Comune di Pisa

Enel
L'ENERGIA CHE TI ASCOLTA.

Vladimir Skoda

Riflessi celesti e meccaniche galileiane

MAZZOTTA

La lampada di Galileo Galilei, ricostruzione

The Pendulum

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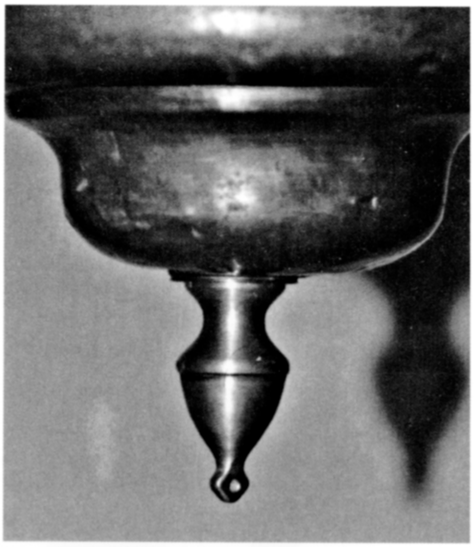
> A thousand times I have given attention to oscillations, in particular those of lamps in some churches hanging from very long cords, inadvertently set in motion by someone, but the most I ever got from such observations was the improbability of the opinion of many, who would have it that motions of this kind are maintained and continued by the medium, that is, the air. It would seem to me that the air must have exquisite judgment and little else to do, consuming hours and hours in pushing back and forth a hanging weight with such regularity. And now I learn that a given moveable, hung from a cord one hundred braccia long, and drawn from its lowest point now ninety degrees and again but one degree, would consume as much time in passing this smallest arc as that maximum arc. I certainly do not believe that I would have ever discovered this, which still seems to me to have in it something of the impossible[1].

A church lamp oscillating is at the same time a *suspended weight*, with its continuous vibration showing to any time's observer the absurdity of Aristotle's explanation of motion.
Not by chance, however, wise Giovan Francesco Sagredo, in whose mouth Galileo put the statement we just read, declares that he never could have discovered isochronism, through which for three centuries the time of watches all over the world will be regulated.
Impossible for the common man, key starting point for the young Pisan scientist to begin building a New Science.
Patiently, with the pendulum, Galileo measures the space covered during its subsequent oscillations, and – trying and trying again – discovers the first law of science, binding space and time forever.

Barely perceived by Kepler's visionary phantasy, the infinite possible subdivisions of time allow today an intuition of universe's musical harmony as a cosmic collection of watches: galaxies, stars and planets perennially rotating; chronometers with vibrating quartz hearts, atomic clocks regulating – through the internet – the working of millions of computers all over the earth; pace maker for the cardiac muscles of millions of human beings. All the times of the world.

> A pendulum hung from a subtle wire of whichever gauge is the most precise divider of time, in the smallest particles; said pendulum being of heavy substance, removed from the perpendicular position and left to flow freely,

makes its own reciprocations, or if we want vibrations, be they large or small, perpetually under the most equal times[2].



Particolare della lampada di Galileo Galilei

The pendulum perceives the change of seasons: slows down its movement in the summer and goes faster in the winter; but the ingenuity of a maker reinforces it in a new structure[3] in order to compensate for the effects of warmth and cold, thus restablishing the constant rhythm to the watches' wheels.
The pendulum reveals the Earth's rotating movement; three centuries after Galileo's death, Foucault[4] convinced even the last disciples of Ptolemy and Urban VIII, and they fault Galileo because he didn't use it to that aim.
The pendulum measures Earth's spherical shape[5] and, like the rabdomant's stick, explores its insides to ascertain how far we are from the mythical center of the world.
The pendulum reveals how earthquakes propagate[6] but the bullett's speed as well.

> Galileo was around the age of twenty in the town of Pisa, in the year 1583, where on his father's advice he was reading philosophy and medicine; and being one day in the Cathedral of that town, for his curious and most sharp nature came into his mind to observe if in the motion of a lamp, which had been moved from the perpendicular, by any chance the times of its coming and going, in the small arcs as well as in the large one, were equal, since it seemed to him that the longer time due to the longer path of the major arc could maybe be compensated by the larger speed the lamp seemed to him to be moving with, like a line in its higher and steeper parts. Thus it came to him, while it was quietly moving, of roughly examining those coming and going through the beats of his heart, and as well with the help of the tempo of the music, in which he also was an expert; and since then from these proofs it seemed to him that his belief in the equality of these times were not false[7].

The heart beating in our wrist: in all wrists, regulated by the square root of the length of an imaginary wire getting longer or shorter according to our emotion, and that one day will certainly break.

[1] *Le Opere di Galileo Galilei*, Barbera, Firenze 1968, vol. VIII, p. 141; transl. Stillman Drake, *Two New Sciences*, University of Madison, 1974, p. 141.
[2] *Le Opere di Galileo Galilei*, Barbera, cit., vol. VIII, p. 453
[3] John Harrison (1693-1776) invented the pendulum with grill compensation, using the different dilatation coefficients of steel and brass in order to keep constant the real length of the pendulum.
[4] Jean-Bernard Foucault (1819-1868) attached a 67 meters long pendulum at the top of the Pantheon's dome in Paris. The bronze sphere weighed 28 kg. The oscillation plane of the pendulum seemed to rotate apparently in a time T= 24h / sin j where j is the latitude of the place.? But it was the Earth-watch rotating under it.
[5] In 1671 an expedition of French astronomers arrivò at the Cayenne island (5° north). The head of the group, Jean Richer, brought a precision pendulum watch. He realized that in the Cayenne the watch was 21.1 minutes a day slower than in Paris (situated at 45° north). Later Newton considered this to be a proof of the equatorial deformation, which would reduce gravity's force provoking a greater distance from the Earth's center. After expeditions in Peru and Lapland confirmed Newton's theory, French mathematician Alexis Claude Clairaut, a member of the Lapland expedition, devised methods for calculating the Earth's flattening from a pendulum's oscillations.
[6] Nicola Cirillo (1671-1735), Neapolitan physician, botanist and naturalist, when earthquakes devastated Capitanata in March 1731, employed two equal pendulums installed on semicircular scales to measure the oscillations amplitude. He placed one in Ascoli Satriano, closer to the epicenter of the quake, and the other in Giovinazzo, four times farther. The difference between oscillations proved the ondulatory propagation of seismic movements.
[7] *Le Opere di Galileo Galilei*, cit., vol. XIX, p. 648. Letter from Vincenzo Viviani to prince Leopoldo de' Medici, August 20, 1659.