



Acoustic Pendulum
Virgile Abela

A digital art project

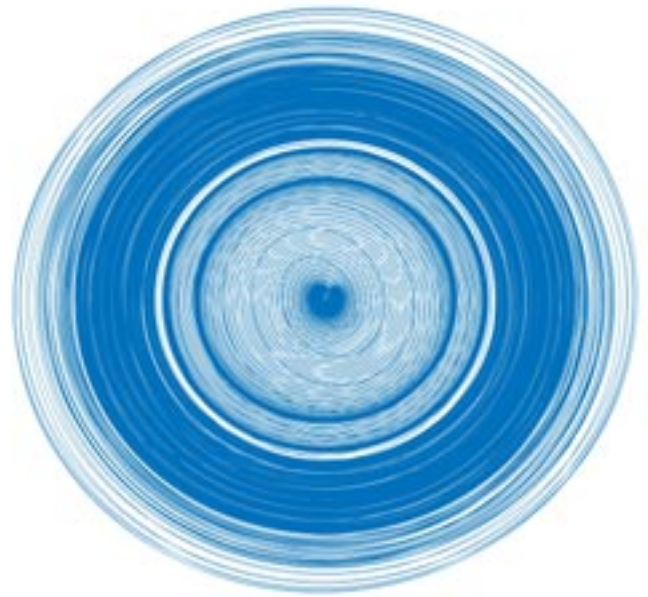
Acoustic Pendulum is an immersive and modular project placing gravity and acoustics in a generative equation.

This **kinetic installation** is an extension of Steve Reich's *Pendulum Music*, where hanging microphones oscillated over speakers put on the ground. Here the device is reversed: the microphone stands located still in the room and the speakers arranged inside the pendulum move in the room space.

Initially motionless, the pendulum oscillates very slightly at human height and progresses at the speed of its resonance frequency, until it sways widely throughout the exhibition space. From lines to ellipses, the pendulum redraws the architectural contours of the space that the visitor discovers, listening to a soundscape finally modulated by the movement.

With its **audio engine based on acoustic feedback**, Acoustic Pendulum operates a translation from movement to the sound, through the acoustic imprint of the exhibition room. This sound evolves slowly over time like a musical flow arisen from the combination of the resonance frequencies of the pendulum and the one of the location.

Through a **complex network** of harmonics interpolations, the max/msp patch generate a sound matter resulting from a quantum entanglement between the pendulum and the acoustic response of the space, making this installation a resolutely in situ work.



Echoing to Foucault's pendulum, this contemplative installation proposes to the audience an aesthetic experience of immateriality, capable to connect us to our cosmic condition. Through the vibratory nature of all matter that forms it, each atomic unit shapes the work, between the balanced behavior of the movement and the chaotic one of the sound performance.

For a **3 years Art & Science residency**, Acoustic Pendulum is supported since 2017 by the MAS (Music-Audio-Sound) platform of the LMA (Laboratory of Mechanics and Acoustics) of the CNRS (French-National Center for Scientific Research) in Marseille, known worldwide for pioneering researches by Jean-Claude Risset in sound synthesis and computer music.

This project is **highly inspired** by the metaphysical poetry that emanates from scientific works as quantum physics, and fully in line with the current concerns of digital art. As a very simple aesthetic proposal, it can communicate with a broad audience, regardless of their culture or level of education.



The basics of a research

Stillness, as a starting point of any movement, dominates the origin of this research: how to give birth to a fluid pendulum movement and keep it going without any time limitation and without any outside help?

Physics tells us that $\text{Frequency} = 1 / \text{Time}$. Therefore the frequency principle of resonance is applied as the central element of the technical approach serving this plastic research.

In the **ambivalent enigma** of Immateriality, what is the quantum part of Matter, Flow and Energy involved in it? And how can we apprehend these concepts **aesthetically, dynamically** and **sonically** within the **ecosystem** of the installation form?

Aesthetic/

The **pendulum** impose itself by its presence in space like a totem pole, with the difference that its anchor point is not a fixed point on the ground that connects it to the center of the earth, but an elevated point in height that radiates in multiple directions. Its dimensions remain within our human conception of volume: comforting in its form, yet destabilising in its movements.

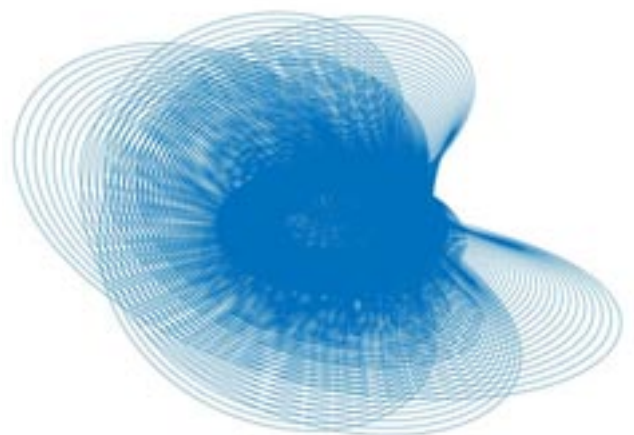
Raw yet orderly, the materials, are mainly metal for the structure and plexiglass for the sphere. The object seeks a certain elegance in the simplicity of its lines and stripped down to its functionality. The transparent sphere renders the animality of the mechanism visible as it arouses a primal function of our curiosity.

When the functioning of the mechanism is assimilated, the viewers forget it and abandon themselves to the sonified movements of the unfolding landscape. The object is reminiscent of a certain science-fiction aesthetic and lends itself to an anthropomorphic imagination of robotics with its cyclops eye, moving parts, membrane ears, fluid movement and luminescent sensors.

Dynamic/

From the **design phase**, the project was significantly associated with the lexical field of dance, primarily the search for the "right gesture" in a time that takes the time to be here. A temporality which has no task other than to disappear, leaving a mark, much like the memory of a drawing, or the body during the choreographic act.

Lateral, elliptical or circular, the movement technically results from implementation of a **double-pendulum** in which gravity cyclically rectifies the imbalance caused by the periodic shift of its balanced weight towards the center of the device.



The weight transfer that displaces the equilibrium point has long been explored in contemporary dance, as evidenced by the recent creations in 2019 of Yoan Bourgeois with "Scala" or Angelin Preljocaj with "Gravity".

Just as a dancers work with their gravitational consciousness combined with an increased knowledge of their bodies, the pendulum invariably requires a resonance frequency at all times to precisely modulate its amplitudes. To do this, its frequency is recorded, then updated in real time by a sensor which tracks all angles of the x, y and z planes of sound oscillation. When going in the opposite direction, the pendulum crosses a brief moment of immobility which the sensor registers with a 0, which is then transformed into a Bang (trigger). Thus, between two Bangs (triggers), the patch calculates a Time (= Frequency).

This time is applied to the swing of the balanced weight in 3 angular speeds (acceleration, constant and deceleration). Each angular velocity is thus calculated in order to cover the correct distance between the ends of its amplitude: the apex.

The fluidity of its progression is obtained by allowing the natural inertia of the pendulum to complete each of its oscillations. To do this, the engine executes 60% of its course during the first 25 degrees of its progression, then up to 40% for the next 25, leaving it to inertia to bring the pendulum to the moment of immobility to be analysed, so that the patch will translate into a Bang to relaunch a new command in the opposite direction, and so forth.

The pendulum begins to oscillate, increasing its angle and speed by one degree every five oscillations. In this way, the pendulum can come to life on its own up to an amplitude of 2, 3, 4 meters above the ground, depending to the height of its range. So, it is through the conjunction of electromechanical, gravitational and inertial forces that the pendulum finds its natural fluidity, a kind of animality sought through the diversity of its behaviours.

Finally, the pendulum has at its hook a rotation motor, used alone, or combined with the oscillation motor. These rotations allow ellipses or circles in space, and favour a mobile projection of the sound in 3 dimensions.



Video Link
Acoustic Pendulum
SolutionF residency
march 2020

Sound/

Acoustic Pendulum creates a favorable environment for the sequential generation of sound landscapes which are sensitive to the situation, capturing and restoring the acoustics of the location. The sound emitted is the result of the continuous acoustic field between the speakers and the microphone, so that there is neither sampling nor memory involved. The audio engine multiplies the incoming signal in 4 matrix programmable units. Within each unit, the signal is fed back on itself with a 10 seconds delay, creating a continuum. The data from the inertial unit (gyroscopic & accelerometric sensor) is routed to the audio engine and, depending on the sequences, stimulates various sound modulations, especially time feedback resulting from relatively granular effects. So the pendulum becomes the interpreter of the sound installation.

At times, it manages to achieve a perfect synchronization between movement and sound, causing all sorts of natural phenomena, such as phasing and doppler effects, as if the spectator had been immersed inside a Leslie cabinet. So we sometimes hear melodies, made by major second or third intervals, fifths and octaves... These are purely aleatoric electroacoustic variations of the natural harmonics of the fundamental feedback, which the movements of the pendulum modulate within the acoustic character of the space.

Most of the sound work is focused on a spectral approach to timbres and on the projection of sound. The sounds can sometimes bear resemblance to acoustic wind instruments, electric bass or chimes, or else modular synthesis.

In addition, the engine's drive belt is audible. It shows the metronomic character of the frequency of the pendulum, and participates in the sound material, like a pulse.

Technically, the speakers are wired in stereo. The choice of the speakers was decisive for prototype. These are Focal 100-ICW6 high definition models, designed to work without VAS, so as to avoid forcing the sphere to act as a speaker in expressing all frequencies in an optimal way. Low frequencies, are outsourced to one or two subwoofers which impart an immersive feeling of the installation due to the natural spatialization of sound.

Finally, any other exogenous sound at installation is able to enter the loop reinjection. So the installation also interacts with the sonic context of its surroundings.



Sound performance at GAMERZ festival the 14th november 2019



Ecosystem/

Acoustic Pendulum induces a global circular conception between the machine and the living; the computational part is designed in max/msp, which constitutes the brain of the loop. Other softwares are also involved, such as Python for the concatenation of messages sent by serial link to the steppers, as well as C for Arduino for programming the sensors.

The general principle of the programming comes alive like a body composed of different organs, each of which plays a precise role in coordination with others. The part that calculates the resonance frequency thus imposes itself as the organic heart of the global system. The part which mainly deals with the movement and the sound is sequenced in the form of phases called "Landscapes". They each succeed one another, as in a score, offering a time frame for the installation. This last one finds its permanence in balancing the predictable functioning of the movement and the chaotic behaviour of the sound, all synchronized through the rhythm of the oscillations that gravity imposes to the pendulum.

4 Variations/

> [Acoustic Pendulum \(Installation\)](#)

A generative and standalone device where movement modulates the sound flow through the acoustic imprint of the exhibition space

> [Acoustic Feedback \(30' Performance\)](#)

An instrumental device where the pendulum is used like an electroacoustic instrument, interpreted from a controller developed on mira & max / msp

> [Sinus \(Lithographs exhibition\)](#)

Imaginary scores resulting from pendulum motion modeling. They can complete the installation

> [Feedback & Musical Gesture \(Workshop\)](#)

A sonic experience through the relation between gesture & listening by playing with the audio feedback resulting from the setting in vibration of the air contained in a small object

