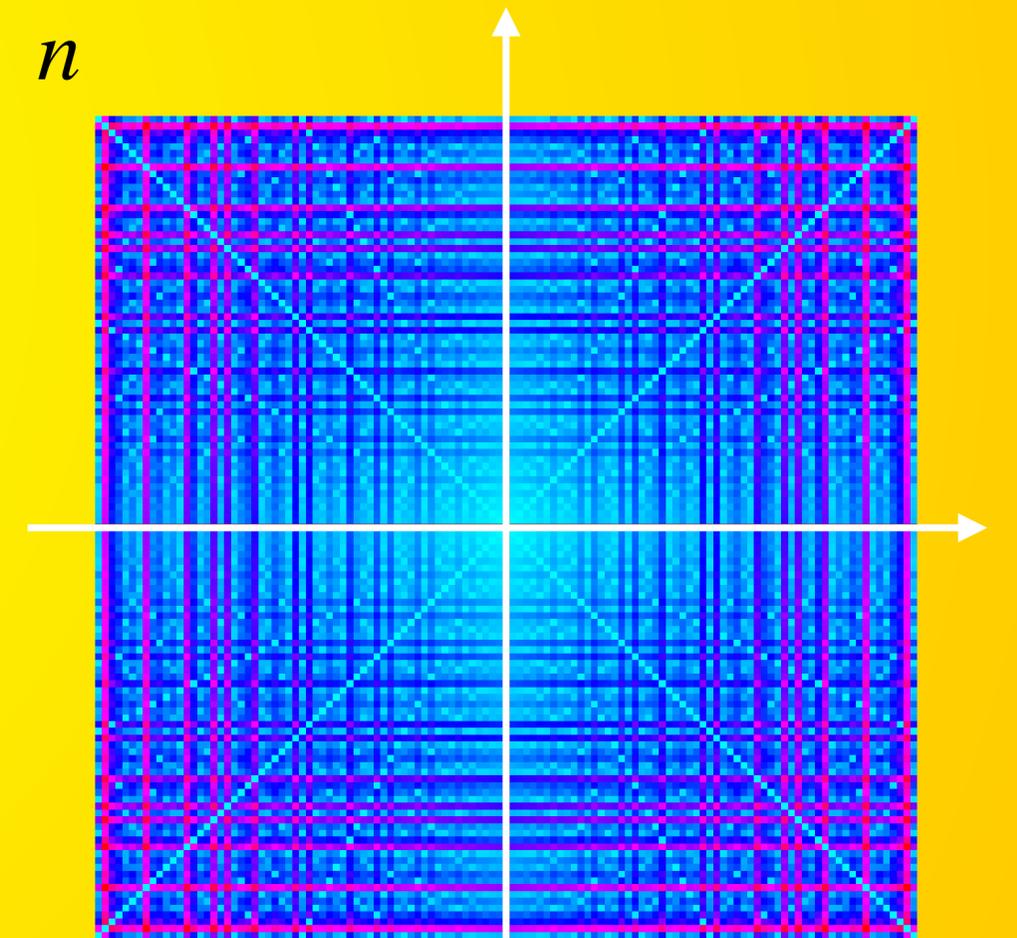
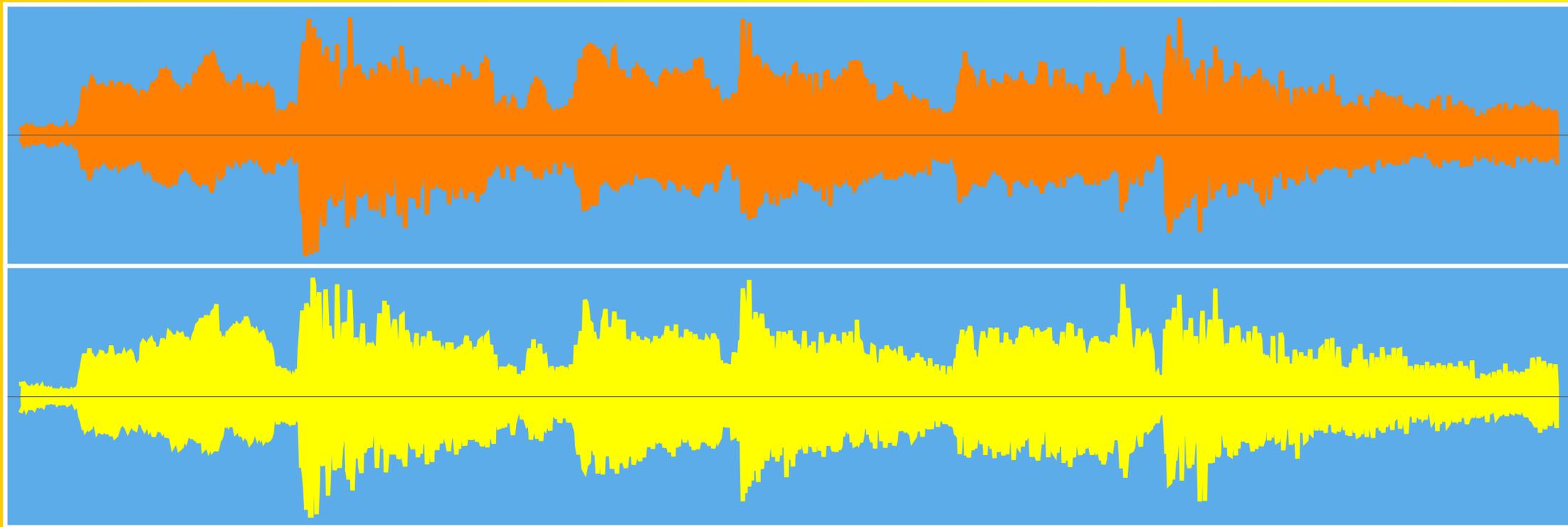


33

Music

$$f(s) = 440 * 2^{(s-69)/12}$$

$$f(t) = \sum_n x_n \text{sinc}(t - n)$$



$$G(a, b) = 1 + \sum_{p=1}^{\infty} (p - 1)$$

PLAN

1. Poll

2. Songs and Sampling

3. Hull and Wave form

4) Midi Scale

5. Gradus Suavitatis

POLL

Which of the following Identities is the correct one?

a)

$$2^x = e^{x \log(2)}$$

$$2^x = \frac{e^x}{\log(2)}$$

b)

c)

$$2^x = e^x \log(2)$$

$$2^x = e^{\frac{x}{\log(2)}}$$

d)

1. SONGS

AND SAMPLING

SONGS

```
A = Import["queen.m4v"];
```

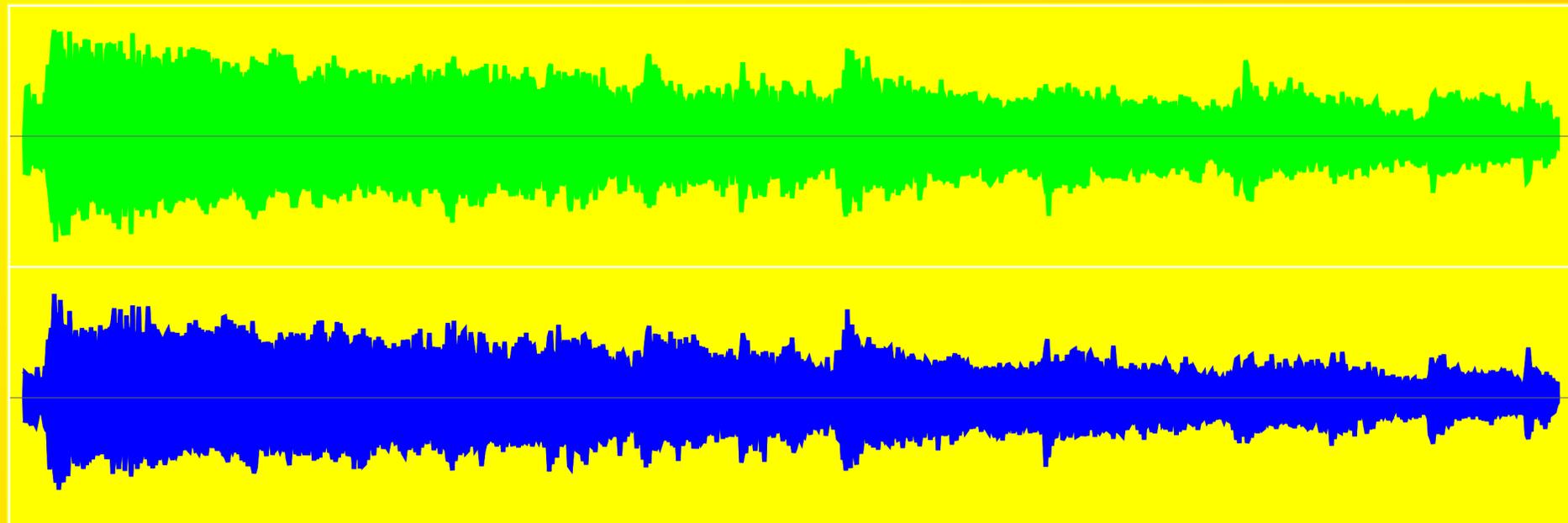
```
Export["queen.mp3", A, "MP3"]
```

5 second song

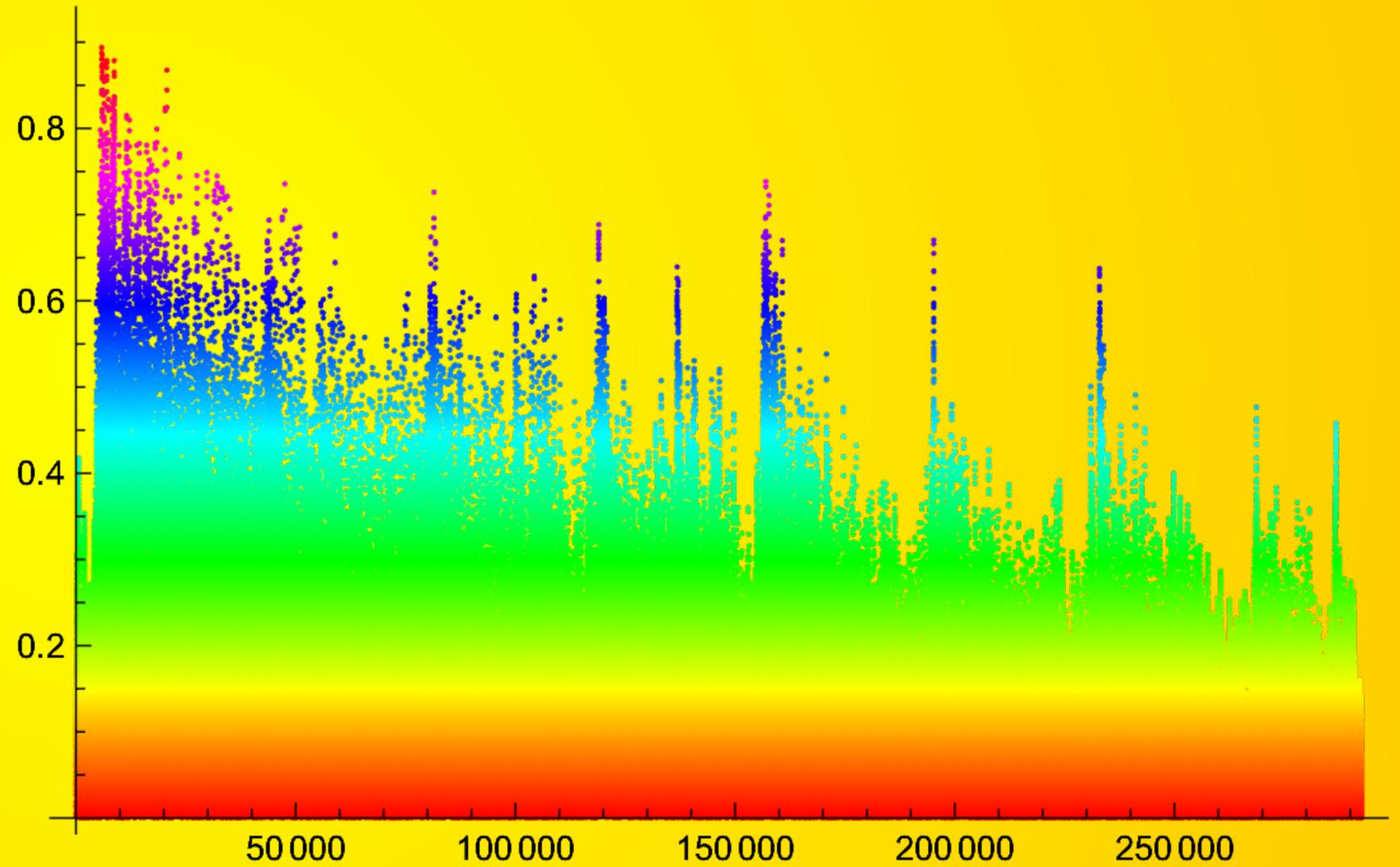
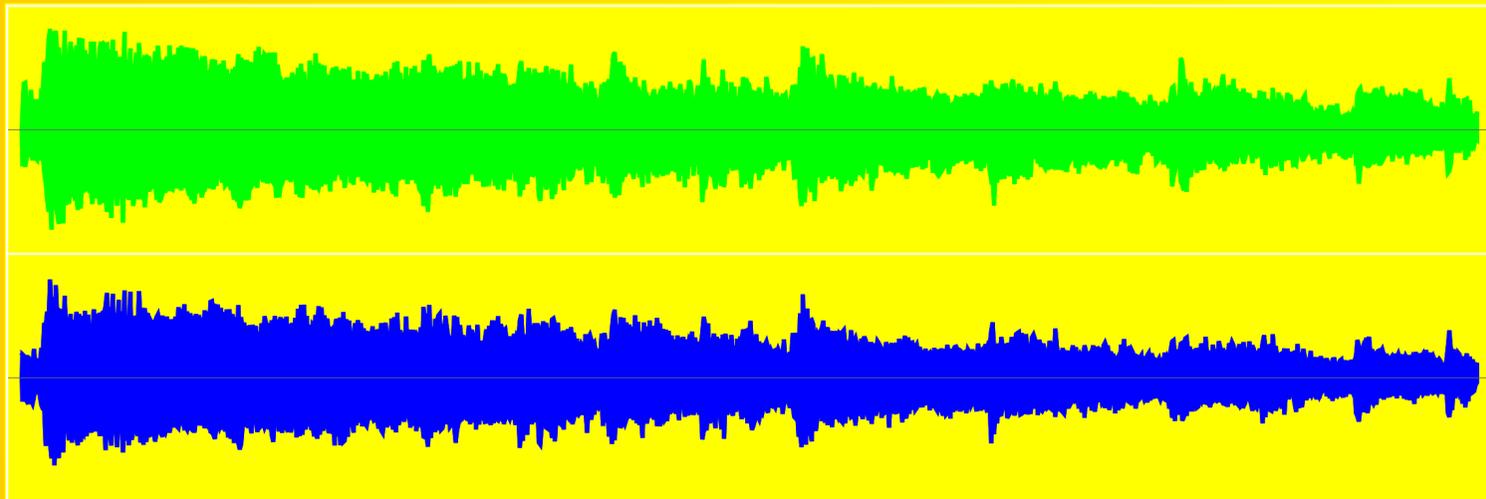
1.2 MegaBytes, WAV

130 KiloBytes, MP3

```
AudioPlot[A]
```



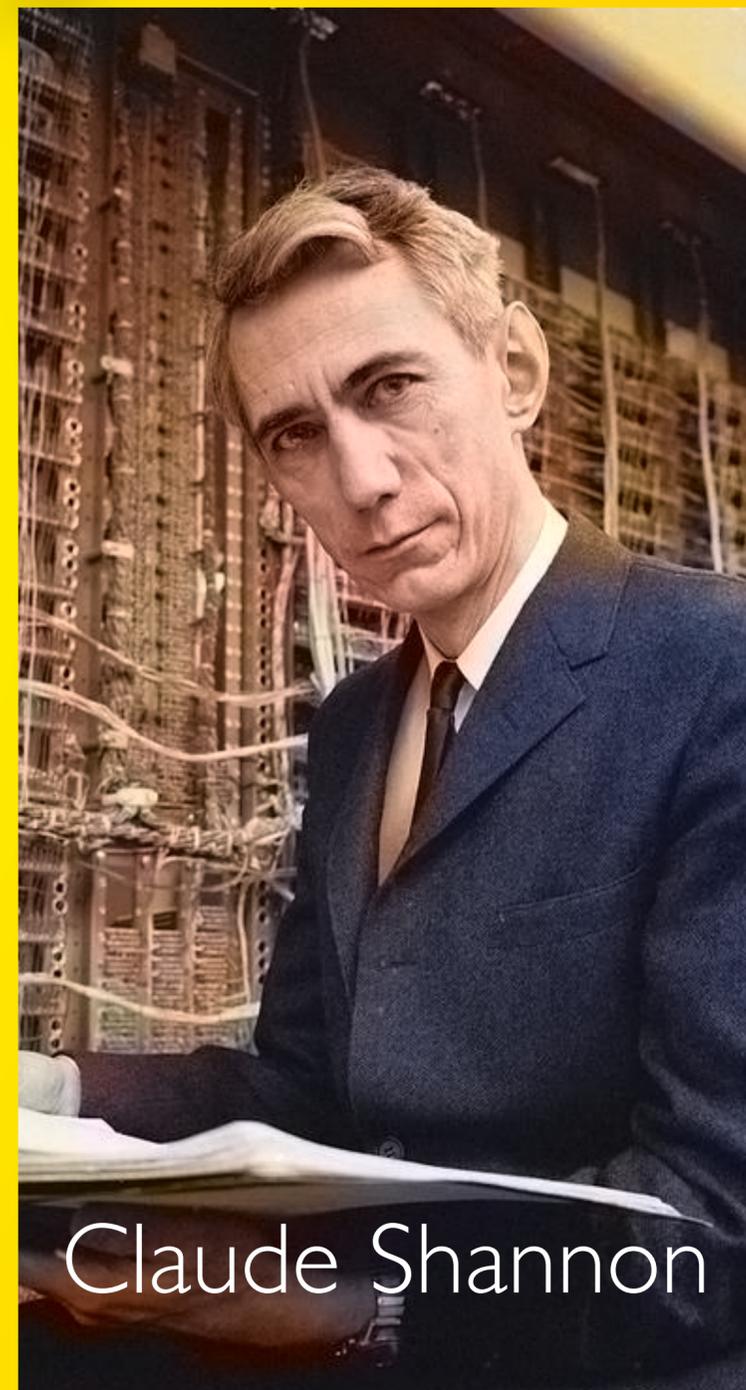
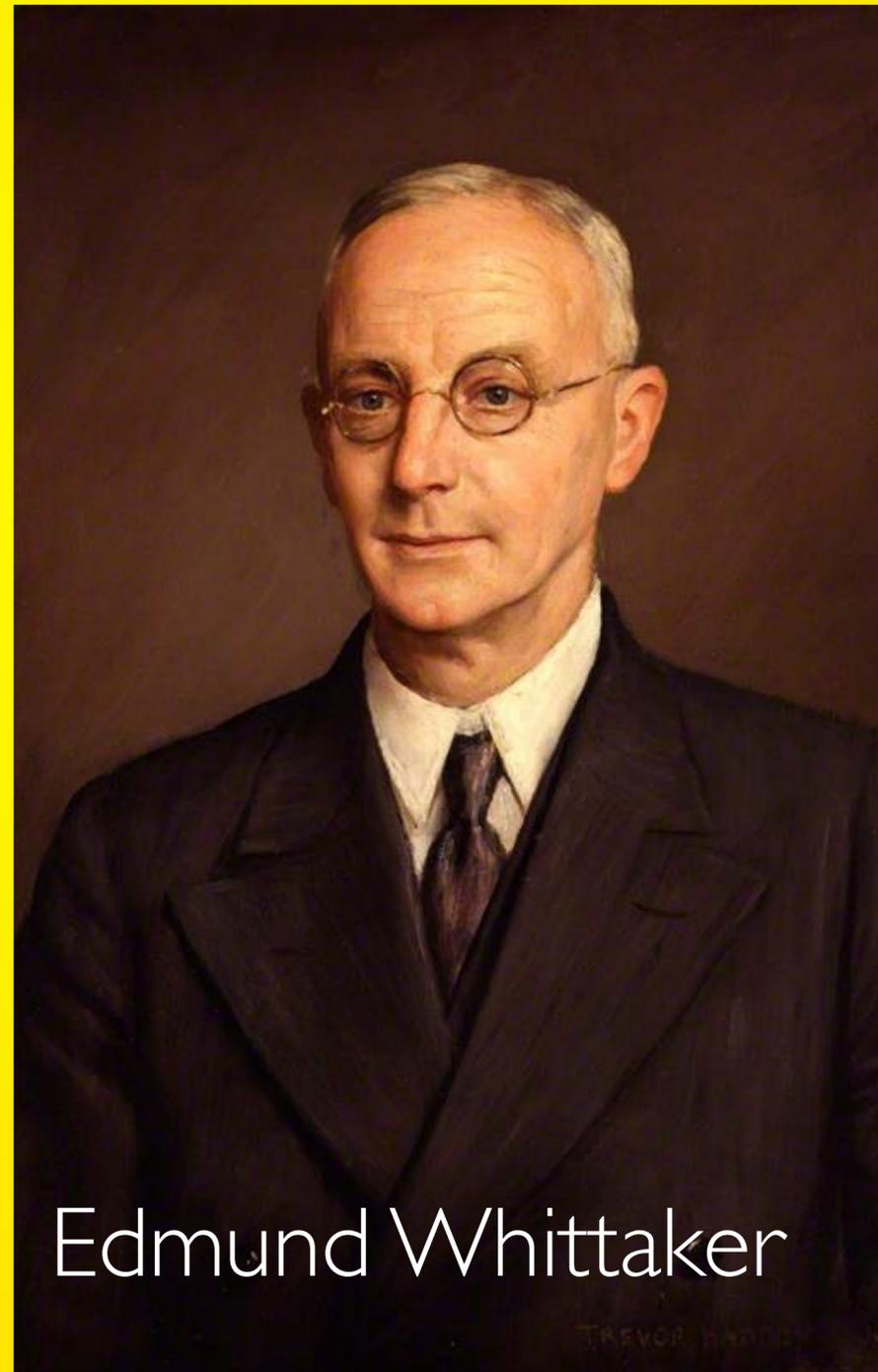
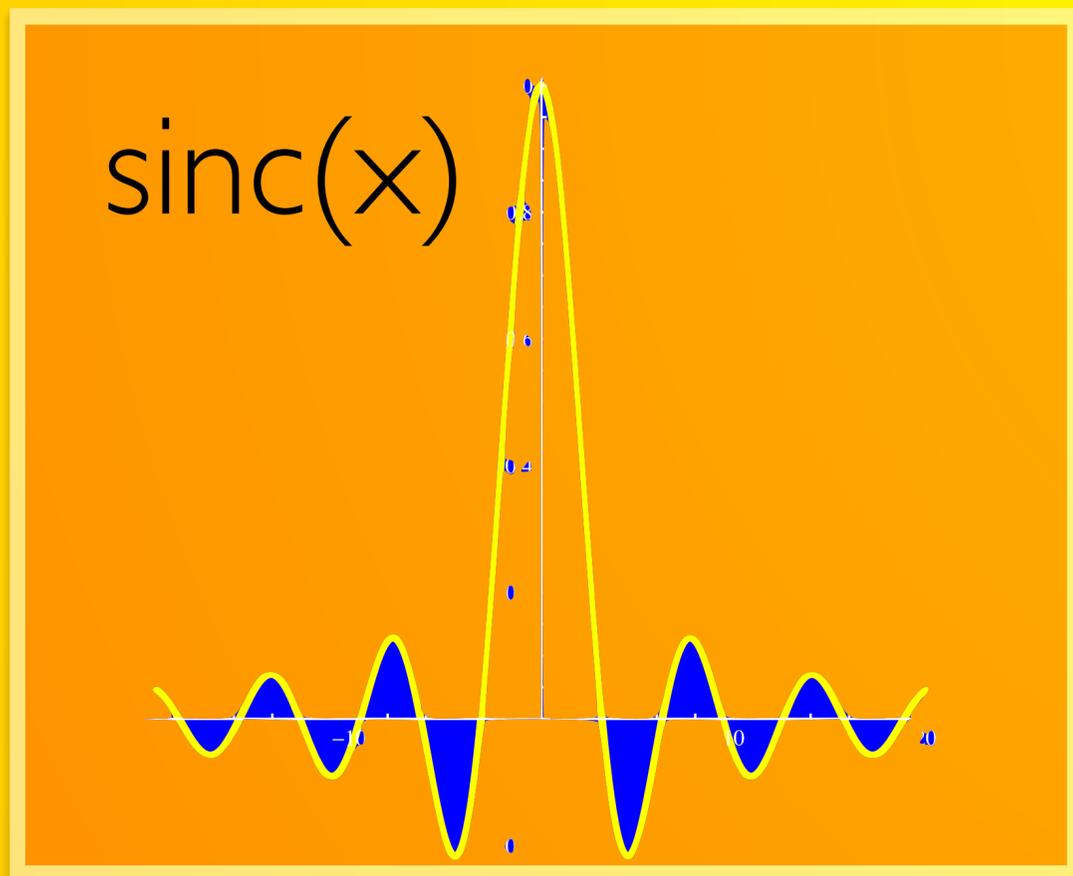
ARE FUNCTIONS



300'000 points

SAMPLING

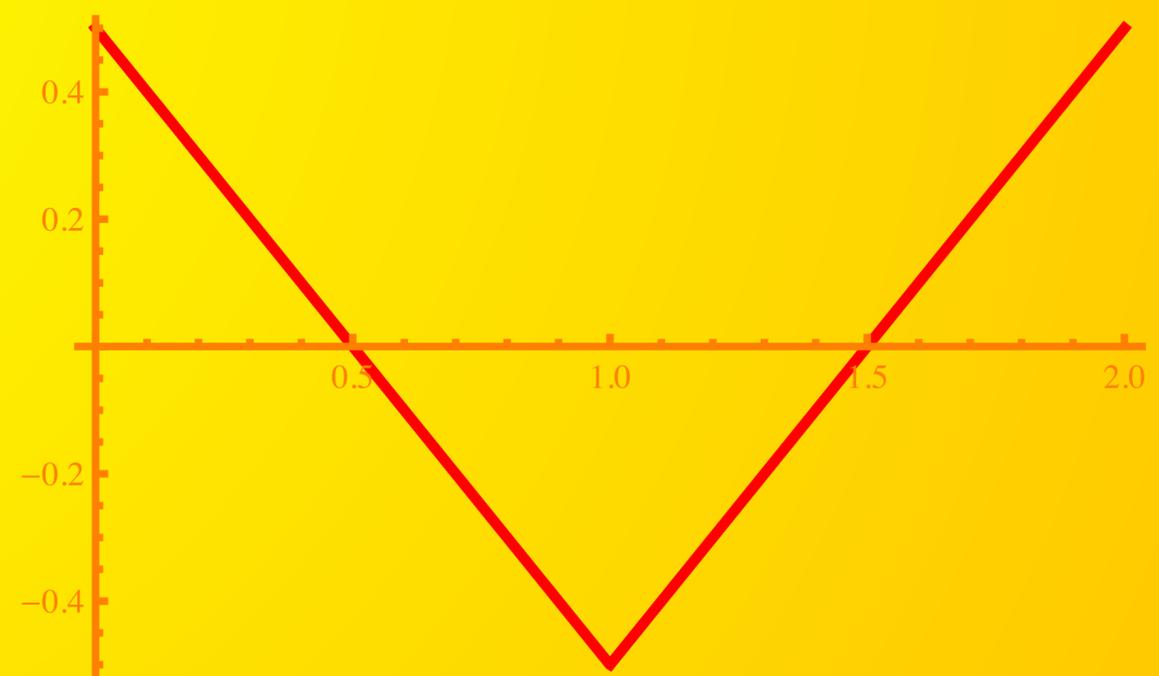
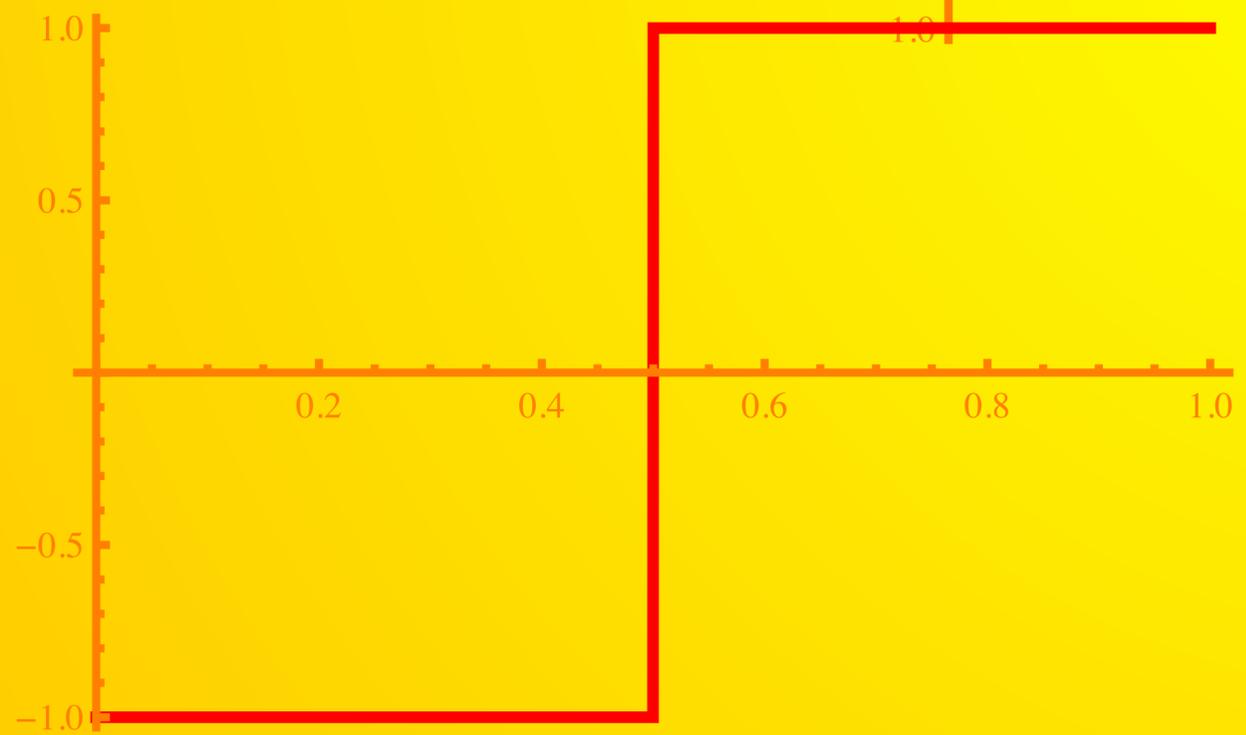
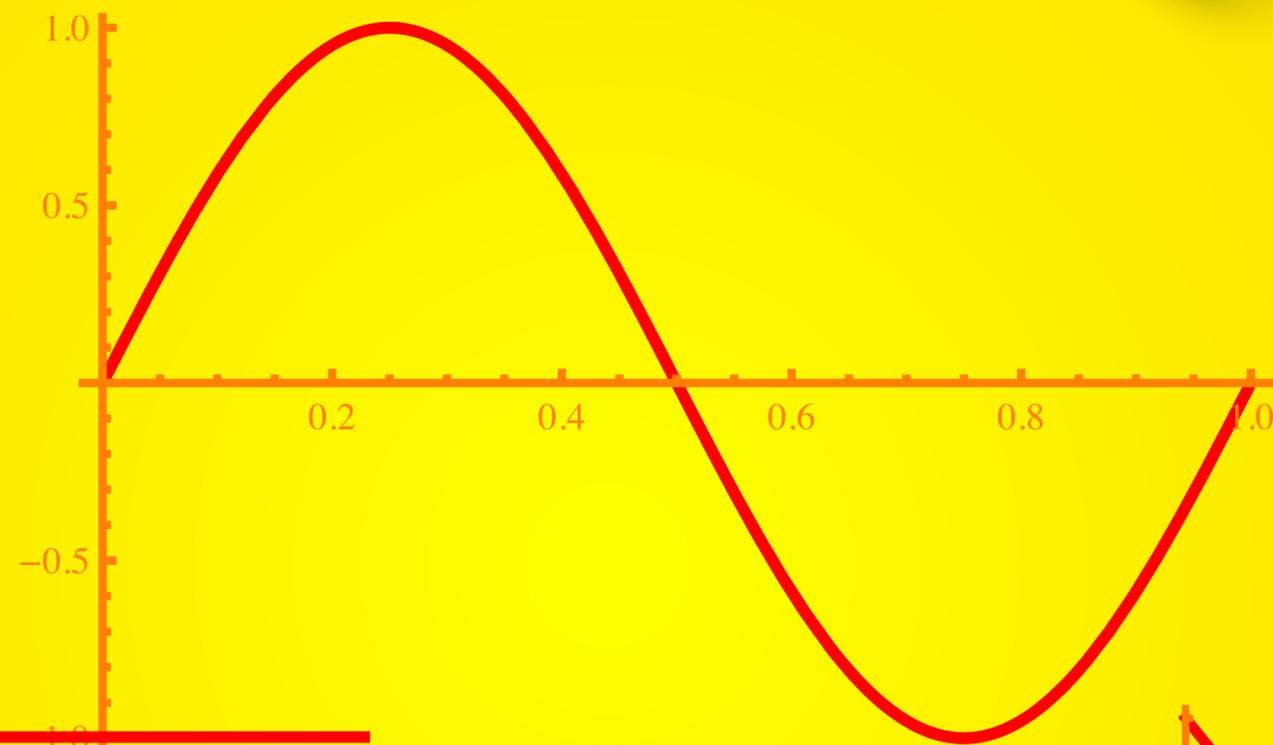
$$f(t) = \sum_{k=1}^n x_k \text{sinc}(t - k)$$



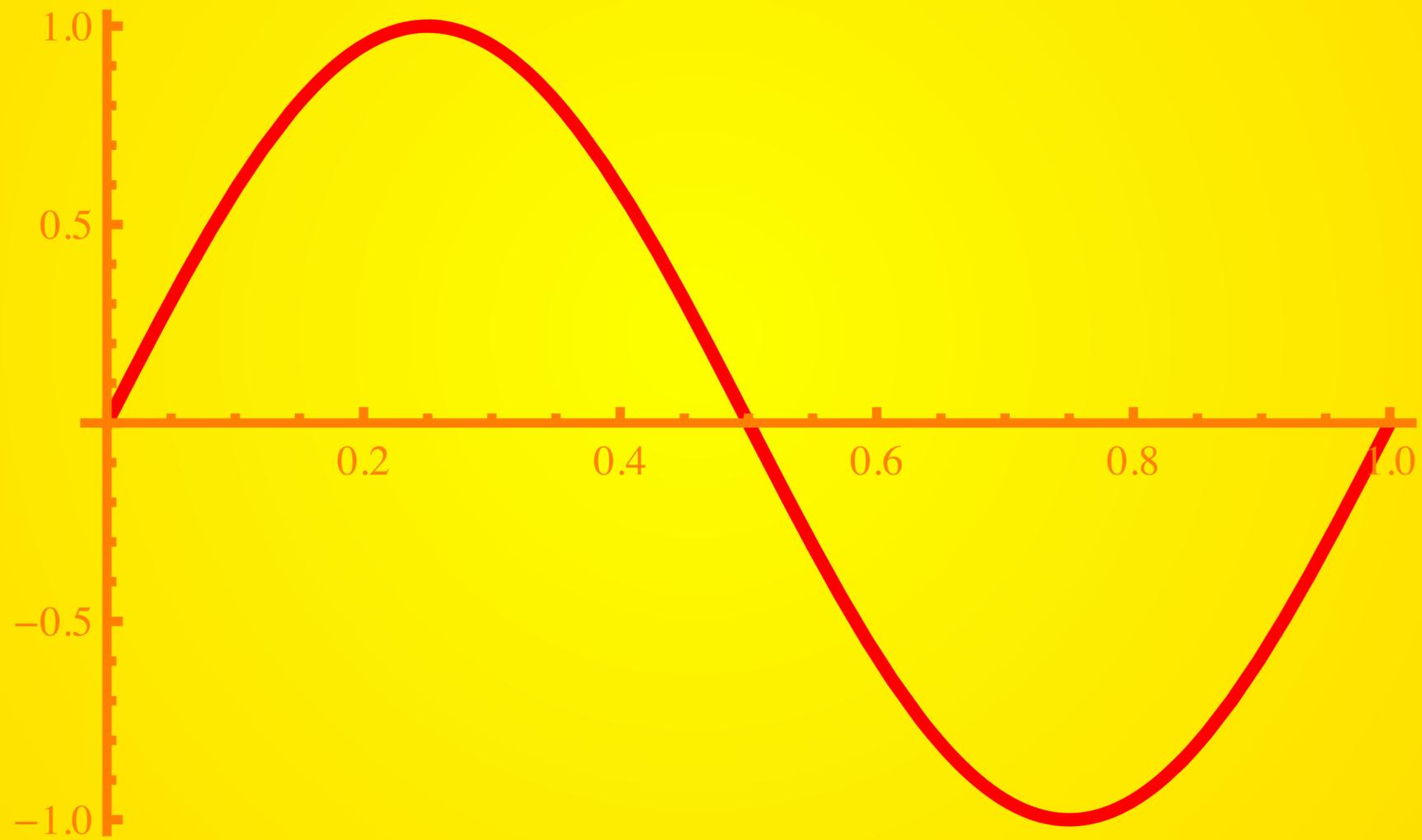
2. HULL

AND WAVEFORM

WAVE FORMS

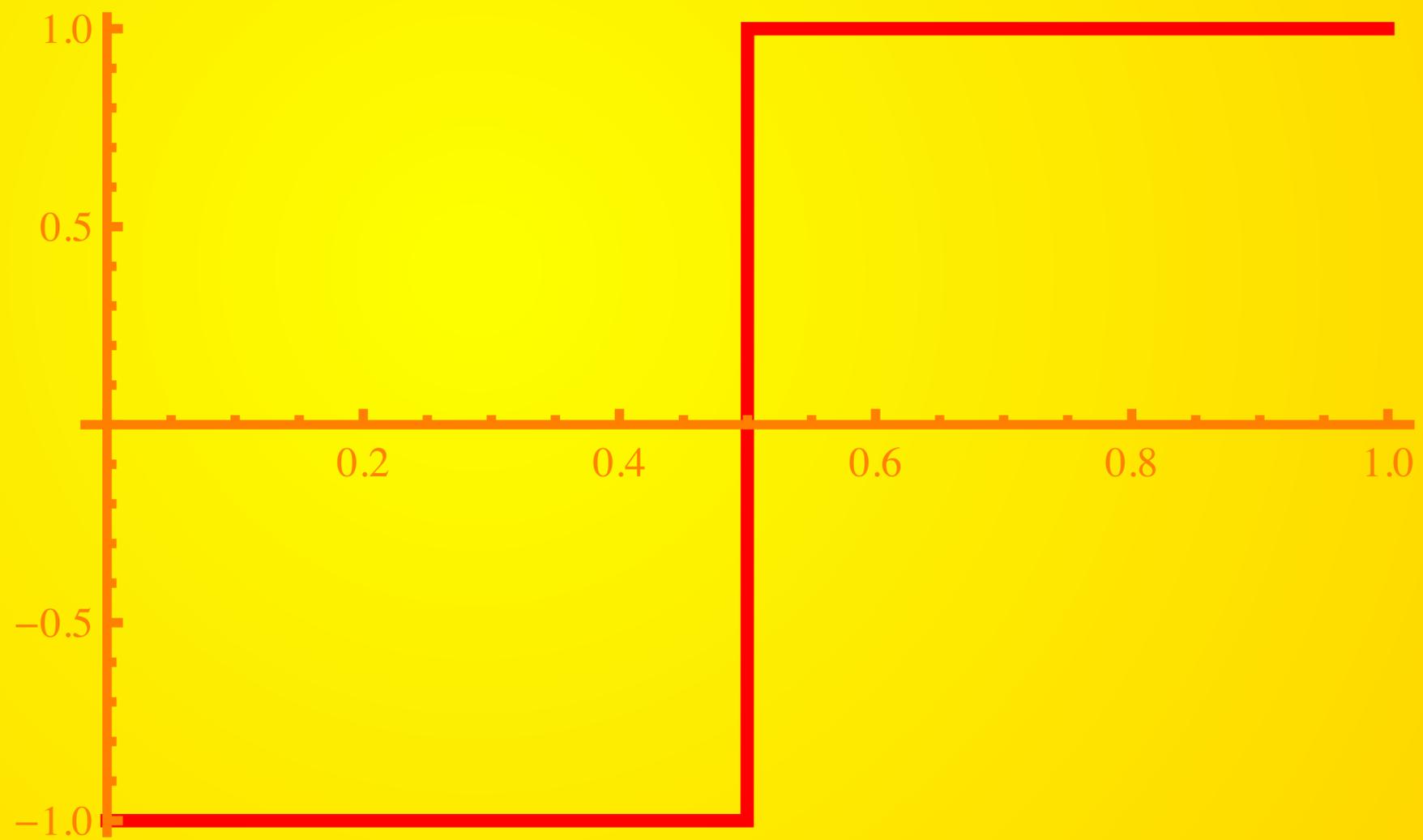


SIN

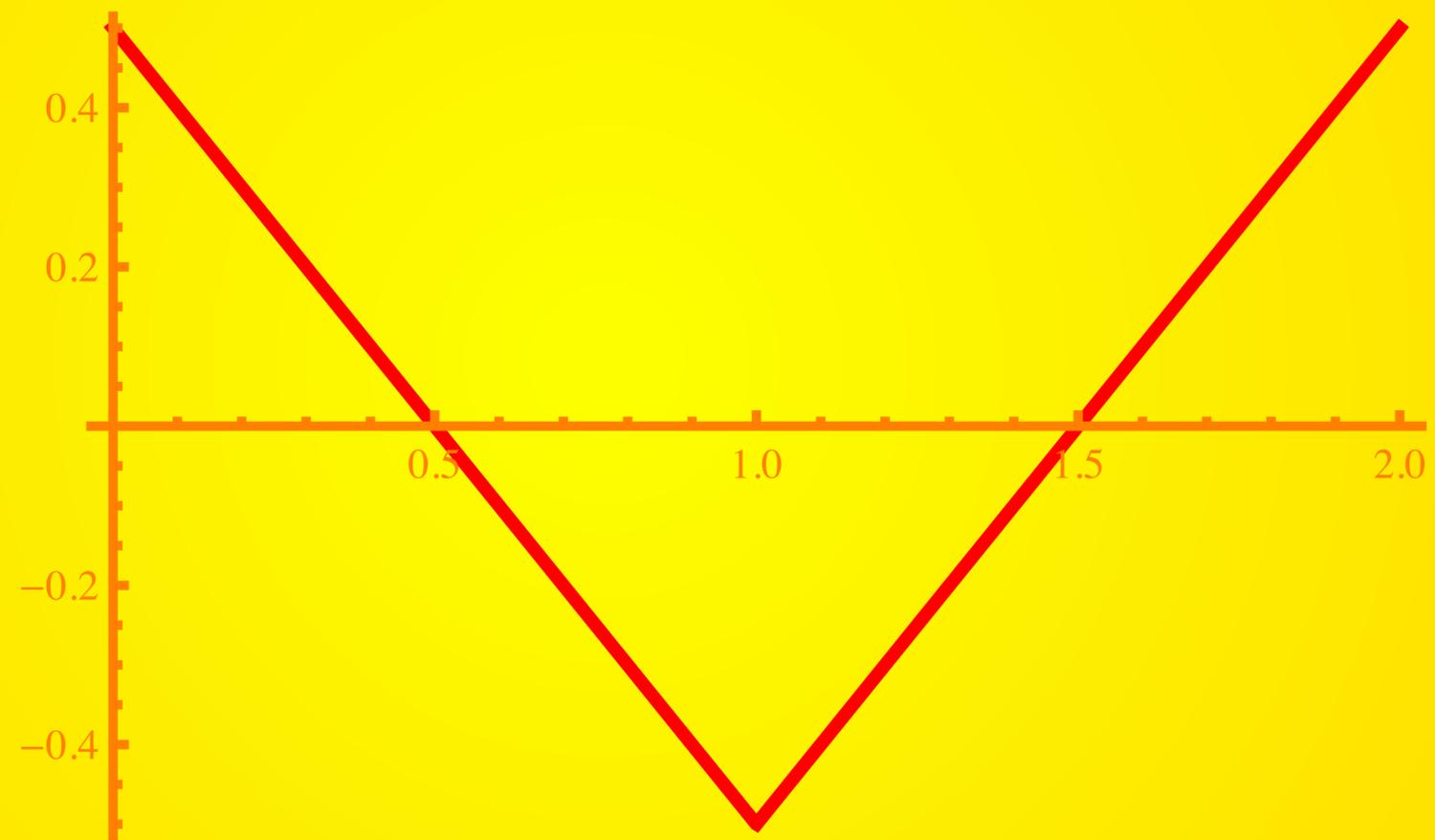


Sin wave form

SIGN



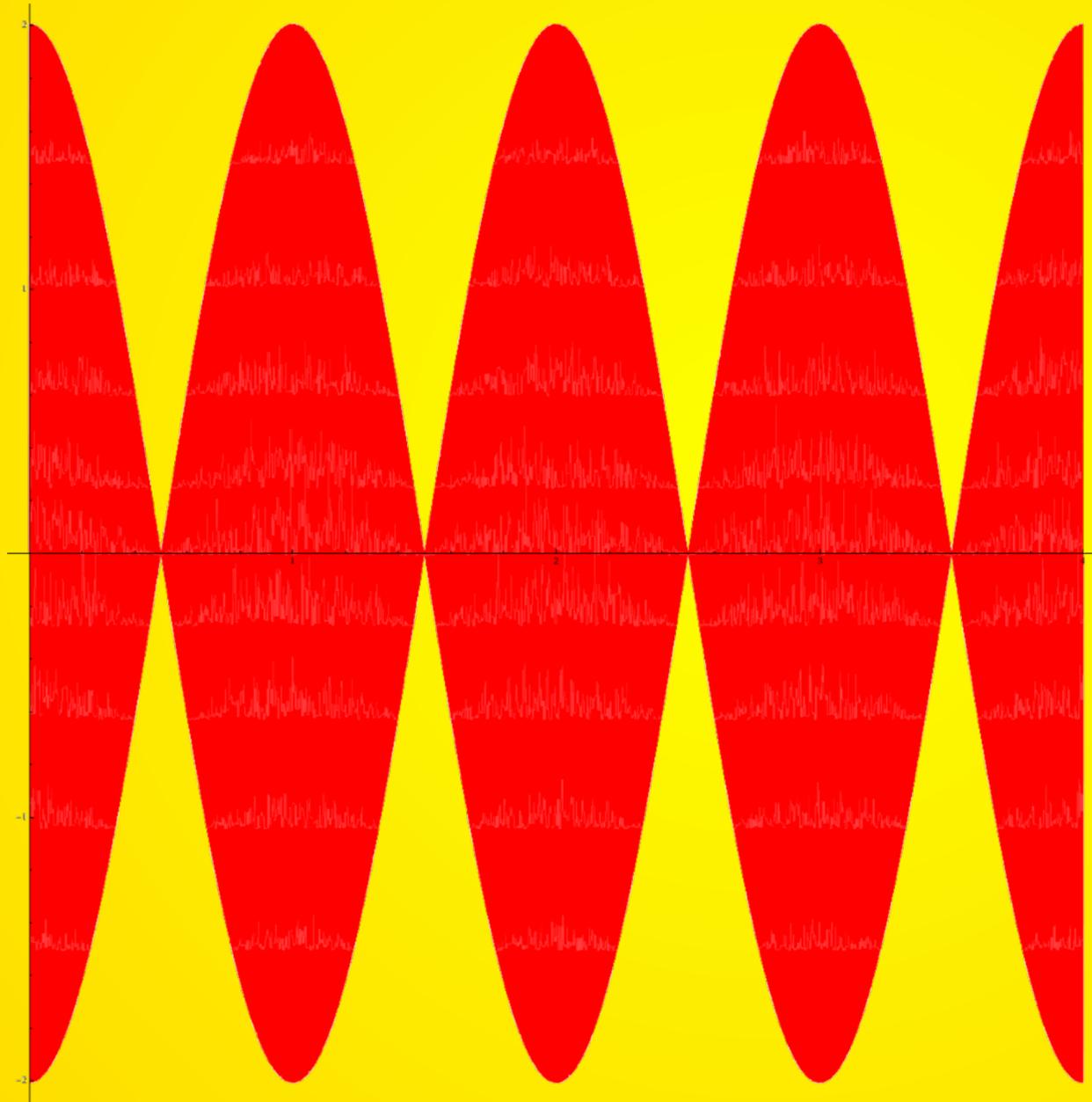
ABS



TRIG POLY

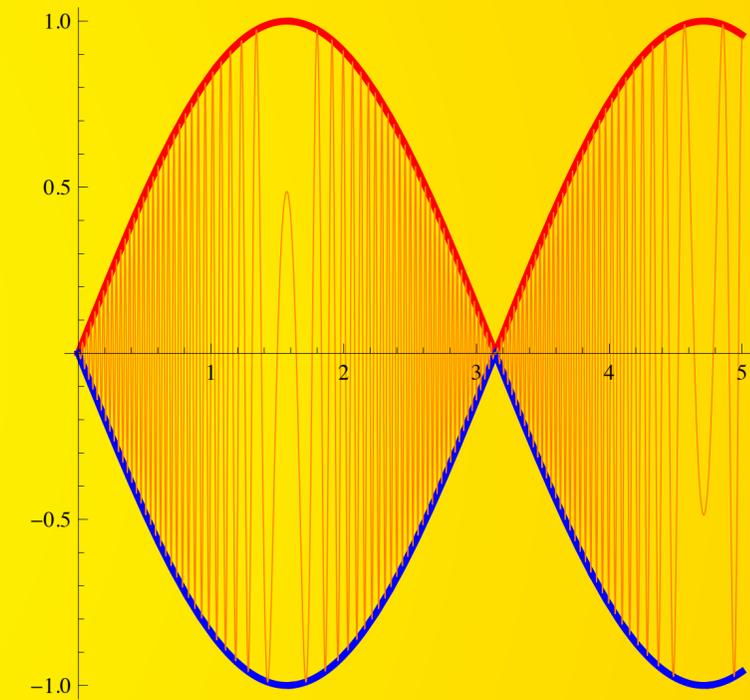
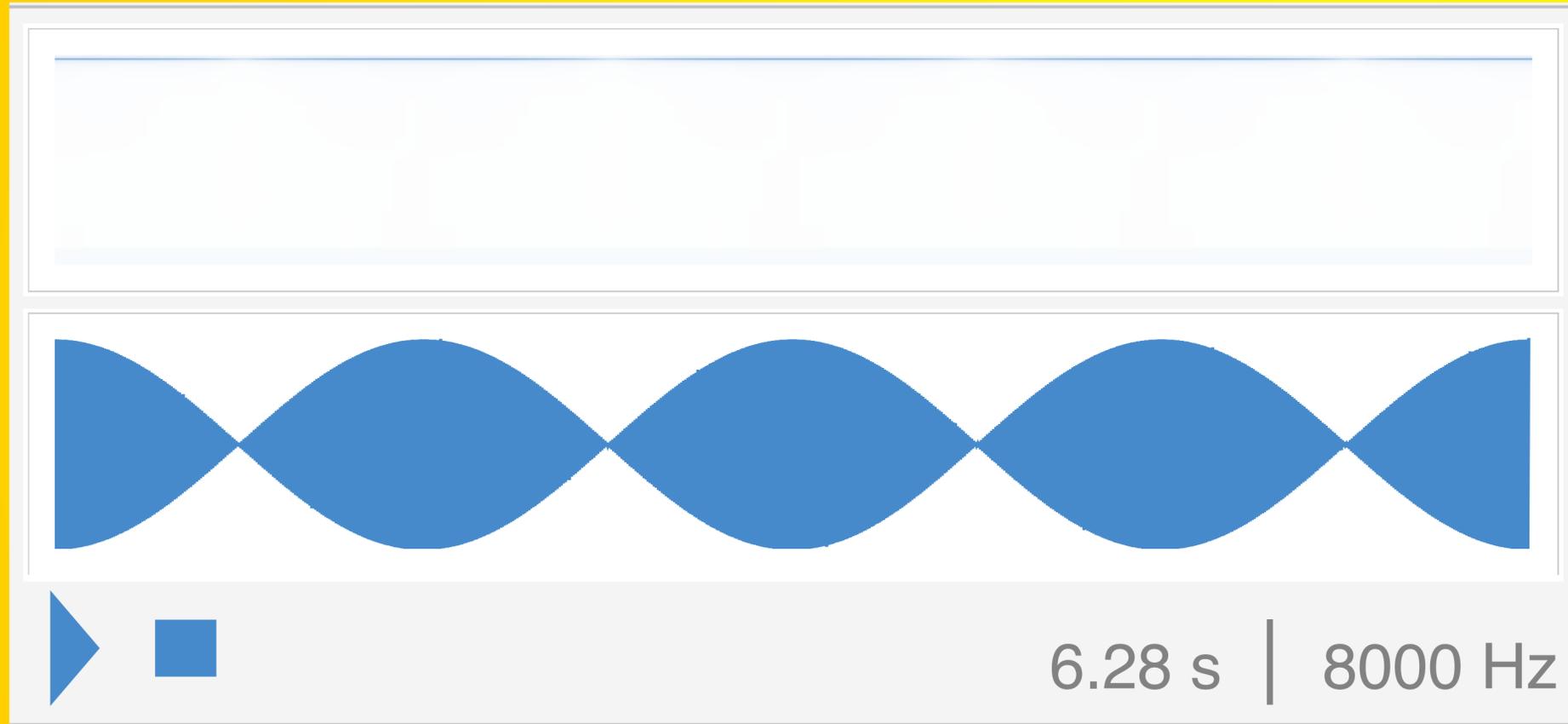


INTERFERENCE



$$f(x) = \sin(300 x) + \sin(301 x)$$

HULL



`Play[Cos[2 x] Sin[4400 2 Pi x], {x, 0, 2 Pi}]`

EXAMPLE 1

$$f(x) = \sin(10000 \sqrt{x})$$

EXAMPLE 2

$$f(x) = \sin(x) \sin(1000 x)$$

EXAMPLE 3

Differentiate a song

$$g(x) = f(x+T) - f(x)$$

3. MIDI

FUNCTION

Frequency

MIDI

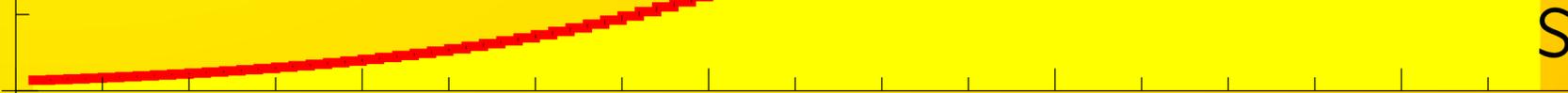
4000

3000

2000

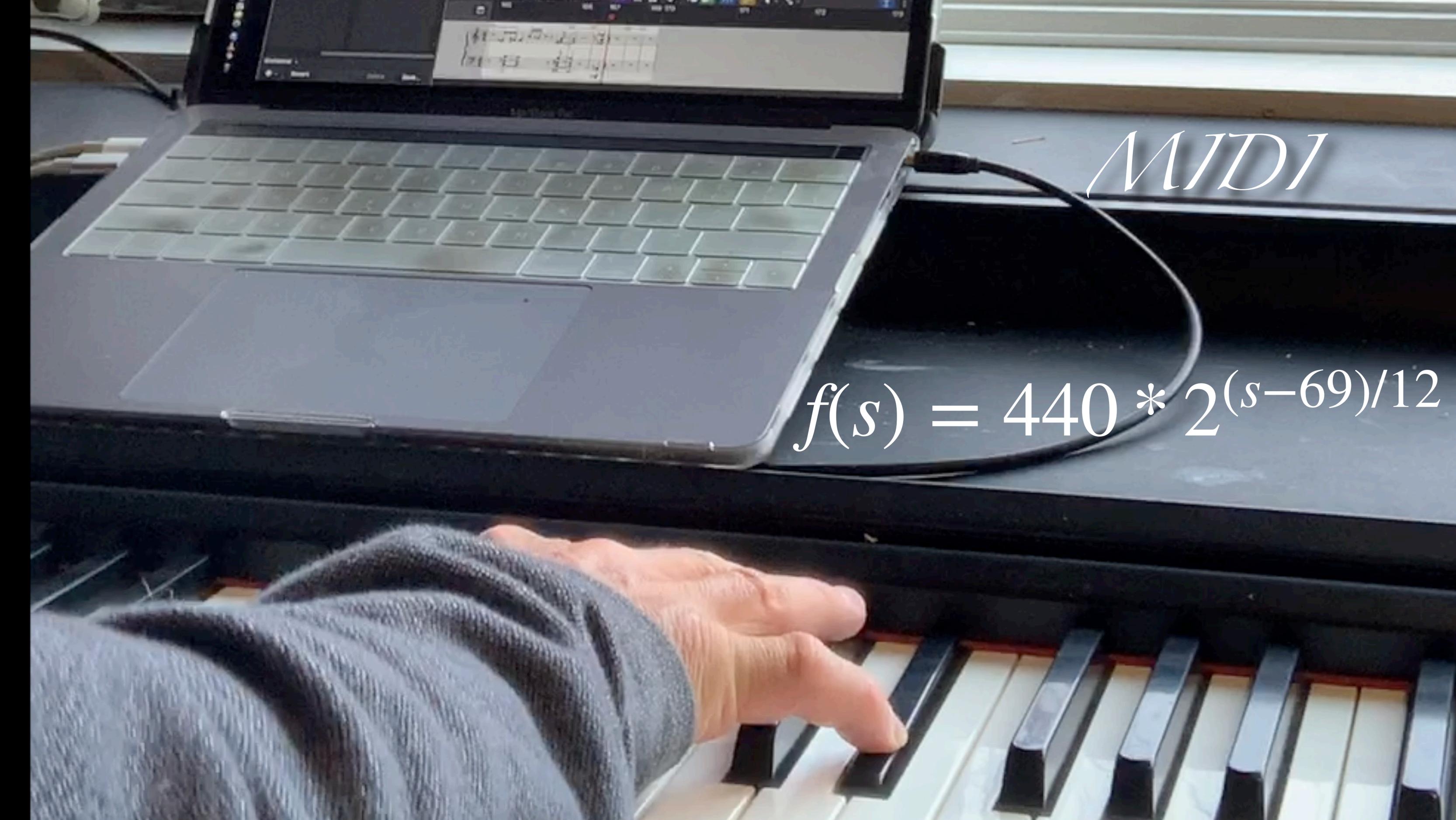
1000

$$f(s) = 440 * 2^{(s-69)/12}$$



MIDI

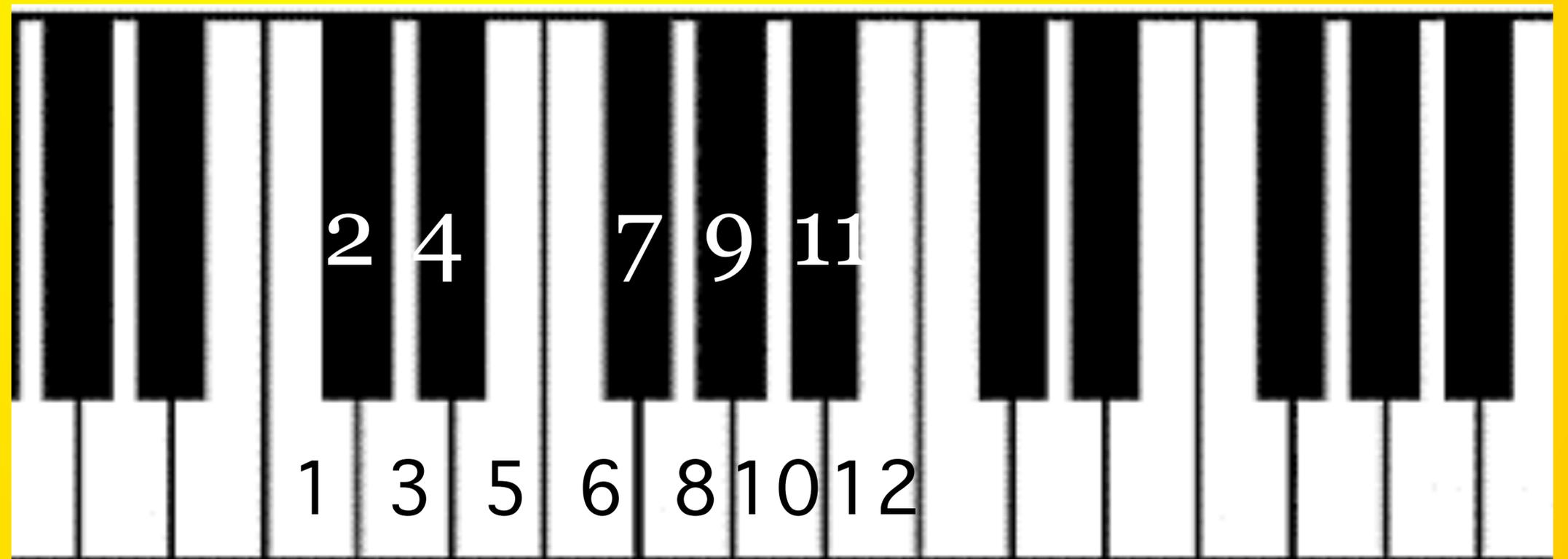
$$f(s) = 440 * 2^{(s-69)/12}$$



TWELF TONE SCALE

Frequency ratio: $2^{1/12}$

Why 12?



27.5 Hz

21



88 keys

108



4186 Hz

Lemons



4. *GRADUS*

SUAVITATIS

*A NICE
COMBINATION*

```
s=Sound[{"Flute", SoundNote[{1, 3, 5, 8}, {0, 1}]]
```

*A LESS NICE
COMBINATION*

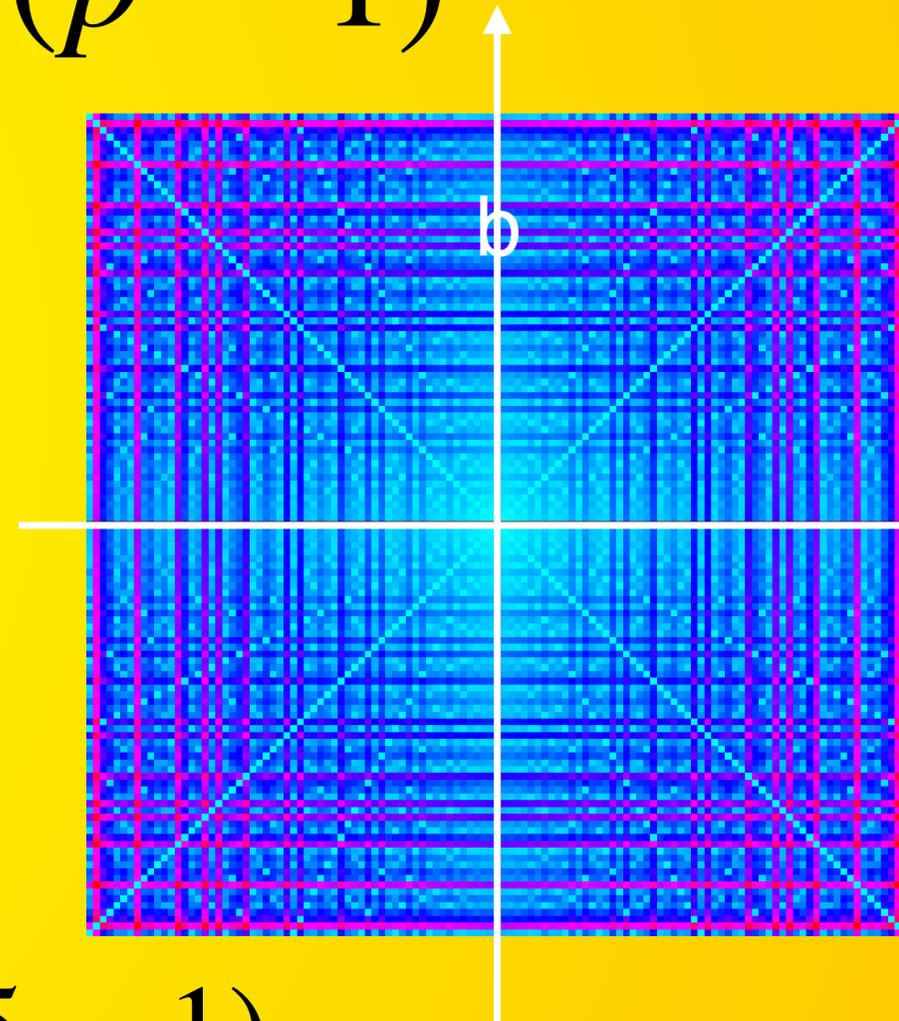
```
s=Sound[{"Flute", SoundNote[{1, 2,3, 4}, {0, 1}]]
```

SUAVIS GRAVITATIS



$$G(a, b) = 1 + \sum_{p|ab} (p - 1)$$

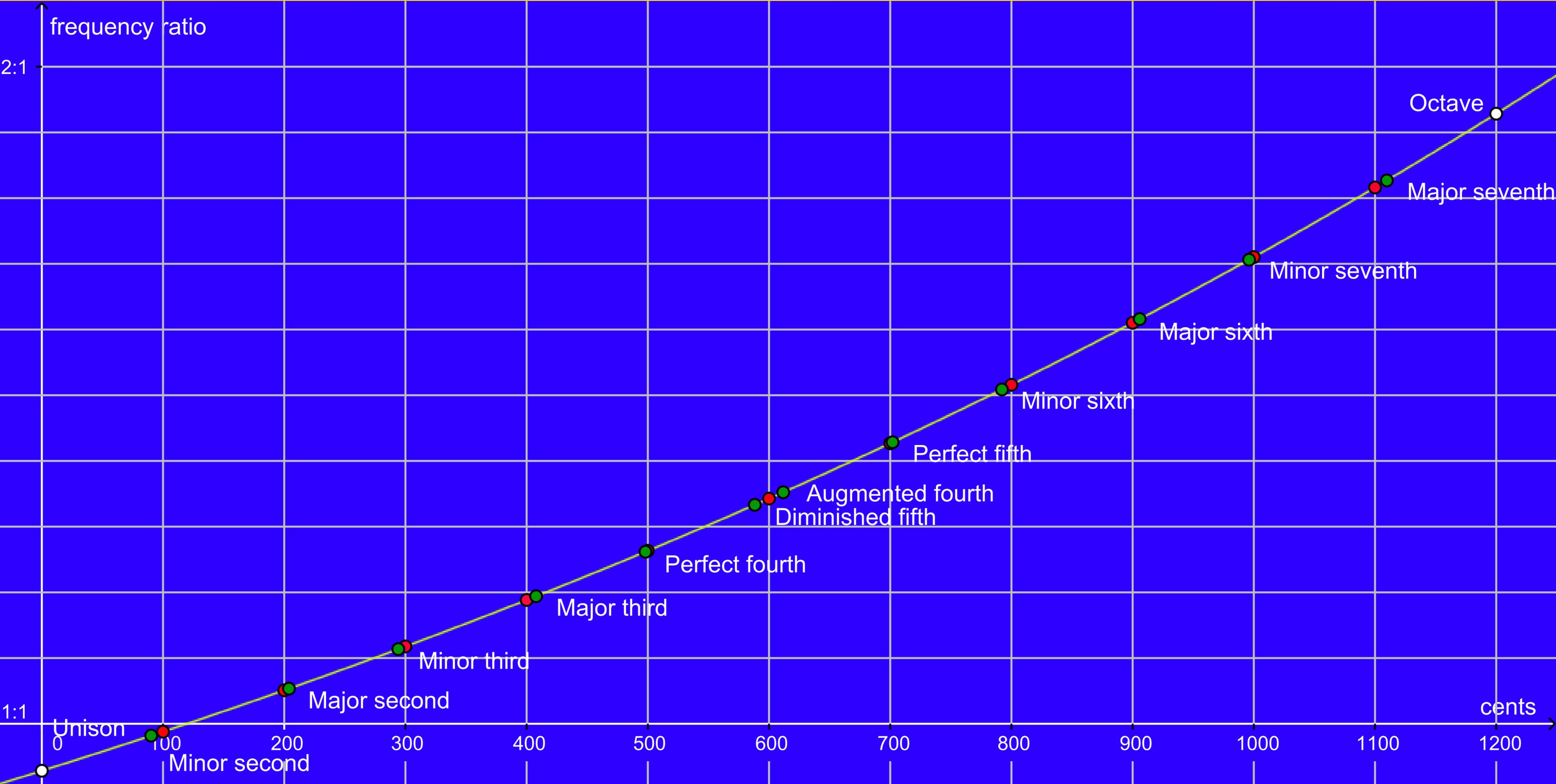
Euler's Suavis Gravitatis
is a measure of "sweetness"
of a fraction.



Example:

$$G(5, 12) = 1 + (2 - 1) + (2 - 1) + (3 - 1) + (5 - 1)$$

```
G[a_,b_]:=Module[{s=FactorInteger[LCM[a,b]/GCD[a,b]]}, 1+Sum[s[[k,2]]*(s[[k,1]]-1),{k,Length[s]}]]
```





Lemons

5 TONE SCALE

Frequency $5^{1/5}$

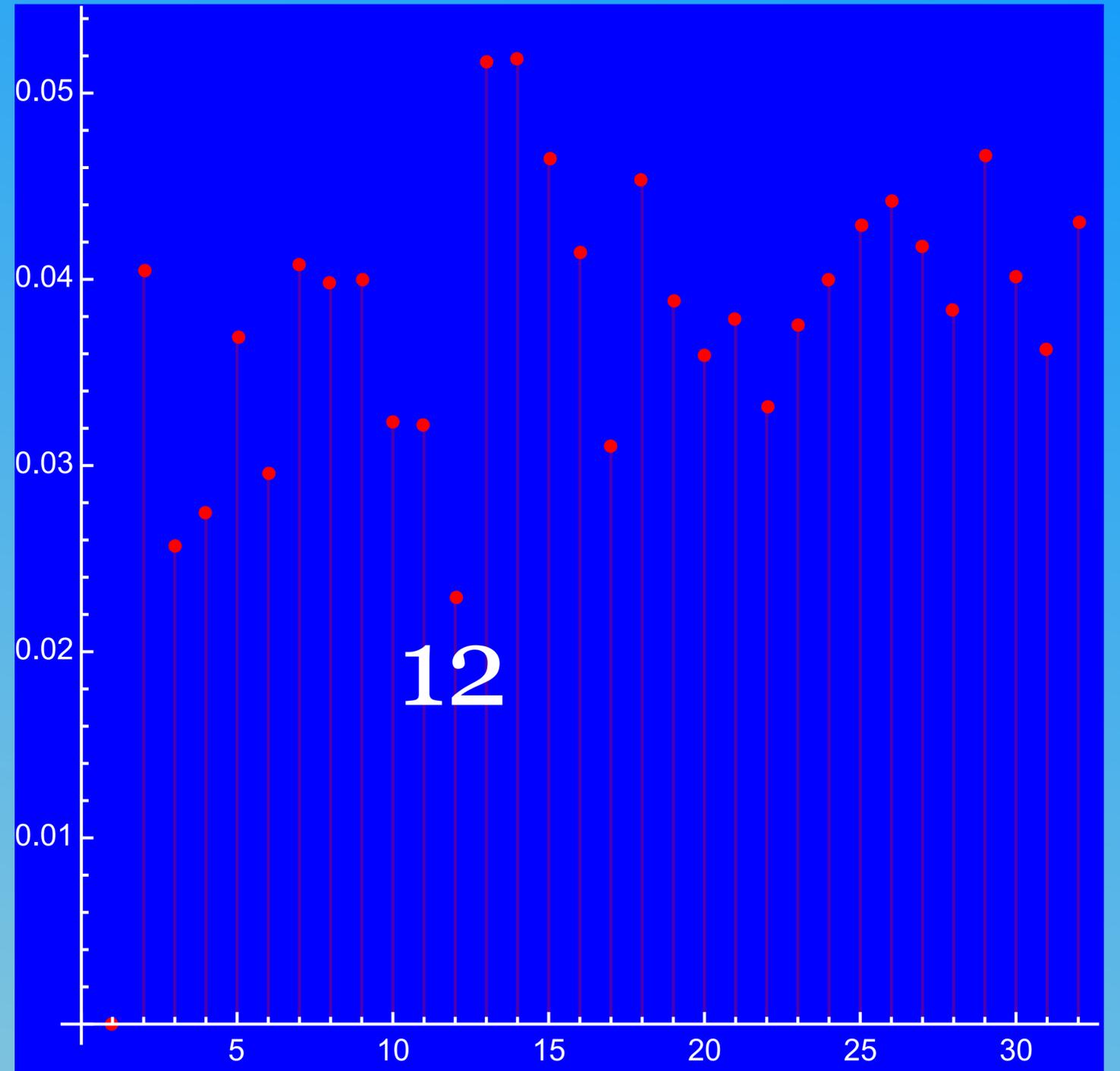


Stockhausen: 1928-2007



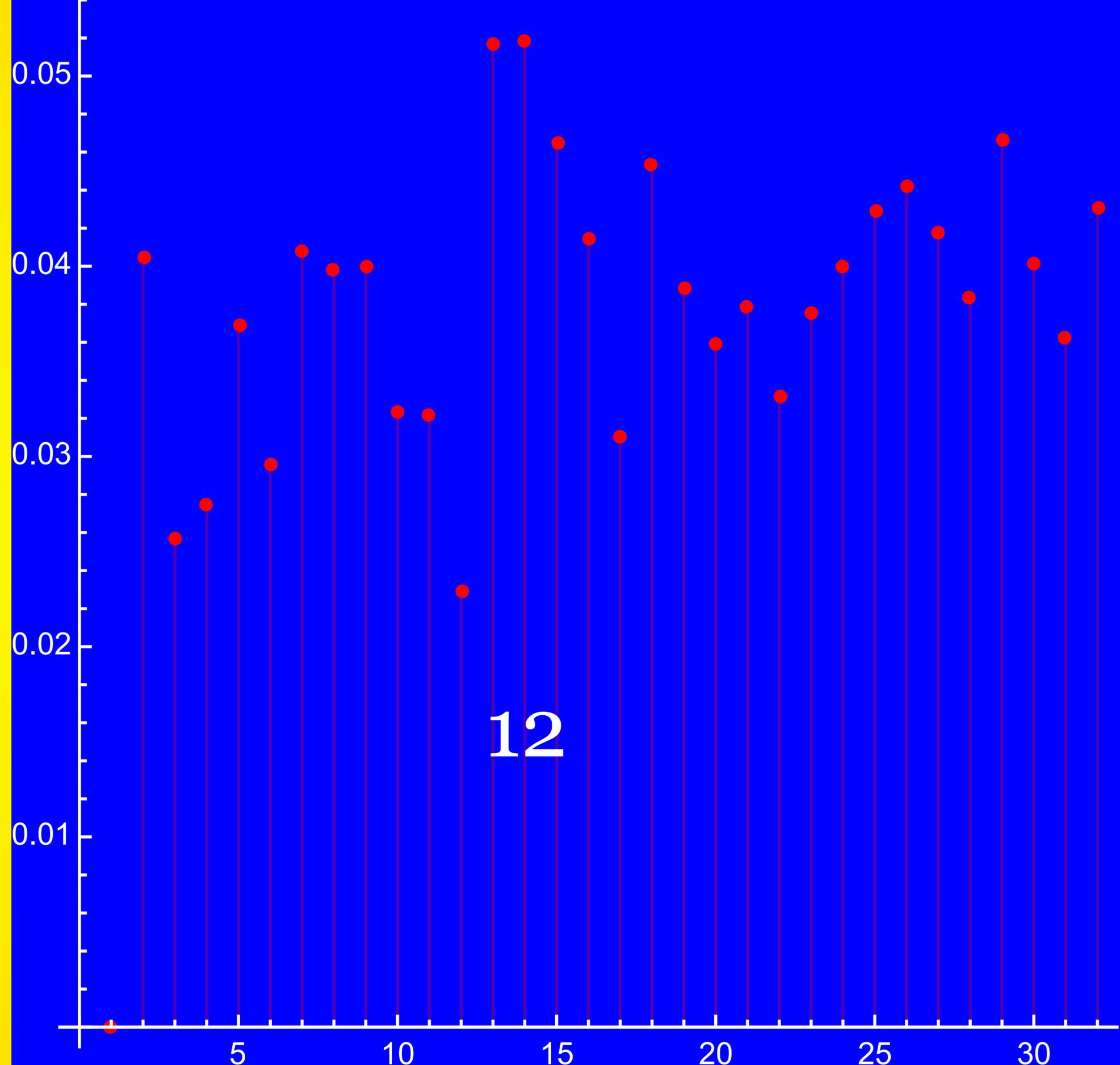
12 IS BEST

$$M(n) = \sum_{k=1}^n \min_{p,q} \left| 2^{k/n} - \frac{p}{q} \right| G(p, q)$$



12 IS BEST

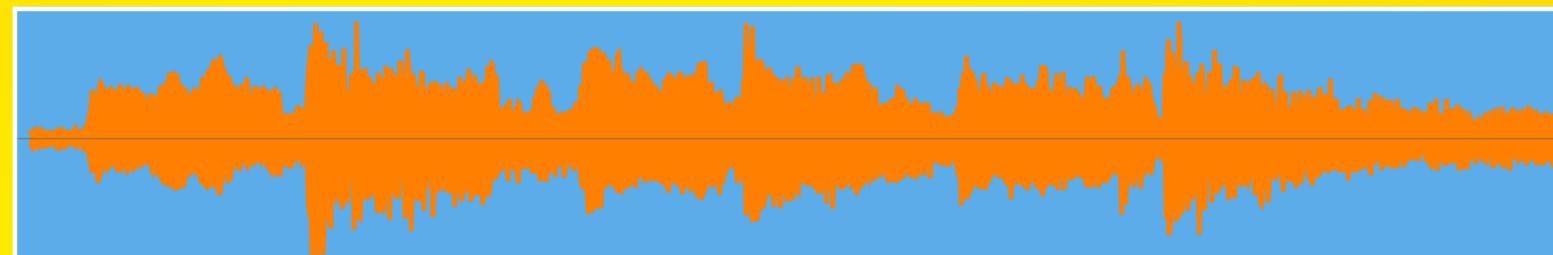
$$M(n) = \sum_{k=1}^n \min_{p,q} \left| 2^{k/n} - \frac{p}{q} \right| G(p, q)$$



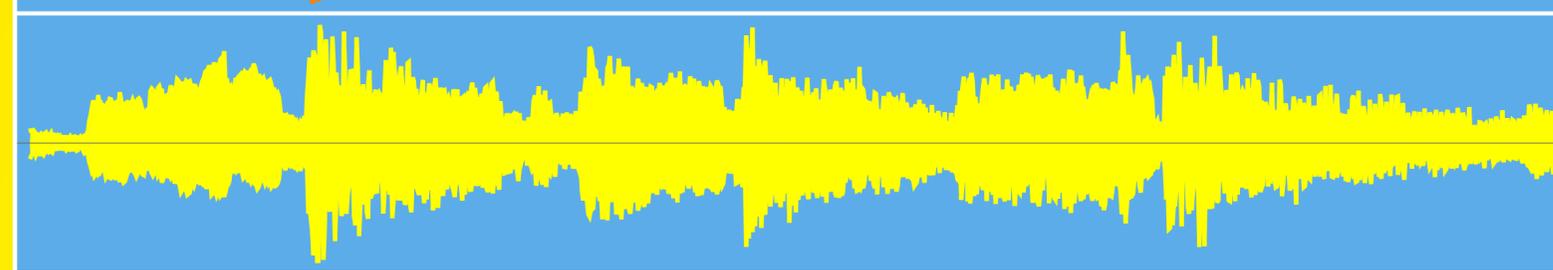
DATA

see next time

Left channel



Right channel



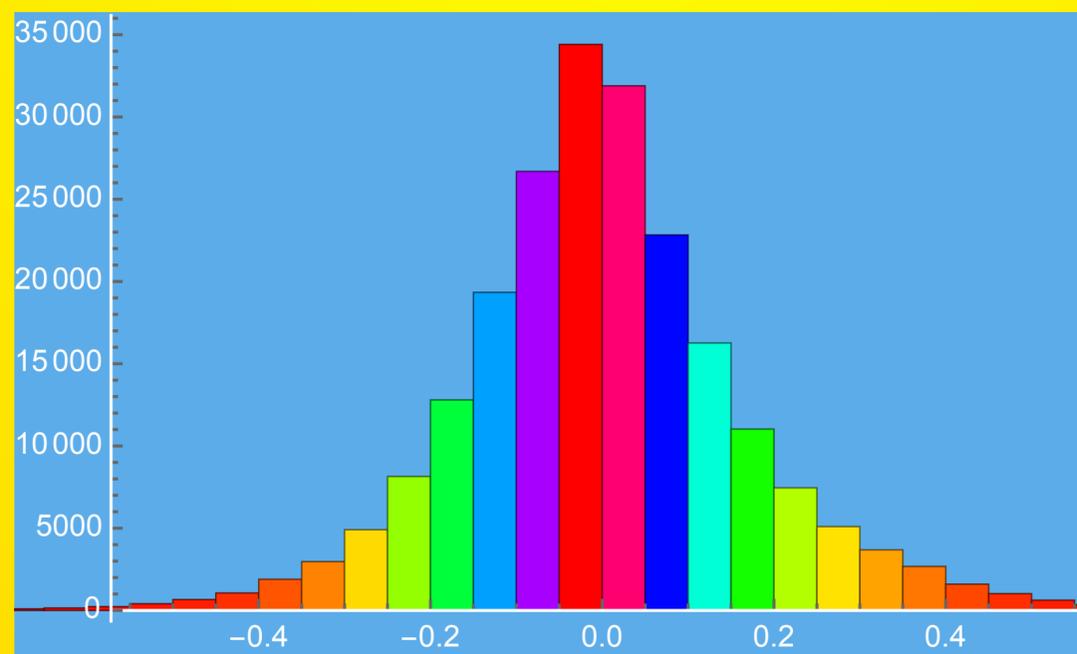
`L=First[AudioData[A]`

`L={0.0466919, 0.0316467, 0.0105591, -0.00143433,....}`

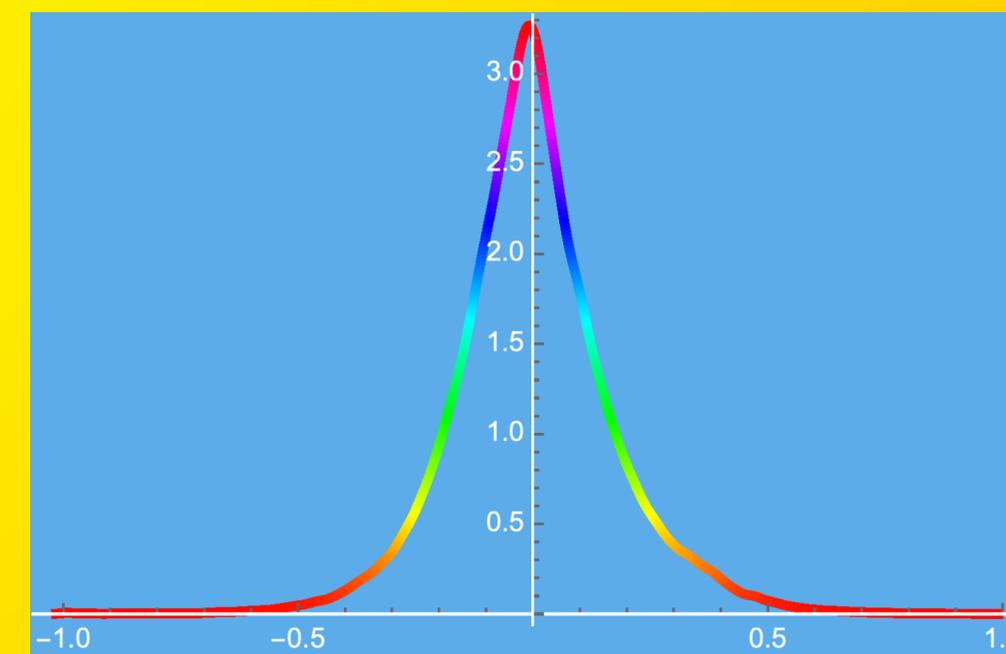
`R=Last[AudioData[A]`

`R={0.0383301, 0.0473328, 0.0524292, 0.0482483,....}`

Histogram[L]



SmoothHistogram[L]



5. SOUND

FROM AI

MATHEMATICA

```
A=Table[SoundNote[k, 0.1], {k, 12}];  
s=Sound[{"Guitar", A}, {0, 2}]
```

MATHEMATICA

```
A = Table[{k, k+RandomChoice[{3, 5}]}, {k, 10}];  
s=Sound["Flute", Map[SoundNote, A],{0,4}]
```

MATHEMATICA

```
A = Table[{k, k+RandomChoice[{3, 5}]}, {k, 10}];  
s=Sound["Flute", Map[SoundNote, A],{0,4}]
```

MATHEMATICA

```
A = Table[RandomChoice[Range[80] - 40], {30}, {6}];  
f[x_] := SoundNote[x, RandomChoice[{1, 2}]];  
Sound[{"Piano", Map[f, A]}, {0, 6}]
```

MATHEMATICA

```
A = Table[RandomChoice[Range[80] - 40], {30}, {6}];  
f[x_] := SoundNote[x, RandomChoice[{1, 2}]];  
Sound[{"Piano", Map[f, A]}, {0, 6}]
```

JAM

Which frequency does Midi number 100 have ?

What is the Gradus Suavitatis of the fraction $7/10$?

What is the hull of $f(x) = x \cos(x) \sin(10000 x)$

The End