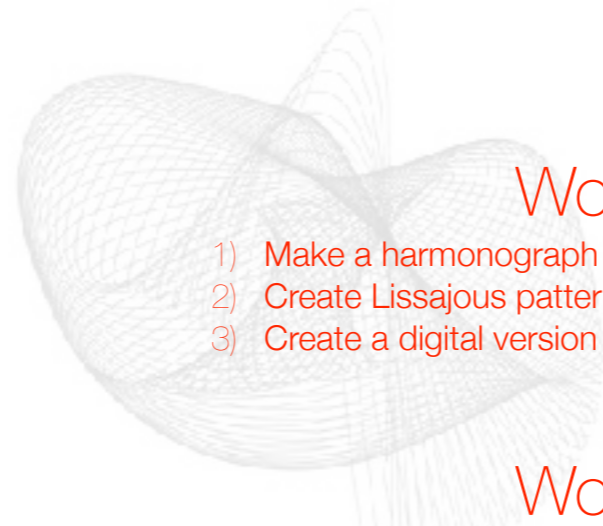


Harmonic motion - 2 oscillators
The oscillators: strings and pendulums
Also pipes, bars, tines.

Simple harmonic motion (SHM) is a special type of periodic motion where the restoring **force** on the moving object is **directly proportional** to the **magnitude** of the **object's displacement** and acts towards the object's **equilibrium** position

Simple harmonic motion is sinusoidal in time and demonstrates a single resonant frequency. Other phenomena can be modelled by simple harmonic motion, including the motion of a simple pendulum



Workshop 1

- 1) Make a harmonograph
- 2) Create Lissajous patterns using the harmonograph
- 3) Create a digital version of the Lissajous patterns

Workshop 2

- 1) Create patterns using different kinds of harmonographs
- 2) Create patterns with pendulum painting (also sand and light)
- 3) Create a digital version of the patterns

- Workshop 1&2 could be combined
- Elements from the Cymatics workshop could be added for more variation
- Making music with simple 5 note scales - ostinato



Workshops

- Discover that vibrations are **oscillations** (backwards/forwards motion)
- Musical vibrations (**itches**) are usually consistent, sustained sounds (unlike noise) and are vibrating at a specific rate (**frequency**)
- Understand how musical **intervals** (the distance between 2 pitches played together or) can be expressed as **ratios** (focus on common intervals: unison, octave, 4th and 5th)
- Explore - via **Lissajous** apparatus - what patterns emerge when common intervals (and other intervals) are sounded
- Explore how that intervals relate to **string length** (also **tension** & **mass** of the strings)
- Create **Lissajous patterns** using the **harmonograph** - explore how altering the pendulum length via the weights, changes the frequency of the pendulum and thus the pattern, just like altering the length of the string.
- Create Lissajous patterns with **pendulum painting** (paint/sand/light)
- Create a digital version of the Lissajous patterns

Sound is an oscillation of pressure

interval - the distance between
two notes (pitches)

Musical Harmony

intervals of unison, octave, fourth and fifth

~ what do intervals sound like?

two notes can be played
together or consecutively

1:1 unison - oscillating (vibrating) at the same speed

2:1 octave - oscillating at 2 times the speed

3:2 fifth - oscillating at $1\frac{1}{3}$ times the speed

4:3 fourth - oscillating at $1\frac{1}{4}$ times the speed

1:1 unison

2:1 octave - Over The Rainbow

3:2 fifth - Twinkle Little Star, The Last Post

4:3 fifth - Amazing Grace, Hedwig's theme

interval - the distance between two notes (pitches)

two notes can be played together or consecutively

Musical Harmony

intervals of unison, octave, fourth and fifth

~ the relationship between pitch & string length

monochord string lengths

monochord demo



2:1 octave (2 times the speed) = 1/2 string length



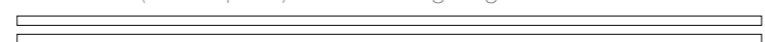
3:2 fifth (1 1/3 times the speed) = 2/3 string length



4:3 fourth (1 1/4 times the speed) = 3/4 string length



1:1 unison (same speed) = same string length



To change the interval, change the length of the string
shorter string = higher pitch (frequency)
longer string = lower pitch (frequency)

Monochord demonstration ~ the relationship between pitch & string length - how the first musical scales were worked out
Pentatonic scale - music is about pitch relationships



Musical Harmony

intervals of unison, octave, fourth and fifth

*interval ~ the distance
between two notes*

What do intervals look like? ~ Lissajous curves

Lissajous apparatus



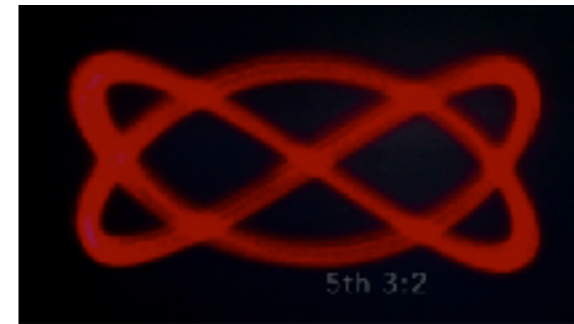
1:1

2:1

3:2

4:3

Jules Antoine Lissajous



~ the relationship between pitch & string tension

Equation for tension

Relation for mass



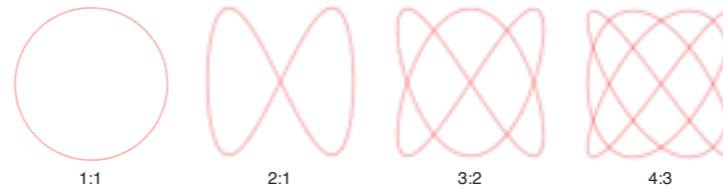
Example of an analog oscilloscope Lissajous figure, showing a harmonic relationship of 1 horizontal oscillation cycle to 3 vertical oscillation cycles.

Musical Harmony

intervals of unison, octave, fourth and fifth

What do intervals look like? ~ Lissajous curves

interval ~ the distance between two notes



1:1

2:1

3:2

4:3

1:1 unison - oscillating (vibrating) at the same speed

2:1 octave - oscillating at 2 times the speed

3:2 fifth - oscillating at $1\frac{1}{3}$ times the speed

4:3 fourth - oscillating at $1\frac{1}{4}$ times the speed

~ the relationship between pitch & string tension

Harmonograph means 'harmony drawing'

interval - the distance between two notes

Musical Harmony intervals of unison, octave, fourth and fifth

What do intervals look like? ~ Harmonograph drawings



Hugh Blackburn



Vertigo Poster

3 pendulum rotary harmonograph

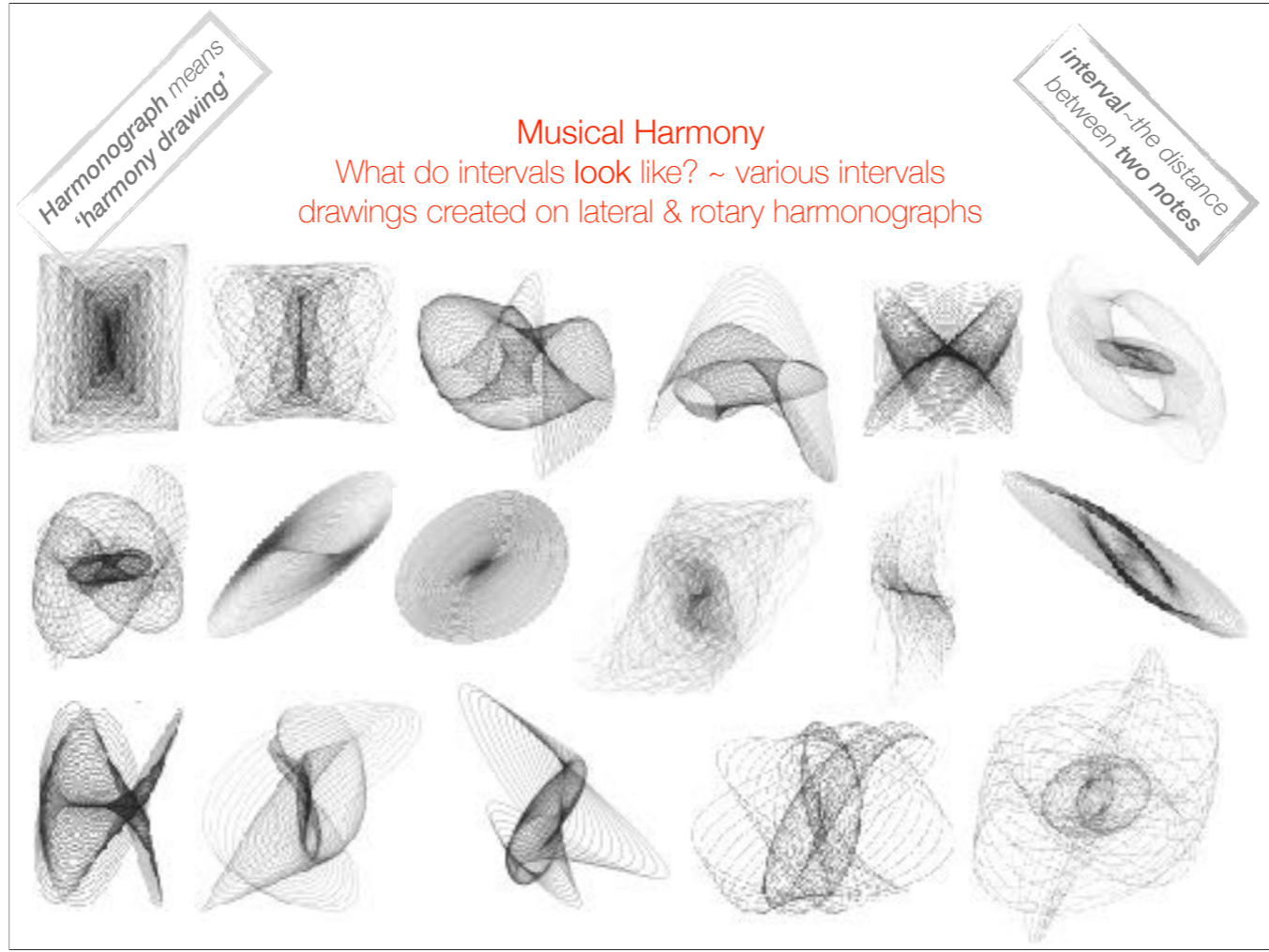


interval of a perfect 5th
lateral & rotary clockwise & rotary anticlockwise



Ratio of pendulum lengths to frequency:

- 1:1 = unison = 1 x length
- 1:4 = octave = 0.25 x length
- 3:2 = 5th = 0.45 x length
- 4:3 = 4th = 0.56 x length



Can be coloured

Can be overlaid

The type of drawing instrument will alter the quality of line

Try and recreate perfect intervals

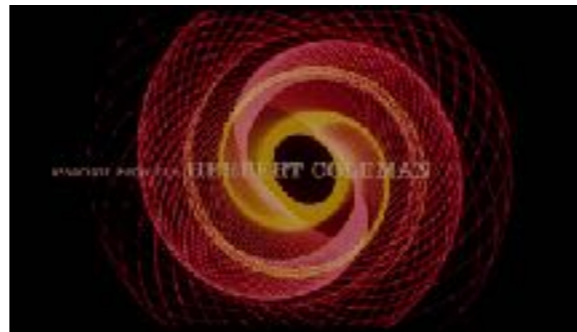
Try random ratios

Musical Harmony
intervals of unison, octave, fourth and fifth

What do intervals look like? ~ Pendulum Painting (paint)



Vertigo film opening credits



- **Paint** - various types (try painting on dry and wet backgrounds, overlaying patterns)
- **Backing** - various (wood, paper etc in a single sheet or in sections. Colour?)
- **Other** - try 2 or more paint colours at the same time via 2 swinging paint vessels

Musical Harmony

intervals of unison, octave, fourth and fifth

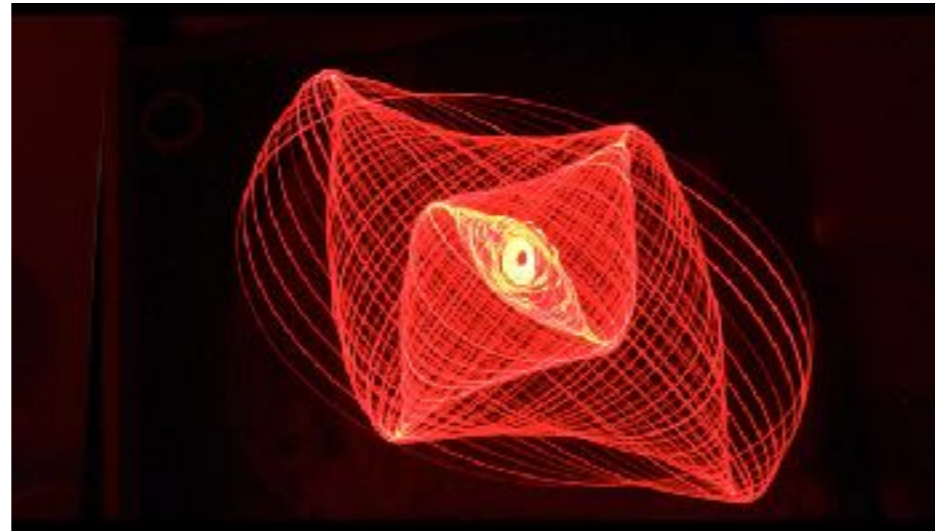
What do intervals look like? ~ Pendulum Painting (sand)



Musical Harmony

intervals of unison, octave, fourth and fifth

What do intervals look like? ~ Pendulum Painting (light)



Musical Harmony
intervals of unison, octave, fourth and fifth

What do intervals look like? ~ harmonograph making

<http://www.1920-30.com/toys/things-to-make/harmonographs.html>

rotary harmonograph (3 pendulum)



1980s harmonograph



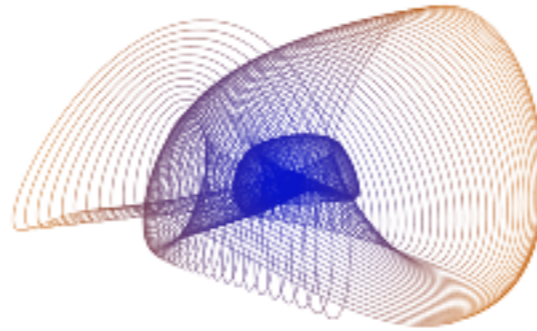
Make a harmonograph - several kinds of varying degrees of technical complexity

Musical Harmony
intervals of unison, octave, fourth and fifth

What do intervals look like? ~ coding Lissajous curves

Digital Harmonograph
coding

<https://javascript.plainenglish.io/the-digital-harmonograph-b932fd3e6c2e>



expanded view

<https://gje7g.csb.app>