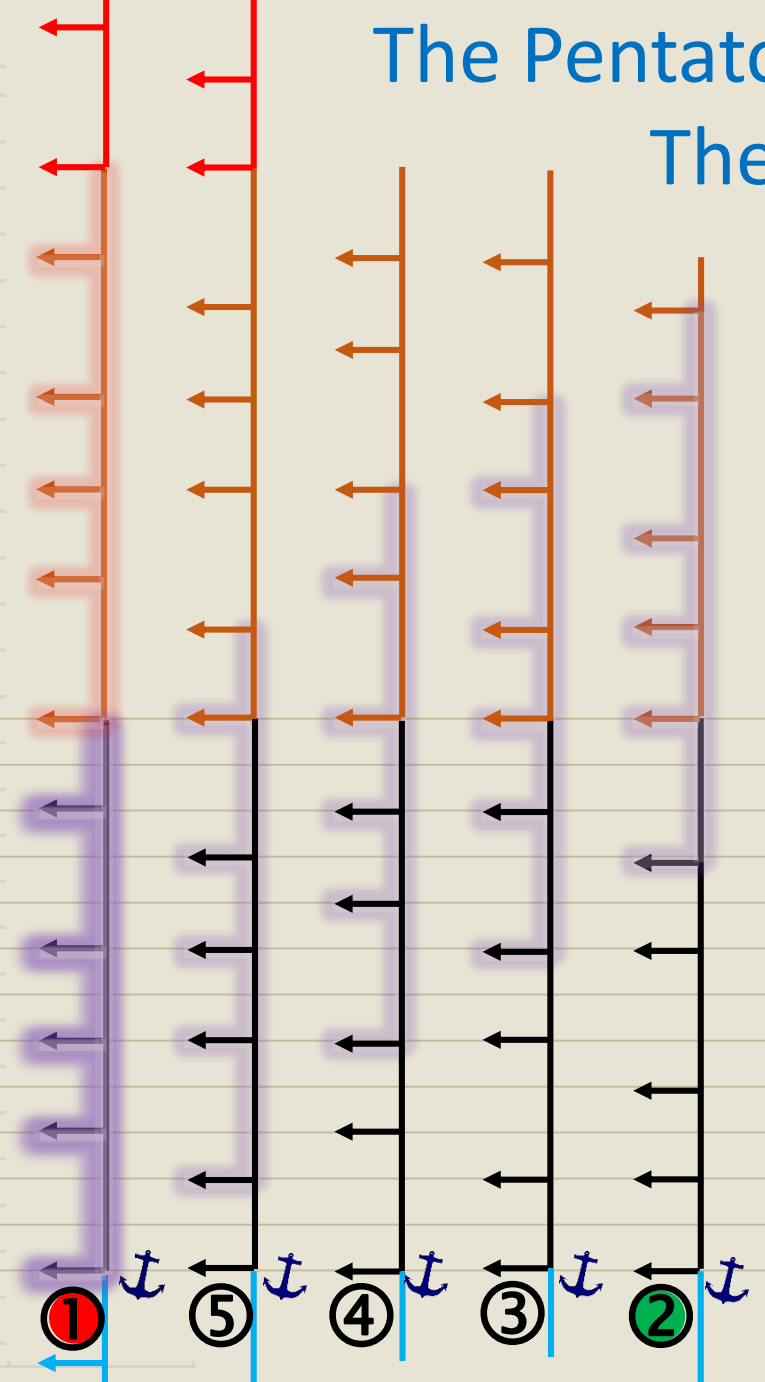
1. Avoid gap of 4 or more
2. Avoid adjacent gaps of 3

With these rules, there are **just 5 Patterns possible!**



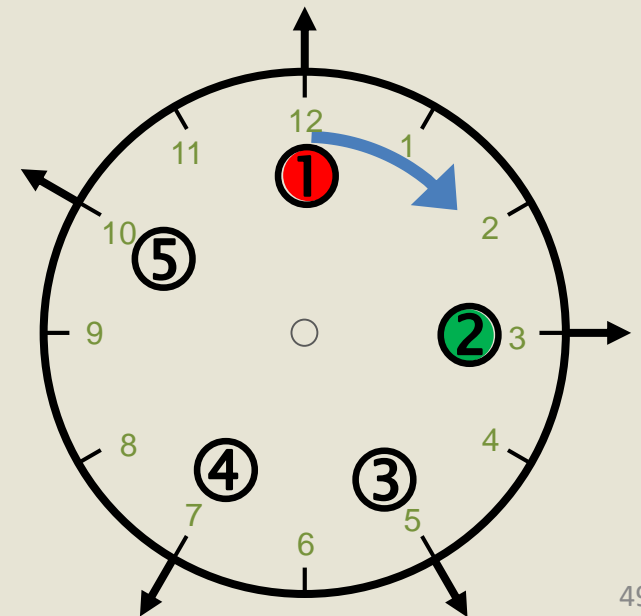
The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	



The Pentatonic Scale Circle:
5 Modes of the Minor Pentatonic Scale

- ① **minor** Pentatonic Scale
- ② **Major** Pentatonic Scale
- ③ Egyptian Pentatonic Scale
- ④ Blues Minor Pentatonic Scale
- ⑤ Blues Major Pentatonic Scale

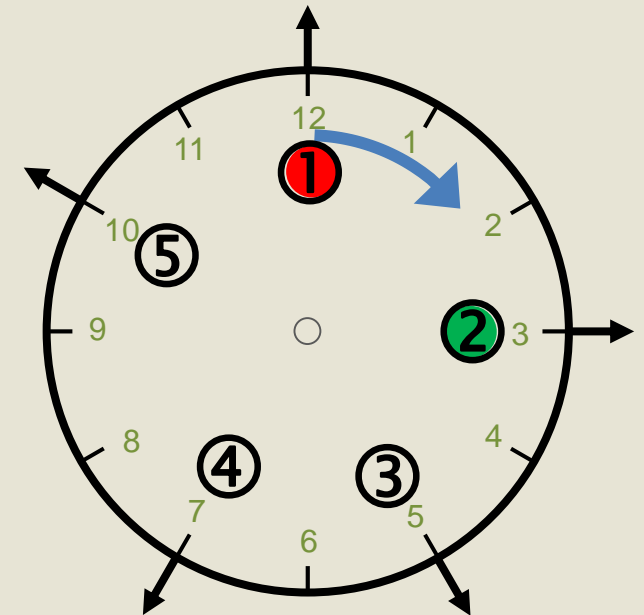


The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

The Pentatonic Scale Circle:
5 Modes of the Minor Pentatonic Scale

- ① **minor** Pentatonic Scale
- ② **Major** Pentatonic Scale

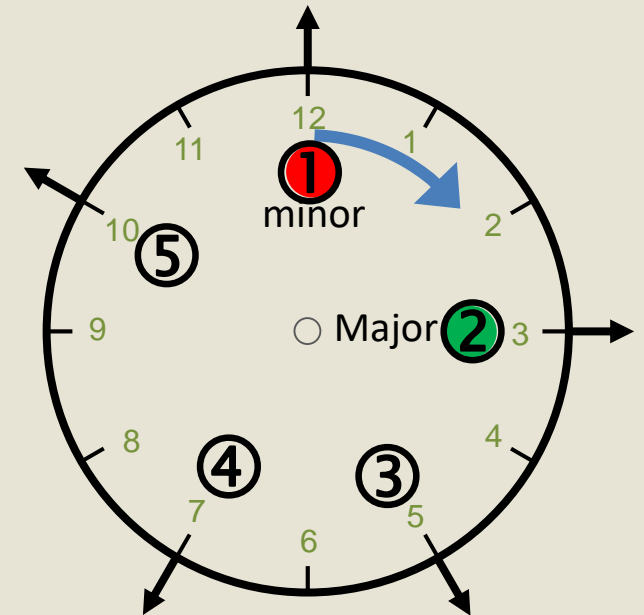


The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

The Pentatonic Scale Circle:
5 Modes of the Minor Pentatonic Scale

- ① **minor** Pentatonic Scale
- ② **Major** Pentatonic Scale



The Pentatonic (5 note) Subscales of The Chromatic Scale

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

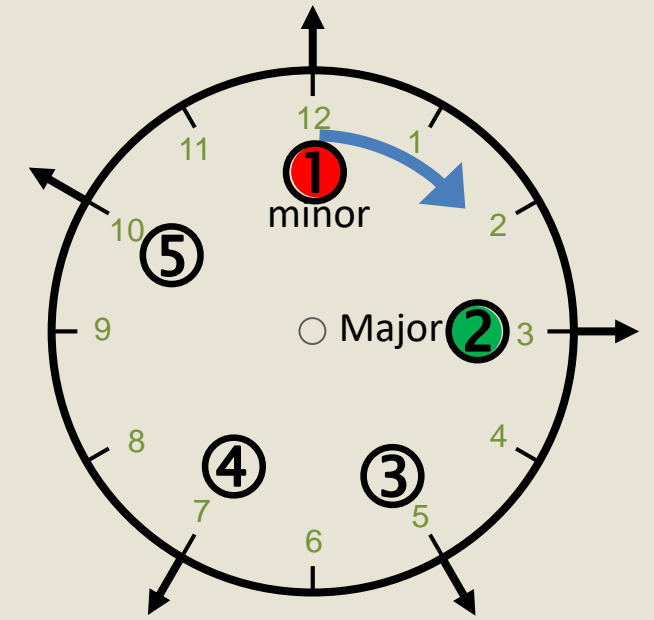
How can musicians remember these scales?

3-2-2-3-2

2-2-3-2-3 DDTDT

The Pentatonic Scale Circle:
5 Modes of the Minor Pentatonic Scale

- ① minor Pentatonic Scale
- ② Major Pentatonic Scale



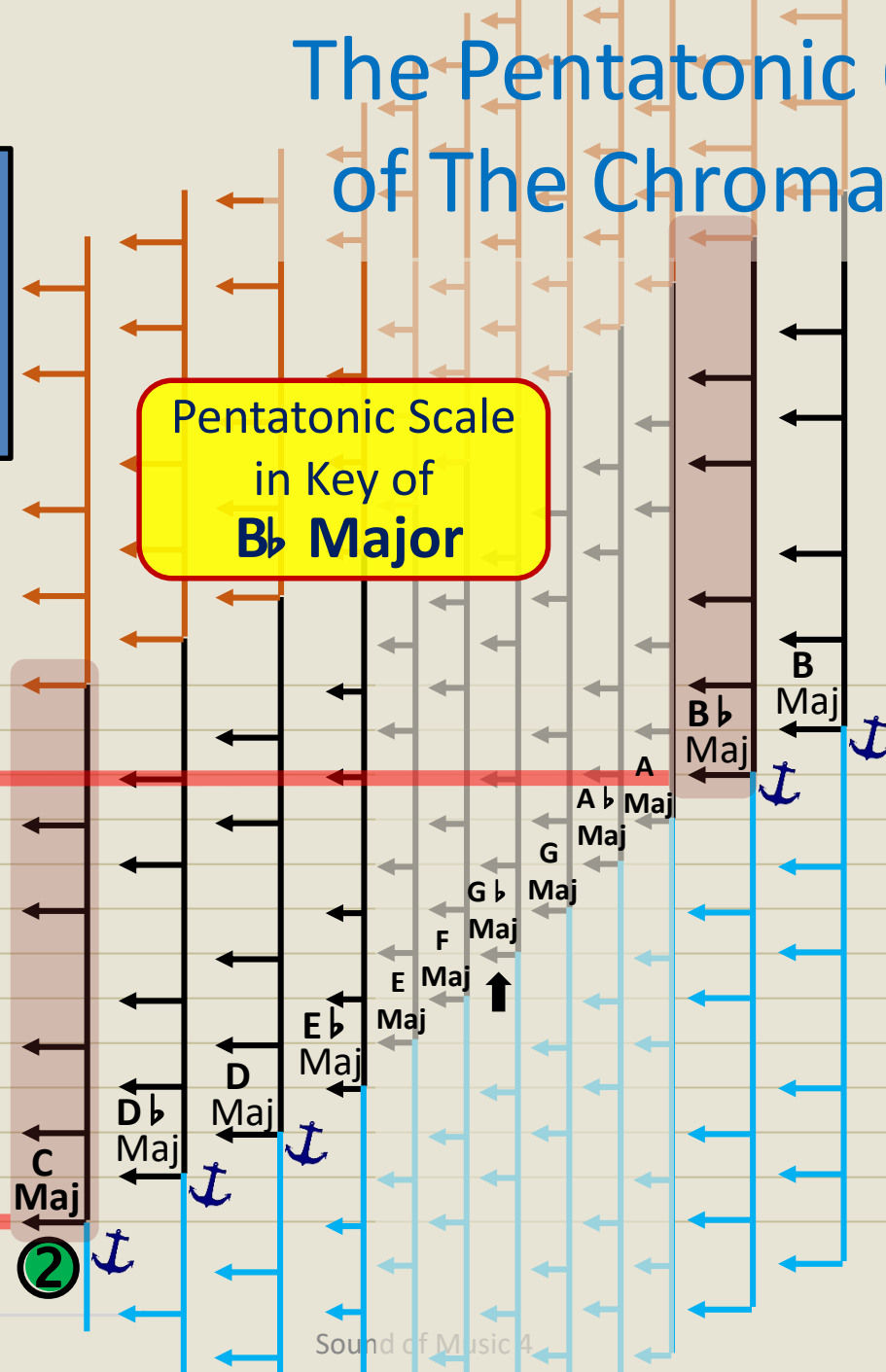
The Pentatonic (5 note) Subscales of The Chromatic Scale: 12 Keys

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	391.9	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

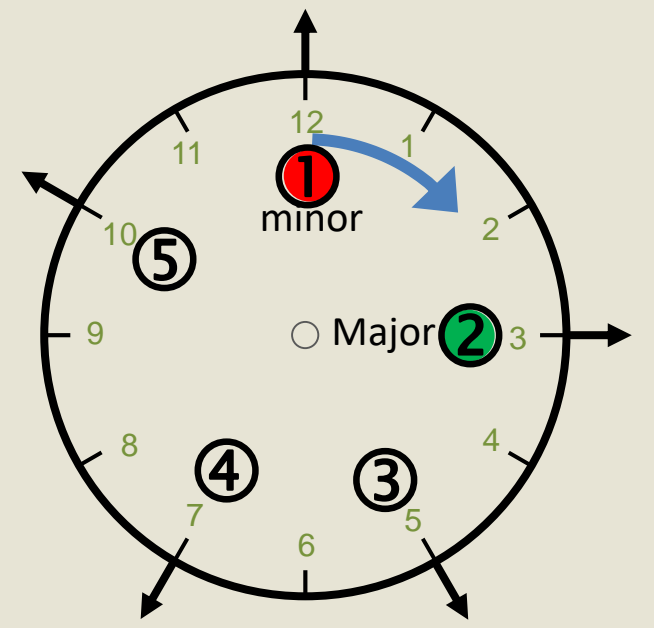
The Pentatonic Major Scale in 12 Keys →

Pentatonic Scale in Key of B \flat Major

Pentatonic Scale in Key of C Major



- ① minor Pentatonic Scale
- ② Major Pentatonic Scale



The Pentatonic (5 note) Subscales of The Chromatic Scale: 12 Keys

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	391.9	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

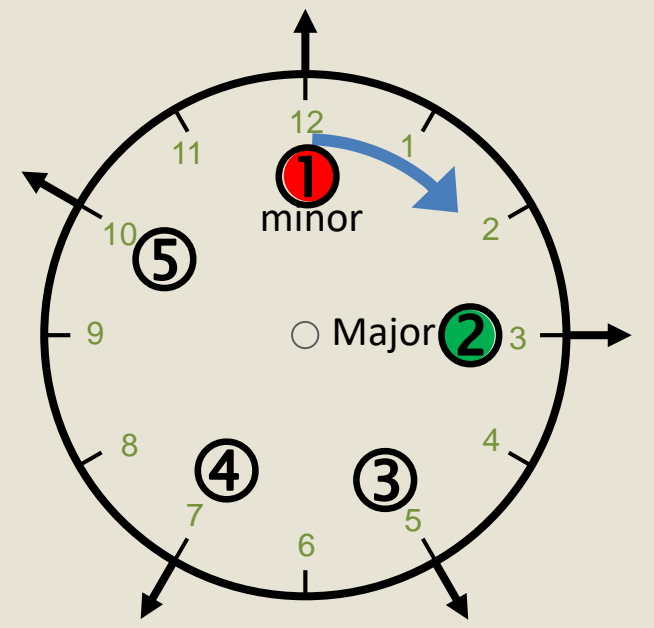
The Pentatonic Major Scale in 12 Keys →

Pentatonic Scale in Key of B \flat Major

Pentatonic Scale in Key of C Major

Curiosity: C Major Uses only White Piano Keys

- ① minor Pentatonic Scale
- ② Major Pentatonic Scale



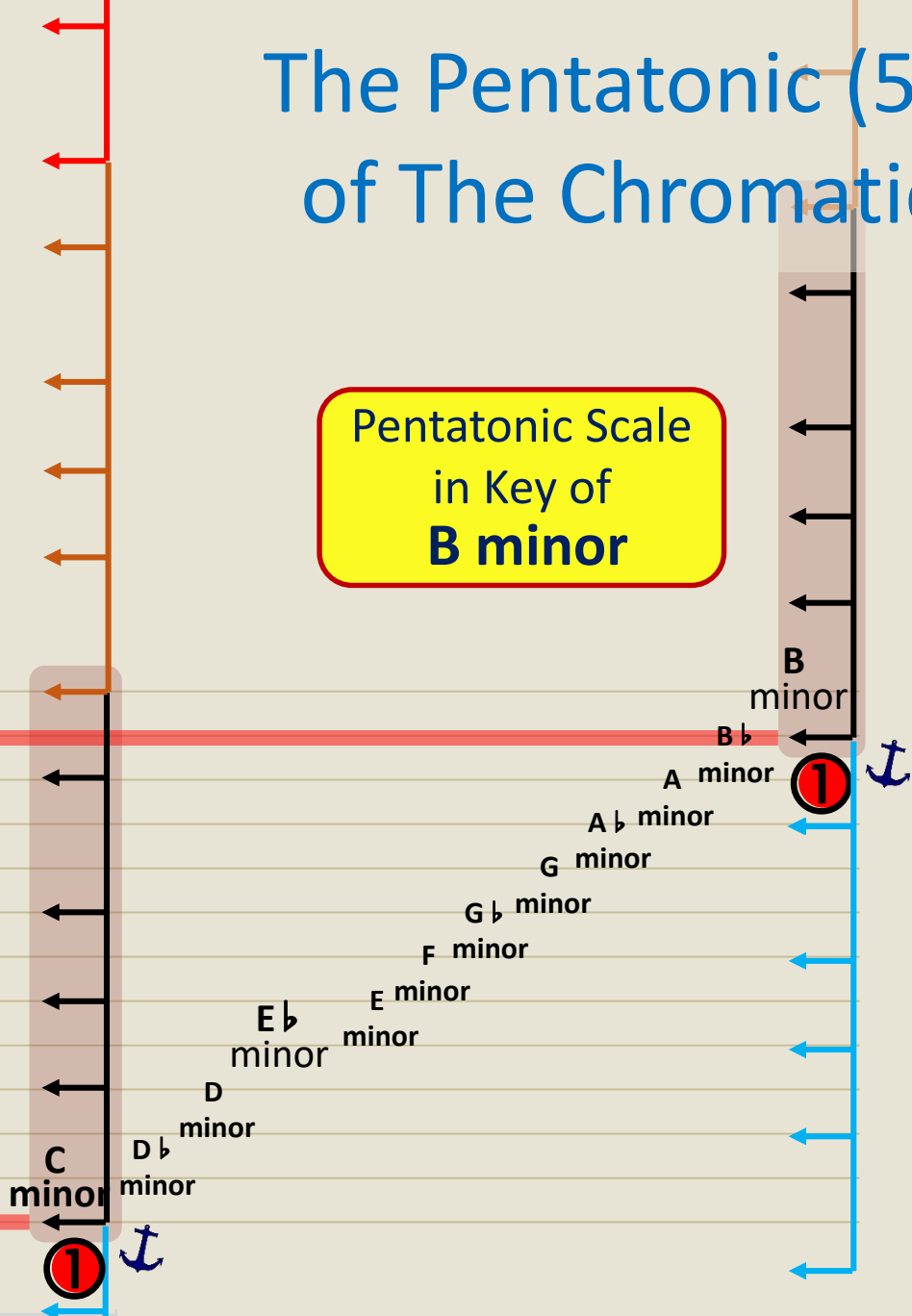
The Pentatonic (5 note) Subscales of The Chromatic Scale: 12 Keys

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	391.9	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

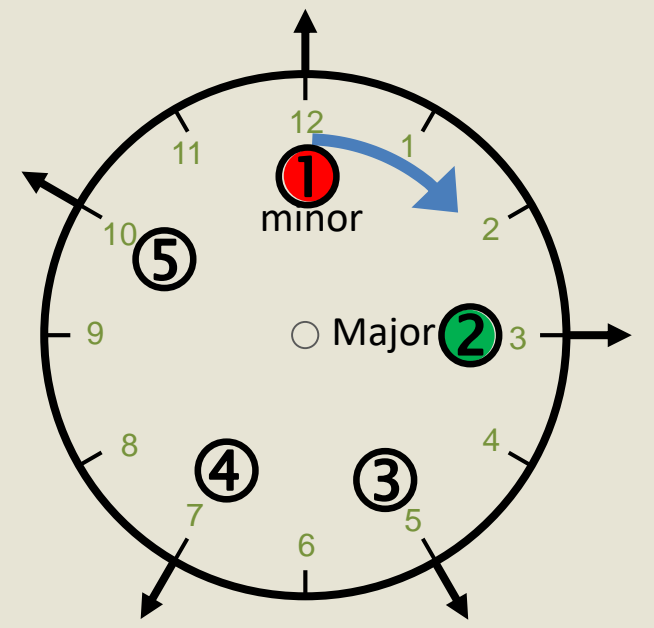
The Pentatonic Minor Scale also has 12 Keys →

Pentatonic Scale in Key of **B minor**

Pentatonic Scale in Key of **C minor**



- ① minor Pentatonic Scale
- ② Major Pentatonic Scale



The Pentatonic (5 note) Subscales of The Chromatic Scale: 12 Keys

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	391.9	
F#/G \flat 4	66	369.6	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

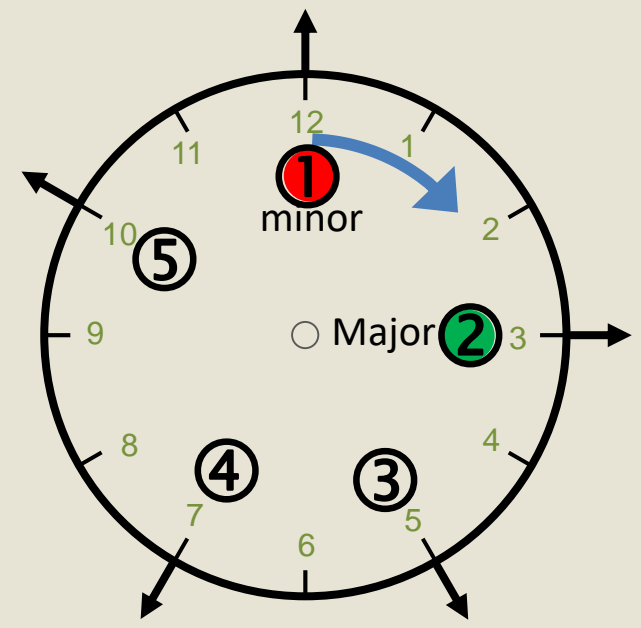
The Pentatonic Minor Scale also has 12 Keys →

Pentatonic Scale in Key of B minor

Pentatonic Scale in Key of C minor

So E flat minor is played using only Black Keys on piano

- ① minor Pentatonic Scale
- ② Major Pentatonic Scale



The Pentatonic (5 note) Subscales of The Chromatic Scale: **Relative Keys**

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

- ① **minor** Pentatonic Scale
- ② **Major** Pentatonic Scale

If these 2 scales share the exact same notes ... then what is the difference between them?



E minor **G** Major

The Pentatonic (5 note) Subscales of The Chromatic Scale: **Relative Keys**

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

- ① **minor** Pentatonic Scale
- ② **Major** Pentatonic Scale

If these 2 scales share the exact same notes ... then what is the difference between them?

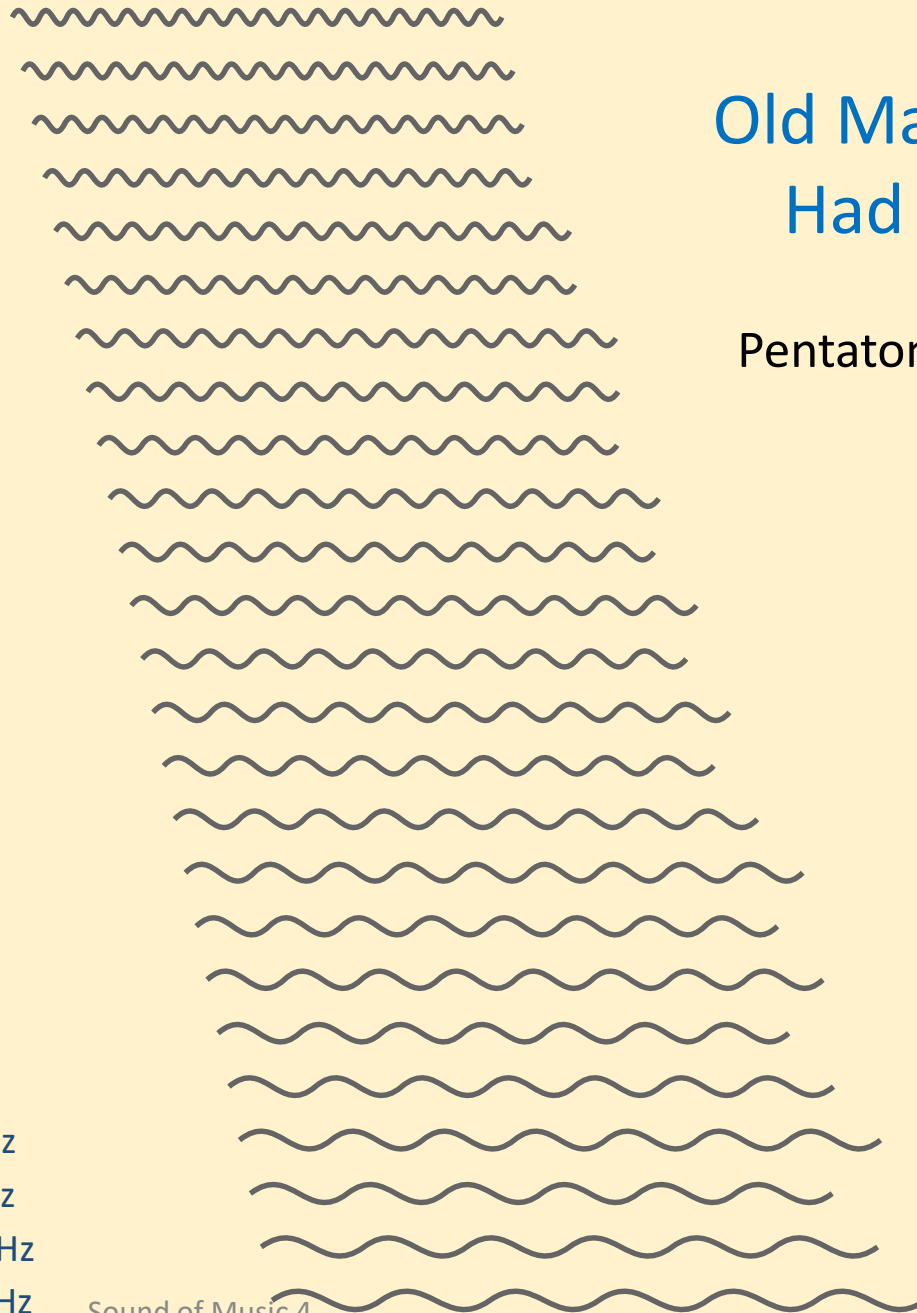
The “anchor notes” are different. These are called the **Tonic Notes**. They form the “Pitch Center” of the musical piece

E minor **G** Major

Pentatonic G Major Scale



f79	G5	783.99Hz
f78	F#5	739.99Hz
f77	F5	698.46Hz
f76	E5	659.26Hz
f75	D#5	622.25Hz
f74	D5	587.33Hz
f73	C#5	554.37Hz
f72	C5	523.25Hz
f71	B4	493.88Hz
f70	A#4	466.16Hz
f69	A4	440.00Hz
f68	G#4	415.30Hz
f67	G4	392.00Hz
f66	F#4	369.99Hz
f65	F4	349.23Hz
f64	E4	329.63Hz
f63	D#4	311.13Hz
f62	D4	293.66Hz
f61	C#4	277.18Hz
f60	C4	261.63Hz
f59	B3	246.94Hz
f58	A#3	233.08Hz
f57	A3	220.00Hz
f56	G#3	207.65Hz
f55	G3	196.00Hz



Old MacDonald
Had a Farm
in
Pentatonic G Major

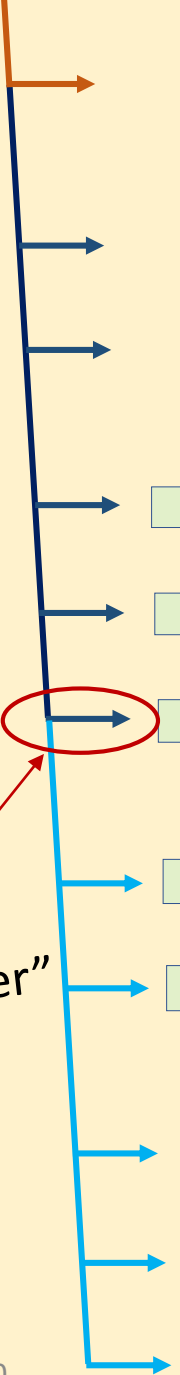
Old MacDonald Had a Farm in Pentatonic G Major

Pentatonic
G Major
Scale



"Tonic"

"Pitch Center"



6

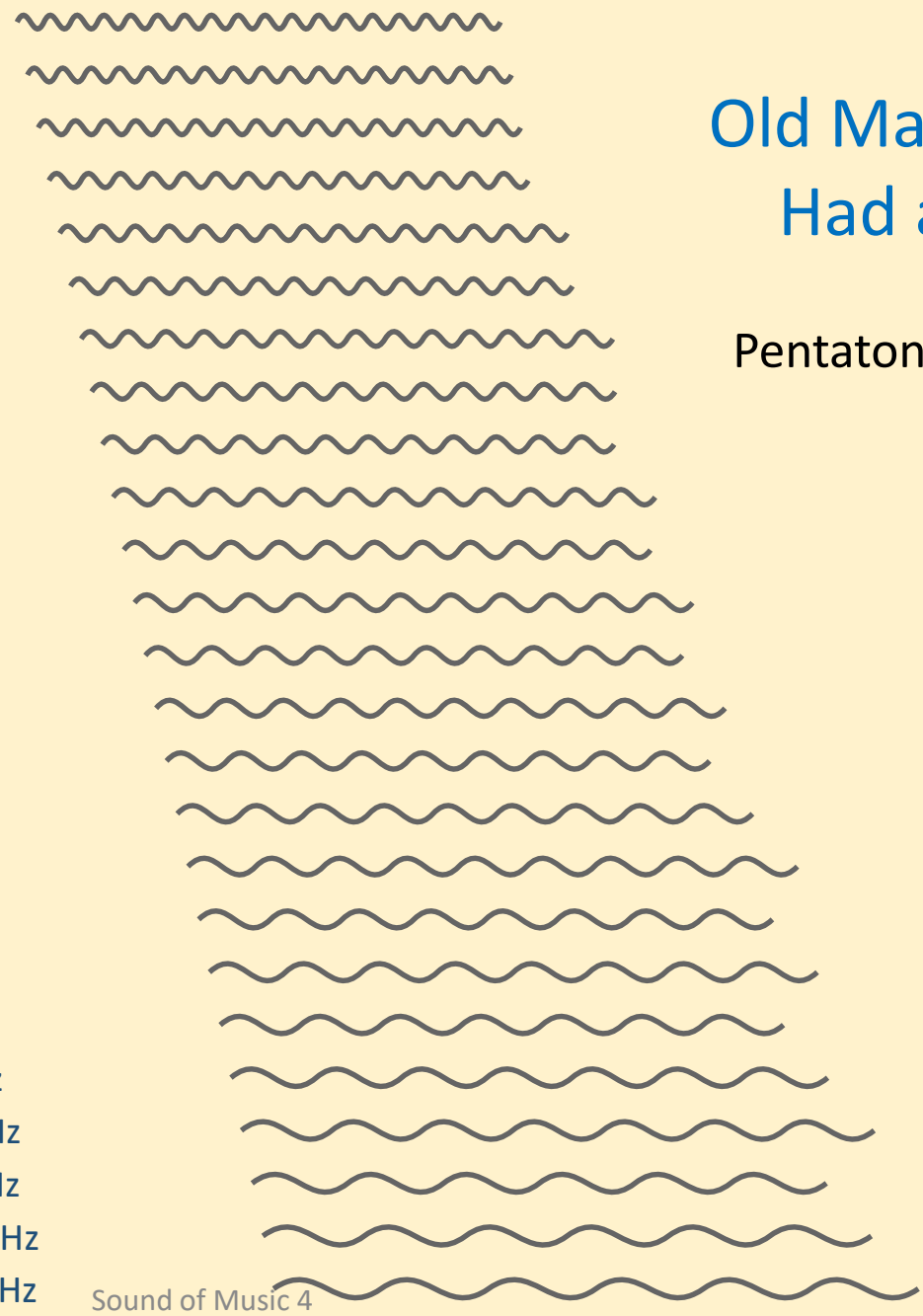
6

30

6

11

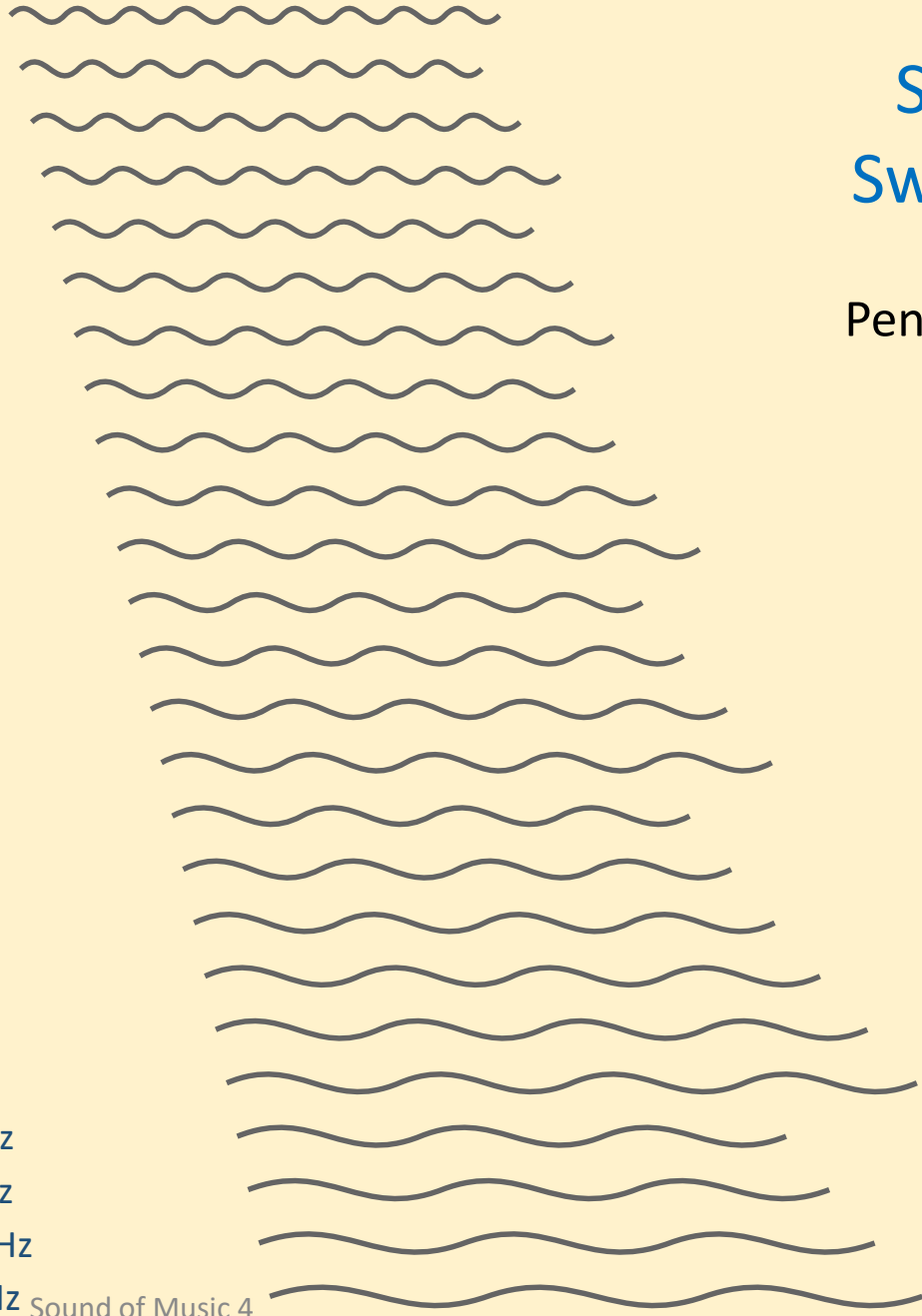
f79	G5	783.99Hz
f78	F#5	739.99Hz
f77	F5	698.46Hz
f76	E5	659.26Hz
f75	D#5	622.25Hz
f74	D5	587.33Hz
f73	C#5	554.37Hz
f72	C5	523.25Hz
f71	B4	493.88Hz
f70	A#4	466.16Hz
f69	A4	440.00Hz
f68	G#4	415.30Hz
f67	G4	392.00Hz
f66	F#4	369.99Hz
f65	F4	349.23Hz
f64	E4	329.63Hz
f63	D#4	311.13Hz
f62	D4	293.66Hz
f61	C#4	277.18Hz
f60	C4	261.63Hz
f59	B3	246.94Hz
f58	A#3	233.08Hz
f57	A3	220.00Hz
f56	G#3	207.65Hz
f55	G3	196.00Hz



Pentatonic G Major Scale



f67	G4	392.00Hz
f66	F#4	369.99Hz
f65	F4	349.23Hz
f64	E4	329.63Hz
f63	D#4	311.13Hz
f62	D4	293.66Hz
f61	C#4	277.18Hz
f60	C4	261.63Hz
f59	B3	246.94Hz
f58	A#3	233.08Hz
f57	A3	220.00Hz
f56	G#3	207.65Hz
f55	G3	196.00Hz
f54	F#3	185.00Hz
f53	F3	174.61Hz
f52	E3	164.81Hz
f51	D#3	155.56Hz
f50	D3	146.83Hz
f49	C#3	138.59Hz
f48	C3	130.81Hz
f47	B2	123.47Hz
f46	A#2	116.54Hz
f45	A2	110.00Hz
f44	G#2	103.83Hz
f43	G2	98.00Hz



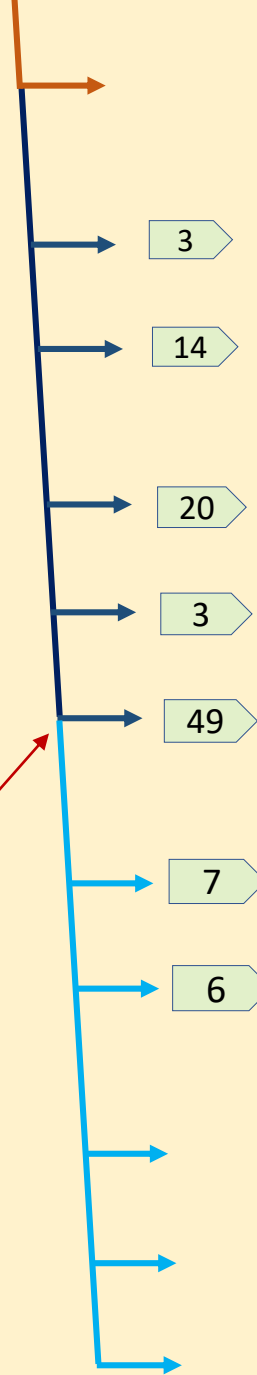
Swing Low
Sweet Chariot
in
Pentatonic G Major

Swing Low Sweet Chariot in Pentatonic G Major

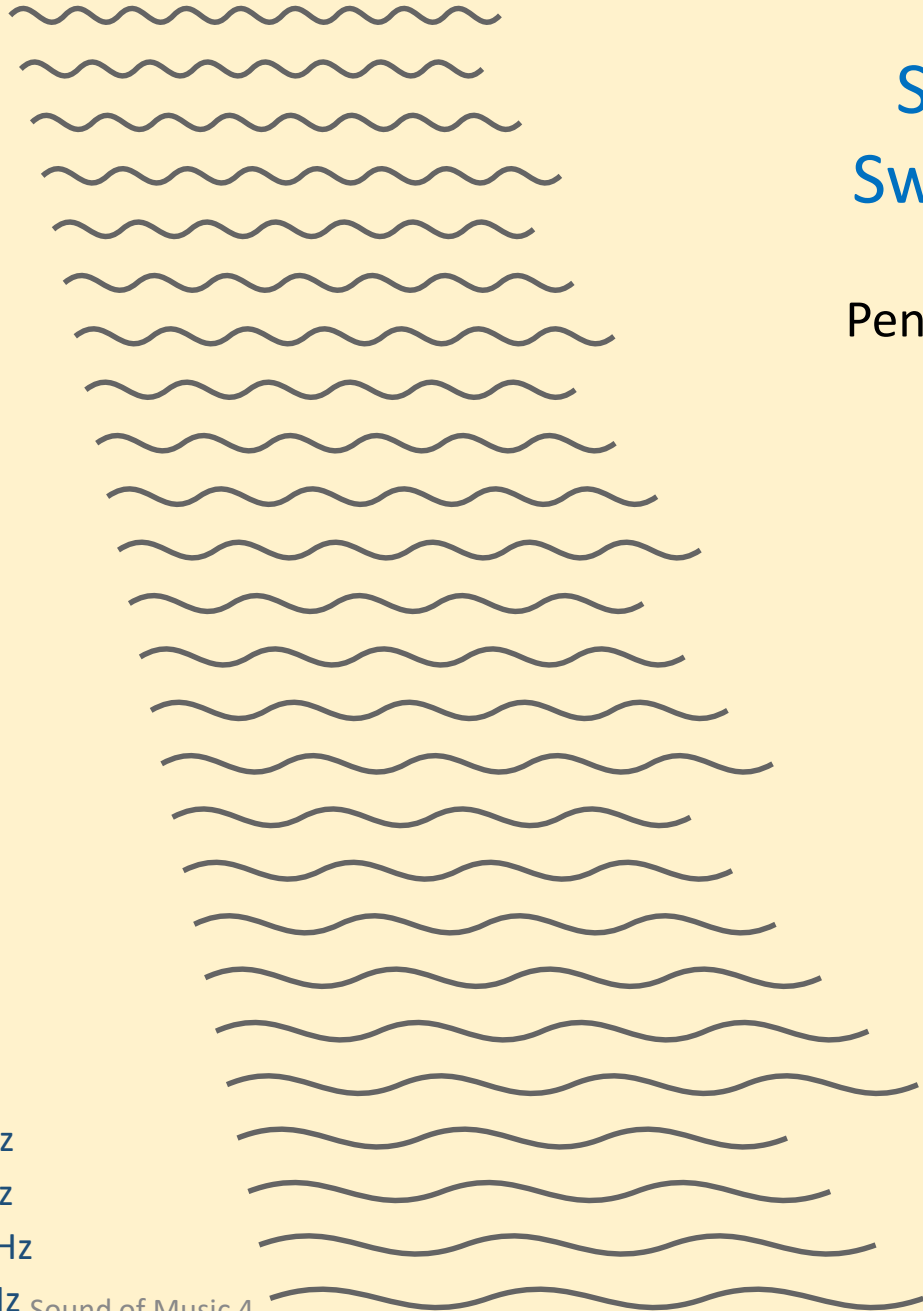
Pentatonic
G Major
Scale

"Tonic"

Tonal Center



f67	G4	392.00Hz
f66	F#4	369.99Hz
f65	F4	349.23Hz
f64	E4	329.63Hz
f63	D#4	311.13Hz
f62	D4	293.66Hz
f61	C#4	277.18Hz
f60	C4	261.63Hz
f59	B3	246.94Hz
f58	A#3	233.08Hz
f57	A3	220.00Hz
f56	G#3	207.65Hz
f55	G3	196.00Hz
f54	F#3	185.00Hz
f53	F3	174.61Hz
f52	E3	164.81Hz
f51	D#3	155.56Hz
f50	D3	146.83Hz
f49	C#3	138.59Hz
f48	C3	130.81Hz
f47	B2	123.47Hz
f46	A#2	116.54Hz
f45	A2	110.00Hz
f44	G#2	103.83Hz
f43	G2	98.00Hz



Subscales of The Chromatic Scale

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Traditional Country Music Blues

Classical Pop Rock

Pentatonic
Heptatonic
(Includes Diatonic)

Used for Jazz?

m Notes	Patterns	Keys	Total Scales
1	1	12	12
2	11	12	132
3	55	12	660
4	165	12	1980
5	330	12	3960
6	462	12	5544
7	462	12	5544
8	330	12	3960
9	165	12	1980
10	55	12	660
11	11	12	132
12	1	12	12

Only a tiny fraction are of use!

Only ~20 are useful

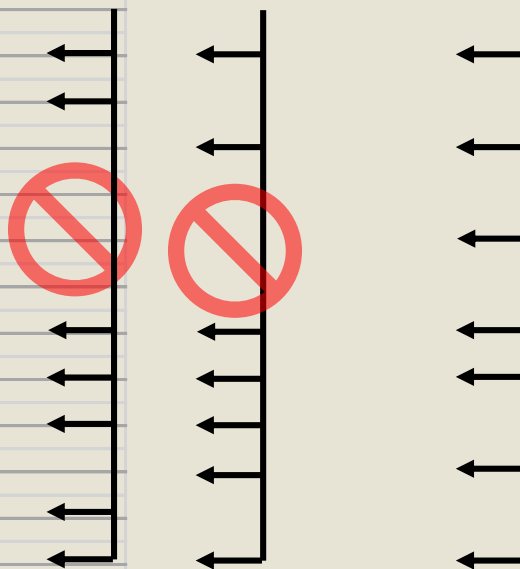
The Heptatonic (7 note) Subscales of The Chromatic Scale

There are **462** m=7 Patterns belonging to 66 families

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

But most are dumb like these

when there are patterns like this



If we require reasonably uniform coverage of the 12 notes of the Chromatic Scale, only **3 main** Pattern families emerge...

The Diatonic (7 note) Subscales of The Chromatic Scale:

The Most Uniform Coverage of the Octave

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

“The” Diatonic Family Pattern

Heptatonic Pattern Family #1: “Diatonic”



The Diatonic (7 note) Subscales of The Chromatic Scale:

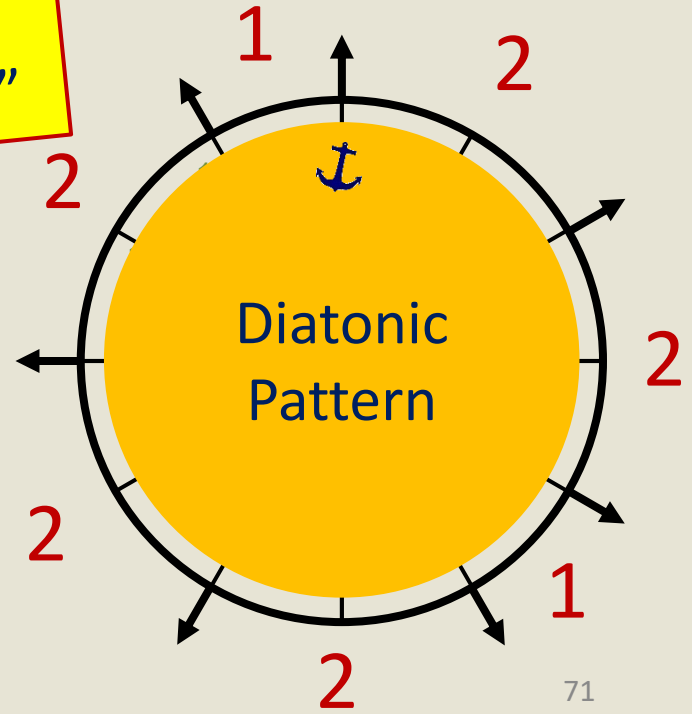
The Most Uniform Coverage of the Octave

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

“The” Diatonic Family Pattern

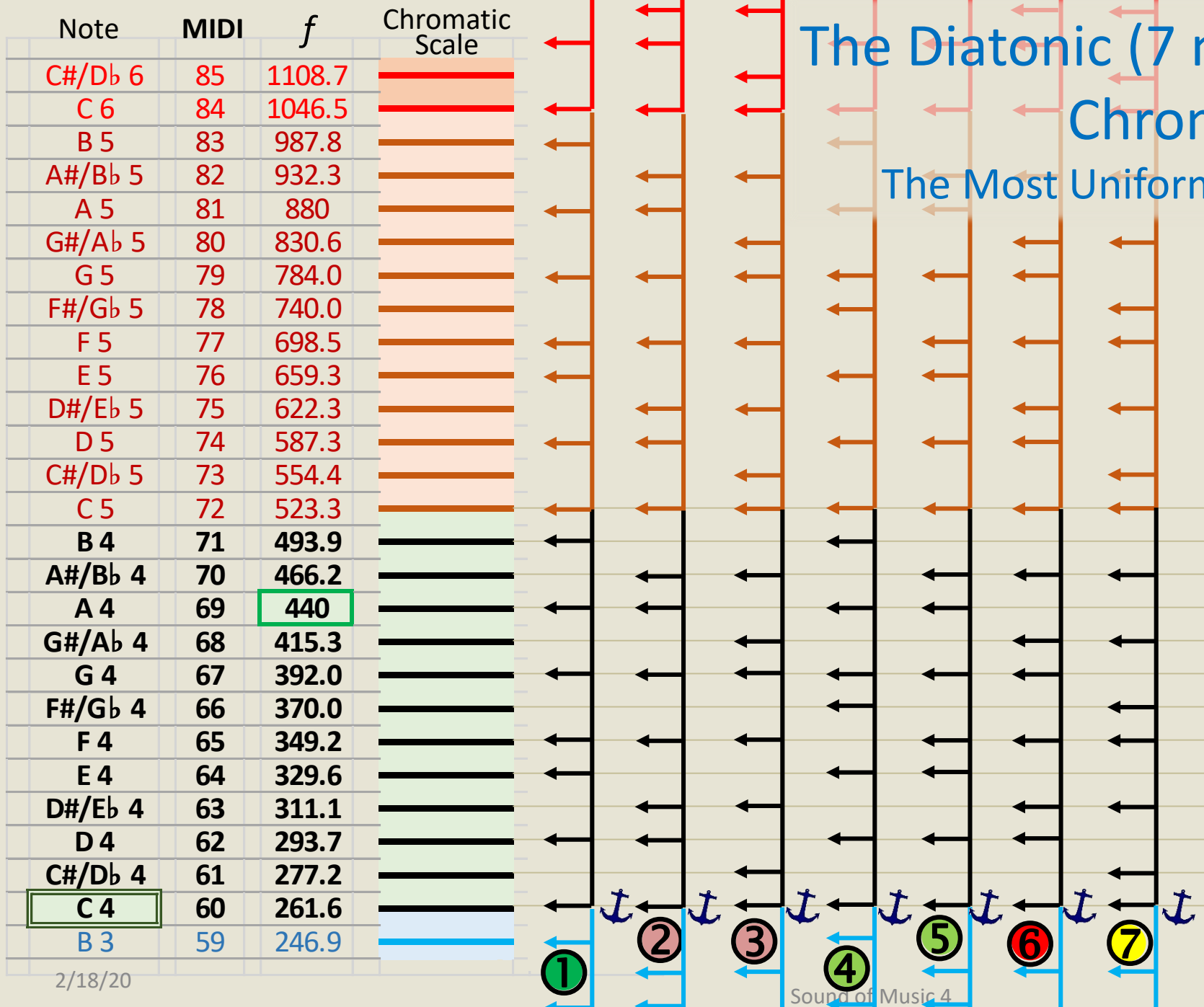
Heptatonic Pattern Family #1: “Diatonic”

Greek **dia-** “through or across”

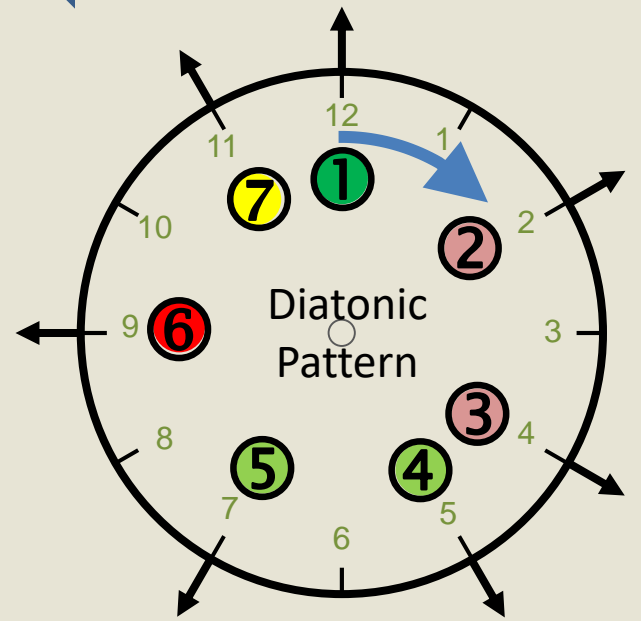


The Diatonic (7 note) Subscales of The Chromatic Scale:

The Most Uniform Coverage of the Octave



“The” Diatonic Family Patterns



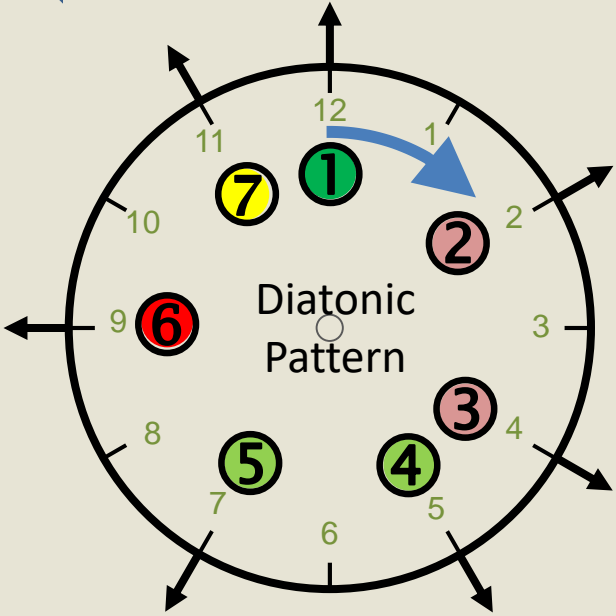
The Diatonic (7 note) Subscales of The Chromatic Scale:

The Most Uniform Coverage of the Octave

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

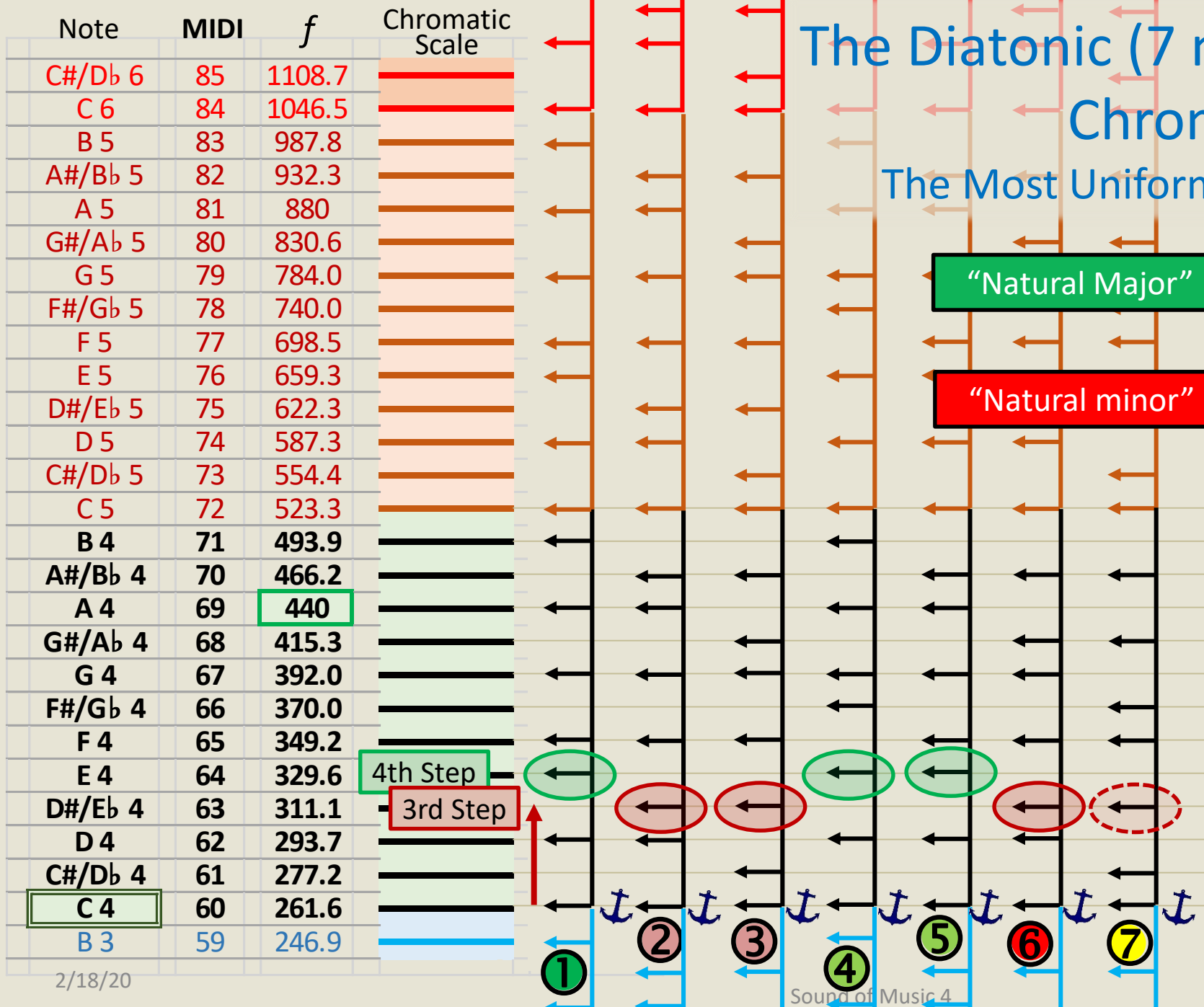
These are the 7 "Modes" of the Diatonic Scale, starting with the Major mode

"The" Diatonic Family Patterns



The Diatonic (7 note) Subscales of The Chromatic Scale:

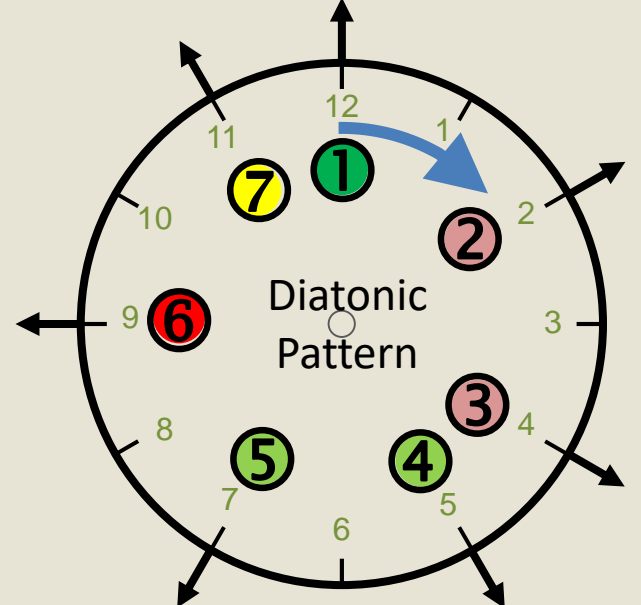
The Most Uniform Coverage of the Octave



“Natural Major” ① ④ ⑤ “Major” modes

“Natural minor” ⑥ ② ③ “minor” modes

⑦ **Rare (sounds terrible)**



The Diatonic (7 note) Subscales of The Chromatic Scale:

The Most Uniform Coverage of the Octave

These 7 Modes have names:

1. **Ionian** (a.k.a. Natural Major)
2. **Dorian**
3. **Phrygian**
4. **Lydian**
5. **Mixolydian**
6. **Aeolian** (a.k.a. Natural minor)
7. **Locrian**

"Natural Major"

① ④ ⑤

"Major" modes

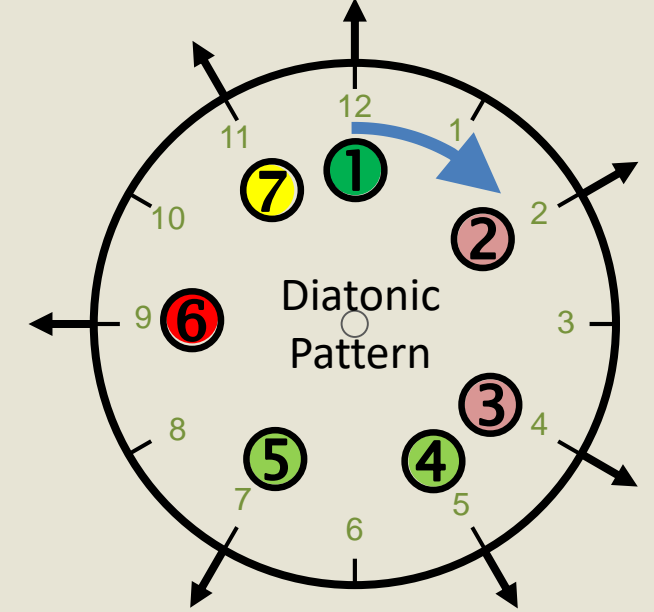
"Natural minor"

⑥ ② ③

"minor" modes

⑦

Rare (sounds terrible)



Note	MIDI	f	Chromatic Scale
C#/D \flat 6			
C 6			
B 5			
A#/B \flat 5			
A 5			
G#/A \flat 5			
G 5			
F#/G \flat 5			
F 5			
E 5			
D#/E \flat 5			
D 5			
C#/D \flat 5			
C 5			
B 4			
A#/B \flat 4			
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	4th Step
D#/E \flat 4	63	311.1	3rd Step
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Diagram showing chromatic scale lines with arrows indicating intervals. Modes 1-7 are indicated at the bottom with colored circles and arrows pointing to their respective notes on the scale.

The Diatonic (7 note) Subscales of The Chromatic Scale: 12 Keys

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	326.6	
D#/E \flat 4	63	305.4	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

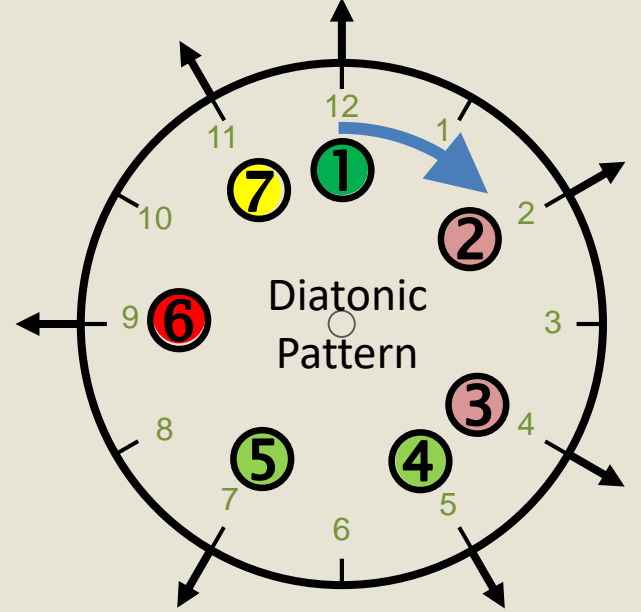
Key of C



① ④ ⑤ “Major” modes

⑥ ② ③ “minor” modes

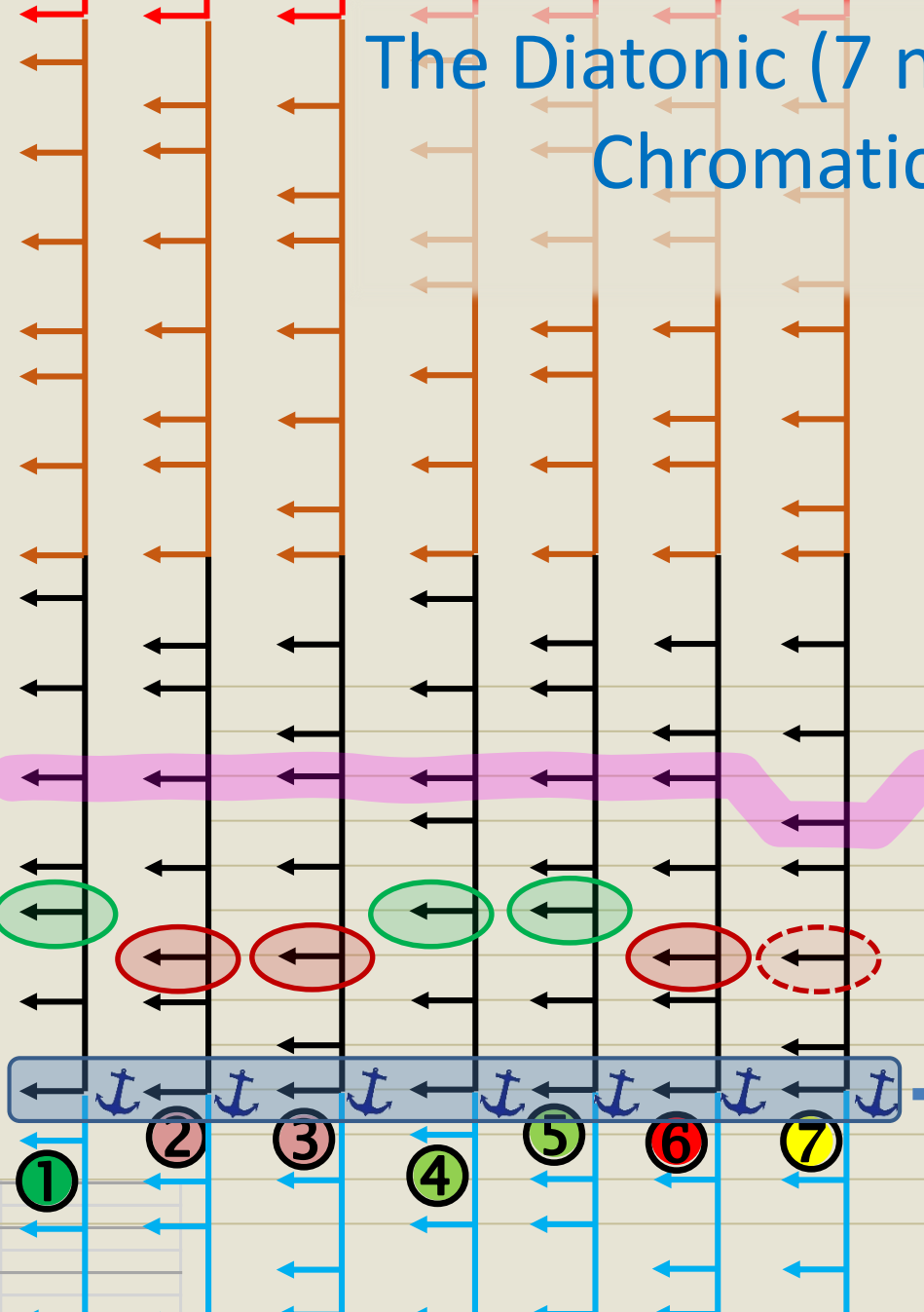
⑦ Rare (sounds terrible)



The Diatonic (7 note) Subscales of The Chromatic Scale: 12 Keys

Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Key of E flat



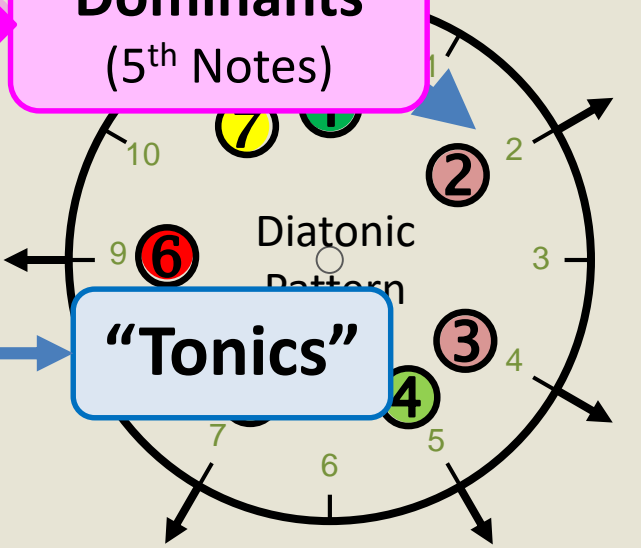
① ④ ⑤ "Major" modes

⑥ ② ③ "minor" modes

⑦ Rare (sounds terrible)

"Dominants"
(5th Notes)

"Tonics"



The Diatonic (7 note) Subscales of The Chromatic Scale: 12 Keys

There are **12** Keys:
 C D♭ D E♭ E F G♭ G A B♭ B
 for each of **7** Modes
for a total of 7x12 =
84 Diatonic Scales

Note	MIDI	f	Chromatic Scale
C#/D♭ 6	85	440.0	
C 6			
B 5			
A#/B♭ 5			
A 5			
G#/A♭ 5			
G 5			
F#/G♭ 5			
F 5			
E 5			
D#/E♭ 5			
D 5			
C#/D♭ 5			
C 5			
B 4			
A#/B♭ 4	70	466.2	
A 4	69	440	
G#/A♭ 4	68	415.3	
G 4	67	392.0	
F#/G♭ 4	66	370.0	
F 4			
E 4		329.6	
D#/E♭ 4	63	311.1	
D 4	62	293.7	
C#/D♭ 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

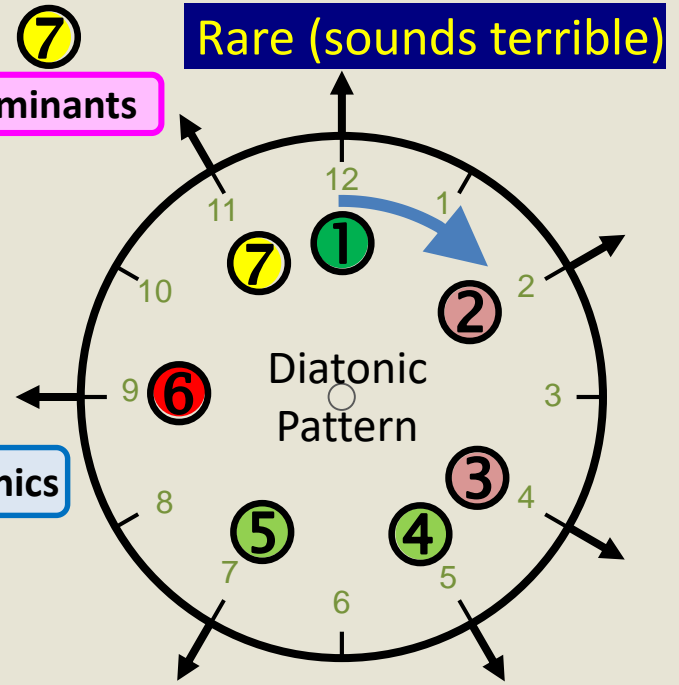
Key of E flat



④ ⑤ "Major" modes
 ⑥ ② ③ "minor" modes
 ⑦ Rare (sounds terrible)

Dominants

Tonics

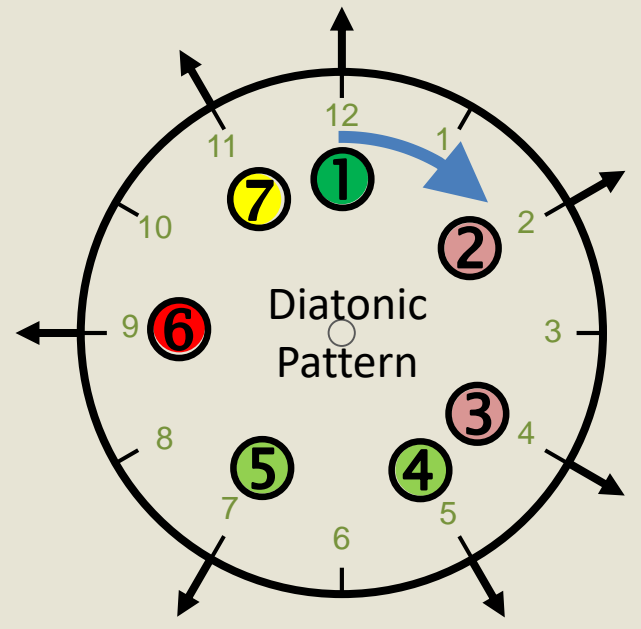


The Diatonic (7 note) Subscales of The Chromatic Scale: The Principal Modes

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

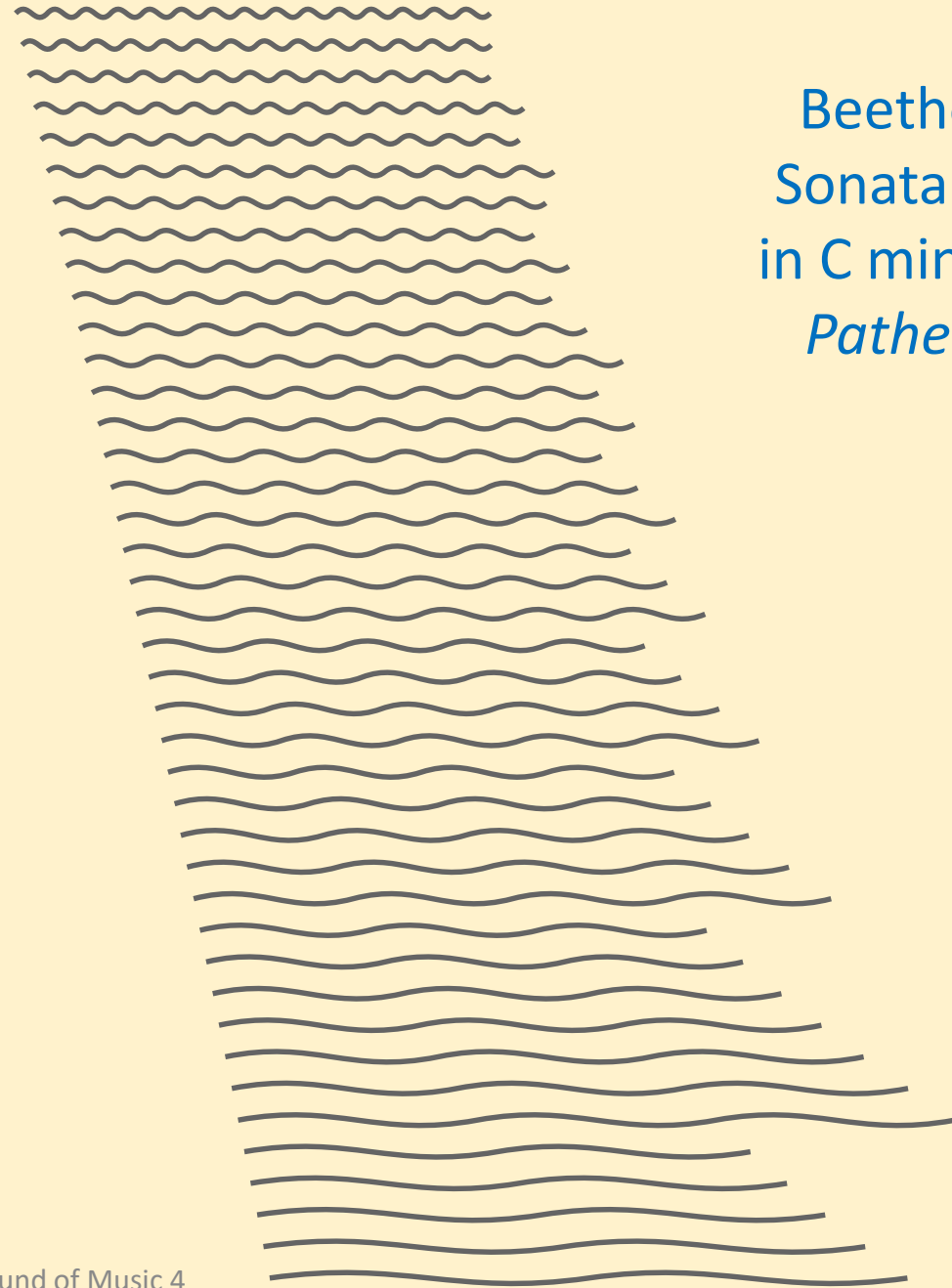
These are the Biggies

- ① "Natural Major" mode
- ⑥ "Natural minor" mode



C minor Scale

f76	E5	659.26Hz
f75	D#5	622.25Hz
f74	D5	587.33Hz
f73	C#5	554.37Hz
f72	C5	523.25Hz
f71	B4	493.88Hz
f70	A#4	466.16Hz
f69	A4	440.00Hz
f68	G#4	415.30Hz
f67	G4	392.00Hz
f66	F#4	369.99Hz
f65	F4	349.23Hz
f64	E4	329.63Hz
f63	D#4	311.13Hz
f62	D4	293.66Hz
f61	C#4	277.18Hz
f60	C4	261.63Hz
f59	B3	246.94Hz
f58	A#3	233.08Hz
f57	A3	220.00Hz
f56	G#3	207.65Hz
f55	G3	196.00Hz
f54	F#3	185.00Hz
f53	F3	174.61Hz
f52	E3	164.81Hz
f51	D#3	155.56Hz
f50	D3	146.83Hz
f49	C#3	138.59Hz
f48	C3	130.81Hz
f47	B2	123.47Hz
f46	A#2	116.54Hz
f45	A2	110.00Hz
f44	G#2	103.83Hz
f43	G2	98.00Hz
f42	F#2	92.50Hz
f41	F2	87.31Hz
f40	E2	82.41Hz
f39	D#2	77.78Hz
f38	D2	73.42Hz
f37	C#2	69.30Hz
f36	C2	65.41Hz

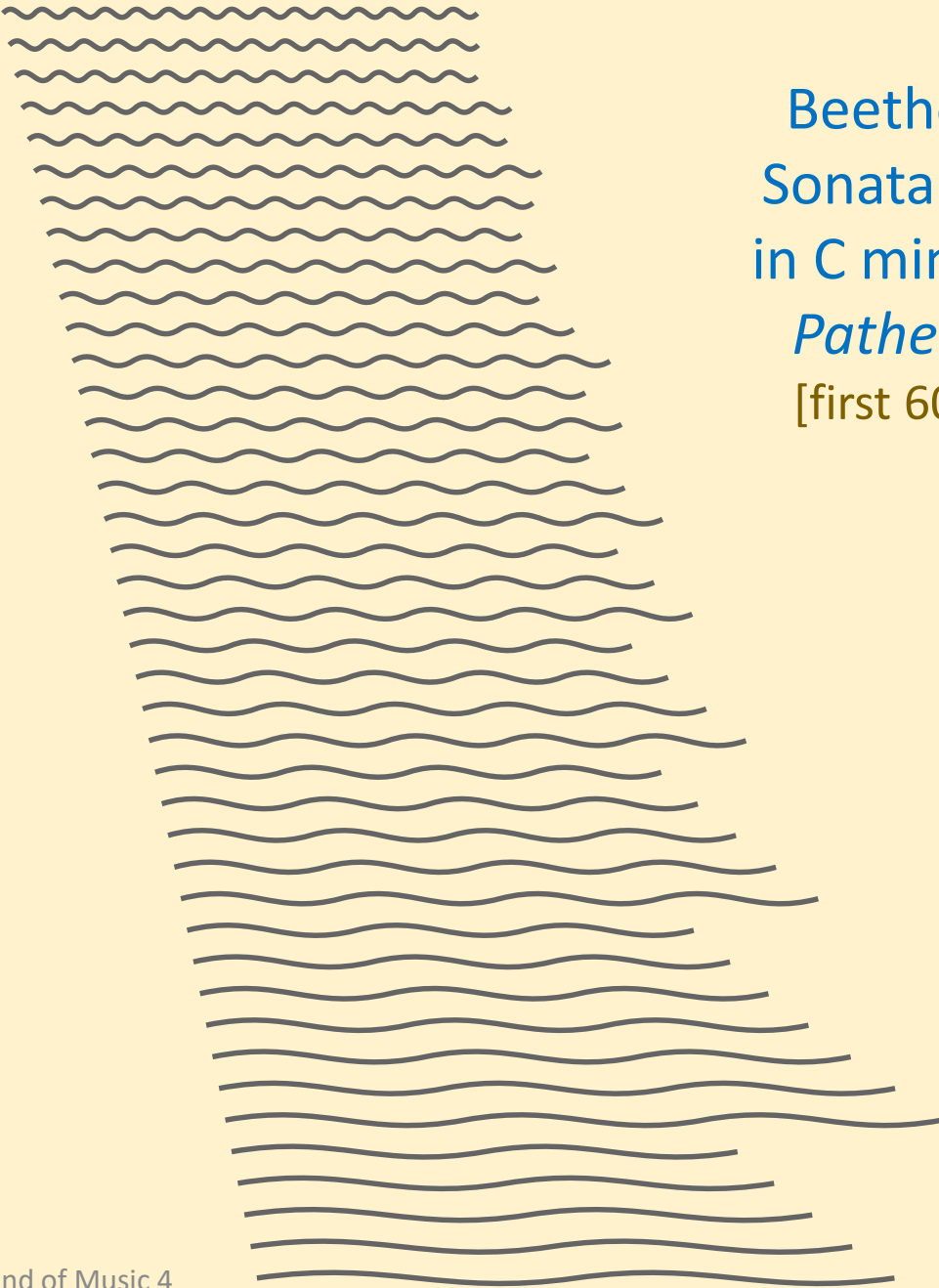
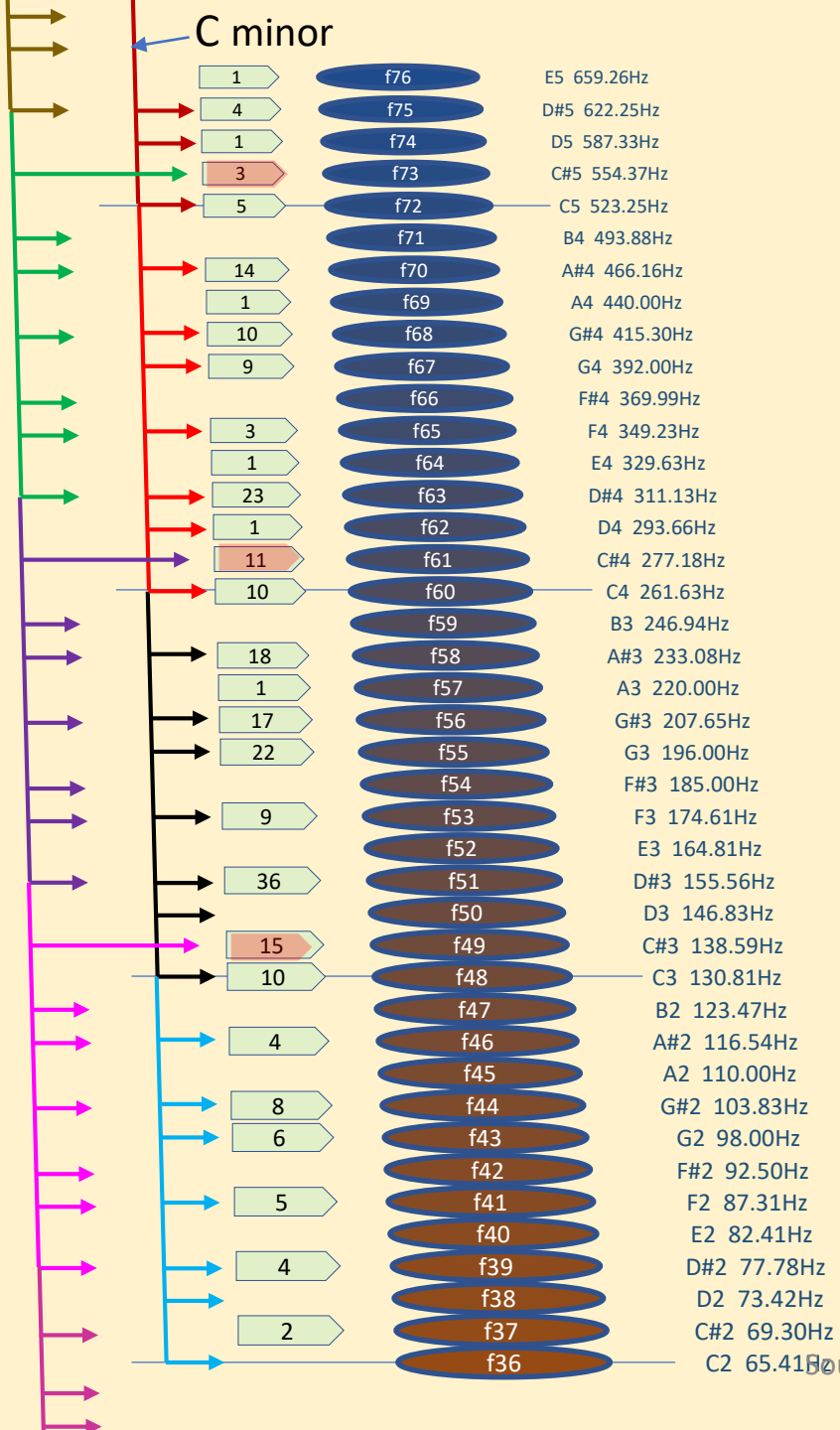


Beethoven Sonata No. 8 in C minor (??) *Pathétique*

Beethoven
Sonata No. 8
in C minor(??)
Pathétique
[first 60 sec]

E flat
minor

C minor

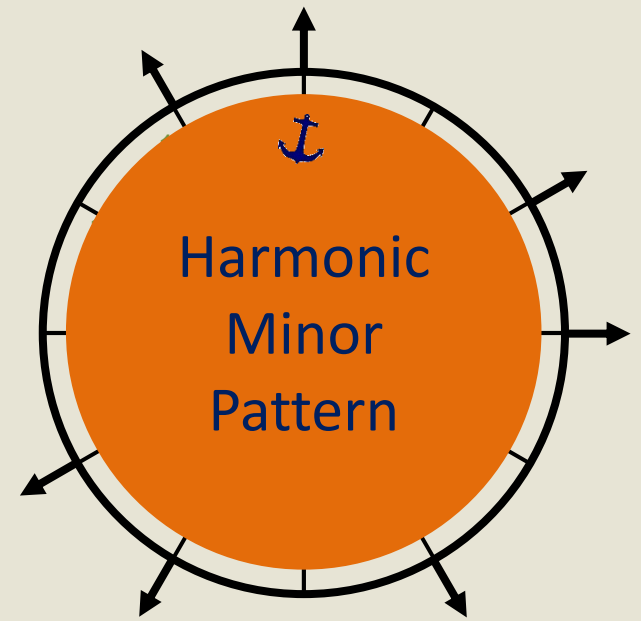


The Harmonic Minor Scale Subscales of The Chromatic Scale: Less Uniform Coverage of the Octave

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Harmonic Minor Family Pattern

Heptatonic Pattern Family #2: "Harmonic Minor"

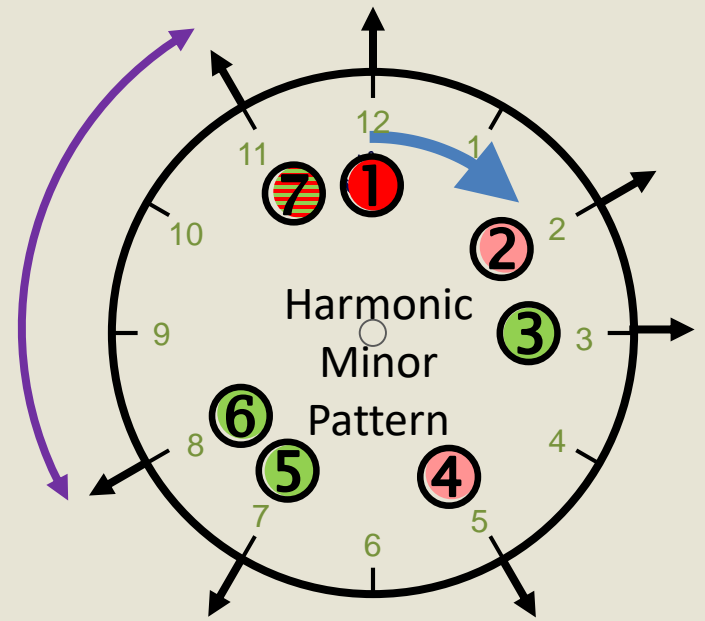


The Harmonic Minor Scale Subscales of The Chromatic Scale: Less Uniform Coverage of the Octave

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Harmonic Minor Family Pattern

Heptatonic Pattern Family #2:
"Harmonic Minor"



The Melodic Minor Scale Subscales of The Chromatic Scale:

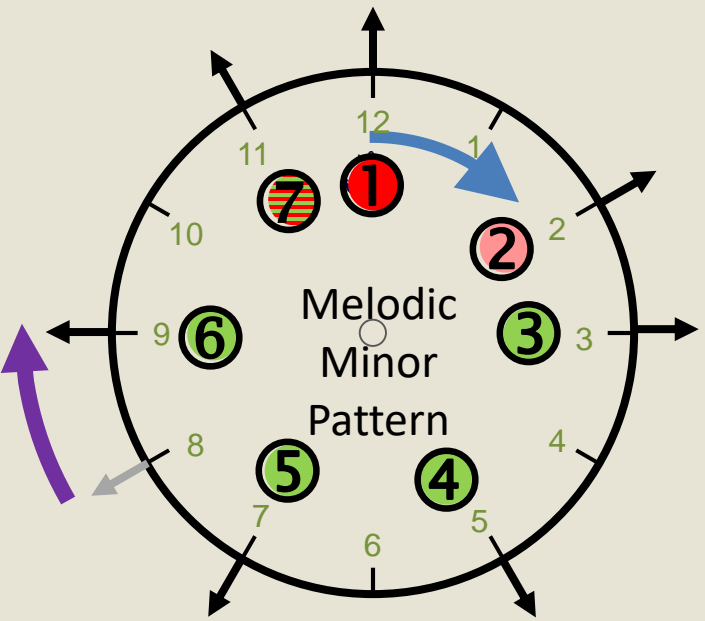
Also Less Uniform Coverage of the Octave

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

Melodic Minor Family Pattern

Heptatonic Pattern Family #3: "Melodic Minor"

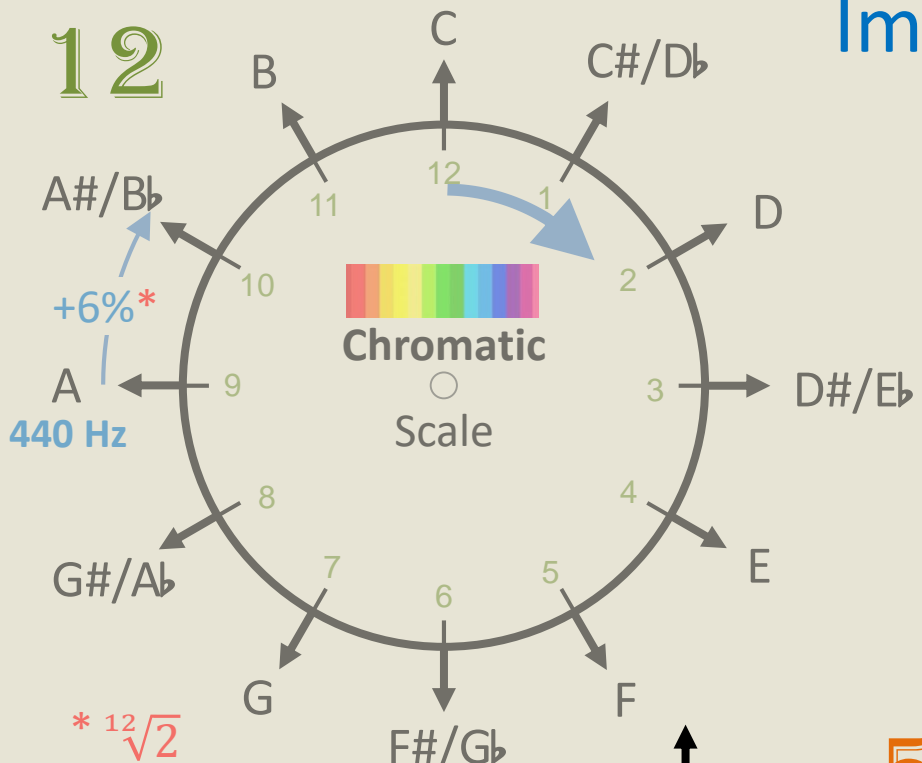
Only Change from Harmonic Minor



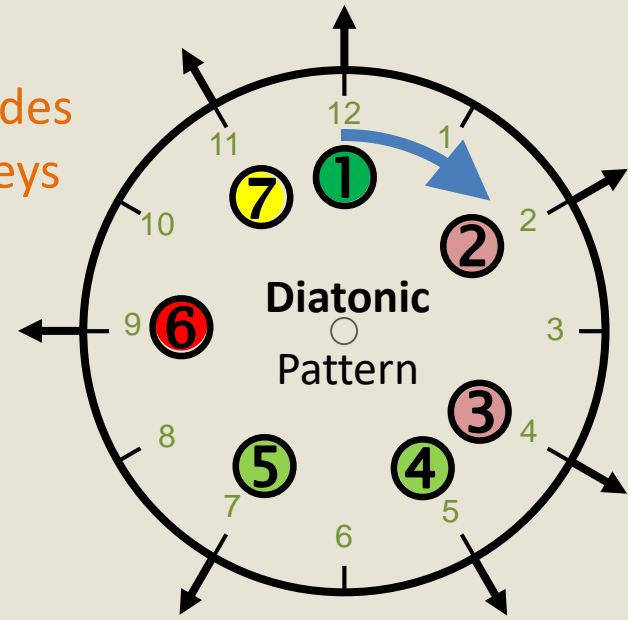


After the Apocalypse.....
What if you were called upon
to reconstruct modern music?

Important Subscales of the Chromatic Scale

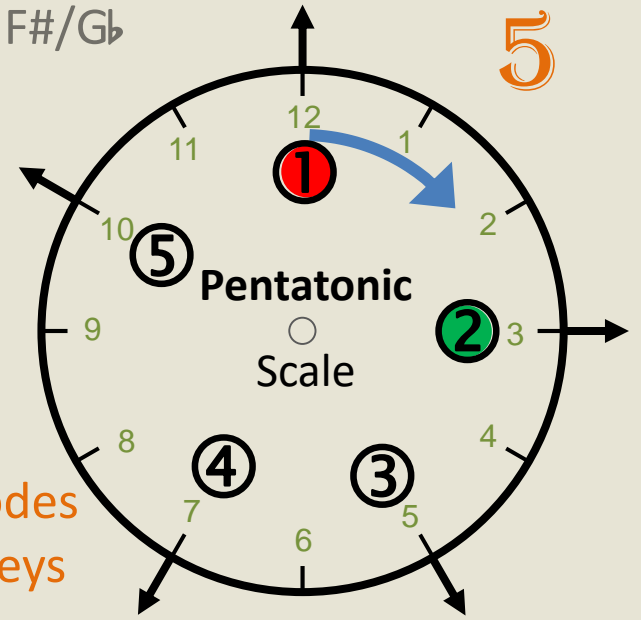


7 Modes
12 Keys



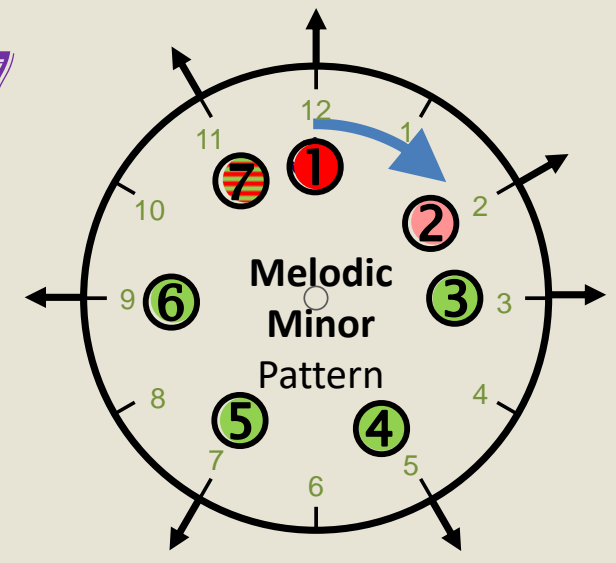
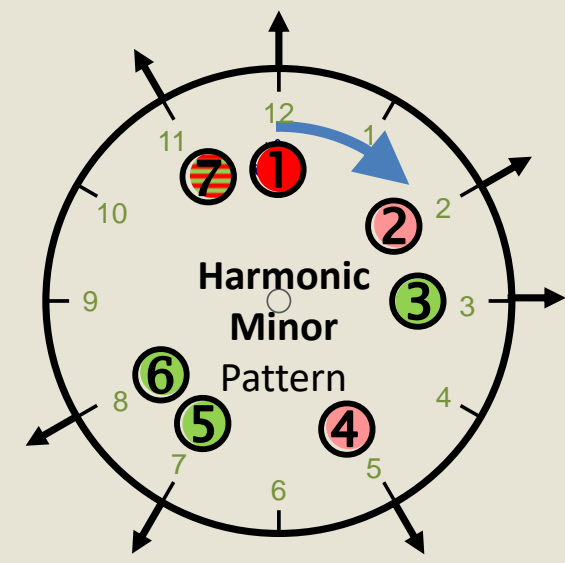
Biggie!

5



5 Modes
12 Keys

7



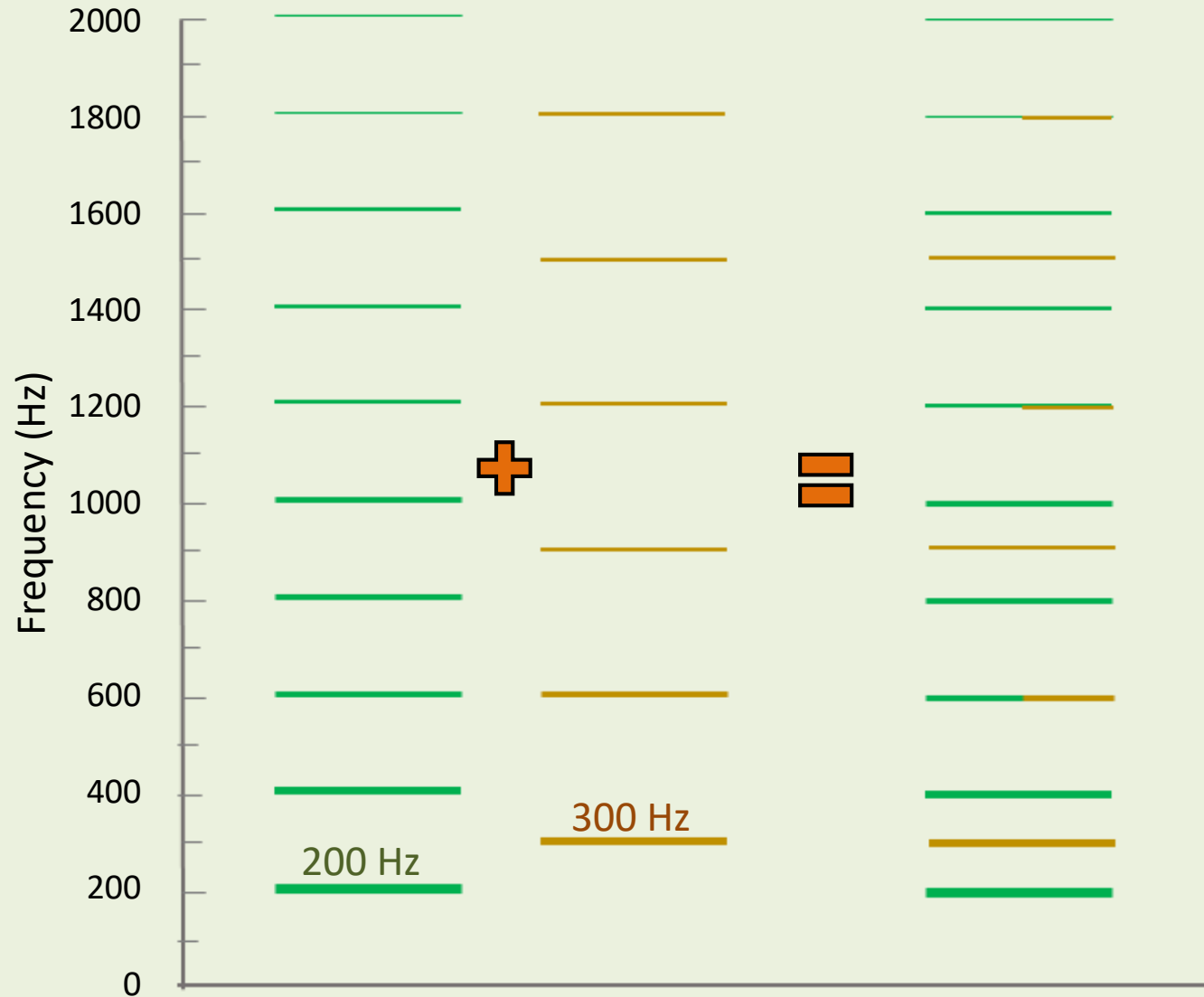
Modes

- M** Major
- m** minor

Chords

- 2 or more notes played simultaneously
 - Commonly 3 or 4 (*Triads or Tetrads*)
 - *Normally* chosen to sound good together
- Require musical instrument capable of simultaneous notes
 - e.g. Piano, Organ, Guitar, Harp
 - **NOT** Singing Voice, Bowed Strings, Woodwinds, Brasses etc.
- Much more common in Western music than in other traditions
- Frequently occur in sequences called **Progressions**

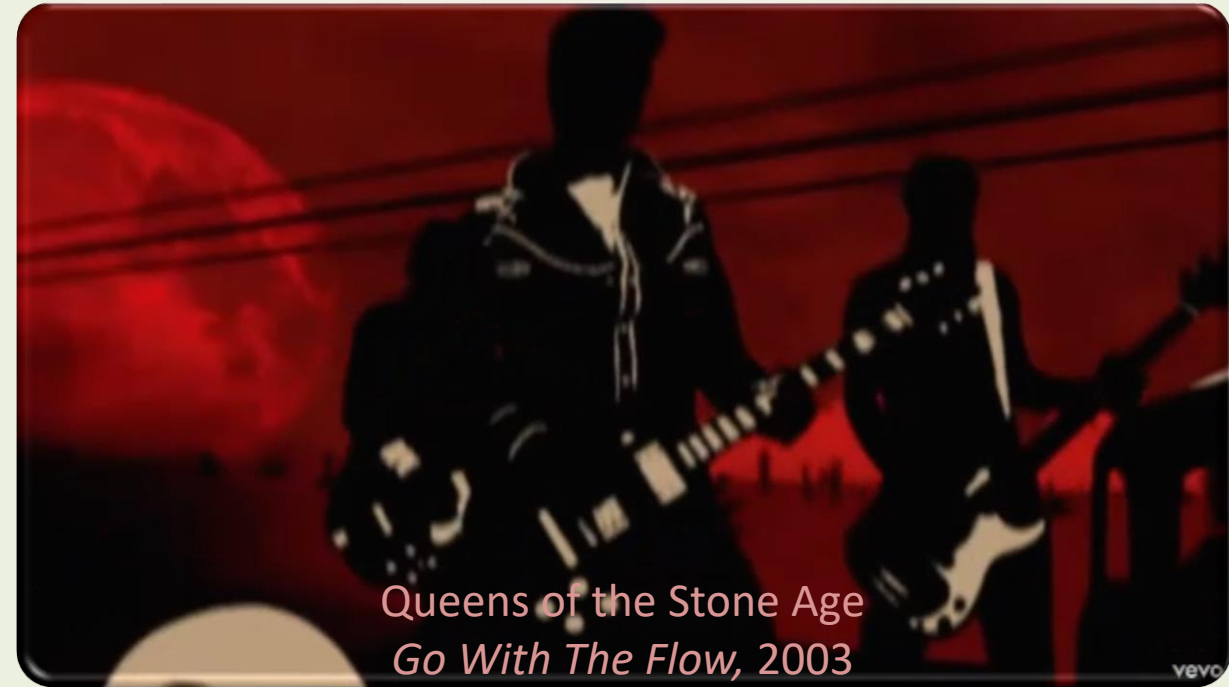
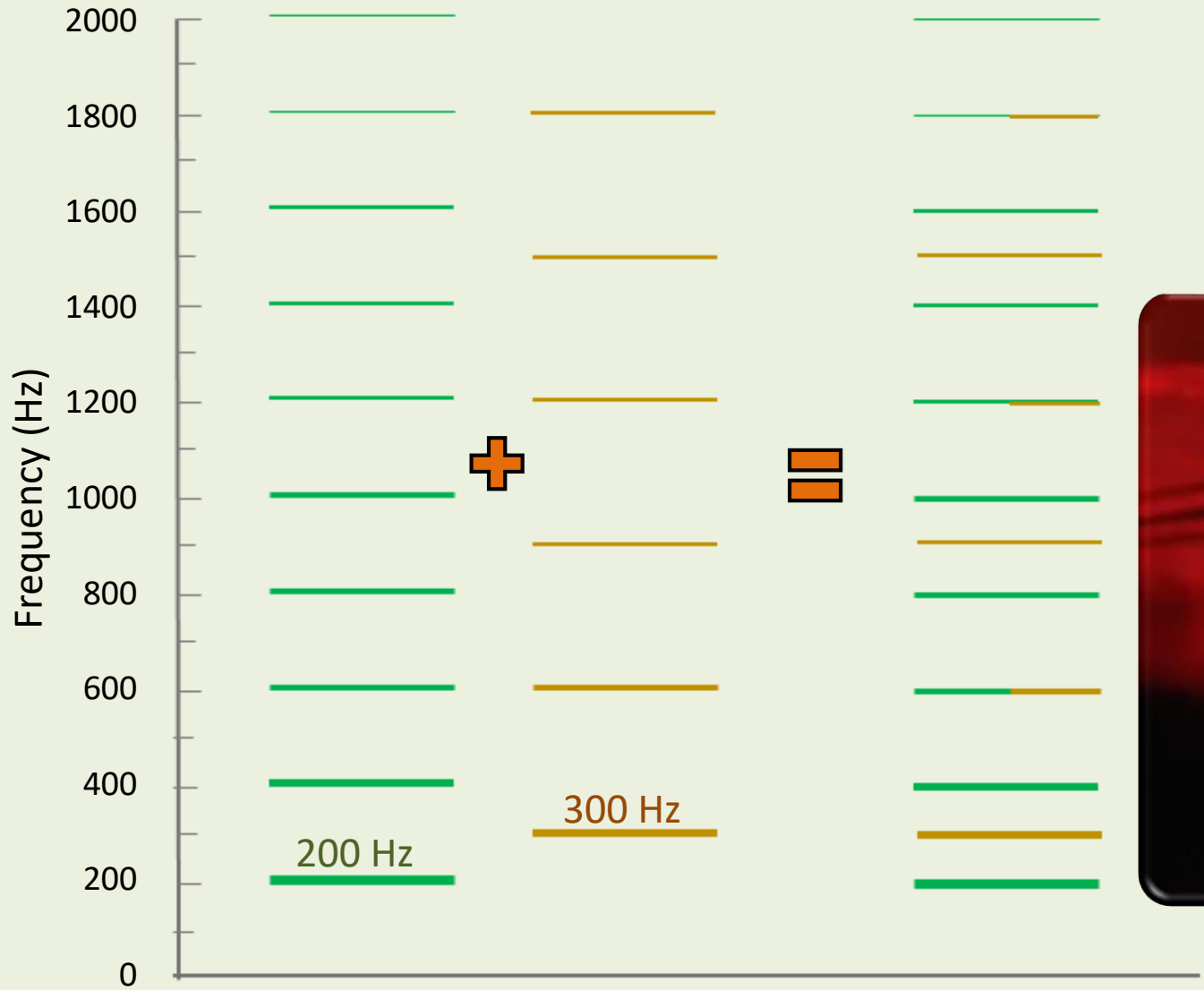
The Power Chord

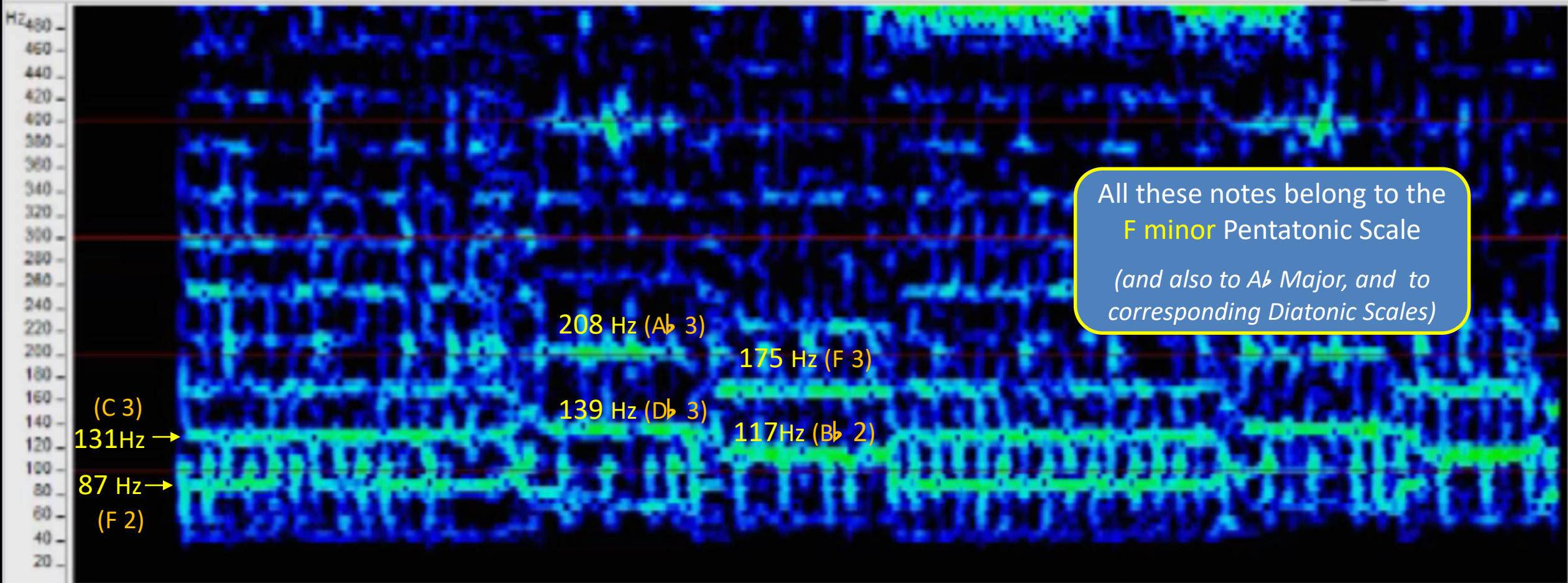


- Combination of 2 notes played together
- **3:2** Frequency Ratio
- Also called “Fifth Chord” or “Open Fifth”

The Power Chord

- Combination of 2 notes played together
- **3:2** Frequency Ratio
- Also called “Fifth Chord”

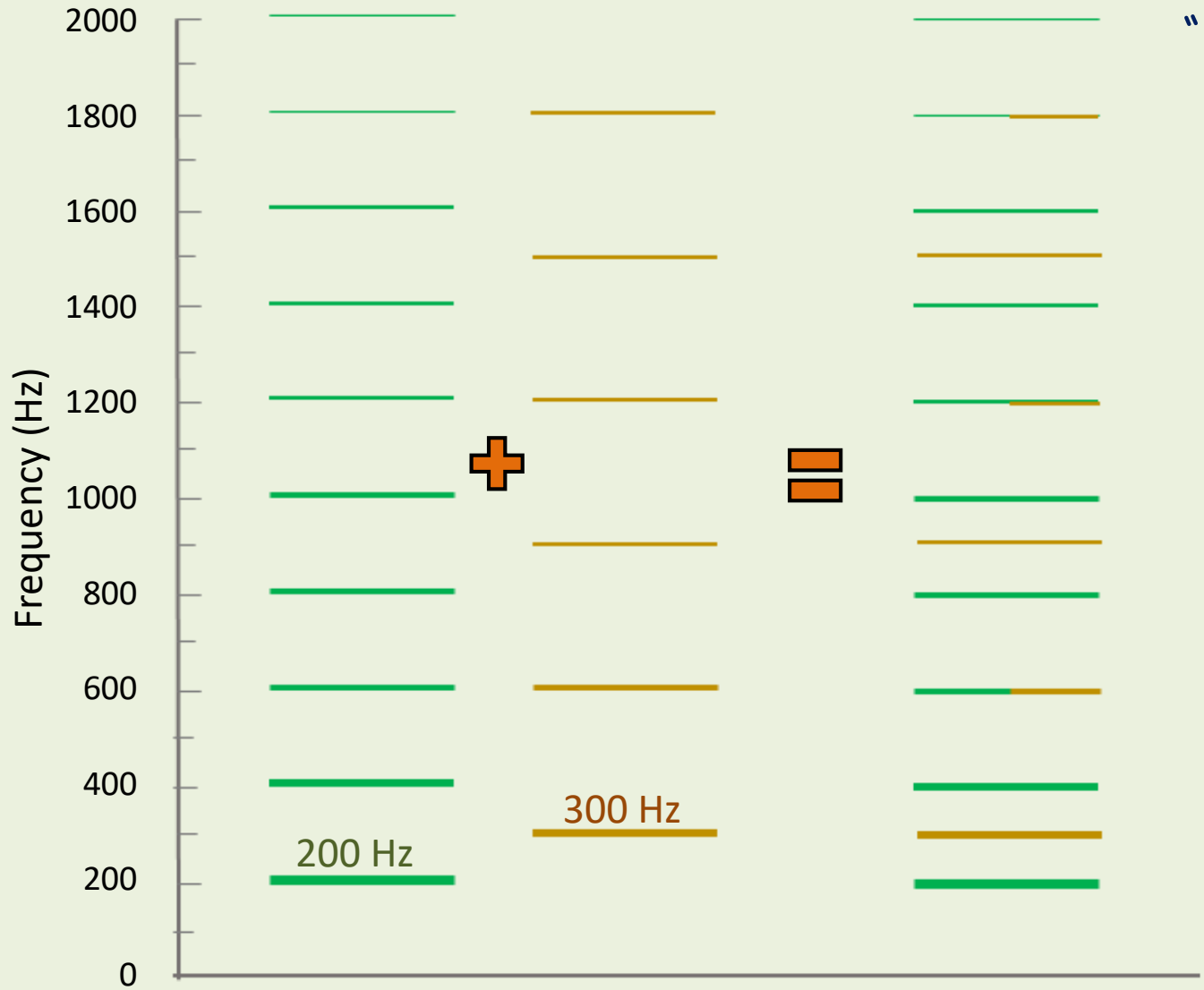




The Power Chord

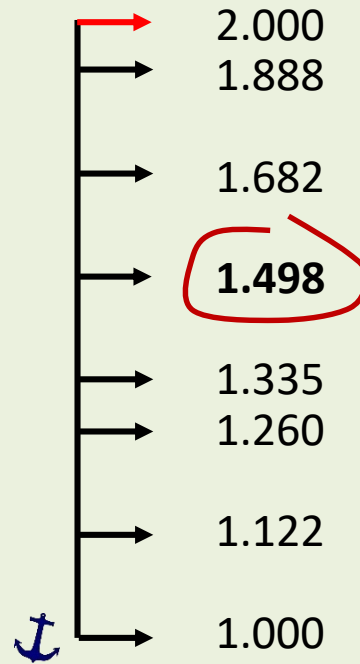
"Open Fifth Chord"

- Combination of 2 notes played together
- **3:2** Frequency Ratio
- Also called "Fifth Chord"



The dirty little secret:
In the scales we have studied so far there *are no* **3:2** frequency ratios!

Example:
Diatonic Major Scale
(Equal Tempered)



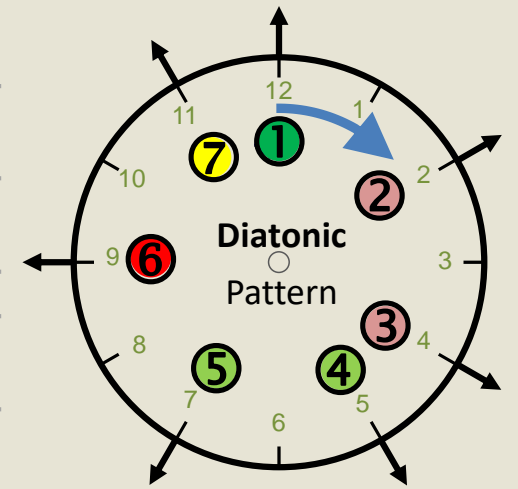
Good enough for human ears!

Common Triad Chords (Based on Diatonic Scales)

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

C Major

Rule:
 a. Pick any note
 b. \uparrow Skip 1
 c. \uparrow Skip 1



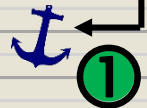
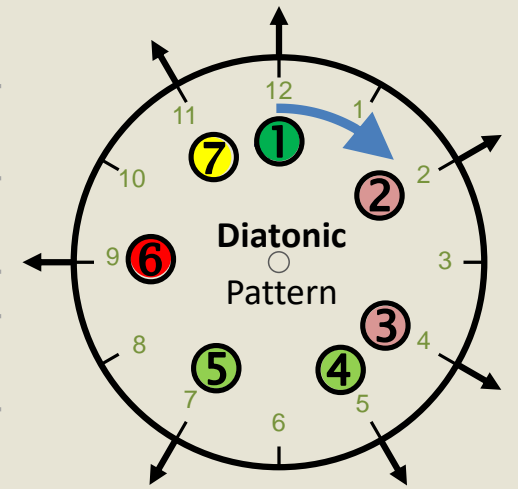
Common Triad Chords (Based on Diatonic Scales)

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

C Major

Rule:
 a. Pick any note
 b. \uparrow Skip 1
 c. \uparrow Skip 1

There are 7 such triads, each starting on a different degree of the C Major Scale.



Common Triad Chords (Based on Diatonic Scales)

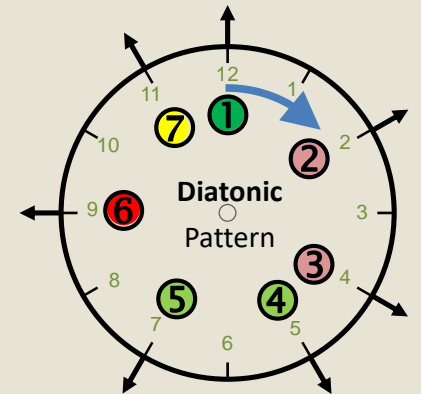
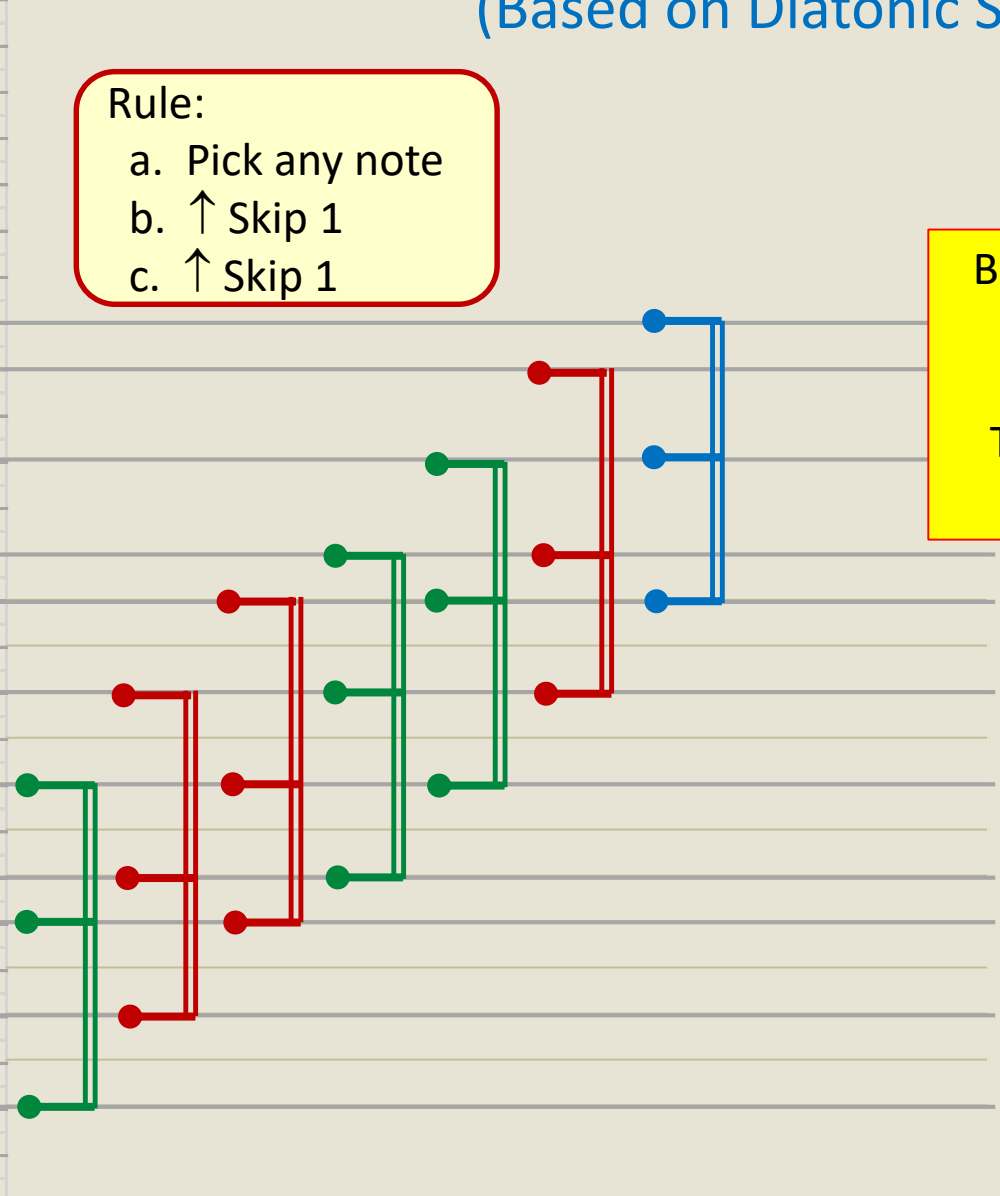
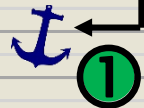
Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

C Major

Rule:
 a. Pick any note
 b. \uparrow Skip 1
 c. \uparrow Skip 1

But some of them are identical.

 There are only 3 different kinds.

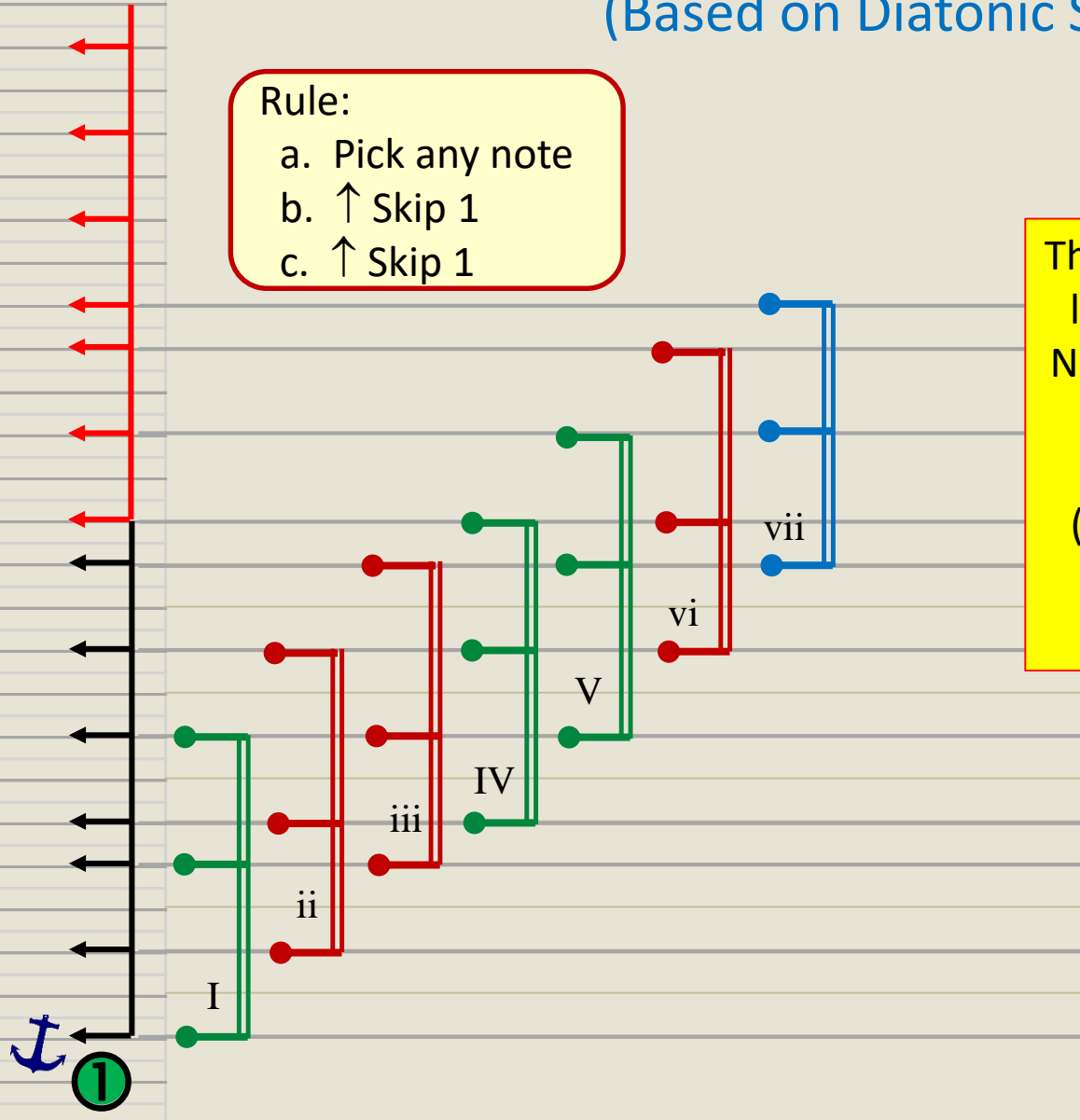


Common Triad Chords (Based on Diatonic Scales)

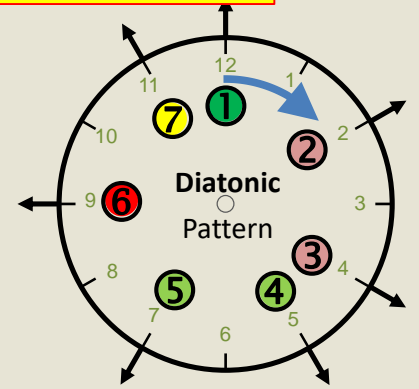
Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

C Major

Rule:
 a. Pick any note
 b. \uparrow Skip 1
 c. \uparrow Skip 1

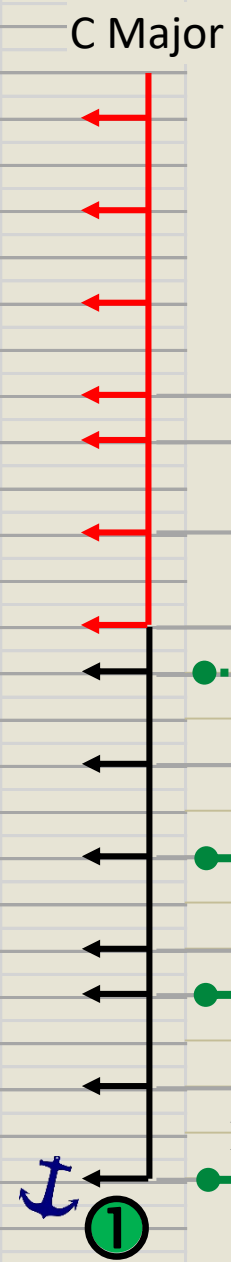


They can be labelled like this in Roman Numerals according to the root note degree (i.e. which note of the Major Scale they start on)

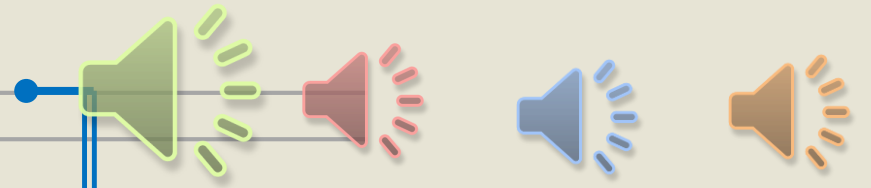


Common Triad Chords (Based on Diatonic Scales)

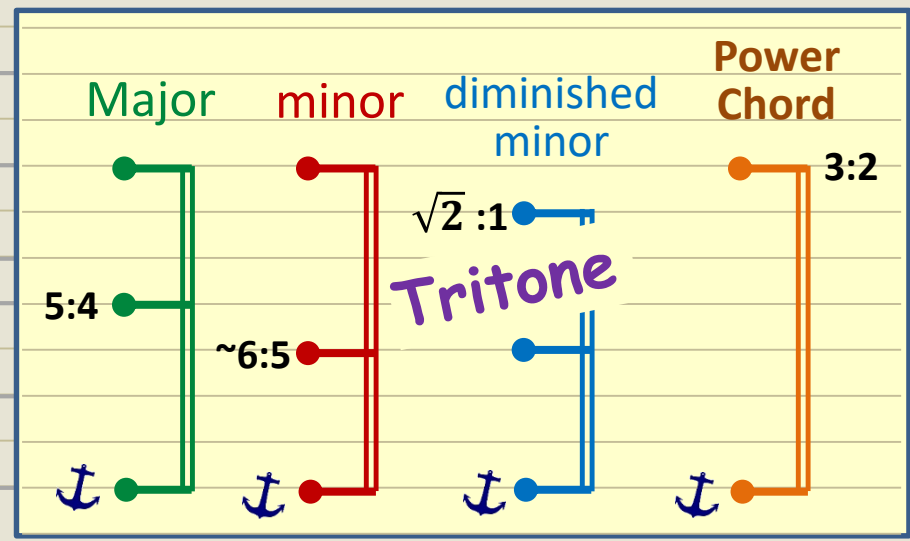
Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	



Rule:
 a. Pick any note
 b. \uparrow Skip 1
 c. \uparrow Skip 1



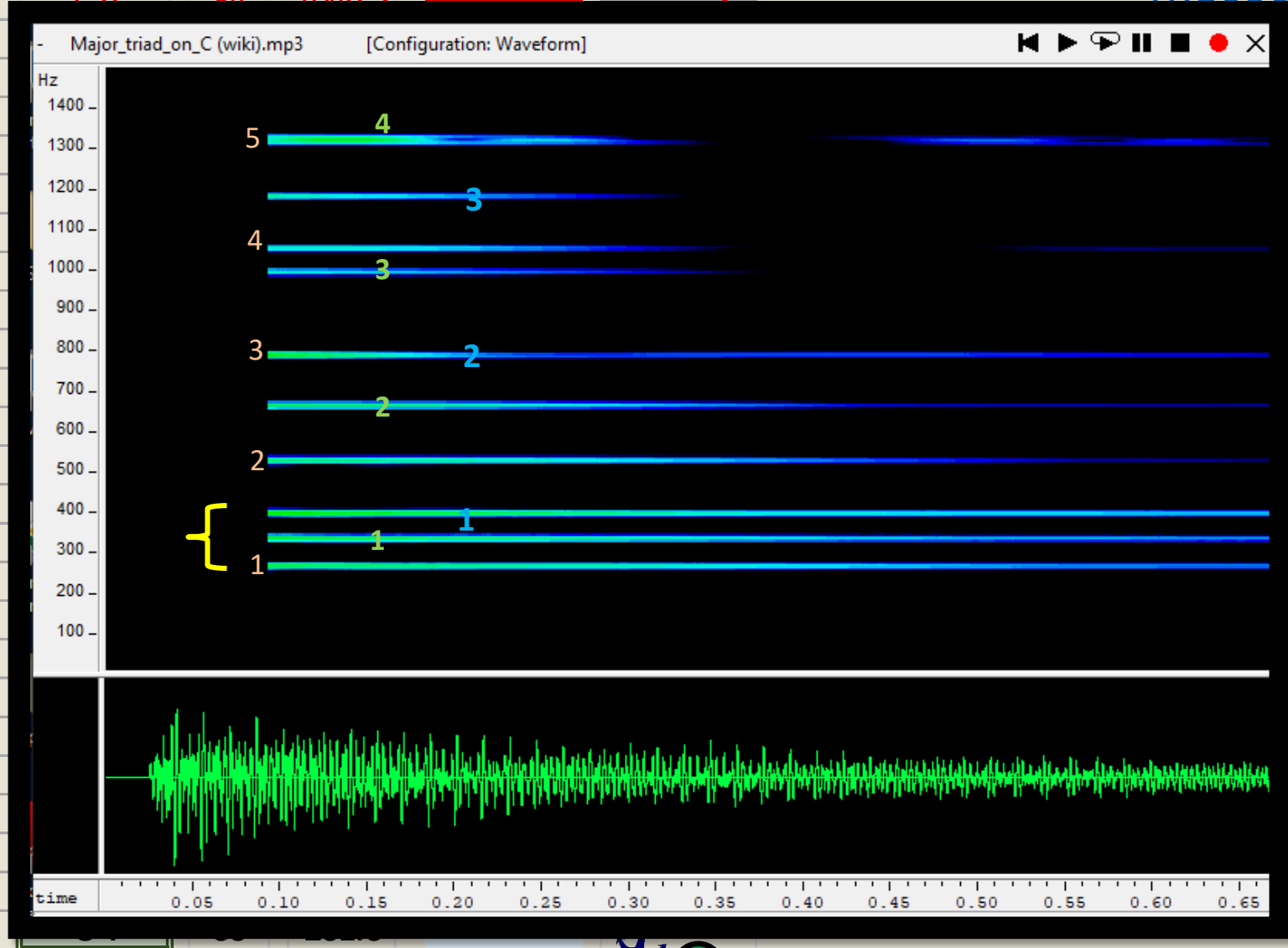
They have names as follows. The approximate frequencies relative to the root note are shown.



Common Triad Chords

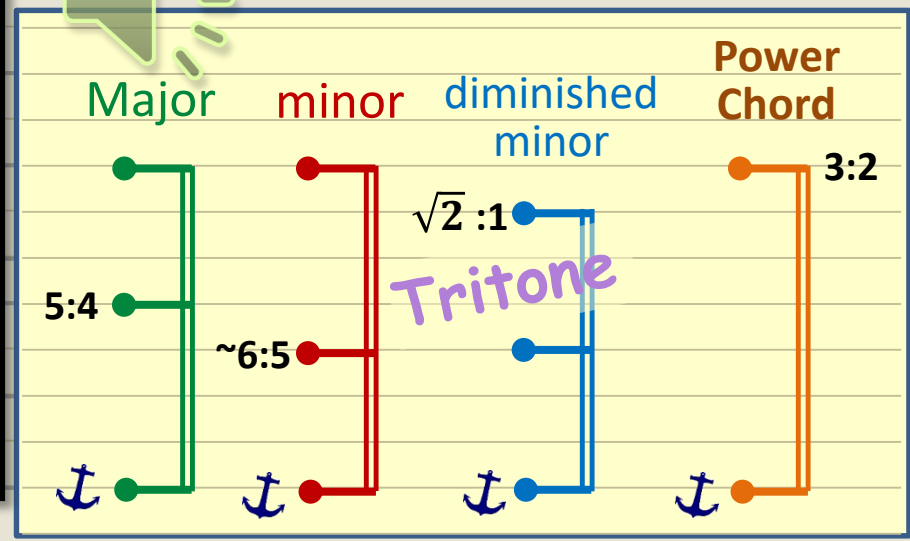
(Based on Diatonic Scales)

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	C Major
C 6	84	1046.5	



Spectrogram of Major Triad showing the 3 notes in ratio of 1:1.25:1.5.

Some of their harmonics coincide, so they sound nice.

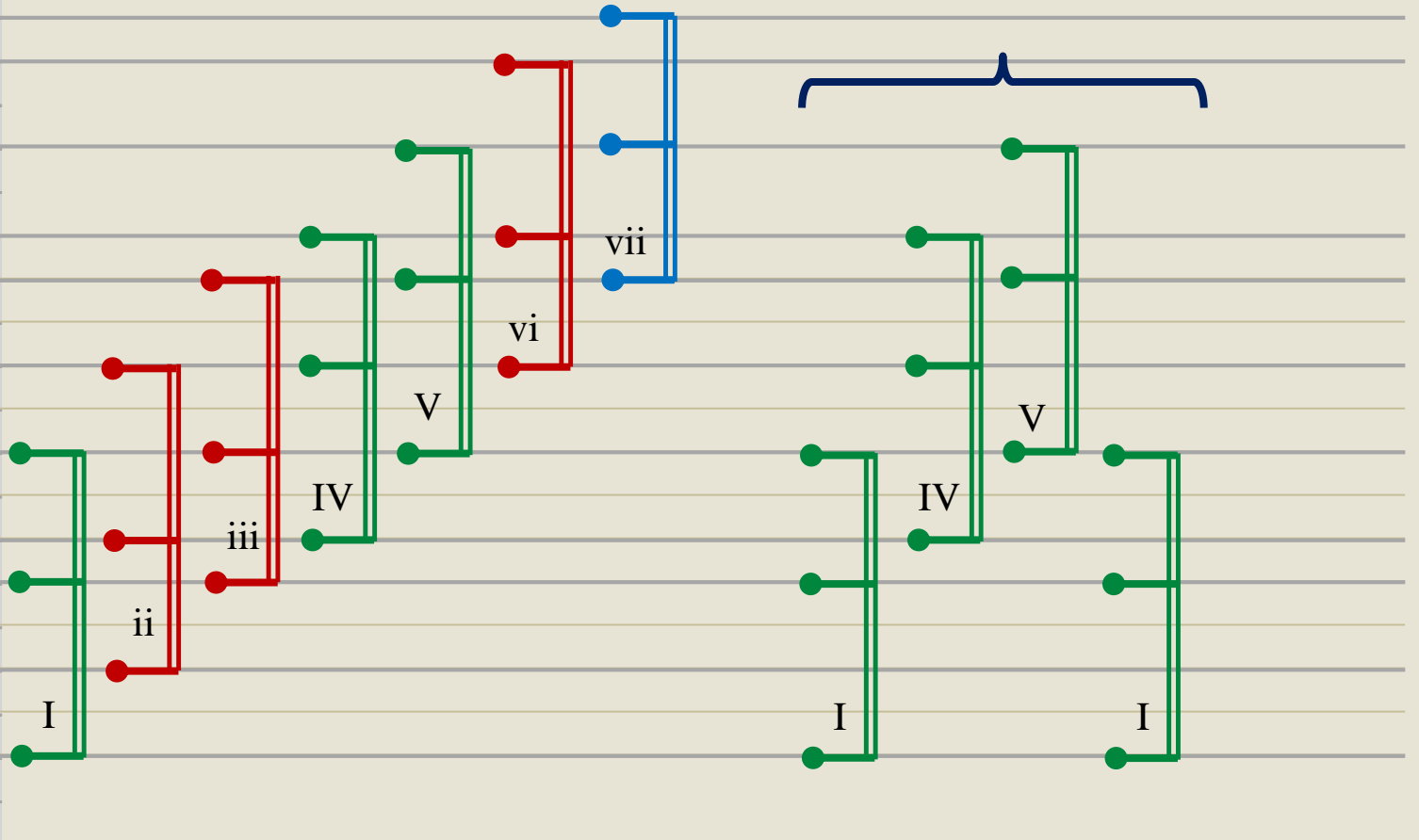
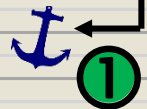


B 3	59	246.9	1
-----	----	-------	---

Chord Progressions

Note	MIDI	<i>f</i>	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	

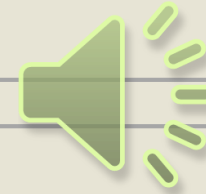
C Major



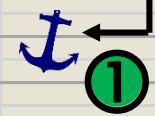
Chord Progressions

"The 12 Bar Blues"

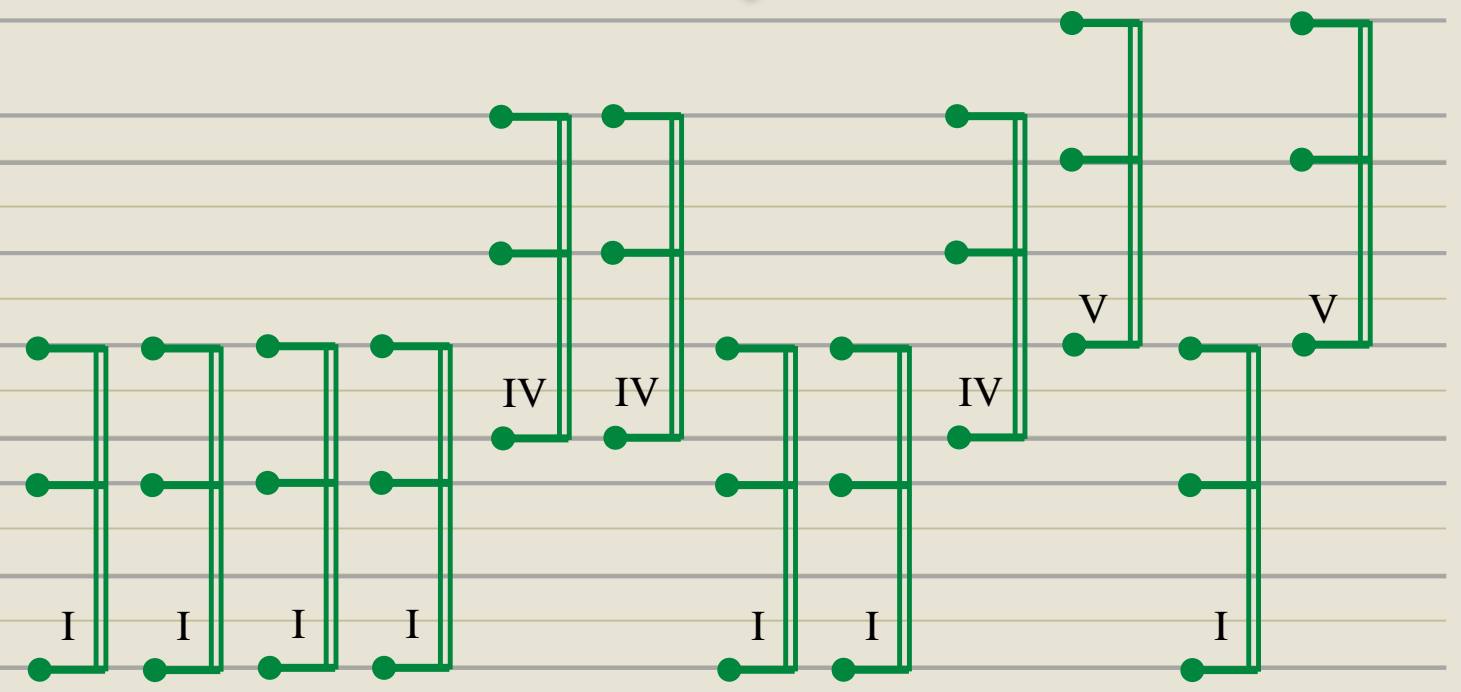
Boogie Woogie



Note	MIDI	f	Chromatic Scale
C#/D \flat 6	85	1108.7	
C 6	84	1046.5	
B 5	83	987.8	
A#/B \flat 5	82	932.3	
A 5	81	880	
G#/A \flat 5	80	830.6	
G 5	79	784.0	
F#/G \flat 5	78	740.0	
F 5	77	698.5	
E 5	76	659.3	
D#/E \flat 5	75	622.3	
D 5	74	587.3	
C#/D \flat 5	73	554.4	
C 5	72	523.3	
B 4	71	493.9	
A#/B \flat 4	70	466.2	
A 4	69	440	
G#/A \flat 4	68	415.3	
G 4	67	392.0	
F#/G \flat 4	66	370.0	
F 4	65	349.2	
E 4	64	329.6	
D#/E \flat 4	63	311.1	
D 4	62	293.7	
C#/D \flat 4	61	277.2	
C 4	60	261.6	
B 3	59	246.9	



C Major







Equal Tempered Chromatic 12 note Scale

Piano Key#	MIDI Code	Frequency (Hz)	Chromatic Scale	Note Name
65	85	1108.7		C#/D \flat 6
64	84	1046.5		C 6
63	83	987.8		B 5
62	82	932.3		A#/B \flat 5
61	81	880		A 5
60	80	830.6		G#/A \flat 5
59	79	784.0		G 5
58	78	740.0		F#/G \flat 5
57	77	698.5		F 5
56	76	659.3		E 5
55	75	622.3		D#/E \flat 5
54	74	587.3		D 5
53	73	554.4		C#/D \flat 5
52	72	523.3		C 5
51	71	493.9		B 4
50	70	466.2		A#/B \flat 4
49	69	440		A 4
48	68	415.3		G#/A \flat 4
47	67	392.0		G 4
46	66	370.0		F#/G \flat 4
45	65	349.2		F 4
44	64	329.6		E 4
43	63	311.1		D#/E \flat 4
42	62	293.7		D 4
41	61	277.2		C#/D \flat 4
40	60	261.6		C 4
39	59	246.9		B 3
38	58	233.1		A#/B \flat 3
37	57	220		A 3
36	56	207.7		G#/A \flat 3
35	55	196.0		G 3
34	54	185.0		F#/G \flat 3
33	53	174.6		F 3
32	52	164.8		E 3
31	51	155.6		D#/E \flat 3
30	50	146.8		D 3
29	49	138.6		C#/D \flat 3
28	48	130.8		C 3
27	47	123.5		B 2
26	46	116.5		A#/B \flat 2
25	45	110		A 2

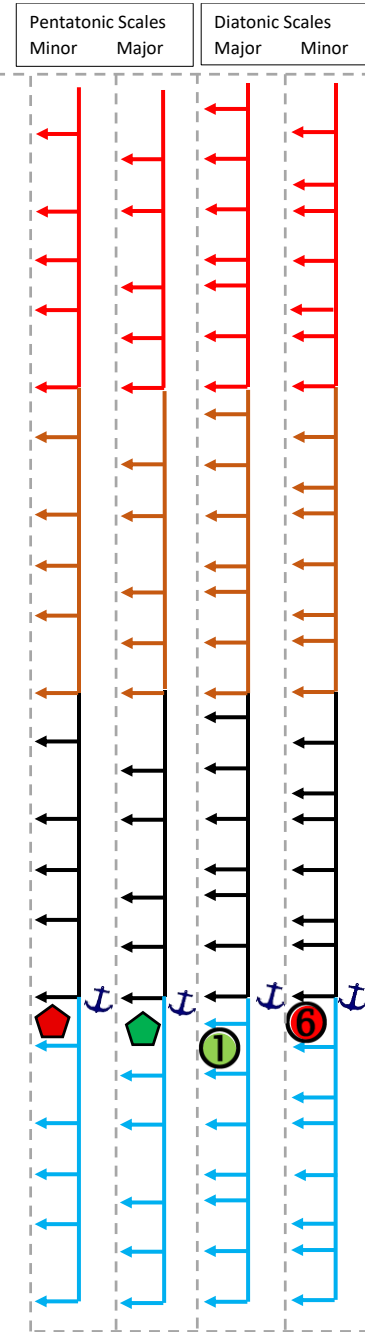
HANDOUT

This side not to scale!

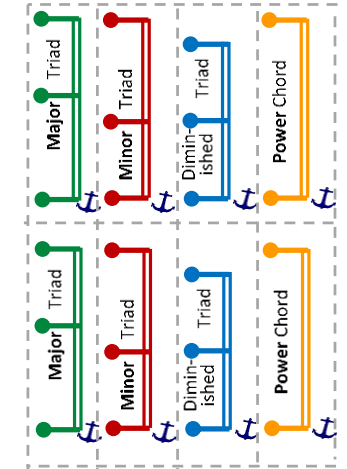
Scale Sliders

-  Pentatonic Major
-  Pentatonic Minor
-  Diatonic Major
-  Diatonic Minor

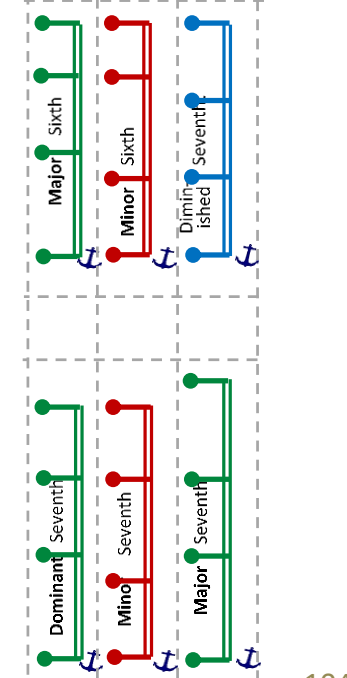
1. Cut out Scale Sliders and Chord Sliders
2. Place Scale Slider on Chromatic Scale at desired key (root note)
3. Place a Chord slider next to Scale Slider to determine possible Chords positions.



Triad Chords



Tetrad Chords



Course Outline



1. Building Blocks: Some basic concepts
2. Resonance: Building Sounds
3. Hearing and the Ear
- 4. Musical Scales**
5. Musical Instruments
6. Singing and Musical Notation
7. Harmony and Dissonance; Chords
8. Combining the Elements of Music

Ukrainian Bandura

Chromatic Scale
65 Strings
With retuning
mechanism

